Economics Bulletin

Volume 46, Issue 1

Can we build inclusion in Africa? The key role of infrastructure

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Abstract

The aim of this article is to analyze the effect of infrastructure on inclusive growth in African countries. Using an unbalanced panel of 37 countries over the period 2003–2020, we apply pooled Ordinary Least Squares (OLS) and dynamic System Generalized Method of Moments (sGMM) estimations. The findings indicate that overall infrastructure significantly and positively influences inclusive growth, with heterogeneous effects across its components, electricity having the strongest effect, followed by water and ICT, while transport shows a more modest effect. Based on these results, we recommend: (i) increasing investment in all infrastructure categories to ensure equitable access; (ii) promoting public-private partnerships to accelerate project implementation; and (iii) easing regulatory constraints, particularly in land acquisition, to improve financing and delivery of infrastructure projects.

This article is an excerpt from a broader essay developed as part of the corresponding author's doctoral thesis defended at the University of Dschang in November 2024. The author gratefully acknowledges the constructive comments provided by the reviewers and the guidance of the editor, which have significantly improved the quality of this manuscript.
Citation: Georges Ngnouwal Eloundou and Honoré Tekam Oumbe and Bruno Emmanuel Ongo Nkoa, (2026) "Can we build inclusion in Africa? The key role of infrastructure", *Economics Bulletin*, Volume 46, Issue 1, pages 1-14
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Submitted: October 06, 2024. **Published:** March 30, 2026.

1. Introduction

The term "inclusive growth" refers to strategies used by countries to promote economic development while ensuring that all citizens can participate in the economy (Hussein et al., 2017; Anand et al., 2013). Growth can be inclusive if governments implement policies that promote economic development without concentrating wealth in the hands of a few. The issue of inclusive growth is addressed by Agenda 2063 and Sustainable Development Goal 8, respectively, of the African Union and the United Nations. Inclusive growth is economic development that benefits everyone, reducing inequalities and providing equitable opportunities for the whole population (Anand et al., 2013). It combines wealth creation with improved income distribution while promoting access to essential services, such as education, health, and employment, to ensure that no one is left behind. According to World Bank figures, sub-Saharan Africa experienced an economic contraction of 2% in 2020. However, growth rose to 4.1% in 2021. This is still the lowest rate. Over the same period, growth was recorded in North Africa and the Middle East (4.3%), North America (5.6%), Central Europe and the Baltic States (5.6%), East Asia and the Pacific (5.8%), Europe and Central Asia (5.8%), Latin America and the Caribbean (6.8%) and, finally, South Asia (8.3%) (World Bank, 2022). The main reasons for Africa's weak performance are the slowdown in global economic activity caused by the global economic crisis and the conflict in Ukraine. However, the continent ranks second globally in income inequality, behind Latin America (Hussein et al., 2017). This raises concerns about the inclusiveness of growth in Africa.

Infrastructure is an important component of an inclusive growth strategy, as it promotes economic development and job creation (Njoya and Nikitas, 2020). Since the theoretical work of Arrow et al. (1970) and Barro (1990), public spending on infrastructure has contributed to productivity and beneficial growth. Public investment plays an essential role in changing the distribution of wealth and income as the economy grows. However, Chatterjee and Turnovsky (2012) show that public investment can generate growth but also increase income inequality. Infrastructure refers to the basic systems that support essential services and functions in a society. This includes transport, electricity, Information and Communication Technology (ICT), water and sanitation, among others. Developed countries invest heavily in their basic infrastructure, but many low-income countries are slow to modernise theirs. Infrastructure affects various aspects of society, including production, income, employment, health, education, and many others (Njoya and Nikitas, 2020; Bhattacharya et al., 2020; Kumar et al., 2016). This is possible mainly through cost reduction.

This article examines the role of infrastructure in promoting inclusive growth in African countries. Its contribution is twofold. First, unlike most existing studies that focus on specific types of infrastructure, this paper uses a comprehensive measure based on the Africa Infrastructure Development Index (AIDI), which aggregates transport, electricity, telecommunication, and water and sanitation. Second, we explore heterogeneity across countries by analysing the effects within groups defined by political regime and level of development, consistent with Africa’s institutional and economic diversity. The rest of the article is organised as follows. Section 1 presents the state of the art. Section 2 examines the stylised evidence on the relationship between infrastructure and inclusive growth. Section 3 describes the estimation strategy. Section 4 presents and discusses the results of the analysis. Section 5 shows the robustness analysis. Finally, the conclusion includes some measures to strengthen inclusive growth.

2. Brief review of the literature

In the 1990s, the expressions "inclusive growth", "pro-poor growth" and "shared prosperity" emerged. These expressions refer to the growth of products that leads to poverty reduction (Habito, 2009). Inclusive growth encompasses several dimensions of development, including income equity, well-being, and participation of the poor (Berg et al., 2012). Acemoglu and Robinson (2013) and Estache

et al. (2013) also stress the importance of human capital development, gender equality, institutions, infrastructure, and social security policies in achieving shared prosperity. The literature is not unanimous on how to measure this. First, Anand et al. (2013) consider the weighted average of average income growth and equity. While Aoyagi and Ganelli (2015) developed an inclusive growth indicator calculated as the weighted average of average income growth and the change in the stock market index. More recently, Whajah et al. (2019) conducted a principal component analysis to derive a measure of inclusive growth using data on indicators such as infrastructure, education, health, and unemployment.

The debate on the sources of growth goes back to the theories of exogenous and endogenous growth. In exogenous growth theory, growth is a long-term process, and policies do not affect it in the steady state (Solow, 1956). However, Easterly (1990) points out that persistent differences in growth and income levels due to exogenous differences in technology or initial growth levels are clearly insufficient. The new theory of growth began with Romer (1986), in which the impact of externalities on economic development is central to sustained growth. With the work of Aschauer (1989) and Barro (1990), the role of infrastructure was reconsidered as a lever for nations' prosperity. Subsequently, Bougheas et al (2000) introduced infrastructure as technologies that reduce the fixed cost of producing intermediate inputs in the context of Romer's (1987) endogenous growth. In this paper, we draw on two theoretical foundations: neoclassical models of economic development (MED) and the sustainable livelihoods (SL) approach. The MED denotes the link between infrastructure and the provision of a level playing field for the masses in economic activity (Kwan and Chiu, 2015). The SL framework has its roots in Sen's notion[1] of the set of 'functions' and 'actions' of people's capabilities (Sen, 1999). The framework, therefore, states that if economic agents have access to assets, they can create opportunities for themselves.

Relevant empirical studies confirm the positive effect of infrastructure on inclusive growth, particularly in developing countries, which are generally characterised by low levels of infrastructure stock (Easterly and Rebelo, 1993). Public spending on infrastructure and irrigation is also crucial for inclusive growth, improving access to opportunities and productivity, particularly in the areas of the wider market, education and health, which would normally have been inaccessible to the rural poor (Calderón and Servén, 2014). Nchofoung et al. (2022) find a positive effect of infrastructure development on inclusive development across all infrastructure development indices used, except for the composite index of ICT infrastructure, which shows a non-significant negative effect. Furthermore, a non-linear effect of infrastructure on inclusive development is established for all infrastructure indicators except the ICT indicator. While Abor et al (2018) show that mobile phone penetration significantly reduces the probability of a household becoming poor and increases per capita household consumption of food and non-food items.

However, Asongu and Odhiambo (2020) argue that the effects of ICT will depend on the measure used. Moreover, the positive net effect is systematically more apparent in Internet-centric regressions than in mobile phone-oriented specifications (Toader et al., 2018; Asongu and Odhiambo, 2020). New technologies in sub-Saharan Africa are assumed to have played an important role in economic activity, particularly in improving access to communications, which has been hampered by poor infrastructure and inadequate housing. Myovella et al. (2020) find that the effect of broadband internet is minimal in Sub-Saharan Africa (SSA) relative to Organisation for Economic Co-operation and Development (OECD) countries. In contrast, the impact of mobile telecommunications is higher in SSA than in other OECD countries. Cheng et al. (2021) argue that, in middle- and low-income countries, only the growth of mobile telephony can stimulate economic growth. In contrast, the growth of the Internet or secure Internet servers cannot. As for transport infrastructure, Banerjee et

[1] Sen argues that what matters in people's well-being is what they are able to be or do with the goods to which they have access.

al. (2020) show that proximity to transport networks has a moderately sized positive causal effect on gross domestic product (GDP) per capita across all sectors, but no effect on GDP per capita growth (Saidi et al., 2018). This is because factor mobility plays an important role in determining the economic benefits of infrastructure development. The empirical results add a new dimension to the importance of investing in modern infrastructure that facilitates the use of more energy-efficient modes and alternative technologies, thereby positively affecting the economy by minimising negative externalities.

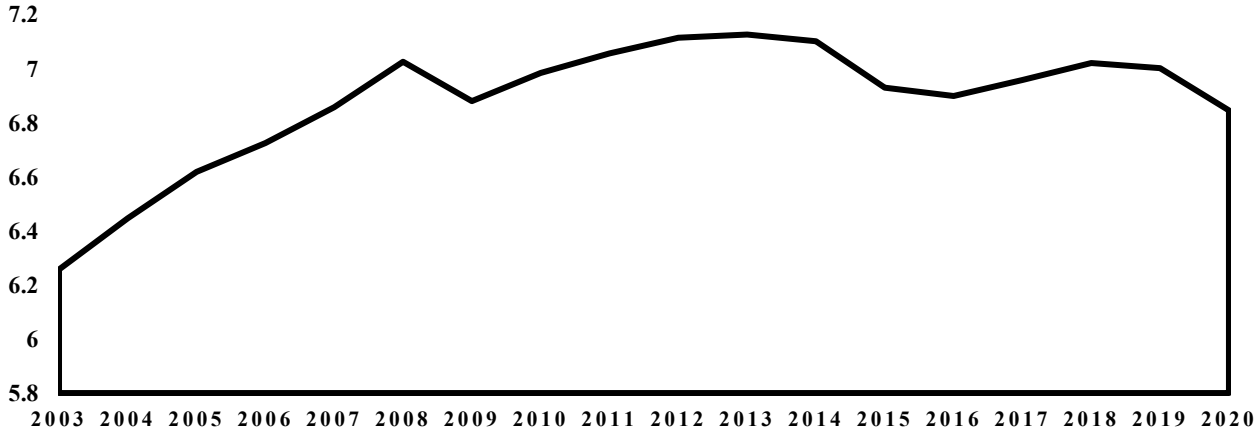
Moreover, the study reveals an obvious gap: even with efficient resource allocation, policy actions aimed at improving infrastructure access can prove crucial to the continent's pursuit of inclusive growth. The preceding theoretical and empirical links lead us to the hypotheses that underpin this study. First, we test whether infrastructure diffusion leads to inclusive growth in Africa. Second, we test whether access to infrastructure yields greater inclusive growth effects across different institutional, developmental, and cultural contexts. Third, we test whether, in addition to its direct effects, access to infrastructure has greater inclusive growth-inducing effects as measured by other indicators.

3. A few stylised facts

3.1. Progress towards inclusive growth in Africa

The inclusive growth indicator is calculated using the formula of Anand et al (2013), which combines the increase in per capita income and equity. The trend in inclusive growth is positive over the study period (Figure 1). Periods of crisis seem to have affected inclusive growth across the continent, notably during the 2008–2009 global financial crisis, the 2015–2016 commodity price collapse, and the 2020 COVID-19 pandemic (see Figure 1).

Figure 1: Evolution of inclusive growth in Africa



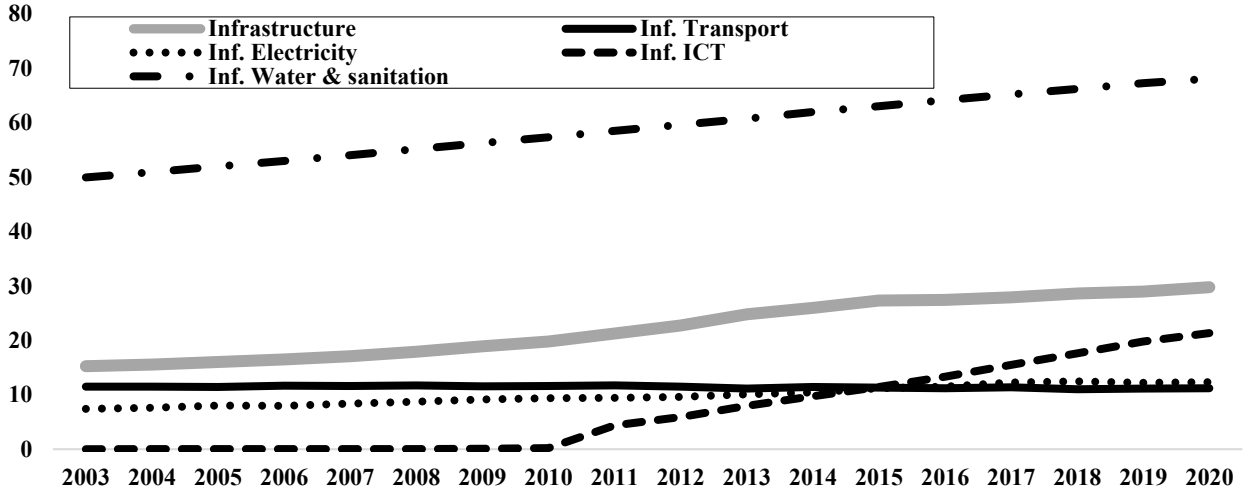
Source: Authors' calculations based on data from the World Bank's World Development Indicators (WDI), Solt's Standardised World Income Inequality Database (SWIID).

3.2. Improving infrastructure in Africa

The AIDI measures infrastructure using quantitative indicators covering road networks, electricity, information and communication technologies, and access to water and sanitation. It expresses these dimensions as a composite index standardised to 0-100, reflecting the level of availability and access to these essential infrastructures. The level of infrastructure in Africa remains low but continues to grow over the study period. However, disparities persist across African regions in infrastructure. North Africa has a high level of infrastructure. Overall, infrastructure levels are continually increasing

(Figure 2). However, several divergences emerge from the graphical analysis. The trend in transport infrastructure differs from that of other sectors, as it combines periods of strong growth and decline.

Figure 2: Infrastructure development in Africa

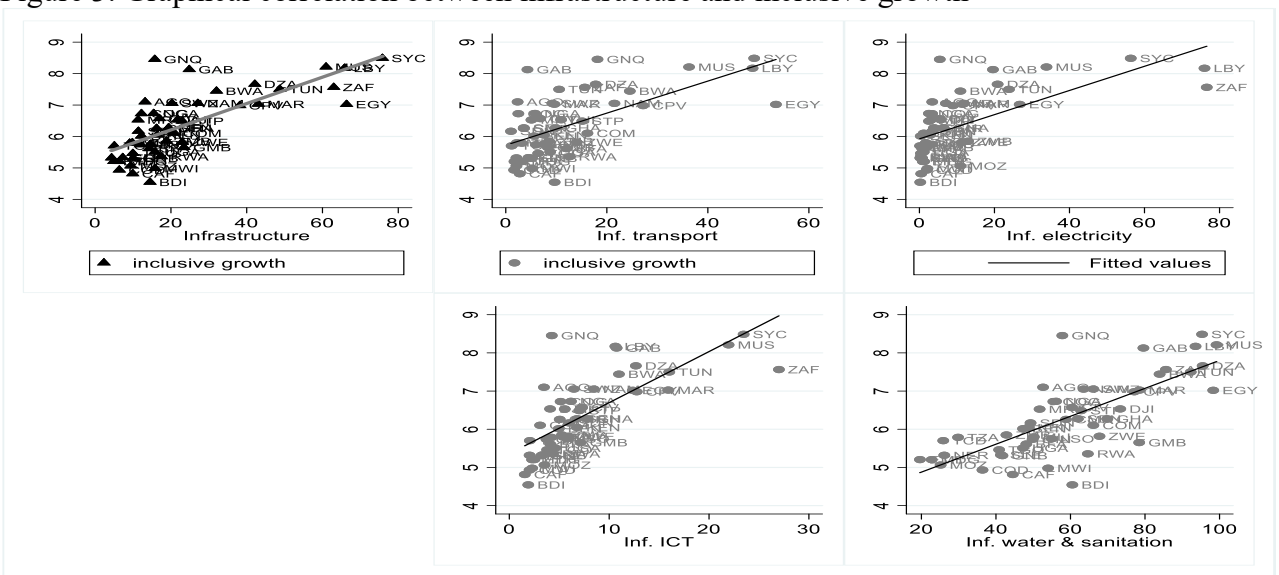


Source: Authors, based on the African Development Bank's Africa Infrastructure Development Index (AIDI) database.

3.3. Infrastructure and inclusive growth are positively correlated

Figure 3 shows a positive relationship between total infrastructure and inclusive growth, but the five graphs reveal distinct sectoral dynamics. Transport, electricity, and ICT infrastructure all show a positive correlation with inclusive growth, but also exhibit substantial dispersion, suggesting that their underdevelopment in several countries still limits their potential contribution. Water and sanitation show a more homogeneous relationship, with countries clustered on the right side of the graph but with varying levels of inclusive growth, indicating that this investment alone does not guarantee more inclusive growth– and it is the strength of this relationship that we test below.

Figure 3: Graphical correlation between infrastructure and inclusive growth



Source: Authors' calculations based on data from the World Bank's World Development Indicators (WDI), Solt's Standardised World Income Inequality Database (SWIID), and the African Development Bank's Africa Infrastructure Development Index (AIDI) database.

4. Methodology

4.1 Model

To analyse the empirical relationship between infrastructure and inclusive growth, we adopt the model of Kang and Martinez-Vazquez (2022), which studies the effects of foreign direct investment on inclusive growth. The basic econometric specification is as follows:

$$Inclu\_g_{i,t} = \beta_0 + \beta_1 Infras_{i,t} + \beta_2 X_{i,t} + \mu_i + \eta_t + \varepsilon_{i,t} \qquad (1)$$

Where ε_{it} is the residual term related to each period and each individual, η_t is the time fixed effect, μ_i is the individual fixed effect, and the coefficients β_i are the parameters to be estimated. In equation (1), $Inclu\_g$ which measures inclusive growth is operationalised as income growth adjusted for income equity in country *i* at time *t*, following one of the most widely used measures in the literature (Anand et al., 2013). It is constructed by combining income per capita series from the World Bank's World Development Indicators with the inequality index from Solt's Standardised World Income Inequality Database (SWIID). This approach integrates economic growth and income distribution to assess whether all population groups benefit proportionally. $Infras$ is measuring infrastructure development. Infrastructure can be of several types, and in this study, we distinguish among them according to the African Development Bank, i.e., transport, electricity, ICT, and water and sanitation. *X* is the matrix of control variables comprising globalisation (*Mond*) measured by the KOF composite index, which is used to assess the overall effect of openness to the world on inclusive growth. Inflation, which measures macroeconomic stability using the consumer price index. The annual rate of demographic growth measures the rate at which the population increases. Control of corruption is an indicator that captures perceptions of the extent to which public power is exercised for private gain, including forms of petty and grand corruption, as well as the 'capture' of the state by elites and private interests. Human capital is approximated by years of schooling and returns to education. Finally, public expenditure is measured by gross national expenditure, which comprises household final consumption expenditure, general government final consumption expenditure, and gross capital formation. The supplementary variables and data sources are presented and described in Appendix 1. Since inclusive growth is a dynamic process that exhibits strong inertia with respect to its past values, it is important to account for this inertia. We then introduce the lagged value of inclusive growth into equation *(1)* to obtain equation *(2)* below:

$$Inclu\_g_{i,t} = \beta_0 + \alpha * Inclu\_g_{i,t-1} + \beta_1 Infras_{i,t} + \beta_2 (Mond + Infl + Pop + Corrupt + HC + Pub)_{i,t} + \mu_i + \eta_t + \varepsilon_{i,t} \qquad (2)$$

The introduction of the lagged dependent variable on the right-hand side of equation (2) above transforms our model into a dynamic model. Dynamic models have the advantage over static models of capturing more information about the life-scale dynamics.

4.2. Data

Our sample is an unbalanced panel of 37 African countries over the period 2003 to 2020. The availability of data on the variables of interest conditions the sample size and study period. Data on the outcome variable, inclusive growth, are generated following the approach of Anand et al. (2013). We calculate an inclusive growth indicator based on a utilitarian social welfare function, which incorporates income growth and income distribution (Kang et al., 2017). The inclusive growth indicator of Anand et al. (2013) assesses whether economic growth benefits the entire population equitably. It combines the GDP growth rate with measures of income distribution, such as the Gini coefficient. Although the precise formula used can be complex and rely on detailed statistical aggregates, the main idea is to weight growth by a factor related to income distribution, such as reducing inequality or increasing the incomes of lower brackets. The indicator is constructed as

follows: $IG_{it} = Y_{it} * (1 - G_{it})$, *IG* is inclusive growth, *Y* is per capita income growth, and *G* refers to the Gini coefficient (SWIID), with *i* and *t* being the country and time horizon, respectively.

We measure infrastructure, following Kengdo et al. (2020) and Malah and Asongu (2022), and approximate it using the African Development Bank's Africa Infrastructure Development Index (AIDI). The AIDI is a composite index that tracks the status and progress of infrastructure development across Africa. The main components are: (i) electricity, which is measured by a given country's electricity generation, including public and private power generated and power imported from abroad; (ii) transport, which is measured by the total road network in kilometres (km) and total paved roads; (iii) ICT, which is measured by the number of internet users per 100 inhabitants and the total number of telephone subscriptions; and (iv) water and sanitation is a proxy for improved sanitation facilities and the percentage of the population with access to a water source.

Table 1: Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Inclusive growth	900	6.306	1.062	3.925	9.088
Infrastructure	900	22.321	18.956	.369	96.732
Inf. transport	900	11.427	12.366	.554	56.59
Inf. electricity	900	9.898	17.454	.056	100
Inf. ICT	900	7.079	10.877	0	71.813
Water and sanitation	900	59.074	21.754	.891	99.793
Economic globalisation	850	45.325	11.256	22.295	84.907
Inflation	889	8.744	26.395	-28.961	558.56
Population growth	900	2.331	.932	-2.629	4.655
Financial development	816	.141	.096	.029	.562
Control Corruption	900	-.61	.612	-1.816	1.23
Human capital	680	1.83	.442	1.098	2.939
Public expenditure	806	23.35	1.478	20.063	26.965

Source: Authors' calculations.

In addition, in line with the African policy and structure, we use inflation to measure macroeconomic stability (Anand et al., 2013; Moosavi and Gharleghi, 2021), and economic globalisation to capture the impact of trade, capital flows and foreign direct investment on inclusive growth (Ajide et al., 2021). We also control for population growth, financial development, control of corruption, human capital, and public expenditure to capture the effects of redistribution, as well as the impact of the region's real sector structure on inclusive growth. The variables are described in Appendix 1. The difference between inclusive growth and per capita growth is presented in Appendix 2. The results of the descriptive analysis in Table 1 suggest that the level of infrastructure development is very low on average across the continent, with water infrastructure [59.07] the most developed and ICT infrastructure [07.07] the least developed. Although there may be strong disparities in the distribution of electricity, ICT, and transport infrastructure, these disparities are evident from the high standard deviations relative to the means. Table 2 suggests a strong and positive relationship between infrastructure and its sub-indices and inclusive growth. It is also evident that the study's control variables are not strongly correlated. This reinforces the model's predictive capacity. The variance inflation factor (VIF) test was conducted to assess the extent of multicollinearity among our variables, in time and space. The results suggest that there is no multicollinearity in the model. Based on a cross-sectional and time-series perspective, preliminary results for the coefficient of interest, β1, are obtained using the pooled ordinary least squares estimator, after controlling for normality, heteroskedasticity, multicollinearity, and omitted variables (see Tables 1 and 2). We also include control variables in the regression to mitigate bias from omitted variables. We then assess the robustness of our results using a dynamic approach.

Table 2: Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Inclusive growth	1.00												
(2) Infrastructure	0.68	1.00											
(3) Transport	0.47	0.78	1.00										
(4) Electricity	0.70	0.83	0.74	1.00									
(5) ICT	0.45	0.66	0.24	0.44	1.00								
(6) Water and sanitation	0.73	0.83	0.65	0.68	0.49	1.00							
(7) Economic glob.	0.51	0.52	0.42	0.52	0.34	0.46	1.00						
(8) Inflation	-0.07	-0.07	0.01	-0.02	-0.13	-0.05	-0.06	1.00					
(9) Population growth	-0.43	-0.53	-0.44	-0.49	-0.28	-0.53	-0.50	0.10	1.00				
(10) Financial dev.	0.55	0.64	0.62	0.50	0.40	0.53	0.60	-0.09	-0.51	1.00			
(11) Corruption	0.31	0.37	0.39	0.27	0.23	0.36	0.47	-0.16	-0.46	0.56	1.00		
(12) Human Capital	0.59	0.57	0.45	0.50	0.43	0.55	0.50	-0.01	-0.34	0.48	0.36	1.00	
(13) Public Expen.	0.46	0.38	0.22	0.32	0.28	0.26	0.12	0.08	-0.01	0.29	-0.09	0.29	1.00

Source: Authors' calculations. The average variance inflation factor (VIF) is 1.84. glob. is globalisation; dev. is development, Expen. is expenditure.

5. Results and discussion

5.1. Basic results

Table 3 presents the effects of infrastructure on inclusive growth. Column 1 presents the results for the specific marginal effect of total infrastructure, while columns 2 to 5 present the results obtained by progressively extending the model to include determinants of inclusive growth. Across all specifications, the effect of infrastructure on inclusive growth remains positive and statistically significant at the 1% level.

Table 3: Basic results

	Dependent variable : Inclusive growth				
Variables	(1)	(2)	(3)	(4)	(5)
Infrastructure	**0.0388*** **	**0.0292*** **	**0.0316*** **	**0.0270*** **	**0.0189*** **
	(0.00132)	**(0.00190)**	**(0.00219)**	**(0.00260)**	**(0.00310)**
Economic globalisation		0.0301***	0.0281***	0.00983***	0.0122***
		(0.00327)	(0.00384)	(0.00373)	(0.00354)
Inflation		-0.00113	-0.00358	-0.00488**	-0.00390
		(0.00106)	(0.00227)	(0.00243)	(0.00242)
Population growth			0.131***	-0.0441	-0.122***
			(0.0439)	(0.0460)	(0.0452)
Financial development			0.840***	1.707***	0.514
			(0.303)	(0.344)	(0.334)
Control Corruption				-0.210***	-0.00406
				(0.0533)	(0.0542)
Human capital				0.514***	0.482***
				(0.0894)	(0.103)
Public expenditure					0.192***
					(0.0211)
Constant	5.440***	4.307***	3.947***	4.048***	0.159
	(0.0392)	(0.114)	(0.219)	(0.260)	(0.501)
Observation	900	839	805	660	612
R-squared	0.480	0.548	0.552	0.567	0.595
Fisher-stat	862.5	523.7	264.9	155.2	161.1

Source: Authors. Robust standard errors in brackets. *** p<0.01; ** p<0.05; * p<0.1. Estimation by Pooled OLS.

These results are in line with those in the literature, which show the positive effect of infrastructure on certain components of inclusive growth, such as income equity (Calderón and Servén, 2004; Chatterjee and Turnovsky, 2012; Ofori et al., 2022) and per capita income (Ofori et al., 2022). The main explanation for this result is certainly due to the reduction in the cost of doing business and creating jobs (Anand et al., 2013), the facilitation of transactions in goods and services, and the increase in per capita income by allowing specialisation, economies of scale, variety of products and services, etc. (Winters, 2014). More specifically, the infrastructure reduces costs (in terms of access to employment, transactions, and information), improves health by facilitating access to health services for the most disadvantaged sections of the population, and improves the population's water, health and productivity at work.

The control variables generally show the expected signs and are consistent with the empirical literature. In the full model presented in column 5, economic globalisation has a positive and highly significant effect on inclusive growth, i.e., trade and financial openness promote employment, income, and economic integration, consistent with the literature (Dollar & Kraay, 2004; Gygli et al., 2019). When public expenditure is introduced into the full model, inflation, financial development and corruption control, which were initially significant, lose their statistical status (col. 5). This attenuation suggests that their effects are absorbed by public expenditure, which is more structural. Indeed, in the only column where it appears, public expenditure is positive and significant, indicating that public investment is a direct channel for inclusive growth, consistent with Rajkumar & Swaroop (2008). Its introduction also changes the demographic dynamics: population growth, which was initially negative, becomes positive and significant, suggesting that the demographic dilution effect can be reversed when public spending offsets pressure on essential services (Bloom et al., 2012). Human capital has a clearly positive and robust effect, confirming its central role in productivity and the expansion of economic opportunities (Barro, 2013; Hanushek & Woessmann, 2012). However, the sensitivity of certain variables to the introduction of new controls, notably the loss of significance of inflation, financial development, and governance, as well as the reversal of the sign of population growth, suggests the need to verify the stability of these relationships.

5.2. Considering the level of development and democracy

To ensure the sensitivity of these results, we use the World Bank's classification of countries by level of income per capita and distinguish between four groups of aggregates of countries: high income (hi) [> $14,005], upper middle income (umi) [$4,516 to $14,005], lower middle income (lmi) [$1,146 to $4,515], and low income (li) [< $1,146]. As the Seychelles is the only high-income country in Africa, it was not possible to include it in the panel regression. On the other hand, the African continent comprises middle-income (mi) and low-income (li) countries. We also account for heterogeneity across countries by grouping our sample according to political and economic characteristics. To do this, we then follow Marshall et al. (2009) and distinguish between autocratic and relatively democratic countries. Democracies are characterised by free elections, guaranteed civil liberties, accountable governance, and inclusive growth promoted through fair and transparent policies. Autocracies, on the other hand, concentrate power, limit freedoms, and often privilege an elite, thereby hindering equity and long-term development. Democracies are therefore generally better suited to inclusive and sustainable investment.

Table 4: Importance of level of development and political regime

	Dependent variable : Inclusive growth				
	lmi	umi	li	Demo	Auto
Variables	(1)	(2)	(3)	(4)	(5)
Infrastructure	0.0241***	0.0600***	0.0341***	0.0301***	0.0217***
	(0.00248)	(0.00626)	(0.00414)	(0.00330)	(0.00325)
Economic globalisation	0.0182***	-0.0166**	0.00459	-0.00982***	0.0511***
	(0.00433)	(0.00723)	(0.00399)	(0.00340)	(0.00470)
Inflation	-0.000690	0.0181***	2.87e-05	-0.0175***	-0.000344
	(0.00232)	(0.00669)	(0.00204)	(0.00450)	(0.00264)
Population growth	-0.290***	0.377***	-0.0716**	-0.00826	-0.246***
	(0.0449)	(0.0987)	(0.0363)	(0.0600)	(0.0546)
Financial development	-4.446***	1.026***	1.194	1.089***	-4.884***
	(0.598)	(0.350)	(1.136)	(0.235)	(0.744)
Corruption control	-0.386***	-0.419***	0.0702	0.272***	-0.222***
	(0.0793)	(0.104)	(0.0544)	(0.0674)	(0.0689)
Human capital	-0.509***	0.944***	-0.136	0.650***	-0.348**
	(0.0938)	(0.205)	(0.0834)	(0.118)	(0.157)
Public expenditure	0.233***	-0.486***	0.273***	0.214***	0.329***
	(0.0308)	(0.0629)	(0.0253)	(0.0284)	(0.0331)
Constant	1.668**	14.39***	-1.109**	-0.0673	-2.495***
	(0.711)	(1.531)	(0.548)	(0.560)	(0.698)
Observation	276	90	246	331	281
R-squared	0.561	0.879	0.467	0.819	0.533

Note: Constructed by the author. Standard errors in brackets. *** p<0.01; ** p<0.05; *p<0.1. Estimated by Pooled OLS. The abbreviations for levels of development are PRII, PRIS, and PRF, which represent lower-middle-income, upper-middle-income, and low-income countries, respectively. A political regime is considered autocratic (auto) when the score is less than 1; otherwise, it is considered democratic (demo).

The positive effect of infrastructure on inclusive growth in democratic countries is greater than that observed in autocratic countries (Table 4). Similarly, with respect to the level of development, we find that the positive effects of infrastructure tend to be greater in developing countries than in developed countries. Several arguments can be put forward to support these results. First, Acemoglu et al. (2019) suggest that democracy promotes higher GDP by inducing economic reforms, improving fiscal capacity and the provision of schooling and healthcare, and perhaps also by inducing greater investment and a better quality of life for all citizens (Kashyap, 2018). Second, per capita income grows more rapidly in democracies because population growth is faster in dictatorships. In general, political regimes have greater effects on demography than on the economy (Przeworski et al., 2000).

6. Robustness analysis: considering the dynamics of inclusive growth

The analysis of the macroeconomic effects of infrastructure on inclusive growth requires consideration of endogeneity. Estimation using the Generalised Method of Moments in Systems (sGMM), therefore, enables overcoming this problem. Table 5 presents the estimation of the previous equation using the sGMM. The results indicate that the signs do not change, and the overall infrastructure and its sub-variables continue to have positive and significant effects. The breakdown of infrastructure in Table 5 suggests that not all components contribute equally to inclusive growth. Electricity appears to be the most influential type of infrastructure, reflecting its central role in supporting productivity, business development and household well-being. Water and transport also have significant positive effects, reflecting their importance in improving sanitation, mobility and access to essential services. ICT, although significant, has a more modest influence, reflecting its role in reducing information barriers and expanding digital opportunities. The positive effect of overall infrastructure remains significant. Still, its impact is more modest than that observed for certain specific components, confirming that gains in inclusion come mainly from the most essential

infrastructure, such as electricity, water, and transport. Taken together, these differences confirm that infrastructure should be considered as a set of distinct sectors rather than a single, homogeneous category.

Table 5: The importance of the dynamics of inclusive growth

	Dependent variable : Inclusive growth Estimation technique : sGMM				
Variables	(1)	(2)	(3)	(4)	(5)
Inclusive growth (t-1)	0.524***	0.550***	0.539***	0.547***	0.523***
	(0.106)	(0.167)	(0.171)	(0.126)	(0.128)
Infrastructure	0.00808*				
	(0.00424)				
Transport		0.0147*			
		(0.00797)			
Electricity			0.0212*		
			(0.0110)		
ICT				0.00766**	
				(0.00365)	
Water					0.0148**
					(0.00656)
Economic globalisation	0.00896*	0.0190**	0.0103	0.00771*	0.0208**
	(0.00457)	(0.00813)	(0.0232)	(0.00419)	(0.0101)
Inflation	0.0239***	0.0179***	0.0218***	0.0216***	0.0200***
	(0.00385)	(0.00654)	(0.00611)	(0.00598)	(0.00516)
Population growth	-0.102*	0.0933	-0.0966	-0.140**	-0.105
	(0.0599)	(0.430)	(0.226)	(0.0631)	(0.116)
Financial development	0.440	0.287	-1.564	0.984	-0.358
	(0.647)	(0.602)	(6.226)	(0.608)	(2.760)
Corruption control	-0.0294	-0.178	0.0701	-0.0933	-0.136
	(0.185)	(0.345)	(0.224)	(0.146)	(0.181)
Human capital	0.0855	0.0581	0.230	0.181	-0.427
	(0.0959)	(0.169)	(0.196)	(0.119)	(0.488)
Public expenditure	0.0770*	0.268*	0.0946	0.0705*	0.153**
	(0.0423)	(0.145)	(0.121)	(0.0374)	(0.0672)
Constant	0.445	-5.052	-0.0211	0.437	-1.545
	(0.613)	(3.572)	(2.633)	(0.567)	(1.153)
Observations	577	577	577	577	577
Country	38	38	38	38	38
Instrument	17	15	12	12	15
ar1p	0.0262	0.0349	0.0518	0.100	0.0485
ar2p	0.128	0.108	0.130	0.122	0.115
Sargan(p)	0.140	0.127	0.420	0.000	0.212
Hansen(p)	0.375	0.260	0.802	0.134	0.481

Source: Authors' calculations. Notes: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

The Sargan and Hansen statistics for all estimates exceed 10%, confirming the validity of the instruments across all specifications used. Alternatively, we also show the results of the Arellano and Bond test for AR(1) and AR(2) autocorrelation. The value of the AR(1) structure is not rejected for the estimated model, from which the dynamic model is appropriate. In contrast, the AR(2) structure is rejected because there is no serial autocorrelation between the first-differenced variables used as instruments and the residuals.

7. Conclusion

This article examines the effects of infrastructure on inclusive growth. More specifically, we find that infrastructure tends to increase inclusive growth (Table 3), but this effect varies across political systems and levels of development. Also, depending on the type of infrastructure, the level of inclusive growth varies. Indeed, we find that the positive effect of infrastructure on inclusive growth tends to be amplified in upper-middle-income countries and democratic countries (Table 4). Furthermore, disaggregating infrastructures shows that while electricity infrastructure has a significant positive effect, the effect of telecommunication infrastructure remains low (Table 5). Compared with the total infrastructure index, these results confirm that the aggregate index masks substantial sectoral heterogeneity, with the strongest effects coming from electricity, water, and transport. In contrast, ICT and the overall infrastructure index display more modest impacts. Based on our analysis, three main policy recommendations emerge. First, it is fundamental for governments to invest in various categories of infrastructure and to implement mechanisms that enable the poor to benefit from it. Secondly, governments should promote public-private partnerships to accelerate the implementation of infrastructure projects, such as toll roads, telecommunications networks, and airports, where it is feasible to recover investment costs through user charges. Finally, to improve the availability of funds, it is necessary to ease regulatory constraints on infrastructure projects, such as those related to land acquisition. A transparent, balanced, and consistent land acquisition process is essential for a healthy infrastructure market.

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Appendices

Appendix 1: Description of variables and sources

Variables	Description	Sources
Inclusive growth	An index constructed by the authors by crossing two variables: GDP per capita and equality.	Anand et al (2013)
Infrastructure	Infrastructure Development Index	AIDI
Water and sanitation	Composite water and sanitation index	AIDI
Electricity	Composite electricity index	AIDI
Transport	Composite transport index	AIDI
ICT	Composite ICT index	AIDI
Financial development	Financial development index reflects the efficiency, access and depth of financial institutions and markets.	Findex
Population growth	Annual population growth rate	WDI

Economic globalisation	Covers trade in goods and services; customs duties, taxes and trade restrictions; capital account opening and international investment agreements.	KOF[2]
Inflation	Consumer price index (2010=100)	WDI
Corruption	The corruption indicator is based on foreign investors' perception of the degree of corruption in a country.	WDI
Human capital	The human capital index is based on years of schooling and returns to education; see Human capital in PWT9.	Penn W.T.
Public expenditure	Gross national expenditure is the sum of household final consumption expenditure, general government final consumption expenditure and gross capital formation.	WDI
Level of development (Income groups)	World Bank 2024 income classification based on GNI per capita. Categories used: PRF = Low income; PRII = Lower-middle income; PRIS = Upper-middle income.	World Bank, *Country Income Classification*
Political regime	Polity2 index ranging from −10 (autocracy) to +10 (democracy). Used in regressions with thresholds: [-10 to 6[is non-democracies (autocracies or hybrid regimes) and [6 to 10] is democratic regimes.	Polity V Project, Center for Systemic Peace

Source: Authors. WDI is the World Development Indicator; Findex is the IMF Financial Development Index; KOF is the Konjunkturforschungsstelle index.

Appendix 2: Presentation of the inclusive growth and economic growth indicator

Country	Inclusive Growth (1)	Ln (gdp per capita) (2)	(1)-(2)	Country	inclusive growth (1)	Ln (gdp per capita) (2)	(1)-(2)
Angola	7.10	8.02	-.92	Morocco	7.02	7.90	-.87
Burundi	4.54	5.35	-.81	Madagascar	5.20	6.11	-.91
Benin	6.01	6.96	-.94	Mali	5.79	6.54	-.74
Burkina Faso	5.61	6.45	-.84	Mozambique	5.06	6.21	-1.14
Botswana	7.44	8.74	-1.30	Mauritania	6.52	7.26	-.74
Central African Republic	4.81	6.04	-1.23	Mauritius	8.21	8.99	-.78
Ivory Coast	6.56	7.47	-.90	Malawi	4.98	5.98	-1.00
Cameroon	6.25	7.21	-.95	Namibia	7.05	8.43	-1.38
Congo. Dem. Rep.	4.93	5.89	-.96	Niger	5.31	6.11	-.79
Congo. Rep.	6.72	7.77	-1.05	Nigeria	6.73	7.58	-.85
Comoros	6.10	7.16	-1.05	Rwanda	5.35	6.34	-.98
Cabo Verde	6.98	8.02	-1.04	Sudan	6.16	6.91	-.74
Djibouti	6.53	7.43	-.90	Senegal	6.27	7.12	-.84
Algeria	7.66	8.29	-.63	Sierra Leone	5.32	6.09	-.76
Egypt. Arab Rep.	7.01	7.74	-.72	Sao Tome and Principe	6.48	7.15	-.66
Ethiopia	5.20	5.97	-.77	Eswatini	7.05	8.17	-1.12
Gabon	8.12	8.96	-.84	Seychelles	8.48	9.42	-.94
Ghana	6.27	7.17	-.90	Chad	5.70	6.59	-.89
Guinea	5.73	6.51	-.77	Togo	5.46	6.37	-.91
Gambia. The	5.65	6.55	-.89	Tunisia	7.49	8.24	-.74
Guinea-Bissau	5.30	6.36	-1.05	Tanzania	5.78	6.63	-.84
Equatorial Guinea	8.45	9.41	-.95	Uganda	5.50	6.40	-.89
Kenya	6.04	6.97	-.93	South Africa	7.56	8.78	-1.22
Libya	8.17	8.91	-.74	Zambia	5.85	7.08	-1.23
Lesotho	5.75	6.89	-1.14	Zimbabwe	5.81	6.77	-.95

Source: Authors' calculations using the formula in Anand et al (2013) and data from the World Bank's World Development Indicators (WDI), Solt's Standardized World Income Inequality Database (SWIID).