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Impact of digitalisation and foreign direct investment on economic growth: Learning from developed countries

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Abstract. In recent years, progress in digitalisation and foreign direct investment has caused many structural changes, reorganisation in economics, rising productivity, globalisation, and increasing trade or international investment flows, which have led to increased capital flows and information availability. Therefore, this research investigated the impact of digitalisation and foreign direct investment on economic growth in developed countries. Panel data analysis was applied to data of 16 developed countries, from 2006 until 2019. The findings show that digitalisation - presented by mobile cellular and internet users - and foreign direct investment positively impacted economic growth, thus they strongly contribute to advancing the economy and increasing welfare. Therefore, developed countries have been learning about the critical role of technology and capital, as stated by economists over several decades, and developing countries can copy their policies into their own economic strategies.

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1. INTRODUCTION

Economic growth is a crucial factor for social well-being because it is the means by which we improve our quality of life. Different economic growth theories have been developed in order to explore the factors of economic growth. For example, classical and neoclassical theories were based on the prevailing conditions at the time and considered labour, land, and physical capital as the main determinants of economic growth. Later, Romer (1986) and Lucas (1990) integrated the role of human capital into the growth models, making a breakthrough in growth theory. Consequently, the determinants of economic growth have received considerable attention in the literature. Over the past three decades, various theoretical and empirical models have shown that information and communication technologies (ICT) and foreign direct investment (FDI) are increasingly important drivers of productivity and economic growth (Niebel, 2018; Nair et al., 2020; Adedoyin et al., 2020).

The contemporary economic environment has created a new economy characterised by the widespread digitalisation shown by the massive utilisation of ICT. The productivity recovery in the 1990s and early 2000s became a popular topic that inspired many growth economists to investigate. Current technological digital revolution is a symbol of ICT and is a crucial factor in promoting industrial, social, and economic growth. The most vital issue in promoting economic productivity is the specification of digitalisation. Electronics, telecommunications, software, networks, and decentralised computer workstations are a combination of ICT and the integration of information for media (Farhadi, Ismail, & Fooladi, 2012); they thus affect companies, industries, and the economy alike. ICT is an indispensable part of our lives—computers, smartphones, and others. Across the globe, people use computers and smartphones to work and play, especially in organisations and online businesses. Indeed, ICT can create new opportunities for accelerating growth (Sharafat & Lehr, 2017). ICT has therefore become vital to many national economies. Most firms use computers and an internet connection to increase their production and sales. Moreover, many firms use computers, and internet connections also contribute to business strategy, such as customising products and improving their quality and quantity (Abed et al., 2016; Kapoor et al., 2016; Yang et al., 2017).

On the other hand, FDI contributes to economic growth by facilitating capital formation, technology spillover, and increasing productivity. The nexus between FDI and economic growth has always been a crucial issue in economics, especially development research. Indeed, Susic et al. (2017) stated that FDI is a form of investment in which foreign investors maintain ownership and control companies with the funds they invest to achieve long-term benefits. Generally, FDI concerns the assets that an investor establishes to operate a foreign company, including establishing ownership and controlling a foreign corporation's interests. FDI differs from portfolio investment in that investors buy shares of a foreign corporation. In all countries, especially developing countries, FDI plays a crucial role in economic productivity. Some developing countries, as well as countries in transition, have become more receptive to FDI and are exploring ways to increase inflows. There are several considerations to these perceptions. The first is a growing preference to invest in equity rather than commercial bank borrowing. As it turns out, the repayment obligations of commercial bank borrowings are unpredictable, onerous, inflexible, and available to many countries. Foreign investment does not merely provide the initial capital inflow, but the following profit outflow also depends on the performance of the investment.

In recent decades, ICT and FDI have been the focus of debate among many scholars of economic growth. Farhadi et al. (2012) investigated the impact of ICT use on economic productivity in different countries and districts worldwide. They concluded that ICT use had a positive effect on economic productivity in 159 countries. Furthermore, Nair et al. (2020) examined the endogenous nexus between research and development (R&D) and ICT infrastructure development on economic growth in the Organisation for Economic Co-operation and Development (OECD) countries between 1961 and 2018. The findings show that R&D and ICT infrastructure development have contributed to long-term economic growth in OECD countries. However, short-term dynamics suggest a complex interrelationship between R&D and ICT infrastructure development on economic growth.

Additionally, Siddique et al. (2017) studied the impact of FDI on economic growth in Pakistan from 1980 to 2016 using Aautoregressive distributed lag (ARDL) and the causality test. The results of the ARDL model revealed that FDI is significant and positive in the short term, but significant and harmful in the long term. Using the same model, Bouchoucha and Ali (2019) explored the impact of FDI on economic growth in Tunisia using time-series data from 1980 to 2015. The empirical results differ from Siddique et al. (2017) and reveal that FDI positively influences economic growth both in the short and long term. However, most researchers have already provided empirical evidence for the relationship between ICT, FDI, and economic growth. However, the impact of digitalisation and FDI on economic growth is lacking; it thus remains an unexplored area and is fundamental in describing the phenomenon of digitalisation and FDI on economic growth in specially developed countries. Therefore, we applied static and dynamic panel models to provide new empirical evidence on the relationship between ICT and FDI effects on economic growth in developed countries.

This study examines the impact of digitalisation presented by mobile cellular subscribers, internet user subscribers, and FDI on economic growth. The findings of this study will contribute to understanding the impact of digitalisation and FDI on economic growth in developed countries. Thus, this article will fill the literature gap on the effect of digitalisation and FDI in various levels of economic activities.

The paper will be organised as follows. Section 2 reviews the existing theoretical literature and empirical findings on ICT use, FDI, and economic growth. Section 3 describes the data and methodology, which consists of data and sources and the specification model, whilst Section 4 presents the empirical results and discusses the study's findings. Finally, Section 5 concludes and summarises the study, recommendations for policy and programme implications, and suggestions for future research.

2. LITERATURE REVIEW

According to economic growth theory, the Harrod-Domar economic growth model was the first to use a Keynesian framework to investigate the necessary conditions for equilibrium income growth with sustained full employment (Harrod, 1939; Domar, 1946). It was concerned with the full use of capital, and labour was assumed to be in unlimited supply. The model argues that even in the simplest of worlds, full employment is doomed to degenerate into hyperinflation or depression if investment deviates from the critical growth rate. After that, the neo-classical models proposed by Solow and Swan introduced labour and capital and technological change as elements of concern (Solow, 1956; Swan, 1956).

Solow-Swan's economic model (1956) is one of long-term economic growth established under the framework of neoclassical economics. It attempts to explain long-term economic growth through capital accumulation, labour force growth, or population growth. The Solow-Swan model is designed to show how capital stock growth, labour growth, and technological advancement interact with the economy and describe how they affect a country's total output. Accordingly, Solow and Swan developed this model in 1956, replacing the Keynesian Harrod–Domar model.

From the perspective of digitalisation, the internet has deepened innovation capacity and capital, which is essential to economic growth. So, the internet may promote economic growth by creating a new product, thus affecting the economy's innovation capacity (Benhabib & Spiegel, 2000). Indeed, the internet is an integral part of the entrepreneurial capital that promotes economic productivity. The definition of entrepreneurial capital is the ability of economic subjects to generate new information (Audretsch et al., 2008). Thus, the internet can pull the economy out of a recession through innovation and deepening entrepreneurial capital.

Similarly, Moshiri & Nikpour (2010) said the internet establishes a network that promotes a country's economic productivity. It is, therefore, a form of cyber capital that improves the economy's overall productivity in different sectors. As a kind of network capital, the internet has a network effect. That is, the more users use the internet, the more benefits it can bring to existing internet users without increasing the cost to users. Several researchers have highlighted the relevance of ICT in promoting economic growth. For example, Choi & Yi (2009) used data from a panel of 207 countries from 1991 until 2000 to examine Internet users' impact on economic growth while controlling for certain macro variables. They used several econometric panel techniques to control for endogeneity among the explanatory variables. The empirical findings show that Internet users positively influence economic growth. In the same vein, Hodrab, Maitah & Lubos (2016) examined the effect of ICT on economic growth in 18 selected Arab countries from 1995 to 2013 with a sample of 341 observations, applying the Ordinary Least Square (OLS), random effects, and fixed effects models. The results determined that internet users positively impact economic growth.

Furthermore, mobile phones will affect economic development in many ways. They can reduce communication costs by reducing search costs and making information more accessible to the general population in developed countries. In contrast, this will lead to more effective market operations, less waste from corruption, and better communication between producers, sellers, and buyers. On the other hand, mobile phones not only increase the economic welfare of the consumers; they can also increase the economic welfare of the producers. Finally, the use of mobile phones can boost employment by stimulating demand for mobile-based services. Additionally, mobile cellular technology brings with it the capacity for services and products based on mobile phones, such as mobile banking. Mobile banking applications also allow all users to transfer money to others and pay bills between bank accounts through mobile cellular (Aker & Mbiti, 2010). Meanwhile, Nickerson et al. (2008) studied attitudes about mobile phone use in social settings, revealing that mobile phone users positively impact economic growth in the UK.

From the perspective of FDI, most studies investigate the impact of FDI in developing economies. However, developed countries are the main recipients of FDI (Gourinchas & Jeanne, 2013). At the same time, empirical research also provides inconclusive evidence of the relationship between FDI and economic growth. As mentioned previously, Siddique et al. (2017) studied the impact of FDI on economic growth in Pakistan from 1980 to 2016 using ARDL and the causality test. The results of the ARDL model show that fixed capital, FDI, and human capital are significant and positive in the short and long term. Furthermore, Tahiri (2017) used simple regression through the OLS model to examine the impact of FDI on economic growth in Afghanistan. The empirical results also show a positive relationship between FDI and economic growth.

Conversely, Rahman (2015) investigated the impact of FDI on economic growth in Bangladesh from 1999 to 2013, showing that FDI has a negative influence on economic growth. Consequently, the results have determined that the impact of FDI has not been associated with positive economic growth in Bangladesh.

Sinha and Sengupta (2019) also analysed the dynamic interrelationship between the FDI inflows, ICT expansion, and economic growth in Asia-Pacific developing countries from 2001 to 2017. Their empirical findings illustrated that ICT should be promoted to shock more high-tech FDI inflows to facilitate better economic growth. This perspective is related to a theoretical approach that considers the potential of ICT in enhancing competitiveness and promoting new socio-economic development opportunities. Thus, ICT facilitates integrated networks between individuals, businesses, and governments to attract new or more investments at the global level (Bon et al., 2016).

3. METHODOLOGY

3.1. Source of data

This study employs the secondary data collected from the World Bank Data, International Telecommunication Union report, and internet live stats. The dataset consists of cross-country observations from 16 developed countries over the 2006 to 2019 period studied. The variables used in this study are i) gross domestic product (the total of private consumption, gross private investment, government investment and spending, and net exports (United States dollar)); ii) internet user subscribers (internet user subscription dividing the total population by the number of Internet users multiplied by 100 (persons)); iii) mobile cellular subscribers (the number of postpaid subscriptions and the number of active prepaid accounts (persons)); and iv) FDI (net outward FDI minus inward FDI (USD)).

3.2. Method of analysis

This research aims to investigate the impact of internet user subscribers, mobile cellular subscribers, and FDI on economic growth in developed countries. Therefore, the Static and Dynamic Panel Models will be used for data analysis in this study. The results will subsequently be analysed and reported through descriptive statistics and statistical inference.

a. Static panel model

Panel data is multidimensional data involving time measurement. Panel data contains observations of multiple phenomena acquired by the same company or individual over multiple periods. Additionally, Static panel data analysis considers both time series and cross-section data. In the analysis of the impact of ICT use concerning internet user subscribers, mobile cellular subscribers, and FDI on economic growth in developed countries, the choice of the appropriate technique is an essential theoretical and empirical question. The sample used in this study includes both time series and cross-section data. Therefore, we apply the static panel data to investigate the impact of internet user subscribers, mobile cellular subscribers, and FDI on economic growth. Static panel data comprise three main Models, namely Pooled Ordinary Least Square (OLS), Random Effect Model (REM) and Fixed Effect Model (FEM). The specification model will therefore be formed as subsequently outlined.

The Pooled OLS Regression Model assumes that the number of observation countries is the same. Therefore, all the data can combine across the countries. The OLS also assumes that this model does not have heterogeneity. The assumption of the Pooled OLS model facilitates the combination of all the data, meaning we will ignore the nature of time series and cross-section data. We can therefore directly use the OLS to run this model, and the pooled regression model is given by:

$$\mathrm{GDP}_{it} = \beta_0 + B_1\mathrm{INU}_{it} + B_2\mathrm{MCS}_{it} + B_3\mathrm{FDI}_{it} + \varepsilon_{it} \tag{1}$$

GDP_{it} is the gross domestic product, INU_{it} is the internet user subscribers, MCS_{it} is the mobile cellular subscribers, and FDI_{it} is the foreign direct investment. Besides that, β_0, B_1, B_2, B_3 are the parameters to be estimated, ε_{it} is the error term, $_i$ indicates cross-section and $_t$ is the period.

The REM differs from the FEM, where considering varies across countries will affect the dependent variable. This model will estimate panel data in which the interfering variables may be correlated across time and individuals. This means that the model assumes that the intercept of each individual is different and that the intercept is a random variable. There are two residual components: i) the residual, where the residuals are a combination of the cross-section and time series; and ii) an individual residual, which is a random character of the i-th unit observation and remains constant at all times. Therefore, the equation of the REM is:

$$GDP_{it} = \beta_0 + \beta_1 INU_{it} + \beta_2 MCS_{it} + \beta_3 FDI_{it} + \mu it + \varepsilon_{it} \quad (2)$$

Where μit is the individual residual, which is a random character of the i-th unit observation and remains constant at all times.

The FEM differs from the general effect model but still adopts the ordinary least square principle, as shown in equation (1). The modelling assumption that constant intercepts are generated for each cross-section and time is considered to be unrealistic. Therefore, more models are needed to capture differences, as shown in equation (5). Furthermore, this model was used to control the influence of variables across countries, meaning that each cross-sectional has obtained its own characteristics by using its intercept values. The FEM assumes that different intercepts can mediate individual differences (cross-section). The dummy variable technique is thus used to estimate the FEM with different intercepts between individuals. This estimation model is often called the Least Squares Dummy Variable technique (LSDV). Therefore, the equation of the FEM is:

$$GDP_{it} = \beta_i + \beta_1 INU_{it} + \beta_2 MCS_{it} + \beta_3 FDI_{it} + \varepsilon_{it} \quad (3)$$

In this study, we apply natural logarithms to the data distribution because the data is measured in different units. Indeed, some variable values are too large or small in some periods. Therefore, all of the variables in equations (1), (2), and (3) need to transform into natural-log form to make equations (4), (5), and (6) estimable. When all the variables are in natural logarithm form, the estimable form of the equation is modelled as:

$$LGDP_{it} = \beta_0 + \beta_1 LINU_{it} + \beta_2 LMCS_{it} + \beta_3 LFDI_{it} + \varepsilon_{it} \quad (4)$$

$$LGDP_{it} = \beta_0 + \beta_1 LINU_{it} + \beta_2 LMCS_{it} + \beta_3 LFDI_{it} + \mu it + \varepsilon_{it} \quad (5)$$

$$LGDP_{it} = \beta_i + \beta_1 LINU_{it} + \beta_2 LMCS_{it} + \beta_3 LFDI_{it} + \varepsilon_{it} \quad (6)$$

Where $LGDP_{it}$ is natural-log of the gross domestic product, $LINU_{it}$ is the natural log of internet users, $LMCS_{it}$ is natural-log of mobile cellular subscribers, and $LFDI_{it}$ indicates the natural-log of FDI. Finally, β_0 is the constant, β_i is the number of individuals (i = 1,2,..., N)

b. Dynamic panel model

Static panel models always specify errors because the within-group error terms are continuously correlated. Thus, the estimates and statistical inferences for these two points are invalid. For this reason, the static panel model cannot thoroughly explore the impact of digitisation and FDI on economic growth. However, dynamic models are usually correctly specified because they are in the model's estimation part and not transferred into the error term, which renders the static FEM/REM estimate invalid. In addition, dynamic panel models are characterised by one or more lagging endogenous variables between explanatory variables and are typically estimated using Arellano and Bond's (1991) generalized method of moments

(GMM) estimators, which differ from static panel estimators in terms of moment condition sets and instrument matrix. The model we specify is the dynamic panel model:

$$\mathrm{GDP_{it}} = \beta_0 + \alpha\mathrm{GDP_{it-1}} + \beta_1\mathrm{INU_{it}} + \beta_2\mathrm{MCS_{it}} + \beta_3\mathrm{FDI_{it}} + \mathrm{u_{it}} + \mathrm{v_{it}} \quad (7)$$

Where y_{it} is the endogenous variables that appear as lagging explanatory variables in the regression analysis and x represents the vector of exogenous variables; the latter variables are internet user subscribers (INU), mobile cellular subscribers (MCS), and FDI. Besides these variables, α and β are the estimated parameters, v_{it} is the random effect, and u_{it} is an error term.

Equation (7) has some potential technical problems. First, there is a causal relationship between the independent variable and the possibility of the error term-related regression quantity. The best solution to this problem is to use the first-different GMM proposed by Arellano and Bond (1991). Therefore, equation (7) is transformed into the first difference GMM form:

$$\Delta\mathrm{GDP_{it}} = \beta_0 + \alpha\Delta\mathrm{GDP_{it-1}} + \beta_1\Delta\mathrm{INU_{it}} + \beta_2\Delta\mathrm{MCS_{it}} + \beta_3\Delta\mathrm{FDI_{it}} + \Delta\mathrm{u_{it}} + \Delta\mathrm{v_{it}} \quad (8)$$

After applying natural logarithms to this study, the model is shown as:

$$\Delta\mathrm{LGDP_{it}} = \beta_0 + \alpha\Delta\mathrm{LGDP_{it-1}} + \beta_1\Delta\mathrm{LINU_{it}} + \beta_2\Delta\mathrm{LMCS_{it}} + \beta_3\Delta\mathrm{LFDI_{it}} + \Delta\mathrm{u_{it}} + \Delta\mathrm{v_{it}} \quad (9)$$

Blundell and Bond (1998) estimated the equation by combining the level equation with the first difference, called system GMM. Their estimators are fixed when T (variable series) is constrained to be small and stationary. They suggested that the instrumental variable $\Delta\mathrm{y_{it-2}}$ be used as an instrument of $\Delta\mathrm{y_{it-1}}$ and claimed that their estimators are more efficient than Arellano and Bond (1991).

4. RESULTS AND DISCUSSION

4.1. Descriptive statistic

Table 1 presents a statistical summary of all the variables in the form of the mean, standard deviation, minimum, and maximum for the 224 observations in this study.

Table 1

Statistical summary of dependent and independent variables

VARIABLE	OBS	MEAN	STD.DEV	MIN	MAX
GDP	224	0.985487	1.357826	0.019	6.158
MCS	224	26.47797	37.95134	1.57	186.514
INU	224	18.59087	25.43876	0.587	117.086
FDI	224	43.40684	72.62863	1	734.01

Source: own calculation

Table 1: A statistical summary of the dependent and independent variables shows that the mean for the gross domestic product (GDP), MCS, INU, and FDI are 0.985487, 26.47797, 18.59087, and 43.40684, respectively.

Additionally, the standard deviation shows that FDI has a high variation with a score of 72.62863. The variables with middling variation are the MCS and INU, with standard deviation scores of 37.95134 and

25.43876, respectively. Subsequently, the variable with low variation is the GDP, with a standard deviation of 1.357826.

Furthermore, the minimum values for the GDP, MCS, INU, and FDI are positive, with scores of 0.019, 1.57, 0.587, and 1, respectively. Moreover, the maximum values also show positive values for the variables of GDP, MCS, INU, and FDI, with scores of 6.158, 186.514, 117.086 and 734.01, respectively.

4.2. Empirical results

Table 2 represents the regression results of the OLS, REM, FEM, Huber White Standard Error (HWSE), and Panel Corrected Standard Error (PCSE).

Table 2

Result of the impact of Digitalisation and Foreign Direct Investment on economic growth in the Static Panel model

VARIABLES	Model 1	Model 2	Model 3	Model 4
LMCS	0.645*** (10.94)	0.425*** (6.95)	0.276*** (4.62)	0.645*** (0.04)
LINU	0.379*** (6.66)	0.228*** (4.52)	0.192*** (4.12)	0.379*** (0.03)
LFDI	0.164*** (8.19)	0.017 (0.26)	0.01 (0.94)	0.164*** (0.03)
Constant	-1.627*** (-52.05)	-1.031*** (-15.07)	-0.828*** (-15.02)	-1.627*** (0.02)
Breach-Pagan LM Test	-	856.22*** (0.000)	-	-
Hausman Test	-	-	116.01*** (0.000)	-
Multicollinearity (VIF)	4.86	-	-	-
Heteroskedasticity	-	-	327.33*** (0.000)	-
R-squared	0.914	0.8879	0.8829	0.9151
Observation	224	224	224	224

Note: *, ** and *** indicate the respective 10%, 5% and 1% significance levels. Model 1, 2, 3, and 4: OLS, REM, FEM, and PCSE. Figures in the parentheses are t-statistic (OLS, REM, and FEM). However, parentheses in (PCSE) are standard errors, except for the Breuch-Pagan LM test, Hausman test, and Heteroskedasticity, which are p-values.

Model 1 shows that LMCS, LINU, and LFDI positively impact LGDP and are significant at the 1 per cent level. In other words, increasing the LMCS, LINU, and LFDI by 1 per cent will cause LGDP to increase by 0.645, 0.379, and 0.164 per cent, respectively.

Additionally, model 2 shows that LFDI did not impact LGDP because it is not statistically significant. However, LMCS and LINU positively affect LGDP at a 1 per cent significance level. Indeed, when LMCS and LINU increase by 1 per cent, LGDP increases by 0.425 and 0.228 per cent.

Furthermore, model 3 also shows that LFDI does not affect LGDP because it is not statistically significant. Nevertheless, LMCS and LINU positively and statistically influence LGDP at the 1 per cent significance level. When increasing LMCS and LINU by 1 per cent, LGDP will increase by 0.276 and 0.192.

Here, we use the Breusch-Pagan LM test to compare the more practical uses of OLS and REM in this study. If the P-value is more than 0.05 (5 per cent), we failed to reject the null hypothesis and conclude that

REM was unsuitable. In contrast, if the P-value is less than 0.05 (5 per cent), we reject the null hypothesis and conclude that OLS was unsuitable. The result shows that the significance level (P-value) of the Breusch-Pagan LM test is 0.000, which is less than 0.05 (5 per cent). Therefore, we have to reject the null hypothesis, conclude that OLS regression is inappropriate, and choose the REM.

After comparing OLS and REM and the results, we choose the REM. The next step must compare this with the FEM. The purpose of comparing REM and FEM is to decide which of the two is more appropriate for this study. In this situation, we can continue the next step, which uses the Hausman test to identify the best model between REM and FEM. When the statistical value of the Hausman chi-square test is greater than the critical value or significance level, the P-value is less than 0.05 (5 per cent). The null hypothesis was rejected, indicating that FEM should be used.

In contrast, when the statistical value of the Hausman chi-square test is smaller than the critical value or the significance level of the P-value is more than 0.05 (5 per cent), this will reject the alternative hypothesis, indicating that REM was suitable for use in the study. As a result, the significance level (P-value) of the Hausman test is 0.000, less than 0.05 (5 per cent). Therefore, we can conclude that the REM is not suitable for use in this study and choose the FEM.

Furthermore, the next step is the homoscedasticity test. If the significance level P-value is more than 0.05, we will fail to reject the null hypothesis and conclude that there is homoscedasticity. However, if the significance level p-value is below 0.05, we should reject the null hypothesis and conclude that there is homoscedasticity. The result shows that the P-value of the homoscedasticity test is 0.000. This means that FEM presents the problem of homoscedasticity. Therefore, we use the option of 'robust' to control for the homoscedasticity problem, which is the PCSE. Based on the results of the PCSE model, all variables are statistically significant at the 1 per cent level. Additionally, the result indicates that LMCS, LINU, and LFDI positively affect LGDP. Thus, the equation is shown as:

$$\mathrm{LGDP}_{it} = -1.63 + 0.38\mathrm{LINU}_{it} + 0.65\mathrm{LMCS}_{it} + 0.16\mathrm{LFDI}_{it} + \varepsilon_{it}$$

Lastly, we need to test the multicollinearity of the regression model by using variance inflation factor (VIF). Hair et al. (1995) documented that if the VIF values are below the maximum threshold of 10, the model has no multicollinearity problem. However, if the VIF is more than 10, this means multicollinearity is present. This study has no multicollinearity problem since the result shows that the mean of VIF is less than 10 (4.86 < 10).

Table 3

Result of the impact of Digitalisation and Foreign Direct Investment on economic growth in the Dynamic Panel Model

VARIABLES	First Difference GMM		System GMM	
	(One-step)	(Two-step)	(One-step)	(Two-step)
Lag LGDP	0.7751 (0.0595)***	0.8168 (0.0202)***	0.9698 (0.0311)***	0.9406 (0.0260)***
LINU	0.0887 (0.0508)**	0.1100 (0.0248)***	0.0551 (0.0357)***	0.0629 (0.0285)***
LMCS	0.0705 (0.0481)***	0.0588 (0.0290)***	0.0294 (0.0312)	0.0119 (0.0563)***
LFDI	0.0092 (0.0040)	0.0054 (0.0017)***	0.0094 (0.0038)***	0.0075 (0.0023)***
Constant	-0.0221 (0.0718)***	-0.0985 (0.0512)***	-0.0388 (0.04662)	-0.0728 (0.0471)
Sargan test	163.9329***	14.78097	182.4301***	13.48768
AR(1)	-	-2.6544***	-	-2.6909***
AR(2)	-	-1.0636	-	-0.98682
NxT	192	192	208	208

Note: *, ** and *** indicate the respective 10%, 5% and 1% significance levels.
Figures in the parentheses are standard errors.
NxT is the total number of observations.

Table 3 displays the results of the first difference and system GMM analysis in equation (13). Every model was analysed using one and two steps in the GDP model. Sargan's test failed to reject the null hypothesis, and identified that there is no serial correlation. AR(1) is significant, but AR(2) is insignificant. Thus, both models of the first difference and system GMM are valid or accepted for the two-step method. However, the system GMM exhibits better results as the lagged LGDP coefficient is between the lower and upper limits at 0.9406. Based on system GMM two-step analysis, the LINU, LMCS, and LFDI positively affect the LGDP at a significance level of 1 per cent. In other words, the result implies that an increase in the LMCS, LINU, and LFDI will increase the LGDP. These findings are strongly supported by Lee et al. (2012), Bruegge et al. (2011), Hodrab et al. (2016), Manyika and Roxburgh (2011), Appiah-Otoo and Song (2021), Ahmed and Ibrahim (2019), Sinha and Sengupta (2019), and Shodiev et al. (2021).

We use a basic validity model in the GDP model. The GDP model shows that one-step results from both models of the first difference and System GMM are rejected because Sargan's test failed to reject the null hypothesis, where the chi-square of the first difference GMM is 163.9329. The chi-square of the system GMM is 182.4301, with a probability higher than the chi-square of 0.000 in both models. In turn, the two-step results for both models from the first difference and System GMM are accepted in the GDP model's hypothesis testing. The null hypothesis is rejected in the Sargan test because the chi-square is 14.78097 and 13.48768, respectively.

In the first difference errors, the autocorrelation and serial correlation tests indicate that AR(1) is rejected, whilst AR(2) is accepted in the LGDP stability model and both first difference and system GMM. That is to say, there is no autocorrelation or serial correlation. Consequently, the autocorrelation test shows that the two-step model is more suitable than the one-step model analysis. In conclusion, the two-step system GMM is the best model with which to explain the impact of digitalisation and FDI on economic growth in this study. Thus, the best model we can rewrite as follows.

$$\mathrm{LGDP_{it}} = -0.07 + 0.94 Lag\ LGDP + 0.06\mathrm{LINU_{it}} + 0.01\mathrm{LMCS_{it}} + 0.01\mathrm{LFDI_{it}} + \Delta \mathrm{u_{it}} + \Delta \mathrm{v_{it}}$$

The results show that MCS positively impacts economic growth in this study. The study is similar to Lee et al. (2012), who investigated the impact of mobile cellular on economic productivity in sub-Saharan Africa and identified that MCS positively influences economic growth. The increase in mobile phones has thus led to an increase in economic productivity. Similarly, Bruegge et al. (2011) investigated the relationship between local content, internet development, and access prices on economic growth, documenting that MCS also positively affects GDP.

The literature has also ascertained that INU positively affects economic growth. Similarly, Hodrab et al. (2016) examined the effect of ICT on economic growth from 1995 to 2013. Their results show that INU and economic growth have a positive relationship where an increase in INU causes a resulting increase in economic growth. In addition, Manyika and Roxburgh (2011) examine the impact of the internet on economic growth in the UK, the US, France, and Germany, determining that internet users exert a strong positive impact on economic growth.

Based on these results, mobile cellular and INU have become an essential driver of economic growth in developed countries, facilitating customers' access to deposits and loans, as well as various financial transactions, such as storing and transferring funds or money and paying bills. It also reduces physical limitations and distance and time costs. The internet will deliver significant cost savings in many sectors of the economy, thus accelerating productivity growth. It would also lower prices for consumers, thereby enhancing growth in living standards. Furthermore, many companies, especially those in data-intensive industries such as financial services and health care, can reduce production costs by using Internet technologies. Internet access can also enhance economic development through its impact on the supply and demand side of the economy. For example, Internet-based technology can help workers complete tasks faster and meet higher quality standards. On the demand side, Internet connectivity may affect the ability of buyers and sellers to access markets, as well as the availability and quality of information about the products and services being traded. For instance, consumers can use mobile cellular with the internet to make online purchases locally or nationally, directly boosting the country's economic growth.

Lastly, the FDI result showed that it has a positive and significant impact on GDP in this study. Similarly, Ahmed and Ibrahim (2019) investigated the impact of FDI inflows and outflows on economic growth in developed and developing countries, revealing that the inflow and outflow of FDI in developed countries (the US and the UK) positively impacted GDP. Additionally, Barauskaite (2012) used the OLS method to analyse the relationship between FDI inflow and economic growth (GDP) in Northern European and Baltic Countries. The result also shows that the global FDI inflow is significantly affected by the state of the world economy. In other words, when FDI increases, so too will GDP. Therefore, FDI can stimulate the economic development of target countries, create a more favourable environment for businesses and investors, and stimulate local communities and economies. FDI also creates new jobs and opportunities as investors establish new companies abroad. This can boost local incomes and purchasing power, promoting the target economies' overall development.

5. CONCLUSION AND RECOMMENDATION

This study examines the impact of digitalisation and FDI on economic growth in developed countries. In conclusion, using static and dynamic panel models, our results find that MCS, INU, and FDI positively impact economic growth in these 16 developed countries. Therefore, digitalisation and FDI play essential roles in the economic growth of developed countries in the 21st century. This study thus contributes to understanding the impact of digitalisation and FDI on economic growth in the selected developed countries with different models, namely static and dynamic panel models. The primary limitation of this study was its failure to collect data over a more extended period and for other developed countries. Therefore, future research could examine the impact of digitalisation and FDI on economic growth in all developed countries for extended periods to enhance the literature. This study concludes that governments should develop several policies and programmes to enhance economic growth in digitalisation and FDI.

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Authors' contributions

All authors contributed to the study conception and designed the research. All authors developed the research question and objective of the manuscript. SUHAL KUSAIRI and WONG ZUN YUAN performed data collection and analysis. SUHAL KUSAIRI and WONG ZUN YUAN wrote the first draft of the manuscript. RATRI WAHYUNINGTYAS and MUHAMMAD NAJIT SUKEMI commented on previous versions of the manuscript. SUHAL KUSAIRI, RATRI WAHYUNINGTYAS, and MUHAMMAD NAJIT SUKEMI read, supervised the research progress and approved the final version of the manuscript.

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The authors agree and declare that the manuscript was conducted without any self-interested and financial conflicts.

Consent to participate

Applicable.

Consent for publication

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