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Effect of Digital Infrastructure on Foreign and Local Direct Investment: A Case Study of Jordan during 2005–2020

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Abstract

The research investigates the impact of digital infrastructure on foreign and local direct investment in Jordan spanning from 2005 to 2020. Through the application of the autoregressive distributed lag model and utilizing indicators from the World Bank encompassing investments in Information Technology and Telecommunication Services, Smartphones subscription ratio, internet usage ratio, and fixed telephone subscription ratio, this study aimed to quantify the effects of digital infrastructure during the specified timeframe. Analysis of the data revealed a statistically significant positive correlation between digital infrastructure and local investment. Notably, the study unveiled a substantial positive relationship between the independent variables representing digital infrastructure investments and local investment in both short and long terms. Furthermore, the research highlighted a statistically significant positive association between digital infrastructure and foreign direct investment, emphasizing the importance of digital advancements in attracting foreign investments. Particularly in the long term, investments in Information Technology and Telecommunication Services, Smartphones subscription ratio, internet usage ratio, and fixed telephone subscription ratio were found to have a positive impact on foreign direct investment. The short-term analysis underscored a significant positive relationship between the internet usage ratio and foreign direct investment. This study provides a quantitative estimation of the influence of digital infrastructure on local and foreign direct investment in Jordan, offering valuable insights for strategic decision-making within the realm of investment during the digital transformation era.

Keywords: digital infrastructure internet connectivity, investment patterns, investment in Information Technology, Telecommunication Services, internet usage ratio.

Introduction

Digital infrastructure has garnered significant attention due to its impact on countries worldwide, especially their economic sectors. It is considered as crucial as physical infrastructure and a necessary complement to a country's overall infrastructure, exerting a substantial influence on the economy. Presently, international organizations, particularly the World Bank, are focusing on digital infrastructure, which is a global concern, particularly in developing nations like Jordan. Additionally, the World Bank provides comprehensive statistics and indicators for countries globally through its data platform. These indicators encompass Technology and Telecommunication Services (ITS), Smartphone subscription ratio (MCS), internet usage ratio (IU), and fixed telephone subscription ratio (FTS) (World Bank Open Data, 2024). On the other hand, various researchers such as Reynolds et al. (2004), Shah and Khan (2019), and Zhanga et al. (2024) have highlighted the positive correlation between improvements in Information and Communication Technology (ICT) infrastructure and increased investment and economic growth in advanced economies. Furthermore, good infrastructure reduces administrative costs, streamlines operations, and enhances efficiency. Addressing expensive capital and horizontal expenses lowers operational and maintenance costs. Advanced infrastructure simplifies processes, reduces bureaucracy, enhancing efficiency and service quality. Therefore, the study specifically examines digital infrastructure using four indicators provided by the World Bank and does not analyze physical infrastructure and its components. It is confined to studying Jordan as a developing country in Western Asia.

Indeed, the analysis covers the period from 2005 to 2020, utilizing data from the ITU, Department of General Statistics, and Central Bank of Jordan. Recent economic and digital initiatives in Jordan aim to foster growth and digital services, emphasizing the necessity of addressing disparities in digital infrastructure and their repercussions on various sectors, local and foreign investments, and overall development. The study seeks to answer the following questions:

1. Does investment in Information Technology and Telecommunication Services have a positive impact on foreign and local direct investment in Jordan?

2. Does the smartphone subscription ratio have a positive impact on foreign and local direct investment in Jordan?

3. Does the internet usage ratio have a positive impact on foreign and local direct investment in Jordan?

4. Does the fixed telephone subscription ratio have a positive impact on foreign and local direct investment in Jordan?

In essence, this study delves into the influence of digital infrastructure on foreign and domestic investments in Jordan spanning from 2005 to 2020. It anticipates a positive correlation, show casing how digital infrastructure can bolster both local and foreign investments. Moreover, the research offers valuable insights into the practical applications of digital technology in the economy, bridging crucial gaps in existing literature for investors, policymakers, and researchers.

Literature review and the hypothesis developers

The influence of digital infrastructure on foreign and domestic investments has emerged as a notable and significant study area. The UK, Sweden, New Zealand, and Singapore are leading in digitalization, offering comprehensive e-services. Sweden and Singapore particularly excel in high internet usage rates and widespread adoption of electronic services. In contrast, the Philippines lags in e-governance, while India grapples with challenges stemming from limited internet access, underscoring the imperative for digital adaptation in the Fourth Industrial Revolution (Gąsiorkiewicz & Monkiewic, 2023).

Initially, investment in Information Technology and Telecommunication Services (ITS) refers to annual spending by entities providing communication networks, covering fixed and mobile services, internet, and TV signal transmission. This investment focuses on acquiring or enhancing fixed assets (capital expenditures). The International Telecommunication Union (ITU, 2024) indicates that countries with greater telecommunication capital expenditure usually have more advanced digital infrastructure.

Multiple studies have consistently demonstrated a positive correlation between digital infrastructure and actual investment. Reynolds et al. (2004) found a relationship between the level of wired and wireless communication infrastructure in developing countries and FDI flows. Their study revealed that improving digital infrastructure leads to increased FDI flows. Similarly, Shah and Khan (2019) conducted a study in developing countries underscoring the positive impact of digital infrastructure. Zhang et al. (2024) conducted a study in 270 Chinese cities from 2012 to 2019 and found that digital upgrades were linked to FDI growth in low-income areas, with a limited impact in richer cities. Additionally, Pradhan et al. (2017) conducted a study across 21 Asian countries highlighting the connection between communication infrastructure, FDI, and economic growth. It emphasizes boosting competitiveness through ICT across sectors. Similarly, Mbiankeu (2020) analyzed the telecom sector in Cameroon and showed a positive influence on FDI. Wang and Gul Rukh Bangash (2021) studied D8 countries (Bangladesh, Indonesia, Iran, Egypt, Nigeria, Malaysia, Pakistan, Turkey) from 1997 to 2018, revealing a positive influence of ICT infrastructure on foreign direct investment flows. In a similar vein, Chang (2021) conducted a study on China's digital economy, FDI, and labor market, showing that the digital economy boosts the impact of FDI on employment, especially in services. On the contrary, Fakher (2016) identified a weak connection between ICT investment and FDI in Egypt, primarily due to the country's insufficient ICT infrastructure. This underscores the importance of improving Egypt's ICT sector and increasing investments. Osei (2024) conducted a study across 28 African nations from 2011 to 2019, revealing a positive correlation between digital infrastructure and innovation. This study emphasized how innovation enhances the synergy between digital infrastructure and human capital. Additionally, Obute et al. (2018) analyzed the effect of Foreign Direct Investment (FDI) in Nigeria's telecommunications sector on long-term economic growth from 1981 to 2014. Their findings unveiled a positive correlation between FDI in the telecom sector and economic growth. According to Wang et al. (2023), digital infrastructure enhances firms by improving digital capabilities (core, operational, integration). Business model innovation positively influences firms, with digital capabilities further amplifying this effect. Masoud and Basahel (2023) found that digital transformation, customer experience, and technological innovation have a positive influence on companies. Similarly, Senadjki (2023) conducted a study in Malaysia and discovered that Digital Transformation (DT) and a green organizational culture positively affect companies' financial performance. Van de Wetering et al. (2018) investigated the relationship between technological and informational infrastructure, identifying a positive correlation between information technology infrastructure and digital capabilities. Moreover, Shin (2001) discovered that increased investment in information technology and communications enhances net profit and supports investment decision-making. Abou-Foul et al. (2020) conducted a study on 185 industrial companies in the US and Europe, measuring the impact of digital transformation (DT) on financial performance. Their findings show that DT positively influences revenue, profitability, market value, and boosts investment. Mahssouni et al. (2023) examined the effects of COVID-19 and digital transformation on European publicly traded companies. They found that COVID-19 adversely affected financial performance, while digital transformation positively impacted financial and investment outcomes. Galindo-Martín et al. (2019) explored the impact of digital upgrades on companies' future financial performance. They concluded that enhancing social networks, using them for corporate objectives, and advanced digital training enhance financial and investment outcomes. Toader et al. (2018) conducted a study on the impact of Information and Communication Technology (ICT) infrastructure on EU growth from 2000 to 2017, revealing a positive correlation with various tech effects. This highlights the crucial roles of ICT infrastructure and economic factors in promoting growth throughout the region.

Secondly, the indicator is the Smartphone Subscription Ratio (MCS) (per 100 people) in a specific country or region. This number is calculated by dividing the number of mobile phone subscriptions by the population and then multiplying it by 100 (ITU, 2024). On the other hand, this indicator assesses the prevalence of mobile phones and access to wireless communication services, enhancing communication, connectivity, access to economic information, and business efficiency. Additionally, smartphones foster entrepreneurship and innovation (Brown et al., 2020; Roessler et al., 2018). Several studies have established a relationship between smartphone usage and investment. Brown et al. (2020) conducted a study that linked smartphone use with investor decisions, particularly when evaluating press releases. The findings reveal that smartphones significantly influence how investors assess news, highlighting their increasing importance in research and investment choices. In a related context, Gulbrandsen and Simensen (2024) explored smartphone data usage in tracking the spread of COVID-19. They discovered non-linear innovation in companies driven by interactions, emphasizing the potential of mobile data for epidemic control. Khan et al. (2022) research demonstrates that smartphones and the internet boost agricultural sales, increasing farmers' income, with internet use positively impacting investments

Thirdly, the Internet Usage Ratio (IU) is an indicator that assesses the proportion of internet users within a specific country or region's total population. This metric is calculated by dividing the number of internet users by the total population and then multiplying by 100 (ITU, 2024). The IU is crucial for evaluating internet penetration and dependency, reflecting technology access and digital competencies. For example, a study by Yin and Choi (2021) in Asia revealed a two-way relationship between internet usage and Foreign Direct Investment (FDI) in South Asia, while showing a one-way connection from the internet to FDI in East Asia. Similarly, the OECD study in 2012 highlighted the internet's impact on economies, improving efficiency, markets, consumer welfare, and governance. It underscored the internet's role in economic progress, emphasizing the importance of policies that promote connectivity and internet usage.Moreover, Choi (2003) conducted research on the internet's influence on FDI inflows through regression analysis, demonstrating a positive correlation. As a result, a 10% increase in internet users or hosts in the host country correspond to a 2% rise in FDI flows. Other studies have explored the impact of digitalization on banks' financial performance. For instance, Jha (2022) found a positive association between online electronic transactions and the operational efficiency of Indian banks. Additionally, Theiri and Hadoussa (2023) illustrated the benefits of investing in digital payment tools for the performance of Tunisian banks, emphasizing the role of digitalization in improving financial performance and supporting investment decisions.

Finally, the Fixed Telephone Subscription Ratio (FTS) indicator, which evaluates the number of fixed telephone subscriptions per 100 individuals in a specific country or region, is of significant importance. Calculated by dividing the fixed telephone subscriptions by the population and multiplying the result by 100 (ITU, 2024), this indicator assesses global fixed telephone usage, a crucial factor for evaluating technology and telecommunications. Higher values indicate advanced infrastructure and widespread access to communication services. (Alawneh .2023).

The study conducted by Alawneh (2023) demonstrated a statistically significant positive correlation between individuals' ownership of smartphones and fixed phones and the financial development index, specifically the ratio of money supply to GDP.. Zhai and Kam (2022) studied the impact of digital technology on Chinese companies from 2009 to 2019, showing enhanced performance. Digital technology enhances efficiency, reduces costs, promotes innovation, and encourages business investment. Moreover, Farhadi and Ismail (2014) conducted a study connecting ICT access with per capita GDP growth, emphasizing the importance of policies that enhance technology access to support economic growth, investment, and development.

Ultimately, previous studies have delved into the impact of infrastructure on both domestic and foreign investments, revealing a positive correlation between infrastructure and the growth of investment companies in most countries. However, this relationship may be less positive or even negative in certain countries. Furthermore, studies exploring the overall effect of digital infrastructure on company growth have suggested a positive correlation between infrastructure and company growth. In general, the impact of digital infrastructure on companies and their investment and financial growth is influenced by various factors, such as the country under study, the infrastructure indicators used, and the economic and political conditions. Therefore, the current study stands out by considering the infrastructure variables mentioned by the World Bank and employing different analytical approaches and testing models that have not been previously considered. Overall, the findings of the reviewed literature highlight the importance of infrastructure, particularly digital infrastructure, in facilitating company growth and investment. However, specific outcomes can vary depending on the context and specific factors involved.

In conclusion, this study confirms the following hypotheses in a more coherent manner: This study provides evidence supporting several hypotheses Firstly, Hypothesis: There is a statistically significant positive effect between investment in Information Technology and Telecommunication Services on foreign and local direct investment in Jordan. Secondly, Hypothesis: There is a statistically significant positive effect between the smartphone subscription ratio on foreign and local direct investment in Jordan. Thirdly, Hypothesis: There is a statistically significant positive effect between internet usage on foreign and local direct investment in Jordan. Fourthly, Hypothesis: There is a statistically significant positive effect between the fixed telephone subscription on foreign and local direct investment in Jordan.

Methodology

The data was analyzed to explore the correlation between digital infrastructure and investment in Jordan. Independent variables included telecom investment, smartphone subscriptions, internet usage, and fixed-line subscriptions (ITU, 2005–2020). The dependent variables were FDI and local investment (Department of Statistics, Central Bank). Additionally, the ARDL model was used in this study to address small sample sizes. Before estimating the standard model, a time series analysis was conducted. The stationarity of the time series was assessed using unit root tests, particularly the Augmented Dickey-Fuller (ADF) test. Moreover, the ADF test assumes that the time series is generated by an autoregressive process and can be estimated accordingly.

$$\Delta Yt = \mu + \lambda Yt - 1 + \varepsilon$$

Selecting the right lag in unit root tests is crucial. The AIC in the ADF test determines the optimal lag. Accepting no unit root implies variable stationarity. If a series is stable in the first difference, it is first-order integrated. This complicates establishing long-term relationships between variables. Therefore, the ARDL model is known for its applicability to small-sized samples and its ability to incorporate variables with different levels of stability, such as I(0) and I(1). Not all variables need to be stationary at the same level. However, this model is ineffective when a series is integrated of order 2 or I(2) (Al-Roub, 2021). On the other hand, the error correction model (ECM), also known as the linear ECM, assesses the model's ability to return to equilibrium following unforeseen shocks. By addressing autocorrelation, the ECM enhances

ARDL model estimates, making them efficient and unbiased. Criteria such as AIC or the Schwarz Bayesian criterion (SBC) are used to determine the co-integration order, ensuring a balance between data interpretation and model simplicity. In the context of model estimation, OLS aims to estimate the correlation between independent and dependent variables by minimizing the difference between actual and predicted values. Additionally, the bound test evaluates the overall relationship in an ARDL model, identifying when independent variables impact the dependent variable. This test scrutinizes the combined integration of variables based on two hypotheses:

1. Null hypothesis: It posits no joint relationship (indicating no long-term equilibrium relationship).

2. Alternative hypothesis: It assumes a joint relationship (suggesting a long-term equilibrium relationship).

Therefore, these hypotheses are tested using critical bounds. The lower critical bound (LCB) provides evidence of no joint integration (no long-term equilibrium relationship) in the case of I(0) integration. On the other hand, the upper critical bound (UCB) offers evidence of co-integration (long-term equilibrium relationship) for I(1) integration. If the F-test value falls between the LCB and UCB, it indicates co-integration, leading to acceptance of the alternative hypothesis. However, if the F-test value falls outside this range, the alternative hypothesis may be rejected, and the null hypothesis is favored.

Hypothesis may be rejected, and the null hypothesis is favored.

Results

Descriptive Statistical Analysis of Study Variables

The study utilized descriptive statistics to analyze data from 2005 to 2020, encompassing mean, standard deviation, range, highest and lowest values, and coefficient of variation. The subsequent outcomes are presented below.

FDI

The results from Appendix No (2): Table 2 indicate that the average FDI is 1,300.663 million JD, with a standard deviation of 535.5236. The highest value was recorded in 2006 at 2,512.700 million JD, whereas the lowest value was observed in 2019 at 518.1000 million JD. FDI exhibits instability because of the high coefficient of variation of 41.17%. The overall trend equation in Appendix No (3): Table 3 confirms a significant annual decline of 6% in FDI. Indeed, this downward trend is also depicted in Appendix No (4): Figure 1: illustrating the decline of FDI in Jordan over time. The reasons for this decline can be attributed to the geopolitical tensions surrounding the kingdom impacting foreign investment. (Jordanian Businessmen Association, 2019).

Local Investment (LI)

The results from Appendix No (2) : Table 2 indicate that the average local investment in Jordan is 5,273.394 million JD, with a standard deviation of 1,054.477. The maximum value was reached in 2018 at approximately 6,279.000 million JD, whereas the minimum value was around 3,025.400 million JDin 2006. Local investment is characterized by stability because of a low coefficient of variation of 19%. The general trend equation in Appendix No (3): Table 3 suggests an increasing trend in local investment over time, with a statistically significant annual growth rate of 3%. Undoubtedly, this outcome is further supported by the graphical representation in Appendix No (5): Figure 2:, which shows the upward trend of local investment in Jordan over time. This upward trend is attributed to various economic improvements in Jordan, such as infrastructure enhancements, tax reductions, skilled workforce. In addition, the growth of promising sectors, particularly the technology sector, encourages local investors to engage in investment.

Investment in Information Technology and Telecommunication Services (ITS)

The results from Appendix No (2) : Table 2 indicate that the average investment in information technology and telecommunication services in Jordan is 185 million JD, with a standard deviation of 61,945,264. The maximum value was recorded in 2010 at around 247 million JD, whereas the minimum value was approximately -23,229,100 dinars in 2016. The investment is characterized by instability, as indicated by the high coefficient of variation of 33%. The statistical significance of the investment values in information technology and telecommunication services over time is not observed in Appendix No (3): Table 3. Certainly, this outcome is further confirmed by the chart in Appendix No (6): Figure 3: which illustrates the fluctuation in investment values in ITS over time in Jordan. This fluctuation is attributed to the intense competition among multiple telecommunications companies in Jordan, leading to significant volatility in investment in this sector.

Smartphones (MCS)

The findings from Appendix No (2) : Table 2 indicate that the average usage rate of smartphones in Jordan is 55.25546 million JD, with a standard deviation of 26.56637. The highest value was recorded in 2010 at approximately 247 million JD, whereas the lowest value in 2016 was 55.25546 million JD. These rates demonstrate stability, as evidenced by the low coefficient of variation of 27%. The statistical significance of smartphone usage is not indicated in Appendix No (3): Table 3. In fact, this outcome is further supported by Appendix No (6): Figure 4, which depicts the fluctuation of smartphone over time in Jordan. This fluctuation is attributed to the high costs associated with utilizing advanced smartphones and telecommunication services for certain individuals as well as the elevated prices of smartphones that may serve as a barrier for some individuals.

Internet Usage (IU)

The results from Appendix No (2) : Table 2 indicate that the average internet usage rate in Jordan is 41%, with a standard deviation of 27%. The highest value was recorded in 2020 at approximately 78%, whereas the lowest value in 2005 was 12%. These percentages indicate slight instability, as evidenced by the slight increase of 48% in the coefficient of variation. The general trend equation in Appendix No (3): Table 3 shows a statistically significant annual growth rate of 11% for the percentage of individuals using the internet in Jordan. Indeed, this outcome is further supported by the chart in Appendix No (8) Figure 5 , which illustrates the increasing trend of internet usage among individuals in Jordan over time. This growth is attributed to the expansion of the telecommunications infrastructure in Jordan to meet the rising demand for internet access in various economic and social activities in the country.

Fixed Telephone Subscription (FTS)

The information presented in Appendix No (2) : Table 2 indicates that the average rate of fixed telephone subscriptions in Jordan is 6%, with a standard deviation of 2.5%. The highest value was recorded in 2005 at approximately 11%, whereas the lowest value was 3.3% in 2019. These percentages exhibit instability, as evidenced by the significant increase of 64% in the coefficient of variation. The general trend equation in Appendix No (3): Table 3 suggests a statistically significant annual decline rate of 7% for fixed telephone subscriptions in Jordan. This finding is further supported by the chart in Appendix No (9) Figure 6:, which illustrates the decreasing trend of FTS in Jordan over time. This decline is attributed to the shift toward wireless communications, such as smartphones, as well as technological advancements, DT, and increased usage of digital solutions and applications. This shift diminishes the importance of fixed telephones (Jordanian Businessmen Association, 2019).

Unit Root Test Results

Analysis of the unit root test results (URT) from Appendix No. 10, Table 3 and the ADF test. FTS is stationary at its levels (I(0)), while FDI, LI, ITS, MCS, and IU are non-stationary at levels but become stationary after differencing (I(1)). This indicates potential co-integration testing. The variables' stationarity conforms to the conditions of the ARDL model, accommodating both I(0) and I(1) variables.

Co-integration Test

After conducting the (URT) for the study variables' time series and determining the degree of integration for each variable, we concluded that the time series of the variables exhibit different degrees of co-integration. To verify the presence of a long-term co-integrating relationship among the study variables, the ARDL bound test for co-integration is employed. The test results in Appendix No (11): Tables 4 and Appendix No (12): Tables 5 indicate that the computed F-statistics are approximately 7.863814 and 28.92415, respectively. Comparing these values to the critical values at significance levels of 1%, 5%, and 10%, we find that both values exceed the upper bounds. This finding implies the rejection of the hypothesis suggesting no co-integration and the acceptance of the alternative hypothesis indicating the presence of a long-term co-integration and an equilibrium relationship between the independent variables and dependent variables.

Standard Estimation of the Effect of Digital Infrastructure on FDI

Thus, conducting unit root and co-integration tests, the ARDL model was used to assess the impact of digital infrastructure on FDI and local investment, considering short- and long-term effects. In Appendix 13: Table 6, estimation results for this impact are provided. The AIC criterion guided model selection. The ARDL (2, 0, 1, 0, 0) model was chosen for the effect of digital infrastructure on FDI, and the ARDL (2, 1, 1, 1, 1) model was selected for local investment. These models meet standard criteria for statistical reliability. A Lagrange multiplier test confirmed no autocorrelation in residuals. Breusch-Godfrey test results indicated no significant autocorrelation. Significance levels for the FDI and local investment models were 0.1532 and 0.3749, respectively, exceeding the 0.05 threshold. The Breusch-Pagan-Godfrey test supported the assumption of homoscedasticity. Varying variance is not an issue. The test statistic values for the first model related to FDI and the second model related to local investment are 0.1851 and 0.3749, respectively, which exceed the significance threshold of 0.05. Subsequently, the Ramsey RESET test was used to test the validity of the standard models. The test statistics for the first model related to FDI and the second model related to local investment are 0.3995 and 0.8730, respectively, which are greater than the significance level of 0.05. This outcome indicates the statistical validity of the models and their suitability for inference. Meanwhile, the normality assumptions were verified using the Jarque–Bera test. The test value for the first model related to FDI is 0.536972 with a probability of 0.734536. For the second model related to local investment, the value is 0.175126 with a probability of 0.916161. These values suggest that the residuals follow a normal distribution at a significance level of 5%.

The Overall, appendix No (14): Table 7 presents the standardized estimation of the impact of infrastructure on FDI using the ARDL method. The table reveals that the sign values of all variables align with economic theory, confirming the statistical significance of all independent variables in influencing FDI. A statistically significant correlation at a 1% significance level is observed between investment in telecommunication services two years ago (ITS(-2)) and FDI. This finding means that a 100% increase in telecommunication services two years ago leads to a 3.13E-09 increase in FDI. A weak A statistically significant correlation at a 10% significance level is observed between the percentage of smartphone subscriptions three years ago (MCS(-3)) and FDI. This outcome means that a 100% increase in smartphone subscriptions three years ago results in a 0.10% increase in FDI. A statistically significant correlation at a 5% significance level is observed between the percentage of internet usage two years ago (IU(-2)) and FDI. This result means that a 100% increase in internet usage two years ago leads to a 4% increase in FDI. Additional, A statistically significant correlation at a 5% significance level is observed between the fixed telephone subscription ratio two years ago (FTS(-2)) and FDI. This result means that a 100% increase in telephone subscription ratio two years ago leads to a 3.6% increase in FDI.

In the same way, appendix No (15): Table 8 presents the results of estimating the short-term effect, indicating a statistically significant positive relationship at a 1% significance level between foreign investment in the previous period and foreign investment in the current period. It also reveals a statistically significant positive relationship at a 1% significance level between internet usage in the two previous periods and foreign investment. The error correction coefficient, CointEq (−1), should be statistically significant and have a negative sign to detect the presence of co-integration among the variables. The negative sign and statistical significance of the absolute value of the error correction coefficient align with standard economic theory. The magnitude of the error correction coefficient, around -0.6790, suggests that about 67.90% of any disparities and imbalances in the explanatory variables' equilibrium from the prior year are rectified in the current year.

Likewise, appendix No (16): Table 9 presents the results of estimating the long-term effect, revealing a statistically significant positive correlation at a 5% significance level between the independent variables of infrastructure (telecommunication service investment, mobile phone subscription ratio, internet usage ratio, and fixed telephone subscription ratio) and FDI in Jordan. Forecasting the development of economic phenomena is an important objective in econometrics. By studying the evolution of a phenomenon over time and analyzing the effect of various factors on it, we can determine its trajectory in the future. This prediction helps in planning, monitoring, and making economic decisions. Time plays a crucial role in this context as it allows the establishment of connections between the development of a phenomenon and the specific time period in which it occurs and the prediction of future developments. However, time is not the sole factor that influences economic phenomena. Other factors, such as economic conditions, political dynamics, technological advancements, demographic shifts, and global changes, also play crucial roles. Therefore, economic phenomena should be studied comprehensively, considering the effect of various factors, including time and other influential elements, on their development. By doing so, we can achieve accurate forecasting of these phenomena and utilize this knowledge in planning and making informed economic decisions.

Testing the Predictive Ability of the ARDL Model to predict FDI.

The results of the tests in Appendix No (17): Figure 7 indicate the predictive ability of the estimated model for forecasting the values of FDI. The root mean square error (RMSE), mean absolute percentage error (MAPE), and mean absolute error (MAE) show low values. indicate the model's predictive accuracy. Additionally, the Theil inequality coefficient (U) approaching zero suggests the model's predictive power, and the forecasted values closely align with the actual values.

Standard Estimation of the Effect of Digital Infrastructure on local investment

To sum up, evident from Appendix No (18): Table 10, all coefficient signs of the indicators align with economic theory, confirming the statistical significance of all independent variables in influencing local investment. A significant positive correlation at a 1% significance level exists between investment in telecommunication services and local investment. A 100% increase in telecommunication services leads to a 4.84E-06 increase in local investment. A significant positive correlation at a 1% significance level exists between the percentage of smartphone subscriptions in the past three years (MCS(-3)) and local investment. A 100% increase in smartphone subscriptions in the past three years leads to a 15.32517 increase in local investment. A significant positive correlation at a 5% significance level exists between the percentage of internet usage (IU) and local investment. A 100% increase in internet usage leads to an 83.95558 increase in local investment. A significant positive correlation at a 5% significance level exists between the percentage of fixed telephone subscriptions and local investment. A 100% increase in fixed telephone subscriptions leads to a (5995.427) increase in local investment.

Similarly, appendix No (19): Table 11 presents the results of estimating the short-term effect, showing a statistically significant positive correlation at a 1% significance level between the independent variables of infrastructure (telecommunication service investment, mobile phone subscription ratio, internet usage ratio, and fixed telephone subscription ratio) and local investment. Furthermore, the table shows that the error correction coefficient, CointEq (−1), is statistically significant and negative, indicating the presence of co-integration among the variables. The negative and statistically significant sign of the absolute value of the error correction coefficient confirms the statistical and econometric rationale, with an absolute value of approximately (−1.403021) and statistical significance at the 1% level. In the current year, approximately 1.4% of the deviations and imbalances in the equilibrium of explanatory variables from the prior year are rectified.

Comparatively, appendix No (20): Table 12 presents the results of estimating the long-term effect, showing a statistically significant positive correlation at a 5% significance level between the independent variables of infrastructure (telecommunication service investment, mobile phone subscription ratio, internet usage ratio, and fixed telephone subscription ratio) and local investment in Jordan.

Testing the Predictive Ability of the ARDL Model to predict LI4.6

The results of the tests in Appendix No (21): Figure 8 indicate the predictive ability of the estimated model for forecasting the values of local investment. The low values of RMSE, MAPE, and MAE suggest that the model has good predictive accuracy. Additionally, the Theil inequality coefficient (U) approaching zero suggests the model's predictive power, and the forecasted values closely align with the actual values.

Discussion

Research by Shah and Khan (2019), Zhang et al. (2024), Pradhan et al. (2017), Mbiankeu (2020), Wang and Gul Rukh Bangash (2021), and Osei (2024) emphasizes the critical role of digital infrastructure in enhancing local investments and attracting foreign capital. These studies highlight the significance of investing in digital infrastructure, smartphone usage, internet accessibility, and fixed phone subscriptions to stimulate both domestic and international investments. Furthermore, understanding the interconnected relationship between digital infrastructure indicators and investment is crucial for economic decision-makers, investors, and firms to enhance investment strategies and facilitate local and foreign investment growth. Emphasizing smartphone indicators is particularly significant. Brown et al. (2020) emphasize the critical role of smartphones in investment decisions, influencing how investors assess information, whether positive or negative. Moreover, the study indicates that internet usage and smartphone adoption positively impact both local and foreign investments. These results align with Khan et al.'s (2022) work, which highlights the importance of the internet and smartphones in agricultural investments and income growth in this sector. Similarly, Yin and Choi (2021) emphasized a two-way relationship between internet usage and foreign direct investment, consistent with Choi's (2003) emphasis on the internet's role in attracting foreign investments. Additionally, the OECD study in 2012 stressed the importance of internet usage in improving efficiency, fostering business growth, and enhancing societal well-being, directly impacting a country's overall economic progress. In addition, this study investigates the impact of digital infrastructure on local and foreign investments in Jordan. It conducts a thorough analysis using key digital infrastructure indicators, drawing on data from the World Bank and previous research. The study emphasizes the role of digital infrastructure through ARDL analysis in the short and long term. Subsequently, ARDL is chosen for its suitability with small sample sizes and its ability to handle variables with different stability levels, as shown by the Error Correction Model (ECM), which assesses the model's ability to return to equilibrium after unexpected disruptions. Meanwhile, analyzing the impact of digital infrastructure on local and foreign investments in Jordan through spending, smartphone usage, and internet access enhances local investment, attracts foreign capital, and supports investors in the digital era. Quantitative data and statistics provide insights for improving infrastructure and guiding investments. At the same time, stakeholders benefit significantly, emphasizing the crucial role of digital infrastructure in attracting both local and foreign investments. Ultimately, digital infrastructure enables investors and firms to use key technologies in finance, like blockchain, AI, machine learning, social media, cybersecurity, fostering advancements, innovation, and entrepreneurship in financial tech, as well as in local and foreign investments. In Jordan, digital infrastructure and culture may differ from that of other countries, affecting the development of digital systems and the acceptance of digitization in new investments. This disparity could influence the laws, regulations, and compliance requirements needed to advance digital infrastructure. Consequently, digital capabilities and infrastructure availability differ by region in Jordan, depending on location and industries. To stimulate investments, developing digital infrastructure requires cybersecurity applications and regulations to enhance trust and drive growth, necessitating support and enhancement. Therefore, future research will explore trends, potential areas, and implications for investigating financial technology's impact on economic growth. It will focus on smartphones, the internet, AI, machine learning in investments, and social media's influence on new investment ideas globally. Studies may look into digital financial advice's effect on local and foreign investments and analyze digital tools on investment dynamics in Jordan.

Conclusion

The results of this study have two main elements. First, infrastructure indicators were used based on World Bank indicators. Second, the focus was primarily on foreign and local investment in Jordan, which previous studies neglect. Previous studies often focus on the effect of certain infrastructure indicators on economic variables, specific economic sectors, or the financial performance of banks and other services.

Based on the findings, a statistically significant positive correlation exists between investment in telecommunication services and FDI. The analysis also shows a statistically significant positive correlation between investment in telecommunication services and long-term local investment. These findings support the hypothesis of a statistically significant positive effect between investment in telecommunication services and both foreign and local investment. They align with economic and financial theories and studies in this regard.

In addition, the analysis shows a statistically significant positive relationship between the smartphone subscription rate and both FDI and local investment. Additionally, the analysis reveals a statistically significant positive correlation between the smartphone subscription rate and both foreign and local investment in the long and short terms. These findings support the hypothesis of a statistically significant positive effect between the smartphone subscription rate and both foreign and local investment. These findings align with economic and financial theories and studies in this regard.

Moreover, the analysis indicates a statistically significant positive relationship between the internet users' rate and both FDI and local investment. The analysis also demonstrates a statistically significant positive correlation between the internet users' rate and both foreign and local investment in the long and short terms. Therefore, the hypothesis of a statistically significant positive effect between the internet users' rate and both FDI and local investment is accepted, aligning with economic and financial theories and studies in this regard.

Furthermore, the analysis shows a statistically significant positive correlation between the fixed telephone subscription rate and both FDI and local investment. The analysis also reveals a statistically significant positive relationship between the fixed telephone subscription rate and both foreign and local investment in the long and short terms. Thus, the hypothesis of a statistically significant positive effect between the fixed telephone subscription rate and both FDI and local investment is accepted, aligning with economic and financial theories and studies in this regard.

The conclusions of this study suggest the need to expand the use of digital tools and increase investment in digital infrastructure, specifically in telecommunication services, to stimulate growth in economic sectors. Decision makers should support the utilization of digital tools, and governments should invest in digital infrastructure to enhance both local and foreign investment, ultimately achieving desired economic growth in the country. Enhancing digital infrastructure enhances efficiency and attracts investments. Expand local infrastructure, provide digital training, upgrade systems to attract funds. Prioritize telecom and IT for improved infrastructure and investments. Align investment policies with digital growth for both local and foreign investments. Utilize digital tools in these sectors. Use apps, the internet, and landlines for efficiency. Employ digital tools such as investments, finance, payments, and consultations to enhance competitiveness.

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Appendix 1

Table (1) : Data on study variables during 2005–2020

Year	FDI**	LI*	ITS***	MCS***	IU***	FTS***
2005	1407	3047	2.19E+08	55.25545854	12.93285	11.05919239
2006	2512.7	3025.4	2.19E+08	71.48490967	13.86711	10.10608426
2007	1859.1	3671.9	1.64E+08	73.71087407	20	8.63526376
2008	2005.7	5068	1.62E+08	80.10953926	23	7.824512847
2009	1713.3	5355	2.47E+08	88.70102642	26	7.392354419
2010	1198.9	5944	2.47E+08	95.50935775	27.2	7.004918876
2011	1,055.00	5963	2.00E+08	105.2402538	34.9	6.545559903
2012	1,074.30	5463	2.03E+08	124.5760215	37	6.023921974
2013	1,281.20	5468	1.94E+08	134.0380157	41.4	4.917740702
2014	1,546.70	5816	2.25E+08	128.1170096	46.2	4.336819963
2015	1,136.20	5981	1.85E+08	145.3297924	54.22	3.88591153
2016	1,102.60	5676	-2.32E+07	98.53271402	56.15	4.055453595
2017	1,182.00	5952	1.57E+08	94.98702055	64.5	3.49671701
2018	678	6279	1.91E+08	83.47869848	65.2	3.52915611
2019	518.1	5804	1.77E+08	72.70773421	70.08467	3.323184732
2020	539.80	5861	1.89E+08	63.94061117	78.4178	3.58217581

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Appendix No (2) : Table 2: Descriptive statistics

Descriptive Analysis	**FDI**	**LI**	**ITS**	**MCS**	**IU**	**FTS**
Mean	1300.663	5273.394	1.85E+08	94.73244	41.94203	5.982435
Median	1190.450	5740.000	1.93E+08	91.84402	39.20000	5.470831
Maximum	2512.700	6279.000	2.47E+08	145.3298	78.41780	11.05919
Minimum	518.1000	3025.400	-23229100	55.25546	12.93285	3.323185
Std. Dev.	535.5236	1054.477	61945264	26.56637	20.91060	2.497217
Coefficient of variation	41%	19%	33%	27%	48%	41%
Observations	16	16	16	16	16	16

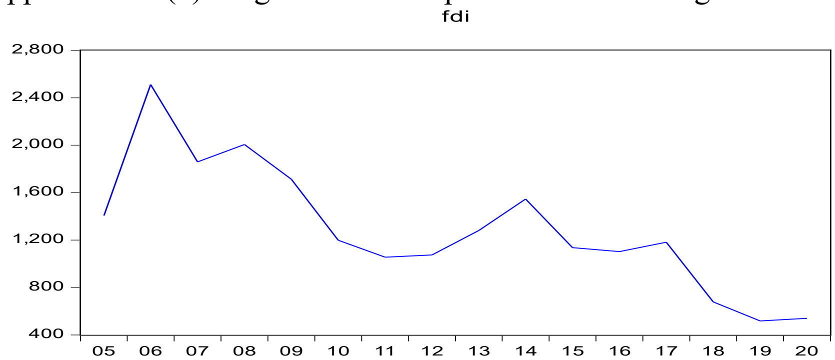
Note: This table presents descriptive statistics of the annual sample spanning 2005 to 2020. FDI denotes foreign direct investment, LI: denotes Roll's local direct investment, ITS: characterizes investing in telecommunications services, MCS: reflects the percentage of smartphone, IU as indicated by the using the internet and FTS captures the percentage of fixed-line telephone subscribers.

Appendix No (3): Table 3: General time trend. .

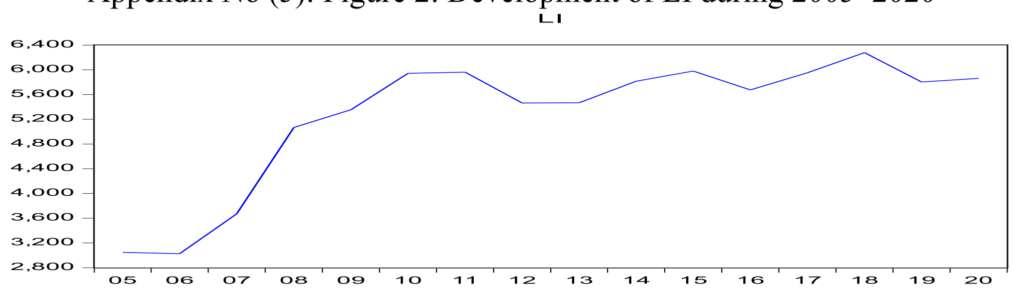
Variable	**Model**	**F**	**R2**
FDI	LOGFDI = 7−0.06Ti	27***	**0.66**
LI	LOGLI = 8.24+0.03TI	17***	**0.55**
ITS	TSI = 2.2−3663399TI	1.7	**0.11**
MCS	LOGMCS = 4.38+0.013TI	1.05	**0.07**
IU	LOGUI = 2.59+0.11TI	***438	**0.96**
FTS	LOGFTS = 2.4-0.07TI	427***	**96%**

Note: This table shows General time trend equations for the study variables during 2005–2020 . The p-values are the F Statistic. ***, **, and * denote statistical significance levels of 1%, 5%, and 10%, respectively

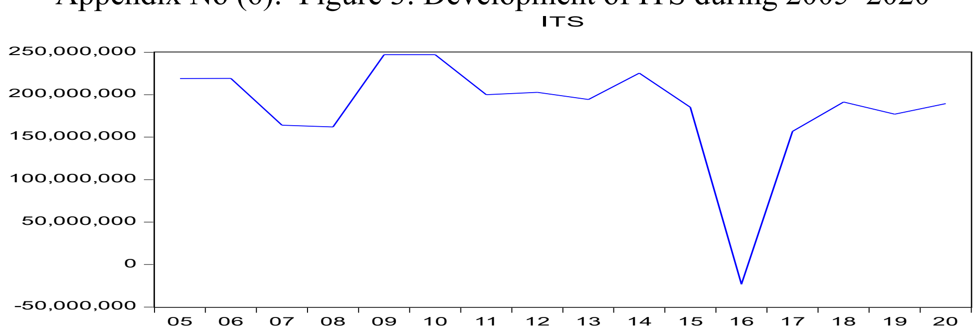
Appendix No (4): Figure 1: Development of FDI during 2005–2020



Appendix No (5): Figure 2: Development of LI during 2005–2020



Appendix No (6): Figure 3: Development of ITS during 2005–2020



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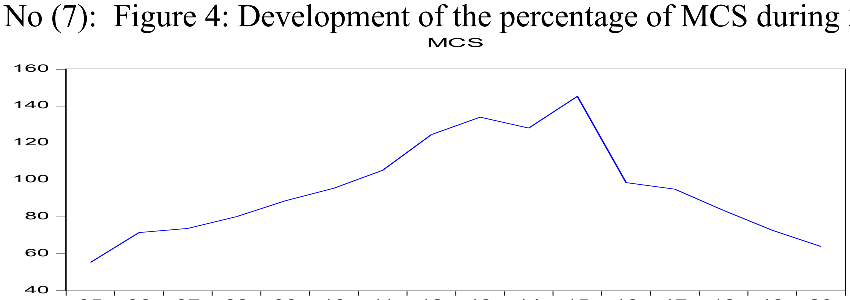
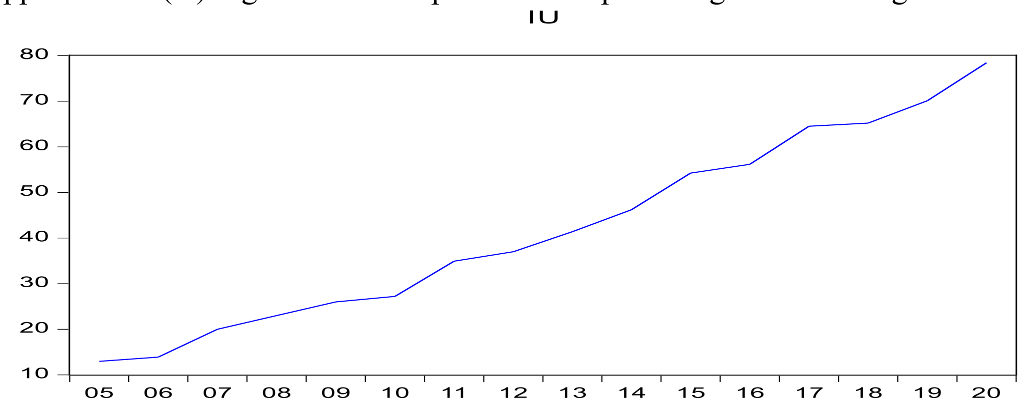
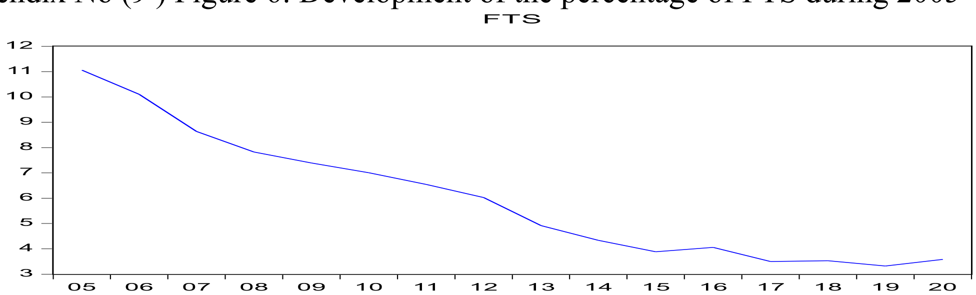
Appendix No (7): Figure 4: Development of the percentage of MCS during 2005–2020



Appendix No (8) Figure 5: Development of the percentage of IU during 2005–2020



Appendix No (9) Figure 6: Development of the percentage of FTS during 2005–2020



Appendix No (10): Table 3: Results of URT for the study variables during 2005–2020

		First difference			**Level**
		NO constant			**NO constant**
Prob.*	t-Statistic	Variables	Prob.*	t-Statistic	**Variables**
***0.0003	-4.374836	D(LOG(FDI))	0.8616	-0.519033	**LOG(FDI)**
0.0166**	-2.503874	D(LI)	0.9133	1.043655	**LI**
***0.0001	-4.774053	D(ITS)	0.3197	-0.876739	**ITS**
***0.0014	-3.637065	D(MCS)	0.5904	-0.219281	**MCS**
**0.0235	-2.344520	D(FTS)	0.0000	-6.736889	**FTS**
intercept and trend			intercept and trend		**Variable**
Prob.*	t-Statistic	Variable	Prob.*	t-Statistic	
***0.0006	-6.699600	D(IU)	0.2312	-2.757587-	**IU**

Note: The time series are stable at the first difference. The p-values are the Critical Value Bounds. ***, **, and * denote statistical significance levels of 1%, 5%, and 10%, respectively

Appendix No (11): Table 4: Results of the co-integration test.

k	Value	Test Statistic Value
4	7.863814	**F-statistic**
	Critical Value Bounds	
I(1) Bound	I(0) Bound	**Significance**
3.01	1.9	**10%**
3.48	2.26	**5%**
3.9	2.62	**2.5%**
4.44	3.07	**1%**

Note: Results of the co-integration test using the ARDL bound test for the first model: Effect of the independent variables on FDI. The p-values are the Critical Value Bounds. ***, **, and * denote statistical significance levels of 1%, 5%, and 10%, respectively.

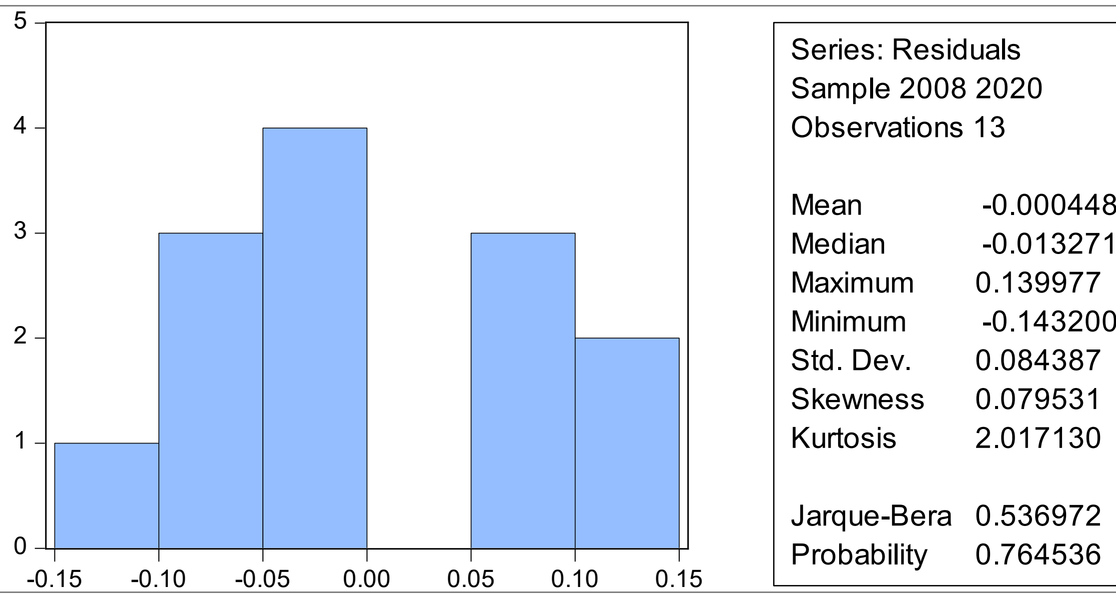
Appendix No (12): Table 5: Results of the co-integration test.

k	Value	Test Statistic Value
4	28.92415	**F-statistic**
	Critical Value Bounds	
I(1) Bound	I(0) Bound	**Significance**
3.01	1.9	**10%**
3.48	2.26	**5%**
3.9	2.62	**2.5%**
4.44	3.07	**1%**

Note: Results of the co-integration test using the ARDL bound test for the first model: Effect of the independent variables on LI. The p-values are the Critical Value Bounds. ***, **, and * denote statistical significance levels of 1%, 5%, and 10%, respectively

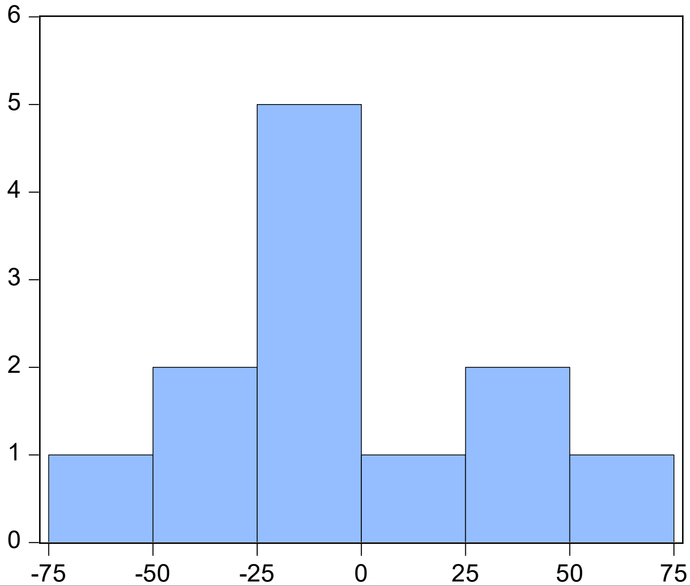
Appendix No (13): Table 6: Results of the goodness test of the estimated model

Results of the goodness test for the first model: Effect of the independent variables on FDI. .			
Breusch–Godfrey Serial Correlation LM Test			
0.1532	Prob. F(2,4)	3.109590	**F-statistic**
Heteroskedasticity Test: Breusch–Pagan–Godfrey Test			
0.1851	Prob. F(7,5)	2.324456	**F-statistic**
Ramsey RESET Test			
0.3995	Probability df(5)	0.920677	**t-statistic**
Jarque–Bera Test			



Results of the goodness test of the second model : Effect of the independent variables on LI .			
Breusch–Godfrey Serial Correlation LM Test			
0.3749	Prob. F(1,1)	2.241848	**F-statistic**
Heteroskedasticity Test: Breusch–Pagan–Godfrey Test			

0.2352	Prob. F(10,1)	10.58207	**F-statistic**
	Ramsey RESET Test		
0.8730	Probability df(1)	0.202205	**t-statistic**
	Jarque–Bera Test		



Series: Residuals	
Sample 2009 2020	
Observations 12	
Mean	-0.048702
Median	-2.367328
Maximum	51.59781
Minimum	-53.64660
Std. Dev.	29.63699
Skewness	-0.060519
Kurtosis	2.420689
Jarque-Bera	0.175126
Probability	0.916161

Appendix No (14): Table 7: Summary of results of estimating.

Selected Model: ARDL (2, 0, 0, 1, 0)

Prob.*	t-Statistic	Std. Error	Coefficient	Variable
0.0017***	5.404118	5.80E-10	3.13E-09	**ITS(-2)**
0.0624***	2.285200	0.004289	0.009801	**MCS(-3)**
0.0483*	2.472388	0.017417	0.043062	**IU(-2)**
0.0170**	3.271481	0.112025	0.366487	**FTS(-2)**

Note: Summary of results of estimating the effect of digital infrastructure on FDI .The p-values are the Critical Value Bounds. ***, **, and * denote statistical significance levels of 1%, 5%, and 10%, respectively

Appendix No (15): Table 8: Results of estimating the short-term.

Prob.	t-Statistic	Std. Error	Coefficient	Variable
0.0065***	4.079467	0.125571	0.512262	**DLOG(FDI(−1))**
0.0034***	4.676325	0.009208	0.043062	**D(IU(-2))**
0.0002***	-8.095171	0.083928	-0.679411	**CointEq (−1)***

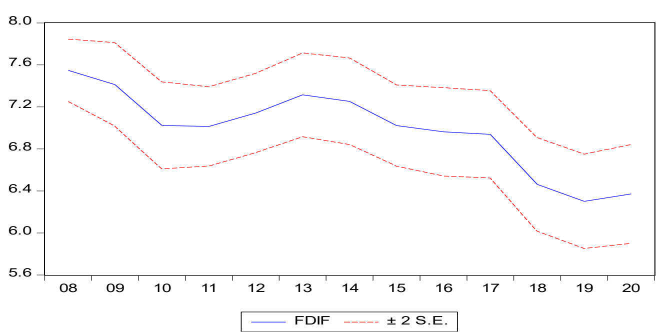
Note: Results of estimating the short-term effect of the first model of FDI as a dependent variable using the ARDL model. The p-values are the Critical Value Bounds. ***, **, and * denote statistical significance levels of 1%, 5%, and 10%, respectively.

Appendix No (16): Table 9: Results of estimating the long-term.

Prob.	t-Statistic	Std. Error	Coefficient	Variable
0.0017***	5.404118	5.80E-10	3.13E-09	**ITS(-2)**
0.0624*	2.285200	0.004289	0.009801	**MCS(-3)**
0.0151**	3.366851	0.007275	0.024493	**IU(-3)**
0.0170**	3.271481	0.112025	0.366487	**FTS(-2)**

Note: Results of estimating the long-term effect of the first model of FDI as a dependent variable using the ARDL mode. The p-values are the Critical Value Bounds. ***, **, and * denote statistical significance levels of 1%, 5%, and 10%, respectively

Appendix No (17): Figure 7: Testing the ability of the ARDL model to predict FDI



Forecast: FDIF
Actual: LOG(FDI)
Forecast sample: 2005 2020
Adjusted sample: 2008 2020
Included observations: 13

Root Mean Squared Error	0.089662
Mean Absolute Error	0.077100
Mean Abs. Percent Error	1.105360
Theil Inequality Coefficient	0.006412
Bias Proportion	0.000057
Variance Proportion	0.041643
Covariance Proportion	0.958300
Theil U2 Coefficient	0.384226
Symmetric MAPE	1.103421

Appendix No (18): Table 10: Summary of the results of estimating.

Prob.*	t-Statistic	Std. Error	Coefficient	Variable
0.0124**	8.909569	5.43E-07	4.84E-06	**ITS**
0.0091***	10.40493	1.472877	15.32517	**MCS(-3)**
0.0159**	7.847004	10.69906	83.95558	**IU**
0.0136**	8.483587	706.7089	5995.427	**LOG(FTS)**

Note: Summary of the results of estimating the effect of digital infrastructure on local investment. The p-values are the Critical Value Bounds. ***, **, and * denote statistical significance levels of 1%, 5%, and 10%, respectively

Appendix No (19): Table 11: Results of estimating the short-term

Prob.	t-Statistic	Std. Error	Coefficient	Variable
0.0017***	24.27124	1.99E-07	4.84E-06	**D(ITS)**
0.0025***	20.11218	0.761985	15.32517	**D(MCS(-3))**
0.0031***	18.03321	4.655609	83.95558	**D(IU)**
0.0028***	18.92160	316.8562	5995.427	**DLOG(FTS)**
0.0023***	-20.82936	0.067358	-1.403021	**CointEq (−1)***

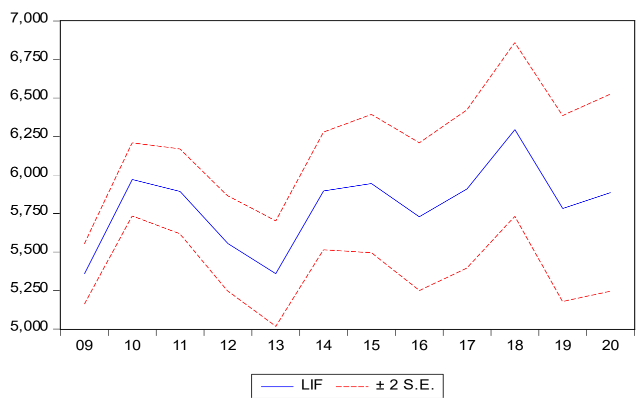
Note: Results of estimating the short-term effect of the first model of local investment as a dependent variable using the ARDL model. The p-values are the Critical Value Bounds. ***, **, and * denote statistical significance levels of 1%, 5%, and 10%, respectively

Appendix No (20): Table 12: Summary of the results of estimating the long-term.

Prob.*	t-Statistic	Std. Error	Coefficient	Variable
0.0124**	8.909569	5.43E-07	4.84E-06	**ITS**
0.0091***	10.40493	1.472877	15.32517	**MCS(-3)**
0.0159**	7.847004	10.69906	83.95558	**IU**
0.0136**	8.483587	706.7089	5995.427	**LOG(FTS)**

Note: Summary of the results of estimating the long-term effect of the second model of domestic investment. The p-values are the Critical Value Bounds. ***, **, and * denote statistical significance levels of 1%, 5%, and 10%, respectively

Appendix No (21): Figure 8: Testing the ability of the ARDL model to predict LI



Forecast: LIF	
Actual: LI	
Forecast sample: 2005 2020	
Adjusted sample: 2009 2020	
Included observations: 12	
Root Mean Squared Error	57.40664
Mean Absolute Error	47.85335
Mean Abs. Percent Error	0.835321
Theil Inequality Coefficient	0.004946
Bias Proportion	0.000327
Variance Proportion	0.001802
Covariance Proportion	0.997871
Theil U2 Coefficient	0.179831
Symmetric MAPE	0.835545