Economic complexity in Africa: the role of Chinese FDI and trade

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Abstract

Purpose – This study aims to examine the effect of Chinese foreign direct investment (FDI) and trade on economic complexity in Africa.

Design/methodology/approach – Panel data from 34 African countries between 2003 and 2022 are used. This study analyzes the data using a two-stage least square proposed by Lewbel (2012) and Driscoll and Kraay (1998) estimator based on robust standard errors and panel quantile regression via moments proposed by Machado and Silva (2019).

Findings – The results show that Chinese FDI and trade effectively upgrade economic complexity in Africa. Also, there is an inverted-U-shaped relationship between Chinese trade and economic complexity, thus revealing evidence of the trade Laffer curve.

Originality/value – Despite the intense debate on the Chinese-African economic relationship, to the best of the authors' knowledge, no known study has examined the implications of Chinese FDI and trade on economic complexity in Africa. Therefore, this study fills this lacuna found in the literature and suggests that Chinese FDI and trade are veritable tools for technology diffusion and innovation, which are capable of upgrading economic complexity in Africa. However, the Chinese-African trade relationship should be complemented with sound trade policies for the sustainability of the beneficial effect of Chinese trade on economic complexity in Africa.

Keywords Economic complexity, Trade, Chinese FDI, Quantile regression

Paper type Research paper

1. Introduction

In this study, we examine the impact of Chinese foreign direct investment (Chinese FDI) and trade on economic complexity in Africa. The relationship between FDI and economic complexity has been well documented in the extant literature (Javorcik *et al.*, 2018; Nguyen and Su, 2021a; Osinubi and Ajide, 2022; Gnangnon, 2022; Nguéda and Kelly, 2022), but an investigation on the effect of country-specific FDI on the African economic complexity is relatively scarce. The China-African economic relationship has been strengthened through various plans and initiatives, including the Belt-Road framework and the Forum on China-Africa Cooperation platform set up in 2000 with the aim of boosting the achievement of the African Union Agenda 2063 (World Economic Forum [WEF], 2024). These initiatives and strategic partnerships have promoted Chinese investment and trade in Africa (China Africa Research Initiative, 2022). In 2018, there were about 3,680 firms across economies in Africa.

Journal of Chinese Economic and Foreign Trade Studies
Vol. 18 No. 1, 2025
pp. 86-108

1754-4408
DOI 10.1108/JCEFTS-07-2024-0063

During this period, Chinese FDI inflow was about $3.3bn, while the Chinese FDI stock was around $9.3bn from $46bn in 2009 in manufacturing, mining, construction, finance, and other industries (Fang *et al.*, 2021; Oladipupo and Ajide, 2023; Eweade *et al.*, 2023).

Furthermore, China has been classified as Africa's largest trading partner in recent years. This is made possible under the initiatives mentioned earlier and the recent African Continental Free Trade Agreement. This has led to a large volume of exports and imports between Chinese and African economies. Accordingly, more than 20% of African exports go to China, while over 16% of the imports come from the Chinese economy, amounting to $282bn total volume of trade in 2023 (WEF, 2024). This development has been acknowledged to boost African economic growth and development with implications for environmental quality (Doku *et al.*, 2017; Sylvaire *et al.*, 2022; Oladipupo and Ajide, 2023). Despite this development, no known study has examined the implication of Chinese FDI and trade on the economic complexity in Africa.

Economic literature suggests that the country's possibility of achieving a high level of sustained development will depend on economic transformation through its productive structure, knowledge, and technology diffusion (Chenery and Taylor, 1968; Kannen, 2020; Ndoya *et al.*, 2024). Accordingly, the classicists, most importantly Ricardian economists, suggest that a country must specialize and produce higher quality goods and services to attain a higher level of wealth. Therefore, improving the complexity of national products goes a long way to improving national wealth and export competitiveness (Poncet and De Waldemar, 2013; Ndoya *et al.*, 2024; Ajide *et al.*, 2023). Unlike other development indicators, economic complexity assesses the amount of materialized knowledge in the production structure of an economy (Hausmann *et al.*, 2007; Hidalgo and Hausmann, 2009). It showcases the level of ubiquity and diversification of exported goods and services (Tacchella *et al.*, 2013). It reveals the degree of economic development by showing the level of product sophistication produced and exported (Lapatinas, 2019; Ajide *et al.*, 2023).

There are various ways by which Chinese trade and FDI can boost economic complexity in Africa. Chinese investment enhances flows of funds for the expansion of productive capacity and improves the level of technology and productive efficiency. It promotes and upgrades the industrial structure and enhances the quality of economic development (Song *et al.*, 2021). The Chinese FDI spillover to African economies may, through the absorptive capacity, promote economic complexity (Jyun-Yi and Chih-Chiang, 2008; Khordagui and Saleh, 2016). An expansion of the Chinese-African trade relationship can boost African innovation and technology, which can be manifested in a productive structure, and further improve the competitiveness of African products. Also, African trade with China may reduce the level of output and export volatility, thus boosting the long-run growth (Loayza and Hnatkovska, 2004). Trading relationships with China have reduced transaction costs and improved the cost efficiencies of inputs in African firms' production systems (Sylvaire *et al.*, 2022), thereby improving economic complexity at a minimal cost.

In contrast, the African trading relationship with China may reduce economic complexity due to the Chinese strong demand for commodity products and raw materials rather than complex product baskets. It has been stated that due to the higher level of raw materials demand, most African economies are more focused on the primary sector's commodity market (Ajide, 2022). This might deepen the issue surrounding the trade Laffer curve and, probably, the resource curse (Carmignani and Chowdhury, 2012). Extraction and exportation of resources may increase the intensity of rent-seeking behavior and downgrade the export complexity of a nation (Busse and Gröning, 2013; Ajide, 2022). Due to the weak institutional level, the positive effect of Chinese trade in Africa may turn out to be negative. Previous literature also acknowledges that trade may promote development by facilitating knowledge

diffusion and technology, specifically through direct high-tech imports (Almeida and Fernandes, 2008; Zahonogo, 2016). Trade enhances integration with the sources of innovations and boosts gains from FDI. By increasing the market size for African products, trade enhances returns to scales and specialization economies (Bond, 2008; Alesina *et al.*, 2005). Chinese Trade facilitates technological progress and improved productivity by reducing the misallocation of economic resources and technology spillover (Sachs and Warner, 1995; Dada *et al.*, 2023).

Since Chinese trade and FDI constitute a larger proportion of cross-border transactions in most African nations, this study deviates from the existing studies because it examines FDI and trade transactions from a specific source, China, thus adding novelty to the extant literature. Furthermore, the study examines the nonlinear effect of Chinese trade effects on economic complexity in Africa. It also examines how the two key variables are heterogeneous by employing the panel quantile regression via moments proposed by Machado and Silva (2019). Our results show that Chinese FDI does promote economic complexity. We also discover that there is a nonlinear relationship between Chinese trade and economic complexity. The panel quantile regression shows that the results are heterogeneous as we moved from lower quantiles to upper quantiles. Chinese trade and FDI boost economic complexity in a country with lower productive knowledge than those nations with high-tech export baskets in the African continent. Since China has occupied an important position in the world's smart technology, our results reveal that China might help fill the technology gaps and be capable of upgrading African productive knowledge. However, it is necessary to minimize the level of natural resource exportation from Africa, which might downgrade the ranking of African economic complexity and competitiveness in the international market. In this case, our study contributes to a better understanding of nature, dynamics, and the path toward Chinese trade and FDI can enhance the sustainable economic complexity of the African productive knowledge. Finally, the findings of this study will aid the formulation of international trade policy and facilitate the sustainability of bilateral trade and investment agreements between China and Africa.

The rest of the study is organized into 4. Section 2 presents the theories and relevant empirics. In Section 3, the methods and materials are presented. Section 4 presents and discusses the results. Section 5 shows the policy implications and conclusion of the paper.

2. Theories and empirical literature

2.1 FDI and economic complexity

There are two types of inward FDI: greenfield investment and mergers and acquisitions (Hennart and Park, 1993). The former investment involves a foreign firm creating a new, wholly-owned subsidiary in a host economy. In contrast, the latter involves a foreign company obtaining ownership or control of an existing company in the host country. This leads to the transaction cost and merger and acquisition (M&A) theories of FDI. Coase (1937) created the transaction cost theory, which Caves (1982) later built upon. The theory explains why companies prefer investing directly in a foreign country rather than exporting or licensing their technology or products. This is because firms incur costs related to any market transaction cost, which firms would prefer to avoid or minimize. Thus, the expansion of foreign firms would improve the production of more complex products. However, this theory has limitations because it primarily focuses on cost minimization and does not capture all motivations for FDI, such as resource or market seeking. Also, measuring transaction costs can be challenging. Other related theories shed light on the motivation for FDI, which include efficiency gains, competitive advantage, lower costs related to exploiting internal

markets, and knowledge and technology spillovers (Chandler, 1969; Williamson, 1985, 1989; Porter, 1980, 1986; Ross, 1973; Harris and Raviv, 1979).

Furthermore, the literature suggests that inbound FDI and greenfield investment can affect an economy's degree of economic complexity. According to Romer (1992), foreign investors have the option to directly participate in the host economy by taking up the manufacture of more sophisticated items that were not previously produced in the host country. This would increase the level of economic complexity. Indirectly, FDI can enhance economic complexity by providing domestic enterprises with knowledge and skills that can improve their production of advanced goods. Antonietti and Franco (2021) reveal that there are various ways in which knowledge might be dispersed. One way to do this is by sharing both tangible and intangible technologies, which tends to boost their productivity and encourage innovative products and modern techniques of doing things (Arnold and Javorcik, 2009). Finally, skilled labor mobility may result from FDI. The degree of economic complexity can be raised by these workers' ability to transfer expertise from one organization to another (Antonietti and Franco, 2021; Braunerhjelm *et al.*, 2016; Görg and Strobl, 2005). Despite all these advantages, FDI has drawbacks of its own. One of them is that local businesses may eventually fail due to the ongoing presence of foreign companies. This is because, according to Antonietti and Franco (2021) and Rojec and Knell (2018), local businesses might not be able to compete with them. As a result, the government must provide the necessary support for local industries to continue operating.

Empirically, scholars increasingly prioritize economic complexity over economic growth since a nation's ability to enhance its economic complexity is now a key factor in determining its competitiveness. Despite the paucity of study in this field, few studies have demonstrated the direction in which FDI can influence economic complexity. Previous research on how FDI affects EC has relied on both cross-border and country-specific analysis. The first body of research indicates that FDI and ECI have a positive correlation. Kannen (2020) looks at how sectoral FDI affects economic complexity and finds that, in both developed and developing nations, tertiary sector FDI has a positive impact on EC.

In contrast, secondary and main industry FDI has no statistically significant impact on EC. Infrastructure, financial services, and business services are all part of the tertiary sector. The author claims that given the perception of the manufacturing sector as the catalyst for economic growth, the findings from the secondary sector are quite unexpected.

Okombi and Tsinguia-Kenfack (2023) examine how sectoral foreign direct investment affects economic complexity in 33 developing nations, akin to Kannen's (2020) research. The findings indicate that whereas primary sector FDI in the countries has no discernible association with EC, secondary sector FDI, tertiary sector FDI, and overall FDI all increase economic complexity. In MINT and BRICS countries, Osinubi and Ajide (2022) investigate how foreign direct investment affects economic complexity. The results demonstrate that FDI boosts the output of advanced products (EC) across the board and in MINT nations. Kamguia *et al.* (2022) examine the connection between EC and foreign aid in 78 developing nations. The authors argue that FDI raises EC in the countries by controlling for FDI as one of the explanatory factors. Amendolagine *et al.* (2017) discovered that FDI boosts the production of sophisticated commodities in Africa. Nguéda and Kelly (2022) report a similar finding in sub-Saharan Africa. Javorcik *et al.* (2018) conducted a country-specific examination of the Turkish manufacturing sector using microdata. They contend that the level of inward FDI in the sector determines how complex the economy can get. Eck and Huber (2016) have reported that there is evidence to support the notion that the manufacturing of complex items in India is significantly increased by spillovers resulting from supplier relationships. Li *et al.* (2021) and Ren *et al.* (2022) claim that FDI raises the

level of export sophistication in China. Liu and Wang (2022), however, show that while FDI boosts EC in the short term in the same nation, it has a negative long-term impact on EC because of competition from international companies.

The second body of research indicates that FDI has a negative EC effect. FDI, according to Osinubi and Ajide (2022), lessens economic complexity in the BRICS nations. According to the study, Nguyen and Su's (2021a, b) documentation of the potential for FDI to push out domestic investment and economic activities supports the claim that FDI has a negative impact on EC. Furthermore, foreign direct investment (FDI) inflows may reduce the level of economic complexity if they are low-technology FDI (Arvanitis, 2005), polluting FDI (Singhania and Saini, 2021), or targeted at natural resource rents (Nguyen and Su, 2021a, 2021b; Ndikumana and Sarr, 2019). A causal association between FDI and EC, which suggests a feedback effect between the two variables, has also been argued for by academics as the third strand of the studies that have already been conducted.

In contrast to the short-term evidence of a one-way causal relationship between EC and FDI, Khan *et al.* (2020) in China show a two-way causative relationship between FDI and EC in the long run. Similar findings are supported by Antonietti and Franco (2021), who use a panel of 117 nations to demonstrate a unidirectional causal relationship between economic complexity in developed nations – that is, nations with above-average levels of tertiary education, gross domestic product, financial development, or tertiarization – and inward and greenfield FDI. The authors discover that knowledge-intensive greenfield FDI granger causes ECI in developing nations only in the short run. On the other hand, Sadeghi *et al.* (2020) found a one-way causal association for a panel of 79 countries running from EC to FDI.

Furthermore, there is literature that finds no significant relationship between FDI and EC. Wang and Wei (2008), for example, demonstrate that other factors – rather than inbound FDI – would raise the level of sophistication of Chinese exports: human capital and the creation of specific high-tech zones with advantageous tax conditions. Similarly, Valette (2018) uses FDI as a control variable in the FDI and EC relationship and finds no statistically significant relationship between FDI and EC for the total FDI in 20 OECD countries.

2.2 Trade and economic complexity

There are two types of trade theory: classical (traditional) trade theory and modern trade theory. To explain international trade, traditional trade theory models depend on differences in productivity (the Ricardian model of comparative advantage) or factor endowment (the Heckscher–Ohlin model). These theories presuppose homogenous goods, perfect competition, and constant returns to scale. New trade theory (NTT) relaxes the assumptions, which instead makes assumptions about imperfect competition, increasing returns to scale, and product differentiation. The theory states that all these presumptions – without variations in productivity or factor endowments – can propel trade flows between comparable nations. This may lead to the specialization of certain industries in a given nation in the production of more sophisticated goods that provide greater economies of scale. Dixit and Norman (1980), Lancaster (1980), Krugman (1979, 1980), Helpman (1981) and Ethier (1982) are all connected to the NTT.

Strategic trade theory (STT), developed by Brander and Spencer (1985), is an additional theory to be discussed. According to the STT hypothesis, governments can encourage homegrown businesses with significant development potential through strategic policies, especially in complicated fields. It is well known that substantial R&D expenditures are necessary to shift from the production of traditional goods to complex goods. As a result, the government may assist the industries in overcoming obstacles like bureaucracy and

achieving economies of scale. A nation can attain a higher economic complexity index by implementing strategic trade policies that stimulate the growth of complex industries, resulting in a more resilient and diversified economy.

Furthermore, Grubel and Lloyd's (1975) intra-industry trade theory (ITT) emphasizes vertical specialization and global value chains (GVCs). According to ITT, developing nations can participate in GCVs by concentrating on particular phases of complex products. By doing this, the countries would be able to contribute to their total economic complexity and acquire important experience and knowledge transfer, even if they are not fully involved in the manufacturing of the final good. Finally, the new new trade theory (NNTT) emphasizes transportation costs and business location. It draws on the works of Melitz (2003) and Antras and Helpman (2004). The theory expands on the new trade theory work of Brander and Spencer (1985). These two elements, in NNTT's view, are essential for increasing economic complexity.

The contemporary theories of trade can be used to explain how trade might promote economic complexity. Policymakers can create an environment that supports the growth of complex industries and economic development by having a thorough understanding of the roles played by economies of scale (NTT), strategic policies (STT), vertical specialization and GVCs (ITT), and transportation costs and firm location (NNTT). There are limitations to modern trade theories. In many modern trade theories, for example, the environmental impact of international trade is not thoroughly examined; the growing importance of intellectual property rights and their impact on trade patterns is not fully addressed; government intervention can result in inefficiencies and trade wars; and the theories fail to acknowledge the potential unequal distribution of economic benefits that may come from trade. However, to enable trade to result in a higher level of economic complexity without having a negative impact on the world economy, these constraints must be taken into account and overcome.

Empirically, studies on the impact of trade on EC are scarce. According to research conducted in specific countries, such as those conducted in China by Khan *et al.* (2020), South Africa by Ghebrihiwet (2019), China by Gao and Zhou (2018), Argentina by Bustos (2011), and Portugal by Teixeira and Fortuna (2010), trade has been shown to enhance EC considerably. Nguéda and Kelly (2022) control trade while analyzing the impact of FDI on EC in SSA based on a cross-country study. The study's conclusions imply that trade boosts SSA's output of sophisticated goods. Saadi (2020) notes a similar result for several developing and emerging nations. According to Osinubi and Ajide (2022), trade raises EC in the BRICS and overall sample countries but has little impact on economic complexity in MINT nations. Trade's beneficial impact on economic complexity suggests that trade openness presents a chance to develop technology and create more complex products.

Conversely, some research looks at how EC affects trade. The impact of EC on export diversification in 109 developed and developing nations is examined by Gnangnon (2022). The findings show that the positive effect of EC on the level of services export diversification is higher in developed countries than in developing countries. Adbi *et al.* (2023) establish that trade flows of various exported commodities, particularly machinery, transport equipment, and manufactured goods, are increased by the rise of economic complexity and diversification in the Common Market for Eastern and Southern Africa (COMESA) and East African countries.

2.3 Summary of gaps

Existing studies have shown that increasing trade and FDI lead to better manufacturing of complex goods. This study, which critically analyses the effect of Chinese FDI on the

economic complexity in African nations, adds to the body of research in this particular case while also advancing our understanding of the subject. To the best of our knowledge, no empirical research has been done on how Chinese FDI affects economic complexity in Africa. Nearly all the studies focus specifically on inward FDI. China continues to be Africa's leading source of FDI based on the significant expansion in China's involvement in the continent over the past few decades. When considering the advantages of inward FDI, it is clear that Chinese FDI in Africa would raise the level of economic complexity, either directly by assisting in the creation of more complex products or indirectly by transferring knowledge and technology.

Furthermore, the study explores the dynamics of the economic complexity effect of the trade with China, which is not covered in previous research. This is based on the idea that trade may increase export diversity, expose people to new information and technologies, and increase value exports – all of which can contribute to an increase in the complexity of Africa's economy. In addition, the study looks at the nonlinear relationship between Chinese trade and Africa's economic complexity. The nonlinearity of the economic complexity effect of Chinese trade in Africa would enable policymakers to design more effective trade policies/strategies.

3. Data and methodology

3.1 Model specification

The study focuses on the effect of Chinese FDI on economic complexity in developing countries between 2003 and 2022. It is based on 34 countries in Africa [1]. Based on the existing literature reviewed above, the models of the study are hereby specified:

$$ECI_{it} = \delta_i + \beta CFDI_{it} + \emptyset' Z_{it} + u_{it} \quad (1)$$

ECI is the economic complexity, and CFDI is the Chinese FDI. δ_i, β, *and* $\emptyset$ are parameters to be estimated; Z is the vector of control variables, which include corruption control (COC), Remittances (REM), ICT proxied by internet and financial development (DCP), while u is the error term. i *and* i represent country identity and time dimension, respectively. Equation (2) is extended to incorporate Chinese Trade as specified below:

$$ECI_{it} = \delta_i + \beta CTrade_{it} + \emptyset' Z_{it} + u_{it} \quad (2)$$

CTrade stands for either Chinese Exports from Africa (CExport) or Chinese Imports (CImport), as the case may be. To examine the nonlinear effect of Chinese Trade on economic complexity, the study specifies equation (3):

$$ECI_{it} = \delta_i + \beta CTrade_{it} + \partial CTrade^2{}_{it} + \emptyset' Z_{it} + u_{it} \quad (3)$$

$CTrade_{it}^2$ is the square of Chinese Trade (that is, export or import) to examine the extent of the trade laffer curve. Laffer's curve of trade explains that there could be a threshold at which trade is beneficial to the economy. In contrast, above this threshold, trade becomes detrimental to the economy, suggesting an inverted U-shaped relationship between the two variables. Economic complexity (ECI) is proxied by the MIT Observatory economic complexity indicator. The control variables (Z) include the remittance inflows (REM) as a percentage of GDP, domestic credit to the private sector (DCP) as a proxy for financial development, the internet as a proxy for information and communication technology, and control of corruption (COC) is taken a proxy for institutional factor in Africa. The study also

utilizes additional control variables for robustness checks. These include technological innovation (TECH), economic growth (GR), government expenditure (GEXP), Population density (Popd), human capital development proxied by secondary school enrollment, and natural resource rent (NRR). The choice of our selected control variables is guided by the extant literature (Gao and Zhou, 2018; Sadeghi *et al.*, 2020; Saadi, 2020; Nguyen and Su, 2021b; Osinubi and Ajide, 2022).

3.2 Estimation technique

The study employs Driscoll and Kraay (D-K) (1998) procedures to estimate the models based on robust standard errors. These procedures correct for cross-sectional dependency by using the weighted least squares, heteroskedastic, and serial correlations. In addition, we address the issue of potential endogeneity and omission biasedness by using an alternative estimator, such as Instrumental variable estimation (Lewbel two-stage-least-square [2SLS]). Lewbel's (2012) 2SLS approach for dealing with endogeneity caused by reverse causality, omission bias, or measurement errors has been widely employed in the extant literature (Acheampong *et al.*, 2021). The Lewbel (2012) 2SLS method is most appropriate, especially when the external instruments are weak or unavailable. As a result, the Hasen J-statistic test is used to determine the instrument's validity. In addition, the study accounts for the conditional distribution of economic complexity indicators by employing the quantile regression via moments by implementing the procedures in Machado and Silva (2019). The technique is represented in (4):

$$Q_{ECI_{it}}\left(\tau_j \ /Chinese_{it},\ X_{it}\right) = \beta_1(\tau_j)\ Chinese_{it} + X'\delta(\tau_i) + \emptyset_i(\tau_j) + U_t(\tau_j),\ \tau_j \epsilon (0,\ 1) \tag{4}$$

$_{\text{Chinese}}\left(\ \tau_{\text{j}}\ /\text{Chinese},\ \text{X}_{\text{it}}\right)$ is the τ_j the conditional distribution impact of ECI, while X_{it} is the vector of explanatory variables. The Chinese can be CFDI, CExport, or CImport. The estimated coefficients are normally derived from the location and scale variant estimates. $\emptyset_i$ and U_t are unobserved cross-sectional identities and time-fixed effects.

3.3 Data and variables measurement

The study relies on unbalanced panel data from 34 (see the list in Table A1 in the appendix) countries in Africa between 2003 and 2022. The sources of the data and the measures of each variable are displayed in Table 1. Economic complexity indicators are extracted from the Observatory of Economic Complexity database, while Chinese FDI, Chinese imports, and Chinese exports are obtained from the Chinese-African Research Initiative database. In their original forms, they are in a million dollars, and we convert them to logarithms to minimize outliers at the estimation stage. Data on remittances, information and communication technology (internet), economic growth, government expenditure, Scientific and technical journal articles, patent application (residence and non-residence), population density, human capital (secondary school enrollment), and credit to the private sector are obtained from World Development Indicators.

In Table 2, we present the results of the descriptive statistics of the key variables and the control variables. The ECI has a mean value of −0.553. The standard deviation reveals that this value is not too dispersed since the minimum and maximum values are −3.11 and 0.96, respectively. Also, the Chinese FDI is US$70.433, with the maximum value being US$4,807.86m. The Chinese exports total US$2,153.637m, and the Chinese imports total 1,470.853 on average. Furthermore, the level of corruption control in Africa is relatively

Table 1. Structure of variables and sources of data

Variable	Measurement	Data source
Economic complexity (ECI)	Economic complexity accounts for the productive knowledge and capability of a country, which is reflected in the ubiquity and the diverse exportable commodities	OEC
Chinese FDI (CFDI)	China-FDI flow (US$ million)	CARI
Chinese exports (CExport)	China's exports to Africa (US$ million)	CARI
Chinese imports (CImport)	China's imports from Africa. (US$ million)	CARI
Corruption control (COC)	Index on control of corruption ranged between −2.5 and +2.5	WGI
Remittances (REM)	Remittances inflow (% of GDP)	WDI
ICT (Internet)	Individuals using the internet (% of the population)	
Economic growth (GR)	GDP growth (annual percentage)	WDI
Government expenditure (GEXP)	It is the total amount spent by governments on goods and services, including interest payments (% of GDP)	WDI
Technological innovation (TECH)	The index was developed by authors via principal component analysis using data on scientific and technical journal articles, nonresidents' patent applications, and resident patent applications	WDI
Population density (popd)	Population density (total population per sq. km of land area)	WDI
Human capital (school)	School enrollment-secondary (% gross enrollment)	WDI
Natural resource rent (NRR)	Aggregate rents on natural resources (% of GDP)	WDI
Credit to the private sector (DCP)	Domestic credit to private sector (% of GDP)	WDI

Notes: The figures are in US$ million. However, in the process of estimation, we converted the figures into natural logs to minimize outliers. OEC = Observatory of economic complexity (http://atlas.media.mit.edu); CARI = Chinese-African research initiative; WGI = world governance indicators and WDI = world development indicators
Source: Authors' compilation

Table 2. Descriptive statistics

Variable	Obs	Mean	Std. dev.	Min	Max
ECI	677	−0.553	0.631	−3.11	0.96
CFDI	677	70.433	230.311	−814.91	4807.86
CExport	677	2153.627	3900.11	6.683	47834.31
CImport	677	1470.853	3859.069	0.008	33561.9
COC	677	−0.435	0.553	−1.592	1.244
REM	652	1.785	3.141	−2.693	21.81
ICT	635	10.266	18.106	−33.238	84.12
GR	677	2.865	8.730	−58.318	153.493
GEXP	677	2.823	8.992	−6.811	53.719
TECH	629	0.054	1.458	−2.230	5.811
Popd	644	41.947	74.119	−27.087	634.118
School	388	23.969	31.281	−22.997	111.802
NRR	644	9.261	12.846	−11.691	66.059
DCP	593	14.969	21.605	−27.759	139.01

Source: Authors' estimates

weak, as evidenced by the mean value of −0.435 and maximum value of 1.24 on a scale ranging between −2.5 and +2.5. Other variables are stable and not too dispersed from mean values, including technological innovation, population density, and school and natural resource rents.

Similarly, Table 3 reveals that the correlation coefficient between Chinese FDI and ECI is positive and significant at a 5% level. Similarly, the correlation between Chinese exports and ECI is positive, while the association between imports and ECI is negative. Resource rents, control of corruption, and credit to the private sector are positive in association with ECI individually. Other control variables have a negative association with ECI. The table also reveals that the coefficients are moderate, and there is no evidence of collinearity because they are within the toleration rate.

4. Empirical results and discussion

4.1 Baseline results

The baseline estimated results based on Driscoll and Kraay (1998) and the Lewbel two-stage least square (Lewbel IV) estimation are presented in Table 4. The coefficient of Chinese FDI is positive and significant at a 5% level, revealing that Chinese FDI promotes economic complexity in Africa. A 1% increase in FDI improves economic complexity within a range of 4.8% and 1.7% for the D-K estimator and Lewbel IV estimate, respectively. This implies that by exploiting the internal market, Chinese FDI provides cost and competitive advantage, which expands the productive capacity of African nations. Chinese investments in African economies enhance product sophistication and promote African competitive advantage in the international markets. Chinese FDI enhances economic complexity by providing domestic enterprises with knowledge and skills that can improve their production of advanced goods (Antonietti and Franco, 2021). On the control variables, corruption control is positive and significant, implying that a low level of corruption is vital for upgrading economic complexity in African economies, as confirmed by Osinubi *et al.* (2024), Ndoya *et al.* (2024), and Vu (2022). The coefficient of ICT is negative and significant, implying that ICT reduces economic complexity in Africa, which may be due to the higher cost of acquiring ICT and the low internet access.

Table 3. Pairwise correlation

Variable	ECI	CFDI	Rem	Internet	GR	GEXP	Cexport	CImport	TECH	Popd	School	NRR	DCP	COC
ECI	1.000													
CFDI	0.012*	1.000												
Rem	−0.099*	−0.033	1.000											
ICT	−0.147*	−0.029	0.238*	1.000										
GR	−0.140*	0.007	0.084*	0.018	1.000									
GEXP	−0.224*	−0.011	−0.068	0.063	0.050	1.000								
Cexport	0.160*	0.214*	−0.009	0.138*	−0.063	0.025	1.000							
CImport	−0.170*	0.157*	−0.140*	0.087*	−0.010	0.367*	0.246*	1.000						
TECH	0.230*	−0.023	0.032	0.124*	0.001	0.036	0.123*	0.015	1.000					
Popd	−0.082*	−0.031	0.289*	0.175*	0.072	−0.027	−0.021	−0.108*	0.036	1.000				
School	−0.304*	−0.061	0.473*	0.570*	0.362*	0.204*	−0.055	0.011	0.279*	0.490*	1.000			
NRR	−0.608*	−0.030	0.092*	0.047	0.238*	0.276*	−0.124*	0.321*	−0.111*	−0.043	0.420*	1.000		
DCP	0.036	−0.004	0.194*	0.522*	0.089*	0.050	0.035	−0.003	0.118*	0.404*	0.657*	0.027	1.000	
COC	0.613*	−0.005	−0.272*	−0.043	−0.080*	−0.181*	0.081*	−0.249*	0.084*	−0.119*	−0.285*	−0.617*	0.091*	1.000

Note: Significant at 5% level
Source: Authors' estimates

Table 4. Baseline results

Variable	D-K estimator (1)	(2)	(3)	Lewbel IV estimation (4)	(5)	(6)
CFDI	0.048** (0.009)			0.017** (0.048)		
CExport		0.001* (0.060)			0.0001* (0.073)	
CImport			0.0003 (0.099)			0.0008 (0.109)
COC	0.883*** (0.000)	0.949*** (0.000)	0.955*** (0.000)	0.962*** (0.000)	0.804*** (0.000)	0.897*** (0.000)
REM	−0.002 (0.778)	0.003 (0.679)	0.002 (0.708)	−0.002 (0.829)	−0.005 (0.655)	0.0007 (0.959)
ICT	−0.006*** (0.000)	−0.006*** (0.002)	−0.005*** (0.000)	−0.003** (0.050)	−0.005*** (0.003)	−0.0050** (0.007)
DCP	−0.001 (0.943)	−0.001 (0.616)	−0.008 (0.555)	−0.001 (0.357)	−0.0004 (0.829)	−0.0004 (0.785)
Constant	−0.207** (0.012)	−0.062 (0.218)	−0.063 (0.194)	−0.052 (0.134)	−0.048** (0.031)	−0.033* (0.074)
F-stat	377.74*** (0.000)	690.47*** (0.000)	525.12*** (0.000)	18.27*** (0.000)	34.87*** (0.000)	31.34*** (0.000)
R-sq.	0.567	0.553	0.552	0.412	0.514	0.511
J stat/*p*-value	n/a	n/a	n/a	0.0711	0.886	0.565
No. of groups	33	34	34	33	34	34
Obs.	447	546	546	406	495	495

Notes: *, ** and *** indicate significance levels at 10, 5 and 1%, respectively. Figures in () are *p*-values
Source: Authors' estimates

Furthermore, Chinese exports increase the level of African product sophistication by 0.1%, implying that Chinese exports to African economies promote economic complexity because they enhance technologies and product ingredients to meet the competitive needs of most African nations. In line with the results, the coefficient of Chinese imports is positive but not significant. This confirms that Chinese import from Africa has no significant impact on the African product sophistication. The main reason is that most African nations import raw materials. In relation to Chinese exports, the results indicate that international trade improves African product sophistication because it facilitates knowledge and technology diffusion from Chinese high-tech goods and services. It facilitates integration and nearness to sources of technology and advanced technology. Chinese trade allows African nations to benefit and capture increasing scale returns and specialized economies.

In Table 5, we report the nonlinear effect of Chinese trade (export and import) on economic complexity in Africa. The results based on D-K and Lewbel IV-estimators reveal that Chinese exports and imports promote economic complexity at the initial stage but later reduce economic complexity at a certain turning point, implying an inverted U-shaped (Trade Laffer Curve) relationship. This confirms that Chinese Trade has a positive impact on economic complexity up to a threshold and, above this threshold, it reduces economic complexity. This result indicates that Chinese trade variables are relevant drivers of economic complexity in Africa but should be controlled and monitored since the related coefficients and the quadratic terms are positive and negative at the 5% level of significance. To measure the threshold, we use the coefficients under the Lewbel IV-estimator due to the possibility of endogeneity and omission error. For Chinese exports, the threshold is 0.038%. Also, for Chinese imports, the threshold is 3.5%. Beyond these thresholds, the effects of Chinese exports and imports decline in economic complexity. Therefore, African nations must control trade efficiently when seeking to upgrade economic complexity via Chinese trade. Trade provides access to intermediate goods and services that are important for economic growth and development, as well as innovation and the production of sophisticated products. However, African trade should be directed to innovation and the transfer of technology to enhance productive complexity. This can happen by ensuring a conducive environment for domestic innovative production systems for dynamic comparative

Table 5. Result of nonlinear estimation

	D-K estimator		Lewbel IV estimation	
Variable	Chinese export	Chinese import	Chinese export	Chinese import
Trade	0.004*** (0.000)	0.006** (0.015)	0.0003* (0.066)	0.007*** (0.003)
Trade^2	−0.006*** (0.000)	−0.0024** (0.007)	−0.008** (0.020)	−0.002*** (0.004)
COC	0.929*** (0.000)	0.951*** (0.000)	0.998** (0.047)	1.006*** (0.002)
REM	−0.009 (0.195)	−0.009 (0.202)	−0.007 (0.822)	−0.007 (0.735)
ICT	−0.0054*** (0.002)	−0.004*** (0.004)	−0.005** (0.035)	−0.004** (0.004)
DCP	0.0004 (0.658)	−0.00009 (0.922)	0.0007 (0.544)	0.0007 (0.557)
Constant	−0.112** (0.009)	−0.074 (0.125)	−0.015 (0.455)	−0.011 (0.599)
F-stat	717.44*** (0.000)	805.47*** (0.000)	26.43*** (0.000)	29.05*** (0.000)
R-sq.	0.572	0.567	0.562	0.563
J stat/*p*-value	n/a	n/a	0.224	0.183
No. of groups	34	34	34	34
Obs.	546	546	495	495

Notes: *, ** and *** indicate significance levels at 10, 5 and 1%, respectively. Figures in () are *p-values*
Source: Authors' estimates

advantage. Our findings are consistent with the previous studies that link trade to economic growth and development (Zahonogo, 2016). Given the nonlinear effect, the results confirm the fragility of Chinese trade and economic complexity in Africa. This is confirmed by Ulaşan (2015), who shows that there is a nonlinear relationship between trade and economic development in the Organization for Economic Cooperation and Development.

4.2 Robustness checks

For the robustness check, we re-estimate the baseline model using the quantile regression via moment by implementing the procedures in Machado and Silva (2019). The quantile regression provides a robust analysis of different quantiles to assess the sensitivity in the presence of outliers and conditional distribution of economic complexity indicators. The results are presented in Tables 6–8. The results further confirm that Chinese FDI, as well as Chinese exports, promote African economic complexity within the period of investigation. It shows that as we move from lower quantiles to upper quantiles, the coefficients reduce. This implies that Chinese FDI and exports are more effective in countries with lower levels of economic complexity.

However, the coefficients of Chinese imports are not significant, which further confirms the results of the baseline model. Furthermore, we include additional control variables into the baseline model, such as GDP growth rate (GR), Government expenditure (GEXP), Technological innovation (TECH), Population density (Popd), Human Capital Development (School), and Natural Resource Rent. (NRR). The result, as shown in Table A2 (see Appendix), still confirms that Chinese FDI and Export upgrade African economic complexity, while the coefficient of Chinese import is not significant. Overall, it reveals that exports and FDI are very relevant in upgrading Africa's economic complexity. Therefore, our findings enrich the literature by providing sound and robust evidence that ascertains the unique contributions and characteristics of Chinese FDI and exports to the economic complexity of Africa. More importantly, the study provides support that Chinese trade and investment in African economies influence technological and productive knowledge for African competitiveness in an international environment. African authorities should start

Table 6. Quantile regression results (Chinese FDI and economic complexity)

Variable	Location	Scale	Q.15	Q.25	Q.50	Q.75	Q.95
CFDI	0.024***	−0.025***	0.054***	0.043***	0.023**	0.002	0.024**
	(0.000)	(0.001)	(0.001)	(0.002)	(0.032)	(0.810)	(0.030)
COC	0.893***	−0.991**	1.015***	0.971***	0.891***	0.806***	0.893***
	(0.000)	(0.030)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
REM	0.001	0.001	−0.001	−0.001	0.001	0.001	0.001
	(0.994)	(0.845)	(0.915)	(0.938)	(0.992)	(0.903)	(0.994)
ICT	−0.005***	0.001	−0.007***	−0.007***	−0.005***	−0.004***	−0.005***
	(0.000)	(0.208)	(0.002)	(0.001)	(0.000)	(0.007)	(0.000)
DCP	−0.001	0.001	−0.001	−0.001	−0.004	0.001	−0.001
	(0.719)	(0.463)	(0.504)	(0.546)	(0.724)	(0.938)	(0.719)
Constant	−0.101**	0.346***	−0.527***	−0.372***	−0.095**	0.199***	−0.101**
	(0.024)	(0.000)	(0.000)	(0.000)	(0.040)	(0.000)	(0.024)
No. of obs.	447	447	447	447	447	447	447

Notes: *, ** and *** indicate significance level at 10, 5 and 1%, respectively. Figures in () are *p*-values
Source: Authors' estimates

Table 7. Quantile regression results (Chinese export and economic complexity)

Variable	Location	Scale	Q.15	Q.25	Q.50	Q.75	Q.95
CExport	0.008**	−0.002	0.001**	0.001**	0.008**	0.005	0.003
	(0.030)	(0.312)	(0.034)	(0.027)	(0.030)	(0.136)	(0.538)
COC	0.946***	−0.100**	1.072***	0.946***	0.946***	0.856***	0.754***
	(0.000)	(0.007)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
REM	0.003	0.010	0.002	0.003	0.003	0.004	0.005
	(0.735)	(0.859)	(0.893)	(0.735)	(0.735)	(0.674)	(0.697)
ICT	−0.005***	0.006	−0.006***	−0.005***	−0.005***	−0.004***	−0.003*
	(0.000)	(0.475)	(0.003)	(0.000)	(0.000)	(0.003)	(0.063)
DCP	−0.001	0.001	−0.002	−0.001	−0.001	−0.0001	0.001
	(0.386)	(0.157)	(0.151)	(0.387)	(0.387)	(0.977)	(0.525)
Constant	−0.044**	0.277***	−0.392***	−0.044***	−0.044***	0.203***	0.485***
	(0.015)	(0.000)	(0.000)	(0.033)	(0.033)	(0.000)	(0.000)
No. of obs.	447	447	447	447	447	447	447

Notes: *, ** and *** indicate significance level at 10, 5 and 1%, respectively. Figures in () are *p*-values
Source: Authors' estimates

Table 8. Quantile regression results (Chinese import and economic complexity)

Variable	Location	Scale	Q.15	Q.25	Q.50	Q.75	Q.95
CImport	0.007	−0.004	0.0007	0.0008	0.0007	0.006	0.006
	(0.207)	(0.912)	(0.355)	(0.281)	(0.206)	(0.250)	(0.440)
COC	0.948***	−0.100***	1.077***	1.023***	0.945***	0.857***	0.752***
	(0.000)	(0.007)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
REM	0.003	0.001	0.002	0.002	0.003	0.003	0.004
	(0.745)	(0.903)	(0.881)	(0.829)	(0.742)	(0.701)	(0.737)
ICT	−0.004***	0.003	−0.005**	−0.005***	−0.004***	−0.004***	−0.004***
	(0.001)	(0.696)	(0.013)	(0.004)	(0.001)	(0.003)	(0.001)
DCP	−0.001	0.002*	−0.003*	−0.002	−0.001	0.002	−0.002
	(0.368)	(0.078)	(0.098)	(0.143)	(0.384)	(0.875)	(0.332)
Constant	−0.034**	0.271***	−0.383***	−0.238***	−0.026	0.209***	−0.496***
	(0.043)	(0.000)	(0.000)	(0.000)	(0.160)	(0.000)	(0.000)
No. of obs.	546	546	546	546	546	546	546

Notes: *, ** and *** indicate significance level at 10, 5 and 1%, respectively. Figures in () are *p*-values
Source: Authors' estimates

prioritizing Chinese investment in sectors and industries that have the potential to harness Chinese technologies to upgrade productive knowledge in Africa.

5. Conclusion and policy implications

Though the nexus between trade, FDI, and development is not a new topic in the literature, in recent times, we have witnessed an intense economic integration coupled with global value chains. This study complements the existing studies and provides new cross-sectional evidence on the effect of Chinese FDI and trade on economic complexity in Africa. The study also examines the nonlinear effect of Chinese trade on economic complexity. Using D-K estimation, Lewbel IV-estimating technique, and panel quantile regression, we show that Chinese FDI and trade promote economic complexity. Our results also confirm an

inverted U-shaped relationship between trade and economic complexity in Africa. That is, trade has a positive effect on economic complexity up to a threshold above which the effect declines. The nonlinear effect of trade reveals that the benefits of trade are not automatic. These findings have policy implications for African economies.

The study suggests that Africa must productively control trade, most importantly, the importation of consumption goods, to boost the economic complexity through the Chinese trade. It suggests that Chinese FDI matters for upgrading African economic complexity. It reveals that Chinese FDI is a key relevant variable for productivity forecast. Chinese-African trade should be complemented with sound trade policies to enhance the positive effect on economic complexity. African nations should implement relevant policies to encourage Chinese investment to promote human capital development and innovations to boost economic competitiveness and product complexity.

The Chinese-African trade and investment agreement should be reformed to focus more on enhancing technological transfer and innovation. Localization strategies for Chinese investments should be encouraged. Chinese firms should endeavor to continue recruiting local African talents and sponsor localization systems of Chinese firms in all African nations. It is believed that the use of indigenous human capital of the host nations would assist in the adaptation to the local markets, culture, regulations and policies of the host nations. It is also recommended that African governments strengthen their investment promotion strategies to attract Chinese investment further and negotiate trade agreements to promote technological diffusion and skill development. Initiatives should be developed and annexed to make Africa marketable to potential Chinese investors. Research and development should be launched to understand the sectors and industries in which Chinese investors are interested. This can be used to channel efforts to align with the potential Chinese investors' interests.

Just like trade, African authorities must identify the specific sectors that are very important for innovative capacity development. Upon identification, Chinese innovative investments should be channeled to these sectors to improve the economic complexity. Africa-China economic relations should focus on attracting efficiency-seeking FDI and trade by crafting a conducive environment for innovative entrepreneurs. This can be done by providing transparency and a conducive regulatory framework, upgrading business infrastructure, developing quality human capital, and offering incentives for every investor, including tax holidays and pioneer status. Moreover, African countries must strive to encourage local processing capabilities so as to lift their participation in higher segments of the global value chains.

Note

1. See Appendix (Table A) for the list of the countries.

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Appendix

Table A1. List of African countries used

1. Algeria	18. Madagascar
2. Angola	19. Malawi
3. Botswana	20. Mali
4. Burkina Faso	21. Mauritania
5. Cameroon	22. Mauritius
6. Congo, Dem. Rep.	23. Morocco
7. Congo, Rep.	24. Mozambique
8. Cote d'Ivoire	25. Namibia
9. Egypt, Arab Rep.	26. Nigeria
10. Equatorial Guinea	27. Senegal
11. Ethiopia	28. South Africa
12. Gabon	29. Tanzania
13. Ghana	30. Togo
14. Guinea	31. Tunisia
15. Kenya	32. Uganda
16. Liberia	33. Zambia
17. Libya	34. Zimbabwe

Source: Authors' own work

Table A2. Results from Lewbel IV estimation

Variable	(1)	(2)	(3)
CFDI	0.029*** (0.002)		
CExport		0.033** (0.035)	
CImport			−0.008 (0.853)
COC	0.412** (0.022)	0.514** (0.042)	0.526** (0.038)
REM	0.007 (0.178)	0.011** (0.034)	0.012** (0.030)
ICT	−0.0016 (0.439)	−0.0015 (0.513)	−0.0018 (0.430)
GR	−0.040*** (0.000)	−0.040*** (0.000)	−0.039*** (0.000)
GEXP	0.0004 (0.939)	−0.0031 (0.551)	−0.0031 (0.553)
TECH	0.051*** (0.006)	0.131*** (0.000)	0.129*** (0.000)
Popd	−0.0007 (0.282)	−0.0012 (0.139)	−0.0013 (0.146)
School	−0.006** (0.050)	−0.003 (0.314)	−0.003 (0.348)
NRR	−0.003 (0.524)	−0.004 (0.363)	−0.003 (0.377)
DCP	0.007*** (0.003)	0.006** (0.021)	0.005** (0.029)
Constant	−0.137*** (0.001)	−0.027 (0.252)	−0.036* (0.092)
F-stat	11.780*** (0.000)	13.930*** (0.000)	14.020*** (0.000)
R-sq.	0.531	0.5558	0.555
J statistic/*p*-value	0.1313	0.1473	0.1695
Obs.	213	270	270

Notes: *, ** and *** indicate significance level at 10, 5 and 1%, respectively. Figures in () are *p*-values
Source: Authors' estimates

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