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Article

# Trade openness, telecommunication infrastructure, institutions and economic growth nexus: The case of landlocked African countries

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**Abstract:** This research analyses the effects of openness, telecommunications, and institutional nexus on economic growth in African countries using a panel model with data from 16 landlocked countries from 1996 to 2021 and employing the pooled mean group estimation technique that mitigates bias from country heterogeneity and discerning short-term and long-term equilibrium dynamics and two-step system-generalized method of moments (GMM) estimation for robustness check. The empirical findings indicate that openness exerts a significantly positive effect on economic growth in the models. This supports the neoclassical model, suggesting that being landlocked should not impede economic growth, but rather, growth should depend on opportunities available to each country. However, institutions and telecommunications show a mixed correlation with economic growth. These findings can guide landlocked developing countries in enhancing their exports and fostering skill acquisition to attract advanced technology. In conclusion, policymakers should improve macroeconomic policies, telecommunications infrastructure, and institutional structure to strengthen the sustainability of economic growth in African landlocked countries.

**Keywords:** landlocked African countries; openness; telecommunications; institutions; pooled mean group, GMM

## 1. Introduction

Landlocked countries do not have access to the sea. Instead, they rely on international transport that connects them to neighbouring countries called transit countries. These have been disadvantaged to their trade and hinder foreign investors (Gallup et al., 1999; Normizan and Yasunori, 2014; Paudel, 2014). Bhattarai (2019) enumerate three main disadvantages of being a landlocked country: firstly, the problem of crossbencher of labour; secondly, the military of the coastal countries that impose a cost on interior landlocked countries; and thirdly, infrastructural development across the natural border. As a result of these three disadvantages, landlocked countries experience a decrease in economic growth of about 1.5% annually compared to non-landlocked countries (Basnet, 2021; MacKellar et al., 2000). As depicted in **Figure 1**, the GDP trajectory of landlocked countries is linear and falls below that of non-landlocked countries and all of Africa. This trend corresponds with the comparatively low export levels shown in developing landlocked nations in **Figure 2**.

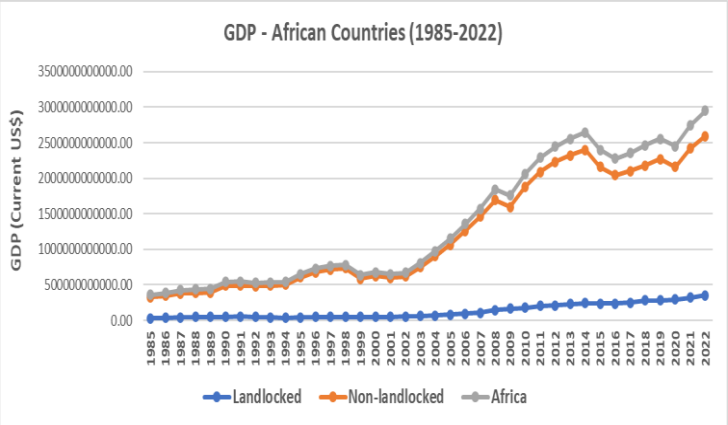


**Figure 1.** GDP of African countries.

Source: Authors' computation from World Bank (2024).

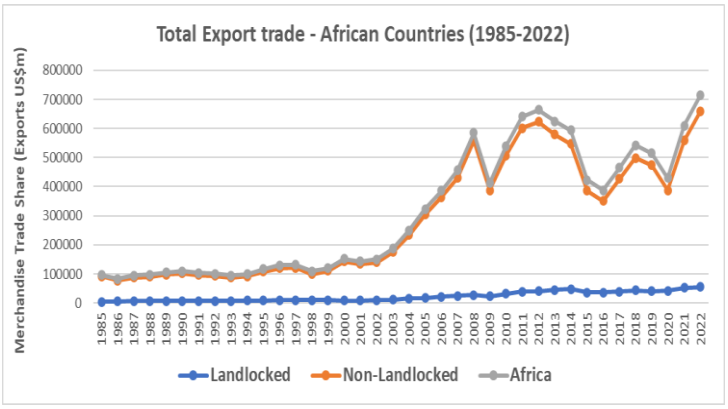


**Figure 2.** Total exports of African countries.

Source: Authors' computation from UNCTAD (2024).

Exporting of goods and services, thus, takes a longer period, making it relatively hard to import inputs needed by the manufacturing industries (Raballand, 2003; Radelet and Sachs, 1998). According to WorldBank-UN (2014), landlocked developing countries spent $3203 to export a container and $3884 to import a container of merchandise, as opposed to the $1602 incurred by their coaster neighbours. Indicating that importing and exporting in landlocked developing countries is twice as costly. These high transport and trade costs have inflated the price of imported input used in the manufacturing sector, reduced the level of investment, and diminished the export profit (Radelet and Sachs, 1998). Other problems that hinder economic growth in landlocked countries are border delay, transport costs, the level of openness to trade, and multiple clearance processes that have been researched extensively in international trade literature (Bhattarai, 2019; Kashiha et al., 2016; MacKellar et al., 2000; Normizan and Yasunori, 2014; Paudel, 2014; Paudel and Cooray, 2018; Raballand, 2003; Radelet and Sachs, 1998; Stone, 2001). Contrarily, Collier and O'Connell (1960) and Raballand (2003) argue that being a landlocked country does not matter; rather, it depends on the opportunities open to the country. For instance, a landlocked country like Botswana and Chad with abundant natural resources (Banegas Rivero et al., 2019) will experience export and economic growth despite the high cost of transportation. Yet, other resource-scarce

landlocked countries will be more dependent on the neighbourhood countries (Paudel, 2014; Radelet and Sachs, 1998).

Therefore, to ascertain whether being a landlocked developing country hinders economic growth, this study prompted the need to examine how trade openness can contribute to the development of landlocked countries in Africa. However, openness to trade cannot be achieved if no basic infrastructure facilities will boost the economy (Limao and Venables, 2001; Radelet and Sachs, 1998). Such infrastructure includes transportation, electricity, and telecommunication (Carlsson et al., 2013). Of importance to this study is evaluating how telecommunication, as one of the dominant infrastructures, promotes growth in landlocked developing countries (LLDCs). Existing studies indicate that despite being landlocked in developing countries, infrastructures help achieve a fast, dependable, and efficient transportation system and reduce transaction costs (Paudel, 2014). According to the WorldBank-UN (2014), with the LLDCs' emphasis on telecommunication investment, the document used by landlocked countries for export value was reduced from 9 in 2006 to 8 in 2014, and for imports, it was reduced from 11 to 10. Meanwhile, the average time LLDCs took for exports decreased from 48 to 42 days, and imports decreased from 57 to 47 days. This indicates that increasing broadband development and connectivity led to economic growth and productivity. Hence, telecommunication is emphasised as a significant infrastructure due to its tangible and intangible positive effects on economic growth (Ward and Zheng, 2016). It is empirically proven to minimise transaction costs and create employment (Abdulqadir and Asongu, 2022; Bakare and Gold, 2011; Bertschek et al., 2015; Borchert et al., 2012; Ward and Zheng, 2016).

Furthermore, as important as the studies on how openness to trade and telecommunication infrastructure impact the economic growth of landlocked countries are. However, these studies neglected the role of quality institutions, which is paramount for developing countries. Understanding that landlocked developing countries need to emphasise quality institutions that will facilitate more trade and investment in the region (Basnet, 2017, 2021; Borchert et al., 2012) and transmit economic growth, which is ultimately important for two reasons. First, the argument on the effect of institutional structure (Basnet, 2021; Paudel, 2014) on economic growth in developing landlocked economies, which is debatable, would be put to rest. Second, some scholars (Gallup et al., 1999; Kashiha et al., 2016; Paudel, 2014; Radelet and Sachs, 1998; Shepherd and Wilson, 2007) argue that geographical matters for economic growth, even when landlocked developing countries are growing poorer than non-landlocked countries, partly because of double costs but mainly due to institutional bottlenecks that this study intends to establish. However, evidence has shown that geography does not matter in economic growth because landlocked European regions are developed, while some non-landlocked nations are poorer in growth than landlocked countries (Paudel and Cooray, 2018; Raballand, 2003). Conversely, Acemoglu and Robinson (2008), Almeida (2018), Basnet (2021), Gold and Rasiah (2022) and North (1991) argue that institution structure, such as rule of law, private property ownership, government effectiveness, control of corruption, and civil liberty, among others, is greater than a geographical location for a country to attain economic growth. Considering that economic growth cannot be

determined by inequality, corruption, and unlawful thought, what defines it is the nation's prosperity and a balanced high growth rate in the long run (Chomen, 2022). This study argues that institutions are a fundamental cause of economic growth in LLDCs in Africa.

On this premise, this research aims to investigate the impact of trade openness, telecommunications infrastructure, and institutional quality on the economic growth of landlocked African countries. To establish the nexus between openness to trade, telecoms and institutions on economic growth, this study utilises data obtainable from WDI, WGI and KOF Swiss Economic Institute from 1996 to 2021 to analyse the short and long-run effects in 16 landlocked African countries. The study seeks to understand how these factors interact and influence growth, given landlocked nations' unique challenges, and to provide policy recommendations to help these countries enhance their economic performance despite their geographical disadvantages. Although previous studies on landlockedness exist (Banegas Rivero et al., 2019; Bhattarai, 2019; Borchert et al., 2012; Paudel and Cooray, 2018; Raballand, 2003; Stone, 2001), as crucial as these existing studies on the determinants of landlockedness are, their scope covers the entire world, combined, or compared landlocked developed or developing countries in Europe, Africa, and Asia, not taking cognisance of their different factor endowment and technological advancement. They study the impact of landlockedness on export performance, geographical distance, institutions, and trade liberalisation as a variable that affects the countries (Basnet, 2021; Limao and Venables, 2001; Paudel, 2019; Raballand, 2003). Others study the nexus of landlocked and economic growth, transport infrastructure and landlockedness (Banegas Rivero et al., 2019; Bhattarai, 2019; MacKellar et al., 2000; Radelet and Sachs, 1998; Stone, 2001). Therefore, the divergence of this study from prior empirical literature is the concentration on landlocked developing countries in Africa solely due to their similar obstacles of poor economic conditions, geographical status, weak institutions, and to achieve a result that is not biased or generalised. Gold (2019, 2022) argued that pooling countries with heterogeneous factor endowment and region results in biased estimates. According to Paudel and Cooray (2018), countries nearly in the same income bracket trade more. The results indicate that openness and growth positively correlate, while telecommunication, institutions and economic growth have a mixed significance. Therefore, the findings suggest that improving telecommunication infrastructure and strengthening the institutions will enhance the standard of living of such countries despite being landlocked. The subsequent sections of the paper will delve into theoretical and empirical literature, methodology, results presentation and discussion, conclusion, and policy recommendations.

## 2. Literature review

### 2.1. Theoretical review

For a country to derive mutual benefit from trade, then such a country should specialise in the sector with good factor endowments and produce goods efficiently and effectively (Ricardo, 1891). However, as a result of openness to trade concerning Ricardo's theory, if each country specialises in the production of a

commodity that has a comparative advantage, it will therefore increase its per capita income through large output and the export of the sector will grow fast and boost the overall economic growth. Bhagwati and Srinivasan (1978), Keho (2017) and Krueger (1978) argue that specialisation in sectors improves trade and increases productivity in the long run. They suggest a positive relationship between trade openness and economic growth through technological advancement (i.e., telecommunications). Blanchard and Leigh (2013) argue that openness to trade encourages countries to specialise in producing commodities on which they have a comparative cost advantage. Contrarily, Almeida and Fernandes (2008) point out that specialisation in a sector where research and development activities are not standard may disadvantage economic growth with trade openness. The neoclassical theory and Solow-Swan growth model (MacKellar et al., 2000; Paudel, 2014) believe that being a landlocked country should not be a hindrance or slow down growth; rather, openness to trade depends on the opportunities open to the country (Collier and O'Connell, 1960). For instance, if the landlocked country has abundant natural resources or technology that can be exported despite the high cost of transportation, the resources-rich landlocked countries at least have something more beneficial to gain from trade openness than resources-scarce landlocked countries. However, the case against landlockedness is vague, considering their lack of access to the seaport that is regarded as the gateway to international trade. Paudel (2019) pointed out that the theoretical literature on economic growth takes for granted that LLDCs are encountering peculiar institutional, infrastructural, geographical, and other endogenous variables that influence their growth performance, such as how neighbouring government bureaucratic processes coupled with LLDCs' weak internal institutions raise the cost of trade and affect growth. Therefore, making a case against landlocked countries in Africa based on the conventional neoclassical theories of trade and growth is difficult. This is because development models prioritising sustainable growth or the improved output impacts of exports-oriented production acknowledge that being landlocked impedes development, as evidenced in the empirical literature below.

## 2.2 Empirical review

### 2.2.1. The trade openness-economic growth nexus

Trade-growth literature is categorised into two. The first is trade openness-economic growth nexus, and the other category is the trade barriers-economic growth nexus (Frankel and Romer, 1999). In this study, the empirical literature will focus on the former because it spurs trade. Bearing in mind that for a landlocked country to develop, there is a need for liberalised international trade that will fast-track the economy of such a nation. Trade openness is the extent to which a country relates to other countries (Osei et al., 2019; Tripathi, 2023). Also, openness to trade increases income in the state of investment through technological knowledge. However, increased investment and improvement in technology and innovation increased productivity, which led to economic growth. Bhattarai (2019), Romer (1994), Tripathi (2023) and Zahonogo (2016) suggest that the more the country participates in trade openness, the greater the use of technology generated in

advanced countries. Moreover, they grow more rapidly than the countries with a lower degree of trade openness. However, trade openness in landlocked countries can be positive or negative, based on the extent of openness to trade in the country and the neighbourhood effect. Using panel data of 46 countries (18 Central Asia landlocked and 28 non-landlocked trading partners), 10,000 observations for a 5year period (1995 to 1999) and the gravity model, Raballand (2003) examined the impact of landlockedness and other negative factors on trade. The findings confirm that border-crossing obstacles result in a high transport costs burden synonymous with landlocked countries, reducing trade by over 80%. Furthermore, landlocked countries have only overland transport, so the burden is higher than coastal countries with maritime transport. Another factor that impacts trade negatively in the landlocked region is the institution, that is, the bargaining power of the landlocked countries with their coastal neighbours. However, infrastructure, a higher degree of trade openness, and new transport means are relevant and positively correlated with landlockedness.

Paudel (2014) study on landlocked developing countries finds that landlockedness hinders the region's economic growth. Trade openness positively correlated with economic growth, indicating that trade liberalisation policy in landlocked countries promotes external trade. Furthermore, effective governance, which indicates the institution's quality, lowers the negative effect of landlockedness. Also, the infrastructure development the neighbouring countries put in place helps the landlocked countries' growth rate. However, the physical market access function in landlocked countries' economic growth is weak. MacKellar et al. (2000) review landlocked countries' economic development issues, and their findings confirm that based on geographic disadvantage, landlocked countries depend heavily on neighbours for export and import, which slows economic growth. The ordinarily least square (OLS) results of 92 developing countries examined show that landlockedness with per capita income level, the proxy used for economic growth performance, correlate statistically. That is, landlockedness impedes trade growth annually by 1.5% from 1980 to 1996, as transportation costs, tariffs, tax, quotas, corruption, inadequate infrastructure, political relations between landlocked countries and transit states, and other associated cost reduces exports and productivity in the regions. Using the random effect estimation technique and panel data of 104 countries, both landlocked and non-landlocked countries, from 1983 to 2017, Bhattarai (2019) analyse the impact of landlockedness on the landlocked countries' export capacity. The result indicates that export and openness to trade relationships and openness and economic growth nexus are significantly positive. That is, a 1% rise in trade openness increases landlocked countries exports by 0.6%. Also, landlocked developing countries' foreign direct investment pull is not substantial because of the neighbourhood effect, lack of factor endowment, inadequate capital and skilled labour input, and basic infrastructure. However, landlockedness negatively impacts Africa's trade capability more than other regions in the study.

Radelet and Sachs (1998) study finds that geographical considerations and distance to major markets of landlocked developing countries determine the shipping costs of manufactured exports, which invariably impact long-run growth. To them,

the lower the shipping cost, tariff, tax, exchange rate, wages, firm's profit, and other associated manufacturing costs, the higher the firms' global competitiveness, foreign direct investment and vice versa. That is, the success of manufacturing output strongly impacts economic growth for developing landlocked countries that put in place quality infrastructure, good institutions, open trade systems, and enabling environment and macroeconomic policies. Paudel and Cooray (2018) utilise panel data from 1995 to 2015 to compare the determinants of export performance for landlocked and non-landlocked developing countries from across the continent. The data used is obtainable from the European Central Bank, World Bank, and CEPII, and the objective is estimated using the augmented gravity model. The findings indicate that exports from LLDCs are a per cent less than non-LLDCs developing countries; the LLDCs manufacturing share declined, and primary products share increased, resulting in less export experience because of trade costs inherent with landlockedness, while manufacturing is the dominant export from non-LLDCs because of the enabling trade environment, tariffs cut and exchange rates reform. Also, due to the strong regional cooperation among the LLDCs, the benefits of regional trade agreements are greater than those of non-LLDCs. The infrastructure effects on landlocked countries are greater than those on non-landlocked countries. Likewise, distance-related trade costs and trade liberalisation do not have the same effects on LLDCs and non-LLDCs. As trade openness aids export performance in LLDCs and non-LLDCs, other variables such as GDP, common language, and border dummies fulfil aprior expectations. They suggest regional trade agreements will foster more trade in the landlocked countries. From the empirical review of trade openness-growth linkage in the LLDCs, the research of the entire 16 African regions solely with data spanning from 1980–2021 is lacking.

### 2.2.2. The institution-economic growth nexus

Although a greater number of the empirical results on the institutional quality in landlocked African countries reveal that the region is plaque with weak institutional structures which impedes trade and hinders economic growth (Borchert et al., 2012; MacKellar et al., 2000; Paudel, 2014; Paudel and Cooray, 2018; Raballand, 2003). Moreover, North (1991) enumerated that institutions determine economic growth and are not restricted to reducing transaction costs, helping the division of labour, or solving societal problems alone, but rather employing policies that create an enabling business environment and motivate investment. The UN-OHRLLS (2013) enumerated the problem and passed the resolution act of landlocked countries, stating that they should establish and practice laws because of the long distance of sea access from transit neighbours, market remoteness, inadequate infrastructure, and institutional hurdles that negatively impact international trade. Acemoglu and Robinson (2008) state that for a country to have a positive economic growth result, it should renew or change its economic and political institutions to avoid instability and economic doldrums. Relatedly, Normizan and Yasunori (2014) use the Cournot duopoly model to analyse the trade rivalry of two firms and their competition in a third country's market. One of the two firms is from a landlocked country, and the other is from a coastal economy. From their findings, the imposition of toll fees by the government (by government, they inferred institution) deter trade. While

strategic government policy on research and development investment is very appropriate, it increases export share and firm's profit and improves their comparative advantage in the third country. Also, Basnet (2017) employ panel data from landlocked countries covering 1996–2014 to examine the determinants of economic growth in landlocked regions. The balance panel model utilises pooled ordinary least square, random, and fixed effect models for a robust estimate. The study found that landlocked countries do not hinder economic growth; a country's institutional structure is the major determinant. As the two institutional variables, political stability and reduction in corruption have significantly positive impacts on economic growth. Despite this, the study failed to address the cause, consequence, and other possible predictors of economic growth in landlocked countries.

Considering Zambia, Laos, and Nepal as a case study of landlocked countries, Borchert et al. (2012) establish that telecommunications and air transport policies are typically more stringent in landlocked countries than their counterparts in coastal regions. The lax policies resulted in the development of dominant market structures and restricted service access, often linked with countries in SSA, where political accountability is notably low. These restrictions impede trade by hindering the flow of services that facilitate global connectivity. Furthermore, the study indicates that implementing liberalisation policy reforms in these sectors led to a 7% rise in cellular subscriptions and a 20% rise in flight numbers. In essence, they contended that policy choices (institutions) could potentially negate the impact of geographical location or income to enhance connectivity and efficient air transport, thereby surpassing the constraints imposed by being landlocked. Using secondary data from 2002 to 2014 for 43 sub-Saharan African countries, Chomen (2022) examines institutions-economic growth linkage. From the GMM results, institutions and economic growth have no significant correlation, except when other control variables were not at interplay; the variables control of corruption and executive constraint positively correlate with growth. This finding implies that institutions are not a determinant of economic growth. From the foregoing review, it is evident that there is no consensus on the institutions-economic growth nexus in both the studies on the landlocked African regions and the landlockedness-related studies, in which this study intends to contribute to the literature.

### 2.2.3. The telecommunication infrastructure-economic growth nexus

The present trend in the global economies has shown the significance of telecommunication infrastructure as an engine of growth. The world economy has evolved from the past war industrial to the information era, and the advent of telecommunication has transformed the world's economies into service-based industries. Thus, telecommunication has influenced the economy by increasing market access and efficiently making business transactions easy (Bahrini and Qaffas, 2019). Abdulqadir and Asongu (2022), Bertschek et al. (2016), Borchert et al. (2012), Harb (2017), Ghosh (2017) and Lee et al. (2012), opinion that telecommunication has caused a remarkable change in information society globally. Hence, telecommunication infrastructure such as fixed-line, internet, broadband, mobile phone, and others have improved the efficient allocation of resources, promoted greater demand, reduced production costs and increased investment in all sectors of

the economy. For Abdulqadir and Asongu (2022), broadband technology supports existing and new applications in all sectors, such as financial services, education, government, and health management. This broadband creates opportunities for individuals, the government, and the business sector. For individuals, technology offers opportunities to improve their personal potential, which helps them have better access to education, health care, and government. For the government, it helps to access e-government applications, which leads to efficiency and cost-saving. For businesses, broadband improves productivity and market expansion, reduces cost, increases revenue and employment, and promotes economic growth. Therefore, for LLDCs and other SSA countries, the impact of telecom on economic growth, trade openness and other economic variables when interacted has been debatable (Abdulqadir and Asongu, 2022). According to Bhattarai (2019), the landlocked countries' poor internal physical and non-physical infrastructural development contributes to their low trade performances. Infrastructure development will boost inputs and productivity, improve human and physical capital formation, and positively impact external markets. MacKellar et al. (2000) emphasise that the major problems of landlocked countries arise through transport. Hence, specific attention should be focused on the sector. Landlocked countries should adopt development plans that do not rely on physical transport but advance more in telecommunications and information technology to ease the task.

In the International Telecommunication Union (2019) thematic report, panel data from 2000 to 2017 was used to analyse the effect of telecommunication on the economic growth of LDCs, LLDCs and Small Island Developing States (SIDS) countries. The three econometric techniques employed were OLS, instrumental variables (IV) and simultaneous equation model. The result shows that broadband positively impacts economic growth. A 10% increase in fixed penetration increases GDP by 2.0%–2.3%. A 10% increase in mobile broadband penetration increases GDP by 2.5%–2.8%. The result indicates that the better the service quality and speed of broadband, the higher the economic growth. Though the study covers landlocked developing countries, the institution fundamental to economic growth in LLDCs was never examined. Using the dynamic panel threshold estimation technique, Abdulqadir and Asongu (2022) examine the effect of internet access on tariffs regime, government regulations, trade openness, private sector credit, and economic growth from 2008–2018 in 42 SSA regions. They found that the internet threshold has a 3.55% effect on growth and positive effects on tariff regimes and government regulations. While the effect on trade openness and private-sector credit is negative. Furthermore, using a two-step difference generalised econometric method to analyse panel data from 1975 to 2006 for 44 SSA countries, Lee et al. (2012) established that mobile telecommunications positively impact economic growth and GDP per capita. However, the study was not solely focused on landlocked developing countries in Africa. Similarly, Gold (2011) analysed telecommunication and economic growth in Nigeria from 2001 to 2008 using the OLS estimation technique. The study found that telecommunication development influences the economy through increased access to the market, reduced distribution costs, ease of business transactions and increased well-being of the citizens. However, as important as the study is, its shortcoming is based on Nigeria's telecommunication infrastructure development, and the study

country, Nigeria, is not landlocked. From the foregoing empirical literature on trade openness, telecommunication, and institutions, it is necessary to examine the nexus among the three important variables and their effect on economic growth within LLDCs in Africa. Considering that a landlocked country incurs the burden of high transportation costs (Raballand, 2003), efficient telecom infrastructure reduces transportation and transaction costs (Bakare and Gold, 2011). Therefore, with the advancement in technological innovation in information technology and broadband networks, estimating its impact on landlocked African countries with the intent to increase trade openness, change market dynamics, and enhance economic growth becomes paramount.

## 3. Materials and methods

### 3.1. Data and variable description

This research focuses on 16 African LLDCs, comprising Burundi, Botswana, Burkina Faso, Chad, the Central African Republic, Ethiopia, Malawi, Lesotho, Mali, Rwanda, Niger, Eswatini, South Sudan, Uganda, Zambia, and Zimbabwe. The panel data utilised in this study covers the period from 1996 to 2021 and was sourced from the World Bank, accessed via the WDI and WGI, and from the KOF Swiss Economic Institute. The detailed measurements and descriptions for each variable are stated in **Table 1**.

**Table 1.** Variables description.

| Variable | Description | Aprior expectation |
|---|---|---|
| Openness | We broadly measure openness by the globalisation index (GI), and the data is obtained through the KOF Swiss Economic Institute. GI sums up globalisation's social, political, and economic dimensions based on equivalent weights. It ranges between 0 and 100, with a higher value indicating more intense globalization (Musibau et al., 2021). | GI is expected to influence economic growth positively. |
| Telecommunication | Telecommunication, according to Pagiatakis (2005), is the process by which information can be transferred through an electronic form from one place to another. We measure this through mobile phone subscription (MPS) from WDI. | Telecommunication is expected to have a positive nexus with economic growth. |
| Institutions | According to Hodgson (2006), institutions are a durable system of entrenched social norms that govern social interactions. We measure institutional quality by Voice and Accountability (VOA), Rule of Law (ROL), Government Effectiveness (GE), Regulatory Quality (RQ), Political Stability and Absence of Violence (PSAV) and Control of Corruption (CC) based on the World Bank's WGI. | Mixed impact on economic growth. |
| Gross Domestic Product (GDP) per capita | Aggregates are calculated using fixed 2010 U.S. dollar values. The measurement is = a country's annual GDP divided by its total population (Fagerberg, 1988). | _ |

### 3.2. Model and estimation technique

The equations formulated to achieve the study objectives are modelled after the works of Lee et al. (2012), Zahonogo (2016) and other relevant research. The first Equation (1) models the relationship between telecommunications (MCSP), institutions (VOA), as other institutional quality indices were not significant, openness (GI) and economic growth (GDPPC). The variable X represents a set of control variables based on their theoretical links to economic growth. To mitigate potential specification bias, we have included certain conventional growth variables,

such as domestic investment (measured by gross fixed capital formation, GFCF) and labour (measured by total labour force, TLF).

$$\mathrm{GDPPC_{it}} = \gamma_0 + \gamma_1 \mathrm{GI_{it}} + \gamma_2 \mathrm{MCSP_{it}} + \gamma_3 \mathrm{VOA_{it}} + \gamma_4 \mathrm{X_{it}} + \mathrm{v_{it}} \quad (1)$$

$$\mathrm{GDPPC_{it}} = \gamma_0 + \gamma_1 \mathrm{GI_{it}} + \gamma_2 \mathrm{MCSP_{it}} + \gamma_3 \mathrm{VOA_{it}} + \gamma_4 \mathrm{VOA_{it}} \times \mathrm{MCSP_{it}} + \gamma_5 (\mathrm{GI} \times \mathrm{MCSP})_{\mathrm{it}} + \gamma_6 \mathrm{X_{it}} + \mathrm{v_{it}} \quad (2)$$

Likewise, the second Equation (2) models the interaction effect of institutions and openness on telecommunications in the panel countries under consideration. Here, $\gamma_i$ ($i$ = 0, 1, 2, ..., 16) denotes the parameters controlling for the intercept and slope coefficients. The term $v_{it}$ serves as an error term that explains the effects of additional variables not accounted for in the models. And *i* denotes the cross-section of countries, while *t* denotes the time series in years. These equations are estimated using the pooled mean group (PMG) estimator. The PMG estimator applied in this study is well-suited for the dataset utilised. Apart from providing both the short and the long-run impacts of the explanatory variables on the explained variable, PMG also hedges against the serious bias of country heterogeneity. This approach allows for distinctive short-term and long-term dynamics, considering the available number of time-series observations for each case is less sensitive to outliers and provides adjustments for any distortions in the equilibrium conditions (see, e.g., Shittu et al., 2022).

Furthermore, the estimator two-step GMM model (Arellano and Bond, 1991) is used to assess the robustness of the analysis. The model is specified as:

$$\mathrm{GDPPC_{it}} = \gamma_0 + \gamma_1 \mathrm{GDPPC_{it-1}} + \gamma_2 \mathrm{GI_{it}} + \gamma_3 \mathrm{MCSP_{it}} + \gamma_4 \mathrm{INSTQ_{it}}(\mathrm{VOA, RQ, ROL, CC, GE, PSVA}) + \gamma_5 \mathrm{GFCF_{it}} + \gamma_6 \mathrm{TLF_{it}} + \mathrm{v_{it}} \quad (3)$$

where: $\mathrm{GDPPC_{it}}$ = GDP per capita; $\Delta\mathrm{GDPPC_{it-1}}$ = lagged GDP per capita; GI = globalisation index; MCSP = telecom; INSTQ = institutions (all 6 institutional quality indices were included); GFCF = gross fixed capital formation; TLF = total labour force; $v_{it}$ = error term; *i* = each country; *t* = time.

In the two-step GMM estimation, the model is estimated by first differencing to remove any country-specific fixed effects and is specified as:

$$\Delta\mathrm{GDPPC_{it}} = \gamma_0 + \gamma_1 \Delta\mathrm{GDPPC_{it-1}} + \gamma_2 \Delta\mathrm{GI_{it}} + \gamma_3 \Delta\mathrm{MCSP_{it}} + \gamma_4 \Delta\mathrm{INSTQ_{it}}(\mathrm{VOA, RQ, ROL, CC, GE, PSVA}) + \gamma_5 \Delta\mathrm{GFCF_{it}} + \gamma_6 \Delta\mathrm{TLF_{it}} + \Delta\mathrm{v_{it}} \quad (4)$$

This specification effectively addresses potential endogeneity and unobserved heterogeneity.

## 4. Results and discussion

### 4.1. Pool mean group—PMG

#### 4.1.1. Results

The empirical results are presented based on the regression of the PMG estimation technique. Descriptive statistics and correlation analysis are depicted in **Tables 2** and **3**, respectively, while the coefficient estimates are shown in **Table 4**.

**Table 2.** Descriptive analysis.

| Variable | | Mean | Std. Dev. | Min | Max | Observations |
|---|---|---|---|---|---|---|
| GDPPC | Overall | 1260.483 | 324.1404 | 17 | 1539 | $N$ = 416 |
| | Between | | 249.1378 | 348.3846 | 1390.923 | $n$ = 16 |
| | Within | | 216.1863 | 323.0216 | 2130.099 | $T$ = 26 |
| GFCF | Overall | 3255.594 | 1669.547 | 17 | 4276 | $N$ = 416 |
| | Between | | 1340.886 | 17 | 4175.846 | $n$ = 16 |
| | Within | | 1047.722 | −532.7139 | 6254.863 | $T$ = 26 |
| TLF | Overall | 6369043 | 9312504 | 277820 | $5.81 \times 10^7$ | $N$ = 416 |
| | Between | | 9180480 | 338616.7 | $3.93 \times 10^7$ | $n$ = 16 |
| | Within | | 2742027 | −8238263 | $2.52 \times 10^7$ | $T$ = 26 |
| MCSP | Overall | 2044.397 | 420.4582 | 17 | 2322 | $N$ = 416 |
| | Between | | 286.9862 | 985.7692 | 2190.692 | $n$ = 16 |
| | Within | | 315.2547 | 41.6274 | 3222.627 | $T$ = 26 |
| GI | Overall | 159.6442 | 111.5489 | 17 | 361 | $N$ = 416 |
| | Between | | 84.24972 | 17 | 280.1538 | $n$ = 16 |
| | Within | | 75.97853 | −86.00962 | 409.9904 | $T$ = 26 |
| VOA | overall | 28.34007 | 17.2499 | 1.449275 | 74 | $N$ = 356 |
| | between | | 17.05017 | 5.472339 | 63.74647 | $n$ = 16 |
| | within | | 5.669203 | 2.391556 | 45.9483 | $T$ = 22.25 |

**Table 2** reveals that economic growth has an average value of US$ 1260.48, with its standard deviation indicating a significant deviation from the mean value. Similar patterns are observed for all variables in the model. Furthermore, apart from the institutional indicator, which comprises 356 observations, each of the other variables consists of 416 observations, spanning 16 cross-sections and 26 time periods. The coefficient of correlation in **Table 3** suggests that each domestic investment, labour force, telecommunication, openness, and institutional quality have a positive and statistically significant correlation to economic growth.

**Table 3.** Cointegration analysis.

| | GDPPC | GFCF | TLF | MCSP | GI | VOA |
|---|---|---|---|---|---|---|
| GDPPC | 1.000 | | | | | |
| GFCF | 0.320* | 1.000 | | | | |
| TLF | 0.086* | −0.131* | 1.000 | | | |
| MCSP | 0.553* | 0.300* | 0.009 | 1.000 | | |
| GI | 0.262* | 0.472* | −0.173* | 0.214* | 1.000 | |
| VOA | 0.202* | −0.108* | −0.192* | −0.021 | 0.049 | 1.000 |

Looking at **Table 4** (Models 1 and 2), it is evident that the coefficient of the cointegrating equation is negative and significant, confirming the convergence of the model to the long-run equilibrium.

**Table 4.** Pooled mean group estimates.

| Dep. Var. = GDPPC | Coefficient (Model 1) | Coefficient (Model 2) | Coefficient (Model 3) |
|---|---|---|---|
| Long-run Coefficient | | | |
| GFCF | −0.080***<br>(0.020) | −0.117***<br>(0.029) | −0.082***<br>(0.024) |
| TLF | 0.00003***<br>($8.72 \times 10^{-6}$) | 0.00003***<br>(0.00001) | 0.00003***<br>($9.33 \times 10^{-6}$) |
| MCSP | −0.113*<br>(0.065) | 0.051<br>(0.191) | −0.160<br>(0.252) |
| GI | 0.269*<br>(0.150) | 1.993<br>(2.697) | −0.167<br>(0.182) |
| VOA | −1.685<br>(1.893) | −9.132***<br>(2.615) | −21.021<br>(17.596) |
| MCSPGI | – | 0.003**<br>(0.001) | – |
| VOAMCSP | – | – | 3.431***<br>(0.607) |
| Short-run Coefficient | | | |
| Cointegrating Equation | −1.064***<br>(0.070) | −1.030***<br>(0.156) | −1.107***<br>(0.060) |
| D.GFCF | 0.919**<br>(0.440) | 0.707*<br>(0.371) | 0.911**<br>(0.408) |
| D.TLF | −0.008<br>(0.008) | −0.008<br>(0.007) | −0.004<br>(0.004) |
| D.MCSP | −0.094<br>(0.107) | −0.075<br>(0.161) | −0.179<br>(0.138) |
| D.GI | 0.133<br>(0.450) | −0.270<br>(0.868) | 0.661<br>(0.615) |
| D.VOA | −6.007<br>(7.855) | −2.047<br>(10.110) | −1.740<br>(5.347) |
| D.VOAMCSP | – | – | −3.783***<br>(0.207) |
| D.MCSPGI | – | 0.002**<br>(0.001) | – |
| _cons | 1775.644***<br>(195.153) | 1908.275***<br>(293.804) | 2082.621***<br>(276.564) |
| Observation | 295 | 295 | 295 |

Note: The standard errors are presented in parentheses.

### 4.1.2. Discussion

The long-run estimates derived from the PMG, Model 1, show a negative relationship between the coefficient of telecommunications and economic growth. Specifically, it suggests that economic growth decreases by US$ 0.11 for each increase in mobile subscriptions per 100 people. Carlsson et al. (2013) affirm the significance of digital communications infrastructure in lowering trade costs, enabling economies of scale and fostering the accumulation of knowledge. Also, Bertschek et al. (2015) argue that telecommunications, particularly broadband development, not only enhance productivity, employment and growth but also partially lead to future development; our findings diverge from this perspective and

contradict the studies of Abdulqadir and Asongu (2022) and Ghosh (2017). However, our results validate that of Harb (2017) concerning Africa and non-OECD European countries where infrastructure deficit constrains its impact on economic growth. This negative telecommunication–economic growth nexus could stem from numerous infrastructural deficiencies across the panel of landlocked African countries, including low technology penetration and inadequate ICT skills and internet usage, which are crucial for economic growth. Moreover, the relative scarcity of local content on the global network restricts telecom users from fully exploiting their potential, impeding economic growth in the landlocked region (Haftu, 2019).

Furthermore, the coefficients of institutions and telecommunications infrastructure individually and jointly yield some intriguing findings in both the short and long run. While the coefficient of the institutional indicator does not significantly affect economic growth in the short run, it retards it in the long run (as seen in Model 2). This result corroborates Chomen (2022) conclusions that the institutional infrastructure of sub-Saharan African countries does not foster economic growth. Beyond the statistical significance, it indicates that where people's voices are not productively heard, there is a tendency for an inefficient institutional environment due to poor accountability on the part of the government. It may also be attributed to the triviality with which specific laws are handled because of rent-seeking activities in the public sector, thereby diminishing productivity and growth (Shittu et al., 2022). Conversely, where the quality of institutions is improved upon, the negative impact of telecommunications infrastructure on economic growth gradually diminishes. As evident in the estimates in Model 3, the moderating effect of institutional quality on the telecommunication–economic growth nexus shows a positive coefficient (institutional quality decreases the adverse effect of telecommunication on economic growth by 3.431%). The outcome is consistent with the findings of Paudel (2014), which state that high-quality institutions reduce the negative impact of being landlocked. It also aligns with Basnet (2017) and Basnet (2021) argument that a nation's institutional structure is the primary determinant of economic growth rather than its status as a landlocked country. Borchert et al. (2012) contend that strengthening institutions can mitigate the constraints of low income and the absence of maritime access imposed on landlocked countries. Overall, the findings show that efficient institutions stimulate the influx of telecommunications infrastructure, promoting economic growth in the landlocked African region.

Similarly, the estimation indicates that telecommunications infrastructure does not significantly affect economic growth in the short run but impedes it in the long run. However, the long-run interaction effect of the two variables indicates that the institutional indicator exacerbates the negative effect of telecommunications infrastructure on economic growth in the panel of landlocked countries considered (see Model 3). Although this result diverges from the aprior expectation, it could be explained by insights from Harb (2017), who infers that external investors are hesitant to invest and efficiently operate in economies with persistently weak institutional structures. Given that studies on landlocked African countries reveal that weak institutions hinder trade and impede economic growth (Basnet, 2021; MacKellar et al., 2000; Paudel, 2014; Raballand, 2003; UN-OHRLLS, 2013). Moreover, in Romer's (1990) model, investment in energy infrastructure, including

electricity, is shown to have a negative impact on growth. This is because it is considered an intermediate input, influenced by the efficiency of supply, which may impede the production process. Consequently, this inhibits significant internet diffusion, reducing internet penetration and negatively impacting the telecommunications infrastructure sector and the general economy. Furthermore, reduced competition resulting from inefficient institutions hampers the growth of the telecommunications sector and economic growth in landlocked countries. Therefore, landlocked African countries must develop an efficient internal infrastructure comparable to their economic sizes (Paudel and Cooray, 2018) and avoid overreliance on inadequate infrastructure in transit states (MacKellar et al., 2000).

The coefficient of openness indicates a positive correlation with economic growth, implying that a one per cent rise in openness translates to a US$ 0.27 rise in economic development. Additionally, in Model 2, the interaction effect of openness and telecommunication suggests that openness reduces the negative effect of telecommunication by 0.003%. This finding aligns with the neoclassical theory and aprior expectation that increased openness facilitates economic performance in landlocked developing countries in Africa (MacKellar et al., 2000; Paudel, 2019; Paudel and Cooray, 2018; Tripathi, 2023). It also implies that promoting trade enhances competitiveness in the telecommunication sector, spurring investments and stimulating economic growth. These results underscore the role of trade as a catalyst for growth (Gold and Rasiah, 2022) and support the notion that openness amplifies the benefits of innovations, productivity enhancements, specialisation, and efficient resource allocation to more sectors, thereby bolstering economic growth (Bhattarai, 2019; Zahonogo, 2016). Lastly, the long-run coefficients of labour and domestic investment indicate that the former promotes economic growth, while the latter exerts a contrary effect.

## 4.2. 2-step system-generalized method of moments—GMM

### 4.2.1. Results

The reported 2-step GMM in **Table 5** serves as robustness to complement the PMG estimates, and the coefficients and the *p*-value significance will be discussed in relation to the PMG, except for where there is variation. It is worth mentioning that the discussion centred on the baseline variables solely, which are openness, telecommunication, and institutions.

**Table 5.** 2-step GMM estimates.

| Dep. Var. = GDPPC | Coefficient (Model VOA) | Coefficient (Model CC) | Coefficient (Model RQ) | Coefficient (Model GE) | Coefficient (Model PSAV) | Coefficient (Model ROL) |
|---|---|---|---|---|---|---|
| GFCF | 7.543**<br>(0.019) | 5.358**<br>(0.016) | 4.887*<br>(0.136) | 2.181<br>(0.474) | 4.075<br>(0.212) | 3.904<br>(0.257) |
| TLF | −0.042**<br>(0.014) | −0.0315**<br>(0.013) | −0.028*<br>(0.122) | −0.0133<br>(0.408) | −0.023<br>(0.207) | −0.0222<br>(0.222) |
| MCSP | 0.267***<br>(0.000) | 0.217***<br>(0.000) | 0.234***<br>(0.000) | 0.248***<br>(0.000) | 0.243***<br>(0.000) | 0.262***<br>(0.000) |
| GI | −0.235*<br>(0.078) | −0.097<br>(0.278) | −0.053<br>(0.738) | 0.031<br>(0.785) | −0.091<br>(0.311) | −0.055<br>(0.698) |

**Table 5.** (*Continued*).

| Dep. Var. = GDPPC | Coefficient (Model VOA) | Coefficient (Model CC) | Coefficient (Model RQ) | Coefficient (Model GE) | Coefficient (Model PSAV) | Coefficient (Model ROL) |
|---|---|---|---|---|---|---|
| INSTITUTION | −5.855*** (0.005) | 2.414 (0.171) | 2.506 (0.426) | 7.009** (0.026) | 2.467 (0.384) | 2.105 (0.516) |
| _cons | 20.762** (0.017) | 18.749*** (0.001) | 16.241* (0.072) | 13.269* (0.053) | 16.642** (0.010) | 14.827* (0.071) |
| Observation | 218 | 218 | 218 | 218 | 218 | 218 |
| R2 | 0.4648 | 0.5860 | 0.6064 | 0.6711 | 0.6360 | 0.6342 |
| Hansen J statistic | 1.696 (0.638) | 1.265 (0.737) | 1.527 (0.676) | 2.186 (0.535) | 1.659 (0.646) | 1.230 (0.746) |

Note: *10%, **5% and ***1% significance of the *p*-values.

### 4.2.2. Discussion

The results of the 2-step GMM robustness largely contradict the PMG, except for the telecommunications infrastructure variable, which is positively significant at 1% across all six institutional variables specified. The economic implication of these results is that a 1% increase in telecom penetrations, all things being equal, will increase economic growth by 0.23. The finding aligns with Abdulqadir and Asongu (2022) and Ghosh (2017) who also found that telecommunications positively impact economic growth in Africa and MENA. Importantly, these results align with the hypotheses proposed by Bhagwati and Srinivasan (1978) and Krueger (1978), which suggest that economic growth can be achieved through technological advancement. Also, it indicates that investment in telecommunication infrastructure will ease the transportation and transaction costs (Bakare and Gold, 2011; Bertschek et al., 2015) for landlocked countries rather than depending solely on coastal neighbouring regions for trade.

Surprisingly, the voice of accountability (VOA) institutional variable in the GMM results aligns with the PMG estimates, showing a negative and significant impact at the 10% level. However, government effectiveness (GE) is positive and correlates with a 5% significance level of economic growth. This result indicates that a 1% improvement in GE translates to a 0.026 increase in the economic growth of LLDCs in Africa. This result supports North's (1991) theory on quality institutions spurring economic growth and is consistent with Basnet (2021) and Paudel (2014) findings on landlocked countries.

However, unlike in the PMG, where the GI result correlates positively with economic growth, its findings negatively impact GDPPC in the GMM estimate. Finally, the performance of the two control variables in the GMM analysis differed from that in the PMG estimates. Although the domestic investment (GFCF) enhances economic growth and was positive across all model specifications, it was only significant in the models, including Voice and Accountability (VOA), Control of Corruption (CC) and Regulatory quality (RQ). Similarly, while the labour (TLF) was positively significant in the PMG estimates, the GMM results contradicted these findings.

## 5. Conclusion

The research investigates the impact of openness to trade, telecommunications infrastructure, and institutional quality on economic growth in 16 African LLDCs from 1996 to 2021. The empirical analysis utilises cointegration and PMG techniques to examine short- and long-term effects and GMM for robustness check. The PMG results of the study reveal several significant findings. Firstly, openness to trade exhibits a significantly positive effect on economic growth in the long run, although its impact is insignificantly positive in the short run. Secondly, when interacting with openness, telecommunications positively correlate with economic growth. However, the findings regarding institutional quality are more nuanced. The coefficient for institutional quality is negatively significant and has an insignificant effect on economic growth in the models. This negative impact persists in the short-run, except for its interaction with telecommunications, which exhibits a significantly positive effect in the short-run model. Furthermore, telecommunications and economic growth generally show a negative effect, except when telecommunications interact with openness in the long run, a positive effect is observed.

On the other hand, the GMM estimates contradict the PMG findings on telecommunications infrastructure, openness to trade and the two variables used as control (domestic investment and labour). Except for the government effectiveness institutional structure variable that correlates positively with economic growth. The voice of accountability findings is akin to the PMG results. Therefore, these results highlight the complex interplay between openness to trade, telecommunications, institutional quality, and economic growth in African LLDCs. Overall, the findings suggest that to achieve economic growth, LLDCs should prioritise policies that promote foreign trade, moderate trade barriers, and simplify trade procedures and controls.

However, it is important to note that over-reliance on foreign trade may challenge fiscal stability and economic growth, as suggested by the Prebisch-Singer hypothesis. Nonetheless, it is recommended that LLDCs aim for a balanced approach to trade policies and focus on economic integration to stimulate intra-trade and expand exports through specialisation in producing goods and services. This could involve regional trade agreements and initiatives to promote collaboration among LLDCs and their neighbours. The government of LLDCs should also prioritise improving institutional quality by curbing corruption and improving accountability. Strengthening governance structures will create an environment conducive to business growth and investment. In addition, LLDCs in Africa should upgrade their telecommunications infrastructure strategies and ensure sustainable resource allocation to make the plan feasible. This could involve initiatives to raise awareness about the importance of telecommunications as aids-to-trade, implementing capacity-building programmes to increase telecommunication literacy, and developing skilled human resources for economic development. Undoubtedly, advanced telecommunication development will reduce transportation and transaction costs and boost regional productivity. Finally, further research is necessary to investigate the impact of electricity provision and foreign investment on the LLDCs.

Understanding these factors will provide valuable insights into additional strategies for promoting economic growth and development in these countries.

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