The Effect of Power and Internet Challenges on the Productivity of Small Enterprises in Southeast Asia: An Empirical Analysis

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ARTICLE INFORMATION	ABSTRACT

This study examines the effect of power shortages and internet interruptions on the productivity of small retail firms in Southeast Asia, specifically in Indonesia, the Philippines, and Vietnam. Using data from the 2015 and 2023 World Bank Enterprise Surveys, the research investigates how these disruptions affect firm output, with a focus on small enterprises, a sector often overlooked in existing literature. Power shortages have been shown to hinder productivity, but the effect varies by country, with regional and national contexts influencing the outcomes. This study incorporates internet interruptions as a newly considered variable in the 2023 data, adding a modern perspective on how digital infrastructure challenges impact small businesses. Using the Fixed Effects Model, Random Effects Model, and Ordinary Least Squares regression techniques, the research identifies significant effects of power shortages on productivity, particularly in Indonesia and Vietnam. However, internet interruptions did not show a statistically significant impact across the regions studied. The findings suggest that small retail firms may be less reliant on stable internet access compared to sectors that are more digitally intensive. The study highlights the importance of tailored, localized strategies to mitigate disruptions and calls for future research to explore contextual factors and adaptive strategies that affect productivity in the face of infrastructure challenges.

Keywords: Asia; Internet; Power Shortage; Productivity; SMEs

INTRODUCTION

Small and medium-sized enterprises (SMEs) are essential to a nation's economic growth and development. They play a pivotal role by generating employment, reducing poverty and inequality, and driving innovation. In many countries, SMEs are the largest source of jobs. Within the Association of Southeast Asian Nations (ASEAN), SMEs are seen as the "backbone of national economic development," representing over 97% of businesses and employing more than half of the workforce in the region (Asia-Pacific Economic Cooperation in Manansala & Valerio, 2024). Despite their significant contributions, ensuring the sustained success of SMEs remains a considerable challenge (Madumi, 2024; Manansala & Valerio, 2024).

In today's highly competitive economies, the availability and reliability of key input factors like electricity and internet connectivity are vital for firm productivity (Levy et al., 2024; Zhong et al., 2020). These infrastructures are fundamental components of production and economic development. The efficient use of electricity and internet connectivity directly impacts a firm's operations, shaping its activities in numerous ways. Interruptions in power, connectivity, or logistics disrupt a firm's ability to deliver on-demand goods and services, creating ripple effects that impact other sectors of the economy. This ultimately reduces the competitiveness of firms in the market (Francisco, 2022; Gao et al., 2022).

According to the World Bank (2021; 2022) and the Global Network Initiative (2017), power outages and internet interruptions are significant obstacles to economic development in the developing world. Osei-Gyebi and Dramani (2023) utilized firm-level data from the World Bank Enterprise Survey (WBES) covering 28 sub-Saharan African (SSA) countries between 2007 and 2018 to assess the combined impact of electricity outage frequency and outage duration on the performance of SSA firms using the instrumental variable (IV) method. Their findings revealed that each unit increase in the frequency and duration of outages leads to a reduction in annual firm sales by $114.9. Additionally, the study showed that small firms in SSA experience losses of $408.89 per joint increase in outage frequency and duration compared to larger firms, primarily due to their inability to manage the effects of electricity outages. Similarly, Yu et al. (2023) provided evidence that power shortages increase firms' carbon dioxide intensity by reducing R&D efforts, increasing energy consumption, and limiting productivity. Using a city-level power shortage index in China from 2008 to 2015, the authors analyzed data from 358,868 firms across 191 cities. These findings suggest that power shortages present a significant development challenge, particularly for developing countries, as they hinder firm growth and negatively affect environmental performance.

Sun (2021) thoroughly reviewed how the Internet impacts firm development, creating a detailed framework to understand these effects. They discovered that the internet influences firm growth through two main mechanisms: internal firm characteristics and the external environment. They identified six key channels where these impacts are most evident: innovation, business models, performance, productivity, trade - both import and export and location selection. The pace and richness of interruptions significantly impact task performance. Levy et al. (2024) examined how the speed and quality of online interruptions influence managerial task performance. In their study, participants engaged in a computer simulation designed to replicate external interruptions. They were exposed to either a slow or fast pace of interruptions and received either lean or rich information during the task. The findings revealed that a slower pace of interruptions led to better task performance compared to a faster pace. Interestingly, information richness alone did not have a significant impact on performance. However, the combination of fewer interruptions and richer information resulted in optimal performance. These findings offer valuable insights for small and medium enterprises. It implies that the pace and quality

of online interruptions must be managed carefully to ensure better tasks and enhanced productivity. Therefore, frequent disruptions should be minimized, and online communications should provide comprehensive and relevant information to improve decision-making and operational efficiency.

Overall, the socio-economic costs of unreliable electricity and internet interruptions are substantial. Despite reforms in the power and ICT sectors, many provinces in Indonesia (Safitri & Noviadhista, 2020; Satriawan et al., 2023; Suwargono & Garniwa, 2024), the Philippines (Department of Information and Communications [DICT], 2014; Francisco, 2022; Taniguchi, 2019), and Vietnam (EVN, 2015 cited in Elliott et al., 2021; Ha, 2022; Pouran et al., 2022; Thao et al., 2023) still face frequent disruptions in both electricity supply and internet connectivity. This study aims to highlight the significant effect of these interruptions on small retail firms' productivity in selected Southeast Asian countries, specifically Indonesia, the Philippines, and Vietnam. Using data from the World Bank Enterprise Survey (WBES) for 2015 and 2023, the research investigates how power shortages affect firm productivity and examines the newly included variable of internet interruptions in the 2023 data to assess its impact on productivity.

This study fills crucial gaps in existing research by focusing on the effects of unreliable electricity and internet services on small retail businesses, a key yet often overlooked sector. Unlike previous studies that may have examined broader sectors or larger enterprises, this research offers targeted insights into how these disruptions uniquely affect small retail firms. By leveraging the latest WBES data and incorporating internet interruptions as a new variable, the study provides a contemporary analysis of these issues. It offers a comprehensive view of the collective effect of power and internet disruptions on productivity using objective and perception-based measures and addresses regional challenges in Indonesia, the Philippines, and Vietnam. This research contributes valuable insights for policy making and business strategies, enhancing the understanding of how essential service disruptions affect small retail businesses in developing economies.

LITERATURE REVIEW

Studies that seek to explain how external challenges like power and internet issues impact productivity in small retail businesses can be classified into two theoretical perspectives: Resource-Based View (RBV) and contingency theory. RBV posits that a firm's resources—both tangible (e.g., stable power and internet access) and intangible—are critical to its competitive advantage (Lubis, 2022). Through this theory, this study asserts that reliable energy and the Internet are essential resources for improving labor productivity and driving sales in SMEs. The RBV emphasizes that firms with better access to these resources are more likely to achieve higher productivity and operational efficiency. The study explains how external factors such as power and internet challenges influence firm productivity by emphasizing that the performance of small enterprises is dependent on the availability and stability of these external environmental factors. Guided by contingency theory, it highlights that productivity outcomes, specifically in terms of labor productivity and sales, are contingent upon the quality of power and internet services without delving into how businesses adapt to such disruptions (Cho et al., 2023; Safari & Saleh, 2022). Based on these frameworks, together with earlier studies, provide a clear understanding of how these external factors, such as power shortages and internet adoption, influence business performance.

Power Shortage and Productivity
A stable and reliable energy supply is essential for economic growth, yet many developing countries continue to face significant power shortages that disrupt operations

and threaten long-term development. Limited resources and infrastructure constraints exacerbate these challenges, and according to Rentschler et al. (2019), the World Bank estimates that businesses in developing countries lose up to $82 billion annually due to power shortages. This substantial economic impact highlights the urgent need to study how power disruptions affect firm performance. Understanding these effects is crucial for devising effective policies and solutions to mitigate disruptions, enhance energy infrastructure, and support sustainable economic growth. Thus, further research into the specific impacts of power shortages, particularly on small enterprises, is essential to address this critical issue comprehensively.

Many scholars collectively highlight the profound negative impact of power shortages on firm productivity, particularly in low- and middle-income countries such as Gao et al. (2022), who extended the standard monopolistic competition model to include energy as an intermediate input. Using data from the World Bank's global enterprise survey, which covered 119 countries between 2007 and 2017, their study revealed that power shortages significantly reduce firm productivity by disrupting the work of skilled employees. The findings also highlighted that private firms in low- and middle-income countries are particularly vulnerable to these power disruptions. In Pakistan, Grainger and Zhang (2019) analyzed a survey of 4,500 manufacturing firms from 2010 to 2011 to assess how regional variations in power outages affect firm performance. Their study examined the impact of electricity shortages on firm revenues, value-added, and the labor share of output. The findings reveal that power shortages significantly hinder firm productivity, as they disrupt efficient operations. As a result, firms facing electricity shortages struggle to maintain productivity, leading to decreased output in the manufacturing sector. Moreover, these shortages also impede corporate digital transformation as firms struggle to implement digital strategies and organizational changes without a reliable power supply. In Ghana, eliminating power outages could lead to substantial improvements in firm productivity. However, common coping mechanisms, such as using generators, are often inadequate to fully offset the negative effects of these disruptions (Abeberese et al., 2021). The authors leveraged exogenous variation in power outages, driven by an electricity rationing program, to study its impact on small and medium-sized manufacturing firms in Ghana. These studies imply that unreliable electricity supply not only weakens immediate business performance but also obstructs long-term corporate growth.

Even a highly developed nation like China faces challenges from electricity shortages. Jia et al. (2023) explored how these shortages impact corporate digital transformation, analyzing 2,160 listed companies between 2011 and 2017. Using machine learning and text analysis to examine newspaper data from 218 Chinese cities, they measured city-level electricity shortages from 2006 to 2017. To address endogeneity, the authors employed an exogenous electricity shortage event and constructed a difference-in-differences model. Their findings reveal that electricity shortages significantly hinder corporate digital transformation, emphasizing the crucial role of strategy-driven and organization-enabling mechanisms in mitigating this effect.

In the Philippines, there is an ongoing exploration of the fundamental dynamics and complexities of power supply interruptions to develop more effective and realistic policy recommendations for the power sector (Francisco, 2022). However, unlike the extensive research in other countries, there is limited investigation into how power interruptions impact firm-level performance, particularly for small enterprises, which are more vulnerable to such uncertainties (Manansala & Valerio, 2024). This gap highlights the need for focused studies on how power disruptions affect smaller businesses in the country. Thus, this study hypothesized:

H1:   Power shortages affect small enterprises' productivity.

Internet Adoption and Productivity
In today's competitive business environment, small enterprises have recognized the importance of adopting digital solutions to meet the rapidly changing demands of global customers, especially in the wake of the COVID-19 pandemic (Ullah et al., 2023). Numerous studies emphasize that leveraging digitalization through digital transformation can enhance and accelerate key business processes, such as sales, procurement, distribution, and marketing (Ashiru et al., 2023; Sarif & Ariyanti, 2024; Zhu et al., 2024). It has emerged as a critical enabler for SMEs, facilitating their participation in global markets (Jean & Kim, 2020; Zhong et al., 2020), enhancing operational efficiencies (Koutroumpis & Sarri, 2023), and improving resilience against economic challenges (Rajala & Hautala-Kankaanpää, 2023).

Sun (2021) highlighted the critical role of internet connectivity in enabling SMEs to engage in export activities. Drawing from two World Bank data sources—the Exporter Dynamics Database, which tracks exporter characteristics from 1997 to 2014, and the World Development Indicators, which measures internet development through the percentage of individuals using the internet—the study underscores the importance of online access in enhancing SMEs' participation in global markets. Improved connectivity offers SMEs opportunities to reach international customers, streamline export processes, and boost competitiveness. By expanding their customer base and facilitating smoother trade operations, internet access can significantly enhance SMEs' ability to compete in global markets.

Both Firouzeh & Satvati (2018) and Jean & Kim (2020) underscore the critical role of the Internet in enhancing the export marketing capabilities of SMEs, which, in turn, boosts their export performance. Firouzeh and Satvati (2018) surveyed managers from 210 small and medium-sized export companies in Tehran province, using Structural Equation Modeling and LISREL to demonstrate that internet marketing significantly improves SME export performance. This improvement is driven by better access to information, enhanced technological infrastructure, and increased customer orientation, with internet-based customer engagement emerging as the most influential factor in achieving export success. Similarly, Jean and Kim (2020) examined SMEs in emerging markets, particularly in China, and found that internet capabilities—specifically platform and web-based technologies—positively impact both export marketing capabilities and performance. Their study also revealed that factors such as product complexity and competitive intensity can moderate the relationship between internet capabilities and export marketing success. These findings highlight the crucial role of stable internet connectivity in enhancing SMEs' export marketing capabilities and performance. Reliable internet access enables SMEs to gather market information, improve customer engagement, and strengthen their technological infrastructure, all of which are essential for export success. Without stable connectivity, SMEs face significant challenges in reaching global markets and staying competitive. Therefore, investing in robust internet infrastructure is vital for SMEs to fully benefit from digital strategies and drive export growth.

Despite the growing trend of how internet use affects the performance of SMEs, academic research on its effect on enterprises when interrupted remains sparse. The addition of items that can measure the effect of internet interruptions in SME operations in the latest WBES data opens the opportunity to fill this empirical gap. Thus, this research hypothesized:

H2:   Internet interruptions affect small enterprises' productivity.

Conceptual Framework
To better portray the idea of this study, the conceptual model of the study is shown in Figure 1.

Figure 1. Conceptual Model of Effect of Power Shortages and Internet Disruptions on Productivity
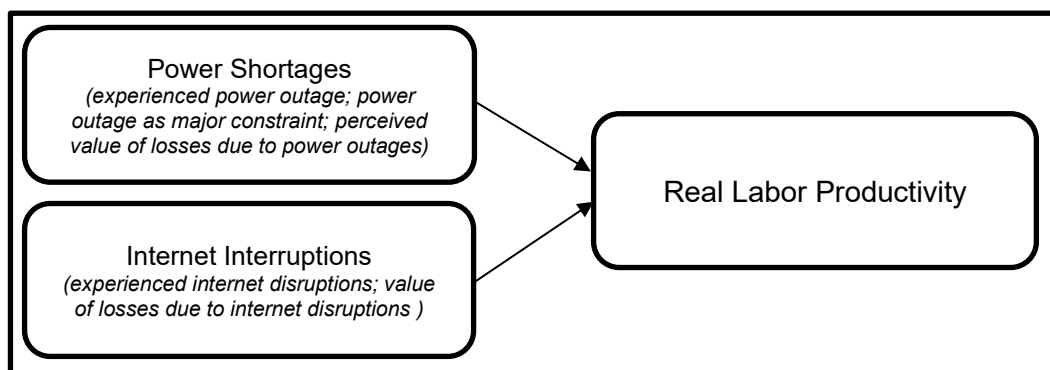
RESEARCH METHOD

Data and Samples
The study draws on firm-level data from the WBES conducted in 2015 and 2023 across selected Southeast Asian countries, including Indonesia, the Philippines, and Vietnam. Since 2022, WBES has compiled detailed microdata on firm activities, covering various indicators of firm characteristics and performance, such as exporting activities, ownership structure, labor composition, employment, sales and productivity, infrastructure, service quality, and management practices. This dataset also includes different variables that cover the extent of power outages and internet interruptions. Data were collected by private contractors of the World Bank who facilitate in-depth interviews with business owners and managers, focusing on the manufacturing and service sectors since 2005 (World Bank, 2023). The inclusion of countries in the sample was driven by data availability, with cross-sectional data from over 1,700 small enterprises providing insights into the operational challenges in these regions.

Variable Measurement
The dependent variable, Productivity, is represented by the log-transformed real labor productivity (RLProd), defined as the number of annual sales for all products and services by a small enterprise per permanent and full-time employee, adjusted for consumer price index (CPI). It is a measure of how efficiently an enterprise uses its labor force to generate output after accounting for changes in the purchasing power of money (Salimova et al., 2022). Equation 1 was used to measure the real labor productivity

$$ln\,(RLProd_{it}) = \ln\left(\frac{Total\ Annual\ Sales_{it}}{Number\ of\ Employees_{it}\ xCPI_{t}}\right)$$

Where i represents the individual firm and t represents the year. CPI is the measurement of the average change over time in the prices paid by urban consumers for a market basket of consumer goods and services. The use of this allows the assessment of productivity changes in constant terms while accounting for the economic changes that affect consumers (Ghodke & Giri, 2023). CPI was sourced in the respective statistics offices of the countries under study.

This study utilizes variables related to power shortages and internet interruptions experienced by small firms, drawing from the WBES dataset as explanatory variables. Data from both WBES 2015 and 2023 were used for power shortages. Objective variables include whether firms experienced a power outage (PowerOut). In contrast, perception-based variables consist of a binary indicator for whether electricity is perceived as a major constraint to operations (POMConstraint) and a continuous variable reflecting the perceived value of losses due to power outages as a percentage of total sales (POVLoss). For internet interruptions, data were sourced exclusively from WBES 2023, as it was the first survey to measure internet connectivity. Proxy variables include InternetOut, a binary indicator assessing whether firms experienced disruptions, such as downtime or slow connection, excluding those caused by power outages, and InternetVLoss, which represents the value of losses due to internet disruptions as a percentage of total sales.

The perceived severity of power outages and internet interruptions often serves as a proxy for the actual extent of these external factors that impact firm productivity. However, as Fakih et al. (2020) suggest, firm performance itself may shape perceptions of the severity of power and internet challenges, creating a potential reverse causality issue. To address this endogeneity, perceptions of power and internet disruptions are instrumented through empirical analysis. These variables reflect inadequacies in power and ICT infrastructure, which are expected to negatively influence firm performance, leading to lower productivity and reduced sales (Abeberese et al., 2021; Fakih et al., 2020; Gao et al., 2022; Grainger & Zhang, 2019; Zhong et al., 2020). Consequently, reliable infrastructure and services—such as stable power supply and high-quality internet access—are anticipated to enhance productivity, with improvements in availability, quality, and cost driving better performance (Gao et al., 2022; Jean & Kim, 2020; Koutroumpis & Sarri, 2023).

Control variables are crucial for accounting for factors that may influence the dependent variable but are not the primary focus of the study. They help isolate the effect of key explanatory variables, such as power outages and internet interruptions, on enterprise productivity by controlling for confounding factors that could otherwise bias the results (Chowdhury et al., 2021). In this study, several firm characteristics are included as control variables. Firm age (LNFirmAge), measured in log form as the number of years since establishment, controls for differences in firm maturity that may impact productivity. The Sector is a dummy variable where one represents retail, and zero refers to other services (such as hotels, professional services, and other service industries). This accounts for varying degrees of sensitivity to power and internet issues across different industries. Additionally, top manager experience (LNExperience), representing the years of experience in the service industry, measured in log form, controls for the managerial ability to navigate uncertainties, ensuring that differences in leadership capacity do not skew the analysis of external challenges on productivity.

In this study, technology adoption (Technology) is defined as the use of social media and websites to promote products and services. As a control variable, it accounts for the influence of digital marketing tools on firm productivity. Similarly, access to finance (Finance) is assessed based on the outcome of the most recent application for a line of credit or loan, with possible categories being approved in full, approved in part, rejected, or withdrawn. This control variable helps account for how variations in financial support impact firm productivity. By including both technology adoption and access to finance, the analysis of the effects of power outages and internet interruptions on productivity is refined, ensuring that these effects are not confounded by differences in financial access or digital marketing capabilities (Wang et al., 2024; Zhu et al., 2024). This approach

provides a clearer picture of how external challenges affect firm performance, independently of the firm's financial situation and online presence.

Model Estimation

This paper examines the impact of power shortages and internet interruptions on the labor productivity and sales growth of small enterprises. The following regression models were developed based on prior analysis.

To address H1, the study employed both Fixed Effects (FEM) and Random Effects (REM) models, as shown in Equations 6, while accounting for key firm characteristics as control variables, using WBES data from 2015 and 2023. The FEM removes time-invariant firm-specific characteristics, focusing on within-firm variation over time. In contrast, the REM assumes that unobserved individual effects are uncorrelated with the independent variables, allowing for the analysis of both within- and between-firm variations (Manansala & Valerio, 2024).

$$Productivity_{it} = \beta_0 + \beta_1 PowerOut_{it} + \beta_2 POMConstraint_{it} + \beta_3 POVLoss_{it}$$
$$+ \beta_4 LNFirmAge_{it} + \beta_5 Sector_{it} + \beta_6 LNExperience_{it}$$
$$+ \beta_7 Technology_{it} + \beta_8 Finance_{it} + \alpha_i + \varepsilon_{it}$$

Where, Productivity$_{it}$ represents the explanatory variables, ln (RLProd $_{it}$) of firm I in year t, PowerOut$_{it}$, POMConstraint$_{it}$, and POVLoss$_{it}$ represent the explained variables of firm i in year t, β stands for the intercept term, LNFirmAge, Sector, LNExperience, Technology, and Finance are the control variables, α_i captures firm-specific effects in FEM or random firm-level effects in REM, and ε_{it} denotes the residual term.

To address H2, the study used Ordinary Least Square (OLS) to estimate the relationship between internet interruptions and productivity while controlling for other variables using WBES 2023 cross-sectional data. The model below was constructed:

$$Productivity = \beta_0 + \beta_1 InternetOut + \beta_2 InternetVLoss + \beta_3 LNFirmAge + \beta_4 Sector$$
$$+ \beta_5 LNExperience + \beta_6 Technology + \beta_7 Finance + \varepsilon$$

where Productivity$_{it}$ represents either the explanatory variables of firm i in year t, InternetOut$_{it}$ and InternetVLoss$_{it}$ represent the explained variables of firm i in year t, β stands for the intercept term, LNFirmAge, Sector, Experience, Technology, and Finance are the control variables, and ε denotes the error term.

Several diagnostic tests were conducted to ensure model validity and adherence to key assumptions, addressing issues such as multicollinearity and heteroskedasticity. Specifically, the Hausman Test was used to determine whether the FEM or REM was more suitable for the data. The Variance Inflation Factor (VIF) was employed to assess multicollinearity among independent variables, while the Breusch-Pagan Test was utilized to detect heteroskedasticity. These tests collectively help to validate the robustness and accuracy of the regression models used. Finally, all the models were tested using Stata version 13 software.

RESULTS

This study explores the effect of unreliable electricity and internet services on small retail businesses, a critical yet understudied sector. Using the latest WBES data and introducing internet interruptions as a variable, it provides a focused analysis of productivity disruptions in three Southeast Asian countries: Indonesia, the Philippines, and Vietnam.

The Effect of Power Shortages on the Productivity of SMEs
Power reliability has long been recognized as a cornerstone for operational efficiency, yet its impacts appear to vary significantly depending on regional and national contexts. This study aims to investigate the effect of power shortages and other factors on the productivity of small retail firms in Southeast Asia (SEA).

Before testing the hypothesis, several diagnostic tests were conducted to ensure reliable results. Table 1 presents the multicollinearity and heteroskedasticity test results.

Table 1. Results of Multicollinearity and Heteroskedasticity Tests

	Variable	SEA	Indonesia	Philippines	Vietnam
VIF					
1	PowerOut	1.10	1.10	1.10	1.14
2	POVLoss	1.07	1.09	1.07	1.08
3	POMConstraint	1.07	-	1.08	1.14
4	Sector	1.04	-	1.25	1.05
5	LNExperience	1.39	1.01	1.76	1.09
6	LNFirmAge	1.37	1.02	1.94	1.11
7	Technology	1.01	1.01	1.02	1.02
8	Finance	1.02	1.00	1.04	1.04
9	Mean VIF	1.13	1.04	1.28	1.08
Breusch-Pagan Test					
1	Chi-squared	19.81	11.09	27.34	159.72
2	Prob > Chi-sq.	0.000	0.001	0.000	0.000

Note: In Indonesia, POMConstraint and Sector were excluded due to high VIF scores.

The multicollinearity test results in Table 1 indicate that most variables across all regions (Southeast Asia, Indonesia, Philippines, and Vietnam) exhibit low VIF scores, suggesting that multicollinearity is not a significant concern. However, in Indonesia, the variables POMConstraint and Sector were excluded due to higher VIF values, which helped address the issue in that region. Overall, the mean VIF scores across all regions remain low, further confirming that multicollinearity is not problematic. According to the VIF concept, a VIF value exceeding 10 suggests potential multicollinearity issues (Pradnyawati et al., 2023; Zhu & Manansala, 2024).

Conversely, the results from the Breusch-Pagan test show significant chi-squared values ($p < 0.05$) across all regions, indicating the presence of heteroskedasticity. This means that the variance of errors in the regression models is not constant, which could affect the reliability of standard error estimates. To account for this, it is recommended to use robust standard errors (R.S.E.) to ensure more accurate results.

Table 2. Hausman Test Results

Variable	Chi-sq.	Prob. > chi-sq.
SEA	3.23	0.919
Indonesia	39.03	0.000
Philippines	9.97	0.267
Vietnam	7.19	0.516

The Hausman test results in Table 2 indicate that for SEA as a whole, the Philippines and Vietnam ($p > 0.05$) suggest that the null hypothesis cannot be rejected, making the

REM the suitable model for regional analysis. In contrast, the results for Indonesia show a low p-value (< 0.05), leading to the rejection of the null hypothesis. This indicates that the FEM is more appropriate for analyzing Indonesian data, as it accounts for correlations between the explanatory variables and the unobserved fixed effects. These findings suggest that while the REM is sufficient for broader regional analysis and for the Philippines and Vietnam, Indonesia exhibits unique characteristics that necessitate the use of the FEM to capture fixed effects accurately.

Table 3 shows panel regression results examining the effect of power shortages and other factors on the productivity of small retail firms in SEA, measured as the log-transformed real labor productivity (RLProd).

Table 3. Panel Regression Results the Effect of Power Shortages on the Productivity of Small Retail Firms in Southeast Asia

Predictor	SEA		Indonesia		Philippines		Vietnam	
	β (R.S.E.)	Sig.	β (R.S.E.)	Sig.	β (R.S.E.)	Sig.	β (S.E.)	Sig.
Constant	7.459 (0.279)	0.000	7.706 (1.854)	0.150	7.051 (0.307)	0.000	14.435 (0.605)	0.000
PowerOut	0.365 (0.184)	0.048	0.555 (1.877)	0.817	-0.156 (0.194)	0.421	0.130 (0.206)	0.529
POVLoss	-0.018 (0.017)	0.293	-0.502 (1.528)	0.798	-0.017 (0.015)	0.253	0.013 (0.059)	0.827
POMConstraint	-0.213 (0.069)	0.002	-	-	0.122 (0.073)	0.094	0.074 (0.095)	0.432
Sector	0.142 (0.170)	0.406	-	-	0.242 (0.209)	0.249	-0.313 (0.217)	0.151
LNFirmAge	0.501 (0.100)	0.000	0.499 (0.346)	0.386	0.094 (0.098)	0.339	-0.113 (0.201)	0.573
LNExperience	0.984 (0.080)	0.000	0.567 (0.524)	0.475	0.139 (0.093)	0.135	0.303 (0.137)	0.027
Technology	-0.065 (0.162)	0.689	0.833 (1.409)	0.660	0.641 (0.190)	0.001	-0.177 (0.191)	0.355
Finance	1.341 (0.175)	0.000	0.317 (1.888)	0.894	0.331 (0.244)	0.175	0.604 (0.156)	0.000
RE/ FE	RE		FE		RE		RE	
No. of obs.	3,735		1,860		1,037		901	
R-squared	0.100		0.002		0.025		0.029	
RE: Wald chi2 / FE: F statistics	428.59		1.40		27.41		26.67	
Prob.	0.000		0.570		0.001		0.001	

Note: RE = random effects; FE = fixed effects; R.S.E. = Robust Standard Error. In Indonesia, POMConstraint and Sector were disregarded in the FE model due to their lack of sufficient variation within entities, being constant or providing limited explanatory power across entities.

The results in Table 3 shed light on the complex relationship between power shortages and productivity in small retail firms across SEA. At the regional level, the positive association between power outages and productivity ($p < 0.05$) might seem counterintuitive at first glance, as power shortages are typically viewed as detrimental. However, this result could reflect the resilience and adaptive strategies of small businesses across Southeast Asia. Firms may have developed effective coping mechanisms, such as utilizing backup generators or shifting operational hours to mitigate power interruptions. Such resilience aligns with the RBV, which suggests that firms capable of mobilizing and optimizing their resources—even in adverse conditions—can sustain or enhance productivity.

When zooming in on individual countries, the narrative becomes more nuanced. In Indonesia, the Philippines, and Vietnam, power outages did not significantly affect productivity, with β coefficients and p-values indicating a lack of strong evidence for a direct relationship. This divergence from the regional trend suggests that country-specific factors, such as infrastructural investments, access to external support, or sectoral dynamics, may play a buffering role. For instance, the Philippines' reliance on technology ($p < 0.05$) as a productivity driver highlights how digital tools can counterbalance challenges posed by unstable power.

Interestingly, the perception of power outages as a significant power constraint emerged as a critical factor regionally ($p < 0.05$). Firms that view outages as a substantial barrier are likely to experience diminished productivity, underscoring the psychological and operational toll of these disruptions. Yet, in the Philippines, a marginally positive relationship ($p < 0.1$) hints at a different narrative—where firms, despite acknowledging constraints, find ways to adapt and perhaps even innovate.

Overall, the study highlights the intricate interplay between power shortages and productivity in small retail firms across Southeast Asia. The results support H1 (power shortages affect small enterprises' productivity) at the regional level but receive mixed support at the country level. Country-specific nuances point to the importance of contextual mediators, such as adaptive strategies and firm-specific characteristics. Future research should delve deeper into these mediators and moderators to offer more precise, evidence-based recommendations for enhancing energy resilience and fostering SME growth in the region.

The Effect of Internet Interruptions on the Productivity of SMEs
Internet connectivity has emerged as a key enabler of SME productivity and competitiveness in global markets. This study fills the gap of limited studies on the effects of internet interruptions. Before hypothesis testing, a series of diagnostic tests were performed to verify the reliability of the results. The outcomes of the multicollinearity and heteroskedasticity tests are shown in Table 4.

Table 4. Results of Multicollinearity and Heteroskedasticity Tests

	Variable	SEA	Indonesia	Philippines	Vietnam
VIF					
1	InternetOut	1.19	1.11	1.15	1.08
2	InternetVLoss	1.16	1.08	1.09	1.04
3	Sector	1.02	1.01	1.01	1.01
4	LNExperience	1.20	1.03	1.21	1.13
5	LNFirmAge	1.18	1.02	1.18	1.14
6	Technology	1.02	1.06	1.05	1.02
7	Finance	1.04	1.01	1.02	1.04
8	Mean VIF	1.12	1.05	1.10	1.07
Breusch-Pagan Test					
1	Chi-squared	14.48	6.34	23.23	0.04
2	Prob > Chi-sq.	0.000	0.012	0.000	0.844

Table 4 presents the results of the multicollinearity and heteroskedasticity tests for the regions analyzed. The VIF values indicate no significant multicollinearity, as all values are well below the threshold of 10, suggesting that the independent variables are not highly correlated with each other.

Regarding heteroskedasticity, the Breusch-Pagan test reveals significant heteroskedasticity in SEA ($p < 0.001$), Indonesia ($p < 0.05$), and the Philippines ($p <$

0.001), indicating that the variance of residuals is not constant across observations. To address heteroskedasticity in these regions, one approach is to apply robust standard errors (R.S.E.), which adjust for heteroskedasticity and provide more reliable estimates. For Vietnam, where the p-value is 0.844, no such adjustments are needed, as heteroskedasticity is not present.

Table 5. OLS Regression Results: The Effect of Internet Interruptions on the Productivity of Small Retail Firms in Southeast Asia

Predictor	SEA		Indonesia		Philippines		Vietnam	
	β (R.S.E.)	Sig.	β (R. S.E.)	Sig.	β (R.S.E.)	Sig.	β (S.E.)	Sig.
Constant	7.581 (0.279)	0.000	9.430 (0.504)	0.000	7.121 (0.415)	0.000	13.734 (0.430)	0.000
InternetOut	0.093 (0.163)	0.569	0.621 (0.585)	0.289	0.082 (0.257)	0.751	0.060 (0.162)	0.712
InternetVLoss	-0.010 (0.024)	0.680	0.008 (0.025)	0.739	-0.055 (0.036)	0.120	0.086 (0.116)	0.459
Sector	0.268 (0.164)	0.103	0.812 (0.308)	0.009	0.184 (0.232)	0.429	0.245 (0.203)	0.228
LNFirmAge	0.045 (0.091)	0.620	-0.810 (0.124)	0.000	0.377 (0.160)	0.019	0.625 (0.168)	0.000
LNExperience	0.170 (0.079)	0.032	1.146 (0.126)	0.000	1.104 (0.105)	0.000	-0.060 (0.100)	0.552
Technology	0.314 (0.176)	0.074	0.819 (0.314)	0.009	0.052 (0.217)	0.812	0.201 (0.157)	0.200
Finance	-0.019 (0.185)	0.917	0.368 (0.324)	0.256	1.420 (0.219)	0.000	0.449 (0.119)	0.000
No. of obs.	489		1,393		2,233		404	
R-squared	0.032		0.116		0.103		0.089	
F	2.32		24.81		34.07		5.81	
Prob. (F-stat.)	0.025		0.000		0.000		0.000	

Note: R.S.E. = Robust Standard Error; S.E. = Standard Error

The results of the OLS regression analysis examining the effect of internet interruptions on the productivity of small retail firms in Southeast Asia in Table 5 reveal mixed findings. Across all regions analyzed—Southeast Asia as a whole, Indonesia, the Philippines, and Vietnam—neither the frequency of internet interruptions (InternetOut) nor internet velocity loss (InternetVLoss) had a statistically significant effect on firm productivity. Specifically, for Southeast Asia, the coefficients for InternetOut and InternetVLoss were not significant. Similar trends were observed in Indonesia, the Philippines, and Vietnam, where neither predictor reached statistical significance.

Despite the non-significant results for internet-related variables, certain control variables were significant in some regions. For example, firm age (LNFirmAge) negatively influenced productivity in Indonesia ($p < 0.001$) but positively impacted productivity in Vietnam ($p < 0.001$) and the Philippines ($p < 0.05$). Similarly, managerial experience (LNExperience) was a significant predictor in Southeast Asia ($p < .05$), Indonesia ($p < 0.001$), and the Philippines ($p < 0.001$), highlighting its consistent importance across regions. The variable Finance significantly contributed to productivity in the Philippines ($p < 0.001$) and Vietnam ($p < 0.001$), emphasizing the relevance of financial resources in these countries.

The findings also challenge the H2, which is that internet interruptions negatively affect small enterprises' productivity. While this hypothesis aligns with the broader understanding of internet adoption's benefits, the study's results do not support this claim in the retail context. This suggests that other factors, such as the firm's resilience,

operational strategies, or sector-specific characteristics, may play a more prominent role in driving productivity. Moreover, the absence of significant moderating factors like product complexity or technological infrastructure, which are emphasized in prior literature, could explain the contrasting results.

DISCUSSION

The findings of this study provide partial support for existing literature, particularly concerning the impact of power shortages. Prior research by Gao et al. (2022) and Grainger & Zhang (2019) reported that electricity shortages negatively affect productivity in low- and middle-income countries by disrupting production and reducing efficiency. Similarly, Abeberese et al. (2021) highlighted that in Ghana, despite the use of generators as backup solutions, power outages still had a harmful effect on firm performance. In line with these findings, this study confirms that power shortages significantly influence productivity at the regional level in Southeast Asia, suggesting that H1 is accepted. However, at the individual country level (Indonesia, the Philippines, and Vietnam), the effects are not statistically significant, indicating that the relationship between power shortages and productivity may be shaped by local conditions, such as infrastructure development, industry type, and firm-level adaptability.

From a theoretical lens, these findings can be interpreted through the RBV, which sees stable electricity as a valuable and strategic resource. Firms that can secure or manage their energy needs effectively may gain a competitive advantage, even under uncertain conditions. The contingency theory complements this view by suggesting that the effects of environmental constraints—such as power shortages—are dependent on context. Firm size, resilience, managerial capability, and available resources can all influence how external shocks impact productivity.

These insights suggest the need for localized approaches to energy resilience. For example, in the Philippines, where technological adoption is associated with improved productivity, investing in digital tools and tech support systems could help small retailers mitigate the effects of unstable power supply. In Indonesia, where sectoral dynamics may play a more significant role, policies tailored to industry-specific needs might be more effective. Meanwhile, in Vietnam, the positive role of financial resources implies that improving access to financing could buffer productivity against infrastructure limitations. Overall, the regional-level support for H1 highlights the importance of continued investment in reliable energy infrastructure to support long-term SME growth in Southeast Asia.

In contrast, the results related to internet interruptions do not support previous studies and show a different narrative. While research by Jean & Kim (2020) and Sun (2021) underscores the importance of stable internet access for improving business performance and expanding market access, this study finds no statistically significant relationship between either internet outages or internet speed loss and the productivity of small retail firms in Southeast Asia. This holds true across the regional analysis and within Indonesia, the Philippines, and Vietnam, leading to the conclusion that H2 is rejected.

One possible explanation for this result is that small retail firms may not rely as heavily on continuous internet connectivity as firms in more digitally dependent or export-oriented sectors. Many small retailers may use offline systems or adopt hybrid operational strategies that allow them to function despite occasional internet disruptions. Furthermore, the significant role of control variables such as managerial experience and firm age points to the importance of internal capacities in determining firm productivity.

For instance, while older firms in Indonesia experienced lower productivity, firm age had a positive effect in Vietnam and the Philippines. Access to financial resources also played a critical role, especially in the Philippines and Vietnam, where it significantly boosted productivity.

These findings challenge the general assumption that internet interruptions inherently reduce productivity in small businesses. While that may hold true in more technology-intensive industries, this study suggests that for small retail firms, other operational and organizational factors—like experience, financial health, and adaptability—are more influential. Moreover, the absence of moderating factors such as product complexity and digital infrastructure, which are often cited in previous research, may also account for the lack of significant internet-related effects in this context.

In sum, the study highlights the importance of context when analyzing infrastructure challenges in small businesses. While H1 is accepted at the regional level, confirming that power shortages do affect productivity, H2 is rejected, indicating that internet interruptions do not have a statistically significant impact on productivity in small retail firms. These results point to the need for more nuanced, sector-specific research to understand how firms adapt to infrastructure constraints in different operational environments. Future studies should explore the coping mechanisms, technologies, and institutional supports that enable SMEs to sustain productivity despite digital and energy-related challenges.

CONCLUSION

This study explores how power shortages and internet interruptions affect the productivity of small retail firms in Southeast Asia, particularly Indonesia, the Philippines, and Vietnam. Drawing on data from the World Bank Enterprise Survey for 2015 and 2023, it sheds light on the unique challenges faced by these businesses and their ability to adapt to infrastructure disruptions.

The findings confirm that power shortages significantly hinder productivity across the region, a trend that is consistent with previous research. However, the effects are not uniform. Each country presents a unique context influenced by factors such as firm age, financial resources, and local business conditions. For example, older firms in Vietnam and the Philippines tend to perform better, while in Indonesia, younger firms appear to be more resilient. Similarly, access to financial resources plays a more critical role in boosting productivity in Vietnam and the Philippines.

Surprisingly, the study finds that internet interruptions do not have a significant effect on productivity for small retail firms. Unlike digitally intensive or export-oriented businesses, small retailers may be less reliant on constant internet access. Many seem to rely on hybrid or offline systems to continue operations, which may explain their resilience to connectivity issues.

These findings highlight the need for targeted solutions to address power and internet challenges. In Indonesia, sector-specific support could help businesses thrive despite power shortages. In the Philippines, encouraging the adoption of technology could enhance productivity, while in Vietnam, improving access to financial resources could be key.

This study underscores the importance of reliable energy infrastructure and localized policies to support small businesses. While internet stability remains crucial for many sectors, its impact on small retail firms appears to be less direct, calling for further

research into how these businesses navigate and overcome such challenges. By focusing on small retail firms, this study provides valuable insights into a key but often overlooked sector. It offers practical recommendations for policymakers and business leaders to help these enterprises adapt, grow, and contribute to the broader economic development of Southeast Asia.

LIMITATION
This study has several limitations. First, it uses cross-sectional data from 2015 and 2023, which limits the ability to track long-term trends or changes in productivity over time. Second, the focus on small retail firms may not reflect the experiences of other sectors, particularly those with more digital dependence. Additionally, the lack of detailed data on internet usage prevents a deeper understanding of how businesses cope with internet interruptions. The research is also limited to three countries—Indonesia, the Philippines, and Vietnam—so the findings may not be generalizable to other countries in the region.

Furthermore, the study relies on self-reported data from the World Bank's Enterprise Survey, which could introduce bias. It also does not explore the specific strategies businesses use to adapt to power or internet disruptions, nor does it consider broader macroeconomic factors, such as policy changes, that could influence productivity. These limitations suggest the need for future research to address these gaps and explore a wider range of factors affecting small businesses' productivity.

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