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Modelling composition of growth, FDI and welfare in Africa: a SEM approach

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Abstract

While there have been separate studies on FDI–growth and FDI–welfare links, few or no studies exist that simultaneously examine FDI–growth–welfare link at aggregate or sectoral level. This study adopted a recent causality method and a simultaneous equation model to analyse the effect of FDI on sectoral growth and welfare using a cross-sectional panel of 23 countries, spanning 1990–2019. The study accounted for sectoral spillover effects, heterogeneity, simultaneity and cross-sectional dependence in our model. Findings suggest that FDI promotes output in the manufacturing and services sectors more than in the agriculture sector, while it fosters human development (HD). Also, the results show that while HD promotes output in the agricultural sector, it deters output in the manufacturing and service sectors. Further findings show that only agricultural output improves HD among the countries. This study therefore recommends that for African countries to improve sectoral output growth and welfare using FDI as a catalyst, a policy framework toward attracting more FDI into the three key sectors (especially in the manufacturing and services) is desirable for increased output and human development in Africa.

Keywords FDI · Sectoral growth · HDI · Africa · Simultaneous equation model

JEL Classification O1 · O41 · I31 · O55

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1 Introduction

A major goal of every economy is the attainment of economic growth that will lead to welfare improvement. The achievement of economic growth requires investment in physical and human capital as well as other production inputs. However, available domestic savings may be inadequate to finance investment to achieve desired level of economic growth. This necessitates attraction of foreign investment especially foreign direct investment (FDI) that is capable of filling the domestic saving-investment gap (complementing domestic investment). Thus, theoretically, FDI should be related to growth and welfare. The channels of the contribution of FDI to growth and welfare in the host country include creation of new plants (or addition to the existing plants) with employment effect; the spread of best practices in corporate governance; better managerial capabilities, accounting rules and legal traditions; the transfer of technology to local firms (particularly in the form of new varieties of capital inputs); human capital development; and increased export (Hausmann and Fernández-Arias 2000). However, the realisation of the foregoing benefits of FDI for growth is not automatic. It depends on the prevailing domestic conditions in the host country such as the business environment and absorptive capacity which is a function of a number of factors especially governance in terms of existence of local content policy (to promote linkages, human capital development and profit plough back), law enforcement (ease of contract enforcement) and the quality of public workforce to facilitate right and timely policy making and execution (Loungani and Razin 2001). For instance, it is unlikely that FDI will be beneficial to countries with missing or inefficient markets. This is because in such situation foreign investors will choose to function directly abandoning the domestic legal system and without linking with domestic financial markets and suppliers. There are other associated problems of FDI such as the adverse selection, excessive leverage and reversal (Loungani and Razin 2001). The former led Loungani and Razin (2001) to conclude that, although FDI has a number of potential gains, host countries should gauge these benefits cautiously and genuinely (against the costs) via thorough research and policy analysis to inform proper and evidence-based decision making.

FDI, via the transfer of technology into different sectors of the economy, has enabled many Asian, Latin American and Caribbean countries achieve sustained economic growth and development in recent times. Over the years, these economies were able to achieve high economic growth rates by attracting much FDI inflow into the productive sectors with higher absorptive capacities. Dutta (2005) submitted that through the approach of targeting the industrial sector, China grew total output to above two-thirds of the total aggregate growth in 2000. Dupasquier and Osakwe (2006) also posited that the substantial FDI inflow in the secondary sector contributed to a large extent, the export diversification and aggregate growth in East Asia. Similarly, Loayza and Raddatz (2010) and Gohou and Soumare (2012) stated that adequate investments in labour-intensive sectors improve growth and welfare faster among countries. However, despite this existing knowledge, several African countries are yet to improve on their growth and development structures by identifying the priority productive sectors and attract the much needed foreign inflows as catalyst for growth and development. According to the World Bank statistics (2020), Africa's average share of FDI (as percentage of GDP) remained one of the lowest when compared to regions of similar classifications (see Appendix).

Is the low FDI inflow responsible for the current growth and development challenges facing the African region? This question is important because in the past two decades Africa's average growth rate stood below 5%, while the average population of the poor that lives below $1.9 per day in Sub-Saharan Africa (SSA) stood at 48%. This statistics repudiates those of South Asia, East Asia and Pacific, Europe and Central Asia, and Latin America and the Caribbean, which stood at 29, 13, 3 and 7%, respectively (World Bank statistics 2020). While the issue of weak growth structure and low human development capacity have remained a great concern to policymakers, the task of designing and implementing appropriate policies that attract adequate foreign and domestic financial inflows into the real sectors for growth and development, remains a daunting challenge to governments at different levels.

Aside the issue of attracting finances for sectoral growth and development, is the challenge of identifying the actual sectors with high absorptive capacities to warehouse any eventual financial inflows for national income growth and welfare development. According to Durham (2004), productive sectors with low absorptive capacity contribute negligible impact on aggregate growth, whereas productive sectors with high absorptive capacities strengthen aggregate growth structures. Therefore, a policy framework tailored toward improving resource inflows into the appropriate productive sectors of the economy for the purpose of improving growth and human conditions is beneficial for countries or regions with growth and human capacity challenges.

This study identifies the following gaps in the literature, whereas there are plethora of studies on the relationship between FDI and economic growth relationship (Choong et al 2010; Belloumi 2014; Iamsiraroj 2016; Anyanwu 2017), or FDI and human capital development relationship (Balasubramanyam et al. 1999; Noorbakhsh et al. 2001; Kar 2013; Yildirim and Tosuner 2014; Cleeve et al. 2015; Kaulihowa and Adjasi 2019) or composition of growth and welfare relationship (Diao and Pratt 2007; De Janvry and Sadoulet 2009; Loayza and Raddatz 2010; Schneider and Gugarthy 2011), very few studies exist that simultaneously examine FDI–growth–welfare relationship at aggregate or sectoral level despite the need for a comprehensive analysis (taking into account the direct and indirect impacts of FDI on output growth and welfare improvement) for evidence-based policymaking. It is against this background that this study used the most recent causality methods and developed a simultaneous equation model (SEM) derived from the endogenous growth theory to conduct a comprehensive sectoral analysis of the FDI–growth–welfare link.

Second, there is a dearth of studies on Africa as regards to some parts of the three links (especially the FDI–welfare and growth–welfare links). Third, earlier studies on cross-country analysis did not consider the problem of cross-sectional dependence which emanates from common global factors inherent in economic variables across sampled countries. The existence of cross-sectional dependence may render model results imprecise. This problem is dealt with in this study using recently developed econometric techniques. The rest of the paper is structured as follows: Sect. 2 reviews relevant literature on impact of FDI on sectoral growth and welfare; Sect. 3 presents the theoretical framework and econometric methodology; Sect. 4 presents the empirical results; and Sect. 5 concludes the study.

2 Literature review

While a huge body of literature exists on FDI and economic growth, studies relating to the impact of FDI on sectoral growth and welfare are beginning to take the centre stage in recent development literature. Received literature shows that many of these studies on FDI–sectoral growth–welfare relationship rely on the endogenous growth theory of 'technological diffusion' to demonstrate how (i) through FDI, technology can move from the secondary to tertiary sectors rather than the primary sector; and (ii) the welfare conditions of a country can be improved. The seminal paper by Findlay (1978) shows that through technological diffusion and growth in total factor productivity (TFP), a relatively backward economy can catch up faster with those of technologically advanced economies provided the sectors have strong linkages.

However, research has shown that not all sectors have the capacity to absorb these foreign technologies and improve welfare because of weak industrial linkages. Theoretically, it has been proven that linkages are weak in the agriculture and mining sectors, unlike in the manufacturing and services sectors. An investment report by UNCTAD (2001:138) states that in the primary sector, the scope of linkages between foreign affiliates and local suppliers is often limited. The manufacturing sector has a broad variation of linkage intensive activities. In the tertiary sector, the scope for dividing production into discrete stages and sub-contracting out large parts to independent domestic firms is also limited. The effect of weak industrial linkage therefore means that certain sectors may not be able to attract the needed foreign investment that can drive economic growth and welfare improvement.

Although there has been an ongoing debate on which sectors that have the higher capacity to absorb foreign technology, improve economic growth and welfare, received empirical studies have shown that the impact of FDI on sectoral growth is ambiguous. While the impact of FDI on sectoral growth is positive among developed economies, it presents a negative relationship in developing countries; and in some cases, mixed. Perhaps some of the reasons behind the weak performance of FDI in developing economies are low absorptive capacity of the sectors to which resource inflows are often channelled and weak human development index (HDI).[1]

Research has shown that African economies are mostly dependent on primary sector resources; and this sector is noted for its low industrial linkage and absorptive capacity. Examining how foreign direct investment affects economic growth in 69 developing countries, Borensztein et al. (1998), report that FDI only drives economic growth in economies with sufficient absorptive capability in advanced

[1] The United Nations defined Human Development Index (HDI) as composite measure of a country's total wellbeing which comprised health, education and standard of living.

technologies and higher productivity level. Adams (2009) reported that an increase in the absorptive capacity of local firms and institutional collaboration are necessary for FDI and domestic investment (DI) to promote economic growth. The contribution of the agricultural sector to economic growth has been noted to be less than those of the industrial and services sectors.

Alfaro (2003) examined the effect of FDI on growth in the agricultural, manufacturing and services sectors in Asia and the Pacific, Africa, Latin America and the Caribbean. The study found that while the effect of FDI on the agricultural sector is negative, it is positive on the manufacturing sector, and diverse in the case of the services sector. Contrary to the findings of Alfaro et al (2004), Msuya (2007) posited that agricultural productivity is considered essential in achieving sustainable growth. Examining the performance of FDI in promoting economic growth in Africa, Dupasquier and Osakwe (2006) submitted that the sustained FDI growth in the secondary sector in East Asia contributed to the higher aggregate growth experienced within the economy. A similar study by Bwalya (2006) demonstrated that FDI inflows in the secondary sector were much higher than those of the primary and tertiary sectors in Zambia between 1990 and 1998.

While FDI in the manufacturing sector in Africa is dominated by non-traditional sources (UNCTAD 2014), studies have shown that FDI promotes economic growth in the manufacturing sector. Akinlo (2004) reported that in Nigeria, the impact of FDI in the manufacturing sector on aggregate economic growth outweighs those of extractive industries. Nonetheless, Basu and Guariglia (2007) noted that while FDI promoted inequality and industrial growth, it reduced the share of agriculture to GDP among 119 developing countries. The study by Tambunan (2004) suggests that the channel by which FDI can lead to welfare improvement is through labour-intensive economic growth with export growth as the most important engine. Studies have shown that the positive impact of FDI on the secondary and tertiary sectors is contingent upon the political structure, environmental challenges, and macroeconomic and industrial policy frameworks of the country. The issue of strong macroeconomic and industrial policies has been highlighted in development literature as a key factor for robust economic growth and development (Collier and Gunning 1999; Eichengreen 2007; Rodrik 2008).

Though the macroeconomic environment of a country may be apt for economic growth, the productive sectors benefit more when FDI is allowed to be the catalyst for economic growth (see Choong et al. 2010). The countries of East Asia were able to apply clear-cut macroeconomic and industrial policy frameworks and robust financial markets to diversify their economies, thus boosting economic growth and aggregate welfare. According to Dutta (2005), through trade and industrial policy reforms, China was able to diversify its economy from the agricultural to the industrial sector, with share of GDP rising above two-thirds of the total aggregate growth in 2000. The successful 'growth miracle' in the South-South is not peculiar to China alone but applies to some other Asian countries like Singapore, Japan, Malaysia and Indonesia. It is therefore evident that the growth of the 'Asian Tigers' and the improvement in their levels of welfare did not just arise from a comprehensive industrial policy and robust institutions but also through sound macroeconomic frameworks which created the enabling environment for economic growth. Growth that can lead to improvement in human capacity among economic agents coupled with sound macroeconomic environment must interact at optimum to produce the desired goals of an economy.

3 Theoretical framework and methodology

3.1 Theoretical framework

This study relies on the endogenous growth theory of 'technological diffusion' initially developed by Kenneth Arrow (1962). Technological diffusion refers to a form of 'conditional convergence' where lagging countries (and sectors) catch up with technological leaders. Technology often flows from industrialised economies to developing ones in the form of foreign direct investment (FDI), helping these economies to fill the technology gap existing across sectors and promoting both sectoral and national output growth. Recent advancements in the endogenous growth theory championed by Romer (1986, 1990, 1994), Lucas (1988), Barro (1991) and Easterly et al. (1994) strongly demonstrate the role of technology and human capital in economic development. According to Gohou and Soumare (2012), FDI can generate both direct and indirect effect on an economy. The direct effect ensues via human capacity development in the form of creation of new jobs, improved skills through technical and managerial skills spillover and better environmental management practices that improve health status (first round effect of FDI itself).

The indirect effect manifests at the sectoral and macroeconomic levels in terms of firm or sectoral level technological transfer which fosters backward and forward inter-sectoral linkages among firms and industries that lead to increase in sectoral output. Increase in firms' output across sectors implies an increase in the quantity of labour required in production processes. This eventually reduces unemployment and hence improves welfare in the economy (second round indirect effect of FDI on welfare via sectoral output growth). Thus, the diffusion of technology from advanced economies to developing countries allows the latter to grow faster, provided the sectors in these economies have strong linkages with other sectors. Where linkages are weak, diffusion of technology may be hindered, sectoral growth retarded while unemployment and welfare conditions may become worse. In essence, there are both direct (welfare) and indirect (sectoral growth) effects of FDI. Thus, the first and second rounds effects of FDI on welfare are expressed in Eq. (1), where welfare (expressed in terms of human development index (HDI)) is a function of both FDI inflow and the sectoral output performance (measured as sectoral output share—SOs).

$$\text{HDI} = f(\text{FDI}, \text{SOs}) \tag{1}$$

Following Barro (1991), Easterly et al. (1994) and Wang and Wong (2012), we capture the role of technology and human capital in economic development by exploring the indirect effect of FDI on sectoral output growth (via technological and skill transfers in addition to existing inputs) and the impact of human capital development on same. Thus, the relation can be written as:

$$\text{SOs} = f(\text{HDI,FDI}) \tag{2}$$

It therefore implies that a system of relationship exists between HDI and sectoral growth where FDI plays a critical role. Thus, output of sector i in country j depends on the country-wide human capital development level and FDI, while human capital development is a function of sectoral output, corrected for inter-sectoral linkages, and FDI. The corrected sectoral output (Z_{ij}) is defined as the product of sectoral share in GDP and annual rate of change of sectoral share in GDP for sector i and country j (y_j). Both sectoral growth rate and HD level are also affected by the level of capital formation (INV), population growth (POPG), sectoral output prices (Price)[2] and trade openness (OPEN) of the economy (Basu and Guariglia 2007) while governance institution—proxied by rule of law (RLAW)—is critical to HD outcomes (Gohou and Soumare 2012; Wu and Hsu 2012).

A major driver of output growth is investment in inputs which is made possible via domestic savings (*domestic capital formation*). Similarly, population growth facilitates sectoral growth. This is because production expansion is induced by demand expansion (which is a function of *population growth*) and availability of labour. Also, *output price* is part of sectoral output growth equation because price is a major determinant of output supply (supply theory). *Trade openness* in the equation captures the role of imported inputs in production and output growth. It also captures competition and efficiency arising from exporting which engenders increased total factor productivity. (Basu and Guariglia 2007) As regards the governance variable (*rule of law*), an effective judiciary system, which improves the business environment and protects investors, aids investments and hence stimulates growth which, in turns, create jobs and improve standards of living (Gohou and Soumare 2012; Wu and Hsu 2012).

The inclusion of *domestic capital formation* (investment) in the FDI equation is informed by the signalling theory and the modern theory of Multinational Corporation which suggest that high private investment in a country is a reflection of high returns to capital in that country. This, in turn, engenders a signalling effect to foreign firms to come and invest in the country, and thus stimulates FDI (Ndikumana and Verick 2008; Lautier and Moreaub 2012; Loungani and Razin 2001). Similarly, the information asymmetry theory states that private domestic investors possess more information about the local business environment than the foreign investors. Consequently, in the presence of incomplete information, domestic investment seems to provide a signal about the situation of the economy to foreign investors. Thus, domestic investment could be seen to lead FDI (McMillan 1998; Lautier and Moreaub 2012; Hausmann and Fernández-Arias

[2] Sector specific prices are used, except in the case of the service sector for which we did not use any commodity price due to data unavailability. Specifically, world agricultural commodity prices were used in the agricultural sector, while beverages commodity prices (by definition this captured manufactured cocoa and tea) was used as proxy for manufacturing sector price.

2000). *Population growth* is also included in the FDI equation following the Dunning (2001) OLI paradigm in which 'L' connotes the locational advantages specific to the host countries that make it attractive for FDI. The locational advantages include labour force participation rate especially well-educated ones and large market (size of host countries' domestic markets or large consumer population). Based on the profit theory, *sectoral output prices* are included in the FDI equation. The FDI–trade link which could be complementarity (FDI may require imported inputs to expand export) or substitutability (FDI and trade replacing each other depending on trade barrier—the tariff jumping hypothesis) informs the inclusion of *trade openness* in the FDI equation (Swenson 2004; Tadesse and Ryan 2004; Loungani and Razin 2001). Good governance in terms of effective *rule of law* promotes FDI. Countries with minimal or low crime level, and high enforceability of contracts attract more FDI (Buchanan et al. 2012; Gohou and Soumare 2012; Wu and Hsu 2012; Mijiyawa 2015). Thus, a system of simultaneous relationship can be established as follows:

$$\mathrm{HDI}_j = f(Z_j, \mathrm{FDI}_j, \mathrm{INV}_j, \mathrm{POPG}_j, \mathrm{Price}_j, \mathrm{OPEN}_j, \mathrm{RLAW}_j) \quad (3)$$

$$Z_{ij} = f(\mathrm{HDI}_j, \mathrm{FDI}_j, \mathrm{INV}_j, \mathrm{POPG}_j, \mathrm{Price}_j, \mathrm{OPEN}_j, \mathrm{RLAW}_j) \quad (4)$$

where Z is later defined for the agricultural, service and manufacturing sectors as AGR, SER and MAN, respectively.

4 Methodology

4.1 Model specification and estimation technique

4.1.1 Heterogeneous panel Granger causality test

In line with the theoretical framework in the previous section, causality between the main variables (FDI, sectoral output–Z and HDI) is first examined. Causality looks at whether the past values of one variable (for example, FDI) can improve the prediction of another variable (for example, Z) apart from the one given by its own past values. Causality captures the antecedence and information content of FDI in respect of Z and vice versa. Recent development in panel data econometric modelling has led to the development of the panel causality test which accounts for potential heterogeneity in the data by permitting all coefficients to vary across cross sections and also recognises cross-sectional dependence using critical values obtained from the block bootstrap procedure. Thus, we adopt the approach by Dumitrescu and Hurlin (2012) to conduct heterogeneous panel causality in this study using the estimation method developed by Lopez and Weber (2017).

Assuming two stationary variables, x (FDI) and y (sectoral out-Z), the Granger non-causality between these variables for individual country i in period t is tested in a panel data framework using the following VAR model:

$$y_{i,t} = \alpha_i + \sum_{K=1}^{K} \beta_{ik} y_{i,t-k} + \sum_{K=1}^{K} \gamma_{ik} x_{i,t-k} + \varepsilon_{i,t} \tag{5}$$

In this case, coefficients differ across individuals but they are time invariant while K (lag order) is identical for all individuals with balanced panel. In line with Granger (1969), determining the existence of causality involves testing for significant effects of past values of x on the present value of y. The null hypothesis is defined as:

$$H_0 : \theta_{i1} \ldots = \gamma_{ik} = 0 \quad \pi_i = 1 \tag{6}$$

This represents a situation where there is no causality for all individuals in the panel. However, the test allows existence of causality for some individuals, in which case the alternative hypothesis is written as:

$$H_0 : \theta_{i1} \ldots = \gamma_{ik} = 0 \quad \pi_i = 1 \ldots N_1$$

$$\theta_{i1} \neq 0 \,\text{or}\, = \gamma_{ik} \neq 0 \quad \pi_i = N_I + 1 \ldots N$$

where $N_1 [0, N-1]$ is unknown.

In the event where $N_1 = 0$, causality exists for all individuals in the panel. In the case where N_1 is strictly smaller than N, there is no causality for all individuals and H_1 reduces to H_0.

According to Dumitrescu and Hurlin (2012), the procedure starts by running the N individual regressions in Eq. (5). Then, perform F tests of the K linear hypotheses $\gamma_{i1} = \ldots = \gamma_{iK} = 0$ to retrieve W_i, before computing $\overline{W}$ as the average of the N individual Wald statistic as follows:

$$\overline{W} = \frac{1}{N} \sum_{i=1}^{N} W \tag{7}$$

W represents the standard adjusted Wald statistic for individual i observed during t periods. Since Monte Carlo simulations of Dumitrescu and Hurlin (2012) show that $\overline{W}$ is asymptotically well behaved, it can genuinely be used for panel causality analysis.

Moreover, given the assumption that the Wald statistic, W_i, is independently and identically distributed across individuals, then the standardised statistic $\overline{Z}$ when $T \to \infty$ and $N \to \infty$ follows a standard normal distribution:

$$\overline{Z} = \sqrt{\frac{N}{2k}}.(\overline{W} - K) \quad d \quad N(0,1) \\ N \vec{\to} \infty \tag{8}$$

For a fixed T dimension where $T > 5 + 3K$, the approximated standardised statistic $\tilde{Z}$ follows a standard normal distribution:

$$\tilde{Z} = \sqrt{\frac{N}{2K} \cdot \frac{T-3K-5}{T-2K-3}} \cdot \left[\frac{T-3K-3}{T-3K-1} \cdot \overline{W} - K\right] d \quad N(0,1) \tag{9}$$
$$N \vec{\rightarrow} \infty$$

The procedure for testing the null hypothesis in Eq. (6) is based on $\overline{Z}$ and $\tilde{Z}$ in Eqs. (8) and (9), respectively. If these statistics are larger than the corresponding normal critical values, then there is Granger causality and H_0 should be rejected. Where N and T are large panel datasets, $\overline{Z}$ can be reasonably considered. Where N is large, but T is relatively small, $\tilde{Z}$ will be appropriate. In addition, Dumitrescu and Hurlin (2012) showed, in Monte Carlo simulations, that the test exhibits very good finite sample properties, even when both T and N are small.

4.1.2 Panel multivariate linear and nonlinear Granger causality test

Given that economic relationships are complex and not bivariate as assumed in the previous causality method, we also used a multivariate approach. Thus, the directions of causality among the main variables in this study (FDI, HDI and Z) are examined in a multivariate panel framework. According to Engle and Granger (1987), if two non-stationary variables are co-integrated, then a VAR in first differences will be mis-specified. When a long-run equilibrium relationship is established among foreign direct investment (FDI), sectoral output (Z) and HDI, a model is specified with a dynamic error correction representation. Following Bai et al. (2011), a panel multivariate linear Granger causality test can be articulated to test the linear relationship between two vectors of different stationary series–for instance X_{jt} (such as FDI) and Y_{jt} (HDI).

4.2 VAR framework

$$\left(\frac{x_{it}}{y_{it}}\right) = \left(\frac{A_{x,it[n_1\times 1]}}{A_{y,it[n_2\times 1]}}\right) + \begin{pmatrix} A_{xx,jt}(L)[n_1 \times n_1] & A_{xy,jt}(L)[n_1 \times n_2] \\ A_{yx,jt}(L)[n_2 \times n_1] & A_{yy,jt}(L)[n_2 \times n_2] \end{pmatrix} + \left(\frac{x_{j,t-1}}{y_{j,t-1}}\right) + \left(\frac{e_{x,jt}}{e_{y,jt}}\right) \tag{10}$$

where $A_{x,it[n_1\times 1]}$ and $A_{y,it[n_2\times 1]}$ are two vectors of intercept terms, $A_{xx,jt}(L)[n_1 \times n_1]$, $A_{xy,jt}(L)[n_1 \times n_2]$, $A_{yx,jt}(L)[n_2 \times n_1]$ and $A_{yy,jt}(L)[n_2 \times n_2]$ are matrices of lag polynomials, and $e_{x,jt}$ and $e_{y,jt}$ are corresponding residual terms.

To test the multivariate causal relationship between vectors X_{jt} and Y_{jt}, two null hypotheses are tested as follows:

$$H_0^1 : A_{xy,jt}(L) = 0$$

$$H_0^2 : A_{yx,jt}(L) = 0$$

There are four different situations for these causality relationships:

(1) There is unidirectional causality from Y_{jt} to X_{jt} if H_0^1 is rejected but H_0^2 is not rejected.
(2) There is unidirectional causality from X_{jt} to Y_{jt} if H_0^2 is rejected but H_0^1 is not rejected.
(3) There is feedback relation when both H_0^1 and H_0^2 are rejected.
(4) X_{jt} and *Yjt* are not being rejected to be independent when both H_0^1 and H_0^2 are not rejected.

A restricted VAR (ECM-VAR) is employed to test the causality relationship between two vectors of non-stationary time series, where the time series are co-integrated.

4.3 ECM-VAR framework

$$\left(\frac{x_{it}}{y_{it}}\right) = \left(\frac{A_{x,it[n_1\times 1]}}{A_{y,it[n_2\times 1]}}\right) + \begin{pmatrix} A_{xx,it}(L)\left[n_1 \times n_1\right] & A_{xy,jt}(L)\left[n_1 \times n_2\right] \\ A_{yx,it}(L)\left[n_2 \times n_1\right] & A_{yy,jt}(L)\left[n_2\right] \times n_2\right] \end{pmatrix} + \left(\frac{x_{j,t-1}}{y_{j,t-1}}\right) + \left(\frac{\alpha_x\left[n_1 \times 1\right]}{\alpha_y\left[n_2 \times 1\right]}\right)\mathrm{ecm}_{j,t-1} + \left(\frac{e_{x,jt}}{e_{y,jt}}\right) \tag{11}$$

where $\mathrm{ecm}_{i,t-1}$ is the lag 1 case error correction model parameter, $\alpha_{x,jt}\left[n_1 \times 1\right]$ and $\alpha_{y,jt}\left[n_2 \times 1\right]$ are vectors of coefficients of $\mathrm{ecm}_{j,t-1}$ term.

Thus, the null hypotheses $H_0^1 : A_{xy,jt}(L) = 0$ and/or $H_0^2 : A_{yx,jt}(L) = 0$ can be tested to identify the causality relationship.

In principle, the multivariate nonlinear causality is similar to the bivariate nonlinear causality test developed by Hiemstra and Jones (1994). In order to identify any nonlinear Granger causality relationship between two vectors of the time series, say X_{jt} and Y_{jt}, in the multivariate setting, the residuals from either the VAR or ECM-VAR model above are obtained, before applying a nonlinear Granger causality test to the residual series.

4.3.1 Simultaneous equation framework

Following the theoretical framework and the possibility of bidirectional causality among the variables, the simultaneous Eqs. (3) and (4) are re-specified in sector specific and log-linear terms.[3] Based on data availability for the variables, the simultaneous equations estimated are given as follows (see next subsection for variables definitions):

$$\mathrm{IN}(\mathrm{AGR}_{jt}) = \beta_0 + \beta_{1i}\mathrm{IN}(\mathrm{FDI}_{jt}) + \beta_{2i}\mathrm{IN}(\mathrm{INV}_{jt}) + \beta_{3i}(\mathrm{POPG}_{jt}) + \beta_{4i}\mathrm{IN}(\mathrm{OPEN}_{jt}) + \beta_{5i}\mathrm{IN}(\mathrm{HDI}_{jt}) + \beta_{6i}\mathrm{IN}(\mathrm{AGPrice}_{jt}) + \beta_{7i}\mathrm{IN}(\mathrm{RLAW}_{jt}) + \mu_{it} \tag{12a}$$

[3] All variables are expressed in logs except Rule of Law, Population Growth Rate and Human Development Index.

$$(\mathrm{HDI}_{jt}) = \beta_0 + \beta_{1i}\mathrm{IN}(\mathrm{AGR}_{jt}) + \beta_{2i}\mathrm{IN}(\mathrm{FDI}_{jt}) + \beta_{3i}\mathrm{IN}(\mathrm{INV}_{jt}) + \beta_{4i}(\mathrm{POPG}_{jt}) + \beta_{5i}\mathrm{IN}(\mathrm{OPEN}_{jt}) + \beta_{6i}\mathrm{IN}(\mathrm{AGPrice}_{jt}) + \beta_{7i}\mathrm{IN}(\mathrm{RLAW}_{jt}) + \mu_{it} \tag{12b}$$

$$\mathrm{IN}(\mathrm{SER}_{jt}) = \beta_0 + \beta_{1i}\mathrm{IN}(\mathrm{FDI}_{jt}) + \beta_{2i}\mathrm{IN}(\mathrm{INV}_{jt}) + \beta_{3i}(\mathrm{POPG}_{jt}) + \beta_{4i}(\mathrm{OPEN}_{jt}) + \beta_{5i}(\mathrm{HDI}_{jt}) + \beta_{6i}\mathrm{IN}(\mathrm{RLAW}_{jt}) + \mu_{it} \tag{13a}$$

$$(\mathrm{HDI}_{jt}) = \beta_0 + \beta_{1i}\mathrm{IN}(\mathrm{SER}_{jt}) + \beta_{2i}\mathrm{IN}(\mathrm{FDI}_{jt}) + \beta_{3i}\mathrm{IN}(\mathrm{INV}_{jt}) + \beta_{4i}(\mathrm{POPG}_{jt}) + \beta_{5i}\mathrm{IN}(\mathrm{OPEN}_{jt}) + \beta_{6i}\mathrm{IN}(\mathrm{RLAW}_{jt}) + \mu_{it} \tag{13b}$$

$$\mathrm{IN}(\mathrm{MAN}_{jt}) = \beta_0 + \beta_{1i}\mathrm{IN}(\mathrm{FDI}_{jt}) + \beta_{2i}\mathrm{IN}(\mathrm{INV}_{jt}) + \beta_{3i}(\mathrm{POPG}_{jt}) + \beta_{4i}(\mathrm{OPEN}_{jt}) + \beta_{5i}(\mathrm{HDI}_{jt}) + \beta_{6i}\mathrm{IN}(\mathrm{MAN\,Price}_{jt}) + \beta_{7i}\mathrm{IN}(\mathrm{RLAW}_{jt}) + \mu_{it} \tag{14a}$$

$$(\mathrm{HDI}_{jt}) = \beta_0 + \beta_{1i}\mathrm{IN}(\mathrm{MAN}_{jt}) + \beta_{2i}\mathrm{IN}(\mathrm{FDI}_{jt}) + \beta_{3i}\mathrm{IN}(\mathrm{INV}_{jt}) + \beta_{4i}(\mathrm{POPG}_{jt}) + \beta_{5i}\mathrm{IN}(\mathrm{OPEN}_{jt}) + \beta_{6i}\mathrm{IN}(\mathrm{MANPrice}_{jt}) + \beta_{7i}\mathrm{IN}(\mathrm{RLAW}_{jt}) + \mu_{it} \tag{14b}$$

Equations (12a) through (14b) are re-specified to correct for cross-sectional correlated errors, following Pesaran (2004), Binder and Offermanns (2007) and Adewuyi (2016) as follows:

$$\begin{aligned}\mathrm{IN}(\mathrm{AGR}_{it}) = {} & \beta_0 + \beta_{1i}\mathrm{IN}(\mathrm{FDI}_{it}) + \beta_{2i}\mathrm{IN}(\mathrm{INV}_{it}) + \beta_{3i}(\mathrm{POPG}_{it}) + \beta_{4i}(\mathrm{OPEN}_{it}) \\ & + \beta_{5i}(\mathrm{HDI}_{it}) + \beta_{6i}\mathrm{IN}(AG\,\mathrm{Pr}\,ice_{it}) + \beta_{7i}\mathrm{IN}(\mathrm{RLAW}_{it}) + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{AGR}}_{ij,p} \\ & + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{FDI}}_{ij,p} + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{INV}}_{ij,p} + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{POPG}}_{ij,p} + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{OPEN}}_{ij,p} \\ & + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{HDI}}_{ij,p} + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{AGPrice}}_{ij,p} + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{RLAW}}_{ij,p} + \mu_{it}\end{aligned} \tag{14c}$$

$$\begin{aligned}(\mathrm{HDI}_{it}) = {} & \beta_0 + \beta_{1i}\mathrm{IN}(\mathrm{AGR}_{it}) + \beta_{2i}\mathrm{IN}(\mathrm{FDI}_{it}) + \beta_{3i}\mathrm{IN}(\mathrm{INV}_{it}) + \beta_{4i}(\mathrm{POPG}_{it}) \\ & + \beta_{5i}\mathrm{IN}(\mathrm{OPEN}_{it}) + \beta_{6i}\mathrm{IN}(\mathrm{AGPrice}_{it}) + \beta_{7i}\mathrm{IN}(\mathrm{RLAW}_{it}) + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{HDI}}_{it,p} \\ & + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{AGR}}_{it,p} + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{FDI}}_{it,p} + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{INV}}_{it,p} + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{POPG}}_{it,p} \\ & + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{OPEN}}_{it,p} + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{AGPrice}}_{it,p} + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{RLAW}}_{it,p} + \mu_{it}\end{aligned} \tag{14d}$$

$$\begin{aligned}\mathrm{IN}(\mathrm{SER}_{it}) = {} & \beta_0 + \beta_{1i}\mathrm{IN}(\mathrm{FDI}_{it}) + \beta_{2i}\mathrm{IN}(\mathrm{INV}_{it}) + \beta_{3i}(\mathrm{POPG}_{it}) + \beta_{4i}(\mathrm{OPEN}_{it}) \\ & + \beta_{5i}(\mathrm{HDI}_{it}) + \beta_{6i}\mathrm{IN}(\mathrm{RLAW}_{it}) + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{SER}}_{ij,p} \\ & + \sum\nolimits_{p=1}^{n}\theta\overline{E}_{ij,p} + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{INV}}_{ij,p} + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{POPG}}_{ij,p} + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{OPEN}}_{ij,p} \\ & + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{HDI}}_{ij,p} + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{AGPrice}}_{ij,p} + \sum\nolimits_{p=1}^{n}\theta\overline{\mathrm{RLAW}}_{ij,p} + \mu_{it}\end{aligned} \tag{14e}$$

$$
\begin{aligned}
(\mathrm{HDI}_{it}) = {} & \beta_0 + \beta_{1i}\mathrm{IN}(\mathrm{SER}_{it}) + \beta_{2i}\mathrm{IN}(\mathrm{FDI}_{it}) + \beta_{3i}\mathrm{IN}(\mathrm{INV}_{it}) + \beta_{4i}(\mathrm{POPG}_{it}) \\
& + \beta_{5i}\mathrm{IN}(\mathrm{OPEN}_{it}) + \beta_{6i}\mathrm{IN}(\mathrm{RLAW}_{it}) + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{HDI}}_{it,p} + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{SER}}_{it,p} \\
& + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{FDI}}_{it,p} + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{INV}}_{it,p} + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{POPG}}_{it,p} \\
& + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{OPEN}}_{it,p} + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{RLAW}}_{ij,p} + \mu_{it}
\end{aligned}
\tag{14f}
$$

$$
\begin{aligned}
\mathrm{IN}(\mathrm{MAN}_{it}) = {} & \beta_0 + \beta_{1i}\mathrm{IN}(\mathrm{FDI}_{it}) + \beta_{2i}\mathrm{IN}(\mathrm{INV}_{it}) + \beta_{3i}(\mathrm{POPG}_{it}) + \beta_{4i}(\mathrm{OPEN}_{it}) \\
& + \beta_{5i}(\mathrm{HDI}_{it}) + \beta_{6i}\mathrm{IN}(\mathrm{MANPrice}_{it}) + \beta_{7i}\mathrm{IN}(\mathrm{RLAW}_{it}) + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{MAN}}_{ij,p} \\
& + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{FDI}}_{ij,p} + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{INV}}_{ij,p} + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{POPG}}_{ij,p} + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{OPEN}}_{ij,p} \\
& + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{HDI}}_{ij,p} + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{MANPrice}}_{ij,p} + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{RLAW}}_{ij,p} + \mu_{it}
\end{aligned}
\tag{14g}
$$

$$
\begin{aligned}
(\mathrm{HDI}_{it}) = {} & \beta_0 + \beta_{1i}\mathrm{IN}(\mathrm{MAN}_{it}) + \beta_{2i}\mathrm{IN}(\mathrm{FDI}_{it}) + \beta_{3i}\mathrm{IN}(\mathrm{INV}_{it}) + \beta_{4i}(\mathrm{POPG}_{it}) \\
& + \beta_{5i}\mathrm{IN}(\mathrm{OPEN}_{it}) + \beta_{6i}\mathrm{IN}(\mathrm{MANPrice}_{it}) + \beta_{7i}\mathrm{IN}(\mathrm{RLAW}_{it}) + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{HDI}}_{it,p} \\
& + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{MAN}}_{it,p} + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{FDI}}_{it,p} + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{INV}}_{it,p} + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{POPG}}_{it,p} \\
& + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{OPEN}}_{it,p} + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{MANPrice}}_{it,p} + \sum\nolimits_{p=1}^{n} \theta\overline{\mathrm{RLAW}}_{it,p} + \mu_{it}
\end{aligned}
\tag{14h}
$$

where $\overline{\mathrm{AGR}}_{ij}$, $\overline{\mathrm{FDI}}_{ij}$, $\overline{\mathrm{INV}}_{ij}$, $\overline{\mathrm{POPG}}_{ij}$, $\overline{\mathrm{OPEN}}_{ij}$, $\overline{\mathrm{HDI}}_{ij}$, $\overline{\mathrm{RLAW}}_{ij}$, $\overline{\mathrm{MAN}_{ij}\mathrm{MANPrice}}_{ij}$, $\overline{\mathrm{AGPrice}}_{ij}$ and $\overline{\mathrm{SER}}_{ij}$ are cross-sectional means of agriculture, service and manufacturing output shares (AGR, SER and MAN, respectively), foreign direct investment (FDI), investment (INV), population growth rate (POPG), trade openness (OPEN), human development index (HDI), world manufacturing price (MANPrice), world agricultural price (AGPrice) and rule of law (RLAW) measured by governance index across countries.

Since the existence of cross-sectional dependence and non-stationarity could make the estimated results imprecise, the estimation started with testing for cross-sectional dependence (CD), and stationarity using Pesaran (2004, 2015) CD tests, and Hadri (2000), Pesaran (2003; CADF and 2007; CIPS) tests, respectively. Therefore, the simultaneous equations for 5a–7b are estimated using the two-stage least squares (2SLS) and the three-stage least squares (3SLS) techniques correcting for cross-sectional dependence since there are relatively large cross sections and time periods as confirmed by the CD tests (Lee and Robinson 2016).

4.4 Data sources and description of variables

One of the major challenges faced in this study was the availability of data for the African countries. In trying to overcome this difficulty, data were collected from different sources for 23 countries[4] for the period 1990–2019. These years capture the

[4] See Appendix for the list of countries.

period when virtually all the regions witnessed positive aggregate FDI inflows (see Table4). FDI data, defined as net inflows of FDI as a percentage of GDP, were sourced from World Development Indicators (WDI) (World Bank 2021), while agricultural and manufacturing world prices (AGPrice and MANPrice, respectively) were obtained from the World Bank's Global Economic Monitor database. Human development index (HDI) which is an aggregate composite of measures of well-being was sourced from (WDI 2021).[5] Data for sectoral output share (share of agriculture–AGR, manufacturing–MAN and services–SER in GDP) and population growth rate (POPG) were sourced from UNCTAD and the World Development Indicators (WDI) (World Bank database 2021), respectively. Data for rule of law (RLAW) which is the measure of institutional quality were sourced from the worldwide governance indicators (WGI 2021). The study adopted the percentile rank among all countries and ranges from 0 (lowest) to 100 (highest). Data for openness to trade (OPEN) defined as the average of the sum of exports plus imports to total output (GDP) was sourced from the World Development Indicators (World Bank 2021). The per capita growth rate of output is measured as the growth of real per capita GDP in constant dollars using data from the WDI (World Bank 2021). Investment–GDP ratio (INV) was proxied by gross capital formation as a percentage of GDP (WDI 2021). This is defined as outlays on fixed assets of the economy plus net changes in the level of inventories.

5 Results and discussions

5.1 Descriptive statistics and correlation analysis

The descriptive statistics and correlation analysis of the variables used in the regression analysis are presented in Table 1. Rule of law (RLAW) recorded the highest mean and maximum while share of service in GDP (SER) had the highest minimum value among the series. Conversely, human development index (HDI) had the least average value while foreign direct investment (FDI% of GDP) had the least minimum value among the variables. It was also observed that variability was highest for rule of law (RLAW), while HDI appeared to be the least volatile among the variables. A weak to moderate correlation exists among all the pairs of variables except between the share of manufacturing and service in GDP and between private consumption expenditure per capita (PCPC) and HDI where correlation is high.

Also, the correlation analysis shows that population growth (POPG) has a negative relationship with all other variables except share of agricultural output in total GDP (AGR). FDI and HDI have a positive relationship with all other variables except population growth (POPG). Similarly, service output and manufacturing

[5] We also employed the Households and NPISHs Final consumption expenditure per capita (constant 2010 US$) as a measure of general wellbeing to check for robustness of results. This data was obtained from the World Bank data base online (WDI 2021).

Table 1 Descriptive statistics and correlation analysis. *Source*: Computed by the authors

	HDI	AGPRICE	AGR	FDI	INV	MANPRICE	MAN	OPEN	PCPC	POPGR	SER	RLAW
Summary statistics												
Mean	0.495	4.264	21.387	5.121	2.981	4.164	20.917	4.239	6.771	0.754	22.507	39.158
Median	0.487	4.194	21.224	5.281	3.030	4.207	20.819	4.195	6.650	0.954	22.323	42.244
Maximum	0.781	4.800	25.424	9.357	4.119	4.753	24.731	5.138	8.826	2.069	26.322	83.663
Minimum	0.208	3.849	18.400	−4.605	−1.228	3.613	16.811	2.980	5.211	−1.877	19.519	0.500
Std. Dev	0.113	0.295	1.493	2.150	0.474	0.329	1.645	0.446	0.870	0.521	1.499	21.357
Skewness	0.154	0.381	0.256	−0.612	−2.374	0.053	0.293	−0.022	0.273	−1.897	0.677	−0.068
Kurtosis	2.643	1.708	2.586	3.889	17.638	1.733	2.682	2.260	2.177	8.367	2.866	1.992
Jarque–Bera	5.668	57.417	11.056	58.353	6039.105	41.192	11.338	14.004	24.877	1101.848	47.256	26.406
Probability	0.059	0.000	0.004	0.000	0.000	0.000	0.003	0.001	0.000	0.000	0.000	0.000
Sum	303.000	2609.372	13,088.770	3133.833	1824.519	2548.342	12,801.460	2594.007	4143.548	461.459	13,774.490	23,964.910
Sum Sq. Dev	7.802	53.232	1362.393	2823.587	137.307	66.090	1653.575	121.579	462.547	165.567	1372.879	278,684.600
Observations	612	612	612	612	612	612	612	612	612	612	612	612
Correlation results												
HDI	1.000	0.280*	0.044	0.455*	0.349*	0.252*	0.497*	0.389*	0.872*	−0.551*	0.509*	0.454*
AGPRICE		1.000	0.118*	0.452*	0.254*	0.930*	0.191*	0.160*	0.181*	−0.051	0.203*	0.003
AGR			1.000	0.502*	−0.220*	0.107*	0.709*	−0.624*	−0.022	0.225*	0.812*	−0.278*
FDI				1.000	0.241*	0.408*	0.558*	0.041	0.328*	−0.114*	0.656*	0.017
INV					1.000	0.212*	0.063	0.412*	0.230*	−0.124*	0.007	0.463*
MANPRICE						1.000	0.171*	0.140*	0.161*	−0.045	0.182*	0.003
MAN							1.000	−0.271*	0.471*	−0.174*	0.904*	0.072
OPEN								1.000	0.374*	−0.369*	−0.318*	0.285*
PCPC									1.000	−0.599*	0.462*	0.479*
POPG										1.000	−0.125*	−0.335*
SER											1.000	0.023
RLAW												1.000

All variables are expressed in logs except rule of law, population growth rate and human development index. *significant at 1%

shares in GDP have positive correlation with all variables except trade openness (OPEN) and population growth (POPG) where correlation is negative. Agricultural output share in GDP maintained a negative association with investment (INV), trade openness (OPEN), rule of law (RLAW) and private consumption per capita (PCPC).

6 Test for cross-sectional dependence (CD) and stationarity

This study conducted the Pasaran (2004) and Pasaran (2015) CD tests to discover the existence of global common shocks or spillover effect that may result in imprecise model estimates. The tests have the null hypothesis of no cross-sectional dependence which is robust in the presence of multi-breaks in slope coefficients and in the error variance. The results of the two tests presented in Table 2 clearly reject the null hypothesis of no cross-sectional dependence among panel groups, except in the case of rule of law where only Pesaran (2015) shows evidence of cross-sectional independence.

The stationarity property of the series was established, using Hadri (2000) LM, Pesaran (2003)'s CADF and Pesaran (2007)'s CIPS tests. The results presented in Table 3 show that the series are stationary either at level or at first difference. Following the results of the above tests, we proceeded to estimate our simultaneous equation models which were corrected for cross-sectional dependence and stationarity status of the variables. It should be noted that although OLS was used along with the simultaneous equation techniques (2SLS and 3SLS), the latter was interpreted and analysed.

In particular, in the next subsection, we shall focus on the interpretation and analysis of the estimates obtained from the 3SLS method because of its ability to account for both endogeneity and contemporaneous correlation of the error terms in the estimated equations.

7 Granger causality among FDI, sectoral output and HD level

The results of the heterogeneous panel Granger causality analysis reported in Table 4 reveal significant positive bidirectional causality between FDI and each of agricultural, manufacturing and service output. A similar bidirectional causality is found between HDI and private consumption per capita (PCPC) as well as each of the sectoral outputs.

The vector auto-regression (VAR) or ECM-VAR models were also employed to examine whether multivariate linear Granger causality relationships exist among foreign direct investment (FDI), sectoral output and human development index (HDI). As presented in Table 5, there is a unidirectional linear Granger causality from agricultural output and HDI to FDI. Unidirectional linear Granger causality from manufacturing output and HDI to FDI was also discovered. For the service sector, no linear Granger causality exists from the output of the sector and HDI to

Table 2 Cross-sectional dependence test. *Source*: Computed by the authors

Variable	Pasaran (2004) CD test	Pasaran (2015) CADF test
MAN	– 64.874* (0.000)	119.362* (0.000)
AGR	– 62.353* (0.000)	119.389*(0.000)
SER	– 108.865* (0.000)	119.387*(0.000)
OPEN	– 13.403* (0.000)	119.078*(0.000)
FDI	– 62.563* (0.000)	103.426*(0.000)
INV	– 14.037* (0.000)	117.128*(0.000)
RLAW	– 0.688 (0.491)	110.475*(0.000)
HDI	– 81.484* (0.000)	118.785*(0.000)
POPG	– 6.191* (0.000)	106.545* (0.000)
AGPRICE	– 82.650*(0.000)	82.650*(0.000)
MANPRICE	– 82.650*(0.000)	82.650*(0.000)
PCPC	– 59.577*(0.000)	82.602*(0.000)

The test assumes null hypothesis of cross-sectional independence, CD ~ $N(0,1)$ with P values close to zero indicate that data are correlated across panel groups, while the Pasaran (2015) CADF test assumes that errors are weakly cross-sectional dependent

FDI or vice versa. Moreover, the multivariate nonlinear Granger causality test was applied to the error terms from the estimated VAR or ECM-VAR models to investigate whether there were any remaining undetected multivariate nonlinear relationships among the variables.

The results show evidence of unidirectional nonlinear causality from FDI to agricultural output and HDI and from FDI to manufacturing output and HDI as well as from FDI to service output. Therefore, combining the results of both the linear and nonlinear multivariate Granger causality tests, it could be concluded that a bidirectional (feedback) causality exists among the variables. This is because, while the linear method discovers one part of the causality, the nonlinear technique finds the other part. Thus, further analysis was conducted using simultaneous equation model that provided not only the causality among the variables but also the direction and precise estimates of the effect of one variable on the others.

In order to account for robustness, the linear and nonlinear causality tests based on the VECM and VAR frameworks are repeated using the personal consumption per capital (PCPC) for individual country with results presented in Table 6. The results reveal bidirectional linear Granger causality from agricultural output and PCPC to FDI and vice versa (reverse from FDI to agricultural output and PCPC). Furthermore, unidirectional linear Granger causality exists from FDI to service output and PCPC while bidirectional linear granger causality is observed to move from FDI to manufacturing output and PCPC and vice versa. On the other hand, the results of the nonlinear multivariate causality show only unidirectional nonlinear Granger causality from FDI to agricultural output and PCPC.

The possibility of feedback relationship among FDI, sectoral output and welfare level as suggested by the results of the multivariate Granger causality tests therefore

Table 3 Panel unit root test results. *Source*: Computed by the authors

		Hadri (2000) LM test			Pesaran's (2003) CADF		Pesaran's CIPS (2007)				Decision
		Hadri *Z* test	No. of periods	No of panels	*t*-bar	*N*, *T*	CIPS*	*N*, *T*	Critical values		
MAN	L	8.965*	27	34	− 1.989***	33, 27	− 1.909	33, 27	0.01	− 2.3	I(0)
	D	3.866*	26		− 2.528*	33, 26	− 4.301*	33, 26			
AGR	L	11.257*	27		− 1.745	33, 27	− 1.897	33, 27			I(1)
	D	1.297***	26		− 2.620*	33, 26	− 4.247*	33, 26			
SER	L	12.698*	27		− 2.162*	33, 27	− 2.360*	33, 27			I(0)
	D	4.994*	26		− 2.596*	33, 26	− 4.927*	33, 26			
OPEN	L	6.823*	27		− 1.736	33, 27	− 2.431*	33, 27	0.05	− 2.16	I(0)
	D	0.063	26		− 2.600*	33, 26	− 5.016*	33, 26			
FDI	L	6.735*	27		− 2.848*	33, 27	− 3.775*	33, 27			I(0)
	D	0.904	26		− 3.626*	33, 26	− 5.722*	33, 26			
INV	L	5.414*	27		− 2.235*	33, 27	− 2.893*	33, 27			I(0)
	D	0.213	26		− 3.036*	33, 26	− 5.007*	33, 26			
RLAW	L	11.160*	27		− 1.131	33, 27	− 1.246	33, 27	0.1	− 2.08	I(1)
	D	1.497***	26		− 2.282*	33, 26	− 4.356*	33, 26			
HDI	L	12.104*	27		− 1.637	33, 27	− 1.224	33, 27			I(1)
	D	3.442*	26		− 2.030***	33, 26	− 3.346*	33, 26			
POPG	L	2.843*	27		− 2.179*	33, 27	− 2.915*	33, 27			I(0)
	D	− 1.421	26		− 2.631*	33, 26	− 3.034*	33, 26			

(a) *, **, *** represent 1, 5 and 10% significant levels, respectively, while *L* and *D* denote stationarity at level and at first deference, respectively. *L* level, while *D* difference

Table 4 Results of heterogeneous panel Granger causality test following Dumitrescu and Hurlin (2012). *Source*: Author(s) estimate using STATA 15

Dependent variable	FDI	AGRS	MAN	SER	HDI	PCPC
FDI	–	14.737 (0.000)***	14.899 (0.000)***	23.809 (0.000)***	–	–
AGRS	9.548 (0.000)***	–	–	–	20.189 (0.000)***	15.368 (0.000)***
MAN	17.772 (0.000)***	–	–	–	47.228 (0.000)***	22.244 (0.000)***
SER	6.204 (0.000)***	–	–	–	20.667 (0.000)***	14.098 (0.000)***
HDI	–	24.726 (0.000)***	16.199 (0.000)***	26.526 (0.000)***	–	–
PCPC	–	10.803 (0.000)***	6.315 (0.000)***	13.868 (0.000)***	–	–

The *Z*-bar statistics were reported with a single optimal lagged chosen from a range of 1 to 7, with probability value in parenthesis. The system was allowed to determine the optimal lagged value by using Bayesian information criterion (BIC) option in the Dumitrescu and Hurlin (2012) Granger non-causality estimates. ***, ** and * denote a significant value at 1, 5 and 10%, respectively

Table 5 Linear and nonlinear multivariate Granger causality test for FDI, sectoral output and HDI

Variables	Null hypothesis: FDI does not cause sectoral output and HDI		Null hypothesis: sectoral output and HDI do not cause FDI		Result
	Chi-square	*P* value	Chi-square	*P* value	
Linear multivariate Granger causality					
HDI, AGR and FDI	1.911	0.384	13.734	0.001	HDI, AGR → FDI
HDI, MAN and FDI	5.703	0.793	6.301	0.042	HDI, MAN → FDI
HDI, SER and FDI	2.891	0.235	3.141	0.127	No linear multivariate Granger causality
Nonlinear multivariate Granger causality					
HDI, AGR and FDI	3.126	0.048	0.726	0.484	FDI → HDI, AGR
HDI, MAN and FDI	2.242	0.084	0.231	0.793	FDI → HDI, MAN
HDI, SER and FDI	3.711	0.025	1.360	0.257	FDI → HDI, SER

HDI human development index, *AGRS* agricultural output, *MANS* manufacturing output, *SERV* service output, *FDI* foreign direct investment

informs the conduct of further analysis using simultaneous equation model to avoid simultaneity bias in the results.

8 Simultaneous equation results

In the estimations for all the sectors, 3SLS estimates were preferred since this solved the problems of endogeneity and contemporaneous correlations among the models' residuals.

8.1 The effect of FDI on agricultural output growth and HD

The results of the OLS, 2SLS and 3SLS methods for the effect of FDI on agricultural sector output and HDI are reported in Table 7. The results reveal that FDI exerts insignificant positive impact on both agricultural output and HDI. This implies that inflow of FDI has little complementary effect on domestic investment in the sector in terms of reducing the application of crude implements in farming activities as FDI produces little technology spillover to replace manual activities and raise productivity as well as human development. This finding is inconsistent with Basu and Guariglia (2007) who noted that FDI reduced the share of agriculture to GDP among 119 selected developing countries. This suggests that while domestic capital formation in most African countries enhances productivity in the sectors with investment in the accumulation of inputs, it does not necessarily translate to welfare improvement.

Similarly, rule of law enforcement exerts significant negative and positive effects on agricultural output and HDI, respectively, as a 1.0% improvement in

Table 6 Linear and nonlinear multivariate Granger causality test for FDI, sectoral output and PCPC

Variables	Null hypothesis: FDI does not cause sectoral output and PCPC		Null hypothesis: sectoral output and PCPC do not cause FDI		Result
	Chi-square	*P* value	Chi-square	*P* value	
Linear multivariate Granger causality					
PCPC, AGR and FDI	4.587	0.100	35.559	0.000	PCPC, AG ↔ FDI (feedback)
PCPC, MAN and FDI	9.391	0.009	7.131	0.028	PCPC, MAN ↔ FDI(feedback)
PCPC, SER and FDI	6.994	0.030	2.597	0.272	FDI → PCPC, SER
Nonlinear multivariate Granger causality					
PCPC, AGR and FDI	2.480	0.084	0.0437	0.957	FDI → PCPC, AGR
PCPC, MAN and FDI	0.268	0.764	0.312	0.731	No nonlinear multivariate Granger causality
PCPC, SER and FDI	2.047	0.130	0.358	0.690	No nonlinear multivariate Granger causality

PCPC per capita private consumption, *AGR* agricultural output, *MAN* manufacturing output, *SER* service output, *FDI* foreign direct investment

the enforcement of the rule of law generated a 0.19% fall and a 0.01% rise in agricultural output and HDI, respectively. This reflects the positive influence of improvement in institutional quality on the implementation and execution of human development and welfare improvement programmes in the African states. However, enforcement of rule of law may hinder agricultural productivity, particularly when such laws prohibit child and female labour among the agricultural or rural populace. The results also indicate that while openness of the economy harms agricultural productivity, it enhances human development. The first part of the results may be a reflection of lack of competitiveness of the African agricultural sector (output) in the international market, while the second part probably exhibits the role of trade in enhancing welfare by broadening production and consumption baskets, and providing commodities at competitive and affordable prices.

The results of the feedback effect between HDI and agricultural output show that HDI had significant positive impact on agricultural output, while the latter also exerted significant positive effect on HDI. Hence, a 1.0% increase in HDI led to a 17.93% increase in agricultural output growth while a similar increase in the latter raised the former by about 0.05%. This may imply that as human development improves, there will be an increase in agricultural output as improved education, health and income enable people to raise their productivity levels.

Also, the results suggest that, as agricultural output rises, food becomes affordable, nutritional status improves and linkage with other sectors progresses thus leading to improvement in overall well-being). This result is consistent with the

Table 7 Regression on FDI, agricultural sector output and HDI. *Source*: Computed by the authors

Dependent variable	AGRS (1)	HDI (2)	AGRS (3)	HDI (4)	AGRS (5)	HDI (5)
	OLS		2SLS		3SLS	
FDI	0.344*** (0.0207)	0.0128*** (0.00226)	0.220 (0.203)	−0.0158 (0.0213)	0.00881 (0.137)	0.00484 (0.0139)
INV	−0.216** (0.0893)	−0.00487 (0.00832)	2.800** (1.315)	−0.217*** (0.0352)	3.969*** (1.017)	−0.223*** (0.0327)
POPGR	0.0953*** (0.0329)	−0.0207*** (0.00296)	−0.119 (0.115)	0.00920 (0.00786)	−0.165 (0.109)	0.00925 (0.00735)
OPEN	−2.046*** (0.0888)	0.107*** (0.0104)	−2.730*** (0.443)	0.208*** (0.0595)	−3.095*** (0.357)	0.160*** (0.0449)
RLAW	−0.0108*** (0.00200)	0.00206*** (0.000171)	−0.142*** (0.0537)	0.0109*** (0.00115)	−0.190*** (0.0416)	0.0104*** (0.00102)
HDI	2.783*** (0.423)		12.95** (5.230)		17.93*** (3.854)	
AGPRICE	0.00273 (0.00245)	9.31e–05 (0.000227)	0.00224(0.00727)	−7.40e–05 (0.001)	−0.000339 (0.00695)	8.08e–05 (0.000502)
FDIMEAN	−0.145 (0.150)	0.000441 (0.0117)	−0.0434 (0.511)		−0.0146 (0.0867)	
INVMEAN	0.554 (0.821)	0.0587 (0.0640)	−2.716 (2.983)	0.252 (0.156)	−5.461*** (1.975)	0.335** (0.134)
POPGRMEAN	−1.112 (0.943)	0.0740 (0.0846)	0.290 (2.853)	0.0336 (0.209)	0.984 (2.535)	−0.0653 (0.183)
OPENMEAN	0.603 (1.215)	−0.203* (0.109)	0.964 (3.739)	−0.0907(0.253)	1.404 (3.360)	−0.0796 (0.236)
HDIMEAN	−4.333(4.397)		−12.07 (14.30)		−4.073 (4.241)	
RLAWMEAN	0.0160 (0.0472)	0.000937 (0.00414)	0.148 (0.147)	−0.0103 (0.00975)	0.173 (0.126)	−0.00905 (0.00908)
AGPRICEMEAN	–	–	–	–	–	–
AGRS		0.0239*** (0.00363)		0.0755** (0.0302)		0.0489** (0.0214)
AGRSMEAN		0.0364 (0.0316)		0.0927 (0.0685)		
Constant	25.65*** (4.434)	−0.812 (0.736)	26.28** (13.22)	−3.777* (2.248)	26.87** (12.84)	−1.327 (1.247)
Observations	621	621	621	621	621	621
R-squared	0.697	0.575				
F-stat (*P* value)	107.82 (0.000)	63.29 (0.000)	14.30 (0.000)	21.00 (0.000)	262.20 (0.000)	286.01 (0.000)
Hansen–Sargan test			90.770 (0.000)		2.145 (1.000)	
Haussmann test			2.10 (0.998)			

Standard errors in parentheses, $^{***}p<0.01$, $^{**}p<0.05$, $^{*}p<0.1$. All the variables are expressed in logs except rule of law and human development index

Chi-square value and probability value are reported in the *F*-statistics column for 3SLS models.

findings of Msuya (2007) where agricultural productivity was considered essential to achieving sustainable growth.

8.2 The effect of FDI on service output growth and HD

The results presented in Table 8 reveal that FDI had significant positive effect on both service sector output and HDI, as a 1.0% increase in FDI inflow resulted in a 1.19 and 0.09% increase in service sector output and HDI, respectively. This reflects the significant spillover effect of FDI in the service sector in the African countries, which translates to significant welfare growth as employment and service delivery in this sector (particularly telecommunication and transportation) rise in most African economies due to complementarity and competition between domestic and foreign investments. Moreover, rule of law exerts significant positive effect on both service output and HDI. This underscores the positive impact of improvement in the enforcement of rule of law on economic activities, as well as better access to basic education and health facilities (under compulsory universal basic education and health insurance programmes) which leads to improvement in general welfare conditions in Africa. Thus, improvement in the enforcement of rule of law is important for the effectiveness of HD programmes in the region.

Domestic investment, however, has significant negative impact on both HDI and service sector GDP, while the influences of both trade openness and population growth are insignificant. The estimates show that a 1.0% increase in domestic investment hurts service sector output and HDI by 5.41 and 0.39%, respectively, aggravating welfare loss. It may also portray diminishing marginal productivity of labour in the sector. Further results show that the influence of HDI on service sector output is significantly negative while the effect of the latter on HDI is negligible. Thus, a 1.0% improvement in HDI (welfare improvement) cripples service output by about 13.96% as the required high skills and energy are produced via improved education and health to engage in more rewarding and specialised or real sector activities than providing services.

Thus, improvement in education (skill) and health status of labour may not significantly raise the level of service output. Hence, improvement in service sector output may not enhance human development following lack of trickle-down effect on the society in terms of increased employment and income as well as social responsibility.

8.3 The effect of FDI on manufacturing output growth and HD

According to the results in Table 9, FDI had significant positive effect on both manufacturing output and human development. This implies that 1.0% rise in FDI raises manufacturing output and human development by about 1.95 and 0.04%, respectively. These results reflect the spillover effect of FDI on the sector in terms of inflow of better technology, skills and managerial capabilities which promote efficiency and productivity growth. FDI, when properly harnessed could lead to transfer of technology and skills to host countries and this in turn promotes human

Table 8 Regression results on FDI service sector output and HDI. *Source*: Computed by the authors

Dependent variable	SERV (1)	HDI (2)	SERV (3)	HDI (4)	SERV (5)	HDI (6)
	OLS		2SLS		3SLS	
FDI	0.340***(0.0193)	−0.00270(0.00193)	1.179***(0.302)	0.0850**(0.0358)	1.191***(0.297)	0.0850**(0.0355)
INV	−0.0986(0.0834)	−0.00184(0.00681)	−5.301**(2.241)	−0.387***(0.103)	−5.412**(2.197)	−0.387***(0.102)
POPGR	−0.0433(0.0307)	−0.0102***(0.00247)	0.178(0.191)	0.0131(0.0118)	0.183(0.188)	0.0131(0.0117)
OPEN	−1.686***(0.0828)	0.123***(0.00721)	−0.237(0.713)	−0.0146(0.0607)	−0.210(0.701)	−0.0146(0.0601)
RLAW	−0.00647***(0.00187)	0.00153***(0.000141)	0.204**(0.0919)	0.0149***(0.00334)	0.209**(0.0900)	0.0149***(0.00331)
HDI	7.488***(0.394)		−13.51(8.547)		−13.96*(8.368)	
FDIMEAN	−0.153(0.140)	0.00710(0.0105)	−0.266(0.807)		0.0199(0.181)	
INVMEAN	0.600(0.749)	0.0268(0.0553)	8.223*(4.774)	0.623**(0.286)	9.094**(4.085)	0.623**(0.283)
POPGRMEAN	−0.870(0.873)	0.0712(0.0693)	−3.099(4.410)	−0.204(0.297)	−2.524(4.074)	−0.204(0.294)
OPENMEAN	0.401(1.091)	−0.129(0.0885)	−4.102(5.664)	−0.372(0.363)	−5.210(4.726)	−0.372(0.360)
HDIMEAN	−3.953(4.085)		−8.603(22.77)		−15.64(11.86)	
RLAWMEAN	0.0182(0.0438)	0.000543(0.00338)	−0.0981(0.230)	−0.00662(0.0142)	−0.0640(0.208)	−0.00662(0.0140)
SERVS		0.0497***(0.00262)		−0.0712(0.0455)		−0.0712(0.0450)
LSERVSMEAN		0.0319(0.0278)		−0.0997(0.0942)		−0.0997(0.0933)
Constant	24.21***(3.919)	−1.568**(0.643)	36.52*(19.50)	4.765(3.114)	38.68**(18.37)	4.765(3.083)
Observations	621	621	621	621	621	621
R-squared	0.745	0.714				
F-stat (P value)	147.88(0.000)	126.36(0.000)	6.91(0.000)	10.42(0.000)	364.74(0.000)	116.83(0.000)
Hansen–Sargan test			274.775(0.999)		0.135(1.000)	
Haussmann test			0.13(0.987)			

(a) Standard errors in parentheses, $***p<0.01$, $**p<0.05$, $*p<0.1$. (b) All variables are expressed in logs except rule of law, population growth rate and human development index. (c) Chi-square value and probability value are reported in the *F*-statistics column for 3SLS models.

development. These findings are in line with Akinlo (2004) where the impact of FDI on manufacturing sector output was reported to outweigh those of the extractive industry and Basu and Guariglia (2007) where FDI promotes industrial growth. The results also show that the effect of trade openness and population growth on manufacturing output and HDI is insignificant pointing to the lack of international competitiveness of this sector. It also reflects the inability of the sector to absorb the growing labour force (majority of which are unskilled), which leads to marginal rise in labour productivity in the sector.

Further, enforcement of rule of law was found to have positive effect on both manufacturing output growth and HDI. Effective enforcement of contract and property rights as well as absence of crimes fosters manufacturing productivity and human development. Similar to the results obtained for service output, HDI had significant negative effect on manufacturing sector output, while there was no feedback effect as the impact of manufacturing output on HDI was insignificant. In this case, a 1.0% increase in HDI is capable of retarding the sector's output by about 43% as diversion to human development programmes may cause increased investment in sectors such as the service (education and health) and agricultural sectors at the expense of the manufacturing sector.

However, improvement in manufacturing sector output may not promote human development. This may be the case in the absence of trickle-down effect of the sectoral growth on the society (in terms of increased employment and income as well as social responsibility) particularly if there is poor linkage of the sector with the agricultural sector, which employs a large share of the labour force and produces food and raw materials.

8.4 Robustness check

For robustness purposes, this study adopts the per capita private consumption expenditure (PCPC). A high private spending may suggest quality welfare conditions, while low spending is an indication of poor welfare conditions in an economy. Robustness results for the agricultural, service and manufacturing sectors are presented in Table 10. The results for the agricultural sector are largely consistent with earlier results in terms of sign and significance. For instance, FDI did not exert significant influence on both agricultural output and per capita private consumption, reinforcing earlier findings that FDI inflow has negligible impact on agricultural output and HDI.

Similarly, robustness estimates confirm the significant positive feedback effect between agricultural sector output and per capita private consumption (or HDI in the earlier results), with elasticities of 2.0 and 0.45, respectively. This implies that high agricultural output has positive influence on private consumption, hence improve welfare. In the same vein, human development or quality welfare condition is important for high agricultural output as improved education, health and nutritional status raise labour productivity and income in the sector, and hence enhance the output of the sector. For the service sector, FDI had significant positive impact on per capita private consumption with elasticity of 0.19, while its positive effect on the output of

Table 9 Regression results on FDI manufacturing sector output and HDI. *Source*: Computed by the authors

Dependent variable	MANS (1)	HDI (2)	MANS (3)	HDI (4)	MANS (5)	HDI (6)
Variables	OLS		2SLS		3SLS	
FDI	0.277*** (0.026)	0.007*** (0.002)	1.732* (0.904)	0.051*** (0.0175)	1.946** (0.850)	0.044*** (0.014)
INV	0.144 (0.113)	−0.0127* (0.00731)	−10.59 (7.051)	−0.313*** (0.0638)	−13.00** (6.229)	−0.300*** (0.0579)
POPGR	−0.109*** (0.0417)	−0.0106*** (0.00268)	0.410 (0.479)	0.0122 (0.00981)	0.541 (0.443)	0.0127 (0.00928)
OPEN	−1.831*** (0.112)	0.107*** (0.00756)	0.972 (2.034)	0.0295 (0.0401)	1.551 (1.865)	0.0377 (0.0364)
RLAW	−0.00619** (0.00254)	0.00161*** (0.000151)	0.436 (0.291)	0.0129*** (0.00229)	0.539** (0.255)	0.0125***(0.00210)
HDI	8.098*** (0.535)		−33.71 (26.99)		−42.98* (23.82)	
MANPRICE	0.00245 (0.00234)	−1.12e–05 (0.00223)	0.00568 (0.0175)	0.000250 (0.0234)	0.00331 (0.0169)	5.70e–05 (0.0200)
MANS		0.0337*** (0.000160)		−0.0290 (0.000565)		−0.0219 (0.000469)
FDIMEAN	−0.0575 (0.191)	0.00700 (0.00952)	−0.337(1.666)		−0.0769 (0.251)	
INVMEAN	0.942 (1.020)	0.0255 (0.0772)	15.79 (12.13)	0.553* (0.287)	17.32 (11.12)	0.389** (0.160)
POPGRMEAN	−0.106 (1.237)	0.0116 (0.0815)	−5.365 (9.841)	−0.111 (0.252)	−5.166 (9.159)	−0.112 (0.239)
OPENMEAN	0.563 (1.591)	−0.177* (0.102)	−7.488 (12.91)	−0.275 (0.311)	−11.27 (10.72)	−0.271 (0.295)
HDIMEAN	−8.070 (5.672)		−10.15 (47.46)		−2.315 (7.528)	
RLAWMEAN	−0.0100 (0.0604)	0.00231 (0.00370)	−0.320 (0.508)	−0.0102 (0.0125)	−0.356 (0.449)	−0.00802 (0.0115)
LMANPRICEMEAN	–	–	–	–	–	–
MANSMEAN		0.0333 (0.0378)		−0.0812 (0.115)		
Constant	21.78*** (5.882)	−0.891 (0.787)	44.00 (45.23)	2.804 (2.545)	56.28 (41.11)	1.310 (1.342)
Observations	621	621	621	621	621	621
R-squared	0.608	0.668				
F-stat (*P* value)	72.66 (0.000)	94.29 (0.000)	1.57 (0.086)	13.86 (0.000)	272.60 (0.000)	184.56 (0.000)
Hansen–Sargan test			122.436 (4.104)		0.616 (0.432)	
Haussmann test			0.60 (0.999)			

(a) Standard errors in parentheses, ***$p<0.01$, **$p<0.05$, *$p<0.1$. (b) All variables are expressed in logs except rule of law, population growth rate and human development index. (c) Chi-square value and probability value are reported in the *F*-statistics column for 3SLS models this sector was insignificant. This partly corroborates earlier results where FDI was found to exert significant positive impact on agricultural sector output.

Also, while the effect of per capita private consumption expenditure on service output was insignificant, the impact of the latter on the former was significantly positive with an elasticity of 0.01. This indicates that while service output growth may not be important for improving HDI, it is critical for raising per capita private consumption. In the case of the manufacturing sector, FDI had a similar significant positive effect on per capita private consumption as HDI (though with a higher elasticity of 0.22). However, its impact on the output of the sector is negligible.

Moreover, while per capita private consumption does not influence manufacturing output significantly, the effect of the latter on per capita private consumption is significantly negative. This shows that manufacturing output growth influences private consumption and HDI differently in most African countries.

9 Conclusion and policy recommendations

This study examined the effects of FDI on sectoral growth and human development in a cross-sectional panel of 34 countries, spanning 1990−2018. It adopted recent causality methods and simultaneous equation models. The paper accounted for sectoral spillover effect, heterogeneity, simultaneity and cross-sectional dependence in the modelling. The results of the bivariate causality tests revealed significant positive bidirectional causality between FDI and each of agricultural, manufacturing and service outputs. Similar bidirectional causality was also found between HDI, as well as private consumption per capita (PCPC), and each of the sectoral outputs. Combining the results of both the linear and nonlinear multivariate Granger causality tests, bidirectional (feedback) causality exists among the variables. This is because while the linear method discovers one part of the causality, the nonlinear technique finds the other part. The results of the simultaneous equation models showed that FDI promotes the outputs of the manufacturing and service sectors, but hinders that of the agricultural sector, while it fosters human development. Also, the results showed that while human development promotes the output of the agricultural sector, it deters the outputs of the manufacturing and service sectors. Further results showed that only agricultural output improves human development among the countries.

This study therefore recommends that for African countries to improve sectoral output growth and welfare using FDI as a catalyst, a policy framework toward attracting more FDI into the three key sectors (especially the manufacturing and services) is desirable for increased output and human development. Also, such policies should target inter-sectoral linkages especially between the agriculture and manufacturing sectors along the local and international value chains. The international competitiveness of the economies should be improved so as to be able to reap the benefits of openness of the economies. One way to do this is to reduce the cost of doing business in African countries and improve products quality. Moreover, there is need for continuous human development via improved quality of education and health so as to complement FDI to produce high sectoral outputs. Thus, African countries

Table 10 Robustness check on the dynamics of HDI, FDI and sectoral output

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	OLS	2SLS	3SLS			
Agricultural						
FDI	0.368*** (0.0199)	0.0664*** (0.0179)	0.314** (0.140)	− 0.200 (0.155)	0.149 (0.0957)	− 0.0373 (0.0988)
INV	− 0.157* (0.0917)	− 0.262*** (0.0659)	2.572** (1.010)	− 1.758*** (0.238)	3.599*** (0.766)	− 1.817*** (0.216)
POPGR	0.109*** (0.0346)	− 0.237*** (0.0234)	0.0557 (0.0843)	− 0.0378 (0.0558)	0.0732 (0.0831)	− 0.0363 (0.0515)
OPEN	− 2.008*** (0.0893)	0.746*** (0.0823)	− 2.628*** (0.342)	1.759*** (0.441)	− 2.934*** (0.281)	1.383*** (0.324)
RLAW	− 0.0104*** (0.00207)	0.0178*** (0.00135)	− 0.117*** (0.0361)	0.0794*** (0.00760)	− 0.153*** (0.0276)	0.0759*** (0.00665)
PCPC	0.296*** (0.0546)		1.467*** (0.500)		1.996*** (0.368)	
AGPRICE	0.00291 (0.00247)	0.000103 (0.00179)	0.00314 (0.00599)	− 0.00125 (0.00399)	0.00114 (0.00567)	− 0.000107 (0.00355)
FDIMEAN	− 0.169 (0.145)	− 0.0231 (0.0923)	− 0.0679 (0.407)		− 0.0216 (0.0774)	
INVMEAN	0.388 (0.719)	0.306 (0.506)	− 2.423 (2.032)	1.624 (1.132)	− 4.373*** (1.579)	2.335** (0.954)
POPGRMEAN	− 1.194 (0.951)	0.714 (0.670)	− 0.275 (2.324)	0.601 (1.518)	0.219 (2.100)	− 0.195 (1.316)
OPENMEAN	0.471 (1.215)	− 1.128 (0.865)	0.427 (3.017)	− 0.327 (1.845)	0.449 (2.748)	− 0.202 (1.698)
PCPCMEAN	− 0.496 (0.617)		− 1.543 (1.642)		− 0.447 (0.478)	
RLAWMEAN	0.0120 (0.0451)	− 0.0130 (0.0327)	0.126 (0.113)	− 0.0927 (0.0710)	0.168 (0.104)	− 0.0836 (0.0652)
AGPRICEMEAN	–	–	–	–	–	–
AGRS		0.156*** (0.0287)		0.663*** (0.223)		0.452*** (0.154)
AGRSMEAN		0.324 (0.250)		0.749 (0.487)		
Constant	27.29*** (5.467)	− 2.757 (5.826)	28.72** (14.54)	− 28.35* (16.20)	22.19** (10.65)	− 8.851 (8.974)
Observations	621	621	621	621	621	621
R-squared	0.691	0.530				
F-stat (*P* value)	1,044,820.24 (0.000)	526,720.24 (0.000)	20.24 (0.000)	19.07 (0.000)	345.85 (0.000)	266.34 (0.000)
Hansen–Sargan test			166.184 (1.000)	2.953 (0.999)		
Haussmann test			2.90 (0.998)			
Service						
FDI	0.384*** (0.0184)	− 0.0676*** (0.0151)	− 33.67 (1,057)	0.188 (0.147)	1.754 (29.17)	0.193*** (0.0453)

Table 10 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)
INV	0.108 (0.0846)	− 0.230*** (0.0533)	335.1 (10,328)	− 1.952*** (0.359)	− 9.510 (287.7)	− 1.961*** (0.212)
POPGR	0.0303 (0.0319)	− 0.157*** (0.0194)	3.575 (110.8)	− 0.0208 (0.0511)	− 0.0983 (9.272)	− 0.0209 (0.0504)
OPEN	− 1.657*** (0.0824)	0.929*** (0.0564)	− 88.04 (2,666)	0.530** (0.239)	1.079 (76.15)	0.523*** (0.133)
RLAW	− 0.00819*** (0.0019)	0.0138*** (0.00110)	− 12.42 (382.4)	0.0725*** (0.0109)	0.334 (10.64)	0.0728*** (0.00625)
PCPC	0.956*** (0.0504)		170.0 (5,213)		− 3.889 (143.5)	
FDIMEAN	− 0.161 (0.133)	0.0271 (0.0819)	14.65 (458.1)		− 15.34 (11.83)	
INVMEAN	0.573 (0.637)	− 0.0472 (0.433)	− 368.4 (11,384)	2.248* (1.175)	− 15.89 (326.8)	2.267** (1.004)
POPGRMEAN	− 1.026 (0.870)	0.661 (0.543)	107.8 (3,363)	− 0.439 (1.313)	− 37.66 (224.0)	− 0.447 (1.277)
OPENMEAN	0.131 (1.082)	− 0.626 (0.692)	156.1 (4,864)	− 1.200 (1.626)	58.48 (157.5)	− 1.219 (1.498)
PCPCMEAN	− 0.487 (0.568)		− 37.05 (1,110)		0.0409 (0.0692)	
RLAWMEAN	0.0293 (0.0413)	− 0.0183 (0.0264)	11.39 (349.5)	− 0.0599 (0.0632)	− 1.991 (10.99)	− 0.0598 (0.0625)
SERVS		0.389*** (0.0205)		0.0173 (0.175)		0.0116** (0.00578)
SERVSMEAN		0.301 (0.218)		− 0.0337 (0.397)		− 0.0409 (0.325)
Constant	22.90*** (4.813)	− 9.355* (5.035)	− 1,015 (32,383)	8.024 (12.84)		8.369 (6.926)
Observations	621	621	621	621	621	621
R-squared	0.745	0.690				
F-stat (*P* value)	147.84 (0.000)	112.91 (0.000)	0.00 (1.000)	24.83 (0.000)	357.02 (0.000)	289.23 (0.000)
Hansen–Sargan test			352.030 (1.000)	0.123 (0.726)		
Haussmann test			0.14 (1.000)			
Manufacturing						
FDI	0.320*** (0.0245)	0.00456 (0.0140)	15.45 (127.8)	0.209** (0.0974)	− 5.230 (15.69)	0.219*** (0.0463)
INV	0.382*** (0.113)	− 0.317*** (0.0563)	− 145.8 (1,251)	− 1.997*** (0.289)	52.01 (160.2)	− 2.030*** (0.215)
POPGR	− 0.0198 (0.0426)	− 0.157*** (0.0206)	− 1.630 (14.04)	− 0.0222 (0.0528)	0.506 (4.110)	− 0.0237 (0.0512)
OPEN	− 1.820*** (0.110)	0.820*** (0.0582)	36.00 (323.9)	0.498** (0.205)	− 15.50 (41.77)	0.465*** (0.134)
RLAW	− 0.00881*** (0.0026)	0.0143*** (0.00116)	5.395 (46.29)	0.0740*** (0.00974)	− 1.904 (5.935)	0.0754*** (0.00630)

Table 10 (continued)

	(1)	(2)	(3)	(4)	(5)	(6)
PCPC	1.079*** (0.0673)		− 72.77 (631.6)		26.96 (80.30)	
MANPRICE	0.00298 (0.00227)	− 0.000993 (0.00123)	− 0.0120 (0.245)	− 8.75e–05 (0.00312)	− 0.0112 (0.204)	− 0.00378 (0.0267)
FDIMEAN	− 0.0625 (0.178)	0.0404 (0.0733)	− 6.519 (58.67)		9.004 (7.213)	
INVMEAN	0.742 (0.851)	− 0.0726 (0.594)	162.0 (1381)	2.444 (1.567)	− 57.72 (162.4)	2.258** (0.878)
POPGRMEAN	− 0.367 (1.221)	0.327 (0.628)	− 45.26 (399.6)	− 0.385 (1.391)	35.21 (95.76)	− 0.371 (1.365)
OPENMEAN	0.208 (1.538)	− 0.820 (0.784)	− 66.42 (575.5)	− 1.250 (1.725)	− 2.798 (61.98)	− 1.285 (1.686)
PCPCMEAN	− 1.141 (0.765)		14.47 (161.6)		− 19.99 (16.09)	
RLAWMEAN	− 0.00847 (0.0568)	0.00219 (0.0285)	− 4.841 (41.86)	− 0.0601 (0.0685)	2.530 (5.033)	− 0.0565 (0.0653)
MANPRICEMEAN	–	–	–	–	–	–
MANS		0.275*** (0.0172)		− 0.0105 (0.117)		− 0.0324** (0.0152)
MANSMEAN		0.319(0.291)		− 0.106(0.643)		
Constant	23.67*** (7.064)	− 5.229 (6.061)	470.7 (3793)	9.919 (14.11)		8.839 (7.059)
Observations	621	621	621	621	621	621
R-squared	0.621	0.652				
F-stat (*P* value)	76.69 (0.000)	87.74 (0.000)	0.01 (1.000)	21.76 (0.000)	367.55 (0.000)	408.59 (0.000)
Hansen–Sargan test			409.061 (1.000)	0.246 (0.884)		
Haussmann test			0.24 (1.000)			

Standard errors in parentheses, $^{***}p<0.01$, $^{**}p<0.05$, $^{*}p<0.1$. All the variables are expressed in logs except rule of law and human development index.

Chi-square value and probability value are reported in the *F*-statistics column for 3SLS models need to learn from the experience of the major Asian economies (China and India) which have shown that population growth can be used to stimulate economic growth if there is a clear and effective framework for human capital development. This calls for compliance with the stipulated minimum budget shares for education and health by the WHO and UNESCO.

S/N	Data	Source	Source link
1	Foreign direct investment (FDI % GDP)	World Development Indicator (WDI 2021)	https://databank.worldbank.org/reports.aspx?source=World-Development-Indicators
2	GDP per capita (growth rate)	World Development Indicator (WDI 2021)	https://databank.worldbank.org/reports.aspx?source=World-Development-Indicators
3	Trade openness (OPEN)	World Development Indicator (WDI 2021)	https://databank.worldbank.org/reports.aspx?source=World-Development-Indicators
	Investment/GDP ratio (INV)	World Development Indicator (WDI 2021)	https://databank.worldbank.org/reports.aspx?source=World-Development-Indicators
4	Human development index (HDI)	UNDP database (2021)	http://hdr.undp.org/en/content/human-development-index-hdi
5	Sectoral output share in GDP (Agriculture, Manufacturing and Services)	UNCTAD Statistics (2021)	https://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx
6	Population growth rate (POGR)	World Development Indicator (WDI 2021)	https://databank.worldbank.org/reports.aspx?source=World-Development-Indicators
7	Agricultural and Manufacturing world prices (AGPrice and MANPrice), respectively	World Bank database (2021)	https://databank.worldbank.org/reports.aspx?source=global-economic-monitor
8	Rule of law (RLAW)	World Bank database (2021)	http://info.worldbank.org/governance/wgi/
9	Private consumption expenditure per capita (PCPC)	World Development Indicator (WDI 2021)	https://databank.worldbank.org/reports.aspx?source=World-Development-Indicators
10	Households and NPISHs Final consumption expenditure per capita (Constant 2010 US$)	World Bank database (2021)	https://data.worldbank.org/indicator/NE.CON.PRVT.PC.KD?view=map

Appendix

See Table 11.

Table 11 Foreign direct investment, net inflows (%) of GDP. *Source*: World Development Indicators (2021)

	2015	2016	2017	2018	2019	Average*
Central Europe and the Baltics	1.7362	8.7555	1.9814	– 1.3251	4.5288	3.14
East Asia & Pacific	2.8184	2.3578	2.2953	2.3225	1.8523	2.33
Europe & Central Asia	5.2549	6.6327	4.2740	– 0.7813	1.6150	3.40
Latin America & Caribbean	5.1970	3.5550	3.0744	3.3662	3.1684	3.67
Sub-Saharan Africa	2.6652	2.0755	1.7556	1.8756	1.8199	2.04
South Asia (IDA & IBRD)	1.8433	1.7425	1.3849	1.4122	1.5780	1.59
World	3.5608	3.5658	2.6875	1.2271	1.8174	2.57

*Authors' computation

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Declarations

Conflicts of interest No potential conflict of interest.

Code availability Not applicable.

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