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# Domestic Capacities and Global Integration: Drivers of Digital Diffusion in Developing Economies

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**ABSTRACT**

The study examines the effects of domestic absorptive capacities (DAC) and external integration dynamics on digital diffusion (DD) across developing economies. The study uses a balanced panel of sixty-eight developing economies from 2010 to 2023 and employs panel-corrected standard errors (PCSE) technique to estimate regression estimates. The findings that higher DAC such as income per capita (INC), capital formation (CAP), and financial development (FD) foster both internet penetration (NET) and mobile usage (MOB), used as proxies for DD. These highlight the importance of DAC in expanding DD in developing economies. Interestingly, macroeconomic instability (MIS) does not undermine DD, reflecting its resilience to short-run economic fluctuations and the price inelastic demand for digital technologies. Conversely, TRD and FDI show significant and negative direct effects on DD, implying crowd-out effects from ICT sectors to well-established manufacturing sector. However, their moderating effects are positive under higher INC context, revealing the primacy of DAC to benefit from TRD and FDI. Moreover, REM significantly increases DD, though its moderating effects show that these inflows are often channeled toward consumption of non-ICT goods and services, in high income context. Broadly, the study suggests that global integration factors (TRD, FDI, REM) are important drivers, the sustainability of DD in developing economies is primarily dependent on DAC.

**Keywords:** Digital Diffusion, Mobile Adoption, Internet Penetration, Trade Openness, International Remittances, Foreign Direct Investment, Income per capita

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## 1. INTRODUCTION

The world is experiencing a unique structural transformation, known as the Fourth Industrial Revolution or Industry 4.0 (De Propris & Bailey, 2021). This transformation refers to the inclusion of Internet of Things, automation, artificial intelligence, cloud computing, big data, and digital connectivity (Munirathinam, 2020). Industry 4.0 determines how economies produce, communicate and compete in international markets, restructuring input market dynamics, efficiency and overall development (David et al., 2025; Guerrieri & Bentivegna, 2011). Developed economies have fully realized the potential benefits and gains through

established digital infrastructure, while developing economies have failed to realize the gains from this digital diffusion (DD), creating a significant digital divide and inequality between developed and developing economies (Mariscal, 2005; Murthy et al., 2021).

A substantial feature of Industry 4.0 is DD, reflected by the level of adoption and effective utilization of digital technologies across firms, households and institutions in society. In developing economies, internet penetration (NET) and mobile adoption (MOB) represent Industry 4.0 which facilitate e-commerce, AI-based logistics, digital finance, and smart manufacturing (Popkova, 2018; Verma et al., 2023). Moreover, this DD is essential for households to perform essential tasks in business, education and global communication. Consequently, a high degree of DD is associated with higher economic returns, global connectivity and contemporaneous structural transformation.

Although several developing economies invested heavily in the establishment of ICT infrastructure over the last two decades, many developing economies still have zero or low DD. The primary factor that determines information and communication technology (ICT) infrastructure and DD is domestic absorptive capacity (DAC), mainly determined by income per capita (INC), financial development (FD), and capital formation (CAP). Moreover, few studies argue that global integration factors such as foreign direct investment (FDI), international remittances (REM), and trade openness (TRD) are crucial drivers of DD by being significant sources of technology transfer, foreign capital inflows (FCI), and advanced digital technologies (Asongu & Odhiambo, 2020; Wang & Blomstrom, 1992). Lastly, macroeconomic stability (MIS) is also found to be an important factor in the adoption of NET and MOB in developing economies (Hooks et al., 2022). The study raises a critical research question: Why do some developing economies remain digitally marginalized in an era of Industry 4.0 characterized by technological openness and globalization?

This research question is critically important for many developing economies as they experience a zero or low level of DD (Murthy et al., 2021). These economies bear a greater opportunity cost in terms of job creation, productivity improvement, trade competitiveness, access to modern technologies and education, and social inclusion, especially after the recent pandemic. Furthermore, economies that delay DD face the risk of long-term isolation from global economic and knowledge networks, as DD mediates interaction between developing and developed economies. As mentioned earlier, DD depends upon DAC which enables economies to establish and sustain ICT infrastructure and determine affordability (Lechman, 2016; Wang et al., 2021). Consequently, without adequate amount of DAC, DD may be unaffordable and inaccessible to members of society.

Furthermore, developing economies are highly dependent on FCI (such as FDI and REM) to bridge saving-investment gaps. Another source of foreign exchange for these economies is TRD. Theoretical literature postulates that both FCI and TRD facilitate transfer of technology, knowledge, and financial stability which enhance DD in developing economies. However, several empirical studies argue that the benefits and spillover effects of FCI and TRD are not transmitted automatically (Behera, 2025; Crespo & Fontoura, 2007; Gachino, 2025). In many developing economies, FCI and TRD are concentrated in traditional manufacturing

industries, resulting in crowding out private investment in ICT-intensive production (Magbonde et al., 2025; Nyiwul & Koirala, 2022; Tu, 2024). Similarly, REM, despite being a significant source of income for many households in developing economies, may be channeled toward personal consumption expenditures rather than investment in ICT infrastructure and skills development (Hasan et al.,2023; Samaratunge et al., 2020). The divergence between global integration and DD underscores an important yet unexplored issue, suggesting that global integration is a necessary but not sufficient condition for DD. Therefore, it must be complemented by adequate DAC and MIC to enhance and sustain DD in the long run. Examining these complex relationships is crucial in the context of developing economies for effective policy formation (in a resource-constrained environment) and strategic planning to reduce digital divide. However, empirical literature provides partial and inconclusive evidence regarding how global integration and DAC jointly affect DD, specifically in term of direct and moderating roles.

Several empirical studies examined the effects of socio-economic, institutional, and external factors on DD (Myovella et al., 2021; Pick & Azari, 2008; Wunnava & Leiter, 2009); however, few significant knowledge gaps exist. First, the majority of studies examine either developed economies or single-country (time-series), limiting the generalizability of these studies to developing countries with no or low absorptive capacity. Second, the moderating effects of global integration dynamics (i.e., FDI, REM, TRD) are unexplored, despite being significant drivers of technology transfer and financial resource inflows. Third, little attention has been given to the effects of macroeconomic instability (MIS) on DD in developing countries, raising questions about the resilience of DD to MIS or short-run economic fluctuations.

The study fills the aforementioned gaps by examining the role of global integration dynamics, DAC, and MIS in determining DD across developing economies. In particular, the study examines the effects of INC, CAP, and FD on DD (using NET and MOB), with a focus on moderating effects of TRD, REM, and FDI. Moreover, the study examines the impact of MIS on DD. Altogether, this study offers a comprehensive understanding of both structural and external determinants of DD in developing economies.

In this context, the study aims to offer a comprehensive and policy-oriented examination of DD in developing economies by examining the complex interplay between global integration dynamics and DAC. The study has four specific objectives. First, the study examines how DAC (INC, FD, CAP) affects DD in the sample countries. Second, it examines the direct effects of global integration dynamics (FDI, REM, TRD) on DD. Third, it examines the moderating effects of FDI, REM, and TRD on the relationship between INC and DD, capturing the conditional nature of spillover effects global integration. Fourth, this study provides robust empirical evidence on whether or not DD is resilient to short-run MIS in the sample countries.

The organization of the paper is as follows. Section 2 discusses theoretical framework and a critical overview of empirical literature, resulting in developing testable hypotheses. Section 3 discusses the methodology used in the study such as sample, data collection, variables and statistical analysis. Section

4 presents results and detailed discussion. Lastly, Section 5 concludes the study by summarizing findings, discussing policy implications, and offering directions for future research.

## 2 LITERATURE REVIEW

### 2.1 Theoretical Background

The study adopts the two most relevant and important theories to provide a theoretical foundation. First, Diffusion of Innovation Theory (DOIT) initially proposed by Rogers (1962), which discusses how technological innovations spread across nations given their socio-economic and institutional dynamics. DOIT argues that economies with higher income and affordability tend to have higher absorptive capacities to adopt information and communication technologies (ICT) faster than low-income economies. Second, the study uses the Endogenous Growth Theory (EGT) proposed by Romer (1990). The theory postulates that CAP, technological advancement, and knowledge spillovers significantly affect long-run economic growth. In particular, the theory argues that higher capital formation (CAP), FD, foreign capital inflows (FCI) enable developing economies to build ICT infrastructure. Collectively, these theories emphasize that DD is determined by absorptive capacities, the stability and speed of DD are governed by economic and financial dynamics.

Furthermore, the DOIT was operationalized by contemporary researchers through formal conceptual and analytical frameworks that model DD as a dynamic function of economics, social, institutional, and structural dynamics. For instance, in social sciences, innovation diffusion models extend DOIT by investigating the determinants of adoption timings and intensity using simulation-based or mathematical models that trade how adoption spreads across individuals and economies over time (Bass, 2004; Meade & Islam, 2006; Shou et al., 2025). Also, these models emphasize the significance of threshold conditions, network externalities, and heterogeneity in adoption behavior (Okour et al., 2021; Wejnert, 2002; Shaw et al., 2022). These frameworks enable researchers to draw propositions on how changes in socio-economic, institutional, and capability dynamics determine the speed and degree of adoption, and how these factors form cross-country patterns of convergence or divergence in DD (Al-Emran, 2023; Xu et al., 2023).

Likewise, researchers operationalize EGT by analytical growth models that include knowledge spillovers, human capital and technological progress as critical endogenous factors to examine long-run economic growth. For instance, modern researchers use Romer's foundational EGT to examine how FD, ICT infrastructure and CAP interlink with knowledge formation and diffusion to enhance and sustain economic growth (Bambi & Pea-Assounga, 2025; Ghosh & Parab, 2021). These theoretical frameworks extend the basic EGT to estimate the role of spillovers and various paths of technological innovation such as role of human skill development and R&D in models of endogenous technological change (De Propris & Bailey, 2021; Kopytov et al.,2024). In other words, these analytical frameworks test the basic EGT by estimating comparative statics, investigating internal reliability, and examining how economic growth responses to changes in critical drivers such as ICT infrastructure and FD.

## 2.2 Review of Empirical Literature

### 2.2.1 Income and Digital Diffusion

Several studies have found that INC is a key determinant, among others, of DD (Kanga et al., 2022; Pick & Azari, 2008; Stump et al., 2022). In developing economies where affordability of NET and MOB is still an important factor, higher INC plays a significant role in easing the financial constraints and fostering access to ICT (Asongu & Odhiambo, 2022; Howard & Mazaheri, 2009; Stump et al., 2022). Furthermore, recent empirical studies argue that the impact of INC on DD, especially in developing economies, is nonlinear and conditional on structural dynamics (Kumar et al., 2023; Siddika & Sarwar, 2024).

Although higher INC increases affordability and enables developing economies to access modern technologies, to sustain DD, ICT infrastructure and a regulatory framework play complementary roles. In particular, a study by David et al. (2025) found that developing economies with poor an institutional framework and inadequate ICT infrastructure experience diminishing marginal effects to income and their DD stops. Similarly, Castillo and Vonortas (2024) argue that the impact of INC on DD is mediated by absorptive capacity rather than by affordability alone. Likewise, a recent study by Wang et al. (2025) found that higher INC enhances DD only if it channels a fraction of INC into ICT infrastructure investments and human capital development. Broadly, empirical literature implies that INC increases DD (both NET and MOB) conditionally and it should be complemented with institutional, structural and global integration dynamics to sustain DD in developing economies. So, our study proposes the following hypothesis:

$H_1$: Income has a significant positive impact on digital diffusion in developing economies.

### 2.2.2 Capital Formation and Digital Diffusion

Developing economies experience increasing returns to investments in ICT infrastructure (Indjikian & Siegel, 2005). Even empirical studies found that higher public CAP encourages private investments in digital infrastructure and increases DD (Kuppusamy et al., 2009; Gholipour et al.,2022; Wang et al.,2025). However, few studies show mixed results of CAP on DD, depending on their absorptive capacity across regions (Castillo & Vonortas, 2024; Keller,1996; Valdaliso et al., 2011). Furthermore, studies found that higher CAP tends to increase DD, specifically NET, due to higher upfront costs in building broadband infrastructure (Das et al., 2016; Kurniawati et al.,2021; Haini & Pang, 2022).

Furthermore, recent empirical literature highlights that the effects of CAP on DD depends on its the sectoral composition instead of its overall size (Wang et al.,2025). Similarly, few empirical studies report that, in developing economies, the CAP is concentrated more into established and traditional manufacturing industries, neglecting ICT and technology-intensive sectors (Castillo & Vonortas, 2024). Castillo and Vonortas also found that CAP increases DD only when DAC and ICT infrastructure coexist. Similarly, another recent empirical study by Dang and Merino (2024) argues that CAP increases DD when it is accompanied by human-skill development and ICT-intensive activities in the economy, causing higher DD. Additionally, inefficient and ICT-biased capital allocation reduces DD in developing economies (Wang et

al.,2025). Empirical literature suggests that CAP with efficient allocation and adequate ICT development may enhance DD in developing economies. So, the study proposes the following hypothesis:
$H_2$: Capital formation has a significant impact on digital diffusion in developing economies.

### 2.2.3 Financial Development and Digital Diffusion

A well-functioning and efficient financial system channels financial resources towards productive investment, particularly in ICT infrastructure and digital technologies (Mayer, 1990; Rousseau & Sylla, 2003; Yartey, 2008). Several studies argue that higher FD enhances DD by reducing financial constraints of household and also supporting ICT investment projects (Nguyen et al., 2020; Verma, 2023).

Furthermore, recent studies emphasize that FD enhances DD through risk sharing, credit provision and long-term funding, but its effects are highly dependent on structural and institutional dynamics. In particular, FD enhances DD in developing economies only when financial market allocates financial resources towards ICT-intensive activities (Verma et al.,2023). Likewise, FD does not increase DD if financial intermediaries fail to allocate financial resources efficiently to households, limiting their ability to adopt ICT-related technologies (David et al., 2025).

Similarly, in developing economies where financial systems are immature and inefficient, financial resources are often channeled to short-term and low-risk projects, resulting in crowding out of ICT-related financing (Dang & Merino, 2024). The empirical literature emphasizes that FD increases DD if it is also accompanied with DAC and ICT-intensive investment, suggesting the importance of examining its role with DAC in a unified framework. Based on this, the following hypothesis is proposed:
$H_3$: Financial development has a significant positive effect on DD in developing economies.

### 2.2.4 Macroeconomic Instability and Digital Diffusion

MIS significantly affects the trajectory of sustainable development including ICT development in developing economies (Arintoko et al., 2023; Roller & Waverman, 2001). For instance, economic and political stability enhances investors' confidence, decreases uncertainty and fosters investment in capital-intensive technologies such as data centers, telecommunication networks, and broadband infrastructure (Hooks et al., 2022). However, empirical evidence on the relationship between MIS and DD is limited and slightly inconsistent, with only few studies examining this association in the context of developing economies (Meijers, 2006).

Moreover, recent empirical literature suggests that developing economies where NET and MOB have become necessity goods may show resilience to short-run MIS. Arintoko et al. (2023) found that MIS has weak and mixed impact on DD in developing economies. Likewise, demand for ICT-goods is price inelastic during an inflationary period due to its significance in essential economic functions (David et al., 2025).

Conversely, prolonged MIS may reduce ICT infrastructure development and DD through uncertainty and affordability (Dang & Merino, 2024). The empirical evidence imply that short-run MIS may

not affect DD, while persistent MIS may weaken long-run DD, highlighting the need for further empirical examination. So, the following hypothesis is proposed:

$H_4$: Macroeconomic instability significantly affects digital diffusion in developing countries.

### 2.2.5 Trade Openness and Digital Diffusion

TRD enables developing economies to import technologies, machinery and knowledge from developed nations (Ali et al.,2023; Abdu et al., 2025; Howard & Mazaheri, 2009). Although the empirical studies show mixed results, with few studies arguing that low absorptive capacity restricts the benefits of imported technologies and devices (Fatima, 2017; Hasan et al., 2023; Keller, 2004). Moreover, it can be argued that TRD may enhance DD by providing affordability for individuals in developing countries (Lee et al., 2016).

On the other hand, recent empirical literature reveals that the effects of TRD on DD are mixed and conditional on DAC and the allocation of trade across industries. A recent study by Abdu et al. (2025) argues that TRD increases DD if adequate ICT infrastructure and effective institutional framework coexist. However, TRD supports traditional manufacturing and primary sectors, neglecting and limiting knowledge spillovers to the ICT-intensive sector (Hasan et al.,2023). Additionally, TRD without ICT-oriented trade policies may result in crowding out domestic ICT-investment because of foreign rivalry (Tu, 2024). The literature suggests that TRD enhances DD if sufficient ICT infrastructure, DAC and institutional framework complement it, indicating the need to examine both direct and interaction effects, especially in the context of developing economies. So, the study proposes the following hypothesis:

$H_5$: Trade openness has a significant effect on digital diffusion in developing countries.

### 2.2.6 Remittances and Digital Diffusion

REM inflows are a major and stable component of foreign capital inflows for many developing economies, often surpassing other forms of inflows such as FDIs, foreign portfolio investments, and official development assistance (Eftimoski & Josheski, 2021; Hasan et al., 2022). Furthermore, REM reduces financial constraints and increases the income of households living in developing economies, may enable access to education, health and DD (Sajid et al.,2021). So, besides being an additional source of income, it is a significant driver of DD in these countries (Ali et al.,2024; Asongu, 2018).

Moreover, recent empirical literature highlights that REM affects DD largely through consumption patterns instead of investment channels. For instance, Ali et al. (2024) found a significant positive association between REM and NET, however as disposable income increases the effects diminish as consumption shifts toward non-ICT goods. Another study by David et al. (2025) reveals that recipients of REM in developing economies allocate the majority of REM inflows to consumption rather than ICT investment. Similarly, Dang and Merino (2024) show that REM does not affect DD at the macro level without FD and supportive ICT policy frameworks. Therefore, the empirical literature proposes that REM enhances

DD; however, its effects on DD are conditional on a higher INC level in the long run. Thus, based on these studies the following hypothesis is proposed:

$H_6$: Remittances have a significant effect on digital diffusion in developing economies.

### 2.2.7 Foreign Direct Investment and Digital Diffusion

The impact of FDI on DD is inconsistent, depending on several economic and institutional factors (Ali et al., 2023; Asongu et al., 2018; Dimelis & Papaioannou, 2010; Sinha & Sengupta, 2022). Although FDI is often considered a major source of technology transfer (Konings, 2001; Nayak & Sahoo, 2023), but recent studies show that it is concentrated in the traditional manufacturing sector rather than in ICT industry in developing economies (Tu, 2024). Furthermore, the empirical evidence shows that FDI fosters DD through expanding digital infrastructure and absorptive capacities in economies with high economic growth (Dang & Merino, 2024; Fatima, 2017; Ogundipe et al.,2020).

Furthermore, recent empirical studies emphasize the importance and relative impact of sectoral composition of FDI on DD in developing economies. For instance, Tu (2024) found that developing economies receive FDI in the traditional manufacturing and primary sectors due to their export orientation. Moreover, FDI increases DD when a recipient country has high DAC and INC (Dang & Merino, 2024). Additionally, FDI often crowds out domestic digital firms and reduces DD if the host country lack adequate DAC (Ali et al., 2023). Therefore, empirical literature implies that FDI may enhance DD only if sufficient DAC and ICT infrastructure complement it, justifying the examination of both direct and moderating effects of FDI with INC. So, the following hypothesis is proposed:

$H_7$: Foreign direct investment has a significant effect on digital diffusion in developing countries.

## 3. METHODOLOGY

The study uses a balanced panel dataset of sixty-eight developing economies spanning from 2010 to 2023, making 952 panel observations altogether. The study follows the World Bank income criteria for the selection of countries, considering low and middle (lower and upper) income economies where DD is low and DAC is limited. The selection of sample countries is consistent with past cross-country studies which highlight that developing economies experience a greater digital divide and heterogeneity in NET and MOB in comparison to developing economies (Lechman, 2016; Myovella et al., 2021). Furthermore, the selection of these countries is also consistent and aligned with the United Nations Sustainable Development Goals (i.e., SDG-9), and global ICT strategic policy formulated by the World Bank and the International Telecommunication Union (ITU), emphasizing the expansion of ICT infrastructure and broad connectivity in developing economies. Lastly, the sample size is determined by the availability of data across all variables over the sample period, ensuring the construction of a balanced panel and robust cross-country comparison.

The sample period (2010-2023) is crucial and relevant for few reasons. First, it examines the post-financial crisis period, when ICT adoption, specifically MOB and NET, increased drastically in developing economies (Howard & Mazaheri, 2009; Lee et al., 2016). Secondly, during this study period, two major digital policy reforms took place, the Broadband Commission targets in 2010 and the SDGs (adopted in 2015), recognizing ICT and DD as crucial determinants of development. Third, the selected study period enables the study to examine the structural transformation in DD resulting from lower ICT costs, high FD and increasing global integration.

The description and measurement of the variables used in the study are reported in Table 1. The selection of the variables is grounded in both theoretical and empirical literature. Also, the table cites the studies used for the measurement of variables. Lastly, all the variables (except FDI and MIS) were transformed into logarithm form to obtain elasticity coefficients. The reason for not transforming FDI and MIS into logarithmic form was the presence of negative values and the ratio nature of MIS.

**Table 1. Description and Measurement of Variables**

| Category | Variable | Description | Source |
|---|---|---|---|
| Digital Diffusion (Dependent Variable) | NET | Individuals using the internet (% of population) | Howard & Mazaheri, 2009; Myovella et al., 2021 |
| | MOB | Mobile cellular subscriptions (per 100 individuals) | |
| Economic Capacity Factors | INC | GDP per capita (constant 2015 US$) | Howard & Mazaheri, 2009; Kanga et al., 2022 |
| | CAP | Gross fixed capital formation (constant 2015 billion US$) | Indjikian & Siegel, 2005; Das et al., 2016 |
| | FD | Domestic credit to private sector (% of GDP) | Yartey, 2008; Nguyen et al., 2020 |
| | FDI | Foreign direct investment, net inflows (% of GDP) | Dimelis & Papaioannou, 2010; Sinha & Sengupta, 2022 |
| External and Global Integration Factors | TRD | Trade (% of GDP) | Lee et al., 2016; Fatima, 2017 |
| | REM | Personal remittances, received (% of GDP) | Asongu, 2018; Ali et al., 2024; Hasan et al.,2024 |
| Macroeconomic Instability Factor | MIS | Proxied by inflation rate, consumer prices (annual %) | Roller & Waverman, 2001; Meijers, 2006 |

### 3.1 Statistical Analysis

The study estimated descriptive statistics and Pearson's coefficient of correlation to understand the data and relationships among variables. Furthermore, the study performed Pesaran's (2021) cross-sectional dependence (CSD) test to check interdependence among sample countries. Additionally, the study applies a few diagnostic tests such as Wooldridge test (for autocorrelation) and modified Wald test (for heteroscedasticity). Lastly, the study employed panel corrected standard errors (PCSE) regression technique based on CSD and diagnostic tests results to estimate the regression models.

### 3.2 Econometric Model

This section discusses specific econometric models. The baseline model of the study is specified as:

$$DD_{it}=\alpha_0+\alpha_1 INC_{it}+\alpha_2 CAP_{it}+\alpha_3 FD_{it}+\alpha_4 MIS_{it}+\theta_i+\varphi_t+\mu_{it} \quad (1)$$

The extended specifications incorporate direct and moderating effects of TRD, REM, and FDI:

$$DD_{it}=\alpha_0+\alpha_1 INC_{it}+\alpha_2 CAP_{it}+\alpha_3 FD_{it}+\alpha_4 MIS_{it}+\alpha_6 TRD_{it}+\alpha_7 (INC\times TRD)+\theta_i+\varphi_t+\mu_{it} \quad (2)$$

$$DD_{it}=\alpha_0+\alpha_1 INC_{it}+\alpha_2 CAP_{it}+\alpha_3 FD_{it}+\alpha_4 MIS_{it}+\alpha_6 REM_{it}+\alpha_7 (INC\times REM)+\theta_i+\varphi_t+\mu_{it} \quad (3)$$

$$DD_{it}=\alpha_0+\alpha_1 INC_{it}+\alpha_2 CAP_{it}+\alpha_3 FD_{it}+\alpha_4 MIS_{it}+\alpha_6 FDI_{it}+\alpha_7 (INC\times FDI)+\theta_i+\varphi_t+\mu_{it} \quad (4)$$

where the models (2 to 4) examine the direct and conditional effects of TRD, REM, and FDI on DD, captured by $\alpha_6$ *and* $\alpha_7$, respectively. Moreover, country dummy ($\theta_i$) and year dummy ($\varphi_t$) are included to account for unobserved heterogeneity in all models. Moreover, DD is measured by two indicators NET and MOB separately.

## 4. RESULTS AND DISCUSSION

### 4.1 Descriptive Statistics, Normality and Correlation Analysis

The descriptive statistics and Shapiro-Wilk test (for normality) results are reported in Table 2. The results show that NET and MOB, on average, are 40% (with an SD of 25 %) and 100.4 (with SD of 33) per 100 individuals, respectively. These results imply that economies are experiencing increasing yet unequal pace of DD across nations. Similarly, the results show a mean value of INC is USD 3575 (with an SD of 2650), suggesting large income variation across sample countries. Furthermore, the findings reveal wide variations in FD, TDO, REM, and FDI across sample economies due to their structural and financial capabilities to encourage DD. Moreover, the results of Shapiro-Wilk test confirmed that all variables do not follow a normal distribution, suggesting the use of robust panel regression approach.

**Table 2. Descriptive Statistic of Variables used in the study**

| *Variables* | *Mean* | *SD* | *Min* | *Max* | *Shapiro-Wilk* |
|---|---|---|---|---|---|
| NET | 40.075 | 25.129 | .58 | 97.7 | 0.956[a] |
| MOB | 100.404 | 32.937 | 17.896 | 207.278 | 0.997[b] |
| INC | 3575.401 | 2650.195 | 253.446 | 14713.567 | 0.908[a] |
| CAP | 42.794 | 107.545 | .087 | 1023.818 | 0.422[a] |
| FD | 42.106 | 29.074 | 3.128 | 164.095 | 0.883[a] |
| MIS | 6.294 | 21.18 | -3.233 | 557.202 | 0.148[a] |
| TRD | 73.985 | 30.964 | 22.24 | 186.676 | 0.957[a] |
| REM | 7.223 | 7.548 | .004 | 49.976 | 0.815[a] |
| FDI | 3.121 | 3.997 | -37.173 | 43.912 | 0.712[a] |

[a, b] shows significance at the 1% and 5% levels, respectively.

Furthermore, Pearson's coefficients of correlation are reported in Table 3. The results reveal that both NET and MOB are strongly and positively correlated with INC and FD at the 1% significance level. This implies that higher economic prosperity and a well-developed financial sector create an enabling environment for DD in developing economies, as higher INC enhances affordability of digital services and higher FD redirect resources towards investment in information and communication technology (ICT) infrastructure. Interestingly, the correlation between DD and FDI, yet statistically significant, but weak. This

implies that FDI may not have direct relationship with digital infrastructure in host countries as it tends to concentrate on established traditional manufacturing industries rather than ICT-intensive sectors.

Moreover, the findings show no significant association between MIS and DD in developing economies. This suggests that short-term fluctuations in price levels have no impact on the process of DD. The reason may be because DD reduces the costs of production and increases price-performance ratio. Also, the demand for digital technologies is price inelastic as it is considered as essential services. Additionally, with respect to CAP, NET has a weak and significant positive correlation, while MOB has an insignificant correlation. These findings suggest that CAP plays a complementary role in DD, and its effect is more pronounced for the expansion of NET as it requires high upfront investments (data centers, broadband, fiber optics) in comparison to MOB.

Furthermore, REM also exhibits mixed correlation with NET and MOB: NET has a significant and weak positive correlation with REM, while MOB has no significant association with REM. The findings imply that REM is channeled into household spending that supports access to internet, rather than MOB due to its affordability in many developing economies. Moreover, the results show that TRD has a significant positive correlation with DD, suggesting that globalization and integration into international economy enable economies to adopt new technologies and digital platforms. This evidence reinforces the argument that TRD enhances technology transfer, knowledge spillovers, and digitalization in developing economies. Lastly, the results confirm that there is no issue of multicollinearity among explanatory variables shown by variance inflation factor (VIF) which is less than 10 (Gujarati, 2004; Hasan et al., 2024).

**Table 3. Pearson's Coefficient of Correlation**

| Variable | NET | MOB | INC | CAP | FD | MIS | TRD | REM | FDI | VIF |
|---|---|---|---|---|---|---|---|---|---|---|
| NET | 1 | | | | | | | | | n/a |
| MOB | 0.571[a] | 1 | | | | | | | | n/a |
| INC | 0.647[a] | 0.436[a] | 1 | | | | | | | 1.415 |
| CAP | 0.113[a] | 0.044 | 0.261[a] | 1 | | | | | | 1.213 |
| FD | 0.469[a] | 0.471[a] | 0.477[a] | 0.158[a] | 1 | | | | | 1.609 |
| MIS | -0.007 | -0.026 | -0.041 | 0.007 | -0.103[a] | 1 | | | | 1.012 |
| TRD | 0.301[a] | 0.331[a] | 0.209[a] | -0.203[a] | 0.442[a] | -0.057[c] | 1 | | | 1.573 |
| REM | 0.088[a] | -0.010 | -0.198[a] | -0.234[a] | -0.017 | -0.002 | 0.216[a] | 1 | | 1.146 |
| FDI | 0.003 | 0.108[a] | 0.025 | -0.086[a] | 0.033 | -0.019 | 0.280[a] | 0.008 | 1 | 1.103 |

[a, c] indicates significance at 1% & 10% level of significance. VIF= Variance Inflation Factor

### 4.2 Diagnostic Analysis and Pesaran's Cross Section Dependence Test

In Table 4, the results of key diagnostic tests are reported. Pesaran (2021) CSD test rejects the null hypothesis of "Cross-Country Independence" and confirms significant dependence among sample economies. Similarly, the modified Wald test confirms the presence of heteroscedasticity across panel countries, while the Wooldridge test indicates the presence of first-order serial autocorrelation. All these diagnostic results were obtained using the same panel-data and they apply uniformly across all econometric model specifications. These results justify the application of Panel-Corrected Standard Errors (PCSE) regression technique, proving robust and reliable estimates in the presence of cross-section dependence, autocorrelation, and heteroscedasticity (Hasan et al., 2024). However, the study also estimated the

regression models using fixed-effects and random effects estimator and their findings are reported in the Appendix.

**Table 4. Results of Autocorrelation, Heteroscedasticity and CSD Tests**

| Test | Test Statistic |
|---|---|
| Pesaran's CD Test | 27.417[a] |
| Wooldridge test for Autocorrelation | 44.980[a] |
| Modified Wald test for Heteroskedasticity | 25176.53[a] |

[a] indicates significance at 1% level of significance.

### 4.3 Regression Results

The regression estimates for the determinants of DD with respect to NET and MOB are reported in Table 5 and 6, respectively. The results provide a comparative representation of the key drivers of DD in developing economies. The results reveal several commonalities with significant differences, specifically regarding the moderating effects of TRD, FDI and REM.

Specifically, the results show a positive and statistically significant impact of INC on DD, for both NET and MOB, across all regression models, indicating the importance of economic prosperity in DD. Higher INC reduces financial constraints, increases affordability and demand for ICT services (Asongu & Odhiambo, 2022; Stump et al.,2022). The results confirmed the previous findings that INC is a key determinant of DD in developing economies. Furthermore, the coefficients of both CAP and FD are statistically significant and positive across all specifications. The results suggest that CAP supports ICT infrastructure (Haini & Pang, 2022), while higher FD is crucial for channeling financial resources towards ICT-intensive projects for expanding DD. Although the effects of both CAP and FD are positive, their magnitudes are slightly different across NET and MOB, highlighting their structural significance.

These findings support the existing empirical studies, validating the argument that INC is a crucial determinant of DD by increasing affordability and demand for ICT-related consumption (Pick & Azari, 2008; Asongu & Odhiambo, 2022; Stump et al., 2022). Similarly, the positive effects of CAP and FD are consistent with the empirical studies, indicating that DD is conditional on ICT infrastructure and efficient financial system (Indjikian & Siegel, 2005; Nguyen et al., 2020; Haini & Pang, 2022). However, the findings of this study imply that DAC have a strong positive impact on both NET and MOB across sample economies, which are inconsistent with the existing empirical evidence that show diminishing effects of DAC due to poor institutional framework (Castillo & Vonortas, 2024; David et al., 2025).

Similarly, the results show consistent sign but different magnitudes of MIS on DD for two measures. For NET, the effect is statistically significant and positive, but small, indicating that NET is resilient to price shocks because it has become a necessity good having inelastic demand in developing economies. For MOB, on the other hand, the magnitude is relatively weaker or insignificant, revealing the cheaper and critical nature of mobile phone technologies, which are even less responsive to short-term price fluctuations.

These results validate the recent studies that found that ICT-related goods particularly NET and MOB have become necessity goods in developing countries, making DD resilient to short-run MIS (Meijers,

2006; Arintoko et al., 2023; David et al., 2025). Additionally, these findings contradict with the recent argument that MIS reduce DD through affordability channel (Dang & Merino, 2024), and indicate that MIS does not undermine DD, specifically for MOB which has relatively lower costs.

Moreover, the direct effects of TRD on DD, with respect to NET and MOB, are same but its moderating effects differ for two measures. For NET, TRD has a significant and negative direct impact, but has no moderating effect on the INC-NET relationship. The results imply that TRD in developing economies supports manufacturing and non-ICT intensive sectors. Furthermore, these countries lack the institutional and regulatory mechanism to expand infrastructure for fixed broadband. Conversely, for MOB, the moderating effect is significant and positive (INC×TRD), indicating that TRD enhances the positive effects of INC on MOB as, in contrast to ICT infrastructure for NET, mobile technologies are easier to import, cheaper to adopt and faster to diffused.

These mixed findings validate the existing empirical evidence which reports the conditional role of TRD in enhancing DD in developing economies with low DAC (Fatima, 2017; Hasan et al., 2023; Tu, 2024). One strand of literature show that TRD increases DD though ICT imports and knowledge spillovers (Abdu et al., 2025; Lee et al.,2016), while others argue that TRD results in crowding-out domestic ICT-investments because it is biased toward traditional manufacturing industries (Hasan et al.,2023; Tu, 2024). The findings of this study extend the empirical literature by demonstrating that TRD has asymmetric effects on DD, reducing NET while increasing MOB in high INC economies, reflecting asymmetric technology spillovers.

In addition, the findings show significant and positive effects of REM on both NET and MOB. The results imply that higher REM raises household disposable income and affordability, enabling them to access ICT adoption. However, the moderating effects of REM on (INC×REM) is negative for both measures, implying that REM significantly affect consumption and investment of non-ICT related goods and services. The magnitude is slightly higher for NET, indicating the relatively higher upfront cost and investment requirements of NET, in contrast to MOB, for which the moderating effect is less pronounced, having smaller adverse effects.

These findings are consistent with the existing empirical evidence that higher REM increases disposable income of recipients and improve access to ICT services (Ali et al., 2024; Asongu, 2018). However, the adverse moderating effects of REM with INC validate the view that REM are spent on non-ICT consumption instead of ICT-investment in high income context (Samaratunge et al., 2020; Dang & Merino, 2024). This result disapproves the optimistic assumption that REM fosters DD, instead it emphasizes that the development effect of REM is consumption-driven, especially in the absence of ICT-oriented financial policies.

Moreover, the empirical findings reveal significant and negative direct effects of FDI on DD, for both measures, suggesting its concentration in non-ICT and traditional manufacturing sectors and lack of absorptive capacity. Thus, it even might crowd out investment in ICT-intensive sector and raised the inequality between FDI-intensive sectors and overall economy, thus increasing the digital-divide across economies. Similarly, the moderating effects of FDI are statistically significant and positive on DD, for both

measures. This implies that for economies with higher INC, FDI may complement domestic resources, increase technology transfer, and enhance DD. This finding is specifically important for MOB because mobile technologies are relatively easier to adopt if absorptive capacity and INC increase. Furthermore, the results indicate relatively greater predictive power of NET models ($R^2$ = 49 to 55%) than that of MOB models ($R^2$= 27 to 31%). This shows that structural and macroeconomic factors are critical in explaining NET, while MOB is more dependent on socio-cultural factors such as education profile, consumer preferences, and affordability.

This finding is in line with the existing empirical studies showing that FDI is largely concentrated in traditional manufacturing and primary sectors, restricting its spillovers to DD (Magbonde et al., 2025; Tu, 2024). Although past studies show that FDI is a major source of technology transfer in developing economies (Dimelis & Papaioannou, 2010; Konings, 2001), however recent studies argue that its effects are conditional on DAC and ICT-specific policy framework (Dang & Merino, 2024; Ali et al., 2023). Similarly, the positive interaction effects with INC show that FDI increases DD only when it is complemented with adequate DAC.

**Table 5. Digital Diffusion using NET: PCSE**.

| Variable | 1 | 2 | 3 | 4 | Sign |
|---|---|---|---|---|---|
| INC | 2.166[a] | 1.351[b] | 2.696[a] | 1.520[a] | Positive |
| | (0.385) | (0.564) | (0.302) | (0.373) | |
| CAP | 0.607[a] | 0.598[a] | 0.516[a] | 0.809[a] | Positive |
| | (0.124) | (0.089) | (0.099) | (0.130) | |
| FD | 0.646[a] | 0.680[a] | 0.461[a] | 0.571[a] | Positive |
| | (0.095) | (0.085) | (0.092) | (0.084) | |
| MIS | 0.003[b] | 0.003[b] | 0.003[a] | 0.003[b] | Positive |
| | (0.001) | (0.001) | (0.001) | (0.001) | |
| TRD | | -2.675[b] | | | Negative |
| | | (1.175) | | | |
| INC×TRD | | 0.204 | | | Insignificant |
| | | (0.130) | | | |
| REM | | | 2.102[a] | | Positive |
| | | | (0.512) | | |
| INC×REM | | | -0.221[a] | | Negative |
| | | | (0.055) | | |
| FDI | | | | -0.486[a] | Negative |
| | | | | (0.074) | |
| INC×FDI | | | | 0.058[a] | Positive |
| | | | | (0.008) | |
| Intercept | -17.131[a] | -6.340 | -21.027[a] | -12.087[a] | |
| | (2.881) | (5.009) | (2.400) | (2.621) | |
| Wald $Chi^2$ | 3082.61[a] | 1187.95[a] | 756.28[a] | 1284.92[a] | |
| Observations | 952 | 952 | 952 | 952 | |
| $R^2$ | 0.739 | 0.761 | 0.752 | 0.768 | |

[a], [b] indicates significance at 1% and 5% level of significance. Each models include country and year dummies, respectively.

**Table 6. Digital Diffusion using MOB: PCSE.**

| Variable | 1 | 2 | 3 | 4 | Sign |
|---|---|---|---|---|---|
| INC | 0.554[a] | 0.442[a] | 0.702[a] | 0.422[b] | Positive |
| | (0.169) | (0.143) | (0.171) | (0.144) | |
| CAP | 0.117[b] | 0.121[a] | 0.092[b] | 0.154[a] | Positive |
| | (0.040) | (0.031) | (0.036) | (0.033) | |

| | | | | | |
|---|---|---|---|---|---|
| FD | 0.158[a] | 0.167[a] | 0.108[a] | 0.143[a] | Positive |
| | (0.027) | (0.028) | (0.027) | (0.026) | |
| MIS | 0.001[c] | 0.001 | 0.000[c] | 0.001 | Positive |
| | (0.000) | (0.000) | (0.000) | (0.000) | |
| TRD | | -1.314[b] | | | Negative |
| | | (0.526) | | | |
| INC×TRD | | 0.139[c] | | | Positive |
| | | (0.067) | | | |
| REM | | | 0.581[b] | | Positive |
| | | | (0.263) | | |
| INC×REM | | | -0.061[c] | | Negative |
| | | | (0.029) | | |
| FDI | | | | -0.117[b] | Negative |
| | | | | (0.042) | |
| INC×FDI | | | | 0.014[b] | Positive |
| | | | | (0.005) | |
| Intercept | -0.595 | 4.992[c] | -1.678 | 0.436 | |
| | (1.326) | (2.742) | (1.366) | (1.122) | |
| Wald Chi$^2$ | 3141.73[a] | 11951.73[a] | 1534.47[a] | 2812.50[a] | |
| Observations | 952 | 952 | 952 | 952 | |
| $R^2$ | 0.953 | 0.953 | 0.954 | 0.953 | |

[a, b,c] indicates significance at 1%, 5%, and 10% level of significance, respectively. Each models include country and year dummies, respectively.

## 4. CONCLUSION

The study examined the role of structural and external integration factors in shaping DD across developing economies. The empirical findings show that domestic absorptive capacities (DAC) measured by INC, CAP, and FD increase DD (both MOB and NET), validating their effects in improving affordability, ICT infrastructure and accessibility. Furthermore, the results show that DD is resilient to price shocks, suggesting that demand for digital technologies is price inelastic due to their nature as necessity goods in recent times.

On the other hand, global integration factors demonstrate mixed yet insighful results. TRD has a negative direct impact on DD, especially NET, suggesting a lack of DAC in developing economies to benefit from imported digital technologies. Conversely, its moderation effect is positive, for mobile adoption (MOB), suggesting that as income rises TRD fosters MOB since mobile technologies are easier to import and diffuse. Furthermore, REM increases DD, however, in a high INC context, these inflows shift towards non-ICT consumption. In addition, FDI directly undermines DD due to its concentration in traditional non-ICT sectors in sample economies, but it enhances DD given high DAC through transfer of technology and knowledge spillovers.

The study provides useful policy implications for the key stakeholders in the light of the findings. For governments, enhancing DAC through inclusive growth policies, effective financial intermediation and ICT-specific investment policies, should become primary policy targets. Additionally, ICT infrastructure and digital industrial policies should be complemented by TRD, incentivizing ICT-intensive imports and decreasing the crowding-out effects on domestic digital firms. For financial regulators, improving credit

intermediation and channeling financial resources towards ICT infrastructure investment may improve the contribution of FD in fostering DD in developing economies. Similarly, policymakers should channel REM toward productive and digital use through incentive-based schemes and financial instruments. For national investment agencies, FDI should be directed towards ICT infrastructure projects and digital ecosystem, ensuring that FDI results in knowledge creation and technology transfer in developing economies,

This study has a few limitations. First, the study proxies DD by NET and MOB which reflect adoption and access to ICT-services and do not capture the efficiency, speed and quality of ICT services. Second, the study does not consider human capital, institutional quality and ICT-specific policy framework which may have a robust association with global integration factors and DAC. Third, the study uses macro data (country level), ignoring substantial difference within countries across regions and socio-economic groups. Therefore, the results should be interpreted in the light of these limitations.

Lastly, future research may extend this study in several ways. First, human capital, institutional quality and ICT-specific policy framework could deepen the understanding regarding the mechanism through which DAC influences DD. Second, using household-level data may provide useful insight regarding heterogeneities in DD within country across region and different socio-economic groups. Lastly, future research may estimate threshold levels to discover minimum DAC requirements for optimizing gains from global integration dynamics (i.e. FDI, TRD, RE

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