

Thi Hoa Nguyen; Minh Khue Nguyen

**Working Paper**

## Does digitalization really foster economic growth in the context of the COVID-19 pandemic?

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## **ADB Working Paper Series**

### **DOES DIGITALIZATION REALLY FOSTER ECONOMIC GROWTH IN THE CONTEXT OF THE COVID-19 PANDEMIC?**

Thi Hoa Nguyen and Minh Khue Nguyen

No. 1472  
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**Asian Development Bank Institute**

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**Abstract**

This study investigates the impact of digitalization measured by digital competitiveness ranking and digital competitiveness scores on the real economic growth of 63 countries over the period 2017–2021, the period pre and during the COVID-19 pandemic. By employing panel data regression models, this study has revealed that digital competitiveness ranking improved the real GDP growth rates after controlling for several macroeconomic factors, but this positive impact was modest. Both digital competitiveness ranking and digital competitiveness scores had a stronger positive impact on the real economic growth during the pandemic, meaning that they reduced the negative impact of the COVID-19 pandemic on the real GDP growth rates of the studied countries. The findings of this study are robust since endogeneity issues were addressed using the GMM method. Based on these findings, this study offers several implications to policymakers and academicians.

**Keywords:** digitalization, digital economy, digital competitiveness, economic growth, the COVID-19 pandemic

**JEL Classification:** O11, O33, O47, O50

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# 1. INTRODUCTION

The COVID-19 pandemic emerged in late December 2019 and spread all over the world in 2020 and 2021, putting the world's healthcare system at risk (Haldane et al. 2021). To deal with this unprecedented health crisis, governments worldwide implemented several strict measures, such as border closures, quarantine, and social distancing, among others, leading to serious supply chain disruptions (Meier and Pinto 2020). As a result, countries experienced a huge decline in their GDP in 2020: The world's GDP growth rate in 2020 was -3.1% (World Bank 2023). Nonetheless, in 2021, although the pandemic was still complicated, several countries recovered with a significant improvement in their GDP (World Bank 2023). Although there are several key enablers of economic growth, it has been argued that digitalization is an important factor (Zhang et al. 2022). Digital technologies helped governments and healthcare systems to respond to the pandemic effectively through population surveillance, case detection, contact tracing, and examination of interventions based on mobility data and public communications (Budd et al. 2020). For firms, digital technologies enabled businesses to maintain their operations in the middle of the pandemic while improving the effectiveness of demand forecasting and optimizing business processes (Li et al. 2022).

Despite the importance of digitalization, the literature on the role of digitalization in fostering economic growth during the COVID-19 pandemic is still thin, although the role of digitalization in improving economic growth before this pandemic has been substantially addressed. Among the thin literature on this topic, Zhang et al. (2022) examined the impact of digitalization in the form of a digital economy on the economic growth of countries along the "Belt and Road" during the COVID-19 pandemic. In this study, the digital economy is measured utilizing the authors' self-measure, using three indicators: "digital economy infrastructure, digital economy openness, and innovation environment and competitiveness required for digital technology development" (Zhang et al. 2022). Furthermore, this study focused on countries along the "Belt and Road," so it did not investigate the impact of digitalization on economic growth on an international scale.

This study differs from the one conducted by Zhang et al. (2022) since it involves the digital competitiveness ranking and scores of countries provided by the International Institute for Management Development (IMD) as measurements of digitalization. Such measurements present the capability and readiness of countries in using digital technologies as a key enabler of economic growth (IMD 2023). Constructed by the IMD, which is an independent academic institution that has strong ties with businesses and that focuses on world impact, measurements of digitalization used in this study are reliable and have become well recognized since its introduction in 2016. Since then, every year, the IMD has published its digital competitiveness ranking and scores with details of measurement processes disclosed. On the other hand, this study's samples include countries from different continents (America, Europe, Asia, Africa, Oceania) classified into both developed and developing countries, so they can represent well the world population. This study is also the first research study to examine the role of digitalization in mitigating the COVID-19 pandemic shocks on economic growth at the country level.

Overall, this study has revealed that in the period 2017–2021, countries with a higher digital competitiveness ranking had higher real GDP growth rates after controlling for several macroeconomic factors. Disregarding measurements of digital competitiveness, higher digital competitiveness rankings or higher digital competitiveness scores had a stronger positive impact on real economic growth, or they reduced the negative impact of the COVID-19 pandemic on real GDP growth rates. This means that digitalization could help countries to mitigate shocks, including shocks from this unprecedented health crisis. This finding is a critical contribution to the literature since it confirmed the role of digitalization in eliminating the negative impact of a crisis on economic growth. Additionally, it also suggested that the improvement in digitalization must reach a certain level, which can change the digital competitiveness ranking of a country, to gain economic benefits. Moreover, when digital competitiveness measures were controlled, the real economic growth was nonlinearly affected by inflation, gross savings, and government spending. This finding, therefore, confirmed the dynamic roles of inflation, gross savings, and government spending in fostering economic growth during normal and crisis periods and suggested a holistic approach to economic growth.

In terms of structure, following this section, this study critically reviews the literature on the role of digital technologies in fostering economic growth. It then clarifies the dataset and methods used in this study. Importantly, the empirical results are then presented and discussed. Finally, this study concludes by discussing its achievements and limitations, and provides several implications for policymakers.

## 2. LITERATURE REVIEW

Initially proposed by Tapscott and McQueen (1996), the term “digital economy,” which is interchangeable with the term “digitalization,” refers to the integration of digital and network technologies for economic development, making a new form of economies following the agricultural and industrial eras. According to Mesenbourg (2001), a digital economy comprises three components: e-business infrastructure, e-business, and e-commerce. The OECD defined a digital economy as the digital transformation of economics and the society. The G20 Digital Economy Development and Cooperation Initiative (DEDCI) saw this term as “a broad range of economic activities that include using digitized information and knowledge as a key factor of production, modern information networks as important activity spaces, and the effective use of ICT as an important driver of productivity growth and economic structural optimization” (cited by Zhang et al. 2022). Because of the different definitions of the term “digital economy,” it is not simple to measure this term. In the literature, scholars mostly measured a digital economy by a self-constructed index. For example, Zhang et al. (2022) measured a digital economy by a self-constructed index using three dimensions, i.e., “digital economy infrastructure, digital economy openness, and innovation environment and competitiveness required for digital technology development” (Zhang et al. 2022), while Mura and Donath (2023) measured digitalization by three components of information and communication technologies, namely mobile subscriptions, fixed broadband subscriptions, and internet users. Although such measures cover major components of a digital economy, they still neglect several other aspects of digitalization when referring to definitions of this term from different perspectives: the OECD, the G-20 DEDCI, and academicians.

With regard to the impact of a digital economy on economic growth, scholars have commonly agreed that the digital economy is an enabler of economic growth in countries worldwide. Guo, Ding, and Lanshina (2017) argued that the digital economy

is critical for fostering sustainable economic growth, but it must be governed properly to eliminate disparities between developed and developing countries, to address cyberattacks, and to promote a higher quality of life for all people. Chakpitak et al. (2018) demonstrated that digital technologies contributed to improving economic growth in Thailand, but this positive impact was modest because digital technologies were not used to their maximum capacity. Zhang et al. (2021) revealed that in the Chinese context, digital technologies and digital integration improved regional total factor productivity. Zhang et al. (2022) figured out that the digital economy positively influenced the economic growth of countries along the “Belt and Road” by promoting an industrial structure upgrade, fostering total employment, and inducing employment restructuring. Additionally, this study found divergent effects of the COVID-19 pandemic on different countries along the “Belt and Road”: While digital industries in Armenia, Israel, Latvia, and Estonia had great growth potential during the pandemic, others such as Ukraine, Egypt, Türkiye, and the Philippines experienced an adverse impact of this pandemic.

During the COVID-19 pandemic, digital technologies were used to assist governments and healthcare systems in responding to the pandemic by assisting with case detection, population surveillance, examinations of the effectiveness of responses, etc. (Budd et al. 2020). Digital technologies also enabled firms to maintain their operations effectively and efficiently. For example, Li et al. (2022) and Heredia et al. (2022) revealed the positive impact of digitalization on firms’ performance during the pandemic.

The literature review indicated that the term “digital economy” has not reached a consensus in terms of its meaning. Therefore, it is challenging for scholars to measure this concept in empirical studies (Zhang et al. 2022). On the other hand, although the digital economy has been considered to foster economic growth, the extent to which digital technologies influence economic growth varies across countries, meaning that specific factors related to countries may influence the impact of digital technologies on economic growth. During the COVID-19 pandemic, digital technologies supported governments and healthcare systems in responding to the pandemic effectively (Budd et al. 2020) and helped firms to maintain their operations efficiently (Li et al. 2022). However, the impact of digital technologies in fostering economic growth under the severe impact of the pandemic and the role of digital technologies in mitigating the negative impact of the pandemic on economic growth have not been examined properly.

With regard to the positive impact of the digital economy on economic growth in general (Chakpitak et al. 2018; Zhang et al. 2021; Zhang et al. 2022), this study first hypothesizes that digitalization fostered the economic growth of countries worldwide during the period 2017–2021, the period pre and during the COVID-19 pandemic.

*H1. Digitalization fostered the economic growth of countries worldwide in the period 2017–2021.*

On the other hand, in light of the positive role of digital technologies in helping governments, healthcare systems, and businesses to respond to the pandemic (Budd et al. 2020; Heredia et al. 2022; Li et al. 2022), this study hypothesizes that the impact of digital technologies on economic growth was strengthened during the COVID-19 pandemic or in other words, digital technologies reduced the negative impact of the COVID-19 pandemic on economic growth.

*H2. Digital technologies reduced the negative impact of the COVID-19 pandemic on the economic growth of countries worldwide.*



### 3. METHODOLOGY

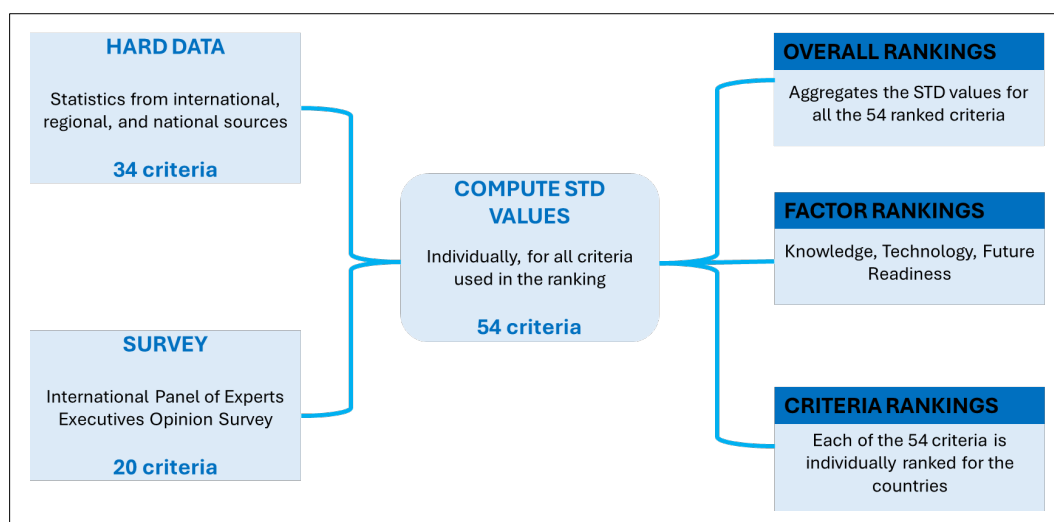
#### 3.1 Data

This study collected data on 63 countries whose digital competitiveness was assessed by the IMD from 2017 to 2021. Digital competitiveness measures the capacity and readiness of countries in adopting and exploring digital technologies as “a key driver for economic transformation in business, government and wider society” (IMD 2023). It is measured by both ranking and scores. The ranking demonstrates the position of a country in terms of digital competitiveness in comparison with others: A lower number means a higher ranking determined based on specific scores awarded for each country. Digital competitiveness scores, therefore, are original measures that can be used to determine digital competitiveness ranking.

To measure digital competitiveness, the IMD uses three main factors: knowledge (“Know-how necessary to discover, understand, and develop new technologies”), technology (“Overall context that enables the development of digital technologies”), and future readiness (“Level of country preparedness to exploit digital transformation”). For each main factor, there are three subfactors, making a total of nine subfactors (talent, training and education, and scientific concentration for knowledge; regulatory framework, capital, and technological framework for technology; adaptive attitudes, business agility, and IT integration for future readiness), which comprise 54 criteria. Notably, the number of criteria is not equal across subfactors (for instance, more criteria were used to evaluate education and training than those utilized to evaluate IT integration). However, disregarding the differences in the number of criteria, each subfactor has the same weight in the overall outcome computation. Criteria include hard data, which means data presenting digital competitiveness as it can be measured (e.g., internet bandwidth speed), and soft data, which means data presenting digital competitiveness as it can be perceived (e.g., company’s agility). The ratio of hard to soft data is 2 to 1 (hard data covers 34 criteria and soft data covers 20 criteria) (IMD 2023).

Figure 1 shows the computing process of digital competitiveness scores and ranking disclosed by the IMD (IMD 2023).

**Figure 1: The Computing Process of Digital Competitiveness Scores and Ranking by the IMD**



Among 63 countries ranked by the IMD, since each country is observed over 5 years and there are two countries that have insufficient macroeconomic data in the studied period, the total number of country-year observations is 302. For each country, data associated with economic growth and other controlled macroeconomic variables (inflation rates, exchange rates, gross savings, FDI, import/export, general government final expenditure) were collected from the World Bank database. Data associated with digital competitiveness ranking and digital competitiveness scores were gathered from the IMD website from 2017 to 2021.

### 3.2 Research Models and Variables

To examine whether a country's digital competitiveness influenced its economic growth in the years 2017–2021, which covered both the pre-COVID-19 pandemic period and during the pandemic, this study developed several research models. In these models, economic growth was measured by the real GDP ( $\text{Real\_GDP}_{i,t}$ ), which was calculated by dividing the nominal GDP by the GDP deflator. The use of the real GDP enabled the removal of inflation from economic growth, which might distort the outcomes of the analysis (Gordon 2014). Dependent variables are either digital competitiveness ranking or digital competitiveness scores taken from the IMD website from 2017 to 2021 (IMD 2023). These models control for several macroeconomic factors that may influence the real economic growth rates, such as inflation, unemployment, foreign exchange rates, gross saving, FDI, import to export, and general government financial expenditures as a percentage of GDP, similarly to the approach of Zhang et al. (2022) drawn from Habibi and Zabardast (2020) and Myovella, Karacuka, and Haucap (2019).

In the literature, the relationship between inflation and economic growth has not reached consensus since there is evidence of both negative and nonlinear relationships between them (Gillman, Harris, and Mátyás 2004; Eggoh and Khan 2014). Similarly, unemployment also has different effects on economic growth with the creation effects, the creative destruction effects, the pool of saving effects, and the coordination failure effects (Nagel 2015). Foreign exchange rates, by contrast, have relatively consistent effects on economic growth: The real appreciation in exchange rates reduces the real economic growth disregarding the use of external instruments that prevent the possible reverse causality from growth to the real exchange rate (Habib, Mileva, and Stracca 2017). The relationship between gross savings and economic growth has also been documented: Gross savings can increase economic growth since they increase the size of the capital stock regarding the Harrod-Domar growth model (Amin, Samia, and Khan 2024). Foreign direct investment (FDI) has been found as a source of economic growth in many countries since it produces externalities (technology transfer, capital provision, and spillovers), which can improve the productivity of a receiving country. However, other studies argue that FDI may undermine economic growth since this investment may consist of several distortions linked with preexisting price, trade, financial aspects, and others that will hurt resource allocation and slow down economic growth (Carkovic and Levine 2005). The ratio between import and export is a proxy of the degree of trade openness, which also has an impact on economic growth (Van den Berg and Lewer 2015). Finally, government spending is a source of economic growth since it boosts demand and consumptions, which, in return, enhances production and employment (Dudzevičiūtė, Šimelytė, and Liučvaitienė 2018). However, empirically, the nonlinear relationship between government spending and economic growth has also been documented (Christie 2014).

$$\begin{aligned} Real\_GDP_{i,t} = & \alpha_{i,t} + \beta_1*DCR_{i,t} + \beta_2*Inflation_{i,t} + \beta_3*Unemployment_{i,t} + \beta_4*EXR_{i,t} \\ & + \beta_5*GS_{i,t} + \beta_6*IMEXP_{i,t} + \beta_7*FDI_{i,t} + \beta_8*GOVS_{i,t} + \beta_9*COVID_{i,t} + \beta_{10}*Inflation^2_{i,t} + \\ & \beta_{11}*GOVS^2_{i,t} + \beta_{12}*GS^2_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (1)$$

In Model (1), digital competitiveness was measured by the digital competitiveness ranking ( $DCR_{i,t}$ ) taken from the IMD website. A country with higher rank was coded with a smaller number. This study controlled for several macroeconomic variables as mentioned: inflation rates measured in percentage ( $Inflation_{i,t}$ ), foreign exchange rates measured as a ratio of a currency to USD ( $EXR_{i,t}$ ), unemployment rates as percentages of GDP ( $Unemployment_{i,t}$ ), gross saving as a percentage of GDP ( $GS_{i,t}$ ), FDI as a percentage of GDP ( $FDI_{i,t}$ ), import to export ( $IMEXP_{i,t}$ ), and general government financial expenditure as a percentage of GDP ( $GOVS_{i,t}$ ). Data used to measure such control variables were taken from the World Bank database.

$$\begin{aligned} Real\_GDP_{i,t} = & \alpha_{i,t} + \beta_1*DCS_{i,t} + \beta_2*Inflation_{i,t} + \beta_3*Unemployment_{i,t} + \beta_4*EXR_{i,t} + \\ & \beta_5*GS_{i,t} + \beta_6*IMEXP_{i,t} + \beta_7*FDI_{i,t} + \beta_8*GOVS_{i,t} + \beta_9*Covid_{i,t} + \beta_{10}*Inflation^2_{i,t} + \\ & \beta_{11}*GOVS^2_{i,t} + \beta_{12}*GS^2_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (2)$$

In Model (2), digital competitiveness was measured by digital competitiveness scores taken from the IMD website. The remaining variables were unchanged from Model (1).

Additionally, in both Models (1) and (2), the squared values of inflation, government spending, and gross saving were added to capture the nonlinear effects of these variables on economic growth since nonlinear patterns had been revealed in the data preparation stage and the literature has also documented the nonlinear effects of these factors on economic growth (Eggoh and Khan 2014; Carkovic and Levine 2005; Christie 2014).

On the other hand, to examine whether the impact of the digital competitiveness of a country on its real GDP growth rates differs between pre and during the COVID-19 pandemic, the interactive variables between the COVID-19 pandemic and digital competitiveness measures were created and added in Models (3) and (4).

$$\begin{aligned} Real\_GDP_{i,t} = & \alpha_{i,t} + \beta_1*DCR_{i,t} + \beta_2*Inflation_{i,t} + \beta_3*Unemployment_{i,t} + \beta_4*EXR_{i,t} + \\ & \beta_5*GS_{i,t} + \beta_6*IMEXP_{i,t} + \beta_7*FDI_{i,t} + \beta_8*GOVS_{i,t} + \beta_9*Covid_{i,t} + \beta_{10}*Inflation^2_{i,t} + \\ & \beta_{11}*GOVS^2_{i,t} + \beta_{12}*GS^2_{i,t} + \beta_{12}*DCR_{i,t}*Covid_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (3)$$

In Model (3), the interactive term between the digital competitiveness ranking and the COVID-19 pandemic was added to figure out whether the digital competitiveness ranking had different effects on the real economic growth before and during the pandemic. If the coefficient of this interactive variable is significant, the impact of digital competitiveness on the real economic growth during the pandemic will be differed from that in the pre-pandemic period or otherwise, there is no difference in the impact of digital competitiveness on the real economic growth between and during the pandemic. Other variables remained as in Model (1).

$$\begin{aligned} Real\_GDP_{i,t} = & \alpha_{i,t} + \beta_1*DCS_{i,t} + \beta_2*Inflation_{i,t} + \beta_3*Unemployment_{i,t} + \beta_4*EXR_{i,t} + \\ & \beta_5*GS_{i,t} + \beta_6*IMEXP_{i,t} + \beta_7*FDI_{i,t} + \beta_8*GOVS_{i,t} + \beta_9*Covid_{i,t} + \beta_{10}*Inflation^2_{i,t} + \\ & \beta_{11}*GOVS^2_{i,t} + \beta_{12}*GS^2_{i,t} + \beta_{12}*DCS_{i,t}*Covid_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (4)$$

Similarly, in Model (4), the interactive term between digital competitiveness scores and the COVID-19 pandemic was added to clarify whether the impact of this factor on economic growth varied between pre and during the pandemic. Other variables remained as in Model (2).

### 3.3 Data Analysis Methods

Since panel data were involved, this study first conducted the fixed-effect (FE) and random-effect (RE) models (Seber and Lee 2012). While fixed effects control time-invariant factors since it is assumed that such factors may have a correlation with outcome or predictor variables, random effects allow the use of time-invariant factors because no correlation between such factors and outcome and/or predictor variables is assumed (McManus 2015). Then, Hausman tests were carried out to determine which models were more suitable between FE and RE (Freund, Wilson, and Sa 2006). Subsequently, this study implemented cross-sectional dependence tests to figure out whether cross-sectional dependence issues existed. Because of the existence of these issues, GLS with cross-sectional weights were estimated (Draper and Smith 2014). Finally, to address endogeneity issues regarding panel data (Hayashi 2011), this study estimated GMM models, using several instrument variables such as the first lag value of the real GDP, the nominal economic growth, and digital competitiveness measures and all exogenous variables.

## 4. EMPIRICAL RESULTS

### 4.1 Descriptive Statistics

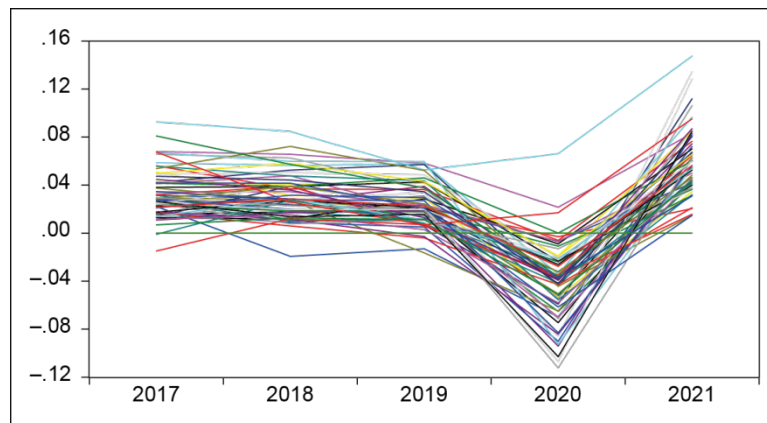
Table 1 presents key statistics of all variables. The real GDP growth rate has a mean value of 0.02 or 2% with a standard deviation of 0.04 (4%), implying a relatively high level of deviation of this variable's data from their mean value among countries across studied years.

Figure 2 presents the real GDP growth rates of 63 countries in the period 2017–2021. Overall, the real GDP growth rates dropped to rock bottom in 2020 and increased again in 2021. This means that the COVID-19 pandemic created a critical shock for the economic growth of studied countries.

For digitalization scores, the mean value of this variable is 71.79 points with a standard deviation of 15.84 points, meaning a low level of diffusion of this variable from its average score. There are 63 countries involved in the study, so digital ranking is ranged from 1 to 63 with the smallest value measuring the highest ranking.

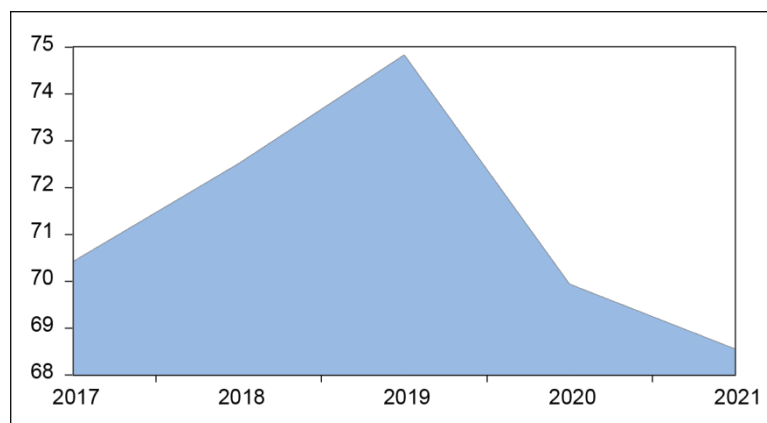
Figure 3 shows that the mean digital competitiveness score of the studied countries peaked in 2019 with nearly 75 points and then plunged from 2020 to less than 69 points.

**Figure 2: The Real GDP Growth Rates (2017–2021)**



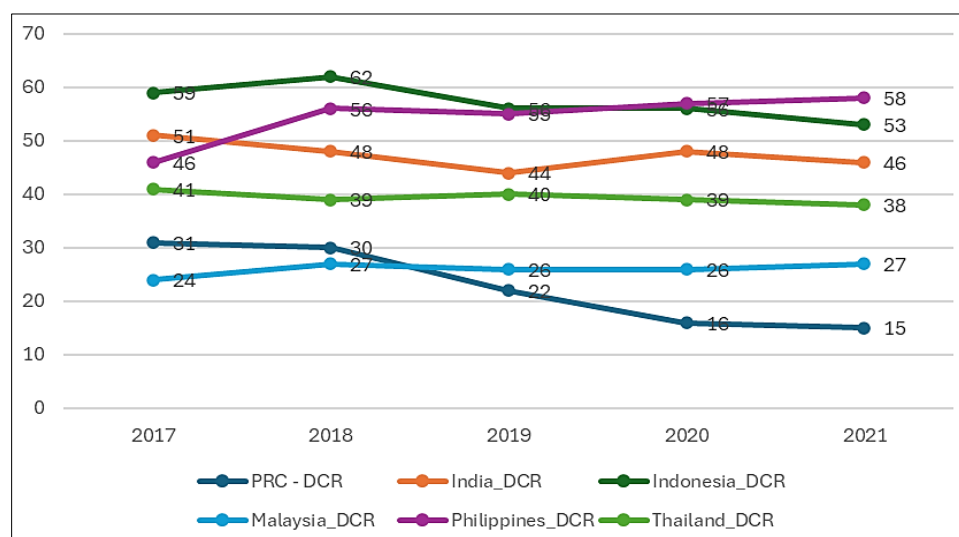
Source: Analyzed by the authors.

**Figure 3: Mean of Digital Competitiveness Scores (2017–2021)**



Source: Analyzed by the authors.

**Figure 4: Digital Competitiveness Ranking of Emerging Asia Countries (2017–2021)**



Source: Analyzed by the authors.

At the regional level, in light of the increasing political and economic role of Emerging Asia countries, which comprise the PRC, India, Indonesia, Malaysia, the Philippines, Thailand, and Viet Nam (IMF 2023), this study looked at how these countries performed in terms of digital competitiveness in recent years (2017–2021). The digital competitiveness ranking of Emerging Asia countries was low in general and did not significantly improve over the years, except for the PRC, which enhanced its digital competitiveness scores over the years and its ranking reached 15th out of 63 countries in 2021. Among Emerging Asia countries, Malaysia and the Philippines reduced their digital competitiveness ranking over the years and underperformed other countries they had already outperformed in 2017 (Figure 4).

In terms of control variables, the mean value of the inflation rate is 0.03 with a standard deviation of 0.06, so inflation rates were relatively dispersed around their mean value, which is approximately 3%. For unemployment rates, the mean value of this variable is 0.07 with a moderate standard deviation (0.04). Thus, in the studied period, the average unemployment rate was approximately 7% with data concentrated within the range of 3% to 11%. The average exchange rate is 385.98 with a relatively high standard deviation (1,872.86), suggesting a high level of dispersion of exchange rates from their average value. The mean value of gross savings is 0.25, meaning that gross savings accounted for approximately 25% of total GDP in the studied period. With the small standard deviation (0.08), the data of gross savings were relatively concentrated around their average value. The ratio of import to export has a mean value of 0.97, implying that import accounted for approximately 97% of export in the studied period. The standard deviation of this variable is 0.15, indicating that most countries had an import to export ratio concentrated within the range of 0.82 to 1.12. The mean value of FDI is 0.04, so FDI accounted for approximately 4% of GDP of the studied countries in the period 2017–2021. However, this variable has a very high standard deviation (0.24), implying a high level of dispersion of FDI data from their mean value or a high level of differences in FDI among countries across the studied years. The mean value of government's general final consumption is 0.18, suggesting that this spending accounted for approximately 18% of GDP of the studied countries. This variable has a relatively small standard deviation (0.04), so the differences in general government final consumption among countries were not high. As regards the distribution patterns, all of the variables have data abnormally distributed because of the significance of the Jarque-Bera statistics.

## 4.2 Correlation Analysis

Table 2 presents the correlations between variables. The real GDP growth rates have positive correlations with digital competitiveness ranking, inflation rates, exchange rates, gross savings, import to export, and FDI whereas they have negative correlations with digital competitiveness scores, unemployment rates, government spending, and COVID-19. The remaining variables have either moderate or low correlations with each other. Therefore, the possibility of multicollinearity in regressions with such variables involved is relatively low.

Table 1: Descriptive Analysis

|              | Real GDP | DCR   | DCS    | Inflation | Unemployment | Exchange Rates | Gross Savings/<br>GDP | Import/<br>Export | FDI       | GOVS  |
|--------------|----------|-------|--------|-----------|--------------|----------------|-----------------------|-------------------|-----------|-------|
| Mean         | 0.02     | 31.76 | 71.79  | 0.03      | 0.07         | 385.98         | 0.25                  | 0.97              | 0.04      | 0.18  |
| Median       | 0.03     | 32.00 | 71.55  | 0.02      | 0.05         | 3.64           | 0.24                  | 0.96              | 0.02      | 0.19  |
| Maximum      | 0.15     | 62.00 | 100.00 | 0.54      | 0.29         | 14,582.20      | 0.51                  | 1.60              | 2.34      | 0.28  |
| Minimum      | -0.11    | 1.00  | 40.69  | -0.03     | 0.00         | 0.71           | 0.07                  | 0.58              | -1.17     | 0.08  |
| Std. Dev.    | 0.04     | 17.87 | 15.84  | 0.06      | 0.04         | 1,872.86       | 0.08                  | 0.15              | 0.24      | 0.04  |
| Skewness     | -0.65    | -0.02 | 0.02   | 6.03      | 2.14         | 6.69           | 0.75                  | 1.08              | 4.10      | -0.16 |
| Kurtosis     | 4.04     | 1.83  | 1.84   | 45.92     | 9.14         | 48.75          | 3.89                  | 5.71              | 51.83     | 2.36  |
| Jarque-Bera  | 35.02    | 17.31 | 16.92  | 25,007.93 | 706.24       | 28,581.73      | 38.67                 | 151.06            | 30,846.84 | 6.32  |
| Probability  | 0.00     | 0.00  | 0.00   | 0.00      | 0.00         | 0.00           | 0.00                  | 0.00              | 0.00      | 0.04  |
| Observations | 302      | 302   | 302    | 302       | 302          | 302            | 302                   | 302               | 302       | 302   |

Source: Analyzed by the authors.

Table 2: Correlation Analysis

|                | Real GDP | DSR   | DCS   | Inflation | Unemployment | Exchange Rates | GS    | IMEXP | FDI   | GOVS | COVID |
|----------------|----------|-------|-------|-----------|--------------|----------------|-------|-------|-------|------|-------|
| Real GDP       | 1.00     |       |       |           |              |                |       |       |       |      |       |
| DCR            | 0.02     | 1.00  |       |           |              |                |       |       |       |      |       |
| DCS            | -0.02    | -0.98 | 1.00  |           |              |                |       |       |       |      |       |
| Inflation      | 0.05     | 0.35  | -0.34 | 1.00      |              |                |       |       |       |      |       |
| Unemployment   | -0.08    | 0.36  | -0.36 | 0.18      | 1.00         |                |       |       |       |      |       |
| Exchange Rates | 0.04     | 0.26  | -0.25 | 0.00      | -0.05        | 1.00           |       |       |       |      |       |
| GS             | 0.12     | -0.44 | 0.43  | -0.23     | -0.53        | 0.05           | 1.00  |       |       |      |       |
| IMEXP          | 0.01     | 0.32  | -0.31 | 0.06      | 0.28         | 0.08           | -0.49 | 1.00  |       |      |       |
| FDI            | 0.06     | 0.02  | 0.00  | -0.01     | -0.01        | 0.00           | 0.01  | 0.00  | 1.00  |      |       |
| GOVS           | -0.20    | -0.25 | 0.23  | -0.14     | 0.13         | -0.30          | -0.16 | -0.05 | -0.10 | 1.00 |       |
| COVID          | -0.24    | 0.00  | -0.10 | 0.02      | 0.05         | 0.01           | -0.02 | -0.03 | -0.04 | 0.17 | 1.00  |

Source: Analyzed by the authors.



### 4.3 Regression Analysis

Table 3 reports the outcomes of different regressions of the real GDP growth rates against the digital competitiveness ranking and other control variables. Since the cross-sectional dependence existed, the GLS method (McManus 2015) with cross-sectional weights was used to test the impact of the digital competitiveness ranking on the real GDP growth rates after controlling for several macroeconomic variables. Furthermore, the GMM method was also applied to address endogeneity issues (Freund, Wilson, and Sa 2006), using different instrument variables as mentioned in Section 3.3. In both GLS and GMM models, coefficients of the digital competitiveness ranking are significantly negative, meaning that a higher digital competitiveness ranking, which is presented by a smaller number, resulted in higher real GDP growth rates: If a digital competitiveness ranking increased by a level, the real GDP growth rate would increase by 0.02%–0.04%, assuming that other factors held constant.

**Table 3: Regression Analysis: The Real GDP Growth Rates and Digital Competitiveness Ranking**

|                                 | Fixed Effects          | Random Effects         | GLS                    | GMM                    | GMM –<br>Interactive<br>Variable<br>Included |
|---------------------------------|------------------------|------------------------|------------------------|------------------------|--|
| Constant                        | 0.1117<br>(0.129)      | –0.0567<br>(0.0476)    | –0.0786*<br>(0.0396)   | –0.0925*<br>(0.0474)   | 0.0443<br>(0.0847)                           |
| Digital competitiveness ranking | 0.0002<br>(0.0008)     | –0.0002<br>(0.0002)    | –0.0002**<br>(0.0001)  | –0.0004**<br>(0.0001)  | –0.0037**<br>(0.0013)                        |
| Inflation                       | 1.4152***<br>(0.1944)  | 0.5431***<br>(0.1046)  | 0.7485***<br>(0.0971)  | 0.9579***<br>(0.1027)  | 0.6937***<br>(0.1973)                        |
| Unemployment                    | –0.4456*<br>(0.2317)   | –0.0083<br>(0.0594)    | –0.0232<br>(0.0491)    | –0.0178<br>(0.0573)    | 0.0520<br>(0.1351)                           |
| Exchange rate                   | 0.0000<br>(0.000)      | 0.0000<br>(0.000)      | 0.0000<br>(0.000)      | 0.0000<br>(0.000)      | 0.0000<br>(0.000)                            |
| Gross savings                   | 0.5515<br>(0.3818)     | 0.2722**<br>(0.1347)   | 0.3187**<br>(0.1157)   | 0.3182**<br>(0.1189)   | 0.2328<br>(0.2492)                           |
| Import/export                   | 0.1093**<br>(0.0436)   | 0.0043<br>(0.0161)     | 0.0038<br>(0.0106)     | 0.0016<br>(0.0132)     | 0.0490<br>(0.0368)                           |
| FDI                             | 0.0004<br>(0.0087)     | 0.0061<br>(0.0082)     | 0.0087<br>(0.0082)     | 0.0071<br>(0.009)      | 0.0143<br>(0.0175)                           |
| Government spending             | –1.4721<br>(0.9539)    | 0.4677<br>(0.3866)     | 0.5862*<br>(0.3088)    | 0.7429**<br>(0.3641)   | –0.0020<br>(0.7049)                          |
| COVID-19                        | 0.0097<br>(0.0064)     | –0.0175***<br>(0.0041) | –0.0156***<br>(0.0027) | –0.0151***<br>(0.0028) | –0.2416***<br>(0.0826)                       |
| Inflation^2                     | –1.7080***<br>(0.3416) | –1.1458***<br>(0.2295) | –1.6129***<br>(0.2796) | –1.9754***<br>(0.3028) | –1.5040***<br>(0.4967)                       |
| Government spending^2           | –1.1346<br>(2.3882)    | –1.6102<br>(1.0690)    | –1.8651**<br>(0.8320)  | –2.2981**<br>(0.9764)  | –0.2854<br>(1.9439)                          |
| Gross savings^2                 | –0.6894<br>(0.6749)    | –0.3403<br>(0.2187)    | –0.4321**<br>(0.1822)  | –0.4105**<br>(0.1756)  | –0.1960<br>(0.3497)                          |
| Digital ranking*Covid-19        |                        |                        |                        |                        | 0.0072**<br>(0.0027)                         |
| R-squared                       | 0.51                   | 0.17                   | 0.30                   | 0.35                   | 0.37   |
| No. Obs.                        | 302                    | 302                    | 302                    | 302                    | 302  |

\*\*\*, \*\*, \* 0.01, 0.05, and 0.1 significance level. Standard errors are in parentheses.

Source: Analyzed by the authors.

On the other hand, the real GDP growth rates were negatively affected by the COVID-19 pandemic: When other macroeconomic factors and the digital competitiveness ranking were controlled, the COVID-19 pandemic reduced the real GDP by 1.5%. The real GDP growth rates were also nonlinearly affected by inflation rates, gross savings, and general government final spending. The real economic growth rates increased along with the increase of inflation, gross savings, and government spending and then declined after the peak positive impact had been achieved. In other words, the inverted U-shaped relationships between three macroeconomic factors – inflation, gross savings, and government final spending – and the real economic growth were documented.

Furthermore, when the interactive variable between the digital competitiveness ranking and the COVID-19 pandemic was added in the GMM model, this variable had a significantly positive coefficient. Because this is an interactive variable, it means that the positive impact of the digital competitiveness ranking on economic growth was strengthened in the COVID-19 pandemic. In other words, a higher digital competitiveness ranking could enable countries to mitigate the negative impact of the COVID-19 pandemic on their real GDP growth rates.

**Table 4: Regression Analysis: The Real GDP Growth Rates and Digital Competitiveness Scores**

|                                | Fixed Effects          | Random Effects         | GLS                    | GMM                    | GMM – Interactive Variable Included |
|--------------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------------------|
| Constant                       | 0.2184<br>(0.1379)     | –0.0620<br>(0.0509)    | –0.0999**<br>(0.0407)  | –0.1075**<br>(0.0477)  | –0.3678***<br>(0.1405)              |
| Digital competitiveness scores | –0.0014*<br>(0.0007)   | 0.0001<br>(0.0002)     | 0.0002<br>(0.0001)     | 0.0002<br>(0.0002)     | 0.0040**<br>(0.0014)                |
| Inflation                      | 1.3490***<br>(0.1959)  | 0.5261***<br>(0.1050)  | 0.7414***<br>(0.0984)  | 0.8541***<br>(0.1119)  | 0.4696**<br>(0.2311)                |
| Unemployment                   | –0.5193**<br>(0.2330)  | –0.0141<br>(0.0594)    | –0.0302<br>(0.0490)    | –0.0430<br>(0.0562)    | 0.0548<br>(0.1470)                  |
| Exchange rate                  | 0.0000<br>(0.000)      | 0.0000<br>(0.000)      | 0.0000<br>(0.000)      | 0.0000<br>(0.000)      | 0.0000<br>(0.000)                   |
| Gross savings                  | 0.4917<br>(0.3776)     | 0.2872**<br>(0.1342)   | 0.3264**<br>(0.1152)   | 0.3484**<br>(0.1233)   | 0.3854<br>(0.2870)                  |
| Import/export                  | 0.1123**<br>(0.0433)   | 0.0035<br>(0.0161)     | 0.0036<br>(0.0104)     | 0.0000<br>(0.0132)     | 0.0675*<br>(0.0401)                 |
| FDI                            | 0.0003<br>(0.0085)     | 0.0060<br>(0.0082)     | 0.0086<br>(0.0082)     | 0.0066<br>(0.0092)     | 0.0157<br>(0.0189)                  |
| Government spending            | –1.3463<br>(0.9484)    | 0.4063<br>(0.3856)     | 0.5671*<br>(0.3080)    | 0.6398*<br>(0.3652)    | –0.5280<br>(0.7651)                 |
| Covid-19                       | 0.0049<br>(0.0068)     | –0.0175***<br>(0.0041) | –0.0151***<br>(0.0027) | –0.0151***<br>(0.0032) | 0.6670**<br>(0.2284)                |
| Inflation^2                    | –1.5968***<br>(0.3436) | –1.1189***<br>(0.2303) | –1.6038***<br>(0.2808) | –1.7872***<br>(0.3082) | –1.1194**<br>(0.5380)               |
| Government spending^2          | –1.465<br>(2.3728)     | –1.4174<br>(1.0656)    | –1.7965**<br>(0.8298)  | –1.9805**<br>(0.9774)  | 1.2801<br>(2.1322)                  |
| Gross savings^2                | –0.5893<br>(0.6691)    | –0.3549<br>(0.2181)    | –0.4439**<br>(0.1822)  | –0.4613**<br>(0.1897)  | –0.3489<br>(0.4125)                 |
| Digital score*Covid-19         |                        |                        |                        |                        | –0.0095**<br>(0.0032)               |
| R-squared                      | 0.51                   | 0.16                   | 0.30                   | 0.31                   | 0.33                                |
| No. Obs.                       | 302                    | 302                    | 302                    | 302                    | 302                                 |

\*\*\*, \*\*, \* 0.01, 0.05, and 0.1 significance level. Standard errors are in parentheses.

Source: Analyzed by the authors.

Table 4 reports the outcomes of different regressions of the real GDP growth rates against digital competitiveness scores and other control variables.

Because of the existence of cross-sectional dependence, GLS with cross-sectional weights were estimated (Draper and Smith 2014). Furthermore, the GMM was also adopted to address endogeneity issues (Freund, Wilson, and Sa 2006). In both GLS and GMM models, coefficients of digital scores are statistically insignificant. Therefore, digital competitiveness scores did not significantly influence the real GDP growth rates of the studied countries in the period 2017–2021.

On the other hand, the real GDP growth rates were also negatively affected by the COVID-19 pandemic while they were nonlinearly influenced by inflation rates, gross savings, and general government final spending when digital competitiveness scores were controlled. This means the inverted U-shaped relationships were illustrated.

In the GMM model with the involvement of the interactive variable between digital competitiveness scores and the COVID-19 pandemic, the coefficient of this interactive variable is significantly negative. This means that the relationship between digital competitiveness scores and economic growth was strengthened during the COVID-19 pandemic, or in the other words, countries with higher digital competitiveness scores could obtain higher real GDP growth rates when the pandemic occurred. In other words, digital competitiveness scores enabled countries to mitigate the negative impact of the COVID-19 pandemic on their real economic growth.

#### 4.4 Discussions

This study has revealed that in the period 2017–2021, a higher digital competitiveness ranking increased the real GDP growth rates of the studied countries after controlling for several macroeconomic factors. This finding, therefore, supported the first hypothesis and aligned with the existing literature on the positive impact of the digital economy on economic growth (Chakpitak et al. 2018; Zhang et al. 2021; Zhang et al. 2022). However, higher digital competitiveness scores did not significantly increase the real GDP growth rates of these countries, although their coefficient was positive. The difference in the impact of the digital competitiveness ranking and the digital competitiveness scores on the real GDP growth rates could be explained by the fact that the gap between ranking levels was not consistent with that between digital scores. For example, the digital competitiveness ranking of the US was one and that of Singapore was two in 2021 (the gap is one). However, the digital competitiveness score of the US was 100 whereas that of Singapore was just 96.576 in the same year (the gap is nearly 4). The digital competitiveness ranking of Canada is 13 and that of the UK is 14, but the digital competitiveness score of Canada is 87.310 while that of the UK is 85.827 (the gap is 1.48). Therefore, while a one point change in the ranking could significantly influence economic growth, a one point difference in the digital competitiveness score could not significantly influence the real GDP growth rates. This finding can also suggest an interesting implication: A country cannot obtain the benefits of digitalization as quickly as when their digital competitiveness scores increase modestly (i.e., a one point increase). Instead, the benefits of digitalization can be only grabbed when the increase in the digital competitiveness scores enables a country to change their digital competitiveness ranking. This finding is one of the critical contributions of this study to the extant literature.

Moreover, this study also made several interesting discoveries: Disregarding measures of digital competitiveness, a higher level of the digital competitiveness ranking, and higher digital competitiveness scores reduced the negative impact of the COVID-19 pandemic on the real GDP growth rates, meaning that digitalization could help

countries to mitigate shocks, including this unprecedented health crisis. This is another critical finding of this study, and it confirmed the positive role of digital technologies in supporting governments and healthcare systems in responding to the pandemic (Budd et al. 2020). Consequently, governments could remove strict measures and renormalize their economies sooner. Furthermore, this finding also supported the prevailing literature on the positive impacts of digital technologies on firm performance (Heredia et al. 2022; Li et al. 2022), which are important in contributing to the overall economic growth.

On the other hand, this study revealed that the real economic growth was nonlinearly affected by inflation, gross savings, and government spending. This finding confirmed the extant literature on the nonlinear relationship between inflation and growth (Crespo, Cuaresma, and Silgoner 2014; Seleteng, Bittencourt, and Van Eyden 2013). Inflation can be beneficial for an economy since it prevents the paradox of thrift and promotes production when such an economy is running under its capacity (Fornaro and Romei 2019). However, high inflation rates are harmful to economic growth since they reduce the purchasing power of consumers, increase layoffs and interest rates, and hinder investment (Eggoh and Khan 2014). Additionally, this study's findings on the inverted U-shaped relationships between either gross savings or government spending and economic growth contributed to the debate on the role of these macroeconomic variables in fostering economic growth from the perspective of Keynesian economic theory (Hsieh and Lai 1994; Bayar 2014; Dudzevičiūtė, Šimelytė, and Liučvaitienė 2018).

In regard to the digital competitiveness ranking of Emerging Asia countries, which are increasing their political and economic roles in the world (IMF 2023), this study found a low level of digitalization and the existence of digital inequality among these countries. Thus, this finding supported the findings of Maji and Laha (2020) on digital inequality in the Asian context and the findings of Kim, Abe, and Valente (2019) on the low level of digitalization measured by the Information and Communication Technologies (ICT) Development Index in Asian countries in general and in Emerging Asia countries in particular. The low level of digital competitiveness ranking might prevent Emerging Asia countries from reaching their highest potential in terms of economic growth (Chakpitak et al. 2018; Kim, Abe, and Valente 2019), assuming other macroeconomic factors remain unchanged.

From findings derived from the data analysis, this study has several important contributions to make to the literature. First, it is the first research study to examine the impact of digitalization on economic growth at the country level before and during the COVID-19 pandemic to clarify whether digitalization is a “powerful” key for countries to mitigate the negative impact of the COVID-19 pandemic. Based on its finding, this study suggests that although digitalization had some positive effects on economic growth, those effects were not strong after controlling for several macroeconomic factors. The mitigating role of digital competitiveness ranking and scores during the COVID-19 pandemic was significant but also modest. Therefore, although countries need to invest in digitalization to support economic growth, they cannot quickly grab the benefits of digitalization until the increase in digitalization reaches a certain level that enables a country to change its digitalization ranking. Furthermore, countries cannot rely solely on digitalization as a sole source of growth. Instead, they need to have a holistic approach to achieve higher economic growth levels. Second, this study confirms the significant roles of other macroeconomic factors in fostering economic growth as well as the nonlinear effects of inflation, government spending, and gross savings after controlling for digitalization as well as the impact of the COVID-19 pandemic. Hence, it can provide helpful implications for policymakers in developing

and applying macroeconomic policies in order to achieve higher economic growth in both normal and crisis periods.

## 5. POLICY RECOMMENDATIONS AND CONCLUSIONS

Since this study has figured out that a higher digital competitiveness ranking increased the real GDP growth rates and a higher digital competitiveness ranking and higher digital competitiveness scores reduced the negative impact of the COVID-19 pandemic on the real GDP growth rates, it suggests several helpful implications for policymakers.

First, policymakers should develop a comprehensive set of new policies and programs that foster the digital transformation of the entire economy to improve their countries' digital competitiveness, and thus to transform their economies towards digital economies. Such initiatives can be classified into different groups: training and education, human resource management, technology development, technology financing, and readiness for the future transformation (IMD 2023). In terms of training and education and human resource management, initiatives should not only focus on technical training but also aim to develop talents, equip civilians with the digital mindset and skills that will enable them to function well in the digital economy, and foster scientific research and application towards the digital economy. For technology development and financing, the development of a regulatory framework associated with a digital economy, including both domestic and international collaborations on digitalization, and the development of financial products that provide capital for a digital economy are needed. Furthermore, governments should foster the adaptive attitudes of different stakeholders of the society and encourage business agility by offering them incentives, subsidies, and support for their business transformation (i.e., tax credits and/or other types of subsidies for enterprises that transform their businesses digitally). Governments may also spend on digital transformation in the public sector and invest in digital infrastructure and its key enablers. The integration of digitalization should also be boosted (Tapscott and McQueen 1996). As a result, the digital competitiveness can improve the real GDP growth rates as well as enabling countries to overcome economic and/or other shocks like the COVID-19 pandemic. The investment in digitalization cannot provide a very quick return since the increase in digital competitiveness scores cannot lead to the increase of real economic growth until such an increase leads to the increase in digital competitiveness ranking as found in this study. Therefore, policymakers need to be well aware of the long-term role of digitalization investment.

Second, the digital competitiveness ranking of Asian emerging countries (Emerging Asia), including the PRC, India, Indonesia, Malaysia, the Philippines, Thailand, and Viet Nam, is still low and presents a high level of digital inequality among countries. Among these, the digital competitiveness ranking of the PRC is highest (ranked 15th in 2021) and improved over the years while the digital competitiveness ranking of others ranges from 27th to 58th out of 63, and some countries also reduced their ranking over years (i.e., Malaysia and the Philippines). Viet Nam was not in the list of countries that were ranked in terms of digital competitiveness. Therefore, it is essential for Asian emerging countries to boost their digitalization through both self-policies and their own efforts as well as regional collaborations and technology exchange. As a result, they can grab the benefits of digital competitiveness through both self-policies and regional collaborations among countries. Such regional collaborations are also important to minimize the regional digital inequality (Kim, Abe, and Valente 2019; Maji and Laha 2020).

Third, although digital competitiveness improved the real GDP growth rates, the impact was still modest. Instead, the real GDP growth rates were nonlinearly affected by other macroeconomic variables. Therefore, to foster real economic growth, policymakers should not solely rely on digitalization. Instead, they should have a holistic approach to economic growth. For instance, they should determine the optimal inflation level to ensure that the economy is running at the optimal capacity since the real GDP growth rates were found to increase along with the increase in inflation until this increase peaked and then declined. Similarly, they should also determine the optimal level of general government final expenditure and gross savings. The increase in gross savings means a higher level of residual incomes that can be used for investment. The increase in investment will boost economic growth. However, such hot economic growth may increase inflation rates, which, in return, reduces economic growth (Eggoh and Khan 2014). The increase in government spending can raise the real GDP growth rates through the multiplier effects referred to the Keynesian economic theory: More government spending means higher demands for buying goods and services, as well as more money in the pockets of workers and suppliers, who then spend their money on goods and services (Coddington 2013). However, too big an increase in government spending may distort interest rates, prop up noncompetitive businesses, and lead to higher taxes, which, in return, decreases the real GDP growth rates (d'Agostino, Dunne, and Pieroni 2016). In other words, to boost economic growth, a comprehensive approach with a combination of different policies is crucial, although digitalization can help countries to obtain a higher level of economic growth and to overcome the negative impacts of shocks.

In summary, this study has achieved its research aims and objectives as it has figured out the positive impact of digital competitiveness ranking on the real economic growth in the period 2017–2021 and the role of digital competitiveness ranking and digital competitiveness scores in reducing the negative impact of the COVID-19 pandemic on the real GDP growth rates. These findings thus aligned with the extant literature on the positive impact of digitalization on economic growth (Chakpitak et al. 2018; Zhang et al. 2021; Zhang et al. 2022). Notably, our research findings went beyond the existing literature as they suggested that the increase of digitalization must reach a certain level, such as a change in digital competitiveness ranking instead of a marginal change in digital competitiveness scores, to have a positive impact on real economic growth. Moreover, in the COVID-19 pandemic, the positive role of digitalization in minimizing the negative impact of the pandemic on economic growth found in this study also confirmed the importance of digitalization in supporting governments in dealing with the pandemic (Budd et al. 2020) and in assisting firms to maintain their operations efficiently (Heredia et al. 2022; Li et al. 2022). Furthermore, this study also suggests several helpful implications for policymakers regarding the development of a digital economy, the regional collaborations on digitalization, and the adoption of a holistic approach to economic growth, considering the nonlinear effects of inflation, gross savings, and government spending. However, this study still has some limitations. It involves 63 countries ranked by the IMD, meaning that there are several other countries that have not been ranked in terms of digital competitiveness. Therefore, future studies may consider using other newly developed measures of digitalization as an explanatory variable of economic growth. Furthermore, the impact of digitalization on corporate financial performance during the COVID-19 pandemic should also be investigated to elaborate this topic at the corporate level.

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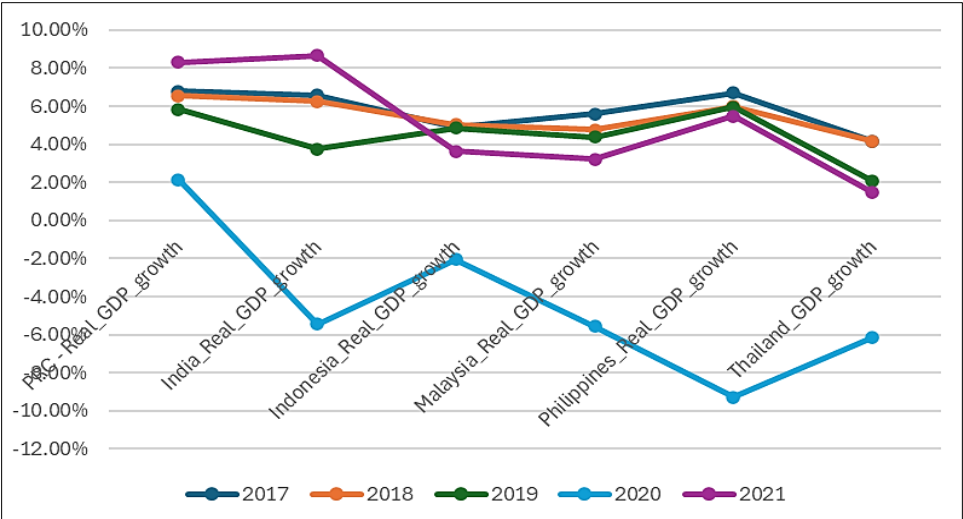
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APPENDIX 1: THE REAL ECONOMIC GROWTH RATES OF EMERGING ASIA COUNTRIES



**APPENDIX 2: DRC AND REAL ECONOMIC GROWTH  
OF EMERGING ASIA COUNTRIES (2017–2021)**

