Examining the Influence of ICT Penetration on Gender Disparities: A Data Panel Econometric Analysis of the Seven Southeast Asian Developing Countries

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Abstract

The aim of the study is to analyse to which Information and Communications Technology (ICT) penetration affects gender disparities in seven Southeast Asia's developing countries. ICT indicators are measured through the individuals using the internet, mobile phone subscriptions, and internet subscriptions. Aside, the seven Southeast Asia's developing countries include Indonesia, Cambodia, Laos, Malaysia, Thailand, Philippines, and Vietnam. These countries are selected as they have comparable economic development stage from lower to upper-middle income economics on the basis 2022's World Bank Country Income Classification. The data panel econometrics is carried out to measure the effect of the independent variables towards gender disparity. Gender disparity is represented by the Gender Inequality Index. The time series data is yearly from 2000 to 2022. The econometric assessment shows the individual internet ownership and subscription have a negative and significant effect to gender disparity. It means that more internet penetration can lower the gender disparity in those seven countries. The academic implication is to enhance economic consideration towards more internet penetration and access to reduce gender disparity. In the heart of policymaking, our research indicates more internet accessibility to reduce gender disparity. As in the common knowledge, the internet is a source of information and knowledge to society.

Keyword: gender disparity; digitalisation; econometrics; southeast asia

1. Introduction

The proliferation and extensive integration of information and communication technologies (ICTs) have fundamentally transformed societies globally. These technologies have become an integral part of everyday life, facilitating unprecedented global connectivity and collaboration, and significantly contributing to sustainable development initiatives (United Nations, 2016). According to the same study, ICTs are crucial for sustainable progress in sectors such as education, healthcare, agriculture, and disaster risk management. A report by the World Bank highlights that mobile phones are now more common than basic sanitation facilities in numerous regions demonstrating the profound impact of ICT (World Bank, 2019)

On one hand, information and communication technologies (ICTs) offer substantial promise for promoting gender equality by enhancing women's access to education, healthcare, and economic opportunities. For instance, Shah & Krishnan (2024) conducted a cross-lagged panel analysis involving 86 countries to examine the relationship between ICT and gender inequality. Their findings reveal a negative correlation between ICT and gender inequality, suggesting that ICT can serve as a powerful tool to empower women and mitigate gender disparities. A practical example can be observed in Africa, where the use of ICT has led to increased female labor force participation (Nkoumou Ngoa & Song, 2021). This study indicates that while the spread of ICT reduces informational inefficiency in the labor market, financial development expands economic and employment opportunities.

ICT has the potential to significantly enhance gender equality by providing women with opportunities for skill enhancement, employment, and empowerment, all of which are vital for their active participation in society. To be sustainable and effective, development policies must address and rectify gender imbalances. The Sustainable Development Goals aim to achieve gender equality, specifically focusing on empowering women through the use of technology. Studies consistently emphasize the importance of investigating the link between ICT and gender, recognizing the crucial role women play in areas where ICT is implemented. Additionally, in the economic sector, ICT can empower women by providing necessary tools and opportunities to thrive in the digital economy.

Conversely, the increase in ICT penetration and the maturation of new generations do not inherently lead to a reduction in gender disparities. While basic ICT skills and access to computers or the Internet might become more widespread, particularly in developed nations, this does not extend to higher-level, specialized ICT competencies (Martínez-Cantos, 2022). This disparity frequently stems from the lower likelihood of women pursuing advanced ICT education and careers, influenced by socio-cultural barriers and the scarcity of female role models. Additionally, biases in the design and implementation of technology can exacerbate these inequalities, highlighting the necessity for a comprehensive approach to address these systemic issues.

Socio-cultural barriers persist even in today's modern era. In many developing nations, women generally do not access the Internet as frequently as men. Furthermore, even when they have access to computers and the Internet, they may not utilize them to the same extent (Antonio & Tuffley, 2014). The implications of unequal participation rates in Internet technologies are profound on both personal and community levels. Women who are restricted to traditional roles such as child-rearing and housekeeping are unlikely to realize their full potential. On a broader scale, the inability of these women to engage in economic activities can significantly hinder the economic growth of their communities and countries.

In this study, we evaluate gender disparities utilizing the Gender Inequality Index (GII), which quantifies the gender-based disadvantages across three dimensions—reproductive health, empowerment, and labor market participation. The GII captures the extent of human development loss attributed to disparities between the sexes in these domains, as outlined by UNDP in 2021. With its scale ranging from 0 to 1, lower scores on the GII suggest reduced inequalities between genders, correlating with enhanced human development outcomes

Our central aim in this study is to delve into how varying degrees of ICT penetration—captured through metrics such as internet usage rates, mobile phone subscriptions, and internet

service subscriptions—correlate with gender disparities in Southeast Asian developing countries. Motivated by the diverse landscape of these factors across nations, we will gather and scrutinize data to assess whether heightened ICT penetration influences gender inequalities, specifically in terms of income disparity, employment prospects, and educational access, within the selected nations. It is within this rich context that our research unfolds, seeking answers to the following research question:

RQ: To what extent does the information and communications technology in Southeast Asian developing nations influence gender disparity, and what are the primary factors and mechanisms shaping this influence?

The key contributions of this study are as follows. First, we will extend the global discourse on ICT penetration and gender inequality by spotlighting SEA, illuminating how regional variances in ICT adoption and cultural conservatism interplay with gendered experiences. This is not merely an academic pursuit; it has profound implications for crafting policy and interventions to foster an inclusive digital sphere where gender equality prevails. Second, this study broadens the comprehension of the interplay between ICT and the Gender Inequality Index (GII), focusing on gender disparities in terms of income inequality, employment opportunities, and educational access. We performed a data panel econometric analysis on seven Southeast Asian developing countries spanning from 2000 to 2022. Third, we contribute methodologically by utilizing a data panel econometric analysis to deepen our insights into the temporal links between ICT and gender disparities. The structure of this paper is as follows: Section Two delves into the theoretical foundations of the study and formulates testable hypotheses. Section Three details the research methodology, Section Four presents the study's findings, and Section Five provides a discussion of the results. The paper concludes with summarizing remarks.

2. Literature Review

2.1 Empowerment and ICT

At the core of persistent gender disparities are traditional societal constructs and cultural norms that define and often limit the roles and opportunities available to women. Said-Foqahaa & Maziad (2011) notes that women have had restricted involvement in decision-making processes, especially within a dominant patriarchal structure that asserts itself at every level. Gender disparities refers to the unfair gap between what men and women have access to, how they are viewed in society, and how well they live. It is a common problem where men generally have more advantages, and these advantages can be ingrained in laws, court systems, and even everyday customs (European Institute for Gender Equality, 2024). For instance, in the Arab world, traditional patriarchy is structured upon a hierarchy of roles and power, as seen in the dominance of the elderly over the youth, men over women, the wealthy over the poor, and the majority over minority groups.

Empowerment, particularly in the context of gender, hinges upon ensuring egalitarian entitlements, amplification of voice, liberty of expression, and arenas for transformative political and social maneuvers, alongside augmented autonomy and the capacity to capitalize on prospects and choices for all individuals, irrespective of both men and women (Pandey & Zheng, 2019). Studies in the field of ICT4D that concentrate on the upliftment of women often

point out that technology gives them a greater sense of liberty. Through technology, women gain new skills and possibilities that they didn't have before.

Wheeler's study (2008) on how women in Egypt use internet cafés shows that even in places where the government is very controlling, women can make significant changes in their lives by having access to computers. In the Arab world, women face many obstacles to empowerment through ICT, such as not being able to read and write, censorship, limited access to technology, a lack of IT knowledge, and not enough technical training. In Egypt's case, women believed that being able to use computers and the internet helped them professionally, broadened their social networks, and changed their awareness of social and political issues. Technology, in this context, becomes a tool that helps create a space for social change and allows women to seek the same rights and chances that men have.

This research uncovered how ICT initiatives were applied in broad areas such as outreach, for instance, promoting health; education, providing opportunities to enhance health knowledge; lifestyle, including peer mentoring and planning; prevention, offering chances for health screenings; addressing health issues like intimate partner violence through applications; and understanding obstacles such as the adoption, use, and omnipresence of ICTs for women.

2.2 The Influence of the Internet on Gender Disparities

The relationship between digitalization and gender disparities is complex and multifaceted. On the positive side, studies suggest the internet can reduce traditional gender stereotypes. Increased exposure to diverse online content can challenge preconceived notions about gender roles, leading to a more egalitarian outlook (Zhou et al., 2019). Furthermore, internet access can empower women economically by providing opportunities for entrepreneurship, remote work, and access to educational resources (Ma, 2022). Yet, some troubling patterns are present as well. Obstacles such as access, cost, limited education, along with deep-seated prejudices and societal customs, restrict the capacity of women and girls to take full advantage of the prospects provided by the digital revolution (OECD, 2018).

Furthermore, the World Economic Forum's Global Gender Gap Report 2020 offers a comprehensive overview of gender-based disparities across various dimensions including economic participation, educational attainment, health, and political empowerment. In the economic realm, the report highlights the persistent obstacles that women face in accessing equal opportunities and resources. This disparity is not only evident in traditional economic sectors but is also pronounced in the digital economy, where women are underrepresented. The report's findings underscore the importance of addressing the systemic barriers that women face, which in turn could influence their internet subscription rates and digital engagement.

Besides, the relationship between internet subscriptions and gender disparities remains a critical issue in the digital age. Studies by the International Telecommunication Union (ITU) consistently report a lower proportion of women using the internet compared to men, with the gap widening significantly in least developed countries. The digital gender divide is exemplified by the fact that internet usage among women lags 12% behind that of men, a disparity that expands dramatically to 32.9% in the world's least developed nations. Moreover, when women do manage to gain access to a phone or navigate the online sphere, they frequently encounter heightened levels of adversity (Chakravorti, 2017).

In their 2023 study, Asongu & Odhiambo delve into the ramifications of information and communication technology (ICT) enhancement on the economic involvement of women in sub-Saharan Africa. The study delineates two core findings: Firstly, a (1) detrimental net influence is noted concerning the role of fixed broadband subscriptions in the engagement of women in the labor force and their unemployment rates, and (2) advantageous net impacts are observed in terms of fixed broadband subscriptions on women's employment figures. Secondly, a comprehensive analysis identifies the precise thresholds needed to mitigate the unwanted net negative influence on female labor force participation. The empirical data dictates that a rate of 9.187 fixed broadband subscriptions per 100 inhabitants is pivotal to entirely neutralize the net negative effect. This identified benchmark serves as the crucial tipping point at which the augmentation of fixed broadband subscriptions can catalyze a net positive outcome on women's labor force participation rates.

2.3 The Effects of Mobile Phone Access on Gender Disparities

The GSMA's annual report offers a critical lens on the gender disparities in mobile phone ownership and usage (GSMA, 2024). The 2024 report elucidates the persistent gender gap in mobile connectivity and how it disproportionately affects women, primarily in low- and middle-income countries. The report provides rich data-driven insights on the barriers women face to mobile internet adoption, such as affordability, literacy and digital skills, as well as social and cultural norms. It emphasizes that closing the mobile gender gap is imperative not only for women's empowerment but also for achieving broader economic and social development goals.

In the heart of Amber & Chichaibelu's 2023 study is the intricate interplay between mobile phone access and the empowerment of women within the workforce in Pakistan. The study's findings reveal a substantial and markedly positive correlation with women's involvement in the labor market. Ownership of mobile phones is linked to a 36.2% increased likelihood of women's participation in the workforce compared to those without. However, the landscape of mobile phone ownership is marred by rigid social and gender norms, which sustain a gender gap. In Pakistan's socio cultural environment, even males facing disadvantages are more likely to possess a mobile phone than females, highlighting the pervasive influence of these norms.

In addition to that, Aker & Mbiti (2010) offer a seminal exploration into the economic repercussions of mobile phone dissemination in Africa. Their research meticulously chronicles how mobile phone technology has become instrumental in enhancing economic development. By focusing on key economic indicators such as market participation, price dispersion, and consumer and producer surplus, Aker & Mbiti illustrate how mobile phone access has reduced information asymmetry, enabling farmers and traders to make better-informed decisions. This has led to increased market efficiency and potentially improved livelihoods. The authors argue that such access can be particularly empowering for women, who often face greater barriers to market information and mobility.

Sey & Hafkin (2019) report provides an exhaustive review of the current state of gender equality in the realm of digital access, skills, and leadership. The authors meticulously compile data from various global sources, offering evidence of the disparities that exist in digital inclusion. They argue that while there has been progress in some areas, women and girls

continue to lag behind in access to digital tools, the acquisition of necessary skills to benefit from these tools, and representation in leadership roles within the ICT sector. The report underscores the need for concerted efforts to address these gender gaps to achieve empowerment and equity in the digital age.

In light of the arguments articulated above, the authors contend that the expansion of ICT will exert a positive influence on women, thereby diminishing gender disparities within a nation. The increased utilization of ICT among women fosters a more informed populace, more inclined to participate in activities that benefit not only themselves but also their communities. This, in turn, leads to a reduction in gender disparities. Thus, we hypothesize:

H0: ICT Penetration does not have a statistically significant impact on gender disparities among the seven selected countries.

H1: ICT Penetration has a statistically significant impact on gender disparities among the seven selected countries.

The proposed hypotheses above primarily address the relationship between independent and dependent variables, with control variables managed separately.

3. Methods

This study uses the quantitative secondary data. The quantitative research method will take place in the form of a panel regression analysis. This method is used to analyze cross-section data, collected for a certain period of time, with a certain number of parties analyzed. With all the data being obtained, then regression models are run, in order to better understand what the relationship between the variables, or dimensions, are like.

There are a total of 5 different variables used, spanning across dependent, independent and control ranges, with each serving their own bespoke purpose as mentioned in Chapter 2.3. The sample itself consists of data from 7 different developing nations within the Southeast Asian region, with Indonesia as the anchor, as well as a time period of 23 years, spanning from the year 2000 to the year 2022. The nations being put into observation consists of 2 countries categorized as being in the upper-middle income bracket, specifically Malaysia and Thailand, with the other 5 being located within the lower-middle income bracket consisting of Indonesia, Vietnam, the Philippines, Laos, and Cambodia. These brackets were pre-determined by the categorization of nations done by the World Bank, as previously stated in Table 1. For the purpose of this research, Indonesia is categorized as a upper-middle income nation, following the World Bank's decision to change its income status in 2024 (Hameth et al., 2023). They were also purposefully chosen for this analysis, in order to ensure the best data availability, as well as the prevention of outliers. The conceptual framework of both independent and dependent variables can be visualized as seen in Figure 6 below.

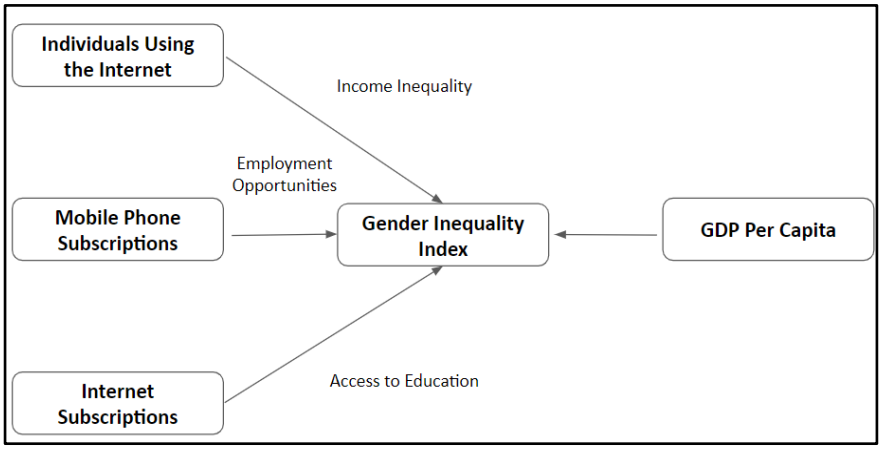

Figure 1. Conceptual Framework of GII and ICT
Source: Authors, 2024

The data obtained will be those panel data which puts into account the independent variables as listed: (1) Individuals using the internet (percentage of population); (2) Mobile broadband subscriptions (per 100 people); (3) Internet subscriptions (per 100 people).

The dependent variable will be Gender Inequality Index (GII), Gender Inequality Index (GII) refers to the parity between men and women, particularly used within the context of the three dimensions synthesized, them being reproductive health, empowerment and the labor market (UNDP, 2023). These factors play a crucial role which leads up to the decision to select and embed this index into the analysis. Reproductive health is the least important one for the purpose of the research, as it is not an aspect that is directly in conjunction with ICT penetration, though the same cannot be said for empowerment and the labor market, as they are both aspects that ICT influences greatly, as shown within Chapter 2. Hence, the relevancy of this index to the research is the best proxy at which can be used, with its closest alternative, Gender Parity Index (GPI), mainly focusing on education and the access of so instead. An important aspect to note however, regards how this index is used to showcase parity, as the lower the number shown, the lower the inequality within the specified nation.

The control variable being used is primarily for safeguarding the results of the model, and for them to also have an standardized anchor, effectively isolating the independent and dependent variables (Frost, 2023). GDP per capita is used to have a reference to the overall growth in population prosperity within the nations analyzed. GDP per capita is preferred over GNI per capita due to its nature of analyzing income and activity solely within a nation's borders, a crucial detail to not miss (Maverick, 2023).

The study proposes the data panel econometric estimation comprising above dependent variable, independent variables and control variables as being stated above. The panel econometric model is as follow:

$$\ln GII_{rt} = \beta_0 + \beta_1 \ln IUTI_{rt} + \beta_2 \ln MBS_{rt} + \beta_3 \ln IS_{rt} + \beta_4 \ln GDPC_{rt} + \varepsilon_{rt}$$

lnGII = Gender Inequality Index (In natural logarithmic form)
lnIUTI = Individuals Using the Internet (% of population, in natural logarithmic form)

lnMBS = Mobile Broadband Subscriptions (per 100 people, in natural logarithmic form)
lnIS = Internet Subscriptions (per 100 people, in natural logarithmic form)
β_0 = Constant Term
$\beta_{(1-4)}$ = Coefficient Estimates
ε = Error Term
r = Country
t = Time Value (Year)

4. Quantitative Result

Table 1 represents the best model based on the panel econometrics methods. The data shown makes use of the logarithmic format of all the variables used within the research, as any further analysis will make use of this format onwards.

Table 1. Fixed & Random Effect Assessment

Tests Conducted	Fixed Effect (3-3 Nation)	Random Effect (4-2 Nation)
Prob > Chi2	0.1474	0.0238
Mean VIF	6.65	6.10
Prob > F	0.0000	0.0000
Hausman Test	0.0000	0.0594
Prob > chibar2	0.0000	0.0000
Rho	0.8982	0.8644
Countries Included	6	6
Total Panel Observations	130	129

`After the confirmation of the validity of the data throughout the pre-testing phase, the results from the model regression itself signify satisfactory and valid data. Most of the independent variables are tagged as statistically significant values, on a level of 5% or 0.05, with the exception of Internet Subscriptions on the fixed effect model, as well as the control variable of GDP per Capita, as in Table 2.

Table 2. Regression of Panel Data Models

Panel Data Models: Dependent Variable (Gender Inequality Index)		
Independent Variables	**Coefficient Fixed Effect (3-3 Nation)**	**Coefficient Random Effect (4-2 Nation)**
Individuals Using the Internet	-0.0600534*	-0.029478*
Mobile Broadband Subscriptions	0.0504304*	0.0466325*
Internet Subscriptions	-0.0145448	-0.0278622*
GDP per Capita	-0.0011349	-0.0048395
Constant	-0.9588567*	-0.9651625*

Note: Statistically significant values are highlighted with 5% (*)

It could also be seen that all the results within both models have movement in the same direction for each respective variable, with the difference in the magnitude of each regression. Though, though the data shown in Table 2, there is no clear-cut winner as to which model is superior, as they both have variables at which have greater values (indicating higher correlation) that are different between one another, as seen with the variables IUTI and MBS having greater values within the fixed effect model, whilst IS, GDPC, and the Constant being greater on the random effect model.

The correlation that could be seen within the model is what was to be expected from the literature review with the movements indicated by the majority of the variables being a negative one, indicating the positive impact that each of the variables have on the overall condition of gender disparities through the proxy variable Gender Inequality Index (GII), one which showcases better equality through a lower GII value. Hence, having a negative relationship showcases positive changes to gender disparities with the development in ICT penetration and usage. In addition, this argument is further validated by the rho (adjusted R squared value) indicator shown in Table 6, with both models having a value of nearly 0.9. This indicates that nearly 90% of the independent variables can explain the dependent variable (in terms of movement).

What is possibly the most interesting and surprising case that could be seen from the results has to do with one of the variables, that being Mobile Broadband Subscriptions (MBS). This variable proved to be a unique anomaly amongst the other variables that are used to tangibly describe ICT penetration, as it is the only one that moves in a positive direction alongside GII. This indicates that mobile phone usage may not in fact lead to positive changes within gender disparities.

5. Discussion

The regression results from the study conducted indicated statistical significance for all the independent variables included, meaning that further discussion can be continued. This means that the alternate hypothesis provided can be accepted, as there is a correlation between the dependent and independent variables, hence meaning that overall growth in ICT penetration will lead to lower gender disparities, with a negative relationship between the two being displayed. This significance is supported with the literature review conducted within the preliminary stages of the research, as done by Shah and Krishnan (2023) had previously shown. When it comes to the usage, adoption and subscriptions towards the internet, the impact that this has on households and individuals returned a positive one, with it allowing for the conventional gender roles to be challenged, providing more opportunities and boosting overall economic growth.

Furthermore, the study finds the positive relationship between broadband subscription and gender disparity. The purposes for which men and women use the internet diverge notably. Men predominantly use the internet for studies and professional purposes, while women use it more for socializing, communicating, and entertainment (Ahmad et al., 2018). This dichotomy underscores a broader landscape where women are more exposed to online harassment and discrimination. For example, a UN Women study found that 60% of women internet users in the Arab States region had experienced online violence (UN Women, 2021). This increased exposure to online harassment can deter women from fully utilizing the internet for empowerment and professional growth, thereby perpetuating gender inequality.

Despite the increasing affordability of mobile phones, the disparity in ownership between men and women remains a significant issue that highlights the broader context of gender inequality. Women in LMIC countries are still less likely than men to own a mobile phone due to pervasive income disparity and restrictive social norms. In Southeast Asia, for instance, women generally earn less than men, exacerbating the barriers to mobile phone ownership (Ing, 2023). For example, in Singapore, the median income for women was 14.3% less than that for men in 2023 (Seow, 2024), and in Indonesia, the average monthly wage for women was 23.8% lower than that of men as of August 2023 (Statista, 2024a).

Moreover, the issue of addiction associated with mobile phone usage significantly exacerbates gender inequality. Unlike traditional internet usage on laptops, the ease of access to the internet via mobile phones has made it substantially more addictive. A study by Bae (2017) found that the frequency of smartphone use is related to dependence on smartphones. This pervasive access allows users to engage with their devices whenever and wherever, contributing to a habit-forming cycle. Unaware use of smartphones, particularly during other activities or late at night, can negatively impact the quality of life (Sela et al., 2022). These results highlight the need for considering social well-being in relation to digital human behavior, smartphone addiction, and healthy usage modes.

In conclusion, while mobile phone access is a crucial step toward digital inclusion, it does not automatically translate into reduced gender inequality. The distinct challenges associated with mobile phone usage, from affordability and ownership gaps to digital literacy and social norms, must be addressed. Policymakers should focus on targeted interventions that improve digital literacy, reduce affordability barriers, and protect women from online

harassment. Only by addressing these multifaceted issues can mobile phone usage contribute positively to reducing gender disparities.

6. Conclusion

This research has provided a comprehensive analysis of the influence of Information and Communication Technology (ICT) penetration on gender disparities in Southeast Asian (SEA) developing nations. Through an extensive review of existing literature, detailed econometric analysis, and a careful examination of ICT indicators, the study offers valuable insights into how technology can drive gender equality in this region.

The findings reveal a significant positive correlation between ICT penetration and reduced gender disparities. Specifically, the study highlights that greater access to mobile phones and the internet plays a crucial role in narrowing gender gaps in education, employment, and economic participation. For instance, mobile phone ownership among women is associated with higher literacy rates and better educational outcomes. This is because mobile technology facilitates access to educational resources and information, which empowers women to pursue learning opportunities that were previously inaccessible. Similarly, internet access provides women with a platform to engage in online learning, access job markets, and participate in entrepreneurial activities, thereby enhancing their economic opportunities and independence.

Moreover, the analysis indicates that ICT penetration contributes to increased female labor force participation. Women with access to digital technologies are more likely to engage in formal employment and entrepreneurial ventures. This is particularly significant in rural areas, where traditional barriers to women's employment are more pronounced. ICT provides these women with new avenues to work remotely, access markets, and connect with broader economic networks. As a result, ICT not only boosts individual economic empowerment but also contributes to broader economic development by leveraging the untapped potential of women.

The study also underscores the importance of government policies and business strategies in maximizing the positive impact of ICT on gender equality. Governments in SEA developing nations must prioritize the expansion of ICT infrastructure and ensure that women, especially those in marginalized communities, have access to affordable and reliable digital technologies. By creating an enabling environment for ICT growth, governments can facilitate greater gender equality and social inclusion. Furthermore, businesses have a critical role to play in designing gender-sensitive ICT solutions and services. Companies that focus on developing technologies catering to women's needs can help bridge the gender gap in digital access and usage.

In addition to these practical implications, the research contributes to the academic discourse on ICT and gender disparities by providing empirical evidence from a region that has been underrepresented in existing studies. The findings from SEA developing nations add a unique perspective to the global understanding of how ICT can drive social change and promote gender equality. This study highlights the need for further research to explore the nuanced impacts of ICT on different dimensions of gender disparity and to identify the most effective interventions for specific contexts.

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