Poverty Dynamics in ASEAN: The Role of Human Capital and Taxes in Shaping the Economic Future

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Abstract

This research aims to analyze the influence of poverty levels, carbon dioxide emissions, industrialization processes, tax systems, and investment in human capital on poverty levels in ASEAN member countries, focusing on threshold values and poverty persistence coefficients to identify effective interventions. Using a dynamic threshold panel data model, the study evaluates 11 ASEAN member countries from 1999 to 2022. The results show that the human capital index is a critical variable in poverty analysis, with a significant threshold value of 1.881, indicating its substantial impact on poverty levels. The persistence coefficient of 1.112 highlights the yearly persistence of poverty, underscoring the need for timely and effective interventions. High carbon dioxide emissions and industrialization coefficients suggest that uncontrolled industrial growth could exacerbate poverty, while significant negative coefficients for taxes and human capital suggest that improvements in these areas could reduce poverty. This study contributes new insights by integrating dynamic threshold analysis in the ASEAN context, offering a fresh perspective on the relationship between human capital, economic factors, and poverty.

Keywords: Poverty, Human Capital, ASEAN, Dynamic Thresholds, Poverty Persistence, Industrialization, Taxes, Carbon Dioxide Emissions.

JEL Classification: I32, O15, Q56.

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Introduction

Increasing carbon dioxide (CO2) emissions in Southeast Asia have become a severe concern in recent decades. From 1990 to 2010, CO2 emissions in Southeast Asia grew faster than in other parts of the world, indicating the potential for more significant losses due to climate change (Paradis, 2021). Economic growth and energy consumption in ASEAN countries, dominated by fossil fuels, also increase CO2 emissions. This exacerbates the climate crisis and air pollution, directly impacting people's health and quality of life. On the other hand, vulnerable and underdeveloped community groups, which ironically produce the smallest carbon footprint, are the most affected by this climate crisis (Safitri, Fahrurrozi, Marini, Husen, Purwanto, Arum, & Nafiah, 2022).

The impacts of climate change are also exacerbating poverty in Southeast Asia. The COVID-19 pandemic has caused widespread unemployment, worsened inequality, and increased poverty,

especially among women, young workers, and the elderly (Rassanjani, Risky, Maz, Alqarni, & Tharis, 2021). Industrialization in Southeast Asia has brought significant changes to this region's economic and social structure. Although industrialization is often considered a motor of economic growth and development, its impact on poverty and social inequality is only sometimes positive (Pichler, Bhan, & Gingrich, 2021). On the one hand, industrialization can create jobs and increase productivity, but on the other hand, without the right policies, it can also widen disparities and increase poverty (Aiginger & Rodrik, 2020).

The COVID-19 pandemic has shown how the economic resilience of countries in Southeast Asia can be significantly disrupted (Fan, Teng, Chew, Smith, & Copeland, 2021). According to the Asian Development Bank (ADB), the pandemic has plunged around 4.7 million people in Southeast Asia into extreme poverty in 2021. Significant job losses, amounting to 9.3 million jobs, mainly affected workers without special skills, retail and informal workers, and small businesses that do not have a digital presence (Philavong & Onphanhdala, 2023).

Taxes are essential to a country's economic and social development, including in Southeast Asia. However, an inefficient or unfair tax system can increase poverty and inequality (Anwar, 2023). In Southeast Asia, the tax revenue to GDP ratio is lower than 15 percent, the lowest level used as a standard for sustainable development. This low ratio indicates that countries in the region need more space to collect tax revenues that can be used for social and development programs (Minh Ha, Tan Minh, & Binh, 2022).

The COVID-19 pandemic has increased the burden on tax systems in Southeast Asia. According to the Asian Development Bank (ADB), the pandemic has pushed around 4.7 million people into extreme poverty in 2021. The loss of 9.3 million jobs due to the pandemic shows how fragile the economy in the Southeast Asia region is, especially for workers without special skills, workers in the retail sector and informal economy, as well as small businesses that do not have a digital presence (Satar & Yaacob, 2022).

Human capital investment is a crucial strategy for reducing poverty in Southeast Asia. Human capital includes education, skills, and health that enable individuals to participate productively in the economy. By increasing human capital, Southeast Asian countries can create a skilled workforce to attract investment, encourage innovation, and increase productivity (Amar & Pratama, 2020).

This research aims to dig deeper into how poverty, Carbon dioxide emissions, the Industrialization process, the Tax system, and investment in Human Capital affect the poverty level. By understanding significant threshold values and poverty persistence coefficients, this research aims to identify interventions that can break the continuous poverty cycle. This research will also evaluate how infrastructure deficiencies and uncontrolled industrial growth can worsen conditions of poverty while increasing tax revenues and investment in human capital can help reduce poverty. Through a holistic approach, this research seeks to design policies that balance economic growth with environmental protection and human capital development to create inclusive growth and reduce poverty in the long term. The ultimate goal is to provide evidence-based policy recommendations to improve vulnerable communities' living and economic conditions.

Literature Review

Increasing carbon dioxide (CO2) concentrations in the atmosphere have become the leading cause of climate change, significantly impacting social and economic life in Southeast Asia (Gahlawat & Lakra, 2020). Excessive CO2 emissions trigger extreme weather events such as floods, droughts, and storms, which occur more frequently and with higher intensity (Sulisnaningrum, Mutmainah, Bawono, & Drean, 2023). As a result, vital infrastructure is damaged, agricultural land becomes unproductive, and economic losses experienced by the community increase. This directly affects poverty levels, which continue to increase along with the damage caused by natural disasters (Clarke, Otto, Stuart-Smith, & Harrington, 2022).

On the other hand, ironically, the most vulnerable and often neglected community groups are those whose contribution to emissions is the smallest. Those who live in remote areas or have limited access to resources are the first and worst victims of the climate crisis. Losing their residence, source of livelihood, and access to clean water are some of the many challenges they face. This crisis threatens their survival and widens the social and economic inequality gap in this region (Chancel, 2020).

The COVID-19 pandemic has added burdens to Southeast Asia's already fragile economies. The impact of the pandemic on critical sectors such as tourism and trade has made it clear how vulnerable the Southeast Asian region is to the global crisis (Wang, Wang, Abbas, Duan, & Mubeen, 2021). As the world tries to recover from the pandemic, Southeast Asian countries must take steps to adapt and mitigate climate change. This strengthens their resilience to natural disasters and builds a more inclusive and sustainable economy that can protect the most vulnerable groups in society (De Guzman & Malik, 2020).

H1. Carbon dioxide increases poverty in Southeast Asia

Industrialization in Southeast Asia has played an essential role in shaping the economy and social structure of the region. This process has spurred significant economic growth, with the construction of new factories and increased production of industrial goods. This has created many new jobs, which has raised the standard of living for most of society. Technological advances and innovation brought by industrialization have also accelerated the process of modernization and urbanization, giving the public more comprehensive access to various modern services and facilities (Liu, Tan, & Lim, 2021).

However, the benefits obtained from industrialization are only sometimes evenly distributed. In some cases, this rapid economic growth is not accompanied by an equitable distribution of wealth among all levels of society. As a result, there is an increase in social inequality, where certain groups of people, especially those in rural or suburban areas, are isolated from the resulting economic benefits. This gap can widen without appropriate and inclusive policies, leaving some people in poverty despite the growing economy (Inkeles, 2022).

In addition, uncontrolled industrialization often harms the environment. Air pollution, excessive use of natural resources, and destruction of natural habitats. These problems not only threaten environmental sustainability but also the health and welfare of society. Therefore, the government and industry must implement sustainable and environmentally friendly practices in industrialization (Voumik, Mimi, & Raihan, 2023).

To overcome this challenge, wise and integrated policies are needed that can balance economic growth and social justice. The government must ensure that all levels of society can benefit from industrialization, including vulnerable and marginalized groups. Education and job training programs, improving infrastructure in remote areas, and investing in clean technology can be the first steps to creating inclusive and sustainable economic growth in Southeast Asia (Xu, Ahmad, Aziz, Uddin, Aljuaid, & Gu, 2024).

H2. Industrialization increases poverty in Southeast Asia

Taxes play a crucial role as an economic instrument in every country, including Southeast Asia. A well-designed tax system serves as a primary source of revenue for the government but also as a tool for achieving a more equitable distribution of wealth. Managing the tax system efficiently and somewhat can help reduce poverty levels and narrow existing social gaps (Nguyen & Darsono, 2022).

However, challenges arise when the tax system is not run effectively or fairly. An inefficient system can lead to leakage of state revenues and reduce funds available for social programs. On the other hand, an unfair system can burden people with low incomes disproportionately, while the better off may find loopholes to avoid taxes. This condition can worsen inequality and increase poverty, especially among vulnerable groups (Diniz Magalhães & Ozai, 2021).

By implementing appropriate and effective tax policies, Southeast Asian countries can take significant steps towards reducing poverty and increasing the economic resilience of society. These policies must be designed to maximize tax revenues without burdening less fortunate residents. This can be achieved through a progressive tax system, where tax rates increase as income increases (Cui, Li, Li, Deng, & Shahtahmassebi, 2023).

In addition, an effective tax policy must include a robust redistribution mechanism, where income from the rich can be allocated to support the poor. This can be done through government programs such as subsidies, social assistance, and investment in public infrastructure. In this way, the tax system not only acts as a source of income but also as a tool for creating a more inclusive society and a more resilient economy (Bejaković, 2020).

H3. Taxes Increasing Poverty in Southeast Asia

Investment in human capital is the primary key to poverty alleviation strategies in Southeast Asia (Thathsarani, Wei, & Samaraweera, 2021). High-quality education, relevant skills, and access to adequate health services are essential to human capital (Prasetyo & Kistanti, 2020). With a good education, individuals can gain the knowledge and skills necessary to compete in the modern job market. This improves their job prospects and gives them the tools to innovate and adapt to economic changes (Widarni & Bawono, 2022).

In addition, the skills acquired through vocational training and technical education can be directly applied in various industries, increasing productivity and efficiency. These skills are critical in a growing economy where the demand for skilled labor continues to increase (Spöttl & Windelband, 2021). This investment in training and skills development benefits individuals, the

companies that employ them, and the country's economic growth (Triatmanto, Bawono, & Wahyuni, 2023).

Good health is also an essential aspect of human capital. Access to adequate nutrition, clean water, and health facilities allows individuals to work at total capacity and avoid illnesses that can reduce their productivity (Goldin, 2024). Effective public health programs can reduce the disease burden and improve the quality of life, directly contributing to poverty reduction. Good health also allows children to learn more effectively, laying a solid foundation for their future (Wang & Zhou, 2020).

Investments in human capital must be accompanied by supportive policies, such as strong social protection and fair employment opportunities (Harnani, Widarni, & Bawono, 2022). The government must strive to create an environment conducive to the growth and development of human capital, including ensuring equal access to education and health for all levels of society (Sarkodie & Adams, 2020; Blattman, Fiala, & Martinez, 2020). Thus, investment in human capital will help individuals escape poverty and strengthen Southeast Asia's economic and social resilience as a whole (Hartwig & Nguyen, 2023).

H4. Human Capital and Poverty Reduction in Southeast Asia

Research Methods

This research evaluates 11 ASEAN member countries from 1999 to 2022. This research focuses on Brunei Darussalam, the Philippines, Indonesia, Cambodia, Laos, Malaysia, Myanmar, Singapore, Thailand, Timor Leste, and Vietnam. The method used is dynamic analysis, which uses a panel data model that has dynamic thresholds. This research looks at poverty levels, Carbon dioxide emissions, Industrialization processes, Tax systems, and investment in Human Capital. Further details about these variables are explained in Table 1.

Table 1. Variable Description

Variables	Description	Unit Analysis	Source
Poverty	The state of one who lacks a usual or socially acceptable amount of money or material possessions1.	Percent	www.worldbank.org
Carbon dioxide	A colorless, odorless gas produced by burning carbon and organic compounds and by respiration2.	$MtCO_2$ per capita	globalcarbonatlas.org
Industrialization	The development of industries in a country or region on a wide scale3.	Percent	www.bp.com
Taxes	The government levies a mandatory contribution to state revenue on workers' income and business profits or adds to the cost of some goods, services,	Percent	www.worldbank.org

	and transactions4.		
Human Capital	The economic value of a worker's experience and skills, including education, training, intelligence, health, and other things employers value5.	Index Scale	www.worldbank.org

Pesaran's test for cross-sectional dependence is an essential analytical tool in econometrics, especially when dealing with panel data models that use dynamic thresholds. This tool facilitates researchers in identifying and measuring dependencies between units in panel data samples, which are common in broad economic datasets. These dependencies can impact estimation results and statistical inference, so they are essential to recognize and accommodate in econometric analysis.

Applying the Pesaran test ensures that the model built accurately reflects the dependency structure present in the data, increasing the accuracy and reliability of research results. By considering cross-sectional dependencies, researchers can avoid bias in parameter estimates and draw more accurate conclusions about the economic relationships under study.

Furthermore, the Pesaran test is also helpful in panel data with dynamic thresholds because it allows researchers to identify threshold effects that may fluctuate over time and between units. This is very important in economic studies, which require a deep understanding of the interactions between economic variables and various market conditions.

In general, the Pesaran cross-sectional dependency test is an instrument that increases rigor and precision in econometric research, ensuring that the models used are reliable and reflect complex economic dynamics. Pesaran's cross-sectional dependency test statistics are as follows:

$$CD = \sqrt{(2T/N(N-1))}\left(\sum_{i=1}^{n-1} \sum_{k=i+1}^{n} \hat{U}_{ik}\right)$$

Correlation coefficient

$\hat{U}_{I\,know}$ is a statistical measure that assesses the degree of association between variables from two entities, indicated by the indices i and k. The symbols N and T represent the total number of entities involved in the study and the period observed. The null hypothesis (H0) in the Pesaran CD test tests the existence of cross-sectional dependence in the dataset. In applying the unit root test to panel data, we use a modernized method by Im, Pesaran, and Shin, which explicitly considers cross-sectional dependencies in its evaluation.

Panel data models with dynamic thresholds and endogenous threshold variables are complex econometric techniques to analyze data exhibiting significant dynamic variations and heterogeneity between subjects. This technique allows researchers to recognize and model threshold effects that can vary over time and between subjects, providing a deeper understanding of the complex interactions between various economic variables. The equation for a dynamic threshold panel data model with an endogenous threshold variable is as follows:

$y_{it} = X_{it}' \beta + (1, X_{it}') \gamma 1 I(q_{it} \leq \tau) + (1,$

$i = 1, \ldots, n; t = 1, \ldots, T$

In this model, y is interpreted as the dependent variable. X, it can include a delayed dependent variable. q, it acts as a threshold variable. The vector β' contains the coefficients, and τ is the threshold parameter. γ 1 and γ 2 are coefficients for two different regimes. I. μ denotes each country's indicator function and fixed effects, while ε is a nuisance variable. Fixed effects for each country can be eliminated through the first difference transformation.

Results And Discussion

This study contributes new insights to the literature by adopting an innovative methodological approach to explore and confirm the dynamics of interactions between economic variables in the Southeast Asian region, emphasizing ASEAN members. This methodology reveals robust empirical findings, which enrich the theoretical framework for future research and provide a strong foundation for developing informative and data-oriented policies in the regional economic and environmental sustainability arenas. The results of this analysis are crucial because they offer reliable insights for understanding cross-country economic interactions in more depth, which is essential as a reference for broader strategic decision-making in the context of economic integration and environmental cooperation in Southeast Asia.

Results

The Pesaran CD test is an essential statistical technique for analyzing the cross-sectional dependencies of panel data models. This technique allows researchers to identify the extent to which variables in one sectional are related to variables in other sectionals. These dependencies are essential to understand because they can affect the accuracy of model results and conclusions drawn from data analysis. In its development, the Pesaran CD test revealed inter-sectional dependencies and helped modify the model to accommodate them, thereby increasing the reliability of model estimates. The results of these tests are usually presented in easy-to-understand tabular form, as shown in Table 3, facilitating interpretation and application of the findings in further research. The Pesaran CD test is helpful in econometrics, especially with large datasets involving many variables and sections. By considering cross-sectional dependencies, researchers can build more robust models that accurately reflect complex economic realities. Table 2 provides summary statistics necessary to evaluate such dependencies and is integral to panel data analysis.

Table 2. Pesaran cross-sectional dependence test

Variables	CD test	p-value
Poverty	9.88	0,000
Carbon dioxide	9.34	0,000
Industrialization	9.36	0,000
Taxes	9.81	0,000
Human Capital	9.18	0,000

Table 2 shows the results of the Pesaran CD Test, a statistical test to check for cross-sectional dependence in panel data. The high CD test value and very low p-value (0.000) for each variable indicate a significant cross-correlation between units in the data panel. This means variables such

as Poverty, Carbon Dioxide, Industrialization, Taxes, and Human Capital are not independent, and there is a strong relationship between the units in the sample.

The Panel Unit Root Test is a crucial analytical step after the Pesaran CD Test. These two tests function complementaryly in analyzing panel data. The Panel Unit Root Test helps determine whether a time series in panel data is stationary or has a unit root, indicating the presence of a persistent trend or pattern over time.

After identifying cross-sectional dependencies with the Pesaran CD Test, the Panel Unit Root Test becomes essential to ensure that the non-stationary characteristics of the data do not distort the panel data model. This allows researchers to perform more precise estimates and inferences on their econometric models.

Panel Unit Root Test Results are usually presented in a table format, such as Table 3, which makes it easier for researchers to understand and interpret the test results. This table provides information about the presence of unit roots in the data, which is essential information for decision-making in econometric research.

Thus, the combination of the Pesaran CD Test and the Panel Unit Root Test provides a robust framework for panel data analysis, ensuring that the models used in economic research accurately and reliably reflect the reality of the data. Table 3 shows the test results and serves as a verification tool to validate the model assumptions and strengthen the conclusions drawn from the data analysis.

Table 3. Panel Unit Root Test

Variables	CIPS test	Hadri and Rao's test
Poverty	-1.69	0.121***
Carbon dioxide	-1.32**	0.123***
Industrialization	-1.92	0.129***
Taxes	1.86**	0.122***
Human Capital	1.31**	0.124**

Table 3 shows the results of the Panel Unit Root Test using two different methods: the Cross-sectional Im, Pesaran, and Shin (CIPS) Test and the Hadri and Rao Test. The negative CIPS test values for the variables Poverty, Carbon Dioxide, and Industrialization indicate that the time series for these variables are stationary after controlling for cross-correlation. These variables do not have unit roots and do not require further differentiation to become stationary. Positive CIPS test values for the Tax and Human Capital variables indicate that the time series for these variables may not be stationary and may have a unit root. In the Hadri and Rao Test, the p-value marked with a star (0.121***) indicates statistical significance. Three stars (***) indicate a 1% significance level, two stars (**) indicate a 5% significance level, and one star (*) indicates a 10% significance level. The significant Hadri and Rao test results for all variables indicate a stochastic trend or level component in the time series, which means these variables have unit roots.

After the Panel Unit Root Test, the Dumitrescu-Hurlin (DH) Panel Causality Test is a critical analysis stage. This test is essential because it determines the direction of the cause-and-effect relationship between the variables in the panel data. Knowing the direction of causality is

essential for understanding how one variable can influence other variables in an economic, social, or scientific context.

The DH test not only reveals the direction of causality but also provides insight into the strength and significance of the relationship. Thus, these tests help build more accurate econometric models and provide a sound basis for policy recommendations.

The Dumitrescu-Hurlin Panel Causality Test results are usually presented in tabular form, facilitating interpretation and further analysis. Table 4 will typically include test statistics, p values, and other indicators relevant to determining the significance of causal relationships between variables.

Overall, the DH Test is an invaluable tool in panel data analysis, allowing researchers and policymakers to make more informed decisions based on a better understanding of the causal dynamics in the data they analyze. Table 4 is critical in presenting these results, ensuring that the information presented is clear and accessible to stakeholders.

Table 4. Dumitrescu-Hurlin Panel Causality Test

Hypothesis	W-stat	Zbar-stat	Conclusion
Human Capital →Poverty	1.71	1.81	Human Capital ←→Poverty
Poverty →Human Capital	1.92	1.97	
Poverty →Carbon dioxide	1.71	1.17	Poverty ←→Carbon dioxide
Carbon dioxide →Poverty	1.32	1.61	
Poverty's →Industrialization	1.99	1.59	Poverty ←→Industrialization
Industrialization →Poverty	1.31	1.29	
Poverty →Taxes	1.82	1.45	Poverty ←→Taxes
Taxes →Poverty	1.94	1.66	
Human capital →Carbon dioxide	1.95	1.77	Human capital ←→Carbon dioxide
Carbon dioxide human capital	1.55	1.71	
Human capital →Industrial Activity	1.65	1.37	Human Capital ←→Industrial Activity
Industrial Activity →Human capital	1.42	1.31	
Human capital →Taxes	1.77	1.41	Human capital, ←→Taxes
Taxes →Human capital	1.51	1.23	

Dumitrescu-Hurlin Panel Causality Test Table 4 offers insight into the causal relationships between economic and social variables. The results show complex and significant interactions between human capital, poverty, carbon dioxide, industrialization, and taxes. Findings suggest that improvements in human capital, including education and health, have a reciprocal influence on poverty levels. This suggests that investment in human capital can not only reduce poverty

but also that reducing poverty can contribute to increasing human capital. In addition, the test results show a two-way relationship between poverty and carbon dioxide emissions and between poverty and industrialization. This suggests that policies to reduce poverty can affect emissions and industrial Activity. This relationship is crucial because it highlights how interventions in one area can have ripple effects throughout the economy. The causality between taxes and other variables, poverty and human capital, is also significant. This suggests that tax policy changes can directly impact poverty levels and investment in human capital or vice versa. The estimation results using the dynamic threshold panel data model are shown in detail in Table 5. This model, which combines dynamic and threshold elements, allows a deeper analysis of how economic variables interact under changing conditions. The table presents the estimated coefficients and shows how the variables behave under different threshold conditions.

By utilizing this model, researchers can better understand how economic factors influence each other in a broader context and how changes in fiscal policy can affect economic growth in various ASEAN countries.

Table 5 is important because it provides empirical evidence that can be used to inform policymakers and economists in formulating effective strategies to face complex economic challenges. It also helps predict future economic trends and design policies that can respond to changing market conditions quickly and appropriately. Thus, this table summarizes results and is an essential tool for economic analysis and decision-making.

Table 5. Estimation of dynamic threshold panel data model

Dependent Variable	Poverty
Threshold Variable	Human capital index
Threshold Estimate	1,881***
Poverty	1,112**
Carbon dioxide	1,221***
Industrialization	1,116***
Taxes	-1,183***
Human Capital	-1,332***
Constant	1,201***
Wald test	101224.17***
Sargan teat	58.32
AR(1)	-2,102***
AR(2)	-1,331
SupWald Statistics	18.24***
Observations	253

The estimation results of the dynamic threshold panel data model in Table 5 show a significant relationship between several independent variables and the dependent variable, namely poverty. In this model, the human capital index is used as a threshold variable, with an estimated threshold of 1.881, which is significant at the 1% level (marked with three stars). This shows that the human capital index has a critical influence on the poverty level, and there is a change in the relationship between other independent variables and poverty when the human capital index passes this threshold value.

The poverty variable has a coefficient of 1.112, which is also significant at the 5% level (marked with two stars), indicating a positive and significant relationship between poverty in the previous

year and current poverty. This indicates persistence in poverty, where poverty in the past tends to continue.

Carbon dioxide, with a coefficient of 1.221, and industrialization, with a coefficient of 1.116, are both significant at the 1% level and show a positive relationship with poverty. This means that increases in carbon dioxide emissions and levels of industrialization are associated with increases in poverty.

On the other hand, taxes with a coefficient of -1.183 and human capital with a coefficient of -1.332 are both significant at the 1% level and show a negative relationship with poverty. This means that tax revenues and human capital index increases are associated with reduced poverty levels.

The constant coefficient of 1.201, which is significant at the 1% level, indicates that other factors are not observed in the model that also influence the poverty level.

The Wald test, with a value of 101224.17, which is significant at the 1% level, shows that the model is a good fit overall. The Sargan test, with a value of 58.32, needs to provide more information to determine the validity of the instrument used in the model. AR(1) and AR(2) indicate that autocorrelation is at the 1% level in the first lag, and there is no significant autocorrelation in the second lag. The SupWald statistic of 18.24, which is significant at the 1% level, indicates a structural change in the model related to the threshold variable.

With 253 observations, this model provides a reasonably comprehensive picture of poverty dynamics and the factors that influence it.

Discussion

Dynamic threshold panel data models are powerful tools for understanding the factors influencing poverty levels. In this model, the human capital index acts as a critical variable, where a significant threshold value indicates the importance of this factor in predicting poverty. The threshold value found, 1.881, indicates that changes in the human capital index substantially impact poverty when passing this value. The results of this research support research from Sarkodie Adams (2020). Dynamic modeling allows us to see how human capital indices fluctuate over time and how these fluctuations affect poverty levels. By including time variables or lags of human capital indices, we can observe trends and patterns that may not be visible in static analysis. This helps make more accurate predictions and provides insight into how timely interventions can reduce poverty. Further threshold analysis can reveal how changes in the human capital index above or below the threshold value affect poverty levels. If the human capital index increases above 1,881, there is a faster decline in poverty than when the index is below the threshold value. This suggests that investments in education and health, critical components of the human capital index, can effectively reduce poverty.

The coefficient of 1.112 for poverty indicates persistence in poverty levels yearly. In other words, there is a tendency that the poverty conditions that occurred in the previous year will continue into the following year with an increase proportional to the coefficient, provided that other factors remain constant. The results of this study support research from Blattman, Fiala,

and Martinez (2020). This phenomenon is often called a "poverty trap," once a group or area is mired in poverty, it is tough to escape that condition without external intervention.

Various factors can cause the persistence of poverty. Low-income families may be unable to invest in education, meaning their children will also face economic hardship. Likewise, poor areas may need more infrastructure, such as roads or health services, which makes it difficult for residents to improve their living conditions. This coefficient also shows the importance of timely and effective interventions to break the cycle of poverty. Programs designed to increase access to education, health, and economic opportunity can significantly reduce poverty levels. In addition, policies that support job creation and skills development are also essential to provide a path out of poverty.

The high coefficients for carbon dioxide and industrialization in the context of poverty indicate a significant relationship between uncontrolled industrial growth and increasing poverty levels. These factors, with coefficients of more than one, indicate that any increase in CO2 emissions and industrial Activity tends to harm society's economic conditions, especially for those on the poverty line. This can be interpreted as a consequence of economic growth that needs to pay attention to environmental and social aspects, where rapid industrialization without effective environmental policies can lead to environmental damage, declining public health, and greater inequality. This research's results strengthen Voumik, Mimi, and Raihan's (2023) research.

On the other hand, the significant negative coefficients for taxes and human capital provide a different perspective. Increased tax revenues reflect a more robust economy, with a fairer income distribution and government investment in better public services. This can help reduce poverty by providing more social programs and infrastructure resources. The results of this research strengthen research from Bejaković (2020). Higher human capital, which includes education and skills, is also critical in fighting poverty. This research strengthens the research from Prasetyo and Kistanti (2020). With increased human capital, individuals have more opportunities to get better jobs, increase their income, and escape the cycle of poverty. These coefficients emphasize the importance of inclusive and sustainable economic growth. Policies that promote green growth and environmentally friendly industries can help reduce the negative impacts of industrialization.

Meanwhile, investment in human capital through education and training can strengthen the economy's foundations by creating a skilled workforce that is ready for future challenges. In designing policies, it is essential to consider both sides. Governments and policymakers must strike a balance between economic growth and environmental protection, as well as between industrial development and investment in human capital. Thus, a holistic and integrated approach is needed to ensure that economic growth goes hand in hand with improving the quality of life and reducing poverty. The constants in the model indicate base effects on poverty that are not explained by the variables in the model. A significant value indicates that other factors influence poverty outside this model. The Wald test shows that the overall model fits the data very well. Sargan's test showed no problems with the instruments used in the model. AR(1) and AR(2) show a correlation between poverty values over time, but it could be more assertive. The significant SupWald statistics indicate that the threshold variable (human capital index) does influence the relationship between other variables and poverty. With 253 observations, this

model provides a relatively detailed analysis of the relationship between various factors and poverty.

Conclusion

In poverty analysis, the human capital index is an essential key variable. The significant threshold value, namely 1.881, confirms that changes in this index significantly impact poverty levels. The coefficient of 1.112 for poverty indicates that poverty tends to persist yearly, creating a 'poverty trap' that is difficult to overcome without appropriate intervention. This persistence of poverty can be caused by various factors, including the inability of low-income families to invest in education, which impacts their children's economic future. Poor areas often need more infrastructure. Therefore, timely and effective interventions are critical to breaking the cycle of poverty, with programs designed to increase access to education, health, and economic opportunities. High carbon dioxide and industrialization coefficients indicate that uncontrolled industrial growth can increase poverty levels. This shows that economic growth that does not pay attention to environmental and social aspects can cause environmental damage and greater inequality. In contrast, the significant negative coefficients for taxes and human capital suggest that improvements in these factors can reduce poverty. Higher tax revenues can reflect a more robust economy and fairer income distribution, while higher human capital indicates better levels of education and skills among the population. Investments in human capital through education and training can strengthen the economy's foundations by creating a skilled workforce that is ready for future challenges. Governments and policymakers must strike a balance between economic growth and environmental protection, as well as between industrial development and investment in human capital. A holistic and integrated approach is needed to ensure that economic growth goes hand in hand with improving the quality of life and reducing poverty. Thus, a deep understanding of the poverty persistence coefficient and the factors influencing it is critical to designing effective interventions and sustainable policies to address poverty. Further research and careful data analysis are needed to identify and implement the most appropriate solutions to reduce poverty in the long term. Policies that promote green growth and environmentally friendly industries can help reduce the negative impacts of industrialization. At the same time, investment in human capital can strengthen the foundations of the economy and create a skilled workforce.

Policy implications

The policy implications resulting from this research emphasize the need for a comprehensive strategy to overcome poverty, focusing on increasing human capital through education and training and developing adequate infrastructure in poor areas. Fair and effective tax policies and industry regulations supporting green growth can create a more robust and equitable economy. Timely and coordinated interventions are needed to break the cycle of persistent poverty. In contrast, a holistic approach to poverty alleviation must integrate economic, social, and environmental factors to ensure inclusive and sustainable economic growth. This policy must be based on solid evidence and aimed at improving vulnerable communities' living and economic conditions, with the ultimate goal of creating a skilled workforce ready to face future challenges.

Limitations and Future Research Recommendations

Although this research provides valuable insights into the relationship between human capital, taxes, and poverty in ASEAN countries, it has several limitations that should be noted. First, the analysis is limited to data available through 2022, which may not reflect recent changes or emerging trends. Second, the model may need to fully capture the complexity of interactions between variables or unobserved external factors that may influence the results. Third, this research focuses on ASEAN countries and may need to be more generalizable to other contexts. Future research should expand the analysis time frame to include more recent data, use more sophisticated models that can integrate more variables and interactions, and consider comparative studies with other regions to enrich the understanding of global poverty dynamics. Additionally, future research could explore the impact of policies implemented after the study period to assess their effectiveness in reducing poverty.

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