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Impact of Internet use on industrial value added: evidence from Southeast Asian countries

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Abstract

The Internet facilitates real-time communication and collaboration, enabling seamless coordination in industrial processes. This enhanced connectivity can increase efficiency and productivity in the production chain. Moreover, the Internet provides a platform for businesses to reach a global audience. Expanded market access can contribute to the growth of industrial activities, fostering international trade, and positively impacting industrial value added. Therefore, this study seeks to explore how Internet usage impacts industrial value added across eight Southeast Asian countries, using a sample collected from the World Bank and Global Economy from 1991 to 2021. Two regression methods were employed: fixed-effects and Driscoll-Kraay standard error models. The research findings indicate that Internet growth has a positive effect on industrial value added in Southeast Asian countries. Additionally, the results reveal a positive correlation between industrial value added, economic growth, and trade openness. This study contributes to a deeper understanding of the connection between Internet usage and industrial value added, with profound implications for the economic restructuring of selected Southeast Asian countries.

Keywords: Internet use, Industrial value added, Southeast Asian countries

1. Introduction

In recent years, Internet growth has played a pivotal role in economic activities (Edquist *et al.*, 2021; Haini, 2019). Previous studies have underscored the multifaceted impact of Internet access on various aspects of society and the economy (Najarzadeh *et al.*, 2014; Chatterjee, 2020; Alshubiri *et al.*, 2019; Ejemeyovwi *et al.*, 2021). These impacts encompass labor productivity, economic growth, income inequality, financial growth, and innovative activities. However, little is known about the relationship between Internet use and the industrial sector

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in Southeast Asian countries. According to the World Bank (2023), the industrial sector comprises businesses that add value to raw materials by converting them into finished goods or by providing services that support the production of finished goods. This sector encompasses mining, manufacturing, construction, electricity, water, and gas. Moreover, industrial value added is a measure of both the industrial sector and industrial growth, as highlighted by Ouyang and Lin (2015), Dutta and Ahmed (2004), Maroof *et al.* (2019), and Abokyi *et al.* (2019). Fenoaltea (1976) also recognized its utility as an output indicator for the industrial sector to prevent the double-counting of intermediate goods. Therefore, this study assesses the industrial sector and development using industrial value added.

This study selects certain Southeast Asian countries for several reasons. Firstly, the recent growth of the Internet has contributed to promoting economic development in these countries (Haini, 2019). Secondly, Southeast Asia comprises 11 countries, most of which fall under the category of low- to average-income nations, often facing information asymmetry challenges. Moreover, prior empirical research in selected Southeast Asian nations has revealed the influence of Internet usage on various facets, such as economic growth, political participation, and sustainable development, as demonstrated by Wahab *et al.* (2020), Lee (2017), Latif *et al.* (2017), Kurniawati (2020), Sharma *et al.* (2021). While numerous studies have underscored the impact of Internet usage on economic development, there remains an unexplored research area: the effect of Internet use on industrial value added within Southeast Asian countries. This study explores the influence of Internet usage on industrial value added, utilizing data from eight countries from 1991 to 2021 to address this research gap. The findings of this study reveal that Internet growth is positively associated with industrial value added. Furthermore, these findings are robust when incorporating fixed effects with the Driscoll-Kraay standard error models.

This study makes three additional contributions to the existing literature. Firstly, this study demonstrates the positive impact of Internet growth on industrial value added in selected Asian countries. This finding underscores the significance of Internet usage in fostering industrial sector growth. Secondly, these results align with Romer's (1986) endogenous growth theory, which proposes that the proliferation of new technology is positively associated with industrial activities. Finally, these findings provide valuable reference data for policymakers in their decision-making processes regarding the industrial sector growth.

This study is structured into five sections, commencing with the introduction. The second section delves into the theoretical foundation, empirical evidence, and research hypotheses. Next, the third section details the data and outlines the empirical design. Then, the fourth section unveils the empirical findings, while the fifth section brings the study to a conclusion.

2. Theoretical foundation, empirical evidence, and research hypothesis

2.1 Theoretical foundation

The endogenous growth theory, as proposed by Romer (1986), posits that factors such as technological progress, innovation, human capital, and knowledge play significant roles in driving economic growth in the long run (Barro and Lee, 1994). This theory confirms

that the spread of new technological resources benefits economic activities (Romer, 1986). Technological advancements are crucial for economic development (Huchet-Bourdon *et al.*, 2018). Among the latest technologies, the Internet is notable for its contribution to growth (Zoroja, 2016), cost reduction in transformation (Palvia *et al.*, 2018), and enhanced communication abilities (Suvankulov *et al.*, 2012). Similarly, Miller (2018) argues that the Internet improves efficiency and provides new business opportunities. Lee and Oh (2020) suggest that the growth of the Internet stimulates sustainable industrial development through technological innovation. Consequently, the expansion of the Internet contributes to increased diffusion that positively affects the economic sector and enhances the process of economic restructuring in a country.

2.2 Empirical evidence and research hypothesis

Numerous empirical studies in the past have consistently demonstrated a positive correlation between the expansion of the Internet and economic activity. For instance, Haini (2019) examined the positive relationship between the Internet and economic growth in the ASEAN economies between 1999 and 2014. Edquist *et al.* (2021) explored the relationship between the Internet of Things and economic growth in 82 countries during 2010-2017, and their findings substantiated the favorable impact of the Internet of Things on economic growth. Najarzadeh *et al.* (2014) conducted a study on the positive impact of the Internet on labor productivity, utilizing a sample of 108 countries from 1995 to 2010. Tripathi and Inani (2016) analyzed the relationship between Internet usage and economic growth in 42 African countries from 1998 to 2014, and their empirical findings indicated a positive association between Internet growth and economic development. Using data from specific African countries between 1991 and 2013, Salahuddin and Gow (2016) found that Internet usage was positively associated with economic growth. Examining 32 European Union countries from 2007 to 2011, Zoroja (2016) investigated the impact of ICT on innovative activities and confirmed the positive influence of ICT on innovation. Canh *et al.* (2020) demonstrated that the expansion of the Internet mitigated income inequality across 87 countries from 2002 to 2014. Similarly, between 1997 and 2013, Wahab *et al.* (2020) concluded that Internet usage positively affected economic development in selected Southeast Asian countries. Wang *et al.* (2022) established the positive impact of Internet growth on green economic development across 269 cities in China from 2004 to 2019. Nguyen *et al.* (2021) investigated the effects of Internet and mobile usage on trade activities in 47 African countries from 2003 to 2017, highlighting the positive influence of Internet and mobile growth on export and import activities. Similarly, Fernandes *et al.* (2019) indicated that the expansion of the Internet promoted export activities among manufacturing firms in China from 1999 to 2007. Meijers (2014) concluded that Internet usage had a positive influence on the openness ratio in 213 countries from 1990 to 2008.

On the other hand, Yu (2022) investigated the influence of the Internet on industrial green productivity in China. They determined that the Internet positively impacts industrial green productivity through technological innovation. In addition, the Internet has sparked remarkable technological advancements, driving innovation in the industrial sector by

creating new products, services, and processes (Lampropoulos *et al.*, 2019). Moreover, the Internet facilitates global business connectivity, enhances process efficiency, encourages specialization, and fosters innovation (Tomas Gomez Arias, 1995). Additionally, through e-commerce platforms and online marketplaces, companies can tap into a broader customer base, access international markets, and participate in global trade (Sawhney *et al.*, 2005). Based on the above analysis, the author argues that the growth of the Internet is significant, and therefore, the diffusion of the Internet can affect the industrial sector. In summary, the following hypothesis is proposed:

H1: The growth of the Internet is positively associated with industrial value added.

3. Research methods

3.1 Research data

Data were gathered from 1991 to 2021 from eight Southeast Asian countries: Vietnam, Cambodia, Singapore, Thailand, Indonesia, Malaysia, Brunei, and the Philippines. However, certain data points were unavailable for specific years and countries. Brunei lacked data on the ratio of bank credit to the private sector as a percentage of the GDP from 1991 to 1998. Singapore had no data on this ratio in 2021. Cambodia had no accessible data on the proportion of Internet users in the total population from 1991 to 1996. Indonesia and the Philippines had no data on the proportion of Internet users in the total population between 1991 and 1993, Malaysia lacked this data in 1991, and Vietnam lacked this data from 1991 to 1995. Consequently, only eight of the eleven Southeast Asian countries were included, as the remaining countries had insufficient data regarding Internet access and domestic credit to the private sector. Additionally, the decision to collect data from 1991 to 2021 was made due to the absence of information on the number of Internet users within their populations before that time in some countries. Therefore, the author chose the time frame of 1991-2021 to collect sufficient data on GDP per capita income, annual urban population growth (%), and the ratios of foreign direct investments to GDP, exports to GDP, and imports to GDP. These data were obtained from the World Bank (World Bank, 2022). Data on industry value added in dollars have been sourced from The Global Economy (The Global Economy, 2022).

3.2 Research model

Based on Maroof *et al.* (2019) and Mohsen *et al.* (2015), the following model is developed:

$$LIND_{i,t} = \beta_0 + \beta_1 INT_{i,t} + \beta_2 FD_{i,t} + \beta_3 LGPP_{i,t} + \beta_4 TO_{i,t} + \beta_5 FDI_{i,t} + \beta_6 URB_{i,t} + \mu_{i,t}$$

where i and t are the country and year, respectively; α represents the intercept coefficient; β represents the regression coefficient of the independent variables; and μ represents the standard error; LIND is the industrial value added; INT is internet usage. The control variables in the model include trade openness (TO), financial development (FD), economic growth (LEG), foreign direct investment (FDI), and urban population (URB).

Table 1 summarizes the variables in the research model and provides specific measurement methods for each variable.

Table 1. Summary the variables

Symbol	Variable name	Measurement	Empirical evidence
LIND	Industrial value added	The natural logarithm of industry value added in Dollar.	Maroof *et al.* (2019)
INT	Internet use	The percentage of people using the Internet is about the total population.	Ozcan and Apergis (2018)
TO	Trade openness	The ratio of total exports and imports to GDP.	Ngouhouo *et al.* (2021), Maroof *et al.* (2019), Yanikkaya (2003)
FD	Financial development	The ratio of domestic credit to the private sector by banks to GDP	Ngouhouo *et al.* (2021), Maroof *et al.* (2019), Osei *et al.* (2019)
LEG	Economic growth	The natural logarithm of per capita GDP	Ngouhouo *et al.*, (2021), Osei *et al.* (2019), Yakubu *et al.* (2018)
FDI	Foreign direct investment	The proportion of foreign capital invested in a country relative to its GDP.	Batten and Vo (2009), Markusen and Venables (1999)
URB	Urban population	The rate of growth in the urban population.	Ngouhouo *et al.* (2021), Mohsen *et al.* (2015)

Source: Author's suggestion

4. Empirical evidence

4.1 Descriptive statistics

Analysis of data sourced from the World Bank was undertaken to delineate the variables utilized in the research model, as presented in Table 2.

Table 2. Summary statistics

Variables	Observations	Mean	Median	Minimum	Maximum
IND	221	76.752	91.293	0.521	472.762
TO	221	142.245	93.042	32.972	437.326
INT	221	30.662	29.616	0.00005	98.080
FD	221	72.043	41.240	5.585	166.503
EG	221	10,537.270	15,295.910	267.409	66,836.540
FDI	221	5.571	6.093	-2.757	29.760
URB	221	2.690	1.045	-1.474	5.321

Source: Author's calculation

Referring to Table 2, the sample mean of IND equals 76.752 billion USD, indicating a low industry value added in certain Asian countries. In contrast, Maroof *et al.* (2019) reported an average IND value of 22.662 billion USD for specific South Asian economies during 2003-2015. Descriptive statistics for the INT variable reveal an average ratio of Internet users to the total population of 30.662. Conversely, the average ratio of domestic credit to the private sector by banks as a proportion of GDP is 72.043%. The average GDP per capita is 10,537.27 USD, with the average proportion of foreign capital invested in a country relative to its GDP standing at 5.571%, and the URB variable has a sample mean of 2.69%.

4.2 Correlation coefficients matrix

Table 3 illustrates a positive relationship between the industrial value added variable and Internet growth, financial growth, and economic growth. However, we did not observe a significant relationship between trade openness, urbanization, and industrial value added. Additionally, the variance inflation factor (VIF) coefficients for each pair of independent variables are below 4 (Table 2). Following Hair *et al.* (1995), the study results show that multicollinearity is not a significant concern in the research model.

Table 3. Correlation matrix

Variables	LIND	INT	FD	LGPP	TO	FDI	URB
LIND	1.000						
INT	0.273***	1.000					
FD	0.354***	0.372***	1.000				
LEG	0.224***	0.704***	0.406***	1.000			
TO	-0.025	0.343***	0.507***	0.584***	1.000		
FDI	-0.153**	0.298**	0.324***	0.416***	0.763***	1.000	
URB	-0.034	-0.456***	0.07	-0.378***	-0.052	-0.177***	1.000
VIF	2.34	1.55	2.87	3.76	2.61	1.50	

Notes: *, **, *** indicate statistical significance at 10%, 5%, and 1%, respectively.

Source: Author's calculation

4.3 Regression results and discussion

Table 4 shows the regression results, indicating that the fixed-effects model is more suitable than the random-effects model based on the p-value from the Hausman test (less than 1%). Additionally, the Modified Wald and Wooldridge tests yield p-values below 1%, confirming the presence of autocorrelation and heteroscedasticity issues in the research model. Regression with Driscoll-Kraay standard errors has been applied within the fixed-effects model to address these challenges (Driscoll and Kraay, 1998).

Table 4. Results of panel data analysis

Variables	$LIND_{it}$			
	FE	Driscoll-Kraay	FE	Driscoll-Kraay
	(1)	(2)	(3)	(4)
INT_{it}	0.021***	0.021***	0.001**	0.001**
	(19.45)	(13.72)	(2.56)	(2.47)
FD_{it}			0.001***	0.001
			(3.23)	(1.50)
LEG_{it}			1.095***	1.095***
			(53.64)	(32.24)
TO_{it}			0.001***	0.001***
			(4.46)	(3.10)
FDI_{it}			-0.0005	-0.0005
			(-0.24)	(-0.21)
URB_{it}			-0.017*	-0.017
			(-1.82)	(-1.16)
Constant	2.941***	2.941***	-5.758***	-5.758***
	(67.30)	(26.73)	(-36.31)	(-22.08)
Number of obs.	221	221	221	221
Number of groups	8	8	8	8
Prob.	0.000	0.000	0.000	0.000
Hausman test			80.88***	
			[0.000]	
Modified Wald test			360.91***	
			[0.000]	
Wooldridge test			17.904***	
			[0.003]	

Notes: This table presents the results of the panel data analysis. FE represents the fixed-effects model, and Driscoll-Kraay is regression using Driscoll-Kraay standard errors. t-statistics are in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1%, respectively.

Sources: Author's calculation

Referring to Table 4, the coefficient of INT shows positive significance at the 5% level in Columns (3) and (4), signifying that the Internet is positively associated with industrial value added and thus supporting hypothesis H1. These findings align with the results of Tripathi and Inani (2016), Wahab *et al.* (2020), and Maroof *et al.* (2019), all of which indicate that Internet growth significantly impacts industrial growth within a country. This outcome can be attributed to the following factors. Firstly, Internet usage enables businesses to streamline operations, enhance communication, and improve efficiency (Attaran and Woods, 2019).

This can lead to increased productivity in the industrial value added, such as companies can manage their resources, processes, and supply chains more effectively (Al-Mudimigh *et al.*, 2004). Secondly, the Internet provides easy access to information, market data, and customer preferences (Khan and Quadri, 2012). Businesses can gather insights and adjust their strategies, leading to improved decision-making and more targeted products and services (Dutta and Bose, 2015). Thirdly, the Internet facilitates collaboration and information sharing, enabling businesses to engage in research and innovation more effectively (Sawhney, 2005). This can result in the development of new technologies, processes, and products that contribute to industrial growth. Fourthly, Internet-based platforms allow businesses to reach a global audience through e-commerce (Rosario and Raimundo, 2021). Expanded market access can boost sales and product demand as well as increase production and industrial value. Finally, integrating Internet-enabled technologies into manufacturing processes, often referred to as Industry 4.0, can lead to increased automation, reduced downtime, and improved quality control (Chen *et al.*, 2020). This, in turn, can contribute to higher industrial output. These findings also align with the endogenous growth theory, which posits that the diffusion of new technology resources positively affects economic activities (Romer, 1986). Nonetheless, the impact of the Internet on the industrial value added is minimal (0.001), signifying that the spread of the Internet has a limited influence on industrial development in certain Southeast Asian countries.

Both coefficients for the LEG variables are positive and statistically significant at the 1% level, as shown in Column (4). Economic development contributes significantly to the increase in industry value added. This finding corresponds to the outcome observed by Maroof *et al.* (2019), who suggest that economic growth positively influences the industrial sector due to a two-way causality relationship. Furthermore, the impact of economic growth on the industrial value added is notably high (1.095), highlighting the significant role that economic development plays in the industrial value added.

The coefficients of the TO variables are positively significant at the 1% level, as shown in Column (4), signifying that trade openness is positively associated with industrial development in certain Southeast Asian countries. This finding aligns with the results of Yanikkaya (2003) who emphasized the positive impact of trade openness on economic activities.

The coefficients of URB are statistically non-significant at the 10% level, as shown in Column (4), signifying that urbanization has no impact on industrial development. This finding is consistent with the result of Henderson (2003). We also observe that the FD variable lacks statistical significance at the 10% level. This absence of significance for the FD variable contradicts the assertion made by Maroof *et al.* (2019). Furthermore, the coefficients of FDI are not statistically significant at the 10% level, as shown in Column (4), signifying that foreign direct investment inflows have no impact on industrial growth. This finding is inconsistent with the results of Batten and Vo (2009).

5. Conclusion

This study investigates the influence of Internet usage on industrial value added by employing data from Southeast Asian countries covering from 1991 to 2021. The empirical research highlights the positive influence of Internet growth on industrial development. These findings also suggest that economic development and trade openness positively affect the industrial sector.

Drawing on these findings, the study suggests several policy implications. First, governments should invest in broadband infrastructure to provide reliable Internet access through partnerships or direct funding, particularly in rural and underserved areas. Second, to boost cross-border trade and enhance industrial value, governments should implement e-commerce-friendly policies, including streamlined customs, secure online payments, and consumer protection. Finally, governments should promote collaboration between academia and industry in digital technology R&D by funding research partnerships, facilitating technology transfer, and supporting innovation clusters.

These results provide empirical support for developing a theory regarding the influence of Internet usage on industrial value added. Moreover, these findings provide valuable reference data for policymakers when formulating relevant decisions. This study makes some contributions, but future studies should consider the following limitations. First, this study is limited by its potential sample size constraints. Therefore, a larger sample size and an extended timeframe should be used to enhance the precision and efficiency of statistical estimates. Second, this study measures the industrial sector through industrial value added. Future studies may consider other aspects of the industrial sector to comprehensively understand the overall influence of Internet use on the industrial sector.

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