

EXAMINING THE RELATIONSHIP BETWEEN MOBILE CELLULAR SUBSCRIPTIONS AND INCLUSIVE GROWTH: SADC MEMBERS

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ABSTRACT

Inclusive growth had faced global challenges in social and gender disparities issues, especially in the Southern African Development Community (SADC) region, which affects its administrations and distributions in modern development contexts. Recognised international institutions have used the term inclusive growth as a description of growth that is formed through labor force and distributions focusing on well-being. This study examines the relationship between mobile cellular subscriptions and inclusive growth to improve the standard of living using a panel autoregressive distributed lag (ARDL) approach from 2000 to 2020. The economic growth context studies applied were unable to capture the demand for improving welfare and expectations to lessen poverty, while promoting inclusivity for SADC. Moreover, SADC economic growth partially dealt with the inclusive growth challenges of network connectivity, poor household benefit sharing, and a fast-growing population by applying non-validated methods that were useful to measure economic growth but fail to respond to inclusive growth. The World Bank (WB) and International Telecommunication Union (ITU) databases were used to identify that there is a positive and statistically significant relationship between mobile cellular subscriptions and inclusive growth in the long run. The findings of this study contribute by clarifying and urging policymakers and researchers concerned about equitable economic development to incorporate this sufficient to the relevant upbringing of communication channels to embrace inclusive growth opportunities to expand inclusive growth rapport and channels.

Keywords: *inclusive growth, mobile cellular subscription, digitalisation, panel ARDL, SADC member states*

1. INTRODUCTION

This study provides an exciting opportunity to advance our knowledge on the relationship between mobile cellular subscriptions and inclusive growth by strengthening some major contributions in recent developments about the need for a clear understanding of what the inclusive growth phrase means? According to Nketia and Kong (2021), Li, Nketia, Kong, and Appiah (2023), there is no universal implicit definition of inclusive growth. So far, the inclusive growth phrase is used interchangeable to match and group other terms such as engaged, comprehensive, shared, broad-based and pro-poor growth to name some few. Some of the recognised

international institutions such as the World Bank (WB), and Organization for Economic Cooperation and Development (OECD), use the term inclusive growth as a pillar to describe growth that is formed through labor force and distributions focusing on well-being (Ianchovichina & Lundström, 2009; OECD, 2015 and Ngepah, 2017).

Although a variety of definitions of inclusive growth may be suggested, this study used the definitions suggested by Dubey and Tiwari (2019), Bacchetta et al. (2021), Kabeer (2021), and Jiang, Chen, Ao, and Zhou (2022), who saw inclusive growth as the creation of equal opportunities such as benefit-sharing, distribution, and participation in accumulating income growth and income distribution per person employed to improve well-being. It is worth noting that in terms of digitalisation (particularly mobile cellular subscriptions), inclusive growth is the usage of country scale to measure growth and distribution opportunities fairly to participants by bridging long-distance communication with a digital electronic device or cellular phone usage as alluded by Aykaç and Civelek (2019); Dubey et al. (2019) and International Telecommunication Union (ITU) (2018).

Although inclusive growth has gained mammoth traction, there have been insufficient empirical investigations into the relationship between mobile cellular subscriptions and inclusive growth. Several studies, such as Sarpong and Nketiah-Amponsah (2022) and Jiang et al. (2022), have made judgement that inclusive growth strategies and policies are unresponsive and irrelevant, and their findings have contributed in expanding the inconclusive debate. This study examined the significance of inclusive growth in the rise of mobile cellular subscriptions in connection with modern development to deliver anticipated inclusive growth practices (Adeleye, Adeteye, & Adewuyi, 2015 and Alekhina, et al., 2021).

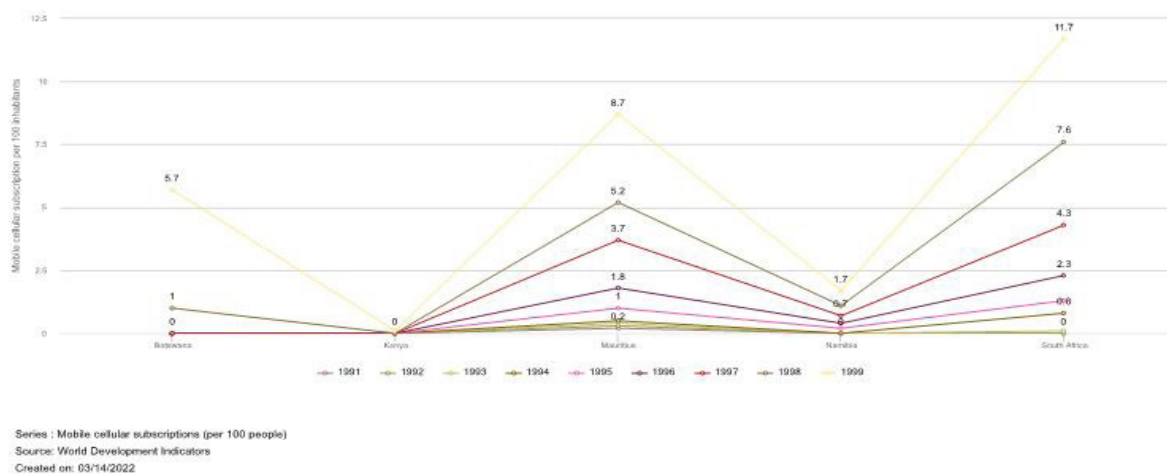
The Southern African Development Community (SADC) region consists of sixteen (16) members, and this study sample focuses on the selected SADC countries (although the status and ranking of countries keep on fluctuating, the selected five were among middle-income during the study projected stage). The middle-income countries classified as the selected SADC countries in the study are Botswana, Eswatini, Mauritius, Namibia, and South Africa, which have joined the SADC for years to improve their status (SADC, 2019). The selected SADC middle-income countries preference was also built on the improved accessibility of data and information from 2000 to 2020, compared to some other countries particularly, for Gross domestic product per person employed (GDPPPE), Mobile-cellular subscriptions (MOBS) per 100 inhabitants, Gross capital formation (GCF), and Gross national expenditure (GNE) variables. The selection was also influenced by their different contributions on the SADC, particularly on digitalisation to achieve a common goal. However, this approach assisted the researchers to remove SADC countries with poor or no contributions to some sectoral responsibility related to inclusive growth. In addition, given the selected SADC countries importance and massive growth on mobile cellular subscriptions, this study seeks to examines the relationship between mobile cellular subscriptions and inclusive growth for the selected middle-income SADC member states as displayed by Zheng, and Su (2022) and Koboyatau (2023).

In addition to inclusive growth, Myovella, Karacuka, and Haucap (2020) and International Telecommunication Union (ITU) (2020) noted that the digitalisation process fell among some of the key factors used to drive a growing economy by stirring both industry and people worldwide. Therefore, mobile cellular subscriptions were adopted as a digital technology aspect used by other countries like India to boost global industrial policy goals within the country's context, particularly by creating massive employment (Kouladoun, 2023). Hypothetically, the study adopted the neo-realist application and the information and communication technologies (ICT), theories to encourage participation in inclusive growth to align SADC principles, such as ethics and morals, different self-betterment strategies and success to inclusive growth. The

neo-realist was endorsed for impressive inclusive growth benefits which were used to minimise miscommunication as spotted in Japan (Van Niekerk, 2019; Ofori, Osei & Alagidede, 2022). Furthermore, the ICT theory was used to reveal the selected SADC levels of inclusive growth in relation to a high level of ICT approval that was also recommended by Johnson (2016) and Ejemeyovwi and Osabuohien (2018). These theories implications were linked to the current study variable.

According to the World Bank (2022) overview trend below, from 1991 to 1999, mobile cellular subscriptions have been gustily. As such, South Africa has been leading mobile cellular subscriptions, followed by Mauritius in the second position. Botswana moved from 1% of subscribers in 1998 to 5,7 at the end of 1999. Namibia had 1,7 subscribers in 1998 and had the least number of mobile subscriptions usage.

Figure 1. Mobile subscriptions (per 100 people) trend prior 2000



Source: Figure developed by the author's based on the data from World Bank, 2022

Based on the demonstration in Figure 1 above compiled by authors based on World Bank, the current study aims to examine whether these mobile cellular subscriptions influence the selected SADC inclusive growth from 2000 to 2020. Additionally, gross capital formation (GCF) and gross national expenditure (GNE) are added as control variables.

As a result, researchers noted the scarcity of regional studies that focused on promoting mobile cellular subscriptions and inclusive growth relationship, especially in SADC member states. This study saw a necessity to examine the inclusive growth benefits attached to mobile cellular subscriptions to improve well-being to minimise this existing gap. Some studies, such as Bacchetta, Cerra, Piermartini, and Smeets (2021), and Ibukun and Aremo (2017) cited in Osinubi, Osinubi, and Ibukun (2022) to name a few, have proved that Southern African economic growth partially dealt with the inclusive growth challenges of network connectivity, poor household benefit sharing, and a fast-growing population by applying Generalized Method of Moments (GMM) methods to validate the usefulness of economic growth and disregard inclusive growth.

Therefore, the findings of the current study have practical implications for the distribution of inclusive growth in the SADC countries. How? The SADC countries will be sympathetic on the mobile cellular subscriptions and inclusive growth factors which was neglected by previous studies such as Ngepah (2017), Sarpong et al. (2022) and Jiang et al. (2022) who under investigated this area as also emphasized in the paragraph above. Furthermore, the study intends to make an original contribution to this growing area of research by envisaging that the selected SADC member state can improve mobile cellular subscriptions and inclusive growth channels

to enhance higher levels of employment, as observed in India during Adler and Uppal (2008) study as cited by Kouladoun (2023). This study could not have made a significant impact than now when the world has experienced the COVID-19 pandemic and see the importance of mobile cellular subscriptions to sustain income growth and distribution among some other things. Based on the foregoing the inclusive growth and mobile cellular subscriptions quest for the selected SADC members states difference has been unnoticed, disregard of Aykaç et al. (2019) who states that the mobile cellular subscriptions have an important role to play in the inclusive growth through distributing and lengthening coverage ratio. Having comprehended this circumstance, entirely, policymakers and other stakeholders were enforced to intrude in order to improve mobile subscriptions benefits knotted to inclusive growth. Even though Africa is among the top mobile subscription users, researchers such as Bacchetta et al. (2021), and Osinubi et al. (2022) have distinguished that their level of inclusive growth remains unattractive, unclear, and feeble. From another perception, the current study introduction has also established that inclusive growth is usually judged due to strategies and policies which are unresponsive and irrelevant and contributes to expand the inconclusive debate as also itemized by Sarpong et al. (2022) and Jiang et al. (2022). This made the selected SADC countries circumstance to be more distinct in this situation as the countries income growth and distributions has been shared unequally. This setting places the SADC countries at the forefront of countries that are highly susceptible to global inclusive growth, therefore examining the effect of mobile cellular subscriptions is very crucial. Subsequently, this study serves as a route to examine the relationship between mobile cellular subscriptions and inclusive growth on the selected SADC countries through empirical observation.

As far as the methodological aspect is concerned, numerous research studies, such as Ghosh (2016), World Bank (2016), and Myovella et al. (2020), on mobile cellular phone subscriptions and inclusive growth have used panel data, the GMM technique. The current study critique previous scholars' approach as it is biased technique on dynamic panel estimates. Furthermore, the GMM is more suitable in the situation of large N and small T meaning the lagged dependent variable is measured among the regressors in a panel with large N and short time span. The researchers found their outcome unimpressive compared to the Panel Autoregressive Distributed Lag (PARDL), which captures both the short run and long run simultaneously together with the speed of adjustment. In contrast to previous methods/ studies, the PARDL bounds testing econometric analytical techniques were applied to estimate the long-run relationship among the variables and to check their level of adjustment to economic activity during the short run. The ARDL was chosen to make a turnaround and provide some assessments that can help equip SADC mobile cellular phone subscribers to harness the desired benefits of inclusive growth.

This situation prompted the need to examine the existing gap in inclusive growth through mobile cellular subscriptions at different stages in the selected SADC countries. It is against this background, that the novelty of the study examines the relationship between mobile cellular subscriptions and inclusive growth in the selected SADC member's countries from 2000 to 2020 to improve inclusive growth within member states. By attempting to reveal whether there is a relationship between mobile cellular subscriptions and inclusive growth in the selected SADC member states?

The overall sections of this study are as follows: Section one: Introduced the aim and inspiration for conducting the study. Outlining the problem statement and significance of the study constructively. Section two discussed the theoretical and empirical literature on the relationship between mobile cellular subscriptions and inclusive growth. Section three: ARDL methodology and relevant econometric tests are discussed to back up the literature and contribute to new knowledge. Section four: Econometric results are analyzed and aligned to the relationship be-

tween mobile cellular subscriptions and inclusive growth. Section five: Summary, conclusions, and recommendations are linked to the study's contributions and limitations.

2. LITERATURE REVIEW

This section reveals the theories and relationships between the variables of interest through the theoretical and empirical literature. The primary reason for adopting the assumptions of the neo-realist, and information, and communication technology theories was to explain the transmission mechanisms between the mobile cellular subscriptions and inclusive growth variables.

2.1. THEORETICAL LITERATURE

This section covers neo-realist, and information, and communication technology theories. These two theories were selected to enhance the link between the advantages of mobile cellular subscriptions and inclusive growth to provide assessable underpinning. According to [Braiton and Odhiambo \(2024\)](#), the neoclassical theory was used to advanced numerous countries level of productivity and growth opening with [Ramsey \(1928\)](#), [Swan \(1956\)](#) and [Solow \(1956\)](#) to list some few. The current study adopted the neo-realist theory which was introduced by Solow, and scholars such as Wall-cook and [Morris \(2017\)](#), [Kabeer \(2021\)](#) and [Ajide, Osinubi and Dada \(2021\)](#) to name some few, extended this theory and ended by adopting the Cobb-Douglas production function approach. According to [Wall-cook et al. \(2017\)](#) and [Ajide et al. \(2021\)](#), the projected model outlined that economic output is created through Labour (L), and Capital (K). The use of these factors of production are used to form the model and is demonstrated as,

$$Y_t = f(K_t)(L.T_t) \quad (1)$$

For instance, in equation (1), $L*T$ stands for actual labour and T is an additional technology while, Y - is output and K represents capital. An increase in L leads T to be augmented when factors of production are utterly employed. To remain relevant, the current study successfully adopts that the independent variable used in this study and was used as substitutes for K , L and technology to clarify the connotation of variables in the function in relation to Y , inclusive growth. Moreover, , as the dependent variable, depends on independent variable for expansion, mobile cellular subscriptions. Furthermore, as the model continues to expand, L and T growth rate is signified by n and g , while expansion of Y is based on $L.T$ and K ([Wall-cook et al., 2017](#); [Ajide et al., 2021](#)). Moreover, this approach was vital to examine the increase in technological growth, or productivity in response to Y . According to [Bourguignon and Morrisson \(1989\)](#), and [Aslam, Nareed, and Shabbir \(2013\)](#), the focus of inclusive growth is based on productive employment creation rather than plain income distribution. This symbolizes that growth in productivity is made from effective labor in order to reduce poverty and increase employment prospects, thus that will produce inclusive growth. Furthermore, the study merged the two theories to examine the relationship between the two variables by expanding equation (1), and presenting it further through the following equation:

$$IG_t = g(y, s, d, n) \quad (2)$$

Equation 2 shows that n tends to rise side by side to enlarge inclusive growth (IG). The actual labor, growth (y), savings (s), depreciation (d), and population (n) increase at the same rate as technology, as also noted by [Wall-cook et al. \(2017\)](#) and [Ajide et al. \(2021\)](#). A major criticism of equation (2) is that many countries make parallel movements that do not align with inclusive growth, by applying utilitarian social welfare function drawn from consumer choice theory and focus on individual welfare while neglecting effective labor participation. As a result, the inclusive growth gap remains unsettled, and this study intends to minimize this gap through mobile cellular subscriptions and adopting of the Cobb Douglas production function.

According to Van Niekerk (2019) and Ofori et al. (2022), neo-realist theory application was deeply rooted in providing encouragement to individual participation in inclusive principles, such as ethics and morals, to improve different self-betterment strategies aligned with their success. Countries that are persuasive to this theory have impressive inclusive growth benefits compared to countries that are reluctant. Among the many studies reviewed globally, the researchers spotted that Japan was among the few countries where inclusive growth was understood. Japan has attested that welfare, security, safety, prosperity, fortune, and success are guaranteed if neo-realist theory can be implemented and monitored. The realist theory was forwarded in advance to rectify and respond to time constraints on decisions made using various strategies. Moreover, this theory also revealed that miscommunication is introduced to misdirect important facts on inclusivity. Consequently, inaccurate information was disseminated and unclearly publicized to cause division among participants' causality (Van Niekerk, 2019; Ofori, et al., 2022). This theory was preferred to rectify the notion that humanity or virtue should be disvalued and hindered to dampen inclusive benefits, as discovered by Rosefelde and Pfouts (2015) and Van Niekerk (2019). To support this theory, information and communication technology theory was also applied.

In addition to the neo-realist theory, this study also utilized the information and communication technologies (ICT) theory that was also applied by Johnson (2016) and Ejemeyovwi et al. (2018). ICT theory revealed that high levels of inclusive growth are associated with a high level of ICT approval. ICT theory classifies countries into three groups: ICT empowered economies (ICTEE). Second, ICT adopts economies (ICTAE), and the last group is ICT-deficient economies (ICTDE). The ICTEE benefits from a high level of inclusiveness, a large ICT infrastructure investment, little disparity, and a low unemployment rate. The ICTAE countries achieve moderate inclusive benefits, while the ICTDE states experience a massive digital divide, lower levels of inclusiveness packages, and unruly unemployment rates. The theoretical framework of this study relied on the above-mentioned theories, as they have signalled relevant and proper knowledge about the study. Based on the above theories, the functions of ICT or digital technology and inclusive growth are related and aimed at advancing growth accumulation through interconnection.

In view of all that has been mentioned so far, the theoretical literature contributions are directed toward motivating individuals to government structures to form an inclusive growth model not based on the mobile cellular subscriptions as the current study intends to amplify through inclusive growth. The theoretical literature reviewed can be used to provide guidance for policymakers to share common intentions for the admission of inclusive growth global practices, particularly in selected SADC countries. The selected theories contribute to the advancement of the presentation of rules, explanations, and clarifies good reasons to manage various people and economies' inclusiveness from ICTEE, ICTAE, and ICTDE. These theories contribute to individual involvement by refreshing and enticing inclusive beliefs at various levels to rich anticipated ends. In addition, the theories were vital to minimise the inclusive growth and technological development gap noted under the utilitarian theory. Finally, the applied theories contribute to reveal the relationship between mobile cellular subscriptions and inclusive growth strategies from ICT empowered economies, ICT adopts economies and ICT deficient/ under-supplied economies.

2. 2. EMPIRICAL LITERATURE

This section presents the connection between mobile cellular subscriptions and inclusive growth to alert the reader about the avenues that the study may take. The empirical literature is presented thus: The relationship between mobile cellular subscriptions and inclusive growth

was examined to reduce stringent documentation required to own mobile phone and in ability to qualify for bank account which have excluded most of the residents who reside in developing countries from inclusion as also stipulated by Allen, Demirgüç-Kunt, Klapper and Martinez (2012). For these reasons, the spread of mobile phone services has become errand, although their main function was money transfer. Researchers have used this platform to expand and twist mobile cellular phone usage functions through inclusive growth.

Subsequently, a survey by Mwashuiya and Mbamba (2020) and Myovella et al. (2020) revealed that by 2006, only 11% of Tanzanian urban residents had gained formal access to financial services through mobile subscriptions. By 2016, more than 50% of the population had access to finances by utilising mobile money subscriptions. According to the World Bank (2016), mobile subscriptions services enable countries to witness better flow of financial inclusion. In addition, mobile subscription gained prominence and was used as a strong instrument that countries used for the settlement of their debts, such as rates and taxes, multichoice accounts, water, and electricity expenses, and many more. According to Nwachukwu (2016a) and Asongu and Boateng (2018b), Somalia has the smallest penetration of ICT, but against this backdrop, it has the highest mobile phone usage. Furthermore, the researcher noted a higher inclusion between mobile services and financial services. Mobile cellular subscriptions (per 100 inhabitants) were used to diverse African markets. Mobile subscriptions have risen in Seychelles, South Africa, Botswana, Mauritius, Cote d'Ivoire, Gambia, Gabon, Ghana, Mali, Namibia, Senegal, Cabo Verde and Kenya from 2015 – 2019 (Roopchund, 2020 and ITU, 2021).

Wamboye, Tochkov and Sergi (2015) applied the System Generalised Method of Moments (SYS-GMM), method to analyse 43 Sub-Saharan Africa (SSA) countries between 1975 and 2010. The outcome was that mobile subscriptions contributed significantly and positively to economic growth and dissemination of information in sectors. Ghosh (2016) conducted a panel data survey in India and suggested that there is an absolute and strong connection between mobile phone penetration and economic growth. As a result, the African countries' mobile services were led by Tanzania and Kenya.

According to the World Bank (2016a) and Ejemeyovwi et al. (2018), Nigeria was regarded as one of the Africa giants by having the foremost number of mobile cellular subscribers of about 9.15 million subscribers by 2004 and escalated to 139 million in 2014. Ghana followed the same steps and revealed about 1.69 million subscribers as of 2004 and 30.3 million subscribers in 2014. Cote d'Ivoire was ranked third position with 1.67 million subscribers in 2004 and 22.1 million subscribers in 2014. Cape Verde was the smallest country in terms of mobile cellular subscribers, with 65,780 subscribers in 2004, and 616,378 subscribers in 2014. The ideals of mobile cellular subscriptions have increased significantly over time beyond the total population of the countries. Consequently, people prefer to subscribe to a minimum of two or three different networks and service providers concurrently. In accordance with the Pew Research Center (2017), the United States (US) market for smartphones increased from 35% to 77% during 2011 and 2016. There was further spread over the global communication extension rate.

Similarly, Aker and Mbiti (2010), Njoh (2017), Abor, Amidu, and Issahaku (2018), and Adeleye and Eboagu (2019) showed that telecommunications and GDP played a transformative role in changing people's lives within the African continent. Moreover, most African countries witnessed positive mobile subscriptions and growth. Furthermore, countries that valued their ICT sector were astonished, particularly by the usage of turn-on mobile subscriptions. The system generalized method of moments (SGMM) was utilized to poll the mobile phones and fixed telephone subscriptions with different significance.

Mobile phone subscriptions were used to bridge or minimize the rural/urban gap. Women were empowered and included in projects that improved well-being, as noted by (Mihai & Iatu, 2020;

Nedumaran, 2020; Yan & Schroeder, 2020 and Koomson, Bukari & Villano, 2021). Moreover, mobile phones have been used to improve rural development, agricultural facilities, and modernize inclusivity. In addition, it was used to bridge distance barriers at the local, national, and international levels by permitting inhabitants to share their cultures, beliefs, norms, and values with the entire world.

According to Tchamyu (2015) and Asongu et al. (2016a), ICT's inclusivity has been attached to implemented and structured policies. Most African countries, particularly those situated in SADC, utilize ICT for mobile subscription and services. Moreover, Huawei (2017), Abid and Siddiqui (2020), David and Grobler (2020), and Adeleye et al. (2021) concur that ICT yields positive additional GDP returns. Inclusive growth was observed in Mauritius because of the high degree of institutional quality. According to Sujata, Sohag, Tanu, Chintan, Shubham, and Sumit (2015), Potnis (2016) and Patil Tamilmani et al. (2020), higher levels of mobile subscription benefits are experienced in India. India moved from 5 million to 37 million mobile subscribers in (2001), escalating to 898.02 million in (2013). There has been a revolt in mobile subscription usage per hundred inhabitants in Africa, although it was lower than the US statistics. Furthermore, Ejemeyovwi et al. (2018) reveal negative and statistically insignificant impacts of mobile cellular phone subscriptions on inclusive growth in West Africa. This study utilized the SGMM.

To expand and make the current study debate more enticing, it was revealed that according to Gabor, Curta, and Oltean's (2024), Google and Apple Mobility indices relationship was influential and statistically significant to report overnights on Travel and Tourism Competitiveness Index 2021 – during the COVID-19 pandemic. The study conducted a Grey Relational Analysis and General Linear Model ANOVA technique for 11 European countries. Furthermore, these positive Google and Apple Mobility indices overnights was based on the accurate ranking of tourism competitiveness, prior to other ITC support.

Likewise, in Osinubi, Ajayi, Osinubi, and Olaniyi's (2021) study the bootstrap simulation method was used to examine the symmetric and asymmetric causal relationships between tourism and inclusive growth in Turkey and Nigeria over the period 1995Q1-2018Q4. The study revealed that there is symmetric causality successively from tourism to inclusive growth in Turkey, although there is no evidence of neither symmetric nor asymmetric causal relationship running between tourism and inclusive growth in Nigeria. There is a need to change the position of tourism sectors in order for both respective countries to harness better performance that is significant to contribute to real GDP and improve effectiveness that will stimulate inclusive growth.

Zatonatska, Dluhopolskyi, Artyukh, and Tymchenko (2022) utilises the Social Activity of Subscribers software by means of SMS and calls to forecast the demand for mobile operator services particularly the Vodafone cases and prevent the outflow of customers to other mobile operators. This big data was useful in the research for both statistical and social characteristics to reveal the scientific novelty and theoretical significance by scoring model for predicting the activity of subscribers of the telecommunications company known as the VF Ukraine, on the basis of which marketing campaigns are conducted as alluded by Zatonatska et al. (2022).

In a nutshell, after exploration of empirical studies conducted globally, mobile cellular subscriptions were compared to economic growth, financial inclusion, rural/urban gap, and women's empowerment and were used as a bridge of distance barriers, export-import coverage ratio, as bootstrap for the tourism sector and to minimise human capital development to mention some few functions, not inclusive growth, as the current study aspires to explore. Studies such as Allen et al. (2012), Asongu et al. (2016), Ghosh (2016), World Bank (2016), Asongu et al. (2018b), Mwashiyu et al. (2020), and Myovella et al. (2020), which were conducted considering mobile

subscriptions, aimed to increase the level of household savings through financial transactions, and inclusive growth was boosted indirectly or spontaneously. Even though Ejemeyovwi et al. (2018) conducted a study on the impact of the use of mobile cellular phone subscriptions and inclusive growth in West Africa, their study applied SGMM, unlike the current study, where PARDL was executed specifically for the selected SADC members, and Ejemeyovwi et al. (2018) denied the claim that the adoption of mobile technology has a positive and significant impact on inclusive growth. As Ejemeyovwi et al. (2018) study, suffer from the fact that there is inverse relationship, difficulties may arise, when an attempt is made to implement and revise the inclusive growth policies. Therefore, the researcher saw an aperture in the relationship between mobile cellular subscriptions and inclusive growth, that is strengthening inconclusiveness arguments. Although, the previous studies are tied to inclusive growth their focus was not on examining the relationship between mobile cellular subscriptions and inclusive growth. The current study is relevant to show how mobile cellular subscriptions can be executed to fill the inclusive growth gap for the selected SADC countries. Therefore, the current study attempts to minimize this gap at the SADC regional level without limiting its outcome to be exploited in the global context. The next section focuses on econometric techniques used to explain the selected methodology.

3. RESEARCH METHODOLOGY

This section presents the methodology employed to achieve the objectives of this study.

3.1. DATA

Panel data from 2000 to 2020 for Botswana, Eswatini, Mauritius, Namibia, and South Africa are used. Data were sourced from the World Bank's World Development Indicators (WBWDI) and International Telecommunication Union (ITU) databases. Following Tella and Alimi (2016), GDP per person employed was used as a proxy for inclusive growth. The GDP per person employed combines the income growth and income distribution. Furthermore, the study also followed Myovella et al. (2019), who used mobile subscriptions per 100 inhabitants as a digitalisation proxy. Gross capital formation (GCF) and gross national expenditure (GNE) were added as control variables to support the study theory, as stated in section one. The data used, sources, and measurements are as follows:

Table 1. Source of data and operationalization of the variables

Variables	Definition of variables	Sources of data	Measurement
Gross domestic product per person employed (GDPPPE)	GDP per person employed is gross domestic product (GDP) divided by total employment in the economy.	WB	Constant 2017 PPP\$
Mobile-cellular subscriptions (MOBS) per 100 inhabitants	Mobile-cellular telephone subscriptions refer to the number of subscriptions to a public mobile-telephone service that provide access to the PSTN using cellular technology. The indicator applies to all mobile-cellular subscriptions that offer voice communications.	ITU	MOBS per 100 inhabitants
Gross capital formation (GCF)	Gross capital formation (formerly gross domestic investment) consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories.	WB	% of GDP
Gross national expenditure (GNE)	Gross national expenditure (formerly domestic absorption) is the sum of household final consumption expenditure.	WB	% of GDP

Source: Authors' own computation/ compilation based on the World Bank and ITU, 2022

3. 2. MODEL SPECIFICATION

In the footprints of [Aslam, Nareed, and Shabbir \(2021\)](#), inclusive growth is linked to social and digital inclusion. Although this study adopted the same measures of inclusive growth applied by Anand et al. (2013 & 2021), but they differ on acceptance of theories. This study challenges the use of utilitarian social welfare function drawn from consumer choice literature, because it focusses on the indifference curves to represent the aggregate demand changes over time and splits the income and substitution effect into growth and distributional components, without the analysis of technological variables. Based on the current study, an inclusive growth correlation was obtained from the mobile cellular subscriptions. The estimated model and the selected theories are likely to provide a theory-driven approach to the current study and to spur positive inclusive growth to the SADC region, particularly in the selected member state countries. Above all, the current study was modified following [Moyo and Khobai's \(2018\)](#) study, which was attributable to the social opportunity function. Therefore, the functional relationship in this study is expressed as:

$$\text{Inclusive growth} = f(\text{mobile cellular subscription}) \quad (3)$$

In line with the inclusive growth proposed in (3), the aim was achieved as follows:

Examining the relationship between mobile cellular subscriptions and inclusive growth:

$$GDPPPE_{it} = \beta_0 + \beta_1 MOBS_{it} + \beta_2 GCF_{it} + \beta_3 GNE_{it} + \mu_i + \varepsilon_{it} \quad (4)$$

Equation (3), adopted a linear format. There were no variable records in percentage. However, all study variables were logged to improve standardization in the equation, as documented by Kharusi and Ada (2018) and Letsoalo (2021). After logging the variables in equation (4) was presented. In line with this aim, the model is presented as follows:

$$LGDPPPE_{it} = \beta_0 + \beta_1 LMOBS_{it} + \beta_2 LGCF_{it} + \beta_3 LGNE_{it} + \mu_i + \varepsilon_{it} \quad (5)$$

Where L represents the logged variables in the model. The conversion of variables into logarithms was done to improve the study lag behavior in econometric interpretation to provide accurate and smooth results from logged data, as recognized by [Kharusi et al. \(2018\)](#) and [Letsoalo \(2021\)](#). β_0 is a constant. Parameters β_1 , β_2 and β_3 denote the output elasticities concerning the corresponding factor inputs. μ_i represents the country-specific effect and ε_{it} is the error term.

3. 3. ESTIMATION TECHNIQUES

E-Views 12 analytical software was used to test the collected data.

3. 3. 1. DESCRIPTIVE STATISTICS ANALYSIS

Descriptive statistics were used to measure the central tendency of the mean by focusing on the values, variance, and standard deviation to monitor the speed of the model. Moreover, this test was used to quantify and measure the position of the skewness and kurtosis of the Jarque-Bera normality test, rather than using a bell-shaped histogram ([Sarker & Khan, 2020](#)).

3. 3. 2. PANEL UNIT ROOT TEST

The unit root test is crucial for the selection and detection of non-stationary panels, as it analyses both time and non-time dimensions, as suggested by [Ajide et al. \(2021\)](#). Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and IM, Peasaran and Shi (IPS), formal unit root tests were conducted to ascertain stationarity and to classify the order of integration among the variables. Unit root tests are essential for obtaining a stationarity series ([Pamba, 2020](#)). Although

the IPS test was designed using ADF, it provides individual integration of regression model conclusions from the Hausman test by selecting the appropriate model between the Fixed Effect (FE) and Random Effect (RE) models, as referred to by [Mugowo \(2017\)](#) and [Cimpoeru \(2022\)](#).

3.3.3. COINTEGRATION ANALYSIS

Cointegration analysis was used to determine and display empirical and meaningful relationships ([Khan, et al., 2022](#)). Cointegration is detected when multiple variables are integrated separately in the same order by moving together in the long run. The study utilised The Hausman test was used to detect the outstanding strength and speed of the variables in the stated model to escort the long- and short-run association prior to the panel ARDL procedure. The Hausman test was used to reveal cointegration of its flexibility in predicting variable outcomes. The researcher applied this test based on these advantages and minimized the defects of denial of cointegration prior to the PARDL long- and short-run tests. The Hausman test preference is based on the decision rule or notion that the RE model symbolizes (or is preferred under) the null hypothesis. The FE model is an alternative (preference for the FE model).

H_0 represent the null

H_1 signifies the alternative

3.3.4. PANEL AUTOREGRESSIVE DISTRIBUTED LAG (PARDL)

The panel ARDL was employed to verify the interpretation of long-run relationships and short-run dynamics ([Kharusi, et al., 2018](#) and [Letsoalo, 2021](#)). PARDL is used for a small or a minimum of 21 observations and is useful for pairing or grouping critical values and classifying lower and upper bound values using a mixture of pure I(0) and pure I(1). The PARDL data uses short-run adjustments to fit the long-run equilibrium process through the error correction term without forgetting information ([Menegaki, 2019](#)).

The inclusive growth PARDL model in this study is presented as follows:

$$\Delta LGDPPPE_t = \beta_0 + \sum_{i=1}^p \Delta \beta_1 LGDPPPE_{t-i} + \sum_{i=1}^p \Delta \beta_2 LMOBS_{t-i} + \sum_{i=1}^p \Delta \beta_3 LGCF_{t-i} + \sum_{i=1}^p \Delta \beta_4 LGNE_{t-i} + \beta_5 LGDPPPE_{t-1} + \beta_6 LMOBS_{t-1} + \beta_7 LGCF_{t-1} + \beta_8 LGNE_{t-1} + \mu_t + E_{2it} \quad (6)$$

where Δ stands for the first-differenced operator, and μ_t is the error term. Character p represents the optimal lag length and β indicates both the long- and short-run dimensions. The short-run parameters range from β_2 to β_4 false, whereas the long-run parameters range from β_5 to β_8 . β_0 is the constant. The ARDL hypothesis is as follows.

$$H_0: a_1 = a_2 = a_3 = a_4 = a_n = 0$$

$$H_1: a_1 \neq a_2 \neq a_3 \neq a_4 \neq a_n \neq 0$$

H_0 is the null hypothesis, which indicates that there is no cointegration, whereas H_1 implies cointegration. The PARDL setup was applied to standardize and pool the selected variables ([Behera & Mishra, 2020](#)).

3.3.5. STABILITY TESTING AND FORECASTING

To detect the unknown and unexpected changes over time in the parameters of the regression equation instead of the slope coefficient, the AR inverse polynomial roots, variance decomposition, and generalized impulse response function tests were preferred, as applied by [Nadeem et al. \(2020\)](#) and [Ncanywa et al. \(2021\)](#). These tests were utilized to detect the reliability, stability,

and validity of the implemented model and to accounted for shocks and innovations through impulse response and variance decomposition analyses by revealing individual variable contributions, as stated by ElemUche et al. (2018) and Yameogo and Omojolaibi (2021). This section provides the sequence of econometric tests performed and interpreted in Section 4.

4. EMPIRICAL PRESENTATION AND DISCUSSION OF FINDINGS

This section has presented the econometric test results as follows.

4. 1. DESCRIPTIVE STATISTICS TEST RESULTS

Descriptive statistics test results are presented in Table 2 below.

Table 2. Descriptive statistics results, 2000 - 2020

Variables	LGDPPE	LMOBS	LGCF	LGNE
Minimum	4.391	4.518	1.072	1.925
Maximum	4.723	7.986	1.619	2.102
Mean	4.581	6.281	1.315	2.013
Standard Deviation	0.087	0.824	0.128	0.034
Skewness	-0.120	0.529	0.140	0.002
Kurtosis	1.940	2.832	2.322	3.438
Jarque-Bera	5.164	5.032	2.354	0.841
Probability	0.075	0.080	0.308	0.656
Observation	105	105	105	105

Source: Authors' own computation

The mean for LGDPPE, which mirrors (4.581), the minimum value of (4.391), and the maximum value of (4.723), is followed by the standard deviation, which shows a nonconformity of (0.087) and LMOBS deviance by approximately (0.824). This deviation captures various levels that cause an increase in LGDPPE in the selected SADC member state countries. The expected differences allow parameters to differ in PARDL during the short run to enforce long-run equality of coefficients in nominated SADC member states. The skewness measures the degree of asymmetry or sharpness of a series. Based on the results, this model LMOBS (0.529 > 0) displays positive skewness and a long right tail, while LGDPPE (- 0.120 < 0) is negatively skewed, indicating that it has a long-left tail. LMOBS (2.832 = 3) reflects a mesokurtic or normal distribution in the curve, with kurtosis corresponding to 3. The Jarque-Bera normal distribution shows LGDPPE (0.075 > 0.05), LMOBS (0.080 > 0.05), LGCF (0.308 > 0.05), and LGNE (0.656 > 0.05). This shows that the residuals are normally distributed when all variable probability values are more than 0.05 level of significance. This study accepts H_0 values because the residual distribution is normal.

4. 2. UNIT ROOT TESTS RESULTS

The study executed the LLC, ADF, and PP Fisher Chi-square tests to determine the variable order of integration. The variables were differenced once to maintain consistency in the panel unit root test. After differencing, all unit root outcomes were significant at the 1% level. This means that the study disapproved of the null hypothesis of sequence uncertainty at the 1% significance (Pamba, 2020 and Ahmed, et al., 2022).

Table 3. Formal unit root test results, 2000 - 2020

Variable	LLC			ADF			PP		
	Level	first-difference	order	Level	first-difference	order	Level	first-difference	order
LGDPPPE	-0.49	-2.82***	(1)	6.63	28.1***	(1)	3.77	30.3***	(1)
	(0.31)	(0.00)		(0.75)	(0.00)		(0.95)	(0.00)	
INTERNu	-1.08	-2.94***	(1)	5.70	24.1***	(1)	5.08	22.0***	(1)
	(0.13)	(0.00)		(0.83)	(0.00)		(0.88)	(0.00)	
POPGA%	12.0	-7.20***	(1)	14.6	64.5***	(1)	19.5**	20.9**	(1)
	(1.00)	(0.00)		(0.14)	(0.00)		(0.03)	(0.00)	
GDPPCGA%	-0.00	-4.24***	(1)	15.7*	46.3***	(1)	11.8	58.9***	(1)
	(0.49)	(0.00)		(0.10)	(0.00)		(0.29)	(0.00)	

Note: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. Probability values are displayed inside the brackets, statistical values are shaded with an asterisk to display the level of significance, and (0) and (1) denote the order of integration. L denotes the logged variables.

Source: Authors' own computation

Table 3 present the outcomes of stationarity in level, and first difference which satisfies the condition of using ARDL as noted by Menegaki (2019) who argue that dependent variable results should always be integrated as I(1) not I(0). Although, the unit root was conducted in level and first difference, observing the individual intercept, individual intercept and trend, and none. Yet, this study reported only the individual trend outcome and utilizes the other fields as validation of the stationarity of the variables in level and in first difference. All the variables showed the strength of the implication between the 1% and 5% level of significance.

4. 3. COINTEGRATION TESTS RESULTS

The cointegration test was executed to provide a standardized economic development level for country-specific results and to advance policymaking plans, as elucidated by Menegaki (2019). The study employed the Hausman test, as outlined in Section 3.2.4, to detect cointegration at the stated level of significance, as observed by Menegaki (2019).

The results of the Hausman test results are presented in table Table 4 below.

Table 4. Hausman specification test results, 2000 - 2020

Test summary		Chi-Sq Statistics	Chi-Sq. D.F	Prob.
Cross-sectional random		5.741	3	0.124
Variable	Fixed	Random	Var(Diff.)	Prob.
LMOBS	0.082	0.084	0.000	0.336
LGCF	-0.182	-0.161	0.000	0.066
LGNE	0.321	0.264	0.001	0.151

Source: Authors' own computation

The cross-sectional random summary reflects 5.741 chi-square statistics results, three degrees of freedom, and a statistically insignificant probability value of 0.124. The Hausman probability results ($0.124 > 0.05$) are more than the 5% level of significance, indicating that the RE model is appropriate. This study fails to reject the null hypothesis because the RE model is independent of the explanatory variables. Furthermore, the estimated model probability values were statistically insignificant for LMOBS ($0.336 > 0.05$), LGCF ($0.066 > 0.05$), and LGNE ($0.151 > 0.05$). The RE model succeeded in capturing individual diverse intercepts and slopes of coefficients between the selected SADC member states and displayed the partial pooling process during

estimation (Mugowo, 2017 and Cimpoeu, 2022). The RE results revealed a positive return of 0.084 between mobile cellular subscriptions (LMOBS) and inclusive growth (LGDPPE) during the study period. This study confirmed that there is cointegration between (LMOBS) and (LGDPPE).

The standard error is expected to be 0.915, indicating that LMOBS, LGCF, and LGNE explain 91.52% of the differences in inclusive growth (LGDPPE). The adjusted R-squared value of 0.909 indicates that approximately 0.90% of the error term results were neglected. The unobserved period among the selected SADC member states may be due to the immeasurable instability of gross capital formation and the gross national expenditure implications, which are handled differently depending on each country's level of development. The Hausman test results agree with those of Ejemeyovwi et al. (2018) and Adeleye et al. (2021), who underlined that Africa differs when compared to the US mobile subscriptions statistics; nevertheless, it has a positive influence on inclusive growth. The Hausman test was necessary to verify the existence of cointegration between variables and affirm that the error term will adjust to equilibrium. The cointegration test justifies the long-run relationship and supports the execution of the PARDL tests.

4. 4. PARDL LONG-RUN AND SHORT-RUN TEST RESULTS

According to Ali et al. (2017) and Menegaki (2019), panel ARDL data provide adjustments that fit the long- and short-run equilibrium processes by regulating the error term.

4. 4. 1. PARDL LONG-RUN TEST RESULTS

The long-run equation was used to determine the effect of the independent variables on the dependent variable. The long-run results are also recognized as pooled coefficients. The long-run PARDL technique was specifically applied to assess the model results, following the Bentzen and Engsted approach of 2001, as mentioned by Kharusi et al. (2018) and Letsoalo (2021).

Table 5. PARDL long-run test results, 2000 - 2020

Variable	Coefficient	Standard Error	t-Statistic	Probability
LMOBS	0.156	0.024	6.304	0.000
LGCF	0.166	0.099	1.670	0.099
LGNE	-0.996	0.307	-3.240	0.001
COINTEQ01	-0.358			0.000

Source: Authors' own computation

The parameters used to estimate the long-run equations were LGDPPE, LMOBS, LGCF, and LGNE. The long-run elasticity is expressed as follows:

$$\text{LGDPPE} = 0.156 \text{ LMOBS} + 0.166 \text{ LGCF} - 0.996 \text{ LGNE} \quad (7)$$

According to the long-run results of the selected SADC member states, LMOBS is positive and statistically significant. The results indicate that a 1% increase in mobile cellular subscriptions leads to an increase in inclusive growth by 0.156. This implies that mobile cellular subscriptions are statistically significant at the 5% level and have a long-run influence on inclusive growth for the selected member states during the study period.

The selected SADC member states are breeding enough and relevant channels of communication to embrace inclusive growth opportunities and improve well-being, as also disclosed by Kabee (2021) and Bacchetta et al. (2021). The long-run PARDL results are in accordance with Ejemeyovwi et al. (2018) and Adeleye et al. (2021), who noted that mobile subscriptions have a

positive influence on inclusive growth. Furthermore, Ouma et al. (2017) also found that the use of mobile subscriptions, services, and operations raises the level of household savings, boosting inclusive growth. Moreover, some sub-Saharan African economies have practiced and experienced the benefits of subscription services using telephones universally. In addition, mobile phone subscriptions were useful in bridging or minimizing the rural–urban gap. Consequently, women are empowered and included in projects that improve their well-being, as noted by Bello-Bravo (2020), Yan et al. (2020), and Koomson et al. (2021). Moreover, mobile phones have been used to improve rural development and agricultural facilities, as pointed out by Nedumaran (2020) and Mihai et al. (2020).

However, the current study opposes Ejemeyovwi et al. (2018) discoveries of statistically insignificant and negative effects on the use of mobile cellular phone subscriptions and inclusive growth in West Africa through the SGMM. Ejemeyovwi et al. (2018) outcome is contradicting the findings of the current study. It is worth noting that, the current study's finding is in line with the neo-realist theory, which documented that better performances are noticed in societies where norms are consistently implemented and monitored to improve inclusive welfare, security, safety, prosperity, fortune, and success, as observed in Japan (Van Niekerk, 2019 and Ofori, et al., 2022). Moreover, this theory encourages individual participation in inclusive growing and is in agreement with the ICTEE benefits outlined in the ICT theory in Section 2.1. meaning that the SADC can use advantage of these higher levels of mobile cellular subscriptions and inclusiveness to improve vibrant and large ICT infrastructure investments, which may lower the level of inequality, unemployment rate and augment inclusive growth.

However, even though mobile cellular subscriptions influence inclusive growth, their links among the selected SADC member states have not yet yielded results for ICT infrastructure development, level of investment, and employment creation as the ICTEE theory benefits demands. These unguarded concerns somehow hamper economic growth and deteriorate inclusive growth. Above all, the study's findings are in line with the prior expectation that digitalisation variables have a positive and direct impact on inclusive growth. The findings also validate the empirical expectation, as debated, and support the positive and corresponding links between mobile cellular subscriptions and inclusive growth overview trends highlighted in Figure 1. This study supports the notion that technological change and inclusive connectivity have ability to drive SADC inclusive growth to desired destination.

LGCF showed a positive and statistically significant relationship with LGDPPPE. This indicates that a 1% increase in gross capital formation increases inclusive growth by 0.166. This result indicates that gross capital formation is significant at 0.10 level of significant. This indicates that the gross capital formation of the selected SADC member state countries has a long-run and positive influence on LGDPPPE. LGCF is worthy of attention as it has a positive stimulus. This finding agrees with those of Huawei (2017), Abid et al. (2020), and David et al. (2020), who concur that ICT yields positive and additional GDP returns in Mauritius. Their studies also highlighted that inclusive growth is practiced more in countries with a high degree of institutional quality. Furthermore, middle- and low-income countries' institutional quality requires additional support to achieve inclusive growth based on their ability.

The LGNE coefficient was negative and statistically significant. A 1% increase in gross national expenditure decreased inclusive growth by 0.996. This implies that even though gross national expenditure is significant in selected SADC member states in the long run, it is not worthy of attention, meaning that it has a negative incentive towards inclusive growth. This finding is in accordance with Fendoğlu et al. (2021) and Bacchetta et al. (2021), who found that the credit-to-GDP ratio has a negative influence, which deepens countries' financial measures and hampers growth.

The findings are also supported by neo-realists who distinguished that the emergence of intra-market as modern drivers of technology, transformation, and information sharing have caused the destruction of ancient economic structures (Rosefielde, et al., 2015 and Van Niekerk, 2019). This theory also implies that innovation can be used to enhance the negative externalities such as self-destruction, disvaluing humanity while advancing national expenditure and hindering inclusive growth distributions (Rosefielde, et al., 2015 and Van Niekerk, 2019). Furthermore, the LGNE study findings contradict those of Wall-cook et al. (2017), who opined that digitalisation improves and modernizes inclusivity by reducing distance barriers at the local, national, and international levels. The current study reports an inverse relationship, because an increase in gross national expenditure variable implying that the inclusive growth process is prolonged.

Evidently, this inverse association between gross national expenditure and inclusive growth was also noted in the Hausman cointegration test results in Section 4.3 above. The Hausman test results reflect an unobserved period among the selected SADC member states, which may be due to the immeasurable instability of gross capital formation and gross national expenditures. In addition, this outlined that the GCF and GNE have overlooked similarities that are handled differently depending on each country's level of development and strength on gross capital formation and gross national expenditure.

The error correction model is statistically significant at the 1% by -0.358 (0.000) and support the long-run cointegration test. This indicates that a 35.8% speed of adjustment is applied to inclusive growth each year. A negative error correction term is corrected, and inclusive growth variable use a speed of 35.8% to adjust to the equilibrium level. This model fulfils the PARDL condition for long run or pooled coefficients. Furthermore, the disequilibrium movement will be corrected within a longer period because the error term has a lower value.

4. 4. 2. PARDL SHORT-RUN TEST RESULTS

The short-run results detect the routines of the speed of adjustment on the dependent variable or inclusive growth towards equilibrium.

Table 6. PARDL short-run test results, 2000 - 2020

Variable	Coefficient	Standard Error	t-Statistic	Probability
D(LMOBS)	-0.106	0.055	-1.919	0.058
D(LGCF)	-3.30E	0.092	-0.000	0.999
D(LGNE)	-0.283	0.112	-2.529	0.013
COINTEQ01	-0.358			0.000

Source: Authors' own computation

According to the short-run results, LMOBS was negative and statistically significant. The short-run results show that a 1% increase in mobile cellular phone subscriptions led to a decrease in inclusive growth by -0.106 . This implies that mobile cellular subscriptions negatively influence the selected member-state inclusive growth in the short run, since the probability value of 0.05 is statistically significant. According to Asongu et al. (2016) and (2018b), Somalia has the smallest penetration of ICT, but has been reported among the highest utilizers of mobile phones. Furthermore, Somalia utilises higher inclusion of mobile to increase financial services. Mobile cellular subscriptions (per 100 inhabitants) have diverse African markets. Mobile subscriptions rose in Seychelles, South Africa, Botswana, Mauritius, Cote d'Ivoire, Gambia, Gabon, Ghana, Mali, Namibia, Senegal, Cabo Verde, and Kenya from 2015 to 2019, as discovered by Roopchund (2020) and ITU (2021).

Furthermore, the study finding contradict those of [Huawei \(2017\)](#), [Abid et al. \(2020\)](#), and [David et al. \(2020\)](#), who concur that ICT yields positive and additional GDP returns in Mauritius. Moreover, the results show that inclusive growth is experienced, along with an advanced degree of institutional quality. Furthermore, the institutional quality of middle- and low-income countries requires reinforcement to achieve inclusive growth. The selected SADC member states highlight the negative influence of LMOBS and LGDPPPE in the short run, although it is important. This indicates that the selected SADC member state LMOBS channels are not linked to LGDPPPE in the short run. Parallel association extends the inclusive growth gap. The study disconfirms that the selected SADC member states mobile cellular subscriptions have a direct influence on inclusive growth in the short-run period from 2000 to 2020, as it does in the long run period. The study also showed that LGCF has a negative and statistically insignificant relationship with inclusive growth in the short run. This indicates that a 1% increase in gross capital formation decreases inclusive growth by -3.30E. This implies that gross capital formation has a negative incentive in the short term. This finding contradicts [Huawei \(2017\)](#), [Abid et al. \(2020\)](#), and [David et al. \(2020\)](#), who contend that a high degree of ICT supports country-inclusive growth. In addition, the selected SADC members LGCF failed to influence LGDPPPE and confirmed that LGCF is not worthy of attention in the short run because it reveals a statistically insignificant probability value of 0.999. LGNE reflects negative and statistically significant short-term results. This reflects that a 1% increase in gross national expenditure decreases inclusive growth by -0.283. This outcome reveals that the selected SADC member states' gross national expenditure is negative, but statistically significant at 0.013. This variable deserves attention in the short run, although it has negative incentives. The study LGCF and LGNE reflect the opposite relationship to the selected SADC member states' inclusive growth in the short-run results. These findings are in line with the panel data limitations or theory that outlines that although panel data produces accurate results, control variables may tend to decrease while economic estimates increase, as suggested by [Behera et al. \(2020\)](#). Their implications differ only because LGCF is negative and insignificant.

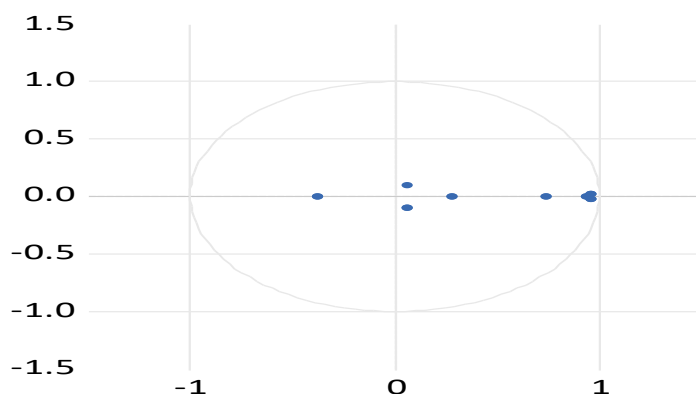
4. 5. STABILITY AND FORECASTING TESTS RESULTS

To detect the unknown and unexpected changes over time in LGDPPPE, LMOBS, LGCF, and LGNE, the AR inverse polynomial test was chosen ([Nadeem, et al., 2020](#) and [Ncanywa, et al., 2021](#)). This test was used to detect the strength and fastness in the long run. To detect the short- and long-run periods' total forecasts, the variance decomposition was employed as opted by [ElemUche et al. \(2018\)](#). The GIRF test was applied to reveal how the shock responds to a zero level ([Ahmad, et al., 2015](#)). These tests were used to detect and strengthen the speed of the variables in the long run. Furthermore, tests were applied to determine whether the regressand or independent variables of the stated model were notable.

4. 5. 1. INVERSE ROOTS OF AR CHARACTERISTIC POLYNOMIAL TEST RESULTS

The inverse roots dynamic stability was displayed inside the unit circle as demonstrated below.

Figure 2. Inverse AR roots illustration, 2000 - 2020
Inverse Roots of AR Characteristic Polynomial



Notes: no root lies outside the unit circle. VAR satisfies the stability condition.

Source: Authors' own computation

The polynomial roots were necessary to determine the value of the unknown variable. The results in Figure 2 indicate that VAR satisfies the stability condition because all inverse roots lie within the circle (Nadeem et al. 2020 and Ncanywa et al. 2021). This also means that the projected model is stable and meets the statistical requirements. This evidence is supported by the stationarity results obtained from all the variables under the formal unit root test results in Section 4.2.

4. 5. 2. VARIANCE DECOMPOSITION (VD) TEST RESULTS

The VD test results were applied to specifically measure the flow from the dependent variable to the rest of the independent variables, and how LMOBS, LGCF, and LGNE flows compared to one another in the model.

Table 7. Variance Decomposition test results, 2000 - 2020

Period	S.E	LGDPPPE	LMOBS	LGCF	LGNE
1	0.016	100.000	0.000	0.000	0.000
2	0.023	98.364	0.292	0.796	0.545
3	0.028	98.155	0.465	0.704	0.673
4	0.031	97.820	0.627	0.593	0.958
5	0.034	97.343	0.780	0.505	1.371
6	0.037	96.718	0.924	0.440	1.915
7	0.039	95.952	1.059	0.394	2.593
8	0.041	95.058	1.183	0.359	3.399
9	0.042	94.051	1.295	0.331	4.321
10	0.044	92.951	1.395	0.310	5.343

Source: Authors' own computation

The results in Table 7 indicate the short- and long-run total forecast of LGDPPPE against other variables. This study arranged periods 1 to 5 as the short run. The long run is reflected from period 6 to period 10 or more years. In the short run, LGDPPPE, which denotes inclusive growth,

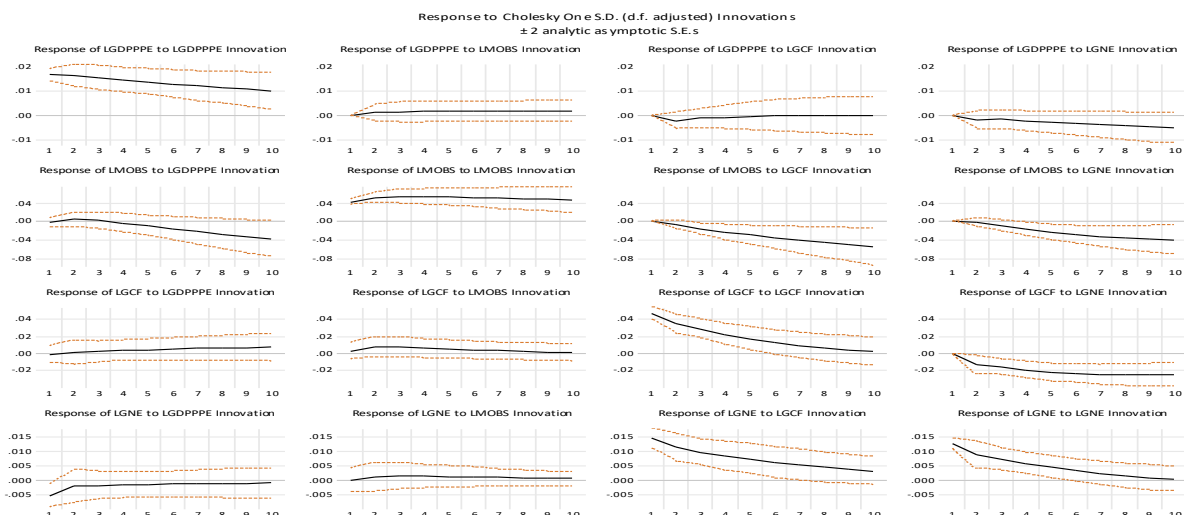
exhibits strong endogeneity. In year 1, LGDPPPE is strongly influenced by its own variable by 100%, which is above the mobile cellular subscriptions, gross capital formation, and gross national expenditure variables. LMOBS, LGCF, and LGNE show strong exogenous influence in forecasting the selected SADC member states' inclusive growth in the short run. Furthermore, the influence of these variables on LGDPPPE is weak compared to their influence on itself. However, the forecast level reflects some improvement over time.

LGDPPPE has strong endogeneity in the long run, while LMOBS, LGCF, and LGNE display strong exogeneity. From year 6 to year 10, LGDPPPE displayed a higher percentage, ranging from 96.718 to 92.951, compared to other variables. Although LMOBS, LGCF, and LGNE have also increased gradually over the years, their long-term influence on LGDPPPE is still weak. The LMOBS and LGCF variables are strongly influenced by their own variables, apart from the LGNE variable that received more influence from gross capital formation than its own variable. VD was necessary to determine the mean squared error of the designed model. Moreover, it revealed and determined the strength of the dependent variable over time. It indicates the information or forecast error variance contributed by each variable in the autoregression of the selected SADC member states. The VD test reveals forecasting and unidirectional results running from LGDPPPE to the rest of the variables in the model from 2000 to 2020, as opted by ElemUche et al. (2018).

4.5.3. GENERALISED IMPULSE RESPONSE FUNCTION (GIRF) TEST RESULTS

The GIRF test results reveal the impact of the short- and long-run shocks in different periods. The outcomes of the GIRF test results are presented in Figure 3 to illustrate inclusive growth's direct reaction to mobile cellular subscriptions, gross capital formation, and gross national expenditures.

Figure 3. Generalized Impulse Response Function illustration, 2000 - 2020



Source: Authors' own computation

The GIRF patterns were useful for refining the theoretical structure and accomplishing the implications that arose during the policy-prediction stage. Furthermore, it is responsible for the overtime system convergence of a stationary series and reveals data windows applied during calculations by revealing 95% confidence intervals. Inclusive growth shock is described by a positive and statistically significant response from the LGDPPPE-to-LGDPPPE graph above the zero mean. Inclusive growth displayed a positive response to mobile cellular subscrip-

tions from periods 1 to 10 of the study. Hence, the shock steadily moves close to the zero line throughout LGDPPPE to the LMOBS trend. The study revealed that the flow from LGDPPPE to LGDPPPE and from LGDPPPE to LMOBS reflected positive, direct, and statistically significant responses above the zero mean.

Inclusive growth shows a negative balance in response to gross capital formation. The response was very low from period 1 to period 5. Thus, the shock slowly dies as the impact of LGCF returns or converges to zero during Period 6. This implies that the selected SADC member states' flow between LGDPPPE and LGCF association reflects negative and statistically insignificant responses that led to positive and significant responses as the period continued. In addition, the study showed that inclusive growth had a negative balance in response to gross national expenditure. The negative and insignificant response hangs on being very low and far from a zero mean from period 1 to period 10. The gross national expenditure shock failed to return to zero mean during the study period, with a negative and statistically insignificant response. This means that the selected SADC countries should abate some expenditures, particularly in the country context.

The results of mobile cellular phone subscriptions and inclusive growth in the selected SADC member states also highlight the positive and corresponding links during the study period. The results for LGNE are inconsistent with the neo-realist theory, as discussed in Section 2.1, but affirm the PARDL short-run results, as all variables were negative but statistically significant. Such results imply a need to link the selected SADC member states LGCF and LGNE to act and respond to inclusive growth, since they are statistically significant in the long run. This study has revealed that mobile cellular phone subscriptions have included most people in the selected SADC member states, although its channel to inclusive growth requires heightening to sustain well-being. The current study's test outcomes reflect meaningful contributions to the five selected SADC member states that can be applied in different ways based on the country level and structured rules. The outcomes are also supported by Roopchand's (2020) and ITU's (2021) findings that mobile cellular subscription penetration caused the African mobile market to diversify.

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The previous sections analysed different econometric tests. This section presents the study's findings by summarizing, concluding, and making recommendations based on the results and contributions acquired, limitations and suggested focus for future studies.

This study examined the relationship between mobile cellular subscriptions and inclusive growth in the selected SADC member countries from 2000 to 2020. The study aim was achieved by means of PARDL and numerous econometric techniques. Suitable data were sourced from WBWDI and ITU databases. The theoretical and empirical literature reviewed was linked to the estimated model. The descriptive statistics analysis was followed by the unit root test, and the cointegration and PARDL's long-run and short-run analyses were executed and accompanied by stability and forecasting tests.

The long-run results of the selected SADC member state countries revealed that LMOBS has a positive and statistically significant relationship with inclusive growth by indicating that a 1% increase in mobile cellular subscriptions is equivalent to 0.156 in inclusive growth. This implies that the selected SADC member states are breeding enough channels of communication to embrace inclusive growth opportunities as divulged by Kabeer (2021) and Bacchetta et al. (2021). However, the results have also demonstrated that mobile cellular subscription systems need to be modified according to the SADC requirements of inclusive growth realities to am-

plify well-being and ICTEE theory benefits. The study findings are in line with the study's prior expectation and neo-realist theory that digitalisation variables have a positive and direct impact to drive inclusive growth, thus validating the empirical expectation as debated. LGCF showed a positive and statistically significant relationship with LGDPPPE. The LGNE coefficient was negative and statistically significant. The selected SADC member states should limit and abate the LGNE and amplify LGCF. The error correction model is statistically significant indicating that a 35.8% speed of adjustment is applied to inclusive growth each year. The study also accounted for shocks and innovations through impulse response and variance decomposition, which was appropriate, since numerous previous studies overlooked the impact of responses.

The purpose of this study was to examine the relationship between mobile cellular subscriptions and inclusive growth in the selected SADC member states from 2000 to 2020. In observation, the current study results may relief and clarify why numerous countries including the selected SADC countries are still struggling to benefit from inclusive growth, which hinders equal distribution and employment creation. This study recommends that expansion of the ICT infrastructure requires to be prioritised by policymakers for mobile cellular subscriptions to contribute to inclusive growth successfully.

Due to diverse digitalisation patterns, economic progress, innovation and upgrades linked to technological renovations, this approach may be revisited for upcoming studies or research to include lower, middle-, and higher-income groups within the SADC region. Further investigation is required to overcome data limitations of the current study and to broaden the sample of countries. However, the limitations of the current study do not influence the outcome of the presented findings, as its findings are in agreement with the study prior expectations.

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