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THE IMPACT OF DIGITAL TRANSFORMATION ON ECONOMIC GROWTH: GLOBAL EVIDENCE

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ABSTRACT

Digital transformation-driven economic growth is a key socio-economic development objective for many countries. This study explores the impact of digital transformation on economic growth across 77 countries, categorized into three income groups: high-income, upper-middle-income, and lower-middle-income countries, over the period from 2005 to 2022. The research employs an econometric approach based on the Cobb-Douglas production function to quantify the effects on economic growth, while the Generalized Method of Moments (GMM) estimation is utilized to address endogeneity concerns. The findings reveal that digital transformation plays a significant role in fostering economic growth. Countries that actively advance digital transformation initiatives tend to experience accelerated economic expansion. Additionally, fundamental economic drivers such as investment capital and labor also exert a positive influence on growth. The study further provides valuable policy insights to assist governments in formulating strategies to enhance economic development in an era of rapid global digitalization.

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1. Introduction

Economic growth is a fundamental component of the core economic and social development objectives of nations. Analyzing economic growth and its influencing factors is crucial in both developed and developing economies (Bukht & Heeks, 2017). Numerous studies have sought to maximize welfare, enhance competitiveness, and stimulate economic growth (Lopes et al., 2021). Consequently, it is undeniable that economic growth has a significant impact on a nation's development and prosperity. Particularly in the era of technological advancement and digital transformation, this topic has garnered increasing attention from individuals and governments worldwide (Li et al., 2020). According to Lloyd (2020), the significance of digital transformation has become more apparent during the global economic shutdown caused by the COVID-19 pandemic. Amid this crisis, the need to restructure business models through digital economic transactions has become imperative for most countries (Soto-Acosta, 2020). Simultaneously, governments have implemented social distancing measures to curb the spread of the virus, accelerating the adoption of digital technologies for virtual learning and remote work (Chandra et al., 2022). Empirical evidence suggests that to adapt to global disruptions, nations must transition from a traditional economy to a digital economy to achieve and sustain economic development (Vaslavski & Vaslavskaya, 2019). Similarly, digitalization represents a fundamental shift in mindset, enterprise systems, and essential tools required to reorganize a segment of the economy or an entire nation. Digital transformation involves leveraging digital infrastructure to transform the technological landscape of society. Research indicates that investments in infrastructure, such as communication networks, yield positive outcomes for economic growth (Khaliq & Noy, 2007). Digitalization enhances labor productivity and production processes, reduces costs, increases profitability, attracts investment capital, and fosters economic expansion.

The Industry 4.0 revolution uses technology to develop industry and production processes, which is linked to the accelerated development of digital technology and the gradual decline in the growth potential and efficiency of traditional industrial, economic, and social systems (Thoben et al., 2017; Litvinenko, 2020). Previous studies have predominantly focused on individual countries or economic regions, with limited research conducted at a global scale to examine the impact of digital transformation on economic growth. However, the extent to which digital transformation impacts economic growth across nations with varying levels of development remains unclear.

Our study, "The Impact of Digital Transformation on Growth: Global Evidence," makes a significant contribution to the existing literature by providing a comprehensive empirical assessment of the relationship between digital transformation and economic growth at the global level. Unlike previous studies that relied on limited samples, our research adopts a broader global perspective and further disaggregates the analysis by grouping countries with similar income levels. In doing so, the study not only addresses existing gaps in cross-country research but also offers valuable policy implications for countries aiming to design effective long-term economic development strategies. To strengthen the theoretical foundation, we conduct a global empirical analysis based on the Cobb-Douglas production function to investigate how digital transformation influences economic growth, emphasizing its pivotal role in promoting innovation and productivity. Methodologically, the study employs the Generalized Method of Moments (GMM) estimation technique with

panel data, which allows for robust inference while accounting for potential endogeneity. Beyond the descriptive framework, we perform regression analyses to assess the linear effects of digital transformation across a diverse set of countries. To deepen the analysis, we also conduct stratified regressions by categorizing countries into three development groups—low-income, middle-income, and high-income. This approach facilitates cross-group comparisons and yields important insights into how the impact of digital transformation varies depending on a country's stage of development.

Based on our findings, this study suggests that digital transformation is a crucial driver of innovation with strategic implications for economic growth. To conclude, we propose several policy recommendations regarding digital transformation and economic growth to guide national development strategies.

2. Literature review

The most classical theories on production factors, such as neo-Schumpeterian theory (Bahrini & Qaffas, 2019) and neoclassical growth theory (Solow, 1956), have demonstrated the positive impact of information technology. Digital transformation factors are incorporated into supply-side inputs as production factors, thereby driving the production process, while technological progress fosters economic growth. However, in contrast to classical theories that consider technology an exogenous factor, recent empirical studies have revealed an endogenous relationship within economic models (Gomes et al., 2022). This relationship is evident not only in its direct contribution to economic growth but also in broader economic development indicators, such as life expectancy, education, healthcare, and poverty reduction (Grossman & Helpman, 1991).

The positive effect of information technology on economic growth is reflected in enhanced business productivity, primarily through lower transaction costs for firms that adopt digital technology (Bahrini & Qaffas, 2019; Haftu, 2019; Pradhan et al., 2018). The digital economy also plays a crucial role in mitigating supply chain disruptions (Song et al., 2022) and enhancing total factor productivity (Acemoglu & Restrepo, 2018), thereby accelerating economic growth. Moreover, it reduces carbon emissions and promotes green development through innovation and entrepreneurship at the regional level (Zhou et al., 2022). Simultaneously, the digital economy facilitates technological advancement (Wang et al., 2015) and improves business quality (Mathushan & Pushpanathan, 2021).

More recently, studies measuring digital transformation through broadband and internet access have confirmed its positive impact on economic growth (Pradhan et al., 2018; Aghaei & Rezagholizadeh, 2017). Bahrini and Qaffas (2019) concluded that broadband penetration and internet usage are key drivers of economic growth. Similarly, David and Grobler (2020) found, in their empirical research on the effects of information technology on economic development, that the expansion of mobile telecommunications has accelerated growth, significantly contributing to economic development. As a result, they recommended increased investment in fixed infrastructure and internet services. In a panel regression analysis, Hodrab et al. (2016) examined the impact of information and communication technology (ICT) on economic growth in 18 Arab countries from 1995 to 2013. Their findings revealed a positive correlation between ICT and economic growth in several Arab nations.

Meanwhile, Bon (2021) used the Arellano-Bond GMM and FE-IV estimation methods to analyze data from 35 developing countries spanning the period from 2006 to 2019. He argued that both digitalization and governance

promote economic growth; however, the interaction term in his model acted as a constraint on this relationship. Specifically, in environments with weak governance, the development of digital technology may be restricted by government policies and regulations that control information and suppress freedom of speech, thereby diminishing the effectiveness of digital transformation and limiting its role in enhancing governance.

Additionally, governments in developing countries often implement restrictive regulations to curb the uncontrolled expansion of social networks, effectively limiting digital technology development and, consequently, hindering economic growth. In a separate study, Georgescu et al. (2021) examined the impact of digitalization on economic growth using Canonical Correlation Analysis (CCA). Their results demonstrated that digitalization accounted for 70.33% of economic growth, with a correlation coefficient of 0.800, leading them to conclude that digitalization has a substantial impact on economic development.

Meanwhile, Hosan et al. (2021) investigated the relationship between demographic opportunities, digitalization, energy intensity, and sustainable economic growth in emerging economies. By employing econometric methods to analyze data, the authors demonstrated that digitalization promotes sustainable economic growth across all quantiles. On the other hand, Habibi and Zabardast (2020) found that its contribution to economic growth is lower in more developed countries that possess the latest and most advanced technologies. This relationship is particularly evident in developing countries, where its impact on the labor market is reflected in rising unemployment among unskilled workers.

Furthermore, despite the implementation of more efficient digital technologies, they often fail to function optimally due to the intensified competitive dynamics of developed markets, which disadvantage developing countries that lack a competitive edge (Krammer, 2017). At the same time, several other studies have also identified an inverse relationship between digital transformation and economic growth in developing countries. A review of previous studies provides an overall perspective on the relationship between digital transformation and economic development. There remains significant debate and a lack of consensus within the academic community on this topic, particularly among countries at different stages of development. Currently, there is a shortage of large-scale global studies that clarify the impact of digital transformation on economic growth, especially in developing nations, where its effects remain uncertain. Given this urgency, it is crucial to conduct in-depth research to gain a deeper understanding of the role of digital transformation in driving economic growth in developing countries. Such research would provide crucial policy implications to help these nations bridge the gap with leading economies *(see Appendix 1 online).*

3. Methodology and data sources

3.1. Econometric methodology

According to the recommendations of Elfaki and Ahmed (2024), Li and Gospodarik (2022), and Welfens (2017), the factors influencing economic growth are identified to determine the representative criteria for dependent and independent variables. Based on this, we propose a research model grounded in the Cobb-Douglas production function, considering labor (L) and capital (K) as input factors. The dependent variable is the economic growth rate, while the independent variables directly explaining economic growth include digital transformation, investment, and labor. To provide the broadest perspective on the relationship between digital transformation

and growth, the author constructs the model with the following structure:

$$\begin{aligned} lnGROWTH_{i,t} = \beta 0 + \beta 1*lnGROWTH_{i,t-1} \\ + \beta 2*lnDIGITALIZATION1_{i,t} \\ + \beta 3*lnlnDIGITALIZATION2_{i,t} \\ + \beta 4*lnDIGITALIZATION3_{i,t} \\ + \beta 5*INVESTMENT1_{i,t} \\ + \beta 6*INVESTMENT2_{i,t} + \beta 7*lnLABOR1_{i,t} \\ + \beta 8*lnLABOR2_{i,t} + \varepsilon_{i,t} \end{aligned}$$

In the digital transformation era, the Cobb-Douglas function can be adjusted to reflect the role of technology, digital transformation, and new factors related to the digitalization of the economy (Elfaki & Ahmed, 2024). Digital transformation refers to the use of digital technology to modify business operating models, enhance production efficiency, and generate new value (Brynjolfsson & McAfee, 2014). One way to explicitly model the impact of digital transformation in the Cobb-Douglas model is to introduce the technology factor into the overall productivity A (Solow, 1956). The extended formula can be rewritten as follows:

$$\mathbf{Y} = A\mathbf{(t).K\alpha.L\beta}$$

Where A(t) is a function reflecting the progress of technology or digital transformation over time, this can be understood as the point at which digital technologies, such as digital transformation and big data analysis, are applied; overall productivity increases, thereby enhancing economic growth. In our analysis, we use factors representing investment capital, such as FDI inflows and private investment flows. Meanwhile, the labor input is represented by variables such as the labor force and labor productivity. Finally, total factor productivity is captured by digital transformation variables, reflecting the role of technology in driving economic growth. Additionally, ε represents the statistical error; i denotes the i-th country in the research sample, and t refers to the t-th year in the study period *(see Appendix 2 online).*

3.2. Data source

This study utilizes annual data sets from three groups of 77 countries worldwide, spanning the period 2005-2022. Based on the World Bank classification, we use Appendix 3 *(see Appendix 3 online)* to divide the total sample into groups of countries with different income levels for deeper empirical analysis, thereby identifying the differences.

The data for all variables were obtained from the World Bank's World Development Indicators database (2024). Descriptive statistics for the research variables are presented in detail in Appendix 4 *(see Appendix 4 online).*

4. Result and discussion

4.1. Descriptive statistical analysis

To determine the impact of digital transformation on economic growth in 77 countries from 2005-2022 through the digital transformation process, investment, and labor resources. The research data are statistically described in detail in Appendix 4 *(see Appendix 4 online).*

4.2. Correlation analysis

Perform Pearson correlation analysis to examine the linear relationship between variables in the model. The correlation coefficients indicate the strength and direction of the relationships between variables, offering initial insights into whether these relationships are positive or negative. Correlation analysis also helps identify multicollinearity issues that may arise when estimating the impact of influencing factors.

Table 1. Correlation matrix in the research model.

VARIABLES	GROWTH	DIGI1	INVESTMENT1	INVESTMENT2	LABOR1	LABOR2
GROWTH	1.0000					
DIGI1	0.4337	1.0000				
INVESTMENT1	-0.0968*	-0.0711*	1.0000			
INVESTMENT2	-0.1467	-0.2509	0.0003***	1.0000		
LABOR1	0.6897	-0.0102***	-0.0169**	0.1201	1.0000	
LABOR2	0.6161	0.6037	-0.1140	-0.3311	-0.1454	1.0000
VARIABLES	**GROWTH**	**DIGI2**	**INVESTMENT1**	**INVESTMENT2**	**LABOR1**	**LABOR2**
GROWTH	1.0000					
DIGI2	0.0789*	1.0000				
INVESTMENT	-0.0968*	-0.0970*	1.0000			
INVESTMENT2	-0.1467	-0.0411**	0.0003***	1.0000		
LABOR1	0.6897	-0.0014***	-0.0169**	0.1201	1.0000	
LABOR2	0.6161	0.1094	-0.1140	-0.3311	-0.1454	1.0000
VARIABLES	**GROWTH**	**DIGI3**	**INVESTMENT1**	**INVESTMENT2**	**LABOR1**	**LABOR2**
GROWTH	1.0000					
DIGI3	-0.1045	1.0000				
INVESTMENT1	-0.0968*	0.0605*	1.0000			
INVESTMENT2	-0.1467	0.1216	0.0003***	1.0000		
LABOR1	0.6897	0.0845*	-0.0169**	0.1201	1.0000	
LABOR2	0.6161	-0.2347	-0.1140	-0.3311	-0.1454	1.0000

The correlation analysis table above shows the presence of pairwise autocorrelation among the independent variables. The absolute values of the correlation coefficients between the variables are all below 0.8, with the highest value being 0.6897. Therefore, there is no strong correlation among the variables in the model. With the dependent variable being Economic Growth, the correlation among the variables in the research model is analyzed using the Pearson correlation coefficient. The correlation coefficient between DIGI1 and GROWTH is 0.4337, indicating a positive relationship between these two variables. This suggests that economic growth increases as the number of fixed broadband subscriptions rises, and vice versa. Although this coefficient is not particularly high, it still highlights the importance of digital infrastructure in supporting and promoting economic activities. The correlation coefficient between DIGI2 and GROWTH is 0.0789, demonstrating a positive relationship between the two variables. Secure internet servers can facilitate better economic transactions and e-commerce activities; however, these effects are often indirect and long-term, and thus may not be immediately reflected in short-term economic growth. The correlation coefficient between DIGI3 and GROWTH is -0.1045, indicating an inverse relationship between these variables. Although this correlation is relatively low, it may still suggest certain implications regarding the impact of the number of mobile subscriptions on economic growth.

The correlation coefficient between INVESTMENT1 and GROWTH is -0.0968, indicating a negative relationship between foreign direct investment (FDI) and economic growth. This implies that an increase in FDI is

associated with a slight decline in economic growth, and vice versa. Foreign investment may be concentrated in sectors that do not directly stimulate short-term economic growth or do not generate significant added value for the economy. The correlation coefficient between INVESTMENT2 and GROWTH is -0.1467, showing a negative correlation between private investment and economic growth. This suggests that an increase in private investment does not necessarily lead to significant economic growth and may even have adverse effects. The correlation coefficient between LABFOR1 and GROWTH is 0.6897, indicating a strong positive correlation. This suggests that the labor force is a crucial factor contributing positively to economic growth. As the labor force expands, the economy benefits from a larger workforce to meet production and service demands, thereby boosting production and consumption and supporting overall growth. The correlation coefficient between LABFOR2 and GROWTH is 0.6161, indicating a positive correlation between labor productivity and economic growth. Labor productivity typically increases with improvements in workforce skills, technological innovation, or business investments in more efficient tools and processes. These factors not only enhance output but also contribute to sustainable growth.

Through the above correlation analysis, the author observes the consistency of the study, as reflected in the strong internal correlation among the independent and dependent variables. This confirms the validity of the research model, providing a foundation for further analysis in this study. To examine whether multicollinearity exists among the variables in the model, we employ the Variance Inflation Factor (VIF) test. Since all independent variables have VIF < 2, with mean VIF values of 1.30, 1.07, and 1.09, the research model does not exhibit multicollinearity among the independent variables. However, actual regression results and further statistical tests are required to accurately assess the impact at different significance levels.

4.3. Panel regression analysis

Next, we conduct quantitative analysis on panel data from 77 countries over 16 years (2005-2022). To overcome the model's shortcomings, we also conduct regression with GMM regression standard errors to find the most reputable results for the article. In more detail, the authors apply the GMM estimation method of Blundell and Bond (2000). This technique is suitable for panel data models and has sample characteristics that include many subjects and not too long of an observation time. In addition, the GMM method helps solve the endogeneity problem in the research model that simple estimations such as OLS, FEM, REM, or FGLS cannot solve. Finally, through the research results, the article suggests essential policy implications for countries. First, with the dependent variable GROWTH, after fully correcting the model's defects through GMM regression. The results after fixing the above errors are shown in the table below:

Table 2. Regression results using GMM estimation

Dependent variable: Growth									
Variables	**OECD**			**Upper-middle income countries**			**Lower-middle income countries**		
	Model 1 DIGI1	**Model 2 DIGI2**	**Model 3 DIGI3**	**Model 1 DIGI1**	**Model 2 DIGI2**	**Model 3 DIGI3**	**Model 1 DIGI1**	**Model 2 DIGI2**	**Model 3 DIGI3**
Growth(-1)	5.32e-07 [1.49]	1.98e-06*** [4.39]	1.04e-06*** [4.56]	1.31e-06*** [2.87]	9.72e-07*** [3.54]	-2.91e-07 [-0.78]	-6.92e-07 [-2.61]	-7.32e-07 [-0.55]	-7.48e-07 [-2.18]

Dependent variable: Growth									
Variables	**OECD**			**Upper-middle income countries**			**Lower-middle income countries**		
	Model 1 DIGI1	**Model 2 DIGI2**	**Model 3 DIGI3**	**Model 1 DIGI1**	**Model 2 DIGI2**	**Model 3 DIGI3**	**Model 1 DIGI1**	**Model 2 DIGI2**	**Model 3 DIGI3**
DIGI1	7.65e-07*** [4.08]	-	-	-1.29e-06** [-2.30]	-	-	7.07e-07*** [3.93]	-	-
DIGI2	-	6.45e-08*** [3.39]	-	-	-2.20e-08** [0.042]	-	-	6.94e-08** [2.13]	-
DIGI3	-	-	-3.30e-07*** [-4.79]	-	-	2.69e-07* [1.71]	-	-	2.30e-07*** [3.22]
INVESTMENT1	1.13e-07* [1.91]	4.88e-07*** [3.83]	6.20e-08 [1.06]	2.61e-07 [1.54]	2.27e-07 [1.32]	1.63e-07 [0.96]	1.52e-07* [1.80]	-1.14e-07 [-0.53]	3.21e-07** [2.28]
INVESTMENT2	1.82e-06*** [16.17]	-2.89e-06 [-1.54]	-2.09e-06 [-3.37]	4.80e-07 [1.49]	4.34e-07* [1.70]	4.77e-07 [1.59]	-2.03e-07 [-1.07]	9.05e-07* [-1.84]	1.73e-08 [0.08]
LABOR1	0 .99*** [2.5e+05]	0.99** [3.9e+05]	1.0*** [6.9e+05]	1.0*** [6.2e+05]	1.0*** [6.5e+05]	1.0*** [6.1e+05]	0.99*** [1.8e+06]	0.99*** [3.7e+05]	1.0*** [1.4e+06]
LABOR2	1.0*** [5.5e+06]	0.99*** [1.5e+06]	0.99*** [3.9e+06]	0.99*** [1.2e+06]	0.99*** [1.7e+06]	0.99*** [1.5e+06]	1.0*** [2.3e+06]	1.0*** [7.5e+05]	1.0*** [2.3e+06]
Instrucments < Groups	30 < 33	27 < 33	33 = 33	16 < 24	19 < 24	17 < 24	20 < 22	15 < 22	20 < 22
Arellano-Bond AR(2) (Pr>z)	z = -0.69 Pr > z = 0.489	z = -1.64 Pr > z = 0.101	z = -1.87 Pr > z =0.061	z = -0.27 Pr > z = 0.784	z = -0.39 Pr > z = 0.698	z = -0.29 Pr > z = 0.769	z = -1.47 Pr > z = 0.141	z = -0.99 Pr > z = 0.320	z = -0.85 Pr > z = 0.395
sargan test	chi2(24) = 35.74 Prob > chi2 = 0.058	chi2(21) = 18.50 Prob > chi2 = 0.617	chi2(27) = 35.61 Prob > chi2 = 0.124	chi2(10) = 6.40 Prob > chi2 = 0.780	chi2(13) = 11.06 Prob > chi2 = 0.606	chi2(11) = 4.99 Prob > chi2 = 0.932	chi2(14) = 6.12 Prob > chi2 = 0.963	chi2(9) = 2.36 Prob > chi2 = 0.984	chi2(14) = 6.59 Prob > chi2 = 0.949

Notes: **, **, *** significant at 10%, 5%, 1%. t-statistics are in [ ].*

The results indicate that the regression coefficients of all independent variables representing DIGI1, DIGI2, and DIGI3 exhibit high statistical significance across all models in this study. This confirms that digital transformation has a profound impact on economic growth across different country groups, including developed nations (OECD), upper-middle-income countries, and lower-middle-income countries, with a high level of confidence. However, other independent variables also demonstrate statistical significance in this model.

Firstly, the digital transformation variable (DIGI1) is the leading independent variable in this research model. For each model, the explanatory variables for digital transformation have different coefficients. In the group of developed countries, Model 1, with DIGI1, has a regression coefficient of 7.6 with high statistical significance (1%), indicating that this variable explains the positive impact of digital transformation on economic growth. In Model 2 for developed countries, the variable representing digital transformation, DIGI2, has a regression coefficient of 6.45 with a confidence level of 99%, affirming the positive impact of digital transformation on economic growth in developed nations. In Model 3 for developed countries, the digital transformation variable, DIGI3, has a regression coefficient of -3.3 with high statistical significance (1%), suggesting that digital transformation negatively affects economic growth. This highlights the critical role of digital transformation in economic growth within the OECD group. Furthermore, the study reveals that digital transformation has both positive and negative effects on economic growth in developed countries, though the negative impact is negligible. These findings

align with the research of Hodrab et al. (2016) and the study of Pohjola (2000).

In Model 1, DIGI1 in upper-middle-income countries has a regression coefficient of -1.29 with high statistical significance (5%), indicating that increased digital transformation reduces economic growth. In Model 2, DIGI2 has a regression coefficient of -2.2 with high statistical significance (5%), suggesting that economic growth is slightly affected by digital transformation. In Model 3, DIGI3 has a regression coefficient of 2.69 with statistical significance (10%), demonstrating that investment in digital transformation can stimulate economic growth in upper-middle-income countries. This study finds that digital transformation has a dual impact on economic growth in upper-middle-income countries, consistent with the findings of Dewan and Kraemer (2000).

In the group of lower-middle-income countries, all digital transformation explanatory variables have positive regression coefficients. Specifically, in Model 1, DIGI1 has a regression coefficient of 7.07 with high statistical significance (1%), showing that investment in digital transformation contributes to economic growth in these nations. In Model 2, DIGI2 has a regression coefficient of 6.9 with high statistical significance (5%), further confirming that digital transformation initiatives support economic development in lower-middle-income countries. Finally, in Model 3, DIGI3 has a regression coefficient of 2.3 with statistical significance (1%), demonstrating a positive relationship between digital transformation and economic growth in these nations. This study confirms that investing in digital transformation in lower-middle-income countries drives economic growth and plays a crucial role in long-term economic development. These findings contrast with those of Papaioannou and Dimelis (2007) and Yousefi (2011), who concluded that ICT only positively impacts economic growth in developed countries. The authors observe that digital transformation investments in developing nations not only enhance economic growth but also create opportunities for these countries to catch up with global trends. Additionally, this study aligns with the findings of Georgescu et al. (2021) and Hosan et al. (2021).

Secondly, the author finds that the lagged growth variable (-1), representing the previous year's economic growth, also influences economic growth. The lagged growth variable (-1) exhibits variations across different models and country groups. In the developed OECD countries, the lagged growth variable (-1) in Model 1 is not statistically significant. Conversely, in Models 2 and 3, it is highly significant (1%) with regression coefficients of 1.98e-06 and 1.04e-06, respectively. This indicates that current economic growth is positively influenced by the previous year's growth in OECD countries. In upper-middle-income countries, the lagged growth variable (-1) has a similar impact in Models 1 and 2, with regression coefficients of 1.31e-06 and 9.72e-07, respectively, both at a 1% significance level. This reinforces the notion that if the previous year's economic growth is positive, the subsequent year's growth is likely to be even stronger in upper-middle-income countries. Lastly, in lower-middle-income countries, the lagged growth variable (-1) is not statistically significant, making it inconclusive in determining its impact.

Thirdly, the author also observes that investment is a crucial factor contributing to economic growth, with varying coefficients depending on country groups and models. In developed countries, the INVESTMENT1 variable has regression coefficients of 1.1 in Model 1 with statistical significance (10%) and 4.8 in Model 3 with statistical significance (1%), indicating that FDI plays a vital role in promoting growth in these nations. In contrast, in upper-

middle-income countries, the INVESTMENT1 variable is largely insignificant, making it uninformative regarding economic growth. Lastly, in lower-middle-income countries, INVESTMENT1 has a regression coefficient of 1.5 with statistical significance (10%) in Model 1 and 3.2 with statistical significance (5%) in Model 3. The study shows that increasing FDI leads to economic growth, highlighting the critical role of FDI in economic development.

The INVESTMENT2 variable has a regression coefficient of 1.82 with a 1% significance level in Model 1 for the OECD group, indicating that greater private-sector investment enhances economic growth in these countries. Similarly, in upper-middle-income countries, INVESTMENT2 has a regression coefficient of 4.34 at a 10% significance level in Model 2, demonstrating that private investment positively impacts economic growth. Lastly, in lower-middle-income countries, INVESTMENT2 has a regression coefficient of 9.05 with a 10% significance level in Model 2, showing that private investment drives economic development in these nations.

Furthermore, labor is also a key determinant of economic growth across different countries. Across various models and country groups, labor generally has a positive impact with high statistical significance. The LABOR1 variable has a regression coefficient of approximately 1 with a 1% significance level across all models, strongly confirming that an increase in the labor force contributes to national economic growth. Similarly, the LABOR2 variable has a regression coefficient close to 1 with high significance (1%), suggesting that labor productivity is also a crucial factor influencing economic growth.

Based on the analysis results from the research models, the author has confirmed the validity of the research steps through regression results, which exhibit a high degree of consistency when examining the impact of digital transformation on economic growth. The regression estimates also reveal the relationship between the digital transformation variable and economic growth across different country groups through explanatory variables. Our findings indicate significant differences in digital transformation across countries with varying levels of development. While positive effects are also observed in other country groups, these effects are weaker and, in some cases, hurt economic growth rates. This provides a clear answer regarding the positive role of digital transformation in the economic development of lower-income countries.

Based on these results, it is evident that digital transformation is a key driver of economic growth in developing nations, shedding light on the ongoing debates concerning its role in economic expansion. To further clarify the relationship between digital transformation and economic growth among country groups from 2005 to 2022, a scatter plot method was employed. The vertical axis represents explanatory variables of digital transformation (DIGI1, DIGI2, DIGI3), while the horizontal axis represents economic growth (GROWTH). The chart illustrates both the positive and negative relationships between digital transformation indicators

and economic growth across different country groups, as analyzed in the research models. The results obtained from the scatter plot analysis complement the correlation and regression analyses presented in the previous section.

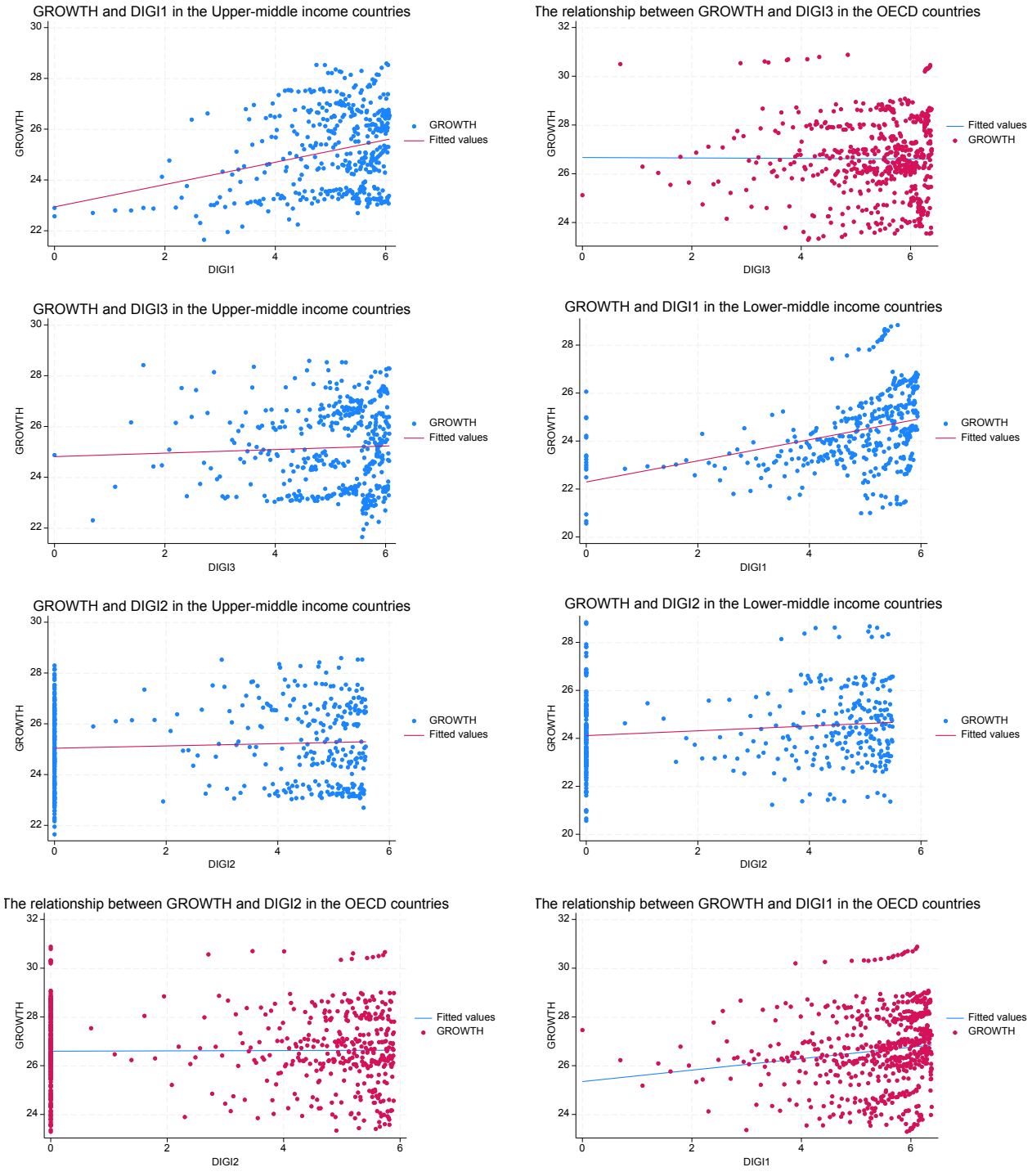

Figure 1. The relationship between economic growth and digital transformation

Based on the results of the multicollinearity test (as indicated by the VIF values), the Arellano-Bond AR(2) test, and the Sargan test, all of which fall within acceptable econometric thresholds, it can be concluded that the research model is both statistically sound and appropriate. The regression results further demonstrate a positive effect of digital transformation variables on economic growth in developing countries, as reflected through the

explanatory variables. In addition, the analysis reveals variation across country groups, with the impact being more pronounced in low-income countries compared to high-income and developed economies. These findings serve as a foundation for the policy implications discussed in the subsequent section of the study.

5. Conclusions and policy implications

This paper aims to determine the impact of digital transformation on economic growth in 77 countries, including developed countries, middle - high - income countries, and low - middle - income countries, using panel data from 2005-2022.

As the above analysis shows, digital transformation positively impacts economic growth. Specifically, when digital transformation develops through increased fixed broadband subscriptions, economic growth tends to increase and vice versa. Also, increasing secure internet connectivity affects economic growth. However, the number of mobile subscribers shows a negative relationship between these two variables. Although this correlation coefficient is relatively low, it can still have some meaning about the impact. It is important to note that the development of digital transformation goes hand in hand with protecting network security and enhancing the security of transactions and people's personal information. The government must also develop digital infrastructure or encourage private investment in telecommunications and digital technology. Strengthening education on technology skills for people is also an important factor. Starting from general education, subjects on information technology and basic digital skills should be included in the curriculum to prepare a skilled workforce to meet the needs of the digital economy. The government can coordinate with businesses to organize short-term training courses and improve skills for workers in digital and high-tech fields, creating conditions for workers to switch to high-demand industries in the digital age.

Foreign investment has an inverse relationship with economic growth. Therefore, it is necessary to attract foreign investment selectively, targeting high-value-added industries such as high technology and sustainable industries and limiting investment in industries that do not contribute significantly to economic growth. At the same time, the government should consider imposing conditions for foreign investment, including commitments to transfer technology and train the domestic workforce, to ensure that these investments bring long-term value.

Similar to foreign investment, private investment also hurts economic growth. Although the negative level is not too significant, increasing support for private investment in high-efficiency areas is necessary for cooperation through organizing seminars and business connection programs.

In addition, considering the labor force factor, whether in terms of force or quality, there is a positive relationship with economic growth. Therefore, to promote the economy, it is indispensable to promote the workforce through policies on training and developing workforce skills. Apply digital techniques to increase labor productivity and encourage workers to learn about technology through bonuses and salary increases. To ensure the country's workforce, avoid population aging, and reduce pension pressure on the state economy. Economic Growth is a complex and arduous process that requires the state to introduce appropriate policies to develop each field to ensure a country's sustainable development. Especially in modern times, it is necessary to pay attention to applying technology to avoid falling behind and select technology suitable for your country.

Limitations and future research direction

Our research has only focused on national digital transformation without mentioning the role of institutions. Good institutions will amplify the impact of digital transformation on economic growth. In addition, other macro variables that impact economic growth in the modern trend have not been mentioned, such as the role of innovation, migration, etc.

In future research directions, we will analyze more closely the role of institutions and government performance in the interaction between digital transformation and economic growth. In addition, we will analyze and compare the differences in the impact of digital transformation on economic growth in geographical areas, for example, between developing countries in Asia and Africa.

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References

Acemoglu, D., & Restrepo, P. (2018). The race between man and machine: Implications of technology for growth, factor shares, and employment. *American Economic Review*, *108*(6), 1488-1542. https://doi.org/10.1257/aer.20160696

Aghaei, M., & Rezagholizadeh, M. (2017). The impact of information and communication technology (ICT) on economic growth in the OIC Countries. *Economic and Environmental Studies, 17*(2), 257–278. https://doi.org/10.25167/ees.2017.42.7

Bahrini, R., & Qaffas, A. A. (2019). Impact of information and communication technology on economic growth: Evidence from developing countries. *Economies, 7*(1). https://doi.org/10.3390/economies7010021

Blundell, R., & Bond, S. (2000). GMM estimation with persistent panel data: an application to production functions. *Econometric Reviews*, *19*(3), 321-340. https://doi.org/10.1080/07474930008800475

Bon, V. (2021). The digitalization–economic growth relationship in developing countries and the role of governance. *Scientific Annals of Economics and Business*, *68*(4), 481-493. https://doi.org/10.47743/saeb-2021-0028

Brynjolfsson, E., & McAfee, A. (2014). *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. WW Norton & Company.

Bukht, R., & Heeks, R. (2017). Defining, conceptualising and measuring the digital economy (GDI Development Informatics Working Paper No. 68). The University of Manchester, Global Development Institute. http://hummedia.manchester.ac.uk/institutes/gdi/publications/workingpapers/di/di_wp68.pdf

Chandra, M., Kumar, K., Thakur, P., Chattopadhyaya, S., Alam, F., & Kumar, S. (2022). Digital technologies, healthcare and Covid-19: insights from developing and emerging nations. *Health and Technology*, *12*(2), 547-568. https://doi.org/10.1007/s12553-022-00650-1

Cusolito, A. P., Lederman, D., & Pena, J. O. (2020). *The effects of digital-technology adoption on productivity and factor demand: Firm-level evidence from developing countries* (Policy Research Working paper No. 9333). The World Bank. https://openknowledge.worldbank.org/server/api/core/bitstreams/c030fe17-dcdc-5b15-be94-e113b2c14d27/content

David, O. O., & Grobler, W. (2020). Information and communication technology penetration level as an impetus for economic growth and development in Africa. *Economic Research-Ekonomska Istraživanja, 33*(1), 1394-1418. https://doi.org/10.1080/1331677X.2020.1745661

Dewan, S., & Kraemer, K. L. (2000). Information technology and productivity: Evidence from country-level data. *Management Science*, *46*(4), 548-562. https://doi.org/10.1287/mnsc.46.4.548.12057

Elfaki, K. E., & Ahmed, E. M. (2024). Digital technology adoption and globalization innovation implications on Asian Pacific green sustainable economic growth. *Journal of Open Innovation: Technology, Market, and Complexity*, *10*(1). https://doi.org/10.1016/j.joitmc.2024.100221

Georgescu, I., Androniceanu, A. M., Kinnunen, J., & Drăgulănescu, I. V. (2021). Correlative approach to digitalization and economic growth. In *Proceedings of the 19th International Conference on Business Excellence, 15*(1), 44-57. https://doi.org/10.2478/picbe-2021-0006

Grossman, G. M., & Helpman, E. (1991). *Innovation and growth in the global economy.* MIT Press.

Gomes, S., Lopes, J. M., & Ferreira, L. (2022). The impact of the digital economy on economic growth: The case of OECD countries. *RAM. Revista de Administração Mackenzie*, *23*(6). https://doi.org/10.1590/1678-6971/eRAMD220029.en

Habibi, F., & Zabardast, M. A. (2020). Digitalization, education and economic growth: A comparative analysis of Middle East and OECD countries. *Technology in Society*, *63*. https://doi.org/10.1016/j.techsoc.2020.101370

Haftu, G. G. (2019). Information communications technology and economic growth in Sub-Saharan Africa: A panel data approach. *Telecommunications Policy, 43*(1), 88–99. https://doi.org/10.1016/j.telpol.2018.03.010

Hodrab, R., Maitah, M., & Smutka, L. (2016). The effect of information and communication technology on economic growth: Arab world case. *International Journal of Economics and Financial Issues*, *6*(2), 765-775. https://www.aaup.edu/sites/default/files/2017-06/1935-6376-1-PB%20%281%29.pdf

Hosan, S., Karmaker, S. C., Rahman, M. M., Uddin, M. A., & Saha, B. B. (2021). Digitalization, energy intensity and economic growth: A panel study on South Asian economies. In *Proceedings of International Exchange and Innovation Conference on Engineering & Sciences (IEICES)* (Vol. 7, pp 7-19). Interdisciplinary Graduate School of Engineering Sciences, Kyushu University. https://doi.org/10.5109/4738553

Khaliq, A., & Noy, I. (2007). Foreign direct investment and economic growth: Empirical evidence from sectoral data in Indonesia. *Journal of Economic Literature*, *45*(1), 313-325.

Krammer, S. M. (2017). Science, technology, and innovation for economic competitiveness: The role of smart specialization in less-developed countries. *Technological Forecasting and Social Change*, *123*, 95-107. https://doi.org/10.1016/j.techfore.2017.06.028

Li, R., & Gospodarik, C. G. (2022). The impact of digital economy on economic growth based on pearson correlation test analysis. In J. Jansen, B., Liang, H., Ye, J. (Eds.). *International Conference on Cognitive based Information Processing and Applications (CIPA 2021), 2,* 19-27. Springer Singapore. https://doi.org/10.1007/978-981-16-5854-9_3

Li, K., Kim, D. J., Lang, K. R., Kauffman, R. J., & Naldi, M. (2020). How should we understand the digital economy in Asia? Critical assessment and research agenda. *Electronic Commerce Research and Applications, 44*. https://doi.org/10.1016/j.elerap.2020.101004

Litvinenko, V. S. (2020). Digital economy as a factor in the technological development of the mineral sector. *Natural Resources Research*, *29*(3), 1521-1541. https://doi.org/10.1007/s11053-019-09568-4

Lloyd, M. W. (2020). Desigualdades educativas y la brecha digital en tiempos de COVID-19. *Educación y Pandemia,* 115-121. https://www.fhcs.unp.edu.ar/practicaprofesional2/wp-content/uploads/2021/09/educacion_pandemia.pdf#page=115

Lopes, J. M., Silveira, P., Farinha, L., Oliveira, M., & Oliveira, J. (2021). Analyzing the root of regional innovation performance in the European territory. *International Journal of Innovation Science, 13*(5), 565-582. https://doi.org/10.1108/IJIS-11-2020-0267

Mathushan, P., & Pushpanathan, A. (2020). Does green innovative practices matter? the effect of green innovation on green entrepreneurship sustainability. *Journal of Business Studies*, *7*(1), 127-148. https://doi.org/10.4038/jbs.v7i1.56

Papaioannou, S. K., & Dimelis, S. P. (2007). Information technology as a factor of economic development: Evidence from developed and developing countries. *Economics of Innovation and New Technology*, *16*(3), 179-194. https://doi.org/10.1080/10438590600661889

Pohjola, M. (2000). Information technology and economic growth: A cross-country analysis (Working paper No. 173). *World Institute for Development Economic Research (UNU-WIDER).* https://doi.org/10.22004/AG.ECON.295500

Pradhan, R. P. , Mallik, G., & Bagchi, T. P. (2018). Information communication technology (ICT) infrastructure and economic growth: A causality evinced by cross-country panel data. *IIMB Management Review, 30*(1), 91–103. https://doi.org/10.1016/j.iimb.2018.01.001

Song, M., Zheng, C., & Wang, J. (2022). The role of digital economy in China's sustainable development in a post-pandemic environment. *Journal of Enterprise Information Management*, *35*(1), 58-77. https://doi.org/10.1108/JEIM-03-2021-0153

Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics, 70*(1), 65–94. https://doi.org/10.2307/1884513

Soto-Acosta, P. (2020). COVID-19 pandemic: Shifting digital transformation to a high-speed gear. *Information Systems Management*, *37*(4), 260-266. https://doi.org/10.1080/10580530.2020.1814461

Tan, N. N., Ngan, H. T. T., Hai, N. S., & Anh, L. H. (2021, January). The impact of digital transformation on the economic growth of the countries. In *International Econometric Conference of Vietnam* (pp. 670-680). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-77094-5_49

Thoben, K. D., Wiesner, S., & Wuest, T. (2017). "Industrie 4.0" and smart manufacturing-a review of research issues and application examples. *International journal of automation technology*, *11*(1), 4-16. https://doi.org/10.20965/ijat.2017.p0004

Vaslavskiy, Y., & Vaslavskaya, I. (2019). Infrastructure public–private partnership projects: Budget consolidation policy in Russia and government expenditures' efficiency increase. In B. S. Sergi (Ed.), *Modeling economic growth in contemporary Russia* (pp. 203-232). Emerald Publishing Limited. https://doi.org/10.1108/978-1-78973-265-820191007

Welfens, P. J. J. (2017). *Macro innovation dynamics and the golden age: New insights into Schumpeterian dynamics, inequality and economic growth* (1st ed.). Springer. https://doi.org/10.1007/978-3-319-50367-7

Yousefi, A. (2011). The impact of information and communication technology on economic growth: Evidence from developed and developing countries. *Economics of Innovation and New Technology*, *20*(6), 581-596. https://doi.org/10.1080/10438599.2010.544470

Zhou, Z., Liu, W., Cheng, P., & Li, Z. (2022). The impact of the digital economy on enterprise sustainable development and its spatial-temporal evolution: An empirical analysis based on urban panel data in China. *Sustainability*, *14*(19). https://doi.org/10.3390/su141911948