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The Effect of Internet Users on Sustainable Development Indicators: Evidence from Selected ASEAN Countries

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ABSTRACT

The current priority worldwide is sustainable development to eliminate poverty, protect the environment, and promote prosperity and security for the world by 2030. The Internet could accelerate global growth due to involvement in individual and industry activities. However, the nexus between Internet users and sustainable development must be explored, especially in emerging and developing economies. This study intends to examine the influence of internet users on sustainable development in ASEAN, a rapidly expanding market in the global world, represented by economic growth, CO_2 *emissions, and life expectancy rate. The panel regression was applied in this study in 7 selected ASEAN countries from 2003 to 2020. Surprisingly, the study revealed that internet users do not significantly affect economic growth. At the same time, it has a positive and significant effect on* CO_2 *emissions and life expectancy. As a result, ASEAN countries must regulate internet users' expansion concerning environmental and social performance indicators.*

Keywords: ASEAN, Business Analytics, Internet, Panel Regression, Sustainable Development.

1. INTRODUCTION

Sustainable development is closely connected to technological growth, with Information and Communication Technologies (ICTs) playing an essential role in several aspects of global progression. ICTs are vital in enabling communication, sharing information, and managing resources. The involvement of ICTs in sustainable development could be found in their contribution to enhancing food production, access to clean water, green energy generation, and improving citizens' health and well-being [1]. In specific applications, ICTs, particularly mobile learning and distance education, play a crucial role in promoting sustainable development goals and improving the quality of life for individuals [2]. Therefore, it is essential to include technology in sustainable development frameworks to fully use its ability to bring about significant change and guarantee humanity a fair, strong, and prosperous future. Recently, the nexus between technology and sustainable development is still debatable due to various effects. Beder (3) stated that the issue of Sustainable development depends on reducing the environmental impact of resource use through technological change, requiring a redesign of technological systems. The implementation of new technology is also beneficial for maintaining long-term competitiveness. It has a positive impact on sustainable development [4]. Nchofoung and Asongu [5] revealed that the application of ICT is positively significant toward sustainable development in 140 countries worldwide for the period 2000-2019. The study by Omri [6] showed that improving technology quality contributed positively to three sustainable development indicators: economic, environmental, and social. However, some studies revealed the inverse effect on several sustainable development indicators. Armeanu et al. [7] found that the technology factor is negatively significant toward sustainable economic growth in the case of EU-28. Another finding

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by Lin and Zhou [8] examined how Internet development mainly increases energy and carbon emission performance by promoting upgrading industrial structures and technology diffusion, which implies decreased environmental performance. Technological innovation and adoption negatively influence CO_2 emissions through fixed telephone, broadband, and mobile cellular subscriptions [9]. On the other hand, [10] found multiple impacts of technology, including a positive impact on the economy and a negative impact on the environment. In the Coronavirus 2019 pandemic (COVID-19), the Internet can be one of the technological options to enhance specific industry performance, leading the national economy [11].

The Internet is one of the crucial ICTs in the world, and it has various positive effects on individuals, organizations, and countries. Furthermore, several scholars have already investigated the impact of the Internet. Some studies found a positive effect of the application of the Internet on economic growth [12–14]. The Internet can be used to boost international trade by several countries in the world [15]. According to Suroso et al. [16], the Internet positively impacts the value added to the agricultural sector, especially in emerging and developing countries. Hence, policymakers should consider using the Internet to make policies for sustainable development. The issue of sustainable development is also essential for the specific agriculture industries to attract investment [17]. The nexus between the Internet and sustainable development is relatively rare, specifically in ASEAN. As one of the prominent organizations in the global world, ASEAN must accelerate sustainable development to increase competitiveness. Based on empirical studies, ASEAN countries must reach sustainable development to address several issues: reducing income inequality, contributing to a clean environment, and increasing liveability [18–20]. In this study, we examine the Internet's effect on sustainable development indicators. It is essential because technology policy is prominent in progressing toward the Sustainable Development Goals (SDGs), promoting the greater global good, and addressing challenges [21]. Furthermore, due to compliance with green growth, Sustainable development has already become the main topic for policymakers. Differing from other studies, this study aims to investigate the nexus between specific ICT development (Internet) and sustainable development, proxied by three aspects (economic, social, and environmental). It is still rare due to some studies only analyzing the sustainable development from two aspects: economic and environmental factors.

2. MATERIAL AND METHODS

This study used secondary data from the World Development Indicator (WDI) for all variables. The type of data is panel data, comprised of seven selected countries in ASEAN from 2003 until 2020, including Brunei Darussalam, Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam. All these countries were selected due to the completeness of the data. There are three regression frameworks to examine the nexus between internet users and sustainable development indicators: the effect of internet users on economic growth, carbon emission per capita, and life expectancy. First, this study utilizes the Cobb-Douglas production function as a grand theory to estimate the economic aspect. Second, we used the CO_2 emission function from Ahmed and Shimada [10] by adding population growth and internet variables. Third, the social aspect proxy is life expectancy based on Kabir [22], which uses two main variables: economic and non-economic. Hence, these models can be seen as follows:

$$Y_{it} = f\,(K_{it}, L_{it}, INT_{it}) \quad (1)$$

$$CO_{2it} = f\,(YG_{it}, POP_{it}, INT_{it}) \quad (2)$$

$$LE_{it} = f\,(E_{it}, NE_{it}, INT_{it}) \quad (3)$$

In equation (1), Y_{it} is the Gross Domestic Product or GDP (Current USD) in country i at year t, K_{it} is the gross fixed capital formation (GFCF) in country i at year t, L_{it} is the labour force (LF) in country i at year t. In equation (2), CO_{it} is the Carbon emission or CO_2 (metric ton per capita) in country i at year t, YG_{it} is the GDP growth or GDPG (%) in country i at year t, and $POPG_{it}$ is the population growth or POPG (%) in country i at year t. In equation (3), E_{it} is the GDP per capita or GDPC in country i at year t, NE_{it} is access to electricity or ACE (%) in country i at year t. In all equations, INT_{it} is the individual use of the internet (%) in country i at year t. In linear form, equations (1), (2), and (3) could be transformed by using the natural logarithm and our proxy in this study. These models can be expressed in three frameworks as follows:

$$LogGDP_{it} = a0 + a1LogGFCF_{it} + a2LogLF_{it} + a3INT_{it} + e_{it} \quad (4)$$

$$CO_{2it} = a0 + a1GDPG_{it} + a2POPG_{it} + a3INT_{it} + e_{it} \quad (5)$$

$$LogLE_{it} = a0 + a1LogGDPC_{it} + a2LogACE_{it} + a3INT_{it} + e_{it} \quad (6)$$

Where log is the natural logarithm, a0 is a constant, a1, a2, and a3 are the coefficient terms, and eit is the residual term.

Panel regression was applied through three estimations, namely, ordinary least squares (OLS), the random-effect model (REM), and the fixed-effect model (FEM). This approach is relevant in examining the impact of internet users on economic growth and carbon emissions. Before we ran our model, a correlation matrix was performed to check multicollinearity, where a value must be below 0.8 or 0.9 for regression [23, 24]. Determining the best model by comparing these three models utilizes the Chow and Hausman tests. A significant value of the Chow test at 1%, 5%, or 10% level means that the FEM is utilized more than the CEM, while a significant value of the Hausman test at the same level implies that the FEM is better than the REM. After model selection, we use the estimated regression to produce the predicted value of economic growth, CO_2 emissions, and life expectancy rate.

3. RESULTS AND DISCUSSION

Table 1 reveals the descriptive statistics, including mean, median, maximum, minimum, and standard deviation (Std. Dev). Mean and Std. Dev. are presented for determining the range and coverage of the data. Four variables have the value of Std. Dev higher than mean, namely CO_{2it}, $GDPG_{it}$, POG_{it}, and INT_{it}, It implies the data of this variable is variant. Table 2 provides the results of the correlation matrix between independent variables with values below 0.8% or 0.9%, which means that there is no multicollinearity in our three regression models.

Table 1: Statistical Descriptive.

Variable	Mean	Median	Maximum	Minimum	Std. Dev
$LogGDP_{it}$	25.882	26.282	27.744	22.604	1.247
CO_{2it}	5.874	3.691	21.706	0.788	5.507
$LogLE_{it}$	4.309	4.309	4.436	4.186	0.053
$LogGFCF_{it}$	24.501	24.875	26.615	20.706	1.319
$LogLF_{it}$	16.397	17.447	18.730	12.020	2.046
$GDPG_{it}$	4.237	5.032	14.520	-9.518	3.383
$POPG_{it}$	1.340	1.256	5.322	-1.475	0.756
$LogGDPC_{it}$	8.797	8.509	11.110	6.185	1.288
$LogACE_{it}$	4.568	4.597	4.605	4.339	0.057
INT_{it}	44.500	43.563	96.069	2.387	26.868

Table 2: Correlation Matrix.

Economic Framework			
Variable	LnGFCF	LnLF	INT
$LogGFCF_{it}$	1.000		
$LogLF_{it}$	0.814	1.000	
INT_{it}	-0.095	-0.550	1.000
Environment Framework			
Variable	GDPG	POPG	INT
$GDPG_{it}$	1.000		
$POPG_{it}$	0.164	1.000	
INT_{it}	-0.308	0.003	1.000
Social Framework			
Variable	LnGDPC	LnACE	INT
$LogGDPC_{it}$	1.000		
$LogACE_{it}$	0.638	1.000	1.000
INT_{it}	0.780	0.670	1.000

Table 3 shows the estimation of panel regression in three dependent variables: (1) GDP as an economic indicator, (2) CO_2 emissions as an environmental indicator, and (3) life expectancy as a social indicator. There are three regression models utilized, namely the common effect model (CEM), fixed effect model (FEM), and random effect model (REM). Based on the Chow and Hausman tests, we found that the FEM is the best model for estimating the economic and environmental frameworks. Conversely, REM is the proper model for social framework estimation. We found that the Internet has no significant effect on economic growth. Based on WDI [25], only three countries in ASEAN have reached above 80% of internet users – Brunei Darussalam, Singapore, and Malaysia- indicating lower Internet penetration in ASEAN. It means that internet improvements from other countries do not follow the increase in the ASEAN economy. Following the previous findings by Wu et al. [26], the Internet could increase the economic disparities in the case of regional economics, implicating the regional group of countries. ASEAN countries must consider several things to improve internet development, namely the country's wealth, telecommunication infrastructure, urbanization, and stability of the government [27]. In the case of a specific agricultural industry, adopting technology in products does not lead to financial performance [28]. GFCF and LF have a positive and significant effect on GDP and support the grand theory of production function. Furthermore, we found the positive impact of the Internet on CO_2 emissions and life expectancy, respectively. In the case of the environment, this result is similar to previous findings by various studies [8,29,30]. Improving the Internet to incorporate green technology is also an option for ASEAN countries because applying green technology can improve energy efficiency and reach sustainable development goals (SDGs) in environmental issues [31]. This result also supports the findings about the positive impact of the Internet on life expectancy [32, 33]. Hence, improving technology could lead to a higher social indicator of sustainable development. GDPC is positively significant in terms of life expectancy, which means that an increase in the country's economy could lead to social development in ASEAN countries. In sustainable development, economic impact must be a priority to maintain environmental and social factors based on a study by Suroso et al. [34].

Table 3: The Estimation of Panel Regression.

Variable	Economic			Environment			Social		
	CEM	FEM	REM	CEM	FEM	REM	CEM	FEM	REM
Constant	3.188*** (0.495)	-2.424 (3.561)	5.420*** (0.775)	2.142* (1.171)	5.059*** (0.377)	4.938*** (0.928)	3.445*** (0.329)	3.966*** (0.155)	3.967*** (0.155)
LogGFCF	0.934*** (0.038)	0.665*** (0.059)	0.761*** (0.049)						
LogLF	-0.006 (0.029)	0.733*** (0.259)	0.110** (0.048)						
GDPG				-0.459*** (0.121)	0.041 (0.029)	0.036 (0.029)			
POPG				0.901* (0.515)	-0.082 (0.137)	-0.050 (0.136)			
LogGDPC							0.018*** (0.004)	0.016*** (0.004)	0.016*** (0.004)
LogACE							0.149** (0.074)	0.042 (0.037)	0.041 (0.037)
INT	-0.002 (0.001)	-0.000 (0.002)	0.000 (0.001)	0.100*** (0.015)	0.017*** (0.005)	0.019*** (0.005)	0.001** (0.000)	0.000*** (7.18E-05)	0.000*** (7.15E-05)
R-Squared	0.969	0.983	0.898	0.409	0.975	0.100	0.601	0.970	0.580
Adjusted R-Squared	0.969	0.982	0.896	0.394	0.973	0.078	0.591	0.968	0.569
F-Statistics	1287.652***	765.446***	358.772***	28.103***	502.748***	4.505***	61.134***	415.78***	56.063***
Chow-Test		77.431***			398.624***			325.925***	
Hausman-Test			9.678**			34.226***			1.264

Notes: *, **, and * = Significant at 10%, 5% and 1%**

4. CONCLUSION

This study investigates the effect of internet users as a proxy of internet development on sustainable development indicators. Three indicators are used in this study: GDP, CO_2, and LE. This research used panel regression across seven selected ASEAN countries from 2003 to 2020. Unexpectedly, the findings show that the presence of internet users does not have a significant effect on economic growth. Nevertheless, it produces a positive and significant impact on CO_2 emissions and life expectancy rates. The results of this study underline the importance of considering a holistic approach to technology for sustainable development. While internet development may not directly impact economic growth in the ASEAN region, internet penetration remains a valuable tool to address environmental issues and improve public health outcomes. Therefore, policymakers and managers should prioritize initiatives that leverage Internet technology to promote environmental sustainability and improve access to health services to increase life expectancy. There are several limitations to this study. Internet users as a proxy for internet development may need to be more accurate, such as internet usage; therefore, other proxies may be used in the future. In addition, the focus of this study on specific ASEAN countries may limit the generalizability of its findings to other regions. Future research could explore causal relationships to explain the complexity between internet usage and sustainable development indicators.

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