UAD Universitas Ahmad Dahlan
Optimum: Jurnal Ekonomi dan Pembangunan
Vol. 14, No. 1, March 2024, pp. 74-81
DOI:10.12928/optimum.v14i1.8542
ISSN 2613-9464

Manufacturing sectors and environmental sustainability: The impact and policy mitigation in Sumatra

Muhamad Fathul Muin [a,1*], Bayu Bastian Jumena [b,2]

[a] BPS-Statistics Indonesia, Jakarta, Indonesia
[b] BPS-Statistics Cimahi, Jawa Barat, Indonesia
[1] fathul.muin@bps.go.id* ; [2] bayu.jumena@bps.go.id

* corresponding author

ARTICLE INFO

Received : 05-07-2023
Revised : 01-02-2024
Accepted : 02-02-2024
Published: 22-02-2024

Keywords
Green economy
Economic-environmental tradeoff
Sustainable environment

ABSTRACT

Industrialization is a locomotive for absorbing labor and improving living standards for the people. In Sumatra, eight of the ten provinces show that manufacturing is the top three sector with the largest share of the economy. Apart from its important role, its existence cannot be separated from its adverse effects on the environment. Therefore, this empirical research will provide insight into how to find appropriate policies to maintain economic and environmental sustainability. Using panel regression, our results revealed that the number of industries and the increase in capital will influence environmental degradation. In addition, energy and fuel consumption have a negative impact on the environment, although with low statistical significance. Government spending for ecological purposes is required to reduce the adverse effects of industrialization. However, its effectiveness in the model is statistically insignificant because of the low fiscal budget allocation. As a recommendation, some policies can be implemented, including monitoring and evaluating program budgets, strengthening and coherency regulations, and synergy-commitment between the government and industry toward zero emissions.

1. Introduction

Many studies have explained that the manufacturing sector plays a crucial role in the economy (Herman, 2016; Haraguchi et al., 2017; Su & Yao, 2017; Sallam, 2021). This claim is based on the fact that manufacturing can absorb the workforce at a large scale (Prananta et al., 2022). Therefore, the Indonesian government reformed its policy by facilitating the licensing process for business establishment to encourage investment and industrialization. However, owing to the high growth of the manufacturing sector, some negative effects must be borne, ranging from wealth inequality to environmental degradation (Asici, 2013). In developing countries facing issues such as water pollution, emissions and increased carbon footprint from industrialization and manufacturing sectors (Hossain et al., 2024). This is inseparable from the fact that the manufacturing sector as a supporting economic growth in developing countries, increasing pressure for competitiveness in terms of product quality, time to market and innovation and encouraging job creation (Abualfaraa et al., 2020).

Recently, many stakeholders have been concerned about balancing economic growth and environmental sustainability (Vidyaratne, 2015; Hawkins et al., 2016; Cumming & Von Cramon-Taubadel, 2018; Agboola et al., 2022). To tackle these ecological issues, micro- and macro-factors must be incorporated into sustainable policies and practices, At the global level, for example, the President of the United States, Joe Biden, is ambitious to achieve zero emissions by 2050, this warning that global challenges today is climate change which can hamper development outcomes (Adedeji et

al., 2020). Even at an extreme level, climate change can destroy future development and civilization (Beske-Janssen et al., 2015). Abualfaraa et al (2020) argued lean manufacturing has to provides organisations with the tools to improve their competitiveness based on increasing value to customers, in terms of productivity, efficiency, quality and costumers' satisfaction, by reducing the resources consumption via waste elimination. These kind of manufacturing philosophies based on customers' demand, together with the improved people living's standards, have led to a growing product demand, fulfilled by a huge amount of produced goods, ending up in an increasing generation of pollution and wastes.

In Indonesia, the government has set a goal of reducing greenhouse gas emissions to 26.87. This goal has been stated for macroeconomic targets. Furthermore, the Ministry of National Development Planning (Bappenas) has established a roadmap for green economic policy, planning, and investment. This roadmap aims to achieve harmony between the economy and the environment. Further, it was expected that the escalation of the economy would not destroy environmental sustainability. With regard to research on economic and environmental sustainability, Sumatra was the most appropriate observation area for this study. From an economic perspective, regional GDP (at constant prices) in Sumatra in 2021 will reach IDR 2,376 trillion. The manufacturing sector contributes 22 percent and is reported as the second-largest share proportion. On the other hand, Sumatra has the third largest forest cover area (BPS, 2022a; BPS, 2022b). Furthermore, Table 1 confirms the reverse relationship between the economy and environment in Sumatra. From the correlation coefficient, we know that rising economy tends to be followed by deteriorating environmental quality (especially water and air quality).

Table 1. Correlation Between The Water Air Quality Index and Regional GDP in Sumatra

Coefficient	Correlation scores	Significancy
Kendall	-0.157	0.047
Spearman	-0.237	0.041

Source: Data processed

Many studies have been conducted on this topic. However, only a few studies have examined Sumatra as a research area. Referring to the last three years in Google Scholar (from the first 100 articles), we found that only two papers discussed the green economy topic: research on decarbonization in the energy sector (Sani et al., 2021) and land use conversion et al. Meanwhile, no research has specifically examined the policy for manufacturing development by considering the environmental sustainability perspective. Therefore, this gap encourages us to conduct such research to enrich the literature on the green economy, especially in the context of Sumatra. Study from Ngepah et al (2024) that industry 4.0 has negative effect to the manufacturing sectors in South Africa and positive correlation between growth of manufacturing sectors in South Africa and carbon dioxide. Ahn & Choi (2023) argued the manufacturing sector has experienced a consistent and notable decrease in audit quality, and companies engaged in overseas operations or with substantial inventory assets have also faced a significant decline. Previous studies conduct that manufacturing sectors and institution of government plays important role to drive green economy. Our study investigated the factors that can affect the quality of the environment and formulated relevant policies to mitigate the environmental degradation caused by industrialization. As an added value in this study, we incorporate industrial and governmental perspectives regarding the actors who will be actively involved in achieving economic and environmental sustainability. This study contribute to the literature in two ways, first to investigate that manufacturing sectors affect to the quality of water and air in Sumatra and second how to mitigate the policy to reduce impact of manufacturing sectors

2. Method

The data used in this study cover all provinces in Sumatra: Aceh, Sumatra Utara, Sumatra Barat, Riau, Jambi, Sumatra Selatan, Bengkulu, Lampung, Kepulauan Bangka Belitung, and Kepulauan Riau. The data series was from 2012 to 2019. All data were obtained from statistical reports published by BPS-Statistics Indonesia and the Indonesian Ministry of the Environment and Forestry. The selection of WAQI as a proxy for environmental sustainability refers to the current manufacturing profile in Sumatra. Among the ten provinces, the food and beverage industries dominated the manufacturing sector. Table 2 shows the definition of the variables used in this study. All the data obtained from statistics Indonesia (BPS) and Ministry of Environment and Forestry of Indonesia. This industry tends to produce liquid waste and gas emissions, which affect water and air quality. We

excluded deforestation as part of the WAQI composition because its impact is negligible (Streets et al., 2006; Basyuni et al., 2018; Austin et al., 2019; Li et al., 2019).

Table 2. Variables and Sources

No	Variables	Proxy	Unit	Sources
	Environmental sustainability	Water and air quality index (WAQI)	Index	Indonesian Environmental Statistics (BPS-Statistics Indonesia)
				Indonesian Environmental Quality Index (Ministry of Environment and Forestry of Indonesia)
2.	Fiscal policy for the environment	Environmental budget (EvB)	Billion rupiahs	Indonesian Environmental Statistics (BPS-Statistics Indonesia)
3.	Nonrenewable energy consumption	Proportion of fossil energy consumption (FEC)	Percentage	Indonesian Environmental Statistics (BPS-Statistics Indonesia)
4.	Increasing the number of manufacturing	Number of large–medium manufacturing industries (LMI)	Units	Indonesian Environmental Statistics (BPS-Statistics Indonesia)
5.	Business escalation	Gross fixed capital formation (GFC)	Billion rupiahs	Indonesian Environmental Statistics (BPS-Statistics Indonesia)

Source: Author Calculation

Regression analysis is one of the most useful methods to determine how economic variables affect environmental sustainability. Regression is very popular among economic researchers compared with other statistical analysis methods. The use of the regression method allowed us to obtain the magnitude of the effect of any change in the independent variable under study through the slope value obtained in the model. The magnitude of the slope is often the focus of many research. In this study, we used static panel regression, which combines data from cross sections and time series. The equation as follows:

$$WAQI_{it} = \beta_1 + \beta_2 EvB_{it} + \beta_3 FEC_{it} + \beta_4 LMI_{it} + \beta_5 GFC_{it} + \varepsilon_{it} \quad (1)$$

Where $WAQI$ is water and air quality index; EvB is the environmental budget; FEC is the Proportion of fossil energy consumption; LMI is the number of large– medium manufacturing industries; GFC is the gross fixed capital formation. The cross-sectional data in this research covers ten provinces in Sumatra (i = Aceh, …, Kepulauan Riau). β_1 is the constanta; β_2 - β_5 is the coefficient independent variables used in this study. The time series data used included data with a span of eight years (t = 2012, …, 2019) and ε is the error term. In our static analysis, we assumed that each of the examined economic variables could impact environmental sustainability within the same year. This allowed us to test the effectiveness of the variable interventions over a relatively short period, i.e., within one year. According to Hill et al (2011) using the panel regression method requires us to follow several sequential stages: a). Identify the appropriate model among the common effects (CEM), fixed effects (FEM), and random effects (REM) models; b). Testing the fulfillment of the assumptions consisted of normality, homoscedasticity, non-multicollinearity, and non-autocorrelation; and c). The feasibility check of the model consists of a simultaneous test (F test), partial test (t test), and goodness of fit test.

3. Results and Discussion

According to Hill et al (2011) the first step for panel data is to conduct the best model for panel data, therefore to identify the appropriate model among the common effects (CEM), fixed effects (FEM), and random effects (REM) models. Table 3 shows based on chow and hausman test REM is preferred for panel models.

Table 3. Chow and Hausman Test

Statistic Test	Purpose of Test	Cross-Section score	Prob	Conclusion
Chow Test	CEM vs FEM	35.5634	0.0000	FEM
Hausman Test	REM vs FEM	4.0197	0.4033	REM

Source: Data processed

The next step is diagnostic tools for classical assumption in panel data. In the model has a time-series data from 2012 – 2019 or eight years, because it has a long enough year, it needs to be tested for autocorrelation. Autocorrelation test using the Durbin– Watson. Table 4, it was found that the calculated score was more significant than the upper limit threshold (for k=5 and n=72). It can be concluded that the dataset used does not correlate with the error terms.

Table 4. Autocorrelation Test

Type	Score	Lower Limit	Upper Limit	Conclusion
dW	1.775219	1.49868	1.73584	There is no positive autocorrelation
4 dW	2.224781	1.49868	1.73584	There is no positive autocorrelation

Source: Data processed

Multicollinearity test is used to see the selection of independent variables is relevant and does not have a strong relationship between the variables. A multicollinearity test was performed using correlations between the independent variables. As shown in Table 5, the correlations between the variables were weaks or below 0.6, it can be concluded that there is no multicollinearity between the variables.

Table 5. Multicolinearity Test

	EvB	FEC	LMI	GFC
EvB	1.0000	-0.1614	0.5211	0.0472
FEC	-0.1614	1.0000	0.4264	0.0371
LMI	0.5211	-0.4264	1.0000	0.1003
GFC	0.0472	0.0371	0.1003	1.0000

Source: Data processed

The Glejser test was conducted to identify the residual variance on the panel model. We calculated this by running independent variables on the modeling residuals. Table 6 shows the probability of all independent variables was greater than 0.05 or 5 percent. Thus, it can be concluded that all variables are free from heteroscedasticity.

Table 6. Heteroskedasticity Test

Variables	Statistics
EvB	0.8076
FEC	0.2065
LMI	0.7308
GFC	0.2420

Source: Data processed

Based on chow and hausman test (Table 3), the random model (REM) was determined to be the most appropriate and successfully fulfilled from the three classical assumptions in the panel regression. The F-test results show that at least one independent variable significantly affects environmental sustainability (particularly the water and air conditions in Sumatra). The value of the adjusted R-squared implies that 31.59% of the environmental sustainability modeling can be explained by the independent variables used in the model. Furthermore, Table 7 shows that manufacturing and

gross fixed capital formation have a significant impact on environmental sustainability. In contrast, the environmental budget and the share of fossil energy consumption are not significant for environmental sustainability.

Table 7. Result of REM

Variables	Coefficient
EvB	0.0030
	(0.2941)
FEC	-0.0174
	(-0.9420)
LMI	-0.0042
	(-1.7010)*
GFC	-0.0104
	(-5.3752)***
C	74.8926
	(39.4987)***
Diagnostic Tools	
Adjusted R-Squared	0.3159
F-stat	9.0822***

Source: Data processed

The regression results show that the fiscal budget for the environment is insignificant, causing the parameter to be ignored in the model. This result indicates that fiscal policy implementation was ineffective. We also suspect that the small budget allocation for environmental purposes is the main reason for this insignificant result. Our finding is supported by Moshiri & Daneshmand (2020) who found similar results in Iran. The data for each province showed that the average budget allocation for ecological purposes in 2019 was 0.01 percent (percentage of the regional GDP). Only Bengkulu, Kepulauan Bangka Belitung, and Riau have budget share in a relatively higher sum of 0.08 percent, 0.03 percent, and 0.02 percent, respectively. For the other seven provinces, it was only 0.01 percent. In general, this amount (0.01-0.08) is extremely low compared to that in Europe. In 2019, the national expenditure on environmental purposes in Europe reached an average of 1.9 percent. As an alternative solution, the government must advocate the provision and optimization of corporate social responsibility (CSR) for environmental purposes. With this option, both the government and enterprises are responsible for environmental sustainability. Furthermore, various policies and strategies can be implemented in various ways. A short-term program of ecological improvement can be executed immediately to provide an immediate effect. For example, a project for trash removal from rivers and water purification. Next, long-term programs must be designed, such as the construction of an infrastructure for waste water treatment.

Currently, the amount of energy consumed is still not environmentally friendly. The data showed that the percentage of fossil fuels still dominated the total energy consumption. Wang et al (2018) argued that more energy consumption will worsen environmental conditions and increase emissions. Unfortunately, parameter estimation in the model was insignificant. However, this does not imply that this variable can be ignored. Many efforts are still needed to reduce various sources of pollution, including fossil fuel consumption. According to the conceptual framework proposed by Zhang (2022) argued industrial pollution can be reduced through reduction, recycling, and reuse. Within the scope of this reduction, the industry can increase production efficiency, reduce the use of non-essential raw materials, and ensure a clean production process. Furthermore, the industry could reduce or shift from fossil fuels to other clean energy sources. In practice, we realize that it is difficult to implement directly. Reducing fossil fuel consumption directly affects production continuity. This caused a decline in the amount of output produced. Therefore, the adoption and application of more efficient new technologies are mandatory. The government can provide subsidies and other privileges; therefore, industries are motivated to use clean energy immediately. Under a strict policy, the government can implement a policy that requires the use of clean energy for each newly established industry. Recently, one of the most recent policies has been to accelerate the implementation of the carbon tax (Law No. 7 of 2021 on Harmonization of Tax Regulations). This policy will be implemented in the energy sector (starting in 2022), transportation (starting in 2025), and building-land sectors (starting in 2025) (Suryani, 2022). However, it is necessary to expand its scope to all sectors, including manufacturing.

Table 7 shows that the number of large and medium-sized industries (LMI) has a significant negative effect on environmental sustainability. Assuming that the values of the other variables are constant, the addition of each industry to Sumatra reduces environmental quality by 0.0042 points. For the last variable, we found that GFC was negative and significant. Under the assumption of ceteris paribus, every 1 billion additional fixed capital for large-medium manufacturing in Sumatra will reduce the water and air quality (WAQI) by 0.0104 points. The previous variable (refer to LMI) focused only on the number of factories operating in Sumatra. Meanwhile, GFC focuses more on production-scale capabilities. Awareness of economic and environmental sustainability is still relatively new for both the government and enterprises. In the early stages of industrialization, the main goals were limited to increasing economic levels and profits. Environmental sustainability has not yet been at the forefront of development agenda. Thus, our findings reveal that an increase in the number of industries affecting environmental degradation is reasonable. Nevertheless, it is possible to minimize environmental damage and reduce industrial emissions. However, we should realize that the economic costs incurred by an eco-friendly vision are not cheap. As an example calculation, a study conducted by McKinsey found that global society must spend 3.5 trillion USD every year to get net zero by 2050 (Broom, 2022). Simply, we can say that the efforts to synchronize between industrialization and environmental sustainability will cause to rising on the production costs. As regulators, the government has the authority to intervene in many scenarios. Governments can accelerate efforts to immediately reduce environmental damage, such as renewing business license requirements for investors to encourage their commitment to green investment. Three main aspects should be considered: efficient technological adaptation, waste management, and waste use recycling optimization. Furthermore, strict enforcement is the key to successful policy implementation. A study by Cainelli et al (2015) has the similar finding and stated that regions with strict waste management policies encourage business owners to adopt environmental innovations and better manage waste.

4. Conclusion

The Water and Air Quality Index (WAQI) indicates the current status of environmental sustainability in Sumatra. In general, environmental conditions have improved since 2012 despite various achievements. Riau, Kepulauan Bangka Belitung, and Sumatra Selatan have experienced significant environmental improvements. Three other provinces, Aceh, Jambi, and Lampung, did not experience drastic improvements. Meanwhile, four other provinces have experienced environmental degradation: Sumatra Utara, Kepulauan Riau, Bengkulu, and Sumatra Barat.

The results show that the number of manufacturing industries (LMI) and industrial production scale (GFC) will injure the environment. This indicates that the production technology is far from environmentally friendly. Consequently, increased production is related to increased waste production. We also emphasize that clean energy is an important issue for the development of a sustainable green economy. Although our findings failed to provide statistically significant evidence, conversion to clean energy is still imperative to support economic and environmental sustainability. As a recovery measure, the government should be actively involved in repairing degraded environments by increasing its fiscal budget for ecological purposes. Our quantitative analysis shows that fiscal budgets have an insignificant effect because of the small budget allocation.

Acknowledgment

We would like to thank BPS-Statistics Indonesia and the Ministry of Environment and Forestry of Indonesia for providing data publications that we could access easily.

Declarations

Author contribution	:	The first author was responsible for leading all aspects of the research, including conceptualization, methodology, data analysis, manuscript preparation, and responding to feedback, to ensure comprehensive and scientific results. The second author assisted the first author in conceptualizing the research idea and data analysis.
Funding statement	:	This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.
Conflict of interest	:	The authors declare no conflict of interest.
Additional information	:	No additional information is available for this paper.

References

Abualfaraa, W., Salonitis, K., Al-Ashaab, A., & Ala'raj, M. (2020). Lean-green manufacturing practices and their link with sustainability: A critical review. *Sustainability (Switzerland)*, *12*(3). doi: 10.3390/su12030981

Adedeji, B. S., Ong, T. S., Uzir, M. U. H., & Abdul Hamid, A. B. (2020). Corporate governance and performance of medium-sized firms in Nigeria: does sustainability initiative matter? *Corporate Governance (Bingley)*, *20*(3), 401–427. doi: 10.1108/CG-09-2019-0291

Agboola, P. O., Bekun, F. V, Agozie, D. Q., & Gyamfi, B. A. (2022). Environmental sustainability and ecological balance dilemma: Accounting for the role of institutional quality. *Environmental Science and Pollution Research*, *29*(49), 74554–74568. doi: 10.1007/s11356-022-21103-2

Ahn, J., & Choi, S. (2023). Factors affecting change in audit quality after COVID-19. *Korean Journal of Financial Studies*, *52*(5), 751–786. doi: 10.26845/KJFS.2023.10.52.5.751

Asici, A. A. (2013). Economic growth and its impact on environment: A panel data analysis. *Ecological Indicators*, *24*, 324–333. doi: 10.1016/j.ecolind.2012.06.019

Austin, K. G., Schwantes, A., Gu, Y., & Kasibhatla, P. S. (2019). What causes deforestation in Indonesia? *Environmental Research Letters*, *14*(2), 024007. doi: 10.1088/1748-9326/aaf6db

Basyuni, M., Sulistiyono, N., Wati, R., & Hayati, R. (2018). Deforestation Trend in North Sumatra Over 1990-2015. *IOP Conference Series: Earth and Environmental Science*, *122*. doi: 10.1088/1755-1315/122/1/012059

Beske-Janssen, P., Johnson, M. P., & Schaltegger, S. (2015). 20 years of performance measurement in sustainable supply chain management – what has been achieved? *Supply Chain Management*, *20*(6), 664–680. doi: 10.1108/SCM-06-2015-0216

BPS. (2022a). *Produk Domestik Regional Bruto Provinsi-Provinsi di Indonesia menurut Lapangan Usaha*.

BPS. (2022b). *Statistik Lingkungan Hidup 2022*.

Broom, D. (2022). What's the Price of A Green Economy? An Extra $3.5 Trillion A Year. In *World Economic Forum*. https://www.weforum.org/agenda/2022/01/net-zero-cost-3-5-trillion-a-year/

Cainelli, G., D'Amato, A., & Mazzanti, M. (2015). Adoption of waste-reducing technology in manufacturing: Regional factors and policy issues. *Resource and Energy Economics*, *39*, 53–67. doi: 10.1016/j.reseneeco.2014.11.004

Cumming, G. S., & Von Cramon-Taubadel, S. (2018). Linking economic growth pathways and environmental sustainability by understanding development as alternate social–ecological regimes. *Proceedings of the National Academy of Sciences, 115(38)*, 9533–9538. doi: 10.1073/pnas.1807026115

Haraguchi, N., Cheng, C. F. C., & Smeets, E. (2017). The importance of manufacturing in economic development: Has this changed? *World Development*, *93*, 293–315. doi: 10.1016/j.worlddev.2016.12.013

Hawkins, C. V, Kwon, S. W., & Bae, J. (2016). Balance between local economic development and environmental sustainability: A multi-level governance perspective. *Journal of Public Administration*, *39*(11), 803–811. doi: 10.1080/01900692.2015.1035787

Herman, E. (2016). The importance of the manufacturing sector in the Romanian economy. *Procedia Technology*, *22*, 976–983. doi: 10.1016/j.protcy.2016.01.121

Hill, R., Griffiths, W. E., & Lim, G. C. (2011). *Principles of Econometrics* (4th ed.). John Wiley & Sons, Ltd.

Hossain, M. I., Ong, T. S., Tabash, M. I., & Teh, B. H. (2024). The panorama of corporate environmental sustainability and green values: Evidence of Bangladesh. *Environment, Development and Sustainability*, *26*(1), 1033–1059. doi: 10.1007/s10668-022-02748-y

Juniyanti, L., Purnomo, H., Kartodihardjo, H., & Prasetyo, L. B. (2021). Understanding the driving forces and actors of land change due to forestry and agricultural practices in Sumatra and Kalimantan: A systematic review. *Land*, *10*(5), 463–477. doi: 10.3390/land10050463

Li, A., Kroeze, C., Kahil, T., Ma, L., & Strokal, M. (2019). Water pollution from food production: Lessons for optimistic and optimal solutions. *Current Opinion in Environmental Sustainability*, *40*, 88–94. doi: 10.1016/j.cosust.2019.09.007

Moshiri, S., & Daneshmand, A. (2020). How effective is government spending on environmental protection in a developing country?: An empirical evidence from Iran. *Journal of Economic Studies*, *47*(4), 789–803. doi: 10.1108/JES-12-2018-0458

Ngepah, N., Saba, C. S., & Kajewole, D. O. (2024). The impact of industry 4.0 on South Africa's manufacturing sector. *Journal of Open Innovation: Technology, Market and Complexity*, *10*(1), 100226. doi: 10.1016/j.joitmc.2024.100226

Prananta, A. W., Rahwawati, A. D., Budiyanti, S., Holisah, J., & Kusumah, W. (2022). Tourism industrialization model and the effects on the income, employment Oopportunity and economy in Sumenep city, Beach 9, Gili Genting District. *Khazanah Sosial*, *4*(2), 284–294. doi: 10.15575/ks.v4i2.17636

Sallam, M. A. M. (2021). The role of the manufacturing sector in promoting economic growth in the Saudi economy: A cointegration and VECM approach. *The Journal of Asian Finance, Economics and Business*, *8*(7), 21–30.

Sani, L., Khatiwada, D., Harahap, F., & Silveira, S. (2021). Decarbonization pathways for the power sector in Sumatra, Indonesia. *Renewable and Sustainable Energy Reviews*, *150*, 111507. doi: 10.1016/j.rser.2021.111507

Streets, D. G., Yu, C., Bergin, M. H., Wang, X., & Carmichael, G. R. (2006). Modeling study of air pollution due to the manufacture of export goods in China's Pearl River Delta. *Environmental Science and Technology*, *40*(7), 2099–2107. doi: 10.1021/es051275n

Su, D., & Yao, Y. (2017). Manufacturing as the key engine of economic growth for middle-income economies. *Journal of the Asia Pacific Economy*, *22*(1), 47–70. doi: 10.1080/13547860.2016.1261481

Suryani, A. S. (2022). Persiapan implementasi pajak karbon di Indonesia. *Info Singkat: Kajian Singkat Terhadap Isu Aktual Dan Strategis*, *14*(8), 19–24.

Vidyaratne, H. (2015). Balancing economic growth and ecological sustainability in Sri Lanka. *South Asia Research*, *35*(1), 119–133. doi: 10.1177/0262728014561362

Wang, H., Ang, B. W., & Zhou, P. (2018). Decomposing aggregate CO2 emission changes with heterogeneity: An extended production-theoretical approach. *Energy Journal*, *39*(1), 59–79. doi: 10.5547/01956574.39.1.hwan

Zhang, Z. (2022). Evolution paths of green economy modes and their trend of hypercycle economy. *Chinese Journal of Population, Resources and Environment*, *20*(1), 1–11. doi: 10.1016/j.cjpre.2022.03.001