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ORIGINAL RESEARCH

Unraveling the Dynamic Nexus Between Trade Liberalization, Energy Consumption, CO_2 Emissions, and Health Expenditure in Southeast Asian Countries

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Objective: Most of the Southeast Asian countries witnessed remarkable economic growth in the last few decades. Trade is a primary factor in achieving this exponential economic progress in these countries. Besides, the positive implications of trade, it has associated cost of escalated energy consumption, CO_2 emissions, and resulting health complications which leads to higher public health expenditures. This study examines the nexus between trade liberalization, energy consumption, CO_2 emissions, and health expenditures in Southeast Asian countries for the period of 1991 to 2018.

Methods: The empirical methods used in this study entail diagnostic testing, correlation analysis, and structure equation modeling (SEM) technique. SEM is an advanced multivariate analysis technique that can test complex multivariate causal associations among a set of variables. Therefore, it is the most suitable econometric approach to explore the dynamic association between trade openness, energy consumption, CO_2 emissions, and health expenditures.

Results: The empirical results reveal a nexus between trade openness, energy consumption, CO_2 emissions, and health expenditure in Southeast Asian countries. Nevertheless, pollutant emissions have a direct impact on health expenditures, whereas trade and energy consumption shows an indirect influence on the escalation in public health spending in sample Southeast Asian countries. Moreover, the mediating path of each indirect effect is energy consumption.

Conclusion: These results imply that Southeast Asian countries heavily rely on fossil energy to fuel economic growth. Hence, to promote sustainable and eco-friendly economic development, the respective governments need to reform their energy sectors by tapping into renewable energy resources and deploy green technologies to reduce pollutant emissions for the development of a healthy society. In addition, governments should levy taxes on highly polluting industries so as to curtail carbon emissions and resulting health expenditures.

Keywords: trade liberalization, energy consumption, CO_2 emissions, health expenditures, Southeast Asia

Introduction

Southeast Asian countries witnessed phenomenal economic growth in recent years. Trade is a mainstay in attaining this exponential economic growth. Association of Southeast Asian Nations (ASEAN) members have substantially reduced tariffs under the Asian free trade agreement to expand trade and investment activities.

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Although trade promotes significant economic activity, yet it also poses serious environmental threats in terms of increased pollutant emissions that have adverse consequences for human health. Besides, ASEAN is a major hub of energy consumption in the global energy market. As per the report of the International Energy Agency (IEA, 2013), energy demand in Southeast Asia is expected to surge by 80% between 2013 and 2035. Southeast Asian countries heavily rely on fossil energy. Hence, the use of non-renewable energy to fuel economic growth is a major cause of environmental degradation in the ASEAN region.[1] Besides, exports also substantially contribute toward carbon emissions in the developed and developing Southeast Asian economies.[2] Thus, in the backdrop of heightened energy demand and trade integration, it is imperative to understand the possible repercussions of trade liberalization on environmental degradation through the channel of CO_2 emissions, energy consumption, and health expenditures.

Trade liberalization attracted considerable attention since 1990 when the globalization and trade openness was embraced by many countries around the World. Trade liberalization notably promotes economic growth, income level, and boost industrial production in a country. Despite the positive aspects of trade, it has associated costs in terms of environmental degradation; especially it escalates the volume of CO_2 emissions of a country. Consequently, CO_2 emissions adversely affect human health and raise the health care expenditures of the government.[3]

CO_2 emissions could potentially cause health complications and respiratory illness in humans which thereby put pressure on governments to allocate more resources for public health endeavors. There are three main channels through which trade activities influence CO_2 emissions. First; trade liberalization increases pollutant emissions due to large-scale production activities, particularly in the export-oriented industries.[4] Second; trade causes a higher volume of CO_2 emissions due to the widespread use of non-renewable energy technologies which aggravate CO_2 emissions. Third; countries specialize in those industries in which they have a comparative advantage in trade, which leads to an expansion in production activities and heightened emission levels.[5] As per the report of Energy Information Administration (EIA), a 75% increase in CO_2 emissions has been recorded for the period of 1980 to 2012, whereas, a 450% increase in international trade was recorded during the same period. In addition, Energy Information Administration report (2013) reveals that developing countries had higher growth in carbon emissions and predicts an anticipated increase of 127% by the year 2020 as compared to the developed countries.[6]

Besides, trade openness also influences energy consumption activities through various channels. Trade allows local manufacturing industries to expand their operations to achieve economies of scale through mass production which leads to higher usage of energy.[7] Coondoo and Dinda[8] also confirm that trade liberalization intensifies the country's overall energy consumption. However, trade provides access to advanced technologies in the production process which are more energy-efficient hence can reduce the wastage of energy resources.[9] Moreover, energy is a key input in the production process; the expansion in trade activities cause an upsurge in the demand for energy and escalates the energy consumption in a country.[10] Empirical studies have employed diverse econometric approaches and data frameworks to unleash the association between trade openness, energy consumption, CO_2 emissions, and economic growth.[11–17] Their findings, however, suggest mixed results. Nevertheless, the impact of trade openness depends on the adoption of manufacturing technologies and the composition of the underlying energy system in a country.

Human health is significantly affected by the surrounding ecosystem and medical science literature contends that air pollution causes various types of fatalities. Health is an essential factor for a vibrant labor force, and labor productivity primarily depends on the overall health status in society. Therefore, spending on health endeavors is a crucial factor that can influence the economic development of a country. Health spending, better health quality, and improved living standards enhance work efficiency and national productivity. Among pollutant emissions, CO_2 is usually acknowledged as a leading contributor towards environmental contamination and national health expenditures are directly influenced by the quality and stability in the climatic conditions. According to the UK National Health Service, 8% of the health expenditures were caused by climate change in developed countries in the year 2009.

A plethora of studies show the adverse effects of trade and economic activities on pollutant emissions and environmental sustainability. However, it still remains unknown how heightened energy consumption and resulting emissions impact the public health expenditure of the government. Therefore, the present research aims to

uncover the potential downside of trade openness and energy intensity through the channel of increased pollutant emissions on health spending in Southeast Asian countries. The contribution of this research is twofold. So far, the linkage between energy consumption, CO_2 emissions, health spending, and economic progress has only been explored in a national context[4,5] which lacks generalizability to a broad regional setting. Southeast Asia has emerged as a major powerhouse of trade and energy consumption. Hence, it is imperative to explore this dynamic association in the context of rapidly evolving Southeast Asian countries. Second, in the backdrop of an over-dependence on fossil energy to spur economic growth in the ASEAN region,[1] it is essential to explore the impact of energy-led growth on the environmental and public health fundamentals of these countries. Therefore, this study empirically investigates the nexus between trade liberalization, energy consumption, CO_2 emissions, and health expenditures using the case of Southeast Asian countries. Third, the study makes a methodological contribution by the application of the structural equation modeling technique. SEM is a second-generation multivariate econometric technique that helps to investigate the complex relationships among multiple variables through a series of regression outcomes. Hence, this analysis approach is better suited to assess the dynamic nexus between trade, CO_2 emissions, energy consumption, and health expenditures to ensure the robust empirical outcome.

Conceptual Framework and Literature Review

Extant literature on trade, energy, environmental sustainability, and health expenditures has explored various aspects covering different time periods and econometric approaches. In general, the effects of free trade policies on the environment and pollutant emissions are controversial on different scales from technology effect to the net composition effect.[18,19] However, trade openness can also positively contribute to the preservation of environment in both developed and developing economies as it can optimize production processes, introduce new energy-efficient technologies that lead to reduced CO_2 emissions and energy consumption. Nevertheless, trade openness is a significant contributor towards CO_2 emissions due to heightened energy consumption.[20,21]

Numerous studies discuss the impact of trade openness on carbon emissions by using linear methodologies; however, their findings show mixed results.[13,19,22–29] Nevertheless, majority of these researches show that trade activities have intensified carbon emissions and energy consumption in the last few decades, both in developing and developed nations.

Energy consumption has a significant positive impact on the economic growth of a country.[30] Emir, Bekun[31] reveal a bidirectional causal nexus between energy intensity and economic growth in the context of Romania, whereas a unidirectional causality was observed running from the use of renewable energy and economic growth, hence confirming the growth-led hypothesis. Alam, Begum[32] and Wang, Cammeraat[33] argue that trade openness escalates the use of energy in developing countries. Globalization and liberalized trade policies of the developed countries are the major factors that lead to an increase in CO_2 emissions.[16,34] Similarly, the empirical results of, [31] [32] establish that industrial production post-trade liberalizations are the main sources of pollutant emissions in the developing economies. Carvalho, Santiago[34] also explore another aspect of the carbon emissions and contend that developed economies cut down their own pollutant emissions as they shift their polluting industries to developing economies by taking advantage of increased globalization and free trade policies. Tang, Tan[35] assert that developing countries show less environmental concerns than their developed counterparts. From the perspective of BRICS economies, it was witnessed that coal rents significantly help in pollution abatement by curtailing the CO2 emissions. Nevertheless, these countries need to implement more stringent regulations to discourage the use of coal and switch to cleaner technologies for a greener and environmental-friendly economic growth.[36] Likewise, Shahbaz, Uddin[37] observed a long-run association between energy consumption, trade openness, CO_2 emissions, and real income through the application of ARDL technique. Their results indicate that in the long run, energy consumption and trade openness has a significant positive impact on CO_2 emissions. Moreover, there exists bi-directional causality between energy consumption and CO_2 emissions, and between trade openness and carbon emissions. However, Bekun, Emir, Sarkodie[38] observed a unidirectional causality between energy consumption and carbon emissions in South Africa. Besides, they found a concave relationship between energy consumption and economic growth

signifying that higher economic growth leads to a decline in energy intensity due to the efficient utilization of energy resources.

Furthermore, Ozturk[39] reveals that although nuclear and fossil energy sources escalate CO_2 emissions yet they also amplified GDP per capita and foreign direct investment in the sample Latin American countries. Farhani, Chaibi[19] indicate a linkage between trade openness and pollutant emissions; their findings show that increased use of energy causes CO_2 emissions and deteriorate air quality. In addition, they found a bidirectional causal nexus between energy consumption and the environmental quality while a unidirectional causality was observed from trade openness and economic growth to CO_2 emissions. Al-mulali and Sheau-Ting[11] empirically explore the perceived linkage between trade, energy consumption, and real income over two decades. Their findings conjecture a positive linkage between trade, GDP, and CO_2 emissions. According to Copeland, Taylor[40] despite the fact that CO_2 emissions are affected by trade liberalization, though trade also leads to an increase in income and production for developing countries.

Moreover, Ozcan, Ozturk[41] examined the renewable energy and economic growth nexus in 17 emerging economies. Their findings show that energy conservation policies have no adverse effects on the economic growth of 16 countries. Ahmad et al[42] found that the use of non-renewable sources of energy can substantially curtail carbon emissions in the northwestern Chinese provinces. Hence, cutting down on fossil fuels in industrial production can significantly improve environmental quality. However, an over-dependence on non-renewable energy sources to spur carbon-intensive trade and economic development can hamper efforts to mitigate the adverse impacts of climate change.[43] Likewise, Bekun, Alola, Sarkodie[44] noted that the consumption of renewable energy enhances environmental quality in sample EU countries. However, fossil energy sources significantly undermine environmental sustainability. In a more recent study, Adedoyin, Alola, Bekun[45] indicate that R&D and renewable energy consumption boost environmental quality. Besides EU countries need to urgently diversify their energy mix to ensure a sustainable ecosystem.

The cost associated with hospitalization has increased substantially nowadays.[46] Public health expenditure is a major component of the government's fiscal spending to support the development of a healthy society.[47] The association between environmental quality and health care has long been an area of interest among researchers. The externalities caused by air pollution have a negative impact on labor productivity, which directly affects industrial efficiency and the national output of a country. Empirical research has also discovered a significant association between CO_2 emissions and health expenditures. For instance, Jacobson[48] juxtaposes that the main cause of air pollution and poor air quality are rising CO_2 emissions which leave harmful substances and toxic matters in the air thus leading to deterioration in the ozone surface. This in turn has an adverse impact on human health, causing increased hospitalizations, and deaths. Similarly, studies like Bedir[49] Ke, Saksena,[50] and Samudram, Nair,[51] also reveal a significant positive relationship between CO_2 emissions and health expenditures.

The findings of Zhang, Chen[52] also confirm that air pollution is the fourth major threat to the ecosystem and human health in China. Nevertheless, a negative relationship between CO_2 emissions, economic growth, and health expenditures was observed by Abdullah, Khan.[53] Similarly, Ullah, Ali[4] found a linkage between trade openness, CO_2 emissions, and health expenditures in China during the period of 1990–2017. Using simultaneous equation modeling, they found that trade openness significantly heightens carbon emissions, which requires an increase in public health expenditure by the government, whereas in the long run, a bidirectional interdependence was observed between carbon emissions and health expenditures, indicating a strong correlation between air pollution and health expenditures. Hence, a better air quality has a substantial contribution toward a healthy environment for the society.

In a study of 30 Chinese provinces, Lu, Chen[54] assert that carbon emissions considerably escalate environmental pollution and adversely affect public health. Moreover, the long-run elasticity estimates depict CO_2 emissions as a key determinant of health care expenditures. The pollution hazards mainly CO_2 emissions have adversely affected the health sectors in recent years. Yazdi, Shakouri[55] also examined a similar phenomenon using cointegration and ARDL techniques and contend that carbon monoxide and sulfur oxide escalate health expenditures in sample countries. Moreover, the positive association between health expenditures and CO_2 emissions was also observed in the following empirical studies; Beatty, Shimshack,[56] Chaabouni, Zghidi,[57] Narayan, Narayan,[58] and Apergis, Payne.[59]

Overall, the literature suggests a link between trade, energy consumption, and carbon emissions. Moreover, empirical studies also validate the association between

carbon emissions and an increase in pubic health care expenditure by the government. Putting things in perspective, it is imperative to investigate the causal nexus between trade openness, energy consumption, CO_2 emissions, and governmental health care expenditure in the rapidly emerging Southeast Asian region.

Stylized Facts of Southeast Asian Countries

Trade Liberalization

Figure 1 illustrates the trade liberalization trends from 1991 to 2018. Cambodia's trade liberalization can be witnessed as having an upward trend in the graph from 1991 to 2004. Though, after 2004, the country exhibits a downward trend in trade, while it again shows an upward trend in trade from 2015, and onward. However, Indonesia reports a flat kind of trade liberalization practices between 1991 and 2018. While data of Lao DPR reveal an upward trend in terms of trade liberalization up to 2014, subsequently a sudden downward trade is witnessed. Malaysia exhibits an upward trend up to 2004, and then a declining pattern is witnessed. Philippine depicts a kind of mixed variation in trade liberalization during 1991–2018. Nevertheless, Singapore posits a serious upward trend in trade liberalization practices until 2008, and then a declining trend is observed, while Thailand shows a continuous upward trend. Likewise, the trade liberalization trend of Vietnam reflects a smooth upward trend. Overall, Malaysia and Singapore reported a continuous upsurge in trade which reflects that these countries are comparatively well engaged in trade activities thus achieved higher economic growth and standard of living.

Energy Consumption

Figure 2 shows the energy consumption patterns for the selected Southeast Asian countries for the period of 1990–2018. Thailand, Vietnam, and Singapore show an overall upward trend between 1991 and 2018, with slight fluctuations. Similarly, Malaysia and the Philippine post an upsurge in energy consumption yet reveal a relatively flat curve for energy consumption practices, whereas Cambodia and the Lao PDR depict a flat trajectory with a slightly increasing trend in their national energy consumption during the study period. Overall, the energy consumption was on the rise in sample countries.

CO_2 Emissions

Figure 3 demonstrates the CO_2 emission levels in Southeast Asian countries. Vietnam, Singapore, and Thailand post

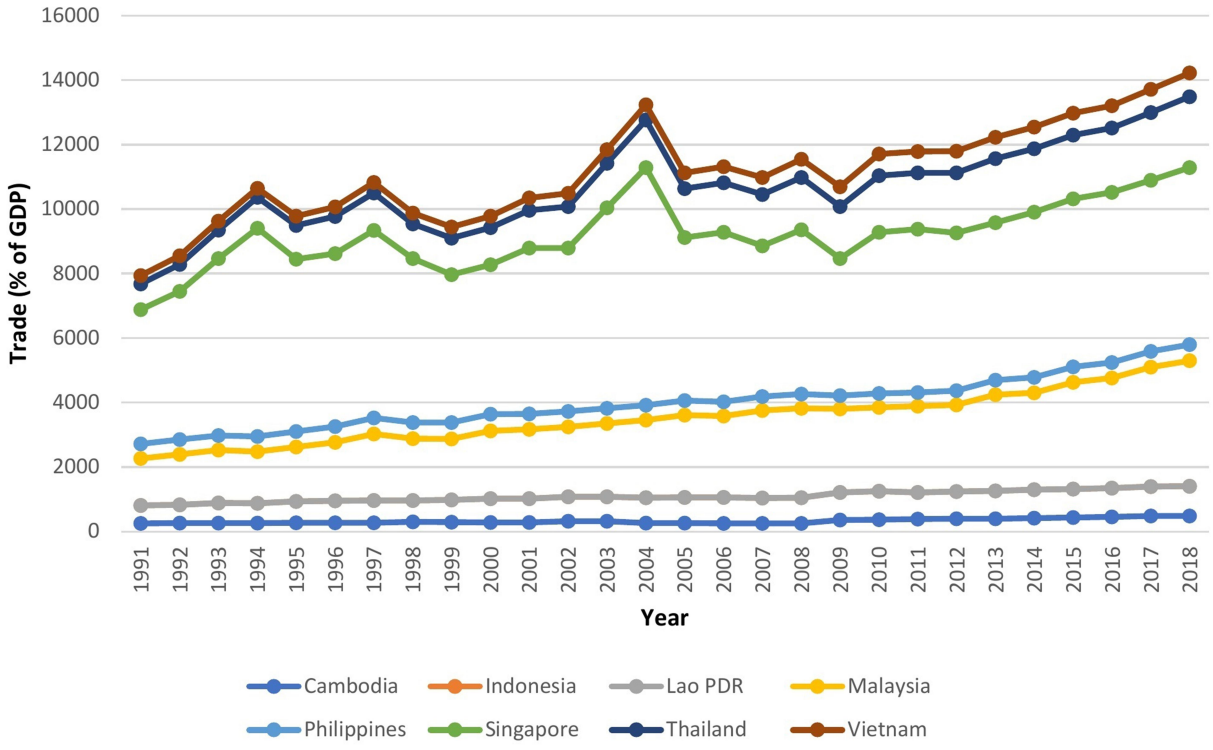

Figure 1 Trade liberalization in Southeast Asian Countries (1991–2018).

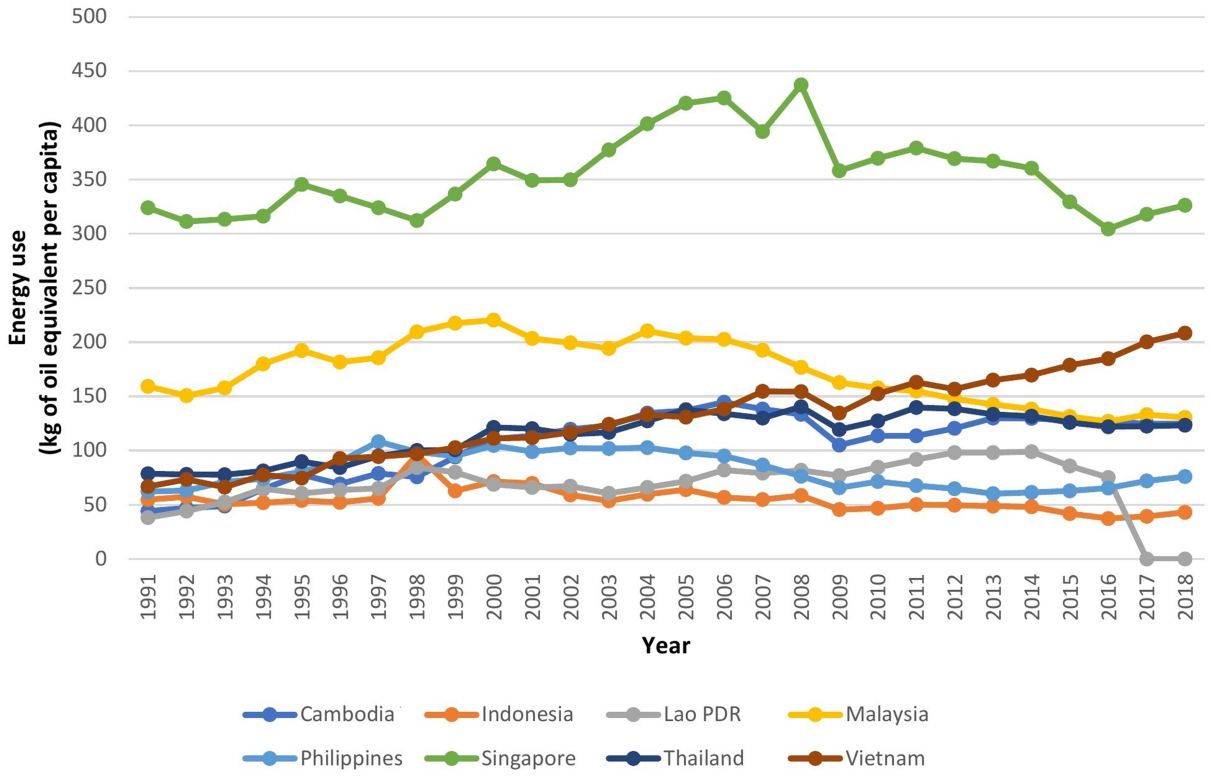

Figure 2 Energy consumption in Southeast Asian Countries (1990–2018).

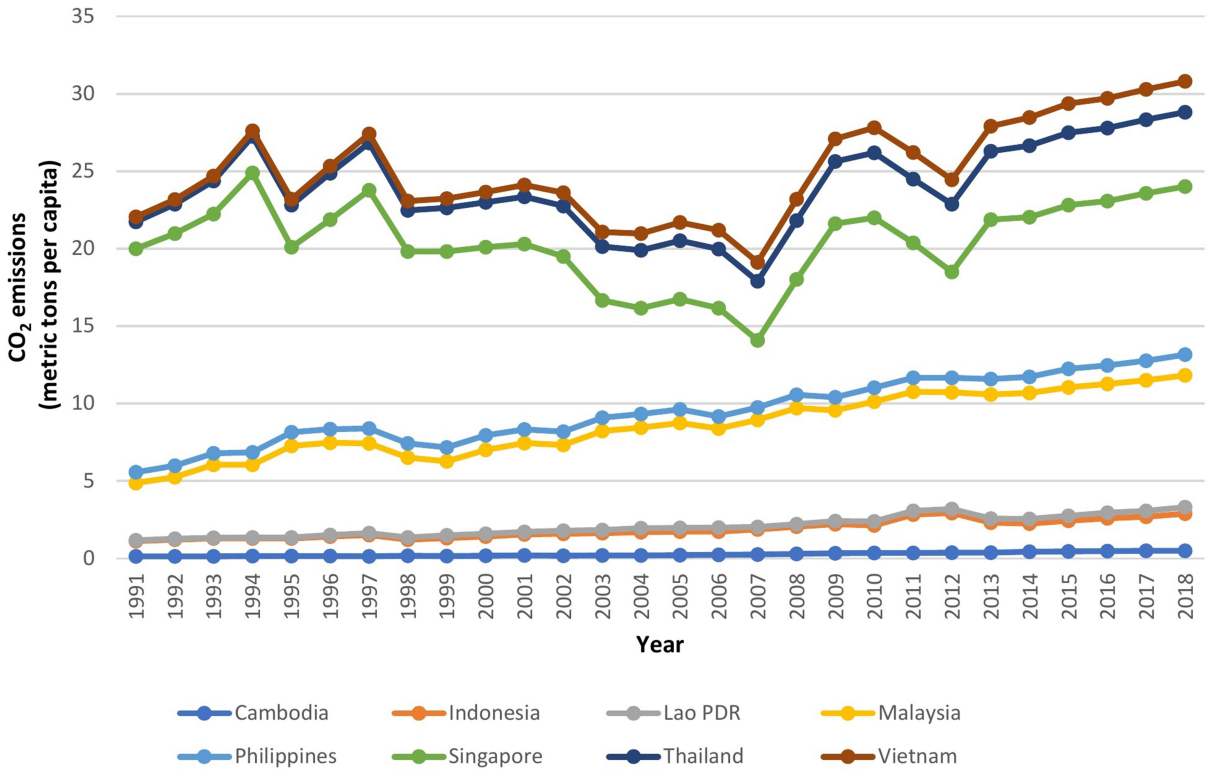

Figure 3 CO2 emissions in Southeast Asian Countries.

a downward curve from 1991 to 2007, afterward a sudden drastic upward trend is witnessed, which is due to heightened energy consumption in these three countries. Besides, Malaysia and the Philippine experienced a flat yet a bit rising trend in CO_2 emissions, which is consistent with their energy consumption practices, as both these countries have somewhat similar energy consumption patterns. Likewise, Indonesia, Lao PDR, and Cambodia present somehow similar increase in CO_2 emissions. Overall, the trend lines show a massive increase in CO_2 emissions in sample countries which should be a concern for the policymakers.

Health Expenditure

Figure 4 depicts the health expenditures in Southeast Asian countries. Vietnam, Singapore, and Thailand show a flat trend in health spending from 1991 to 2002. Afterward a steep upward trend is evident, which can be attributed to increased CO_2 emissions in these countries due to an expansion in trade and industrial activity which accounted for a massive surge in the value of health expenditures in these three countries. These trends verify that increased CO_2 emissions cause more health complications which leads to an upsurge in overall public health spending. Similarly, Malaysia and the Philippine show a flat, but slightly upward trend in health spending which is in line with the pattern of CO_2 emissions in these countries. Hence, we can infer that CO_2 emissions and health expenditures have a direct association. Likewise, the Lao PDR, Indonesia, and Cambodia show a similar trend for health expenditure as indicated by the level of CO_2 emissions in these respective countries. However, owing to rapid industrialization and resulting pollutant emissions, Singapore, Thailand, and Vietnam reported the highest values in health expenditures which should be an area of concern for the respective governments.

Methods

Data and Sample

We extract data for CO_2 emissions, trade liberalization, energy consumption, and health expenditures for the sample countries, ie Malaysia, Singapore, Vietnam, Indonesia, PDR, Philippine, Thailand, and Cambodia from the World Development Indicators (WDI) published by the World Bank.

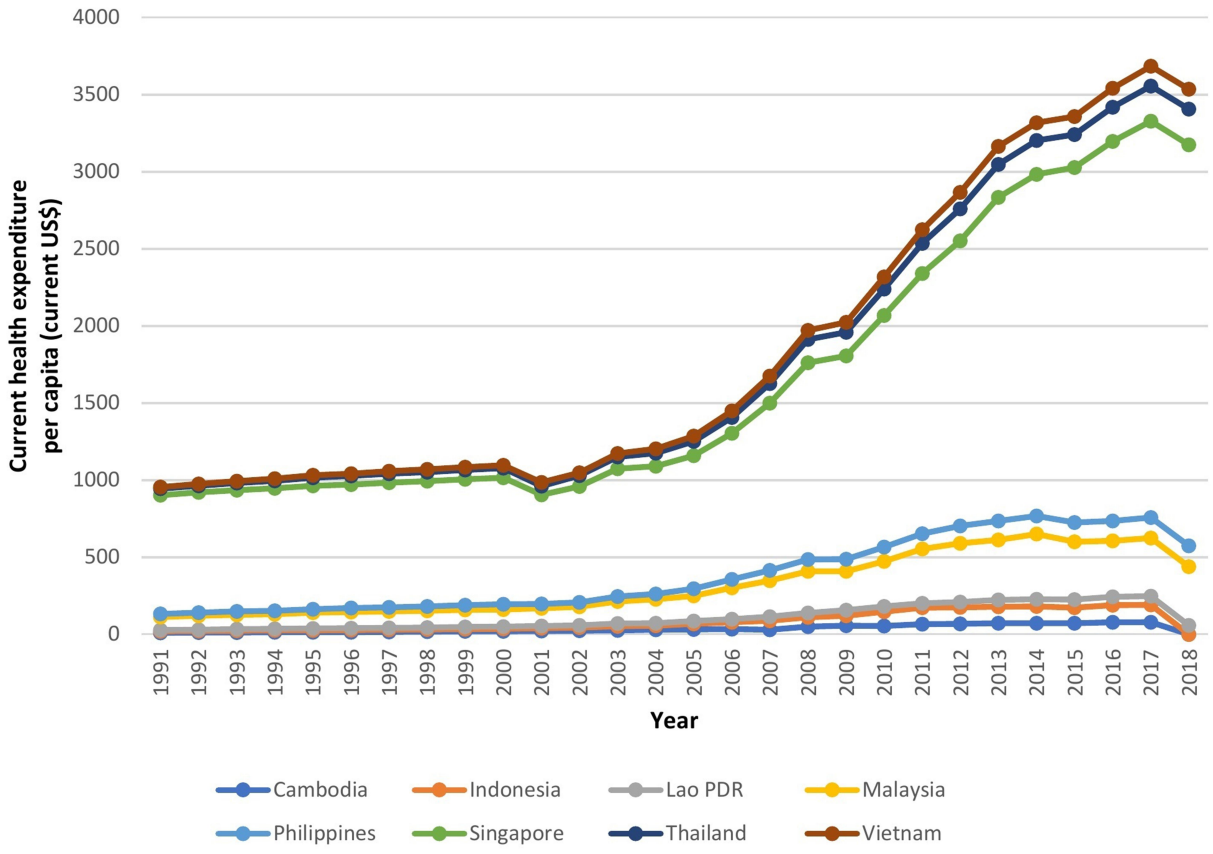

Figure 4 Health expenditures in Southeast Asian Countries.

Table 1 exhibits the variable names and notations used in this study. Moreover, the calculation methodology and the data sources of these variables are also listed.

Empirical Strategy

The application of a robust econometric approach in the process data analysis often distinguishes between the success and failure of empirical research. Fan, Chen[60] state that structural equation modeling (SEM) is a robust multivariate technique becoming very famous especially in social sciences research due to its ability to test complex multivariate causal associations. SEM is different from alternate econometric models as it examines both direct and indirect associations between perceived causal relationships.

Recent studies[61–63] found numerous commonalities between SEM and ARMA models. SEM is also used as a tool in the analysis of the ARMA model and this combination has produced good results. SEM examines the underlying research questions through qualitative causality which encompasses the application of multivariate regressions and confirmatory factor analysis. SEM is one of the latest econometric approaches for multivariate data analysis developed to overcome the shortcomings observed in the previous models such as the OLS regressions. SEM is a second-generation technique for data analysis developed for analyzing the inter-linkages among multiple variables. These inter-relationships among variables can be expressed in a series of regression models.

Therefore, we apply SEM for examining the proposed relationships among various variables used in this study. Byrne[64] highlights the importance of SEM, and argue that SEM is a preferred model for analysis, as it provides appropriate estimates to clearly understand the issue when analyzing a complex structure to comprehend a causal relationship in multiple structural regression equations. SEM is also an appropriate choice of being an effective estimator when the researchers explore multiple associations among different variables.[65] SEM measures the relationship among variables by extracting several goodness of fit indices, which exposit the validity of a structural model. These indices have specific critical values to confirm the fitness of the model. In this regard, Sumner, Bryan,[66] also documents that the structural equation model stands reliable and the relationship among variables provides better fit indices under this empirical setting.

Besides, SEM also enables us to conduct and rationalize the interrelationships among various variables through path coefficients.[67] Moreover, the regression path coefficients predict the significant and insignificant effects of one variable on another variable. Hence, we observe the interrelationship of trade liberalization, CO_2 emissions, energy consumption, and health expenditures through SEM analysis. That is why SEM is an appropriate estimation technique to predict the complex relationship proposed in this study.

Table 1 Variables Definition and Measurement

Variables	Notation	Definition	Source
Energy Consumption	Energy	Energy use (kg of oil equivalent per capita)	WDI
CO_2 Emission	CO2	Carbon dioxide emissions (metric tons per capita)	WDI
Trade liberalization	T	Trade liberalization (% of GDP)	WDI
Health expenditures	HE	Current health expenditure per capita (current US$)	WDI

Abbreviation: GDP, gross domestic product.

Research Hypothesis

Based on the structural equation modeling we test the following hypotheses;

H1: Trade liberalization positively affects Energy Consumption

H2: Trade liberalization positively affects CO_2 Emissions

H3: Trade liberalization positively affects Health Expenditures

H4: CO_2 emissions positively affect Health expenditures

H5: Energy Consumption positively affects CO_2 emissions

Results and Discussion

Diagnostic Testing

We apply various diagnostic tests to authenticate the data and to assess its appropriateness for further application of baseline analysis. We apply Wooldridge test to check the serial correlation in the data. In this regard, the value of the test is Prob> F = 0.375 which shows that there is no autocorrelation present in the data. Besides, we also perform Breusch-pagan/Cook- Weisberg test for heteroscedasticity and the value of Prob> chi2= 0.435, which confirms that there is no issue of heteroscedasticity in the data.

Correlation Analysis

Table 2 shows the correlation analysis among various variables of this study. The results confirm a positive moderate correlation between trade and health expenditures, as the recurring value of the correlation coefficient (r=0.27, p<0.01), determines that an increase in trade openness tends to increase health expenditures. Similarly, CO_2 emissions and energy consumption indicate strong and weak correlation, respectively, with health expenditures in the context of Southeast Asian countries. This signifies that both CO_2 and energy consumption also significantly contribute to more health expenditures for the governments in this region. Furthermore, trade also portrays a positive and moderate strong correlation with CO_2 and EC, confirming that trade openness in a country causes more use of CO_2 and energy consumption. CO_2 exhibits a positive and moderate strong correlation with energy consumption, which determines that more CO_2 emissions are expected when the country uses more energy consumption.

Goodness of Fit and Incremental Indices of the Model

At first, the model fit has been statistically examined. Subsequently, the factor loadings between combinations of variables have been investigated. The chi-square value of the research model is 1.653 ($p < 0.05$) which shows that the goodness of fit of our model is reasonable. Similarly, absolute fit indices demonstrate that our model is quite robust; 1.653 (CMIN/DF), 0.996 (GFI), and RMSEA as 0.054. These results also validate that incremental fit indices are in the feasible ranges as NFI, 0.998, CFI, 0.999; and TLI, 0.996. Nevertheless, both goodness of fit and incremental indices justify the validity of the proposed association between study variables. Overall, the results are consistent with the ranges prescribed by Hair et al.[65]

The path coefficient of trade % of GDP to energy reveals that the value is significant ($p < 0.001$) inferring that for a one-unit increase in spending on trade % of GDP, it contributes a 15.44-unit increase in energy consumption.

Table 2 Correlation Matrix

Variables	HE	T	CO2	Energy
HE	1			
T	0.276	1		
CO_2	0.498	0.349	1	
Energy	0.210	0.365	0.360	1

Thus, the hypothesis that trade % of GDP and energy consumption has a positive relationship is supported. The result of the hypotheses are presented in Table 3.

Regression Weights and Hypothesis Testing

The model which demonstrates the standardized regression weights between constructs is shown in Figure 5. Table 4 depicts a standardized regression weight of 0.893 ($p < 0.05$) from Trade % of GDP to energy. This means that trade activities have a positive impact on energy consumption. The regression weight from trade to energy suggests that a one-unit change in trade results in a 0.89-unit change in energy consumption. Similarly, energy consumption shows a positive and significant effect on CO_2 emissions, as the value of regression weight is significant at 5% probability level, confirming that a 1-unit change in energy consumption, accounts for a 0.85-unit change in CO_2 emissions. This shows that energy usage substantially escalates the volume of CO_2 emissions in sample countries. Likewise, the standardize weight, from trade to HE is also significant at 5% probability level (β=0.253, P<0.05), this indicates the positive and significant effects of trade on health spending and the beta value suggest that a unit change in trade contributes 0.25 unit change in HE expenditures in sample countries.

The results also portray a positive and significant impact of energy consumption on health expenditures.

Table 3 The Results of Hypotheses Testing Through Path Analysis

Hypothesis Statements for Path Analysis	Estimates	P-value	Result of Hypothesis
H1: Trade % of GDP has a significant association with energy consumption	15.447	0.000	Supported
H2: Energy consumption has a significant relationship with CO_2 emission	0.002	0.000	Supported
H3: Trade % of GDP spending has a significant relationship Health expenditure	1.258	0.000	Supported
H4: Energy consumption has a significant association with Health Expenditure	0.144	0.000	Supported
H5: CO2 emission has a significant effect on health expenditure	15.563	0.000	Supported

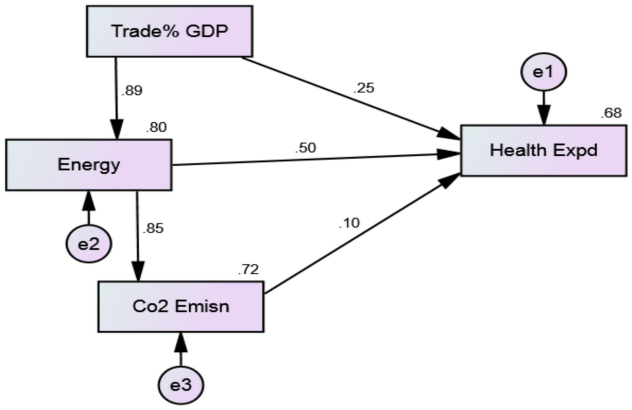

Figure 5 Research model and standardized factor loadings.

Besides the regression weight from energy to HE has a p-value significant at 5% and recurring weight is 0.50, which suggests that one-unit change in energy consumption accounts for a 0.50-unit change in health expenditures. Likewise, CO_2 also reveals a positive and statistically significant impact on health expenditures as the corresponding p-value from CO_2 to HE is statistically significant and the regression weight from CO_2 to HE is 0.10, which demonstrates that every unit change in CO_2 results in 0.10 unit change in health expenditures. These results empirically validate that trade openness heightens energy consumption which leads to more CO_2 emissions in Southeast Asian countries due to heavy dependence on fossil energy sources. The increased emissions in turn cause health complications in public which require higher health spending by the respective governments.

As reported in Table 5, there are two indirect effects observed in our proposed model; the standardized value from energy to Health expenditure is 0.085. Likewise, the standardized value from Trade to Health Expenditure is 0.524. Moreover, the mediating path of each indirect effect is energy consumption. Nevertheless, the total and indirect effects between Health expenditure and CO_2 emissions are the same as there is no indirect effect (Table 5). Besides, there is a significant contribution of direct effects toward total effects. These empirical outcomes assert that CO_2 aggravate Health complications in sample countries and escalate health care expenditure directly, while no indirect effect was apparent in this model. Besides, the coefficient between CO_2 emissions and health care spending is also statistically significant (Table 3). These findings are in line with the existing studies[4,67] which confirm a positive linkage between trade and health expenditures in various regional settings. Similarly, the study results uncover a positive nexus between trade, energy consumption, and CO_2 emissions. These findings reinforce the results of previous studies such as[5,24] which suggest that trade activities significantly escalate both CO_2 emissions and energy consumption. The results also highlight a positive relationship between CO_2 emissions and health expenditures consistent with previous studies.[53,58] Likewise, we also find a positive association between energy consumption and CO_2 emissions in Southeast Asian countries.

Table 4 Standardized Path Coefficients Between Variables

			Regression Weight	S.E.	C.R.	P
Energy	←	T	0.893	0.521	29.662	***
CO_2	←	Energy	0.849	0	24.004	***
HE	←	T	0.253	0.419	2.998	***
HE	←	Energy	0.502	0.03	4.813	***
HE	←	CO_2	0.1	11.185	1.391	***

Note: ***Denotes a significance level of 1%.

Table 5 Direct, Indirect, and Total Effects Between Constructs

Endogenous Variable	Exogenous Variables	Direct Effect	Indirect Effect	Total Effect
HE	Energy	0.502	0.085	0.587
	CO_2	0.100	0.000	0.1
	Trade	0.253	0.524	0.777

Conclusions and Policy Implications

Southeast Asian countries have adopted the policy of trade openness and attained substantial economic growth in the last few decades. Although trade positively contributes to the economy, yet it is a key determinant of environmental degradation and health expenditures. This research investigates the nexus between trade liberalization, CO_2 emissions, energy consumption, and health expenditures in sample countries. We employ the SEM technique for econometric analysis during the period of 1991 to 2018. SEM is considered as an appropriate model to examine the complex association between various attributes in a multivariate setting. The empirical results indicate a positive impact of trade liberalization on CO_2 emissions and health expenditures in Southeast Asian countries. This confirms that exporting industries in South East Asian countries heavily rely on fossil fuels that lead to CO_2 emissions, heightened energy consumption, and public health expenditures. Besides, sample counties did not

adopt energy-efficient technologies in their production processes which is reflected by a positive association between trade and energy consumption. The empirical results validate the positive and significant effects of trade on energy consumption, signifying the contribution of trade in intensified energy usage in this region.

Likewise, the results demonstrate a positive and statistically significant impact of energy consumption on pollutant emissions in the Southeast Asian region, confirming that manufacturing industries mainly deploy non-renewable energy sources in the manufacturing process which significantly escalates CO_2 emissions. Extant studies also confirm similar nexus between these variables.[5,68,69] Furthermore, the results show a positive and statistically significant association between trade and health expenditures. It implies that heightened trade activities in host countries increase the health burden faced by the government mainly caused due to harmful emissions in the air, which causes a variety of health complications for the local residents.[5,70] Likewise, energy consumption and CO_2 emissions significantly affect health expenditures, as increased energy usage leads to a considerable surge in CO_2 emissions. Thus, a higher volume of toxic emissions adversely affects public health which ultimately increases the financial health burden of the governments.[3,71]

This research has some useful policy implications for the governments in the respective countries. Given the exponential growth in the demand for energy, sample countries should take urgent steps to preserve the environment and health of their citizens. First, the policymakers should account for the adverse effects of non-renewable energy consumption and shall devise prudent and sustainable policies to rationalize the level of CO_2 emissions. Second, special attention shall be paid to devise policies for highly contaminating industries that massively contribute towards carbon emissions. Measures such as imposing a carbon tax and penalties on highly polluting manufacturing units could prove helpful. Third, efforts shall be made to develop and promote green and energy-efficient technologies in the production processes so as to transform those industries which are responsible for larger volumes of pollutant emissions. Fourth, considering that Southeast Asian countries heavily rely on fossil energy, governments shall offer rebates and incentives to encourage the use of renewable energy technologies to improve their overall energy portfolio.

Notwithstanding, health complications in society and the resulting health spending is a major factor influencing labor productivity and economic growth. Our results do not suggest a reduction in public health spending rather governments shall roll out measures to curtail carbon emissions which could result in lower health spending associated with air pollution. Nevertheless, there is a need for proper legislation to curb industrial emissions to ensure a cleaner environment for the society and reduce the burden of public health expenditure for governments. Future research in this domain shall examine a similar association in other diverse economic and regional settings, ie SAARC, MENA, GULF, BRICS, Latin America, and Sub-Saharan countries. Besides, it will be interesting to explore the mediating effects of demographic factors in influencing the nexus between trade liberalization, energy consumption, CO_2 emissions, and health expenditures.

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Disclosure

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