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ASSESING THE IMPACT OF 5G NETWORK ON ECONOMIC IN ASIAN COUNTRIES IN THE PERIOD 2012-2022

Manh Duc Dang[1], Thu Nguyen Thi Minh[2*]

[1,2] International Economics, Foreign Trade University, Vietnam
Email: ducmanh.dang22702@gmail.com, thuntm@ftu.edu.vn

*Corresponding Author

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ABSTRACT

This thesis evaluates the impact of 5G technology on the economic growth of Asian countries during the period 2012-2022. As the latest advancement in wireless network technology, 5G has promised unprecedented connectivity speeds, lower latency, and the capacity to simultaneously support a vast array of devices. This research focuses on understanding how the deployment of 5G networks has influenced the economic trajectories of countries within Asia. This region has been at the forefront of 5G adoption. The study employs a quantitative analysis method, combining trend comparison analysis and the Difference in Differences (DID) regression model to assess the economic impact of 5G deployment. By examining data from various Asian countries, this thesis seeks to draw correlations between 5G technology implementation and financial performance indicators such as Gross Domestic Product (GDP) growth, inflation rates, and foreign direct investment inflows. Findings from this research indicate that 5G technology has had a significant, positive impact on economic growth in the region. The high-speed, reliable connectivity offered by 5G has facilitated advancements in various sectors, including manufacturing, healthcare, education, and transportation, contributing to overall economic development. The thesis also discusses the policy implications for countries, particularly Vietnam, aspiring to harness the full potential of 5G technology for economic advancement. Recommendations are provided for policymakers to support the growth of 5G infrastructure and to foster an environment conducive to technological innovation. This study contributes to the existing literature by providing empirical evidence on the economic benefits of 5G technology in Asia. It also offers practical insights for countries looking to leverage 5G technology as a catalyst for economic development.

Keywords: *5G, growth economics, Asian countries*

1. INTRODUCTION

Economic development-oriented nations place the utmost importance on technological innovation in the age of digital technology. Stable future development necessitates that each nation give the utmost importance to scientific and technological advancements. Emerging technologies that aid and improve human existence have accompanied the fourth technological revolution. The most advanced wireless network technology to date, 5G, has been the subject of extensive research and development by several nations since 2018. The commercial deployment of 5G, which began in 2020, marked a significant milestone in its advent and technological progression.

Asia has heavily invested in technological advancement and global competitiveness. Nations such as China, India, and South Korea have emerged as innovative and high-tech industrial hubs. Asia is integral to the global supply chain by providing many goods and services worldwide. Novel prospects for enhancing performance and integrating supply chains have emerged with the advent of 5G technology. Asia is at the forefront of advancing emerging economic sectors, including information technology, artificial intelligence, tourism, and renewable energy. The advancement of 5G networks can drive progress in these domains. In addition to facilitating technology and telecommunications firms, the governments of these

nations have launched initiatives to invest in the development of 5G. Promoting 5G services, according to South Korea's Deputy Prime Minister Hong in 2019, would enhance the standard of living for the nation's populace. To promote the integration of 5G technology into a wide range of other industries, the Chinese government has enacted policies to direct the growth and development of the sector. The objectives include developing intelligent connectivity networks, fostering economic and social progress, and expediting digital transformation. The Vietnamese government is implementing policies to improve its connectivity network and infrastructure, thereby constructing a conducive environment for the growth of technology companies. As a result, a contemporary and competitive digital economy is formed. Vietnam's active integration into the global economy is achieved through a strategic blend of national policy and international cooperation. This approach concurrently bolsters the nation's technological prowess and creative potential.

The development of 5G technology

Around the world, several writers have delved into the diverse facets of 5G networks. Prior research has examined the progress and breakthroughs in 5G technology, its effects on various sectors, security concerns, and the practical uses of 5G in daily activities. The following are research papers about 5G networks written by international authors:

Singh et al. (2017) examined the rapid advancements in communication technology, which have resulted in the widespread use of various smart devices in networks. The interaction among these technologies often includes their social dynamics and connections. Moreover, the forthcoming 5G network is anticipated to amalgamate diverse network technologies like the Internet of Vehicles (IoV), Internet of Things (IoT), Mobile Cloud Computing (MCC), Smart Grid (SG), Big Data, and Device-to-Device (D2D) communication into a cohesive network. To achieve this collective goal, leveraging the social characteristics of various intelligent devices employed by these technologies presents a potentially effective strategy. Utilizing social factors helps create an efficient network by circumventing problems like congestion and resource allocation.

Additionally, it results in the merging of emerging 5G network technologies with human civilization, giving rise to a novel paradigm known as "social 5G network technology.". The report examines the progress made in social 5G network technology, specifically highlighting six crucial technologies that 5G aims to facilitate in a unified network: Internet of Vehicles (IoV), Internet of Things (IoT), Mobile Cloud Computing (MCC), Smart Grid (SG), Big Data, and Device-to-Device (D2D) communication. A study by Akhil Gupta and his colleagues (2015) centred on the architecture of the fifth-generation (5G) mobile network and the emerging technologies crucial for augmenting the architecture and meeting user needs. The study primarily centers on the architecture of 5G mobile networks, the technologies related to Multiple Input Multiple Output (MIMO), and the communication method known as Device-to-Device (D2D). In addition, the paper discusses new technologies that are currently developing, including noise management, spectrum sharing using cognitive radio, ultra-dense networks, integration of multiple radio access technologies, fully duplex radio, millimetre wave solutions for 5G mobile networks, and the use of cloud technology for 5G radio access networks and Software Defined Networks (SDN). Potential components of the 5G mobile network architecture include compact mobile access points, device-to-device communication (D2D), cloud networking, and the Internet of Things (IoT).

Li and colleagues (2018) state that the development process of the fifth-generation (5G) network is becoming more streamlined, positioning it as the primary catalyst for advancing

Internet of Things (IoT) applications. According to a 2018 International Data Corporation (IDC) forecast, an estimated 70% of firms are projected to invest $1.2 billion in human connection management solutions, spurred by the deployment of global 5G services. In the future of the Internet of Things (IoT), emerging applications and business models provide novel performance needs and improvements. The parameters include extensive connection, robust security, dependable dependability, comprehensive wireless communication coverage, minimal latency, and substantial throughput.

Economic growth

Economic development is paramount for every nation and region, and it has been the subject of extensive research over an extended period. Nevertheless, research into economic development experienced a slowdown towards the end of the 1960s and only regained momentum in the late 1980s. Prominent classical economists such as Adam Smith (1776), David Ricardo (1817), and Thomas Malthus (1798), followed by Frank Ramsey (1928), Allyn Young (1928), Frank Knight (1944), and Joseph Schumpeter (1934), introduced vital concepts that have become integral to modern understandings of economic development. These concepts cover fundamental strategies for competitive behaviour and equilibrium dynamics. They also explore the connection between diminishing returns and the accumulation of material and human capital, the interaction between per capita income and population growth rates, the influence of technological progress through increased specialization of labour and the discovery of new goods and production methods, and the role of monopoly power in driving technological advancement. In the late 1950s, Harrod (1939) and Domar (1946) endeavoured to merge Keynes's theory with aspects of economic development. Later, additional substantial contributions were made by Solow (1956) and Swan (1956). The Solow-Swan model features a neoclassical production function that assumes constant returns to scale, diminishing returns to each input, and a flexible, favourable ability to substitute inputs. This production function, combined with the continuous savings rate rule, resulted in a highly simplified general equilibrium model of the economy.

Only recently has conditional convergence, as predicted by these models, garnered significant empirical attention. Economies with an initial per capita GDP lower than their long-term or steady-state levels tend to grow more rapidly. Economies with lower initial capital per worker relative to their long-term levels typically show higher rates of return and faster growth rates. In the Solow model, conditional convergence is influenced by the steady-state levels of capital and output per worker. In this model, factors affecting economic growth include the savings rate, population growth rate, and the positioning of the production function, all of which may vary among countries. Recent empirical studies have revealed national disparities, encompassing differences in government policies and initial levels of human capital. However, the critical concept to consider is conditional convergence, a fundamental feature of the Solow model. This concept can significantly elucidate the variances in economic development observed across countries and regions.

Following the mid-1980s, a plethora of new studies surfaced regarding economic growth, with Romer (1986) and Lucas (1988) leading the way in pioneering this research. This research was inspired by the realization that factors influencing long-term economic growth hold greater importance than the mechanisms of the business cycle or the counteractive measures of monetary and fiscal policies. Consequently, subsequent studies sought to transcend the limitations of the neoclassical growth model. In this model, the per capita long-term average growth rate depended on external rates of technical progress. Recent developments have, in various ways, incorporated the long-term growth rate directly into the model. This approach

led to the definition of endogenous (or 'spontaneous') growth models. The neoclassical model facilitated the analysis of economic growth across different nations, gaining mainstream attention in the 1990s. Additionally, new research employing models that identified mechanisms for sustained growth gave rise to what is now termed the concept of endogenous growth. This is now known as the idea of spontaneous growth.

The impact of 5G on Economic Growth

Erumban et al. (2016) explored the impact of technological advancements on economic growth. Assuming no external variables interfere, technological advancements exert a long-term influence on economic growth. For sustainable economic development over the long term, a nation must prioritize advancing its indigenous science and technology. Matti Pohjola (2020) emphasized that investing resources in information technology significantly impacts economic progress. The impact of science and technology on economic development is nearly as significant as other factors.

In 2017, IHS Markit anticipated that 5G would act as a catalyst, having a significant and broad impact on forming new business models and transforming economies and industries globally. 5G technology will enhance the mobile broadband experience, adapting to the evolving needs of MIoT and MCS applications and thus expanding mobile networks. IHS Markit assessed three dimensions of 5G's prospective economic influence on the global economy by 2035, assuming that development-conducive rules have been implemented. The widespread use of 5G technology across multiple industries would enable efficient sales of products and services, optimize fundamental operations, and facilitate the development of innovative business models. The 5G value chain is projected to grow substantially, focusing on continually improving 5G technology platforms via specific research and development, infrastructure investment, and application development. Implementing advanced mobile technology, specifically 5G, can stimulate sustained and significant increases in global Gross Domestic Product (GDP), the benchmark for robust economic progress. Within the 5G economy context, introducing new business models and significantly altering or abandoning traditional delivery methods will pose more significant challenges for governance and management. The emergence of disruptive companies such as Uber and Airbnb during the 4G era gave rise to legal challenges within the "sharing economy". These legal challenges are expected to continue and intensify in the 5G economy. To fully harness the economic benefits of the 5G economy, it is crucial to maintain research and development efforts and allocate resources toward fostering innovation and advancing new technology generations. Policymakers should prioritize the following actions:

a) Facilitate collaboration between the public and private sectors to establish 5G standards;
b) enable firms to make substantial investments in research and development to expedite the transition to the 5G economy;
c) ensure that licensing and regulatory frameworks keep up with the speed of innovation.

Furthermore, the extensive use of 5G technology and the fast advancement of technology impose extra demands on policymakers to stay abreast of how 5G will profoundly transform several industries and facets of everyday life. To prepare society for the implementation of 5G technology, it is necessary to update legislation and regulations in several domains, such as public safety, cybersecurity, privacy, public infrastructure, healthcare, spectrum licensing, permits, education, training, and development.

The report titled "The Contribution and Prospects of 5G Technology for China's Economic Development" by Fu et al. (2020) suggests that the extensive implementation of 5G technology would enhance corporate efficiency. Nonetheless, it might lead to unemployment for certain

individuals. Conversely, there is a belief that the introduction of 5G technology will create numerous high-paying jobs. The widespread adoption of 5G is anticipated to trigger swift growth in the manufacturing sector. Substantial investment in network equipment will be required during the building phase of 5G. This need will compel Chinese equipment producers to develop novel electronic machinery, comprehend the fundamental principles of technology, and achieve autonomy from human labour. Furthermore, the use of 5G technology promotes the creation of advanced and varied mobile phones and facilitates the prompt and effective upgrading of mobile devices. 5G will enhance the whole information services industry, particularly the Internet and other connectivity firms, leading to the development of more advanced applications. 5G boosts employment in the telecommunication industry and facilitates the emergence of many new professions in the information services sector, particularly in areas such as cloud computing and the development of advanced algorithms. Given the expanding scope and complexity of 5G use, this technology is projected to create approximately 35 million additional employment opportunities by 2025.

Fahn and Yan (2021) researched the macroeconomic effects of 5G development and found that it would substantially influence the labour market. Regardless of size, most organizations anticipate increased productivity using 5G technology. Implementing 5G technology will significantly impact remote work, often considered a voluntary option. However, it will need a consistent and fast internet connection, compelling people to work in confined home offices or similar settings. Due to the enhanced speed and dependability of 5G, employees can carry out their tasks remotely, significantly reducing the need for working from home. 5G technology facilitates remote work by reducing latency and connection failures, diminishing the need for extensive physical office spaces and operating expenses. Organizations may allocate their resources toward hiring more personnel. The areas impacted include job search, employment training, virtual and augmented reality, and job loss or development. Enhanced 5G connections have expanded the potential applications of virtual reality (VR) and augmented reality (AR) for future usage. Implementing 5G technology will be very advantageous in industrial and manufacturing environments, where the prevalence of remote control operations and real-time maintenance instructions necessitate its use. Introducing 5G technology will inevitably result in employment reductions and new prospects. According to IHS Markit's analysis, implementing 5G technology is projected to create 22 million employment opportunities worldwide by 2035, considering indirect impacts. However, it is also anticipated that an equivalent number of 22 million jobs would be eliminated over the same timeframe.

Previous studies suggest that advances in science and technology, including the creation of 5G network, benefit economic growth in numerous aspects. However, the majority of earlier studies released between 2018 and 2020, during the period when 5G was still being researched and not yet deployed for commercial reasons, mostly made predictions and did not provide a comprehensive evaluation of the actual effect of 5G on economic growth.

Previous studies conducted overseas, such as those by Erumban and colleagues (2016) and Matti Pohjola (2020), have provided a clear understanding of the global effects of technological progress. Although the studies above often evaluate the influence of technical progress, they seldom differentiate between distinct categories of technology and their respective effects. Research is still being conducted on the correlation between the 5G network and its impact on economic development. Most research on 5G has focused on introducing and elucidating the benefits that 5G technology provides. These studies generally evaluate the effects of 5G on sectors like healthcare and education, but they do not specifically consider its influence on economic development.

Regarding the date of the study, prior studies only examined the period before 2020, during which the 5G network was undergoing research and testing. The study's conclusions are prognostic and do not provide pragmatic consequences.

Past studies have just evaluated the impact of 5G in certain nations, focusing on its geographical extent. Ji et al. (2018) and Li et al. (2018) assess the effects of the 5G network in China.

Recognizing this factual circumstance, the author selected Asian countries from 2012 to 2022 as the subject of an investigation to establish a strong correlation with prior research deficiencies. The author aims to precisely evaluate the influence of the 5G network on economic growth. Based on industrialized nations' experiences, the author suggests the development of 5G technology in Vietnam.

2. RESEARCH METHOD

The author used two analytical techniques, namely trend comparison and the Difference in Differences (DID) model, a sophisticated statistical tool, to assess the influence of 5G on economic development. These integrated techniques are often used to assess the causal effect of an intervention or policy when it is impractical to carry out a randomized controlled trial.

Propensity Score Matching

Propensity Score Matching (PSM) is a quasi-experimental approach in which researchers use statistical methods to generate a synthetic control group by pairing each treated unit with an untreated unit with comparable features. Using these corresponding results, researchers may calculate the effect of an intervention. Matching is a valuable technique in data analysis for estimating the effects of a program or event when it is not possible or practical to assign participants randomly.

The Propensity Score Matching (PSM) technique primarily depends on the probability-based categorization of treatment based on observable baseline characteristics. Propensity score matching (PSM) enables the design or analysis of observational research (non-random) to use the particular attributes of a randomly assigned control group (RCT). The likelihood score serves as a balancing score. Therefore, using propensity score matching, the distribution of baseline characteristics will be comparable between the participants who received treatment and those who did not. There are four ways to calculate propensity scores: the matching method (PSM), stratification method, inverse probability of treatment weighting using propensity score (IPTW), and covariate adjustment.

According to Greenland and colleagues (1999), randomized controlled trials (RCTs) are widely accepted as the most reliable approach for assessing the impact of therapeutic interventions and exposures on intended outcomes. The assumption underlying randomized controlled trials (RCTs) is that the measurement of initial characteristics has no bearing on treatment allocation. This allows for estimating treatment effects on outcomes by directly comparing the outcomes of individuals in the intervention group with those in the control group.

Difference-in-Differences Model

Variation in Difference-in-Differences Regression is a statistical approach used to estimate the effects of a new policy or event by comparing the outcomes before and after its implementation. The difference-in-differences (diff-in-diff) method is a technique used to quantify the effects

of newly implemented policies. To use the difference-in-differences method, it is necessary to have data on the outcomes of individuals who were subjected to the intervention (treated group) and those who were not exposed to the intervention, both before and after the intervention.

Fundamentally, the difference-in-differences technique involves comparing the impact and control groups by examining the differences in outcomes throughout each observation period. The difference-in-differences technique calculates the average impact by comparing the results of the impact and control groups before and after program implementation, denoted as T=0 and T=1, respectively. The outcomes for the impact and control groups at time t are represented as Yti and Yci.

Expected model

Based on the theoretical framework presented above, the author proposes a regression model to assess the impact of 5G on economic growth in Asian countries from 2012 to 2022.

$$GDPG = \beta_0 + \beta_1.G_{it} + \beta_2.Post_{it} + \beta_3.Post \times G_{it} + \beta_4.INF_{it} + \beta_5.FDI_{it} + \beta_6.LE_{it} + \beta_7.lnPOP_{it} + \beta_8.D_{it} + \varepsilon_{it}$$

In the regression model proposed, the terms are defined as follows:

β_0 is the intercept coefficient.

$\overline{\beta_1 \dots \beta_8}$ are the regression coefficients of the corresponding independent variables.

i = 1,40 represents the observed countries, indicating that data from 40 different countries are included in the analysis.

t = 2012,2022 represents the observed years, indicating the time frame for the data spans from the year 2012 through 2022.

e_i is the random error of the model, accounting for the variability in economic growth not explained by the independent variables.

Table 1. Data source
Source: The author compiled it himself.

Variables	Description	Source	Roles	Sign expectations
GDPG	Economic growth rate of country i at time t	Indicators - World Bank Open Data	Dependent variable	
G	Binary variable indicating whether country i is using the 5G network at time t	5G Availability Around the World	Independent target variable	+
Post	Binary variable indicating the time when 5G is used for commercial purposes worldwide	Indicators - World Bank Open Data		+/-
GxPost	Created by the multiplication of G and Post			+
INF	Inflation rate	Indicators - World Bank Open Data	Independent variable	-
FDI	Foreign Direct Investment			+
LE	The average age of the country			+

lnPOP	The logarithm of the country's population			+
D	Dummy variable assessing the impact of Covid-19	Dummy variable		-

3. RESULTS AND DISCUSSIONS

Table 2 Results of running the DID model
Source: Author's own compilation of results on Stata14

	G
INF	0,0461***
	(0,0151)
FDI	0,00490
	(0,0241)
LE	0,100***
	(0,0263)
lnpop	0,178**
	(0,0720)
D	2,836***
	(0,318)
Coefficient	-12,54***
	(2,601)
Observation	425

Standard errors in parentheses
**** p<0.01 ** p<0.05 * p<0.1*

R_squared = 0.1903, meaning the independent variables explain 19.03% of the variation in GDPG.

Observations on estimated coefficients:
The PostxG variable is statistically significant at the 5% level. With other factors constant, countries that use 5G at the time of its commercial deployment have a GDPG higher by 5988 units compared to countries that do not use 5G when it is not used for commercial purposes.

The positive DiD number further confirms that nations that have implemented 5G technology will see more incredible GDP growth than countries that have not entirely implemented 5G. By 2035, it is projected that 5G technology will produce $13.2 trillion in worldwide sales. Scientists forecast that this technology will facilitate the creation of the world's first "intelligent factories". These factories will use the enhanced speed and superior dependability of 5G technology to remove the need for cable connections, enhance automated operations, and, most significantly, gather more data. Nevertheless, robots will not be the exclusive recipients. Despite the presence of equipment in modern industries, human presence is necessary to address any concerns that arise. Specific processes may also possess a level of complexity that hinders their successful automation, necessitating the involvement of human intervention. Reducing latency, or the time delay, in virtual and augmented reality systems might enhance their reliability for high-precision tasks. This promising advancement significantly enhances worker efficiency and fosters seamless collaboration between workers and robots. Currently, these technologies are already being used in industrial settings.

4. CONCLUSIONS AND SUGGESTIONS

After the analysis and evaluation, the research essentially achieved the objectives set out by the author: (1) To synthesize and systematize the theoretical basis; (2) to present a research model to assess the impact of the 5G network on economic growth; (3) to propose recommendations for Vietnam in developing economic growth.

Firstly, the research consolidated and organized studies about the advancement of technology in a broad sense, with a specific focus on the 5G network. The author conducted preliminary research and created a comprehensive model to evaluate the influence of the 5G network on economic development. The model incorporates five distinct control variables: Inflation, Foreign Direct Investment, Average age of the country, Population, and COVID–19. The objective independent variable is to evaluate the influence of 5G.

Furthermore, the author conducted a study on the influence of the 5G network on economic development by using the trend analysis approach and the estimate method of Difference in Differences on the Different in Different model. Upon executing the model, the findings indicate that nations using 5G technology for business tend to see a rise in their economic growth rate, surpassing the growth rate observed when 5G is not used. Implementing the 5G network is advantageous for nations in fostering economic expansion.

Thirdly, drawing on the insights gained from the experiences of South Korea and China in implementing the 5G network, the author put out many proposals for the government. The government needs to establish supportive policies for businesses to build and expand the 5G network together. In light of the expanding user base and intensifying competition, government advice and direction will play a crucial role in facilitating enterprises' effective and expeditious deployment of the 5G network.

The study found that the impact of the 5G network on economic growth aligns with the hypothesis. However, it is difficult to accurately assess the impact of 5G at a time when COVID-19 had a significant negative impact on nations' economies. While researching and gathering data, the author encountered several challenges, particularly with nations that must make their data available on the Internet platform. Simultaneously, more comprehensive data about the specific timelines of countries implementing the 5G network must be collected. Given the time limitations, the author needed help presenting an ideal model. More research is needed on the effects of the 5G network on global economic growth.

Future studies might extend the research period until 2023 and broaden the scope to include nations globally to evaluate the influence of 5G on economic development visually.

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