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A MODEL FOR CONSTRUCTION SECTOR DEVELOPMENT IN MIDDLE-INCOME SUB-SAHARAN AFRICAN COUNTRIES

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Abstract. Buildings and other constructed facilities form the essential framework of a country's physical and economic infrastructure. Construction serves as a key capital input to production, driving economic growth and wealth generation. This impact can be particularly transformative in low-to-middle-income countries. Physical infrastructure, including construction, is a powerful engine of economic growth and is closely related to national economic performance. However, not all studies agree with the commonly held belief that construction investment has a positive impact on economic growth, particularly concerning the amount of investment and the relationship between construction investment and economic growth. So far, cross-country studies dealing with the construction sector-economic growth relationship have used indicators of national output and construction that are not strictly comparable between countries. This article reviews the main strands of the literature on the role that the construction sector plays in the national economy and economic development. It also uses novel data drawn from the "capital file" of the PENN World Table (version 10.1) to assess the development pattern of the construction sector in two groups of sub-Saharan African (SSA) countries on the middle-income status of economic development, for the period between 1990 and 2019. The study reveals that construction shares, measured as the proportion of gross fixed capital formation attributable to construction in the gross domestic product, revolve around a norm determined by the level of built assets preceding the reference period. The results of the study could have policy implications for the economic sustainability of the construction industry in SSA.

Keywords: built assets, built capital-national output ratio, construction sector, economic sustainability, PENN World Table, sub-Saharan Africa.

JEL Classification: C01, C67, L74.

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1. Introduction

The relationship between the construction sector and the national economy during national socioeconomic development has been studied by various researchers and national and international development agencies. Construction, as a sector of the economy, accounts for a significant share of national output, in the range between 5 and 10% of gross domestic product (GDP) (United Nations, 2024), and has a multiplier effect on other sectors of the national economy. In the European Union, the broad construction sector, including construction, real estate activities, and manufacturing, represents about 9% of GDP, 3 million enterprises and 18 million jobs, according to the European Construction Sector Observatory (European Commission, n.d.). Construction is a very segmented industry. Construction products are as diverse as dwellings, office buildings, public and utility buildings, or construction products such as highways, bridges, tunnels, railways, airfields, water projects, irrigation systems, sewerage systems, pipelines and electric lines (Carassus et al., 2006). Another way to look at construction outputs is to categorise them as building and civil engineering works. The latter segment is closely related to construction infrastructure, also known as economic or hard infrastructure (World Bank, 2017). Construction infrastructure plays a key role as a capital input into production and wealth generation. The economic impact can be transformative, particularly for countries with low-to-middle-income levels per capita (OECD, 2013). As highlighted by Maddison (1987), the strong correlation between physical capital, such as infrastructure, and various indicators of national economy is a key reason why it's considered a powerful engine of economic growth and development. Many countries rely on infrastructure investment to boost their economies, and the construction industry plays a critical role in making these plans sustainable (Narbaev, 2022; Ruddock & Ruddock, 2022). One of the main challenges in the development of different countries is reconciling the need for rapid economic growth with the need for long-term sustainability (Goubran, 2019; Cataldo et al., 2022).

Early studies on the role of the construction industry in the development process found that there is a positive correlation between various measures of construction output and gross national income (GNI) per capita (Strassmann, 1970; Turin, 1973; Wells, 1985). However, the current dominant paradigm suggests that the share of construction in the gross domestic product (GDP) tends to increase in the initial stages of development, stabilise in the middle-income range, and decrease in the later stages of development. According to Bon (1992), the construction industry has a special historical link with urbanisation and industrialisation, especially with the manufacturing industry, which is the construction sector's primary partner in the development process. Rodrik (2016) highlighted the role of the industrial revolution in enabling sustained economic growth in Europe and North America. This period also saw some non-Western nations, like Japan in the late 19th century, the Republic of Korea, Taiwan, and several East Asian countries after the 1960s achieve significant economic catch-up and convergence with the West. The earlier stages of development are characterised by intense urbanisation, demographic growth, the establishment of basic infrastructure, and the construction of industrial plants (Bon, 1992; Girardi & Mura, 2014). Rapid development propels the construction sector to surge ahead of the rest of the economy, boosting its output share. However, as these processes mature and slow down, construction investment growth tends to lag behind overall economic growth. Although construction investment is generally seen as positive for economic growth, some studies (Yiu et al., 2004; Lopes et al., 2017; Dell'Ariccia et al., 2021) challenge the extent of its impact and the causal relationship between construction and GDP.

Regarding construction infrastructure, quantitative assessments of the contribution of infrastructure to aggregate output were pioneered by Aschauer (1989) on the effects of public infrastructure capital on US total factor productivity. Since then, several studies dealing with the infrastructure investment-economic growth relationship, using a variety of data and methodologies, have provided widely contrasting empirical results (Ansar et al., 2016; Kodongo & Ojah, 2016; Saccone et al., 2022; Meng et al., 2023) (for a detailed review, see Calderón et al., 2015; Banerjee et al., 2020; and Timilsina et al., 2020). Calderón et al. (2015) employed an infrastructure-augmented production function approach to assess the contribution of infrastructure capital to aggregate productivity and output. Their panel data set comprised 88 developed and developing countries during the period 1960–2000. They discovered that the marginal product of infrastructure was greater when the relative infrastructure stock was lower but diminished at higher levels. Kodong and Ojah (2016) analysed the relationship between infrastructure and economic growth for a panel of 45 countries in sub-Saharan Africa (SSA) during the period 2000–2011. They found that both spending on infrastructure and improvements in access to infrastructure influence economic growth and development in SSA. Meng et al. (2023) examined the eventual impact of the massive post-2008 global crisis stimulus package of the Chinese government on the economic downturn. They distinguished between the effects of "traditional" and "new" infrastructure and found that it is "traditional" infrastructure, which provides the strongest effect as a growth engine with long-term benefits. On the other hand, Ansar et al. (2016) analysed the impact of infrastructure investment on China's economic growth from 1984 to 2008. They found that excessive investment in infrastructure projects with low returns contributed to the country's economic vulnerability. The study also suggests that a massive infrastructure investment programme is not a viable development strategy for other developing countries that may look to China as a model of development. Building on this, Banerjee et al. (2020) examined the impact of access to the transportation network on regional economic performance in China during a period of rapid economic growth (1986–2006). They found that, while proximity to transportation networks leads to higher regional GDP levels, it does not necessarily accelerate economic growth itself. This suggests that simply building infrastructure is not sufficient to stimulate economic development. The World Development Report 1994 (World Bank, 1994) documents substantial differences between countries in the efficiency with which public infrastructure is used. Building on this point, to further enhance productivity, it could be argued that public capital productivity would increase through adequate maintenance and upgrading of existing infrastructure stock, along with prioritising investments that modernise production and enhance international competitiveness (Lopes, 2022). A particular feature related to the role of infrastructure in the development process is a trend of deindustrialization in most developing countries, particularly in Latin America and SSA, since the 1980s. This phenomenon is known as "premature deindustrialisation". Using data from the Groningen Growth and Development Centre (GGDC) 10-Sector Database, Rodrik (2016) found that developing countries, with some exceptions primarily in Asia, have experienced declining shares of manufacturing in both employment and real value-added, particularly since the 1980s. Since 1990, developing countries have reached peak manufacturing employment at per capita incomes that are around a third of the levels experienced before 1990. For the value added in manufacturing at constant prices, the corresponding ratio was less than half (Rodrik, 2016).

The mixed results on the relationship between infrastructure spending (construction infrastructure) and economic growth point to the importance of the level of capital stock in the future development pattern of less developed countries and that of the construction industry in these countries as well. The dynamic nature of the construction sector and economic development complicates efforts to model their relationship (Ruddock & Lopes, 2006). Particularly considering the ongoing changes in the industrial structure of developing countries. Empirical tests of Bon's (1992) proposition have yielded mixed results. Choy (2011) concluded that the Bon's inverted U-shaped curve holds within most developed countries over time, but not across countries at a given time. Girardi and Mura (2014) employed panel data techniques to analyse the construction-economic development relationship. The sample covered the majority of developed and developing countries during the period 2000–2011. They found that the construction-development curve is asymmetric with respect to its maximum, that is, the share of construction in GDP decreases at a slowing pace after industrialisation, approaching a type of "plateau" in mature economies. The peak in construction share is reached at per capita income levels closer to the origin, a pattern similar to that of manufacturing in Rodrik's (2016) study. Sun et al. (2013) studied panel data on construction and other economic indicators in advanced and emerging (in 2011) countries of Europe, over the period 2000–2011. Empirical findings suggest that the geography, demographics, and economic conditions of a country are key determinants of the norms around which construction shares revolve. The study also found that construction activity in many European countries increased in the years preceding the 2008 financial crisis, surpassing their historical norms. However, this growth abruptly stopped after the crisis, leading to a significant decline in construction shares. Lopes (2012) analysed construction trends in 45 SSA countries from 1990 to 2008. Interestingly, the study found that in middle-income SSA economies, the share of GDP of the construction sector stagnated after 2000, despite that these economies experienced rapid GDP per capita growth during the same period.

As emphasized by Stern (1991), research on growth accounting has facilitated the documentation and analysis of the empirical growth process by economic historians and statisticians. Significant contributions have arisen from a particularly valuable set of data, which has allowed the recalculation of national income and physical capital based on purchasing power parity (PPP). For almost five decades, the Penn World Table (PWT) has been a standard source of data on national economies (Feenstra et al., 2015). Using prices collected across countries in benchmark years by the International Comparisons Programme (ICP) and employing these prices to derive purchasing power parity exchange rates, PWT converts national economic data to a common currency (USD), facilitating inter-country comparisons. The PWT (version 10.1) (Feenstra et al., 2015) is a database encompassing data on relative price levels of income, output, capital and productivity, covering 183 countries from 1950 to 2019. The "capital file" of the PWT provides investment and net capital stock estimates (at current national prices) disaggregated for structures, machinery and equipment, and other assets. It also provides data on the deflators of the different components of investment and net capital stock. Intuition and descriptive overviews of the dynamics observed in middle-income countries suggest that the level of capital stock is an additional variable to model the construction-economic growth relationship in developing countries. It appears that the level of the net capital stock (particularly built capital stock) captures some dimensions of the level of urbanisation and, to some extent, of the level of industrial structure. This study investigates whether construction output (measured as a proportion of the formation of gross fixed capital in construction in GDP) revolves around a norm that is determined by the level of built capital stock of a country before the reference period. The study represents a novel approach in two interrelated ways: it utilizes the most comprehensive dataset that enables comparable prices of consumption and investment goods across countries and time; to overcome some of the heterogeneity problems in growth accounting exercises, the sample analysed here comprises countries of the same African subregion and with the same economic development status (middle-income countries).

The rest of this paper is organised as follows: a brief review of the literature on the macroeconomic level of the construction sector is presented in Section 2. Section 3 presents the data set used for the analyses and a model of the construction investment development pattern in middle-income economies in SSA. Two groups of countries were established: one in which the capital-output ratio was equal or greater than 4 in the period 1985–1995 (average for the period); the other one in which the capital-output ratio was less than 4 in the period 1985–1995 (average for the period). Section 4 presents an overview of the evolution of GDP and construction-related economic indicators in SSA and South Africa and Nigeria, the two economically dominant poles of the SSA region, over the period 1970–2022. Empirical results and discussion are presented in Section 5; a concluding remark is presented in the final section.

2. The macro-level of the construction sector: a brief review

There are three main strands in the literature at the macroeconomic level of the construction industry. A more detailed review of these different strands of literature is provided by Choy (2011). The first one deals with the relationship between construction and economic growth and development (Bon, 1992; Nafziger & Yoder, 2021; Correia & Ribeiro, 2022; Lopes, 2022). The second tries to assess whether construction investment leads to GDP growth or vice versa (Dasgupta et al., 2014; Aali-Bujari & Venegas-Martínez, 2021). The third employs input-output analysis to study the pull and push effects of the construction sector within the national economy (Gloser et al., 2017; Ali et al., 2019; Ma et al., 2019). Early influential papers investigating the role of construction in economic development (Strassmann, 1970; Turin, 1973; Drewer, 1980; Edmonds & Miles, 1984) were based on Keynesian economic philosophy, particularly on the features related to the role of capital formation in the process of economic growth and development. In this sense, construction plays a unique role in economic growth and is often seen as a key barometer of economic conditions. Construction increases the physical infrastructure of a country (including housing stock), which is a critical factor for long-term growth (OECD, 2013). Furthermore, the construction industry has also historically been linked to the process of industrialisation and urbanisation, especially since the Industrial Revolution. Railroad networks and canals played a crucial role in fostering development in various regions of Europe, North America, and parts of Latin America (Donaldson & Hornbeck, 2016).

The most influential of these early works was probably that of Turin (1973). His study encompassed 87 countries in all regions of the world, representing all stages of economic development, during the period 1955–1965. Turin (1973) distinguished two key observations: 1) capital formation in construction ranged from 6 to 9% of GDP in developing countries and 10 to 15% in industrialized countries; and 2) cross-country comparisons reveal a direct relationship between income per capita and construction activity as a share of total value added. These findings have been corroborated by many other studies (Edmonds & Miles, 1984; Wells, 1985; Ofori, 1988). However, as noted by Chiang and Pheng (2011), some of these early studies acknowledged that the role of construction in the economy would diminish as countries progress toward the middle-income development stage. Drewer (1980) highlighted that increased construction activity does not inherently correlate with economic growth when resources are misallocated and that the necessary level of construction value added for sustained economic growth should be around 5% of GDP.

Bon (1992) analysed a sample of countries representing all stages of economic development and presented a development pattern of the construction industry based on the stages of development. Bon's model suggests an inverted U-shaped relationship between the construction industry's share of GDP and development. That is, it increases in the early stages of development, stagnates in the middle-income range, and begins to decrease in the later stages of development. Moreover, in the long run, in the most advanced industrial countries, construction will decline not only relatively, but also absolutely. Bon (1992) appeared to align with Maddison's (1987) observation that as an economy becomes more developed and realizes its economic potential more fully, it becomes less dependent on any sector to drive economic growth and development. However, Ruddock and Lopes (2006) and Carassus et al. (2006) challenged this notion, finding no evidence of an absolute decline in construction output within the most economically advanced countries.

As longer and more reliable time-series data become available, alongside advancements in econometric methodologies concerning the analysis of economic relationships between variables, a new category of studies has emerged (Lopes, 2022). Several studies have employed the Granger causality framework (Granger, 1969) to investigate the causal relationship between construction investment and various measures of national economic aggregates. Some argue that construction spending causes growth in the national aggregate by creating physical facilities needed for the development of other productive activities (Anaman & Osei-Amponsah, 2007; Aali-Bujari & Venegas-Martínez, 2021). In contrast, another perspective holds that growth in GDP causes construction growth (Yiu et al., 2004; Pheng & Hou, 2019; Alaloul et al., 2021). Other studies have also proposed a bi-directional relationship in which activity in different segments of the construction industry influences and is influenced by national output (Osei et al., 2017; Abubakar et al., 2018). Yiu et al. (2004) discovered that in Hong Kong, real growth in the overall economy drives real growth in construction output, rather than the other way around, at least in the short term. Similarly, Ogunbiyi et al. (2017) demonstrated a unidirectional causality between construction investment and economic growth in Nigeria, with the causality running from the latter to the former. However, Wong et al. (2008) using more recent data for Hong Kong, found a different pattern. Analysing a longer period of Hong Kong's high-income status, Wong et al. (2008), suggested causality from construction, particularly civil engineering, to GDP. Similar findings of construction leading to economic growth emerged in the study of Ghana. Using time series data from 1968 to 2004, Anaman and Osei-Amponsah (2007) found that the construction industry leads to economic growth in Ghana. Similarly, Osei et al. (2017) examined the relationship between construction expenditure and economic growth in 33 sub-Saharan African (SSA) countries using data from 1990 to 2014. They found a positive long-term relationship between construction spending and economic growth, although the short-term impact was statistically insignificant.

This underscores the importance of the construction industry for sustained economic growth in SSA. Chen and Zhu (2008) analysed provincial data on housing investment in China's three main regions. They found that the bidirectional causal relationship between GDP and housing investment differed within each region. However, the impact of housing investment on GDP differed between regions. Earlier, Green (1997) investigated causal relationships in the US using national data from 1959 to 1992. His study examined whether residential and non-residential construction investment Granger-cause GDP and vice versa. Green found that housing investment led to economic growth (GDP) but was not influenced by it. Conversely, non-residential investment was not a driver of GDP growth but responded to it. These findings suggest that housing investment precedes economic upswings, while other construction investments tend to lag behind the business cycle. In the same vein, Abubakar et al. (2018) explored the relationship between construction output and GDP in Nigeria, using data from 1990 to 2015. Their findings suggest a bidirectional link, where construction activity and GDP growth mutually influence each other in one year. Sahoo and Dash (2009) investigated the relationship between infrastructure development and economic growth in India using data from 1970 to 2006. Their analysis included variables such as energy, telecommunications, and aviation infrastructure. They found that both existing infrastructure (infrastructure stocks) and new investment in infrastructure (total infrastructure investment) significantly to India's economic growth. Specifically, their study establishes a causal relationship between infrastructure investment and GDP growth, suggesting that increased infrastructure spending directly leads to economic expansion. Wilhelmsson and Wigren (2011) examined the causal links between construction investment and economic growth in 14 Western European countries using panel data analysis. Their research revealed that investment in residential construction impacts GDP growth both in the short and long term. Interestingly, this effect was not observed for infrastructure or other types of building construction. This review of the role of the construction sector in economic growth highlights the complexity of its causal relationship. Studies reveal a mixture of unidirectional, bidirectional, and even insignificant causal links between construction investment and national output growth, which presents a challenge to policy makers. Although Granger causality (Wong et al., 2008) is a valuable statistical tool, it analyses the predictability of time-series data, not the definitive cause-and-effect.

3. Data set and methodology

3.1. Data and data sources

The main indicators of economic activity used for the analysis are GDP per capita, gross national income (GNI) per capita, and gross fixed capital formation in construction. Buildings and other construction products are components of the country's gross fixed capital formation (GFCF) as described in the United Nations System of National Accounts (SNA) (United Nations, 2009). According to the SNA 2008 guidelines, the GFCF encompasses the acquisition of goods and services intended for production that lasts more than a year. Capital stock statistics are classified according to the type of assets, institutional sector, and economic sectors, as outlined in the International Standard Classification of Economic Activities (ISIC revision 4) (United Nations, 2008). In terms of the type of assets, the built capital stock comprises dwellings, other buildings and structures, along with major improvements to land. Other gross fixed capital assets recognised in both the European System of Accounts (ESA) 2010 (Eurostat, 2013) and SNA 2008 (United Nations, 2009) comprise machinery and equipment, weapons systems, cultivated biological resources, costs of ownership transfer on non-produced assets, and intellectual property products. In the realm of national accounting, there are two different types of capital measures, each reflecting a different function of capital (OECD, 2013). The first type of capital measure focuses on the contribution of productive capital to production by providing a flow of services. The second type of measure captures the total wealth of the economy by estimating the net stock of capital. Its aggregate is the net capital stock (NCS), which represents the replacement cost, not necessarily the market value, of capital goods. Unlike gross capital stock (which does not account for asset depreciation), NCS is a key component of an economy's balance sheet within income and wealth accounting (OECD, 2009). Most modern works publishing capital stock statistics, both at national and international levels (see, e.g., Gormsen & Koijen, 2020; Di Pietro et al., 2021; Bontadini et al., 2023; Lopes et al., 2024), often rely on the perpetual inventory methodology (PIM) (OECD, 2009). In addition to the fact that NCS is the accumulation of GFCF over time, it is worth pointing out here the choice of GFCF in construction as an indicator of the activity of the construction industry rather than gross value added (GVA) in construction. The GVA in construction is calculated in the same way as in any other productive sector of the economy (production approach) but includes only the activities of the construction industry. Some authors have argued (de Vries et al., 2014) that the production approach has generally been used by national statistics offices in developing countries as the main approach to compiling estimates of GDP. However, the GVA in construction and its relation to gross construction output varies over time as more items are fabricated off-site and less trade-type work is done on-site. Thus, construction investment (GFCF in construction), although limited to capital work, is arguably a more useful metric. GDP per capita, which considers a nation's population alongside its total economic output (GDP), is often seen as a more accurate reflection of the general well-being of a country compared to GDP alone. It is also worth referencing here the concept of developed and developing economies, or the status of a country's economic development. There is no established convention for the designation of "developed" and "developing" countries in the United Nations system (Ruddock & Lopes, 2006). The World Bank, through the World Development Indicators (WDI), classifies countries according to their GNI per capita: low-income countries (LICs); lower-middle income countries (LMICs); upper middle-income countries (UMICs) and; high income countries (HICs). LMICs and UMICs are usually aggregated into the middle-income countries (MICs) category. For the year 2022, in which the most recent data are available, LIC are countries with a GNI per capita less than 1,135 USD (current price); LMICs are those with a GNI per capital between 1,136 USD and 4,465 USD; UMICs are those with a GNI per capital between 4,465 USD and 13,845 USD; HICs are those with a GNI per capital of 13,845 USD or higher. All SSA countries that are the subject of this study (see below) belonged to the WDI MICs status for the year 2022, including Comoros, Senegal and Zimbabwe, which increased the status of income development (from LICs to LMICs) in 2019. Most studies dealing with the macro level of the construction industry (Bon, 1992; Ruddock & Lopes, 2006; Girardi & Mura,

2014) follow the WDI characterisation of the state of economic development of a country.

The main statistical sources used for the analysis are the PTW-Version 10.1 (Feenstra et al., 2015) and the World Development Indicators 2022 (World Bank, 2024). PWT 10.1 provides GDP and NCS data at current PPPs (2017 USD) and constant 2017 national prices (USD), dating back, for some countries, to 1950. As the PWT figures at constant prices are based on national account data, it is possible to compare the capital-output ratios across time and countries. Constructions from the data presented in PWT show essentially no systematic pattern of cross-country variation in the capital-output ratio, particularly in the middle-to-high income levels of economic development (Feenstra et al., 2015). However, for highly developed countries and some middle-income countries, a slight trend of decline is observed with increasing per capita income over time, as implied by the Solow model (Solow, 1956). It should be noted that the depreciation rates presented in the PTW vary between countries and over time, reflecting asset composition for a given country and at a given time. Constructions of the capital-output ratios at national accounts-based constant prices (from PWT) also indicate that the majority of European countries were in a range from 3 to 5 in the period 1980–1990, so a value of 4 for the capital-output ratio seems to be reasonably constructed for this analysis. It is worth noting that, for less developed countries, the NCS-output ratios measured at constant 2017 national prices (USD PPP), are generally higher than those measured at national prices. As pointed out by Inklaar et al. (2019), the price level of capital stock tends to be similar to that of consumption for both low- and high-income economies. Due to its lower rate of depreciation, buildings and other constructed facilities form a large part of the price index of the capital stock, and since they are non-traded, the price level for structures tends to be lower for less developed countries. Therefore, the price level of the capital stock is usually lower than that of GDP. The "capital file" of the PWT presents GDP, investment, and NCS data at current national prices. The latter two are disaggregated into: structures (building and civil engineering works); machinery; transport equipment and; other assets. Deflators for different components of investment and NCS are also provided. So, it is possible to calculate the investment in structures and NCS in structures at constant national prices, and the NCS in structures to output ratio at constant 2017 national prices (USD) as well. Assuming that structures investment represents about 80% of a country's NCS (Feenstra et al., 2015), this figure corresponds to a built capital stock-GDP ratio of 3.2.

Section 5 analyses two groups of countries based on their NCS-output ratio averaged over the period 1985–1994.

- Group 1 (high NCS-output ratio): This group includes countries where the NCS-output ratio was equal to or greater than 4 during the specified period. These countries are: Angola, Benin, Cape Verde, Congo Republic, Comoros, Eswatini, Gabon, Ghana, Mauritania, Nigeria, Sao Tome and Principe, Seychelles, South Africa, and Zambia.
- Group 2 (low NCS-output ratio): This group consists of countries where the NCS-output ratio was less than 4 during the same period. These countries are: Botswana, Cameroon, Côte d'Ivoire, Equatorial Guinea, Guinea, Kenya, Lesotho, Mauritius, Namibia, Senegal, Tanzania, and Zimbabwe.

3.2. Econometric methodology

This study assesses whether the level of built capital stock before the period of reference (1990) determines the development pattern of the construction industry in the middle-income countries of SSA. That is, the development pattern of the construction industry (in terms of share of structures investment in GDP) in Group 1 is different from that of Group 2. The concern here is the long-term development rather than natural annual fluctuations that characterise the output of the construction industry.

The model is tested using a statistical test for the equality of two correlations (Hogg et al., 2015). The variables used in this model are $Istruct/GDP_{2017}$ (the share of structures investment in GDP, at constant 2017 prices) and $GDPpc_{2017}$ (GDP per capita measured at constant 2017 prices, in USD).

Let i =1, 2 corresponding to the two groups whose correlations are being compared. Sample correlations R_{ij} were observed based on n_{ij} observations for i = 1, 2 and j = 1, . . ., n_i, n_1 is 14 and n_2 is 12 so $R_{1_1} \ldots R_{1_{14}}$ and $R_{2_1} \ldots R_{2_{12}}$ can be bserved, and n_{ij} is 30 (i.e., time series data for the period 1990–2019).

For each sample correlation, it is necessary to evaluate:

$$W_{ij} = \frac{1}{2} \ln \frac{1+R_{ij}}{1-R_{ij}}. \tag{1}$$

And let

$$W_i = \frac{1}{n_i} \sum_{j=1}^{n_i} W_{ij} \tag{2}$$

be the averages of W_{ij} in the two groups.

Also, define

$$v = \frac{1}{n_1^2} \times \sum_{j=1}^{n_1} \frac{1}{n_{1j-3}} + \frac{1}{n_2^2} \times \sum_{j=1}^{n_2} \frac{1}{n_{2j-3}}. \tag{3}$$

Then, a $100_{\alpha\%}$ test of the null hypothesis $H_0 : \rho_1 = \rho_2$ against the alternative hypothesis $H_1 : \rho_1 \angle \rho_2$ is obtained by comparing the test statistic

$$z = \frac{W_1 - W_2}{\sqrt{v}} \tag{4}$$

with the lower N (0, 1) critical value – z_α, e.g., for a 5% test, z_α = 1.645.

Proof

Hogg et al. (2015) suggest that an approximate test of size α can be obtained by leveraging the fact that

$$W_{ij} = \frac{1}{2} \ln \frac{1+R_{ij}}{1-R_{ij}} = \sim N\left(\frac{1}{2} ln \frac{1+\rho_i}{1-\rho_i}, \frac{1}{n_{ij-3}}\right).$$

That is, W_{ij} is asymptotically distributed with mean $\frac{1}{2} \ln \frac{1+\rho_i}{1-\rho_i}$; and variance $\frac{1}{n_{ij-3}}$.

Assuming that the W_{ij} are independent, it follows that

$$W_i = \sim N\left(\frac{1}{2} l_n \frac{1+\rho_i}{1-\rho_i}, \frac{1}{n_i^2}\sum_{j=1}^{n_i}\frac{1}{n_{ij-3}}\right).$$

For i = 1, 2, hence

$$W_1 - W_2 = \sim N\left\{\left[\frac{1}{2}\ln\frac{(1+\rho_1)*(1-\rho_2)}{(1-\rho_1)*(1+\rho_2)}\right];\ \frac{1}{n_1^2}\sum_{j=1}^{n1}\frac{1}{n_{1j-3}} + \frac{1}{n_2^2}\sum_{j=1}^{n2}\frac{1}{n_{2j-3}}\right\}.$$

So, under $H_0 : \rho_1 = \rho_2$

$$z = \frac{W_1 - W_2}{\sqrt{v}},$$

where $v = \frac{1}{n_1^2}\times\sum_{j=1}^{n_1}\frac{1}{n_{1j-3}} + \frac{1}{n_2^2}\times\sum_{j=1}^{n_2}\frac{1}{n_{2j-3}}$, as required.

4. An overview on the long-run development of GDP and construction industry-related indicators for SSA, Nigeria and South Africa

Tables 1 to 3 provide details on the weights and growth rates of GDP, GFCF, and GVA in construction for SSA and the two economically dominant powers of the SSA region, Nigeria and South Africa, in the period 1970–2022. For comparison purposes, these indicators are also presented for the world as a whole. The first observation of note is that the SSA economy represented 2.18% of the world output in 2015, despite representing 18.9% of the world population in the same year (United Nations, n.d.). Regarding the SSA economy, Nigeria and South Africa combined accounted for 51.4%, 38.7%, and 33.9%, respectively, of the total GDP, total GFCF and total GVA in construction of 48 countries comprising SSA. This suggests that the fate of the SSA economy is, in some sense, intrinsically linked to those of the Nigerian and South African economies. Looking closely at Table 1, the evolution of GDP shows a pattern of increasing growth for all economic groups/countries over the period of analysis, except in the 1980 decade for SSA, Nigeria and South Africa, in which a depressing economy was pervasive across countries belonging to SSA. It is also worth noting that despite the small increase in GDP in the 1990s, SSA as a whole and Nigeria experienced a decreasing growth in GDP per capita for the increase in population was higher than that of GDP in the same decade (United Nations, n.d.). Tables 1 to 3 also indicate the negative effect of the COVID-19 pandemic on total output, GFCF, and GVA in construction for all economic groups/countries in 2020. The downturn in South Africa in 2020 was particularly striking; the contraction in GDP, GFCF, and GVA in construction is, respectively, –6.0%, –14.6% and –17.8%.

Tables 1 and 2 indicate that, in the analysis period, the evolution of GFCF for SSA and the world as a whole is similar to that of GDP for respective economic groupings, except in the 1980s for SSA, in which GFCF contracted remarkably, after a period of a high (5.7%) average growth rate in the preceding decade. Again, compared to a sluggish growth in GDP, GFCF for SSA, Nigeria, and South Africa also shrank markedly in the 1980s, particularly that for Nigeria, for which the average rate of growth fell from 9.1% in the 1970s to –8.1% in 1980s.

Table 1. Weights and real growth rates of Gross Domestic Product (source: authors' calculations based on United Nations, 2024)

Major area, sub-region and country	Base year weights as percentage of total for World in 2015	Average rates of growth (%)					Annual rate of change (%)				
		1970–1979	1980–1989	1990–1999	2000–2009	2010–2014	2015	2019	2020	2021	2022
World	100.00	4.1	3.2	2.8	2.8	3.3	3.1	2.5	–2.9	6.2	3.1
SSA	2.18	3.4	1.6	2.0	5.7	5.5	3.3	2.8	–1.9	4.5	3.8
Nigeria	0.66	5.3	–0.3	1.2	7.9	6.1	2.7	2.2	–1.8	3.6	3.3
South Africa	0.46	3.0	1.7	2.5	3.5	3.3	1.3	0.3	–6.0	4.7	1.9

Table 2. Weights and real growth rates of Gross Fixed Capital Formation (source: authors' calculations based on United Nations, 2024)

Major area, sub-region and country	Base year weights as percentage of total for World in 2015	Base year share as percentage of total GDP in 2015	Average rates of growth (%)					Annual rate of change (%)				
			1970–1979	1980–1989	1990–1999	2000–2009	2010–2014	2015	2019	2020	2021	2022
World	100.00	25.1	4.1	2.8	2.7	3.4	4.9	3.7	3.2	–2.3	5.2	3.2
SSA	1.81	21.3	5.7	–4.8	3.2	5.6	5.8	3.0	4.2	–4.9	6.6	3.2
Nigeria	0.38	14.8	9.1	–8.1	1.5	–0.2	3.6	0.7	8.3	–7.6	–3.4	3.3
South Africa	0.32	18.0	3.5	–1.5	2.3	7.9	4.8	1.3	–1.7	–14.6	0.6	4.8

Table 3. Weights and real growth rates of Gross Value Added in construction (source: authors' calculations based on United Nations, 2024)

Major area, sub-region and country	Base year weights as percentage of total for world in 2015	Base year share as percentage of total GDP in 2015	Average rates of growth (%)					Annual rate of change (%)				
			1970–1979	1980–1989	1990–1999	2000–2009	2010–2014	2015	2019	2020	2021	2022
World	100.00	5.3	2.1	2.0	0.7	1.3	3.2	3.3	2.0	–3.5	3.8	1.5
SSA	2.21	5.4	3.0	–1.6	2.6	10.1	9.1	4.8	6.3	–6.1	3.3	3.3
Nigeria	0.45	3.6	7.8	–6.9	4.0	8.9	13.5	1.4	1.8	–7.7	3.1	4.5
South Africa	0.30	3.5	1.9	–1.2	–0.6	9.3	3.1	1.0	–3.4	–17.8	–2.0	–3.4

However, for SSA, Nigeria, and South Africa, the average growth rates of GFCF in the period 1970–1979 are higher than those of GDP, for the respective economic grouping/countries, in the same period. The share of GFCF in GDP, in the base year, is 25.1% and 21.3% for, respectively, the World as a whole and SSA. However, figures from the United Nations (2024) show that, in the analysis period, there is a remarkable uniformity in the evolution of the World's GFCF. The proportion of world GFCF is in the range from 22% to 23% of GDP in the period 1970–2005, and from then on experienced a slightly increasing trend, reaching 25.1% of GDP in 2015, remaining practically stable until the end of the analysis period. This is explained by the spectacular growth of this indicator for China in the period from 1990 onwards. China's GFCF accounted for an astonishing 26% of the total in the world in 2015 (United Nations, 2024). The low level of the proportion of GFCF in GDP for Nigeria and South Africa, in 2015, compared to that of SSA in the same year, needs to be placed in the context of the capital accumulation process in these countries and in SSA as a whole. Nigeria and South Africa are part of the countries belonging to Group 1, in which construction investment as a proportion of GDP generally decreased in the period 1990–2019. Figures drawn from PTW-10.1 (Feenstra et al., 2015) show that the NCS-output ratio (measured at 2017 USD PPP), in 1980, is 6.48 and 3.95 for, respectively, Nigeria and South Africa. Constructions of PWT 10.1 indicate that that figure for SSA as a whole, in the same year, is about 3.5. This aspect will be addressed in Section 5. The figures presented in Tables 1 and 3 suggest changing patterns throughout the period 1970–2022. However, the pace of growth of Gross Value Added (GVA) in construction for SSA is distinct, both in absolute and relative terms, from that for Nigeria and South Africa throughout the analysis period. These characteristics are more clearly seen in Table 4, which shows the indices of GDP and GVA in construction, and the share of GVA in construction in GDP for selected years of the analysis period.

Table 4 indicates that GVA in construction and GDP (both measured at constant 2015 prices), for SSA, increased by, respectively, 608.3% and 431.8% in the period 1970–2022. For Nigeria, the same indicators of economic activity increased by, respectively, 590.2% and 516.9% in the same period. In South Africa, the GVA in construction and GDP increased by, respectively, 103.6% and 241.6% in the period 1970–2002. For SSA, Nigeria and South Africa, the evolution of GVA in construction is distinct in different sub-periods of the period of analysis. The share of GVA in construction in GDP for SSA was 4,0% in 1970, remaining stable until 1980; then it decreased to 3.0% in 1990; again, it rose to 5.7% in 2019, followed by a slight decrease to 5.3% in 2022. The share of GVA in construction in GDP of Nigeria increased from 3.0% in 1970 to 3.8 % in 1980; then it decreased to 1.9% in 1990, followed by an increase to 3.6% in 2015; then it decreased slightly to 3.3% in 2022. In South Africa, the share of GVA in construction in GDP decreased from 4.0% in 1970 to 2.2% in 2000; it increased to 3.5% in 2015, followed by a decrease to 2.4% in 2022. The evolution of the GVA in construction for South Africa, a somewhat mature economy in the SSA region, mirrored that of the world as

Table 4. Indices of GDP and GVA in construction, and Share of Gross Value Added in construction in GDP (source: authors' calculations based on United Nations, 2024)

Major area, sub-region and country	Indices of GDP and GVA in construction (1970 = 100) for selected years						Share of GVA in construction in GDP (%) for selected years						
	GDP			GVA in construction									
	1970	1990	2022	1970	1990	2022	1970	1980	1990	2000	2015	2019	2022
World	100.0	198.8	497.6	100.0	144.4	241.0	10.5	8.6	7.6	6.2	5.3	5.7	5.1
SSA	100.0	165.7	531.8	100.0	122.1	708.3	4.0	4.0	3.0	3.1	5.4	5.7	5.3
Nigeria	100.0	176.5	616.9	100.0	115.7	690.2	3.0	3.8	1.9	2.4	3.7	3.5	3.3
South Africa	100.0	161.8	341.6	100.0	116.6	203.6	4.0	3.7	2.9	2.2	3.5	3.1	2.4

a whole, in the analysis period. GVA in construction in the world decreased from a staggering 10.5% of GDP in 1970 to 5.1% of GDP in 2022. Thus, the data analysed here show that there was an absolute increase in GVA in construction, in the period 1970–2022 for all economic groupings/countries; there was a relative increase in GVA in construction for SSA and Nigeria, and; there was a relative decline in GVA in construction for the world as a whole and South Africa, in the same period.

5. Empirical results and discussions

Before proceeding with the analysis of the construction investment-GDP relationship, it is worth presenting the economic development status of the WDI and the GDP per capita dynamics for each of the 26 countries belonging to SSA, which were in the middle-income range of economic development in 2022. Tables 5 and 6 present the GNI per capita for the year 2022 (current USD) and the GDP per capita (at constant 2017 prices, in USD) for selected years of the period 1990–2019 for, respectively, Group 1 and Group 2. Group 1 is shown to comprise 3 UMICs (Gabon, Seychelles, and South Africa) and 11 LMICs. Group 2 comprises 4 UMICs (Botswana, Equatorial Guinea, Mauritius and Namibia) and 8 LMICs. The absence of HICs and the low proportion of UMICs in SSA is a concern for the research community dealing with development accounting, national governments, and international development agencies: the difficulty for countries in the middle-income range to jump to the next level of economic development. This is what is known as the "middle-income trap" (Yülek, 2017). Tables 5 and 6 also indicate that, in general, the countries studied, regardless of the grouping, experienced an increase in GDP per capita (constant 2017 national prices, in USD) in the period 1990–2019. The exceptions to this development pattern are the Congo Republic and Gabon (in Group 1), for which GDP per capita in 2019 was lower than in 1990. In Comoros (also in Group 1), GDP per capita remained practically stable throughout the analysis period. Tables 5 and 6 also indicate that Angola and Gabon (in Group 1), and Equatorial Guinea (in Group 2), which together with Nigeria are the top oil exporting countries in SSA, experienced a decrease in GDP per capita in the period 2015–2019 (for Equatorial Guinea, in the period from 2010 onwards). The high volatility in the market price of oil tends to affect the economic performance of oil-income reliant countries, particularly those with weak industrial structures. However, the general economic performance of the middle-income countries that belong to SSA contrasted with the development pattern of SSA as a whole in the 1980s and early 1990s, as can be observed in Table 1.

Tables 7 and 8 show the variables that are used in this investigation, as well as their averages, standard deviations, and maximum and minimum levels. For example, of the 14 countries that comprise Group 1, the average GDP per capita ($GDPpc_{2017}$) is 3,234.34 USD (constant 2017 national prices), the standard deviation is 3,101.03 USD. The maximum GDP per capita is 16,945.28 USD and it corresponds to Seychelles, and the minimum GDP per capita is 556,67 USD and it corresponds to Benin. The average share of GFCF in construction in GDP for Group 1 ($Istruct/GDP_{2017}$) is 0.162, with a standard deviation of 0.098, with a minimum of 0.021 corresponding to Zambia, and a maximum of 0.627, which corresponds

Table 5. GNI per capita (2022) and GDP per capita in selected years for Group 1 (sources: World Bank, 2024, PWT-version 10.1)

Country	GNI p.c. (curr. USD) in 2022	WDI status	GDP p.c. (constant 2017 national prices, in USD)							
			1990	2000	2010	2015	2016	2017	2018	2019
Angola	1,880	LMIC	3,231.90	2,642.19	4,309.56	4,502.27	4240.42	4,095.81	3,884.38	3,703.93
Benin	1,400	LMIC	556.67	658.71	718.91	1,099.80	1,105.58	1,136.59	1,180.00	1,277.23
Cape Verde	3,950	LMIC	1,400.46	2,128.30	3,073.08	3,106.11	3,213.07	3,292.64	3,402.15	3,554.65
Comoros	1,610	LMIC	1,368.62	1,258.93	1,107.78	1,276.96	1,282.49	1,323.81	1,344.30	1,356.68
Congo Republic	2,290	LMIC	2,463.35	2,138.42	2,629.85	2,647.55	2,318.13	2,154.63	1,969.45	1,902.29
Eswatini	3,750	LMIC	2,473.67	2,634.18	3,521.92	3,925.22	3,939.48	3,980.64	4,033.07	4,037.18
Gabon	7,530	UMIC	9,168.95	8,221.67	6,943.33	7,471.30	7,398.87	7,230.39	7,131.68	7,210.61
Ghana	2,380	LMIC	906.02	1,061.92	1,435.36	1,796.11	1,816.75	1,921.56	1,997.62	2,081.53
Mauritania	2,080	LMIC	1,381.10	1,355.57	1,481.82	1,593.73	1,568.38	1,578.11	1,567.31	1,615.36
Nigeria	2,160	LMIC	1,235.08	1,128.00	1,868.87	2,090.16	2,002.45	1,966.80	1,953.54	1,945.84
Sao Tome and Principe	2,400	LMIC	1,214.28	1,182.27	1,152.83	1,754.94	1,793.89	1,828.19	1,846.91	1785.42
Seychelles	12,010	UMIC	8,297.82	11,067.16	12,049.33	14,707.25	15,260.68	15,811.53	16,290.46	16,945.27
South Africa	6,780	UMIC	4,995.74	4,896.64	6,043.95	6,232.13	6,165.58	6,164.81	6,129.18	6,058.26
Zambia	1,240	LMIC	983.49	876.81	1,376.55	1,516.61	1,526.99	1,534.87	1,550.96	1,528.44

Table 6. GNP per capita (2022) and GDP per capita in selected years for Group 2 (source: World Bank, 2024, PWT-version 10.1.)

Country	GNI p.c. curr. USD (2022)	WDI status	GDP p.c. (constant 2017 national prices, in USD)							
			1990	2000	2010	2015	2016	2017	2018	2019
Botswana	7,430	UMIC	4,209.21	5,309.30	6,556.11	7,757.22	7,944.19	8,007.49	8,184.31	8,245.52
Cameroon	1,640	LMIC	1,206.49	1,084.09	1,215.92	1,363.21	1,389.12	1,400.98	1,420.30	1,437.43
Côte d'Ivoire	2,620	LMIC	1,392.81	1,294.25	1,221.64	1,930.25	2,017.04	2,111.03	2,199.62	2,227.88
Equatorial Guinea	5,240	UMIC	1,252.94	5,677.08	14,895.52	12,142.76	10,647.50	9,671.40	8,731.65	7,959.80
Guinea	1,190	LMIC	527.72	612.51	662.02	738.79	797.43	855.58	883.24	907.01
Kenya	2,170	LMIC	1,246.59	1,108.58	1,293.92	1,486.28	1,536.02	1,572.35	1,633.58	1,682.56
Lesotho	1,230	LMIC	486.81	607.40	938.96	1,126.10	1,173.81	1,149.15	1,134.84	1,142.86
Mauritius	10,360	UMIC	3,950.89	5,830.12	8,240.38	9,766.24	10,121.70	10,485.85	10,857.06	11,220.59
Namibia	5,160	UMIC	3,086.05	3,531.86	4,687.33	5,530.61	5,414.19	5,300.10	5,237.56	5,082.20
Senegal	1,620	LMIC	993.35	1,032.03	1,191.41	1,260.78	1,303.96	1,361.70	1,408.61	1,441.90
Tanzania	1,200	LMIC	491.66	552.90	789.29	933.03	967.71	1,002.82	1,041.03	1,081.16
Zimbabwe	1,240	LMIC	988.33	912.14	1,162.16	1,512.36	1,500.37	1,548.19	1,600.23	1,449.86

to Angola. The average value of GDP per capita for Group 2 is 2,890.24 USD, with a standard deviation of 3,361.06 USD, a maximum of 17,690.52 USD corresponding to Equatorial Guinea and a minimum of 486.81 USD, which corresponds to Guinea. For Group 2, the average share of construction investment in GDP is 0.112, with a standard deviation of 0.063, a maximum of 0.352, corresponding to Equatorial Guinea, and a minimum of 0.007, which corresponds to Zimbabwe. Tables 7 and 8 also show that, with respect to the average GDP per capita, Group 1 and Group 2 present similar statistics. In contrast, the average share of construction investment in GDP is very different between groups. The similarity in the average GDP per capita in the two groups was not unexpected, since there is a preponderance of LMICs in both groups. This also suggests that GDP per capita is not a determining factor in explaining construction investment behaviour (measured as a proportion of GDP) in the middle-income countries of SSA.

A statistical test for the equality of the two correlations was used to assess whether the relationships between the share of GFCF of construction in GDP and GDP per capita are different in the two groups of countries, in the period 1990–2019. In this analysis, the hypothesis $H_0 : \rho_1 = \rho_2$ was tested against the alternative hypothesis $H_1 : \rho_1 \angle \rho_2$ at an α = 0.05 significance level. The groups corresponding to these correlation coefficients (Groups 1 and 2) were defined above. The variables used in this model are $Istruct/GDP_{2017}$ (the share of GFCF of construction in GDP at constant 2017 prices) and $GDPpc_{2017}$ (GDP per capita at constant 2017 prices, measured in USD).

The sample correlations R_{1j} and R_{2j} are based on n_{1j} and n_{2j} observations (time series data for the period 2000–2018) for, respectively, Group 1 and Group 2. As referred to, n_1 is 14, n_2 is 12, and n_{1j} and n_{2j} are 30 (time series data for the period 1990–2019).

Table 7. Descriptive statistics for Group 1 (source: authors' calculations based on PWT-version 10.1)

Variable	Name	Average	S. dev.	Max.	Min.	Nº obs.
Gross domestic product per capita (constant 2017 national prices, USD)	$GDPpc_{2017}$	3,234.34	3,101.03	16,945.28	556.67	420
Share of GFCF in construction in GDP (constant 2017 national prices)	$Istruct/GDP_{2017}$	0.162	0.098	0.627	0.021	420

Table 8. Descriptive statistics for Group 2 (source: authors' calculations based on PWT-version 10.1)

Variable	Name	Average	S. dev.	Max.	Min.	Nº obs.
Gross domestic product per capita (constant 2017 national prices, USD)	$GDPpc_{2017}$	2,890.25	3,361.06	17,690.52	486.81	360
Share of GFCF in construction in GDP (constant 2017 national prices)	$Istruct/GDP_{2017}$	0.112	0.063	0.352	0.007	360

Thus, for Group 1:

$$W_{1j} = \frac{1}{2}\ \ln \frac{1+R_{1j}}{1-R_{1j}}, \qquad W_1 = \frac{1}{n_1}\sum_{j=1}^{n_1} W_{1j}$$

- Angola: R_{1_1} = –0.6239987
- Benin: R_{1_2} = 0.808669692
- Cape Verde: R_{1_3} = 0.354805464
- Congo Republic: R_{1_4} = 0.498714976
- Comoros: R_{1_5} = = 0.346909952
- Eswatini: R_{1_6} = –0.920987102
- Gabon: R_{1_7} = –0.4802282
- Ghana: R_{1_8} = –0.14598334
- Mauritania: R_{1_9} = –0.12217084
- Nigeria: $R_{1_{10}}$ = –0.856798787
- Sao Tome & Principe: $R_{1_{11}}$ = –0.618107606
- Seychelles: $R_{1_{12}}$ = –0.675529956
- South Africa: $R_{1_{13}}$ = 0.706928456
- Zambia: $R_{1_{14}}$ = 0.963957562

W_1 = –0,16504058

For Group 2:

$$W_{2j} = \frac{1}{2}\ln \frac{1+R_{2j}}{1-R_{2j}}, \qquad W_2 = \frac{1}{n_2}\sum_{j=1}^{n_2} W_{2j}$$

- Botswana: R_{2_1} = 0.833536661
- Cameroon: R_{2_2} = 0.813759312
- Côte d'Ivoire: R_{2_3} = 0.830655191
- Equatorial Guinea: R_{2_4} = 0.660871944
- Guinea: R_{2_5} = 0.722502127
- Kenya: R_{2_6} = –0.892478805
- Lesotho: R_{2_7} –0.376260453
- Mauritius: R_{2_8} = –0.367871062
- Namibia: R_{2_9} = 0.63905777
- Senegal: $R_{2_{10}}$ = 0.936356283
- Tanzania: $R_{2_{11}}$ = 0.90176
- Zimbabwe: $R_{2_{12}}$ = –0.0722847

W_2 = 0.81340177

under $H_0 : \rho_1 = \rho_2$, the null hypothesis, $Z = \frac{W_1 - W_2}{\sqrt{v}} \dot{\sim} N(0,1)$

and at an α = 0.05 significance level,

$$Z = \frac{-0{,}165040588 - 0{,}813401772}{0.07570946} = -12.9236 \angle -1.645.$$

Therefore, the null hypothesis H_0 was rejected in favour of the alternative hypothesis H_1.

Some robustness check was undertaken by changing the reference year (to 1995, the year from which SSA, in general, started a process of sustained economic growth) and by excluding Lesotho (Group 2) from the analysis. Lesotho's net capital-output ratio is 3.8 in the period 1985–1994 (average for the period), almost reaching the threshold of 4 taken for the analysis. In both scenarios, the null hypothesis was rejected.

The evolution of the construction industry (measured as a share of GFCF in construction in GDP), illustrated in Figures 1 and 2, is in line with the results of the above statistical test that shows that the pattern of the construction industry in the two groups presents distinct developments from the period between 1990 and 2019. Figure 1 indicates that in the countries in which the capital-output ratio was equal or greater than four in the period 1985–1994 (Group 1), the share of GFCF in construction in GDP (both indicators measured at constant 2017 prices) remained, for the group average, practically constant during the period 1990–2019 (about 15% of GDP). The share of construction investment in GDP increased from 14.9% in 1990 to 20.4% in 1994, which corresponds to the period of deceleration growth rate of GDP. It then fell to 15.1% in 2000, and remained practically stable up to 2017. However, a slight trend

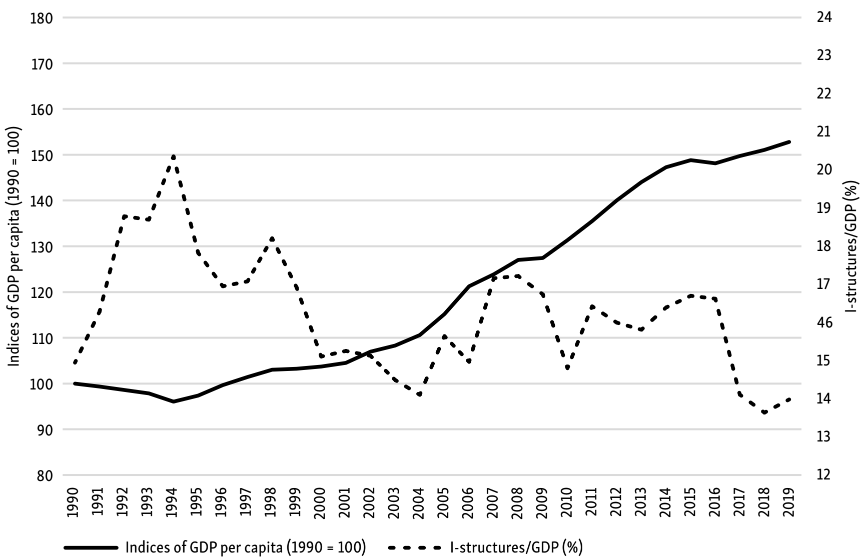

Figure 1. Share of Structures Investment in GDP and Indices of GDP per capita (1990 = 100) for Group 1 (constant 2017 prices)

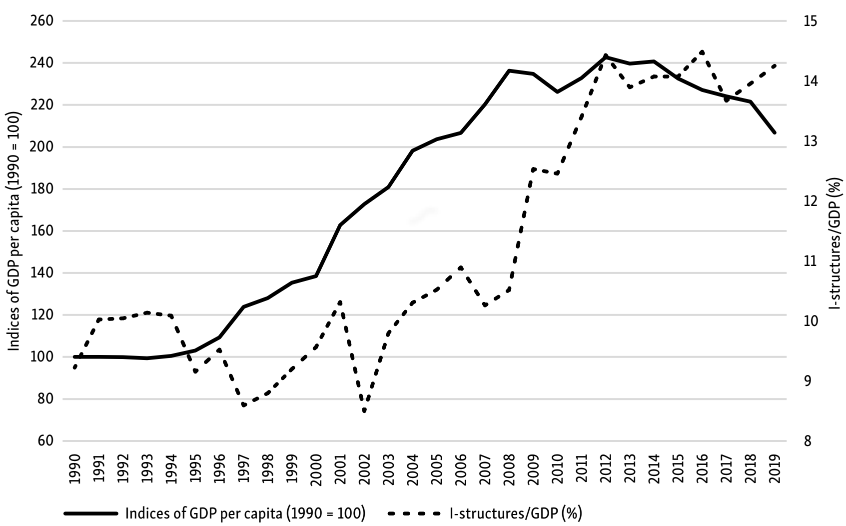

Figure 2. Share of Structures Investment in GDP and Indices of GDP per capita (1990 = 100) for Group 2 (constant 2017 prices)

of decline is observed in the late years of the period, falling to about 14% in the period 2017–2019. The construction volume increased, in general, absolutely but not relatively. This pattern also holds, generally, for individual countries, disregarding annual fluctuations that characterise the output of the construction industry activity.

The other side of the picture shows that in the group of countries in which capital-output ratio was less than four in the period 1985–1994 (Group 2), the share of GFCF in construction increased remarkably during the period of analysis. Construction investment increased continuously from 9.2% of GDP in 1990 to 14.3% of GDP in 2019, reaching practically the same level of that of Group 1 at the end of the period of analysis. Construction volume, in Group 2, increased relatively, not only absolutely, accompanying the evolution of the general economy.

These results follow the findings of previous works (Lopes et al., 2002; Ruddock & Lopes, 2006) that posit that there is a minimum required level of construction investment (the share of GVA in construction in GDP of around 5%) for efficient functioning of the construction industry. It is worth noting that the 5% value is consistent with Syrquin and Chenery's (1989) value pertaining to the construction sector, in their study of norms for structural change and per capita income. The singularity in this analysis compared to that of Lopes et al. (2002) is that the grouping of countries here is based on the level of capital stock rather than the stage of the country's growth process (increasing versus decreasing growth).

The results of this study do not corroborate the inverted U-shaped pattern proposed by Bon (1992) or Girardi and Mura (2014). Our findings suggest that the "plateau" in construction activity, referred to in Girardi and Mura (2014), begins in the middle-income range, before countries reach an advanced stage of industrialization. Additionally, the results contradict previous studies (Anaman & Osei-Amponsah, 2007; Aali-Bujari & Venegas-Martínez, 2021) that found a causal relationship between increased construction spending and GDP growth. On the contrary, this study aligns with research suggesting the construction industry is not a driver of GDP growth, but rather a follower of fluctuations in the macroeconomy (Yiu et al., 2004; Ogunbiyi et al., 2017).

The results presented here suggest that the level of NCS in structures has a determining effect on the pattern of development of the construction industry. Figures 3 and 4 present the evolution of NCS in structures (group averages for the periods 1990–1999, 2000–2009, and 2010–2019) and the indices of NCS in structures intensity for, respectively, Group 1 and Group 2. Figure 3 shows that the NCS in structures to GDP ratio for Group 1 decreased from 5.18 in the period 1990–1999 to 4.04 in 2000–2009, and to 3.76 in the period 2010–2019. That is, construction investment as a proportion of GDP has decreased throughout the analysis period, as illustrated in Figure 1. However, the NCS in structures intensity (NCS divided by the number of inhabitants) increased throughout the same period, rising by 19.7% at the end of the period, compared to 1990. As the intensity of NCS in structures can also be calculated by multiplying the NCS in structures to GDP ratio by GDP per capita, an increase in the latter indicator, in a specific period, may correspond to an increase in the intensity of NCS in structures even with a value of NCS in structures to GDP ratio lower than that of the preceding period. Figure 4 shows that the NCS in structures to GDP ratio for Group 2, remained practically unchanged throughout the period 1990–2019. This ratio increased slightly from 2.23 in the 1990–1999 period to 2.31 in 2000–2009 and increased slightly again to 2.41 in 2019.

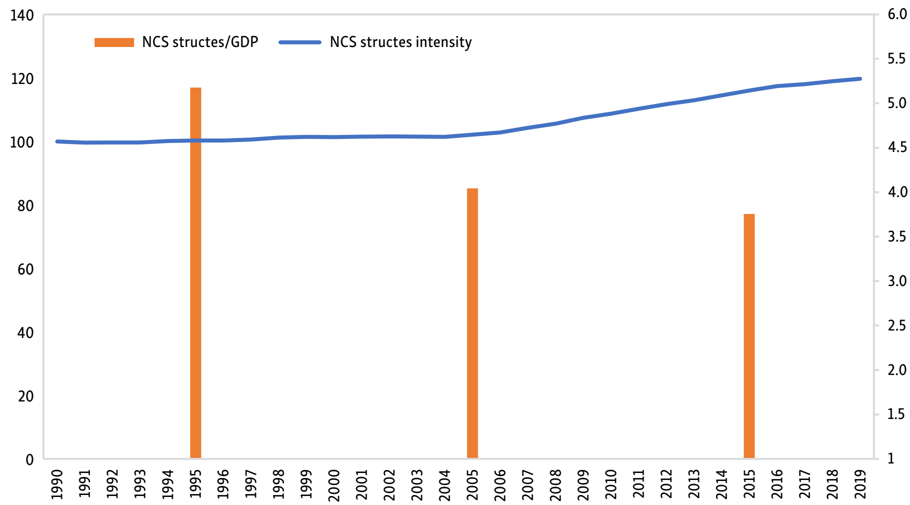

Figure 3. NCS in structures to GDP ratio and Indices of NCS in structures intensity (1990 =100) for Group 1 (constant 2017 USD PPP)

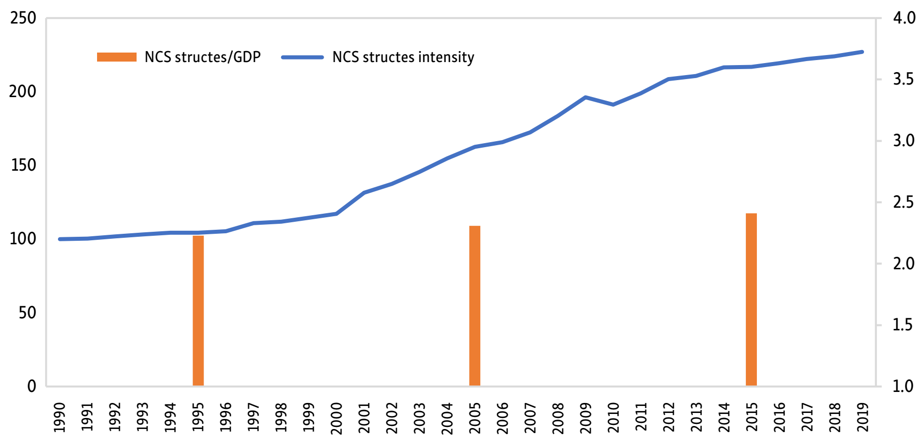

Figure 4. NCS in structures to GDP ratio and indices of NCS in structures intensity (1990 = 100) for Group 2 (constant 2017 USD PPP)

The striking increase in the intensity of NCS in structures in the 1990–2019 period (by 127% in 2019 compared to 1990) was due to an increase in GDP per capita in the same period (as can be observed in Figure 2) rather than an increase in the NCS in structures to GDP ratio.

Of course, the group average measures in these indicators do not fully capture the behaviour of individual countries. For example, for Mauritius (Group 2), one of the most economically advanced countries in SSA, the NCS in structures to GDP ratio increased from 2.36 in 1990 to 2.72 in 2019 and; NCS in structure intensity increased from 19,714.18 USD (constant 2017 PPP prices) to 64,816.68 USD, in the same period. For Lesotho (also in Group 2), NCS in structures to GDP ratio increased from 2.39 in 1990 to 3.83 in 2019 and; NCS in structures intensity increased from 3,073.32 USD in 1990 to 11,691.68 USD in 2019. For Seychelles

(Group 1), the NCS in structures to GDP ratio decreased from 5.62 in 1990 to 5.52 in 2109 and; NCS in structures intensity increased from 68,696.66 USD to a strikingly high value of 137,800.92 USD in 2019. For Angola (Group 1), the NCS in structures to GDP ratio decreased from 10.74 in 1990 to 5.42 in 2019 and; NCS in structures intensity, on the contrary, also decreased in the same period- from 45,087.22 USD in 1990 to 37,083.74 USD in 2019. As these values, expressed at constant PPP prices, are national accounts-based, they are more comparable between countries, and over time. A note of caution is needed. As pointed out by Feenstra et al. (2015), the price levels of products and services are more comparable between countries of the same region, and with similar levels of economic development than between countries of different regions, or with different status of economic development. However, each country has its specificities. For example, the price levels of construction products are more comparable between South Africa and Namibia- they are part of the same Southern African subregion and belong to the same economic community – than, say, between South Africa and Cape Verde.

The construction industry, in every country, faces a number of challenges, one of which is how it can contribute to the global agenda of the Sustainable Development Goals (SDGs). Of particular interest to the construction industry are SDG 6 – "Ensure the availability and sustainable management of water and sanitation for all", SDG 7.1 – "Ensure access to affordable, reliable, sustainable and modern energy for all", and SDG 13 – "Take urgent action to combat climate change and its impacts". As Ofori (2023) pointed out, the construction industry is related to most of the SDGs, and an adequate level of construction investment is needed to achieve the SDGs related to infrastructure (Global Infrastructure Hub, 2018). However, sustainability is a multi-dimensional concept – it encompasses environmental, economic, and social aspects. Sustainability, in a sense, is a set of protection goals that concern different types of capital. These capitals must be maintained for future generations (Hassler & Kohler, 2014). However, most of the research on the sustainability of the construction sector has focused on the environmental aspects of sustainability. Economic sustainability can be seen from the perspective of integration between economic development and environmental balance (Oliveira et al., 2019). This concept of economic sustainability is very relevant for countries in the development process. As noted by Calderón et al. (2015), referring to the construction infrastructure segment of the construction industry, research has paid much less attention to the costs of infrastructure development than those devoted to quantifying the output impact of infrastructure. Government financial constraints are typical in low- and lower-middle income countries, which need to balance investment in infrastructure and other construction products (such as housing) with investment in other sectors of the economy, such as health and education (Lopes & Tavares, 2024). It appears that for developing countries that have already achieved an adequate level of built capital stock for efficient functioning of the economy, as well as to achieve infrastructure-linked SDGs targets, the minimum level of construction investment that accompanies the development of the general economy is both more economically sustainable and environmentally sustainable than the general pattern of construction investment that exceeds that minimum level. Botswana and Mauritius are two of the most economically advanced countries in SSA (Tables 5 and 6). The results of this study show that the average proportion of construction investment in GDP in the period

1990–2019 was 15.6% and 13.7% for, respectively, Botswana and Mauritius. These values are approximately two-thirds of the 22%-23% band that characterises the development pattern of the world's GFCF (as percentage of GDP) over the long period 1970–2022. And construction investment contributes, on average, about two-thirds to the GFCF mix for the countries analysed in this study. The results presented here may provide fertile ground for further research in the modelling of the construction industry.

6. Conclusions

This paper presents an analysis of the relationship between construction investment and economic growth in middle-income countries in sub-Saharan Africa. Two groups of countries were chosen for the analysis. One (Group 1) in which the NCS-output ratio was equal to or greater than 4. Another (Group 2) in which the NCS-output ratio was lower than 4. The singularity in this analysis compared to those of previous research is that the grouping of countries here is based on the level of the capital stock rather than the stage of the countries' growth process (increasing versus decreasing) or the status of the country's economic development. Another relevant aspect in this study is that data on construction investment and other measures of the national economy were drawn from PWT, which are more suitable for comparative analyses between countries.

The study results show that, for Group 1, the share of GFCF in construction in GDP (both indicators measured at constant 2017 prices) remained practically unchanged for the group average throughout the period 1990–2019 (about 15% of GDP). However, a slight trend of decline is observed in the late years of the period. The construction volume increased in general, absolutely but not relatively. For Group 2, the share of GFCF in construction increased significantly during the analysis period. Construction investment continuously increased from 9.2% of GDP in 1990 to 14.3% of GDP in 2019, reaching practically the same level as that for Group 1 at the end of the analysis period. The volume of construction in Group 2 increased relatively, not only absolutely, accompanying the evolution of the general economy.

The study has also presented an overview on the evolution of GDP and construction industry-related indicators for SSA, Nigeria, and South Africa, in the period 1970–2022. The results show that there was an absolute increase in GVA in construction in the period 1970–2022, for the SSA as a whole and for these two countries. And there was a relative increase in GVA in construction for SSA and Nigeria and a relative decline in GVA in construction for South Africa in the same period.

The findings of the panel data suggest that the development patterns of the construction industry in middle-income economies in SSA follow rather than lead economic growth. These findings lend credibility to the proposition that as developing countries reach an advanced stage of economic development, construction output tends to decrease relatively, but not absolutely. The results of the study could have policy implications for the economic sustainability of the construction industry in SSA. The size of the construction sector is not just a function of per capita output, but is also related to broader socioeconomic trends, namely urbanisation, industrialisation, and creation of basic infrastructure. The level of capital stock in the structures captures some dimensions of these development dynamics. National governments in these countries should use the level of intensity of NCS to establish public policies in the construction sector, with the aim of maintaining the sustainability of this sector in all its dimensions.

This research has limitations. The results for construction investment and NCS in structures are provided here in an aggregate manner. Unfortunately, PWT does not provide construction data disaggregated in different segments of the industry. Knowledge of capital stock statistics concerning the construction infrastructure segment, more of the remit of national governments, would be more useful for setting up public policy.

Some suggestions for further development are put forward: to use the level of net capital stock in structures as a variable in the study of the construction investment-economic growth nexus; to expand the sample of the study by including the middle-income countries of other regions of the world. This approach would undoubtedly shed more light on our understanding of the effect of the level of built capital stock on the development of the construction industry.

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