Contribution of Agricultural Productivity to Industrialization in Africa. Does Infrastructural Development Matter?

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Research Article

Abstract

Purpose: *The objective of this study is to investigate the direct and indirect effects of agricultural productivity on industrialization. It also looks for the mediating role of infrastructural development on the effects of agricultural productivity on industrialization.*
Method: *The* system *Generalized Method of Moments (*GMM) *methodology for 45 African countries is applied. It covers the period from 2005 to 2022.*
Results: *The results show that agricultural productivity has a positive significant role on industrialization in Africa. This result is robust when industrialization is measured by employment in industry (EMIND). Infrastructural development has an enhancing role on the agricultural productivity-industrialization nexus. These results are robust for the two different measures of industrialization but are more enhancing on Employment in Industry than on Manufacturing Value Added (MVA). The study also observes that agricultural productivity interacts with the Water and Sanitation Index (WSS) on MVA to yield a positive net effect. Moreover, agricultural productivity interacts with ICT (Information and Communication Technology) and ECI (Electricity composite index) on both MVA and EMIND to yield positive synergy effects.*
Implications: *The Electricity Composite Index is still not sufficient in Africa. Equally, there is a need for some countries like Chad, Ethiopia, Mozambique, and Niger to boost WSS above this threshold of 32.96 since this threshold is below the mean value for Africa as a whole. Policy-wise, it could be recommended that both agricultural productivity and infrastructural development should be strengthened, with emphasis on electricity, so as to achieve the much-needed level of industrialization for Africa.*

Keywords: Industrialization, Agricultural productivity, Infrastructures, System GMM, Africa.

1. Introduction

Based on the plan by the United Nations Congress in 2000 that gave birth to the Millennium Declaration of 2001 and has continued since 2015 as the sustainable development goals, one of the main aims of these goals is to end poverty and hunger through sustainable economic growth. Notably, due to the heavy reliance of the continent's population on agriculture (World Bank Group, 2015; Kadzere et al., 2016; Suri & Udry, 2022) sustainable economic growth in Africa cannot be discussed without mentioning agricultural productivity (Djoumessi et al., 2020; de Janvry & Sadoulet 2010; Gajigo & Lukoma, 2011). To shed further

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light, more than 80% of the poor in Africa resided in rural regions in 2018 (World Bank, 2020), and about two-thirds of the world's poor reside in sub-Saharan Africa. For this population, smallholder agriculture is the primary economic activity. Because of this, global development policy has long been concerned with the productivity of African small farmholders (Suri & Udry, 2022). The Maputo Declaration on Agriculture and Food Security in Africa, which was adopted in 2003, was a pledge made by African heads of state to enhance funding for agricultural productivity and rural development. Their dedication was mirrored in the UN Millennium Project's 2005 report, which urged a "doubling or more of agricultural productivity" in Africa as a means of lowering hunger and poverty. This goal is still present in the Sustainable Development Goals from 2015; SDGs 1 and 2 explicitly call on the world community to double the agricultural productivity and incomes of small-scale food producers by 2030.

According to Hughes (1984) and Griffin (1989), industrialization is a process of structural transformation that entails switching from a primary production structure (the production of primary goods) to an industrial production structure. Early in the 1980s, certain developing nations were able to integrate into a fiercely competitive international market thanks to aid from northern nations that encouraged the development of industries in such nations. It was in this context that some African nations, such as Kenya and Ivory Coast, recorded substantial shares of manufactured goods in overall exports, at 60.8% and 33.6%, respectively, between 1973 and 1981.

Unfortunately, with some notable exceptions, African attempts at industrialization failed (Griffin, 1989). According to the author, this failure may have endogenous or external origins. He emphasizes that excessive government engagement in national economies, poorly planned investment initiatives, and overprotection of emerging industries were the major endogenous causes of this failure. In terms of exogenous sources, the study highlights the decline in export revenues (for instance, in the agricultural sector) and the stagnation of production brought on by an unfavorable environment.

Productivity, at its most fundamental level, relates to output per unit of manufacturing inputs. Productivity growth is linked to increased production efficiency; a rise in output occurs without necessarily corresponding increases in labor, human capital, natural resources, or physical capital. Productivity growth is necessary for long-term economic expansion (Kim & Loayza, 2019). Without sustained agricultural productivity, a continent like Africa cannot really advance in the manufacturing sector or industrialization (Djoumessi et al., 2020). According to the Australian Government's Department of Agriculture, Fisheries and Forestry (2020), agricultural productivity is the effectiveness with which farmers use inputs (such as labor, land, capital, materials, and services) to produce outputs (such as crops, livestock, and wool). It is a region-specific measure since a variety of factors (including climate, land, soil quality, machinery, manpower, capital, and know-how) affect a given country or region's overall productivity. Agriculture productivity is a critical factor to consider when discussing Africa's economic development and accomplishing its development goals, such as reducing poverty and hunger (Djoumessi et al., 2020). In sub-Saharan Africa (SSA), 60% of the active population work in the agricultural sector. Agriculture employs 50% or more of the workforce in Africa, except some Gulf of Guinea oil-producing nations, South Africa, Nigeria, Cameroon, and Ivory Coast (World Bank Group, 2015).

The FAO forecasts, which were released in 2022[1], place the number of rural Africans at 728 million in 2018 and 740 million in 2019, which are both significantly lower estimates than the actual numbers. About 70% of the people in East Africa work in the agricultural sector, and for Africa as a whole, about 48% of the entire population. African agriculture in the past 30 years has been unique from the rest of the world in terms of its capacity to absorb a sizable portion of the workforce and its contribution to the reduction of

[1] **https://www.fao.org/faostat/en/#data/OA**

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malnutrition (Djoumbessi, 2022). This in turn demonstrates the significant impact that agricultural productivity has on the various components of economic development in Africa. Following political and institutional reforms in the 1990s, some studies (Alene, 2010; Nin-pratt et al., 2008; Fuglie & Rada, 2012) have shown that African agricultural performance has improved because of these reforms. Other studies (Coomes et al., 2019; Villoria, 2019) have attributed this improved performance to the diffusion of sustainable programs, technological advancements, and investments in agricultural research. However, some other studies (Nin-pratt & Yu, 2012; Coelli & Rao, 2005) have indicated that agricultural productivity is really declining in Africa. This continuous fluctuation in agricultural productivity poses a problem in Africa as economic development and industrialization will equally fluctuate instead of following a specific trend.

The above controversy persists as Western European and Asian countries prove to have a different experience from Africa. In the case of China for example, the country's industrialization and growth were not agriculture-dependent but rather came as a result of the country's liberalization policies (Koo and Lou, 1997). The situation in Africa is different because concentrating only on "modern economic drivers" will not result in industrialization and sustained economic progress. Kadzere et al. (2016) note that it is only when the continent can feed itself and export food for a population that is constantly growing around the world will its full economic potential be realized. The recent trend and changes in Zimbabwe, which can be utilized to emphasize the significance of agriculture, revealed this. If one were to closely examine the situation in Zimbabwe from the perspectives of agricultural and economic development, one would come to the conclusion that when the nation's agriculture performed well, the economy grew, and when agriculture failed, the economy also suffered. The critical significance of agriculture in economic growth and the subsequent industrialization of Africa would be better understood if Zimbabwe's agricultural development and economic growth circumstances were generalized across the continent. Dethier and Effenberger (2012) observed and recommended that policymakers should establish favorable settings in their nations for this to occur because agriculture is essential for economic development and industrialization in Africa.

In addition, Johnston and Mellor (1961) concluded that rapid agricultural growth is the key to long-term development (together with its many components). However, this is not the result of agriculture as concerns the increase in food production, saving rates, the demand for manufactured goods, or foreign exchange (via higher exports). Rather, it is the result of rapid agricultural growth and its reduction in the prices of non-tradable services, the emergence of new revenue streams, and the sustainability of economic transformation. It equally, hangs on the transfer of labor from the agricultural sector to the industrial sector. The above presents the important role played by agricultural productivity in fostering industrialization in Africa, and the need for more investments in the sector to secure continuous growth and industrialization in the region.

When it comes to industrialization and economic growth, infrastructure development is crucial, and growth, particularly in the manufacturing sector, is impossible without it. However, without funding for these infrastructures, there will be no infrastructural development. Therefore, financing infrastructure projects in Africa is crucial. As a result, the World Bank (2010) emphasizes the significance of investments in key economic sectors, such as real estate, electricity, water networks, gas, transportation, and an appropriate telecommunications system which have the potential to improve quality of life, create adequate employment opportunities, and reasonably impact the educational system, while bridging the gap between rural and urban living conditions. It is important to note that all of the above-mentioned investment areas pertain to the various infrastructural components of a country's infrastructural system.

The infrastructural deficit in Africa is one of the main obstacles stopping the continent from realizing its full potential for economic growth, industrialization, and attaining its sustainable development goals, including poverty reduction. This is demonstrated by the fact that the majority of the rural population,

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which makes up 60% of the continent's population, typically lack access to modern infrastructure services for transportation, electricity distribution, communication, and sanitation, according to ('Union Africaine,' 2009; Nchofoung et al., 2022). In a similar spirit, Kuete and Asongu (2021) affirm that a lack of infrastructure is a significant obstacle to industrialization because industries can only thrive in a country with a sound infrastructure. The deficiency of productive infrastructure in sub-Saharan Africa in the areas of transport and telecommunications (African Development Bank, 2018), water and energy services (World Bank, 2017), and other services, is one of the main factors impeding industrialization. Closing this deficit would enable businesses to thrive in industries where they have significant competitive advantages (African Development Bank, 2018). It would also enable Africa to address its key socio-political and economic issues and become a significant contributor to global demand. As a result, infrastructure development can accelerate Africa's industrialization (Sané, 2017). In view of its importance, infrastructural development could present itself as a mediator between agricultural productivity in Africa and the structural transformation of its economies via industrialization.

Existing literature has examined the theoretical and literary aspects of the relationship between industrialization and agricultural productivity in the African environment, but there is a scarcity of research on empirical data. This study aims to close this information gap. Examining the link between agricultural productivity and industrialization is fundamental to achieving the Sustainable Development Goals (SDG1 and SDG2) with regards to solving poverty and hunger issues which hinder considerable economic performance and SDG9 on sustainable industrialization. Therefore, the objectives of this paper are to examine the effect of agricultural productivity on industrialization in Africa and how infrastructural development modulates this relationship.

This study makes several contributions. First, previous studies on the topic (Kadzere et al., 2016; Grabowski, 2013) tended to be literature and theory-based, with a direct effect focus. This study, however, differs from those studies in that it brings in recent empirical evidence on the subject, and in addition, it adds a modulating role played by infrastructural development. This is particularly imperative given the importance of a well-developed infrastructural system for the needed industrial development. Second, policy thresholds for complementing policy orientations are offered for the element of the interactive variable.

The remainder of the essay is structured as follows. The literature review is included in section two. The information about the data and the approach is provided in Section 3. Section four presents the findings and their policy implications, and Section five concludes.

2. Literature Review

The first half of this section lays out the theoretical underpinnings of the connection between agricultural productivity and industrialization, while the second section refers to the empirical evidence between the two variables.

2.1. Relationship between agricultural productivity and industrialization: Theoretical Perspective

2.1.1. Maslow's hierarchy of human needs: adapting agriculture

Humans have a basic need for food. As a result, if a nation cannot feed its people, it will find it difficult to develop economically. After all, proper nutrition is essential for a person's healthy mental and physical growth, especially throughout their early years of development. It is for this reason that Dethier and Effenberger (2012) argue that growth in agricultural productivity must come before economic expansion. In a similar spirit, Binswanger et al. (1991), Johnson (1998), and Mellor (2001) contend that times of rapid agricultural growth are closely associated with a decline in rural poverty. Strong agricultural expansion, according to these authors, leads to a reduction in food prices, more chances for rural farmers to earn an

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income, and favorable cross-sectoral spillover effects like increased trade and productivity in other economic sectors.

2.1.2. The 3-sector model

In Grabowski (2013), a 3-sector model is presented and makes the observation that increasing agricultural productivity could help develop a potential comparative advantage in manufacturing through the expansion of non-tradable services and learning by doing brought about by the manufacturing sector. However, the government and ruling class of the majority of countries are hesitant to undertake the necessary reforms to spark such a development process. The state's need for revenue is the root of this hesitation. Agriculture in the unregulated sector is challenging to tax, whereas manufacturing is simpler. Accordingly, the incentive to change is boosted if the agricultural sector has a substantial technological backlog. Agricultural productivity will increase as a result of investments made to adapt technology to local conditions. This will lower the cost of non-tradable inputs and encourage the emergence of a competitive edge in manufacturing. In the same study, an initial model is adopted in which it is assumed that there is no international trade and the economy is closed. Economic growth is only possible in this circumstance if agricultural productivity increases. If it rises, eventually there will be more food available, which will lead to additional increases in agricultural production that will be used to buy manufactured goods. As the industrial sector expands, learning by doing becomes more prevalent, and structural change and productivity development follow (Eswaran and Kotwal, 2002).

A two-sector economy with non-homothetic needs was modeled by Matsuyama (1992), providing more compelling theoretical support. He demonstrated how, under the closed economy assumption, an increase in agricultural production results in a larger industrial sector. Due to the presence of technological advancement brought about by learning by doing, a larger industrial sector then results alongside a higher rate of economic growth. In addition, prominent development economists including Lewis (1955), Ranis and Fei (1961), and Rostow (1960) have emphasized a positive relationship between agricultural productivity and industrialization. These theoretical foundations act as this work's driving force.

2.2. Empirical Literature

In order to have a thorough understanding of all the study's variables and how the main independent variable (agricultural productivity) and the mediator (infrastructure development) affect the dependent variable (industrialization), this section will be further divided into two sub-sections.

2.2.1. Agricultural productivity development and industrialization

Kadzere et al. (2016) conducted a thorough theoretical literature review on how the development of agriculture is closely related to the development of the economy and industrialization, as well as how Africa can accept this reality and advance its industrialization and agricultural development. Based on historical backing, it has been shown that the development of agriculture comes before economic expansion and full-scale industrialization. The most industrialized countries in the world understand the critical part that agriculture plays in economic development and modernization, and as a result, they make wise investments. A great illustration of how agricultural progress is inextricably linked to economic success is South Africa's dualistic agriculture. It is worthy of note that the regions of the nation that have developed agricultural systems have thriving economies, while former homelands, where agriculture is underdeveloped face the complete opposite. The authors contend that if underperforming agriculture is developed, Africa's industrialization and economic growth will be boosted. A coordinated delivery and extension of research, and training is necessary to ease the development of agriculture throughout the continent. Countries that offer integrated agricultural services, like the United States of America with its Land-grant system, have

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thriving agro-based industries and agriculture, as well as strong economies. Therefore, if Africa is to industrialize, its nations should think about making investments in agricultural development as well as adopting and adapting integrated service delivery models that take into account the unique demands of each nation.

A favorable correlation between agricultural and economic growth was found in an econometric analysis of data from China between 1952 and 2007, in which Xuezhen et al. (2010) concluded that agriculture remained an essential engine for economic expansion. The authors did point out, however, that agriculture's contribution continued to grow even while its percentage of the Gross Domestic Product (GDP) had been steadily declining over time because of a growing manufacturing sector. The author came to the conclusion that agriculture generates jobs and interacts in a bi-directional way with the rest of the economy.

Irandoust (2022), in contrast to earlier studies, discovers a two-way relationship between agricultural productivity and industrialization (measured using manufacturing output). The investigation of the connection between agricultural output and manufacturing industry output was the study's main aim. In order to explain the variation in agricultural output, the empirical analysis used a co-integration and Johansen error correction specification on time series data for macroeconomic variables for the period 1982 to 2017. The Granger causality test results showed a bidirectional relationship between the output of the industrial and agricultural industries, which suggests backward and forward linkages at the input-output interface. This reciprocal relationship suggests that government spending on agriculture and manufacturing both increases manufacturing production. A rise in manufacturing output will inevitably result in an increase in agricultural productivity.

Gollin (2010) reviewed the theoretical justifications and empirical studies supporting the claim that increases in agricultural production result in economic growth in developing nations. He found that agricultural development is crucial for economic growth in nations with substantial populations living in local communities, and having no access to global markets. The significance of agriculture-led prosperity for nations, in general, will rely on the relative affordability and expense of importing food.

Using the Schumpeterian growth model, Chu et al. (2022) investigated the impact of agricultural technology on the endogenous take-off of an economy. It was shown that advancement in agricultural technology reallocates labor from agriculture to the industrial sector due to the subsistence requirement for agricultural consumption. Consequently, agricultural development increases the number of firms in the industrial sector, which influences innovation and initiates an endogenous change from stagnation to growth. The authors eventually discovered that without the shift of labor from farm to industry in the early 19th century, the US economy's expansion would have been delayed by about four decades. This analysis was determined after adapting the model to the US economy's data.

By highlighting the relevance of agricultural development in many theories of economic development and policy, Shifa (2015) explored the role of agricultural development in industrialization. The author points out that endogeneity issues make it difficult to empirically evaluate the effect of agricultural growth on manufacturing growth. However, random weather variations were used to instrument agricultural growth in order to overcome the identification difficulty. The instrumental variable estimations revealed that industrial growth is significantly and positively influenced by agricultural growth. In addition to the aforementioned research, other studies have examined the role of agriculture in economic development. One such study is Alston and Pardey (2014), which hypothesize that the slow expansion of the agricultural sector may be the cause of low incomes and slow economic growth in developing nations. A positive association between agricultural productivity and economic growth was also identified by Self and Grabowski (2007), Gollin (2010), and Diao et al. (2010), who concluded that a rise in agricultural production is a requirement for economic expansion.

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2.2.2. Infrastructural development and industrialization

Empirically, the relationship between infrastructure and industrialization has been established in several studies. Abri and Mohamoudzadeh (2005) discovered a positive correlation between information and communication technologies and industrial productivity. According to the research of Steenkamp and Rooney (2017) and Anyanwu (2017), ICT infrastructure positively and significantly impacts industrial production in the various regions where they conducted their investigations. Njangang and Nounamo (2020) investigated the impact of information and communication technology on the industrialization of 46 African nations between 2000 and 2015. Internet and mobile phone penetration were employed as two measures of information and communication technologies, and employment in the industrial sector and added manufacturing value were utilized as two indicators of industrialization. The findings demonstrate that ICTs have a favorable and considerable impact on the industrialization of African nations using Generalised Moments (GMM) methods.

Hulten and Isaksson (2007) regressed total factor productivity levels on power generation capacity for 112 nations from 1970 to 2000 in relation to energy infrastructure and transportation. Following the World Bank's classification, countries were divided into five groups based on their respective income levels. The findings showed that total factor productivity was positively and strongly correlated with energy infrastructure. The overall conclusion points to infrastructure investment as a means of achieving the required level of industrialization in developing nations. However, Abokyi et al. (2018) concluded that Ghana's manufacturing production is negatively impacted by energy usage. To defend their findings, they state that despite possible improvements in Ghana's electricity supply, the industrial sector's average electricity consumption has progressively declined.

The work of Azolibe and Okonkwo (2020), in contrast to other writers, stands out since it incorporates the infrastructure development index (energy, roads, transport, and information and communication technologies) into its analysis. The authors examined the effects of infrastructure growth on industrialization in sub-Saharan Africa between 2003 and 2018. The study's findings suggest that the quantity and quality of telecommunications infrastructure are the primary factors impacting the productivity of the industrial sector in sub-Saharan Africa. The analysis demonstrates that the underutilization of water supply and sanitation infrastructure, as well as the poor quality of their electricity and transportation infrastructure, are the main causes of the relatively low level of productivity of the industrial sector in sub-Saharan Africa.

The impact of infrastructure development on industrialization in Africa was verified by Nkemgha et al. (2023), who equally used an infrastructure index. The system GMM technique was used to investigate these goals, and data were collected from 33 African nations between 2003 and 2019. Industrial value-added per capita and manufacturing value-added were used to gauge industrialization. The analysis' findings demonstrated that infrastructural development had a favorable impact on African industrialization.

Overall, although the central role of agricultural productivity in enhancing industrialization has been recognized in the literature, some findings suggest that agricultural productivity has a negative impact on industrialization. Due to regional differences and the times associated with industrialization, this study will be acting on this basis to examine this relationship while considering infrastructural development as a mediating variable.

3. Methodology

3.1. Model design

Inspired by the work of Nchofoung and Simplice (2021), the following empirical model is specified in Equation (1) as follows:

$$\mathrm{INDUS}_{it} = \beta_0 + \beta_1 \mathrm{LAPROD}_{it} + \beta_j X_{it} + \upsilon_i + \gamma_t + \varepsilon_{it} \qquad (1)$$

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Where INDUS being the dependent variable is a vector for industrialization captured by Manufacturing Value Added (LMVA) and Employment in Industry (EMIND), LAPROD is the log of Agricultural productivity (GDP in Agriculture divided by employment in agriculture), Xit is a vector of control variables for the different countries **i** and years **t** (2005 to 2022). $\boldsymbol{\upsilon_i}$ and $\boldsymbol{\gamma_t}$ represent the country-specific and time-fixed effects respectively.

Dependent variable
The dependent variable is industrialization measured here by Manufacturing Value Added (MVA) and Employment in Industry (EMIND) as could be seen in Nkemgha et al. (2023) and Irandoust (2022).
Equation (1) above could be written as:

$$\mathrm{LMVA}_{it} = \beta_0 + \beta_1 \mathrm{LAPROD}_{it} + \beta_j X_{it} + \upsilon_i + \gamma_t + \varepsilon_{it} \quad (1a)$$

$$\mathrm{EMIND}_{it} = \beta_0 + \beta_1 \mathrm{LAPROD}_{it} + \beta_j X_{it} + \upsilon_i + \gamma_t + \varepsilon_{it} \quad (1b)$$

Independent variable of interest
The independent variable of interest is Agricultural productivity (LAPROD). In the first place, agricultural productivity was arrived at by dividing GDP in Agriculture by employment in agriculture for the different countries. Making use of LAPROD on industrialization is backed empirically by Chu et al. (2022), Shifa (2015), Gollin (2010), and Diao et al. (2010). From the previous studies, the hypothesis of the study can be stated thus: Agricultural productivity positively and significantly impacts Industrialization in Africa.

Control Variables
Infrastructural development is the main control variable under study through which we assess the role of agricultural productivity on industrialization and find the indirect effect between these two using infrastructural development. The principal sub-indexes for infrastructural development added to the African Infrastructural Development Index (AIDI) are further used. These include the Water and sanitation composite index (WSS), the Information and Communication Technology composite index (ICT), the Electricity composite index (Electricity), and the Transport composite index (Transport). These indexes have been used in contemporary literature to capture infrastructural development including the works of Nchofoung et al. (2022) and Kengdo et al. (2020).
According to the research of Steenkamp and Rooney (2017) and Anyanwu (2017), ICT infrastructure positively and significantly impacts industrial production in various regions. Azolibe and Okonkwo (2020) examined the effects of infrastructure growth on industrialization in sub-Saharan Africa between 2003 and 2018 and the findings suggested that the quantity and quality of telecommunications infrastructure are the primary factors impacting the productivity of the industrial sector in sub-Saharan Africa. These analyses' findings and others have demonstrated that infrastructural development had a favorable impact on African industrialization. Similar results are expected in this study.
Other control variables in our model include tertiary school enrollment (SETT), Trade Openness (TOPEN), life expectancy (LEXP), inflation (INFLA), gross fixed capital formation (GFKF), foreign direct investment (FDI) and broad money supply (BMSG). These variables inspired by empirical literature influence the agricultural productivity-industrialization nexus.
To include the interactive effect, Equation (1) can be specified below as follows:

$$\mathrm{INDUS}_{it} = \beta_0 + \beta_1 \mathrm{LAPROD}_{it} + \beta_2 \mathrm{INFRAS}_{it} + \beta_j X_{it} + \pi_l (\mathrm{LAPROD}_{it} \mathrm{x} \mathrm{INFRAS}_{it}) + \mu_{it} \quad (2)$$

Where infrastructure (INFRAS) is a vector of the different Infrastructural indices (AIDI, WSS, ICT, ECI, and TCI) as defined above, β the direct effect coefficients and π is the indirect effect coefficient. Equation (2) could further be detailed as:

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$$\begin{aligned}\mathrm{LMVA_{it}} = {} & \beta_0 + \beta_1\mathrm{LAPROD_{it}} + \beta_2\mathrm{AIDI_{it}} + \beta_3\mathrm{WSS_{it}} + \beta_4\mathrm{ICT_{it}} + \beta_5\mathrm{ECI_{it}} + \beta_6\mathrm{TCI_{it}} + \beta_j\mathrm{X_{it}} \\ & + \pi_1(\mathrm{LAPROD.AIDI_{it}}) + \pi_2(\mathrm{LAPROD.WSS_{it}}) + \pi_3(\mathrm{LAPROD.ICT_{it}}) \\ & + \pi_4(\mathrm{LAPROD.ECI_{it}}) + \pi_5(\mathrm{LAPROD.TCI_{it}}) \\ & + \mu_{it} \qquad (2a)\end{aligned}$$

$$\begin{aligned}\mathrm{EMIND_{it}} = {} & \beta_0 + \beta_1\mathrm{LAPROD_{it}} + \beta_2\mathrm{AIDI_{it}} + \beta_3\mathrm{WSS_{it}} + \beta_4\mathrm{ICT_{it}} + \beta_5\mathrm{ECI_{it}} + \beta_6\mathrm{TCI_{it}} + \beta_j\mathrm{X_{it}} \\ & + \pi_1(\mathrm{LAPROD.AIDI_{it}}) + \pi_2(\mathrm{LAPROD.WSS_{it}}) + \pi_3(\mathrm{LAPROD.ICT_{it}}) \\ & + \pi_4(\mathrm{LAPROD.ECI_{it}}) + \pi_5(\mathrm{LAPROD.TCI_{it}}) \\ & + \mu_{it} \qquad (2b)\end{aligned}$$

Differentiating Equation (2) in first place with respect to Agricultural productivity (LAPROD) yields Equation (3)
as follows:

$$\frac{\partial \mathrm{INDUS}}{\partial \mathrm{LAPROD_{it}}} = \beta_1\pi_1\mathrm{INFRAS_{it}} \qquad (3)$$

Where, $\boldsymbol{\partial}$ is the partial derivative operator. Bearing in mind the vector of the different infrastructural indices being the transmission channels in this case, a unit change in either LMVA or EMIND (representing industrialization) depends on the signs and significance of the direct and indirect coefficients of β and π. If β and π are significant in the same direction, there exists a synergy effect. However, if they are significant in opposite directions, there exists a net effect $[(\beta 1 + (\Omega \times \pi)]$ and a threshold effect ($\beta 1/ \pi$k) for the modulating variable which is required for the net effect to be nullified.
Equation (2) is further specified as

$$\mathrm{INDUS_{it}} = \beta_0 + \beta_1\mathrm{LAPROD_{it}} + \beta_2\mathrm{INFRAS_{it}} + \beta_j\mathrm{X_{it}} + \pi_l(\mathrm{LAPROD_{it}xINFRAS_{it}}) + (\beta 1 + (\Omega \times \pi) + \mu_{it} \qquad (4)$$

Thus, the only condition for Equation (4) to hold is that $\beta 1$ and π are opposing in signs and are both significant. Ω is the mean of the modulating variable. This is specified by equating Equation (3) to zero to get the threshold:

$$\mathrm{Threshold} \xrightarrow{\text{yields}} \left\{\frac{\beta_1}{\pi_1}\right. \qquad (5)$$

However, if the values computed in Equation (5) are not within the range of values of the modulating variables, then this threshold is not evident, and as a result, could only be computed in such a case for specific countries in the sample whose mean of the modulating variable is less than the threshold.

3.2. Data

The data for this study is collected for 45 African countries[2] between 2005-2022. The data for the infrastructure variables are collected from the African Development Bank, and the other variables are from the World Development Indicators (WDI) of the World Bank.

[2] Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Comoros, Congo Democratic Republic, Cote d'Ivoire, Eswatini, The Gambia, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, South Africa, Tanzania, Togo, Uganda, Zambia, Zimbabwe, Cape Verde, Cameroon, Central African Republic, Chad, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Ghana, Guinea, Madagascar.

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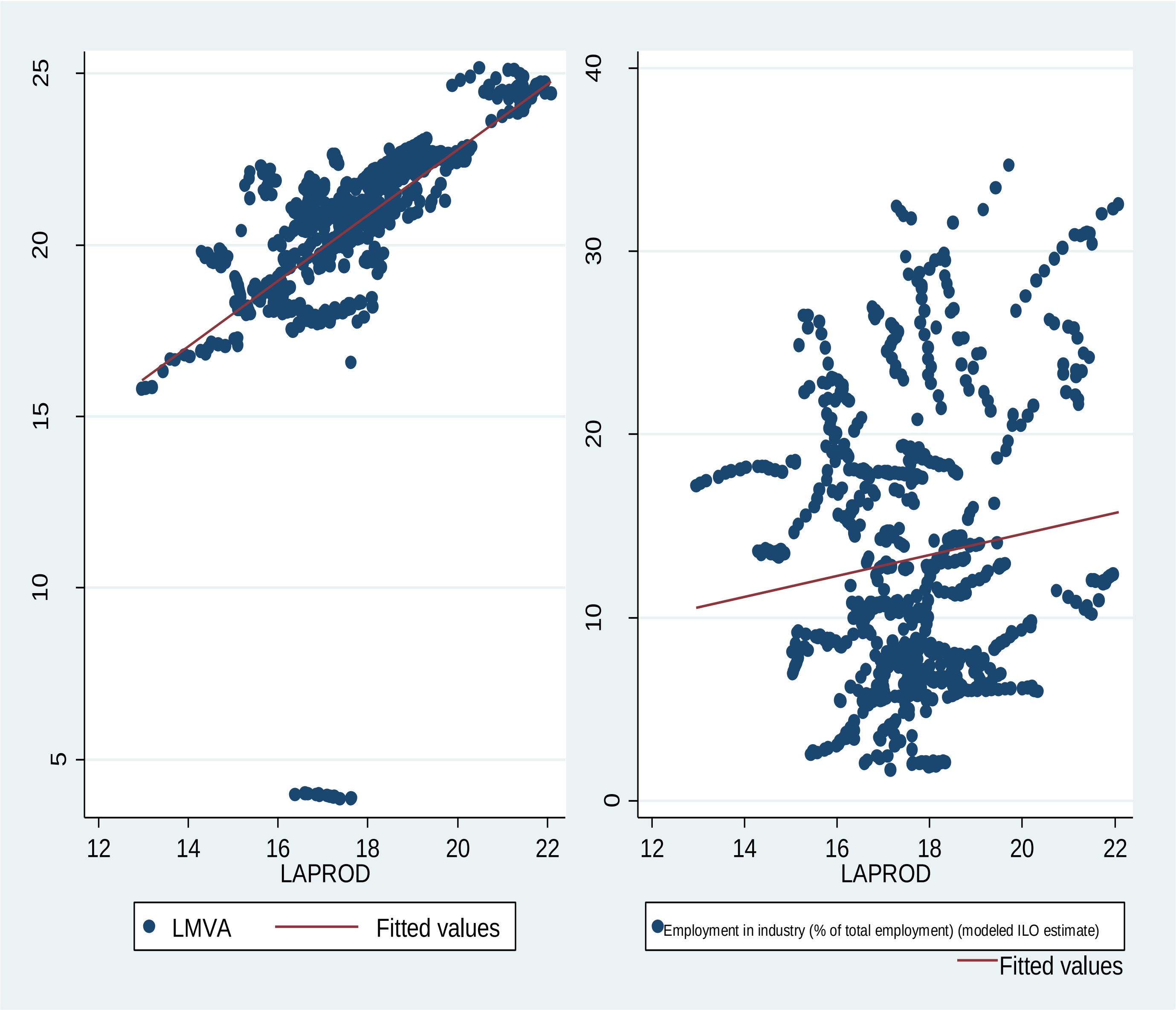

Figure 1. Scatter plots linking LAPROD and the two different measures of Industrialization (MVA and EMIND)

Source: Authors' computation

Figure 1 indicates a positive link between LAPROD and the two different measures of Industrialization (MVA and EMIND). However, there are several macroeconomic pointers that could influence this relationship. In this regard, the following section presents a suitable regression methodology in tackling this through the linear model specified hereafter.

3.3. Estimation Method

With the influence of several factors, this study applies the system Generalized Method of Moments (GMM). Firstly, our dependent variables (LMVA and EMIND) and their first-period lag have a strong correlation. This can be seen from their 0.998 and 0.997 coefficients of correlation between LMVA and EMIND and their lag values. The lagged dependent variables are treated as part of the model's explanatory

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factors. Secondly, according to Roodman (2009), the cross-sectional dimension must be bigger than the time dimension for a GMM to be utilized in a regression, which is the case with our data (the cross-sectional dimension of 45 countries is larger than our time dimension of 20 years). Thirdly, when the lagged dependent variable is included in the model, it correlates with the fixed effects in the error term. When this correlation is estimated using techniques like OLS, it results in a dynamic panel bias (Nickell, 1981). This bias is eliminated by the GMM estimation approach, which also controls cross-country dependence across panels in an equitable manner (Nchofoung et al., 2021).

The issue of too many instruments is typically the biggest issue with GMM estimates. Although the exact number of instruments that are deemed excessive is unknown, Roodman (2009) adopted the forward orthogonal deviation as a continuation of Arellano and Bover (1995) in order to curtail the proliferation of instruments and increase the sample size. When imputing this method, the methodology directs us to subtract the mean of all available observations of a variable instead of subtracting previous observations from simultaneous ones. This limits the number of lags of the possible regressors orthogonal to error and is available as a regression tool or instrument in the regression. The forward orthogonal deflection method and the two-step procedure are used in this study to first limit instrument proliferation and to control for heteroscedasticity instead of the one-step procedure which is consistent with homoscedasticity.

Equations (6) and (7) below, respectively summarize the GMM procedure in level and in difference.

$$\mathrm{INDUS}_{it} = \beta_0 + \beta_1 \mathrm{INDUS}_{i(t-\tau)} + \beta_2 \mathrm{LAPROD}_{it} + \sum_{h=1}^{k} \delta_h W_{h,i(t-\tau)} + \upsilon_t + \gamma_i + \varepsilon_{it} \quad (6)$$

$$\begin{aligned} \mathrm{INDUS}_{it} - \mathrm{INDUS}_{i(t-\tau)} &= \beta_1 (\mathrm{INDUS}_{i(t-\tau)} - \mathrm{INDUS}_{i(t-2\tau)}) + \beta_2 (\mathrm{LAPROD}_{it} - \mathrm{LAPROD}_{i(t-\tau)}) \\ &+ \sum_{h=1}^{k} \delta_h (W_{h,i(t-\tau)} - W_{h,i(t-2\tau)})(\upsilon_t - \upsilon_{t-\tau}) + \varepsilon_{i(t-\tau)} \quad (7) \end{aligned}$$

The variables mentioned are all defined as above.

Another problem that GMM estimation can pose is the problem of identification, simultaneity, and restrictions. In this respect, all of our explanatory variables are considered to be a source of endogeneity and treated as endogenous with respect to contemporary literature (Asongu & Leke, 2019; Nchofoung et al., 2021). Also, period dummies are used as instruments in both the level and difference equations.

4. Results and Discussion

4.1. Direct Effects of Agricultural Productivity on Industrialization in Africa

Table 1 presents the results of the direct effect regression. The result shows that agricultural productivity has led to a significant increase in industrialization in Africa represented by Manufacture Value Added (MVA) by a coefficient of 0.058 and proxied Employment in Industry (EMIND) by a coefficient of 0.277. Past realizations from LMVA and EMIND are said to positively and significantly influence the present values. It is acknowledged that the industrial sector has a lot of potential for the economy. This is due to the fact that industries employ a sizable number of people and account for a sizable portion of the nation's GDP. Most developing economies are built on agriculture. Its ability to change the country's developmental course is unquestionable because it is a source of rural and infrastructural development, among other things. Since agriculture provides the raw materials for industry, a successful agricultural system has the ability to support a thriving industrial sector.

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Table 1. Direct Effects of Agricultural Productivity on Industrialization in Africa

	(1)	(2)
VARIABLES	LMVA	EMIND
L.LMVA	0.988***	
	(0.00562)	
L.EMIND		1.006***
		(0.00739)
LAPROD	0.0580***	0.277***
	(0.00511)	(0.0456)
SETT	-0.00261***	-0.0266***
	(0.000839)	(0.00538)
LTOPEN	0.131***	-0.582***
	(0.0205)	(0.0504)
LEXP	-0.000370	0.00958
	(0.000680)	(0.00685)
INFLA	0.00478***	-0.00853*
	(0.00130)	(0.00491)
LGFKF	-0.0379***	-0.669***
	(0.00904)	(0.0303)
LFDI	0.00626	0.412***
	(0.00530)	(0.0515)
BMSG	0.00342***	-0.000904
	(0.000340)	(0.00128)
Constant	0.0260	1.141**
	(0.0641)	(0.555)
Time Fixed Effects	YES	YES
Observations	606	641
Number of id	45	45
Prob>AR1	0.001	0.029
Prob>AR2	0.021	0.316
Instruments	39	39
Prob>Sargan	0.000	0.186
Prob>Hansen	0.207	0.241
Fisher	8,54e+08***	2.31e+07**
DHT for instruments (a) In level		
H excluding groups	0.043	0.520
Dif(null H=exogenous)	0.557	0.183
(b)iv (years, eq(d))		
H excluding groups	0.043	0.438
Dif(null H=exogenous)	0.742	0.186

Standard errors in parentheses and *** p<0.01, ** p<0.05, * p<0.1
Source: Authors' computation

Also, looking at the other control variables in our model, the tertiary school enrollment (SETT) has a negative influence on industrialization, LTOPEN and LGFKF have a positive and negative effect on LMVA and EMIND respectively. Tertiary school enrolment affects industrialization in Africa because of the lack of viable training centers and practical workshops, of which the course might not be completed because of the inability to afford fees of imported expertise training, and the quest for means to sustain most households from the poverty level. The same explanation goes with GFKF since most countries in Africa have not attained the much-needed level of capital intensity needed to spur industrialization (Monga and Lin, 2019). However, for the said results to be binding and effective, there should be an absence of both first and second-

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order autocorrelation of residuals. In this case, the probability of AR1<10% and AR2>10% for first and second-order autocorrelations, respectively. Also, the null hypothesis of Sargan and Hansen's over-identification restrictions tests for the validity of instruments should not be rejected (that is P-value >10%). Besides, the null hypothesis of the Fisher statistics for the overall significance of the model should be rejected (that is P-value should be<10%). Moreover, the Difference in the Hansen Test (DHT) for exogeneity of instruments is employed to assess the validity of results from the Hansen test of over-identification restriction, in which case the null hypothesis of exogeneity should not be rejected.
Lastly, the number of instruments is kept to be less than the number of cross-sections as recommended by Roodman (2009). Our results meet these criteria highlighted above only in the case of EMIND (measure of industrialization) because of the presence of the second-order autocorrelation of residuals in the case of LMVA. To test the validity of our instruments, we focused on the Hansen test and the difference in the Hansen test instead of the Sargan test. This is principally because Sargan is not robust and its power is not weakened by instrument proliferations. Therefore, there is a need to account for the role of infrastructural development on the Effects of Agricultural Productivity on Industrialization in Africa.

4.2 **Accounting for the Role of Infrastructural Development on the Effects of Agricultural Productivity on Industrialization in Africa**

Table 2 shows the role of the composite index of infrastructural development (AIDI, WSS, ICT, ECI, TCI) on the effect of agricultural productivity on industrialization (LMVA and EMIND) in Africa. With the presence of the composite infrastructural development indicators in our model, agricultural productivity impacts manufacturing value added positively and significantly but more significantly on employment in industry on our sample as compared to the baseline model with coefficients of 0.339 (AIDI), 0.331 (WSS), 0.313 (ICT), and 0.328 (TCI).
Moving a nation's productive resources from low-productivity industries like primary agriculture to higher-productivity industries like the industrial or service sectors is known as structural transformation. Agriculture's decreasing role in production and employment, the movement of employees from low to high-average productivity industries, and improvements in productivity and efficiency are boosted with infrastructural development (Monga and Lin, 2019).
The said results are now valid in the case of LMVA as compared to the baseline model. The model meets the criteria of the absence of both first and second-order autocorrelation of residuals, the null hypothesis of the Sargan and Hansen over-identification restrictions tests for the validity of instruments which is not to be rejected, the P-value of Fisher statistics which is <10%, and the number of instruments is kept to be less than the number of cross-sections as recommended in Roodman (2009). Our results actually meet these criteria highlighted above in the case of EMIND (a measure of industrialization).
The same effect as described above could be seen in Table 3 below when Infrastructural development is introduced into the model. The effect of agricultural productivity on industrialization (proxied EMIND-employment in industry) increases more with all the different infrastructural indices but for ECI (electricity composite index) as compared to the baseline model that had a coefficient of 0.277. Thus electricity as far as infrastructure is concerned needs to be boosted in Africa in order that agricultural productivity could better influence industrialization. This confirms the results obtained by Kuete and Asongu (2021).
Generally, from the baseline model to the role played by infrastructural development, it can be remarked that EMIND records better effects from agricultural productivity than LMVA. This simply implies that the manufacturing value added in Africa still has some lapses. However, a trickledown effect from employment in the industry could better improve industrialization in Africa when agricultural productivity is concerned.
Given the positive links established in Tables 2 and 3, there is a necessity to see through which mechanisms of infrastructural development can agricultural productivity better improve industrialization in Africa, given

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the importance of industrialization for economic development. Tables 4 and 5 present these results of the indirect effect of LAPROD on LMVA and EMIND respectively.

Table 2: Role of Infrastructural Development on the Effects of LAPROD on LMVA in Africa

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Log of Manufacturing Value Added				
L.LMVA	0.981***	0.984***	1.005***	0.974***	0.945***
	(0.00804)	(0.00926)	(0.0188)	(0.00920)	(0.00938)
LAPROD	0.0652***	0.0560***	0.0763***	0.0618***	0.0766***
	(0.00922)	(0.00571)	(0.0173)	(0.00717)	(0.0129)
SETT	-0.00169	-0.00456**	-0.0143***	-3.61e-05	0.000554
	(0.00252)	(0.00186)	(0.00344)	(0.00271)	(0.00430)
LTOPEN	0.0957***	0.107***	0.198***	0.0267	0.0325
	(0.0241)	(0.0226)	(0.0508)	(0.0340)	(0.0267)
LEXP	-0.00438	2.80e-05	-0.00637**	-0.00411*	-0.00450
	(0.00294)	(0.00207)	(0.00313)	(0.00216)	(0.00331)
INFLA	0.00540***	0.00429***	0.00534***	0.00481***	0.00277
	(0.00155)	(0.00147)	(0.00196)	(0.00147)	(0.00171)
LGFKF	-0.0617***	-0.0233**	-0.0730***	-0.0787***	-0.0398**
	(0.0183)	(0.0111)	(0.0178)	(0.0143)	(0.0166)
LFDI	0.0275**	0.000299	0.0283	0.0454***	0.0367**
	(0.0134)	(0.00996)	(0.0190)	(0.0149)	(0.0162)
BMSG	0.00397***	0.00304***	0.00398***	0.00353***	0.00394***
	(0.000526)	(0.000519)	(0.000306)	(0.000400)	(0.000670)
AIDI	0.00305**				
	(0.00118)				
WSS		-7.31e-05			
		(0.00103)			
ICT			0.00733***		
			(0.00248)		
ECI				0.00392***	
				(0.000878)	
TCI					0.00781***
					(0.00278)
Constant	0.276**	-0.0665	0.157	0.473**	0.121
	(0.117)	(0.115)	(0.147)	(0.190)	(0.119)
Observations	606	606	606	606	606
Number of ids	45	45	45	45	45
Prob>AR1	0.001	0.001	0.001	0.001	0.001
Prob>AR2	0.021	0.019	0.021	0.018	0.023
Instruments	39	39	39	39	39
Prob>Sargan	0.000	0.000	0.000	0.000	0.000
Prob>Hansen	0.128	0.243	0.126	0.177	0.201
Fisher	6.30e+08***	1.88e+08***	1.51e+08***	1.89e+09***	1.66e+08***
DHT for instruments In level					
H excluding groups	0.196	0.035	0.077	0.046	0.073
Dif(null H=exogenous)	0.177	0.628	0.282	0.465	0.433
(a) iv (years, eq(d))					
H excluding groups	0.034	0.028	0.079	0.045	0.030
Dif (null H=exogenous)	0.578	0.878	0.369	0.646	0.797

***** p<0.01, ** p<0.05, * p<0.1**; AIDI-African infrastructural development composite index, WSS-water and sanitation index, ICT-information and communication technology index, ECI-electricity composite index, and TCI is Transport.

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Table 3: Role of Infrastructural Development on the Effects of Agricultural Productivity on EMIND (Employment in Industry) in Africa

	(1)	(2)	(3)	(4)	(5)
VARIABLES			Employment in Industry		
L.EMIND	1.000***	0.999***	1.011***	1.007***	0.992***
	(0.00700)	(0.00612)	(0.00775)	(0.00917)	(0.00821)
LAPROD	0.339***	0.331***	0.313***	0.261***	0.328***
	(0.0411)	(0.0523)	(0.0469)	(0.0762)	(0.0507)
SETT	-0.0283***	-0.0290***	-0.0516***	-0.0344***	-0.0155*
	(0.0103)	(0.00584)	(0.00915)	(0.00447)	(0.00810)
LTOPEN	-0.680***	-0.674***	-0.485***	-0.462***	-0.648***
	(0.0798)	(0.0608)	(0.0724)	(0.0572)	(0.0769)
LEXP	-0.00454	-0.00166	0.00373	0.0182***	0.00368
	(0.0118)	(0.00804)	(0.0101)	(0.00616)	(0.0108)
INFLA	-0.00942	-0.00552	-0.0102	-0.00788*	-0.00902*
	(0.00643)	(0.00538)	(0.00643)	(0.00459)	(0.00511)
LGFKF	-0.855***	-0.719***	-0.761***	-0.581***	-0.772***
	(0.0419)	(0.0387)	(0.0474)	(0.0913)	(0.0379)
LFDI	0.559***	0.438***	0.529***	0.345***	0.487***
	(0.0485)	(0.0527)	(0.0543)	(0.0672)	(0.0453)
BMSG	0.00311*	0.00150	0.00129	-0.000920	0.00172
	(0.00179)	(0.00161)	(0.00173)	(0.00131)	(0.00149)
AIDI	0.0165***				
	(0.00287)				
WSS		0.0102***			
		(0.00316)			
ICT			0.0139***		
			(0.00157)		
ECI				-0.00631***	
				(0.00210)	
TCI					0.0213***
					(0.00413)
Constant	1.696**	0.843	0.728	0.481	1.117**
	(0.665)	(0.609)	(0.643)	(0.519)	(0.498)
Observations	641	641	641	641	641
Number of id	45	45	45	45	45
Prob>AR1	0.019	0.029	0.021	0.037	0.024
Prob>AR2	0.352	0.332	0.339	0.302	0.342
Instruments	39	39	39	39	39
Prob>Sargan	0.483	0.156	0.422	0.097	0.265
Prob>Hansen	0.247	0.340	0.279	0.264	0.146
Fisher	9.67e+07***	1.38e+07***	3.59e+06***	2.08e+08***	2.73e+07***
DHT for instruments (a) In level					
H excluding groups	0.628		0.549	0.448	0.517
Dif(null H=exogenous)	0.165		0.214	0.232	0.103
(b) iv (years, eq(d))					
H excluding group	0.400		0.424	0.321	0.359
Dif (null H=exogenous)	0.215		0.239	0.292	0.121

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Source: Authors' Computation

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4.3 Transmission Mechanisms/ Indirect Effects of Agricultural Productivity on Industrialization in Africa Through Infrastructural Development

In Table 4, agricultural productivity interacts with WSS producing a negative direct effect and a positive indirect effect on manufacturing value added. Thus producing a positive net effect of 0.04677. This is up to the Water and sanitation index (WSS) threshold of 32.9609 when the positive net effect is nullified. As a result, for WSS to have a justifiable effect on industrialization in Africa, the WSS level is required to go above this threshold. This is valid if the threshold falls within the range of the minimum and maximum values (4.87 and 99.795), and it is above the mean value of WSS (see appendix). However, this is not the case since the mean of 59.09>the threshold of 32.96. In this case, it is nonjustifiable for Africa as a whole following our sample but could be valid for specific countries like Chad, Ethiopia, Mozambique, and Niger with a WSS mean of 28.36, 24.45, 29.79 and 29.09 respectively.

Table 4: Indirect effect between LAPROD and LMVA through the five indices for Infrastructural Development

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Log of Manufacturing Value Added				
L.LMVA	0.978***	1.001***	0.996***	0.982***	0.939***
	(0.00936)	(0.0185)	(0.0111)	(0.0160)	(0.0116)
LAPROD	**-0.00799**	**-0.0590***	**0.0625*****	**0.0418*****	**0.105*****
	(0.0117)	(0.0298)	(0.0125)	(0.0149)	(0.0324)
SETT	-0.00460	-0.000850	-0.0127***	0.00491	-0.000302
	(0.00278)	(0.00260)	(0.00317)	(0.00389)	(0.00442)
LTOPEN	0.168***	0.183***	0.201***	0.0797**	0.0424
	(0.0375)	(0.0376)	(0.0512)	(0.0316)	(0.0284)
LEXP	0.00495**	0.00538*	-0.00427	-0.00619**	-0.00486
	(0.00227)	(0.00268)	(0.00334)	(0.00254)	(0.00333)
INFLA	0.00575***	0.00702***	0.00538***	0.00508**	0.00160
	(0.00193)	(0.00198)	(0.00165)	(0.00210)	(0.00212)
LGFKF	-0.0288*	-0.0600***	-0.0725***	-0.0832***	-0.0400**
	(0.0165)	(0.0141)	(0.0219)	(0.0255)	(0.0167)
LFDI	0.0268*	0.0238	0.0382**	0.0477**	0.0308*
	(0.0136)	(0.0182)	(0.0148)	(0.0187)	(0.0172)
BMSG	0.00307***	0.00322***	0.00398***	0.00402***	0.00395***
	(0.000476)	(0.000466)	(0.000515)	(0.000540)	(0.000676)
AIDI	-0.0429***				
	(0.00752)				
LAPRODAIDI	**0.00221*****				
	(0.000413)				
WSS		-0.0349***			
		(0.00792)			
LAPRODWSS		**0.00179*****			
		(0.000434)			
ICT			-0.00659		
			(0.00636)		
LAPRODICT			**0.000698***		
			(0.000349)		
ECI				-0.0710***	
				(0.0179)	
LAPRODECI				**0.00397*****	
				(0.000948)	

TCI					0.0368
					(0.0309)
LAPRODTCI					**-0.00154**
					(0.00163)
Net Effect	n.a	0.04677	s.e	s.e	n.a
Threshold	--	32.9609	--	--	--
Constant	0.586**	1.779***	0.259**	0.777***	-0.113
	(0.234)	(0.558)	(0.124)	(0.275)	(0.268)
Observations	606	606	606	606	606
Number of id	45	45	45	45	45
Prob>AR1	0.001	0.001	0.001	0.001	0.001
Prob>AR2	0.019	0.016	0.022	0.031	0.025
Instruments	39	39	39	39	39
Prob>Sargan	0.000	0.000	0.000	0.000	0.000
Prob>Hansen	0.131	0.123	0.102	0.175	0.190
Fisher	7.30e+07***	7.20e+08***	2.46e+09***	6.59e+07***	2.04e+08***
DHT for instruments (a) In level					
H excluding groups	0.375	0.195	0.465	0.719	0.114
Dif(null H=exogenous)	0.120	0.167	0.077	0.099	0.330
(b) Iv(years, equation(d))					
H excluding groups	0.025	0.017	0.054	0.043	0.064
Dif(null H=exogenous)	0.646	0.713	0.371	0.633	0.572

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; n.a for none applicable and s.e for synergy effect

Source: Authors' Computation

When alternative interactive variables of Infrastructure are used with LAPROD on LMVA, there is a positive synergy effect. That is a positive direct and a positive indirect effect. This is the case for ICT and ECI. This implies that both variables in each case (LAPROD-ICT, and LAPROD-ECI) improve on each other to better and significantly influence Industrialization. *This confirms the results obtained by* Njangang and Nounamo (2020) investigated the impact of information and communication technology on the industrialization of 46 African nations between 2000 and 2015

In the case of the alternative measure of Industrialization (EMIND), there is a positive synergy effect when AIDI, ICT, and ECI interact with agricultural productivity (LAPROD) to impact industrialization. Table 5 represents this situation.

Table 5: Indirect effect between LAPROD and EMIND through the five indices for Infrastructural Development

	(1)	(2)	(3)	(4)	(5)
VARIABLES			Employment in Industry (EMIND)		
L.EMIND	0.995***	1.001***	0.997***	0.990***	0.990***
	(0.00770)	(0.00941)	(0.00792)	(0.00694)	(0.00849)
LAPROD	0.206**	-0.0397	0.293***	0.154*	0.288***
	(0.0965)	(0.112)	(0.0616)	(0.0874)	(0.0799)
SETT	-0.0434***	-0.0356***	-0.0504***	-0.0490***	-0.0137
	(0.00863)	(0.00703)	(0.00700)	(0.00743)	(0.00824)
LTOPEN	-0.378***	-0.473***	-0.300***	-0.139	-0.641***
	(0.0827)	(0.0803)	(0.0702)	(0.0903)	(0.0774)
LEXP	0.0405***	0.0370***	0.0314***	0.0533***	0.00565
	(0.00883)	(0.00950)	(0.00783)	(0.00763)	(0.0111)
INFLA	-0.00572	-0.00499	-0.00555	-0.00781	-0.00567
	(0.00614)	(0.00557)	(0.00580)	(0.00699)	(0.00639)

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LGFKF	-0.859***	-0.827***	-0.814***	-0.669***	-0.748***
	(0.0681)	(0.0527)	(0.0443)	(0.0665)	(0.0476)
LFDI	0.559***	0.551***	0.516***	0.436***	0.478***
	(0.0608)	(0.0575)	(0.0556)	(0.0700)	(0.0455)
BMSG	0.00311	0.00104	0.00194	0.00350*	0.00225
	(0.00187)	(0.00198)	(0.00156)	(0.00180)	(0.00154)
AIDI	-0.0851**				
	(0.0406)				
LAPRODAIDI	0.00471**				
	(0.00209)				
WSS		-0.101***			
		(0.0250)			
LAPRODWSS		0.00554***			
		(0.00133)			
ICT			-0.0575**		
			(0.0230)		
LAPRODICT			0.00346**		
			(0.00128)		
ECI				-0.256***	
				(0.0598)	
LAPRODECI				0.0132***	
				(0.00321)	
TCI					0.00257
					(0.0377)
LAPRODTCI					0.00101
					(0.00199)
Net Effect	s.e	n.a	s.e	s.e	n.a
Threshold	--	--	--	--	--
Constant	2.111*	6.123***	1.088*	0.908	1.344**
	(1.116)	(1.694)	(0.598)	(0.888)	(0.648)
Observations	641	641	641	641	641
Number of id	45	45	45	45	45
Prob>AR1	0.019	0.019	0.023	0.032	0.025
Prob>AR2	0.330	0.334	0.323	0.322	0.337
Instruments	39	39	39	39	39
Prob>Sargan	0.508	0.448	0.460	0.532	0.219
Prob>Hansen	0.353	0.347	0.274	0.379	0.137
Fisher	6.59e+08***	2.12e+07***	4.12e+07***	2.27e+07***	2.16e+07***
DHT for instruments (a) In level					
H excluding groups	0.507	0.754	0.419	0.468	0.609
Dif(null H=exogenous)	0.303	0.225	0.254	0.345	0.086
(b) iv (years, eq(d))					
H excluding groups	0.375	0.457	0.307	0.271	0.288
Dif (null H=exogenous)	0.365	0.298	0.317	0.504	0.143

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; n.a for none applicable and s.e for synergy effect
Source: Authors' Computation

5. Conclusion, policy implications and limitations

The objective of this study was to empirically verify the effect of agricultural productivity on industrialization in 45 African countries between the 2005 and 2022 periods. The contribution of this study brings out the direct and indirect effects (through the five different indices of infrastructural development) of agricultural productivity on industrialization while comparing two measures of industrialization (LMVA and EMIND).

The system GMM results from the methodology reveal various tendencies. The direct effect regression shows that agricultural productivity in Africa positively and significantly influences industrialization in

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Africa; a result that was robust for the dependent variable of Employment in Industry (EMIND). Infrastructural development across the five indices plays a more positive and significant role on the effect of Agricultural productivity on industrialization in Africa. This applied to both measures of industrialization. This confirms the results obtained by Kuete and Asongu (2021) and Sané (2017) since industries can only thrive in a country with a sound infrastructure.

When the regression on the indirect effect was carried out by interacting agricultural productivity and the different infrastructural development variables, the following results were derived. In the first place, agricultural productivity interacts with infrastructural development (Water and Sanitation -WSS) variables on manufacturing value added and produces a positive net effect of 32.96 which is applicable for countries like Chad, Ethiopia, Mozambique, and Niger. That is the Water and Sanitation (WSS) of these countries must by-pass the threshold value for the mediating role to be effective. The other variables of infrastructural development (ICT and ECI) had positive synergy effects when interacting with LAPROD. In the second place, agricultural productivity interacts with infrastructural development (AIDI, ICT, and ECI) to produce positive synergy effects on Employment in Industry (EMIND).

This work informs decision-makers in Africa about the best course of action to take in the continent's long-term pursuit of industrialization, which calls for massive agricultural productivity and infrastructural development. It highlights the extent to which infrastructure development needs to be enhanced and the knowledge of the low level of manufacturing value added in Africa, when used to capture industrialization, as compared to the influence on employment in industry. Through the indirect result, some nations are implicated in the water and sanitation threshold. The structural peculiarities of the countries in Africa should be taken into consideration to draw insights from these dimensions and measures of economic diversification in order to determine the unique policy solutions for Africa.

Future research on the topic might try to include sub-regional and country-specific studies for particular policy approaches. Additionally, other modifying policy parameters could be employed to evaluate different complementing policy thresholds.

Author's contribution: Ofeh Evina conceived the idea, collected the data, did the analysis, and put the whole paper together; Ndzembanteh Aboubakary reviewed the paper; Ofeh Marilyn did the review of the Literature.

Conflict of Interest: The authors declare no conflict of interest.

Availability of Data: Data are open access from the following sources:

I. The World Bank: https://databank.worldbank.org/source/world-development-indicators and https://databank.worldbank.org/source/worldwide-governance-indicators
II. The African Development Bank: https://infrastructureafrica.opendataforafrica.org/rscznob/africa-infrastructure-developmentindex-aidi

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Appendix

A1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
LMVA	773	20.39026	3.122002	3.800957	25.15552
EMIND	792	13.1491	7.39875	1.719799	34.65171
LAPROD	787	17.60966	1.622976	12.96339	22.08624
AIDI	810	22.03491	18.34845	1.12	98.88
WSS	810	59.09056	20.40975	4.87	99.79547
ICT	810	7.779609	10.16379	0	58.90417
ECI	810	9.920893	18.86774	0	100
TCI	810	10.8054	11.21073	1.09	56.04151
SETT	810	14.32596	3.072544	8.673048	19.52035
LTOPEN	784	-.0567314	2.339061	-1.573949	15.46033
LEXP	810	60.7518	7.12687	42.518	77.88223
INFLA	767	5.84324	5.8987	-8.97474	44.39128
LGFKF	776	21.70007	1.652508	17.87973	25.54222
LFDI	769	19.45464	1.805362	10.36072	23.02867
BMSG	802	15.00888	16.57034	-23.79796	249.8353

A2: Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) LMVA	1.000											
(2) EMIND	0.315	1.000										
(3) L.LMVA	0.998	0.319	1.000									
(4) L.EMIND	0.309	0.997	0.316	1.000								
(5) LAPROD	0.538	0.126	0.531	0.119	1.000							
(6) SETT	0.087	0.035	0.083	0.033	0.192	1.000						
(7) LTOPEN	-0.845	-0.148	-0.846	-0.145	-0.101	-0.018	1.000					
(8) LEXP	0.176	0.424	0.181	0.425	0.136	0.431	-0.153	1.000				
(9) INFLA	-0.034	-0.211	-0.029	-0.195	0.039	-0.245	0.034	-0.124	1.000			
(10) LGFKF	0.514	0.199	0.515	0.192	0.840	0.189	-0.046	0.215	0.141	1.000		
(11) LFDI	0.295	0.047	0.294	0.026	0.672	0.140	0.095	0.076	0.079	0.773	1.000	
(12) BMSG	0.043	-0.161	0.040	-0.165	-0.011	-0.183	-0.061	-0.140	0.205	0.016	0.066	1.000

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