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Does Tax Revenue Improve Economic Complexity in Africa?

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Abstract This study assesses the effect of tax revenue on economic complexity in Africa using a sample of 29 African countries from 1995 to 2018. Applying the system generalized method of moments (GMM), we found that tax revenue spurs economic complexity in Africa by providing countries with critical financial resources to produce complex and sophisticated goods. We performed several robustness tests, including controlling for macroeconomic volatility and employing various measures of economic complexity and tax revenue, and the results remain robust. Furthermore, the mediation analysis results show that the effect of tax revenue on economic complexity is mediated by financial development and government spending. This study advocates for government strategies to enact tax reforms and maximize tax revenue mobilization, which will help finance economic complexity.

Keywords: tax revenue, economic complexity, GMM, Africa

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I. Introduction

According to development economic theories, a country's ability to achieve a high level of development depends on transforming its productive structure, which involves the transfer of resources from low- to high-productivity activities (Chenery & Taylor, 1968; Kaldor, 1967; Lewis, 2013). According to classical and, in particular, Ricardian theories, the specialization of countries in the production of high-quality goods contributes to national wealth (Mariani et al., 2015), and economies grow by improving the quality and complexity of the product lines they manufacture and export (Poncet & De Waldemar, 2013; Stojkoski et al., 2016).

Accordingly, scholars have recently developed a new research field known as "economic complexity," which appears to be the primary explanation for differences in country development

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levels. This is a framework for analyzing the sophistication of manufactured and exported goods (Hausmann et al., 2007; C. A. Hidalgo et al., 2007; César A. Hidalgo & Hausmann, 2009; Saviotti & Frenken, 2008). They developed an index of economic complexity to assess the amount of knowledge materialized in a country's productive structure.

Economic complexity refers to the amount of knowledge materialized in an economy's product system (Hausmann et al., 2007; Hidalgo & Hausmann, 2009). It reflects the diversification and ubiquity of the exported products (Tacchella et al., 2013). According to recent scholarly contributions, economic complexity reveals the economy's degree of growth by showing how sophisticated products are produced and exported (Hartmann et al., 2017; Hausmann et al., 2007; Lapatinas, 2019).

Although the economic literature on economic complexity has evolved over the last decade, the analysis of its main determinants remains a vast field to be explored (Avom et al., 2021; César A. Hidalgo, 2021; Nguyen, 2021). The few empirical works available on the determinants of production and export of more sophisticated/complex products are not consistent and have focused on human capital (Bahar et al., 2020; Cristelli et al., 2015; Lapatinas & Litina, 2019; Poncet & De Waldemar, 2013; Saviotti & Frenken, 2008; Vu, 2020); technology (Gao & Zhou, 2018; Lapatinas, 2019; Yu & Hu, 2015); innovations (Sweet & Eterovic, 2019); internet (Lapatinas et al., 2019); foreign direct investment (FDI) and the Aid for Trade flows (Antonietti & Franco, 2021; Avom et al., 2021; Gnangnon, 2021); and financial development (Javorcik et al., 2018; Lapatinas & Litina, 2019; Nguyen et al., 2020; Yu & Hu, 2015).

However, the tax revenue issue has not been thoroughly examined in terms of the determinants of economic complexity. Nonetheless, tax policies have been identified in the literature as an important lever for economic structural transformation. Moreover, fiscal financial incentives have been shown to significantly impact, either directly or indirectly, the research and development (R&D) investment, export dynamics (Krizanic et al., 2021), and economic growth (Bleaney & Halland, 2014). Thus, financing development remains a major concern in most developing countries, and tax revenue remains one of the most effective tools available to governments.

As demonstrated by the OECD (1987), differences in the long-run economic performance of industrialized countries stemmed from the interaction of tax incentives and the stock of knowledge in economies, as tax policy influences the enhancement or disappearance of knowledge production. To that end, Lapatinas et al. (2019) theoretically demonstrated, for the first time, how tax policies can aid in explaining cross-country differences in sophisticated goods production and export. According to them, economic complexity is related to economic growth, which depends on knowledge accumulation. In this case, tax policies encourage firms to invest more in R&D to ensure capital accumulation.

Given that creating a new range of sophisticated products requires the development of new skills, additional financial resources, including domestic ones, need to be mobilized to finance

the provision of public goods and services. In 2019, tax revenue as a percentage of GDP reached its highest level in Africa, averaging approximately 16.6%, but it remains lower than other regions. In comparison, average tax revenue volumes in Asia-Pacific, Latin America and the Caribbean, and the OECD regions were 21%, 22.9%, and 33.8%, respectively, over the same period. Furthermore, increased tax revenues in Africa have enabled finance economic development, particularly to develop the economy's productive structure further. For example, Diao et al. (2017) and McMillan and Harttgen (2014) have demonstrated that African countries have experienced growth in both productive employment and manufacturing value added since the early 2000s. This allowed a few countries, such as South Africa, Tunisia, Egypt, and Botswana, to better position themselves in the production and export of complex and sophisticated goods.

This paper investigates the impact of tax revenue on economic complexity in Africa. It adds to the literature on at least three major points. First, although previous research has focused primarily on the determinants of economic complexity, very few have examined how to finance the production of complex and sophisticated products. To the best of our knowledge, this is one of the first studies to link tax revenue to economic complexity, particularly in Africa, where tax revenue mobilization remains a challenge and the level of economic complexity is the lowest globally. Second, this study examines the impact of economic complexity on the various components of tax revenue (direct and indirect taxes) in addition to total tax revenue. We can better understand which tax components impact economic complexity and guide economic policy by disaggregating tax revenue. Third, this paper goes further by conducting a mediation analysis. Without being exhaustive, we highlight and empirically assess the mediating effect of two channels, including financial development and government spending.

The remainder of this article is organized as follows: Section 2 presents a selective literature review, and Section 3 describes the data and the empirical strategy. Section 4 discusses the empirical results, and Section 5 concludes.

II. Selective Literature Review

A. Determinants of economic complexity

Over the last decade, a growing literature on economic complexity has rekindled great interest in its explanatory factors, particularly in developing countries. Although this literature has recently evolved in an ad hoc manner, the analysis of its main determinants remains a vast field to be explored. In fact, demographic, technological, financial, and other factors have been widely cited as important predictors of economic complexity.

In particular, in terms of demographic and cultural factors, the accumulation of human capital

has been found to positively influence the export sophistication and thus economic complexity (Bahar et al., 2020; Cristelli et al., 2015; Hausmann et al., 2007; César A. Hidalgo & Hausmann, 2009; Poncet & De Waldemar, 2013; Schott, 2008; Vu, 2020). For instance, using panel data from 94 countries from 1968 to 2015, Chu (2020) discovered that higher education and population density are positively associated with economic sophistication by promoting knowledge accumulation. Similarly, Alemu (2013) observed that in East Asia, science infrastructure, R&D investment, and the number of R&D researchers all contribute to higher export competitiveness of high-tech products.

Similarly, Aw et al. (2011) showed that R&D investment has gradually improved the productivity of Taiwan's electronics industry. Culturally, Bahar et al. (2020) found a positive relationship between economic complexity and the diversity of birthplaces.

Regarding financial determinants, a large literature highlights the role played by FDI (Antonietti & Franco, 2021; Avom et al., 2021; Chu, 2020; Nguyen et al., 2018) and financial development (Javorcik et al., 2018; Lapatinas & Litina, 2019; Nguyen et al., 2020; Yu & Hu, 2015) in promoting export sophistication. According to Harding and Javorcik (2012), attracting FDI improves the quality of exports in developing countries. Furthermore, the authors note that FDI positively affects export unit values in developing countries, but the effect is ambiguous in high-income economies. Furthermore, Antonietti and Franco (2021) discovered that accumulating a larger stock of inward FDI per capita leads to increased economic complexity in a country. However, the causal effect is very weak and only occurs in countries with relatively high GDP per capita, higher education, and tertiarization. Furthermore, Swenson and Chen (2014) demonstrated that contacts between multinational firms and their affiliates are associated with more frequent, higher-value, and longer-lasting new business transactions as a result of the' beneficial spillovers of multinationals. Furthermore, Fang et al. (2015) reported that when credit constraints are tight, firms preferentially produce goods of lower quality. However, the credit constraint is likely to limit firms' investment in product quality improvement innovation.

Then, using different proxy measures for financial development, Nguyen and Su (2021) showed that financial institutions, financial markets, financial depth, financial access, and financial efficiency positively and consistently affect economic complexity. In the same vein, Chu (2020) discovered that the developments of the banking sector and the stock market have positive effects on economic sophistication. Finally, migrant remittances have also been evidenced by Saadi (2020) as a main financial determinant of export sophistication in developing countries.

Turning to studies on the impact of physical and technological capital, Yu and Hu (2015) argued that improvements in factor structure through capital accumulation determine the manufacture of technology-intensive products, resulting in a faster improvement in a country's export sophistication. The results of Gnangnon (2021) also showed that strengthening productive capacity increases economic complexity. Furthermore, Lapatinas (2019) and Gnangnon (2020) discovered that internet use positively affects a country's economic sophistication and services

export diversification. For example, Gao and Zhou (2018) found that technological innovation positively impacts economic complexity in China. Furthermore, according to Gao et al. (2017), introducing high-speed rail increased economic spillovers between newly connected sites in China via knowledge diffusion and interregional and inter-industry learning. Meanwhile, Gala et al. (2018) specified that a higher proportion of manufacturing and sophisticated service jobs to total workers increases a country's economic complexity.

In the existing literature, institutional factors have also been identified as determinants of economic complexity. This literature posits that institutional quality improves the economic activity conditions and thus increases economic complexity (Ndoya et al., 2023; Avom & Ndoya, 2022; Nguyen et al., 2018). According to Sweet and Eterovic (2019) and Sweet and Eterovic Maggio (2015), strengthening of property rights is an institutional determinant of economic complexity, which leads to higher levels of economic complexity. Moreover, the distribution of public funds is another explanatory factor of economic complexity.

Indeed, the endogenous growth models developed by Barro (1990) and Rivera-Batiz and Romer (1991) have emphasized the importance of public investment in education, health, and infrastructure. These investments boost the productivity of factors that promote economic growth. Agénor (2008) and Turnovsky (2004), for example, discovered that government-provided services have a positive effect on the accumulation rate of educated labor, which can improve the performance of high-tech exports. Similarly, Cassou and Lansing (1998) demonstrated how suboptimal tax policies contributed to the productivity slowdown in the United States. Furthermore, Fang et al. (2015) contended that public investment is critical in promoting sophisticated product exports.

Finally, several authors have demonstrated that tax incentives directly or indirectly affect a firm's financial allocation to R&D and thus the dynamics of exports (Krizanic et al., 2021). Indeed, research on the relationship between economic complexity and taxation shows that economies that use less capital taxation than labor taxation tend to export more sophisticated goods (Lapatinas et al., 2019). In addition, fiscal policy affects credit to the economy and loan market conditions. For example, Melina and Villa (2014) showed that in the United States, the bank spread responds negatively to an expansionary government spending shock. In the same vein, Aydın and Igan (2012) revealed that government finances have a greater impact on loan supply via the bank credit channel. Furthermore, Kollmann et al. (2013) specified that fiscal stimulus measures, particularly increased government purchases during an economic downturn, help stabilize firms' output.

B. How does tax revenue affect economic complexity?

We present, without being exhaustive, two main channels through which tax revenue affects economic complexity in this section, based on the assumption that the relationship between

tax revenue and economic complexity can be established indirectly through some transmission mechanisms.

1. The government spending channel

Government intervention in the economy can be accomplished by strengthening the institutional ability of the economic affairs administration to provide public services that promote private investment. Faruq (2011) argued that a weak institutional environment will not encourage enterprises to invest more in technology and innovation to improve the quality of their products. However, the financial capacity for public intervention in developing nations is partly dependent on the performance of its tax collections to establish favorable conditions for economic activity development (Mawejje & Munyambonera, 2016). Furthermore, according to Fan et al. (2015), public resources assist finance R&D capable of providing new knowledge to benefit the private sector, because R&D investment is required to improve economic complexity. As a result, tax-funded government spending in production support sectors helps promote the private sector. However, increasing government spending fosters economic complexity by promoting R&D, human capital development, and the diffusion of technological advances to manufacture sophisticated goods and services (Fang et al., 2015; Javorcik et al., 2018; Lapatinas, 2019).

Furthermore, government spending on health and education is linked to tax revenue. Thus, tax revenues may have an impact on economic complexity. As a result of these spillover effects on the private sector business climate, increased government revenue collection and tax base expansion would improve a country's economic complexity. In theory, using tax revenues to support government spending would be more efficient than borrowing, as demonstrated by the Ricardian equivalence theory in David Ricardo's growth models. Furthermore, Agnello and Sousa (2011) showed that budget deficits cause crowding out effects on private investment due to rising interest rates in developed countries.

Furthermore, increased public spending can potentially crowd out private investment. Therefore, this may lead to a mitigate effect of tax revenues on economic complexity. According to theoretical arguments, the impact of public capital on private capital will be determined by the degree of complementarity or substitutability between the two types of capital. When the government spends more money on public goods and services, it may increase competition for resources, such as labor and capital, thereby potentially raising firm costs. This can lead to less private investment, as companies may be less willing to invest in new projects or expand their operations. In addition, increased government spending can lead to inflation and can increase the demand for goods and services, thus increasing prices. Consequently, businesses may find it more difficult to operate as a result of higher input costs and lower demand for their products (Deleidi et al., 2020; Alfonso & St Aubyn, 2019).

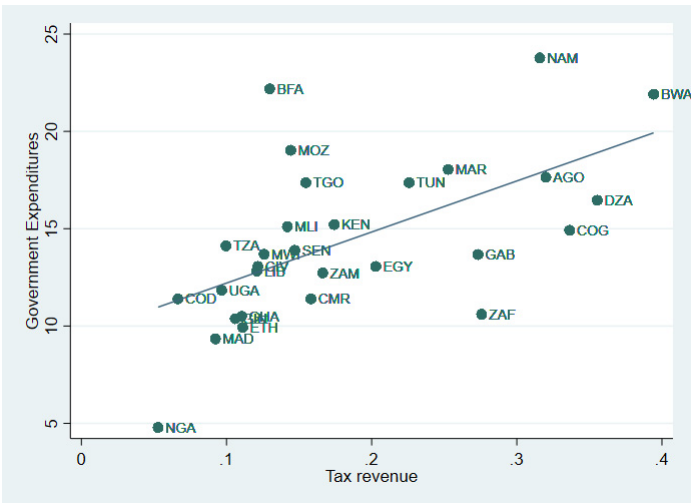
Similarly, although governments can use tax revenues to promote economic complexity,

increasing taxes can have negative effects. For starters, higher taxes may result in lower consumer spending. People with less disposable income due to higher taxes may be less likely to purchase goods and services. This can hurt government revenues, which are largely dependent on taxes levied on the consumption of goods and services by individuals and businesses (Gnangnon, 2022). Then, higher taxes can reduce the incentive for individuals and firms to invest and innovate. This can lead to lower productivity and innovation, hampering the production and export of sophisticated goods. Finally, higher taxes may discourage foreign investment. Foreign investors may be less inclined to invest in a country when taxes are high, as higher tax rates may be viewed as a disincentive to invest. This may decrease FDI, which can be a source of technology transfer and the creation of industries producing complex goods.

In summary, although increased tax revenues can lead to increased government spending and the promotion of economic complexity, several adverse effects must be considered. Governments must therefore find a balance in using tax revenues to increase government spending while ensuring private investment to promote economic complexity better.

Figure 1 illustrates the relationship between tax revenue and government expenditures. Furthermore, as shown in the figure, tax revenue is positively correlated to government expenditures.

Figure 1. Correlation between tax revenue and government expenditures



(Source) Authors' construction.

2. The financial development channel

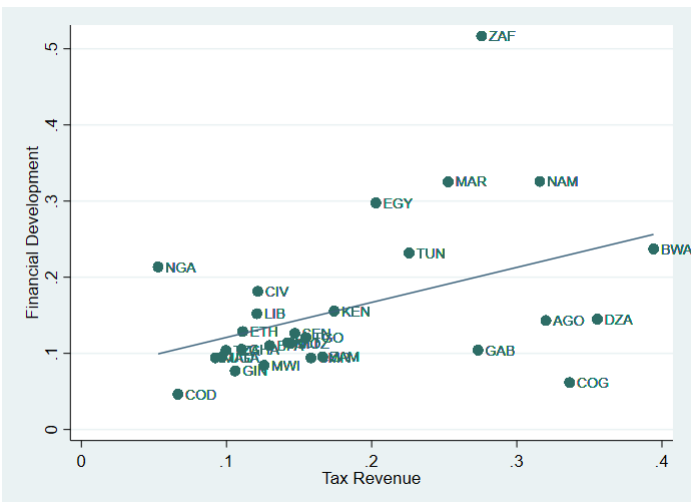
Because of the resulting financial development, tax revenue is thought to be a stable source of internal financing for a country's development. Although Gala et al. (2018) found that total government spending does not affect economic complexity, this is not the case for public

investment (Lapatinas & Litina, 2019). Indeed, tax revenues, through the presence of public financial institutions and levels of government intervention in financial markets, can affect economic complexity through financial development. For example, financial development positively influences economic complexity through the efficiency of financial markets and firm innovations (resident patents) (Nguyen et al., 2020). Furthermore, financial development opens up new avenues for attracting alternative financial flows to fund patents and develop new knowledge (Ductor & Grechyna, 2015; Nguyen et al., 2020). Moreover, Al Mamun et al. (2018) and Hsu et al. (2014) pointed out that developing financial markets for equity and financial credit positively affects technological innovation in a country.

Another way tax revenues help develop financial markets is by increasing them, which can foster the development of financial markets by providing governments with the resources they require to fund regulatory bodies and promote financial market growth. These regulatory bodies ensure that financial markets operate fairly and transparently, protect investors from fraud and abuse, and promote financial markets' stability, thus reducing tax evasion and the underground economy (Oz-yalaman, 2019). Indeed, developed financial markets allow firms and governments to raise sufficient funds to finance their investments, particularly in producing complex and sophisticated goods.

Figure 2 presents the relationship between tax revenue and financial development, revealing a positive correlation.

Figure 2. Correlation between tax revenue and financial development



(Source) Authors' construction.

III. Data and Empirical Strategy

A. Data

Our study uses a sample of 29[1] African countries during 1995-2018. The availability of data conditions the choice of the sample and study period. The data used come exclusively from secondary sources.

Our dependent variable is the economic complexity index (ECI), obtained from the Massachusetts Institute of Technology's Observatory for Economic Complexity (https://atlas.media.mit.edu). The ECI measures the sophistication of an economy's structure. This indicator evaluates the availability of productive capacities that allow nations to generate complex goods. The productive capacities present in a country is determined by information on its exports, including the variety of products it exports and how many other countries export that product (Hidalgo & Hausmann, 2009). A nation's productivity increase when it can export a diverse range of goods. Their low ubiquity shows that only a few economies export sophisticated goods because they necessitate several scarce skills. Combining this information using the so-called method of reflections, Hidalgo and Hausmann (2009) constructed the ECI.

We use tax revenue from the International Center for Tax and Development as the main explanatory variable. This variable is based on harmonized data gathered from various sources, including IMF financial statistics, OECD tax data, and African economic data. This database produces the most important data on global tax revenues.

We adopted the determinants of economic complexity in the literature as control variables (Antonietti & Franco, 2021; Chu, 2020; Nguyen et al., 2020; Saadi, 2020). We control our model with GDP per capita, total natural resource rent, population density, and trade openness, taken from the World Bank's World Development Indicators, and human capital from the Penn World Tables version 9.1.

Table 1 shows the descriptive statistics of the variables. Meanwhile, Figure 3 depicts that the correlation between tax revenue and economic complexity is positive. However, this correlation does not necessarily mean causation; hence, this relationship deserves to be investigated empirically.

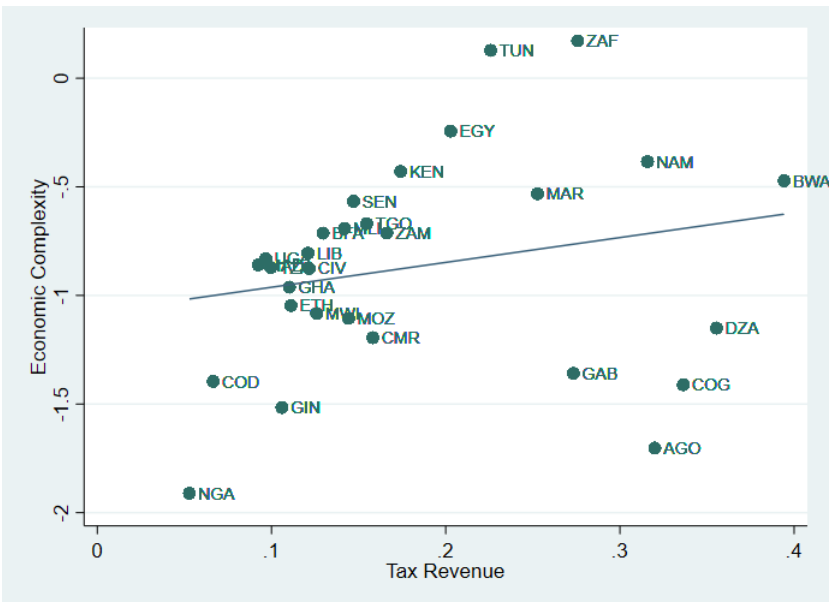
1) Algeria, Angola, Burkina Faso, Cameroon, Congo, Congo, Dem. Rep., Cote d'Ivoire, Egypt, Ethiopia, Gabon, Ghana, Guinea, Kenya, Liberia, Libya, Madagascar, Malawi, Mali, Morocco, Mozambique, Namibia, Nigeria, Senegal, South Africa, Tanzania, Togo, Tunisia, Uganda, Zambia.

Table 1. *Descriptive Statistics*

Variable	Unity	Obs.	Mean	S.D.	Min	Max
Tax revenue	Percentage	662	0.183	0.098	0.010	0.540
ECI	Index	710	-0.883	0.541	-2.791	0.512
ECI+	Index	710	-0.611	0.761	-1.361	2.465
Tax on income, profit and capital	Percentage	558	0.031	0.022	0	0.105
Tax on goods and services	Percentage	578	0.041	0.021	0.001	0.102
Tax on international trade	Percentage	577	0.026	0.023	0.001	0.131
GDP per capita	Constant USD	681	2188.572	2413.674	170.581	12120.56
Natural resources	Percentage	715	13.438	12.795	0.192	67.917
Human capital	Index	644	1.767	0.408	1.049	2.885
Population density	People per km²	720	52.386	45.11	1.977	215.064
FDI	Percentage	682	3.957	8.269	-8.589	103.337
openness	Percentage	664	72.500	31.850	20.722	311.354
Government expenditures	Percentage	638	14.541	4.869	0.911	30.069
Financial development	Index	690	0.158	0.102	0.0196	0.626

Note. ECI, economic complexity index; ECI+, improved ECI; GDP, gross domestic product; FDI, foreign direct investment.
(Source) Authors' calculations.

Figure 3. Correlation between tax revenue and economic complexity



(Source) Authors' construction.

B. Econometric specification

To assess the effect of tax revenue on economic complexity, our study draws on the methodology proposed by Lapatinas et al. (2019) and Nguyen et al. (2020). Our contribution is to highlight the fiscal policy direction in the model to explain the dynamics of economic complexity in Africa. The following dynamic equation synthesizes this relationship:

$$ECI_{i,t} = \beta_0 + \beta_1 ECI_{i,t-1} + \beta_2 TR_{i,t} + \beta_3 X_{i,t} + \mu_i + \lambda_t + \epsilon_{i,t} \quad (1)$$

where $ECI_{i,t}$ is the ECI of country i on date t, and $TR_{i,t}$ denotes tax revenue, which refers to total tax revenue as a percentage of GDP. X is the vector of control variables, μ_i represents individual fixed effects, λ_t denotes time fixed effects, and $\epsilon_{i,t}$ is the error term.

We use the system generalized method of moments (GMM) suggested by Arellano and Bond (1991) and developed by Arellano and Bover (1995) and Blundell and Bond (2000) as our regression approach. The GMM is used for a variety of reasons. First, we exploit the fact that the individual dimension is greater than the time dimension in our panel data. Second, this strategy addresses the current endogeneity issues in panel data regression. The endogeneity in this study could be caused by measurement errors, omitted variables, and reverse causality. Concerning measurement errors, economic complexity and tax revenue variables are known to be associated with errors in their measurement. This is justified by the absence of these variables' consensual measure in the literature. Concerning omitted variables, some main variables may be omitted from the model. Although several determinants of economic complexity are important, these omitted variables can be correlated with the other variables in the model and therefore not included. Finally, the concern about reverse causality can be explained by the fact that, although tax revenue affects economic complexity, the reverse causation is also possible because increased production and export of sophisticated goods can increase tax resource mobilization. Noteworthily, because economic complexity is a path-dependent process that depends on its past development, including the lagged variable of economic complexity in the model makes it even more important to consider its memory effect (Teng & Lo, 2019). For all these above-mentioned reasons, GMM is the method that better fits our study. Although the GMM is declined in two versions, namely, difference GMM and system GMM, Bond et al. (2001) recommended system GMM as the more robust.

The GMM estimator's consistency is determined by two factors: the validity of the assumption that the error term does not exhibit serial correlation (AR (2)) and the validity of the instruments (Hansen test). Too many instruments can severely weaken and bias the Hansen over-identifying restrictions test, so the general rule is that the number of instruments should be less than the number of countries (Roodman, 2009).

IV. Empirical Results

A Baseline results

We estimate the direct effect of tax revenue on economic complexity, using ordinary least square (OLS), bootstrap, and jackknife methods as an initial step. Table 2 summarizes the results, with the total tax revenue serving as the primary variable of interest.

Table 2. *Tax Revenue and Economic Complexity, Baseline Results*

	OLS						Bootstrap	Jackknife
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Tax revenue	0.7855***	1.0684***	1.2932***	1.1188***	1.6499***	1.6307***	1.6307***	1.6307***
	(0.260)	(0.402)	(0.292)	(0.282)	(0.283)	(0.291)	(0.242)	(0.295)
GDPPC		-0.0533	-0.0828***	-0.1587***	-0.0982***	-0.1414***	-0.1414***	-0.1414***
		(0.035)	(0.029)	(0.031)	(0.033)	(0.035)	(0.030)	(0.036)
Natural resources			-0.2880***	-0.2605***	-0.2627***	-0.2659***	-0.2659***	-0.2659***
			(0.023)	(0.021)	(0.021)	(0.021)	(0.024)	(0.022)
Human capital				0.2873***	0.1971***	0.1749***	0.1749***	0.1749***
				(0.052)	(0.052)	(0.053)	(0.058)	(0.054)
Population density					0.1286***	0.1453***	0.1453***	0.1453***
					(0.019)	(0.019)	(0.021)	(0.019)
Openness						0.2330***	0.2330***	0.2330***
						(0.070)	(0.061)	(0.070)
Constant	-0.9974***	-0.6685***	0.1110	0.1367	-0.6995***	-1.3586***	-1.3586***	-1.3586***
	(0.044)	(0.198)	(0.177)	(0.173)	(0.234)	(0.316)	(0.297)	(0.318)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	652	628	610	587	587	566	566	566
R^2	0.0202	0.0217	0.2869	0.3032	0.3551	0.3619	0.3619	0.3619

Note. Robust standard errors are reported in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. *OLS, ordinary least square*; GDPPC, gross domestic product per capita.
(Source) Authors' calculation.

In Table 2, column (1) presents the results of the bivariate relationship between tax revenue and economic complexity, that is, without control variables or fixed effects. In line with Figure 3, we find that tax revenue has a positive and significant effect on economic complexity at the 1% level. In columns 2-6, we include the control variables, and our variable of interest remains significant at the 1% level. In columns 7 and 8, we perform a bootstrap and jackknife regression to ensure the stability of our results. As we can see, the results remain stable.

The results presented in Table 2 may be sensitive to fluctuations in the business cycle. Indeed, to control for cyclical movements in the economy, we divide the sample for this study into non-overlapping three-year periods (1995-1997, 1998-2000, 2001-2003, 2004-2006, 2007-2009, 2010-2012, 2013-2015, and 2016-2018). Therefore, we re-estimate our baseline model

using the three years' average data, without and with the same set of control variables. As before, we perform bootstrap and jackknife regressions to test the stability of our estimates. The results show that the coefficient associated with the tax revenue variable remains positive and statistically significant, confirming the results in Table 2.

Table 3. *Tax Revenue and Economic Complexity, Control for Business Cycle*

	OLS						Bootstrap	Jackknife
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Tax revenue	0.7722*	1.2296*	1.3376***	1.1724***	1.7172***	1.6325***	1.6325***	1.6325***
	(0.414)	(0.645)	(0.462)	(0.443)	(0.443)	(0.445)	(0.409)	(0.463)
GDP per capita		-0.0670	-0.0943**	-0.1745***	-0.1185**	-0.1575***	-0.1575**	-0.1575***
		(0.057)	(0.047)	(0.050)	(0.054)	(0.056)	(0.065)	(0.057)
Natural resources			-0.2859***	-0.2587***	-0.2612***	-0.2660***	-0.2660***	-0.2660***
			(0.036)	(0.032)	(0.034)	(0.033)	(0.034)	(0.035)
Human capital				0.3020***	0.2200***	0.2149***	0.2149**	0.2149**
				(0.079)	(0.080)	(0.082)	(0.090)	(0.084)
Population density					0.1224***	0.1368***	0.1368***	0.1368***
					(0.030)	(0.030)	(0.032)	(0.031)
Openness						0.2064*	0.2064*	0.2064*
						(0.112)	(0.120)	(0.116)
Constant	-0.9968***	-0.6010*	0.1713	0.2006	-0.5980	-1.1865**	-1.1865**	-1.1865**
	(0.070)	(0.317)	(0.279)	(0.274)	(0.372)	(0.523)	(0.493)	(0.532)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	224	224	217	209	209	203	203	203
R^2	0.0209	0.0286	0.3187	0.3433	0.3934	0.4001	0.4001	0.4001

Note. Robust standard errors are reported in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. OLS, ordinary least square.
(Source) Authors' calculation.

However, as shown in Table 3, the magnitude of the effect is nearly as important as previously, with tax revenue-related coefficients greater than those obtained in Table 2.

Moreover, given the limitations of the estimation methods discussed in the preceding, including their weakness to overcome endogeneity issues, we resort to a more robust estimator. We repeat the regressions of Equation (1) using the averaged data for system GMM with the three-year periods, which is more appropriate for this method and provides better findings. We follow the same steps as in Table 2. The results are reported in Table 4, which are similar to those obtained earlier. Moreover, the results of the different diagnostic tests show that the model is well specified. The Hansen test confirms the instruments' validity. Furthermore, the hypothesis stating no second-order autocorrelation (AR 2) is not rejected. Finally, too many instruments in the model can skew the results, so the rule is that the number of instruments in the model should not exceed the number of countries (Roodman, 2009). As presented in Table 4, in all the specifications, the number of countries is greater than the number of instruments.

Table 4. *Tax Revenue and Economic Complexity, GMM Estimates*

	Dependent variable: ECI					
	(1)	(2)	(3)	(4)	(5)	(6)
L.ECI	0.840***	0.847***	0.727***	0.811***	0.888***	0.780***
	(0.050)	(0.041)	(0.067)	(0.063)	(0.105)	(0.083)
Tax revenue	1.321***	1.296***	1.263***	2.607***	2.543***	1.839***
	(0.431)	(0.273)	(0.421)	(0.707)	(0.595)	(0.583)
GDP per capita		-0.079***	-0.090***	-0.251***	-0.306***	-0.156***
		(0.025)	(0.031)	(0.073)	(0.088)	(0.055)
Natural resources			-0.093*	0.057	0.084**	0.001
			(0.051)	(0.047)	(0.038)	(0.048)
Human capital				0.251**	0.327***	0.154**
				(0.108)	(0.115)	(0.066)
Population density					-0.031	0.081***
					(0.073)	(0.028)
Openness						0.090
						(0.066)
Constant	-0.394***	0.221	0.384**	0.593**	0.990	-0.354
	(0.115)	(0.160)	(0.165)	(0.264)	(0.639)	(0.269)
Country fixed effects	No	No	No	No	No	No
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	197	197	197	197	197	197
Countries	29	29	29	29	29	29
Instruments	8	13	22	15	18	23
AR (1)	0.000	0.002	0.001	0.005	0.007	0.004
AR (2)	0.960	0.958	0.752	0.899	0.834	0.838
Hansen	0.664	0.817	0.553	0.928	0.828	0.507

Note. Robust standard errors are reported in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. GMM, generalized method of moments, ECI, economic complexity index; L.ECI, lag economic complexity index.
(Source) Authors' calculation.

Overall, the results of Table 4 demonstrate that tax revenue has a positive and significant effect on economic complexity. Other things being equal, these findings demonstrate that tax revenue mobilization allows countries to produce complex and sophisticated goods by providing a significant source of financing. Similarly, these findings show that increasing tax revenue will aid in financing the sectors that support production (road connectivity infrastructure, electricity, internet, and modernization of economic and political governance, education, and R&D). Thus, good fiscal policy leads to economic sophistication, as measured by the ECI.

Furthermore, we find that, except for the variables "GDP per capita and trade openness," all the control variable coefficients have a positive sign and are significant in at least one of the model specifications. Similarly, the coefficient on the ECI's one-period lag is statistically significant and ranges between 0.763 and 0.981. This demonstrates that knowledge accumulation in producing sophisticated goods and services in Africa in the previous period has a positive

and lasting effect on product sophistication in the current period. This persistence demonstrates both the existence of high knowledge productivity as highlighted by Chu (2020) and a knowledge production spillover effect in Africa. This emphasizes the importance of public investments in R&D and human capital to reap the benefits of knowledge production's externalities.

B. Robustness checks

The previous section used total tax revenue as a measure of tax revenue. However, because total income is made up of various direct and indirect taxes, this metric may result in a limited examination of the effect of tax revenue on economic complexity. Furthermore, the results may be affected by the measure of economic complexity. Hence, we run two significant robustness tests. Firstly, we replicate the prior regressions with the various tax components, and secondly, we adjust the economic complexity metric and employ a different metric.

As mentioned earlier, we used total tax revenues. This variable is then disaggregated into its various components: (i) the tax on income, profit, and capital, (ii) the tax on goods and services, and (iii) the tax on international trade. Table 5 shows the results confirming those obtained previously using total taxes.

Table 5. *Robustness Check by Using the Components of Tax Revenue*

	Dependent variable: ECI		
	(1)	(2)	(3)
L.ECI	0.981***	0.763***	0.835***
	(0.098)	(0.106)	(0.063)
Tax on income, profit and capital	2.284**		
	(1.010)		
Tax on goods and services		3.312***	
		(1.106)	
Tax on international trade			5.950***
			(2.103)
GDP per capita	-0.058*	-0.093*	-0.076**
	(0.031)	(0.051)	(0.036)
Natural resources	0.095**	-0.033	0.052*
	(0.044)	(0.064)	(0.025)
Human capital	0.125*	0.228***	0.188***
	(0.073)	(0.065)	(0.058)
Population density	0.019	0.005	0.112***
	(0.027)	(0.025)	(0.037)
Openness	0.074	0.061	0.125**
	(0.085)	(0.076)	(0.047)
Constant	-0.501	-0.280	-1.102***
	(0.439)	(0.397)	(0.333)

Table 5. *Continued*

	Dependent variable: ECI		
	(1)	(2)	(3)
Country fixed effects	No	No	No
Time fixed effects	Yes	Yes	Yes
Observations	197	197	197
Countries	27	27	27
Instruments	26	22	25
AR (1)	0.007	0.006	0.008
AR (2)	0.270	0.638	0.537
Hansen	0.439	0.863	0.705

Note. Robust standard errors are reported in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. ECI, economic complexity index; L.ECI, lag economic complexity index.
(Source) Authors' calculation.

The results confirm that each tax revenue component is positively and significantly associated with economic complexity. The magnitude of the effect, however, is greater for taxes on international trade and taxes on goods and services.

We change the measure of economic complexity as a second robustness analysis. In the baseline analyzes, we used the traditional economic complexity. In this section, we use as an alternative measure the "improved" ECI (ECI+) constructed by Albeaik et al. (2017), based on the reflection method applied by Hidalgo and Hausmann (2009). The ECI+ measures an economy's total exports adjusted for the difficulty of exporting each product. The ECI+ outperforms the ECI in terms of economic growth prediction and estimator consistency across most econometric specifications.

Table 6 shows that the results obtained with and without control variables corroborate those obtained with the traditional index of economic complexity. Tax revenues are positively and significantly associated with the ECI+ at the 1% level.

Table 6. *Robustness Check by Using an Alternative Measure of Economic Complexity*

	Dependent variable: ECI+					
	(1)	(2)	(3)	(4)	(5)	(6)
L.ECI+	0.953***	0.972***	0.938***	0.960***	0.912***	0.902***
	(0.046)	(0.059)	(0.056)	(0.064)	(0.051)	(0.062)
Tax revenue	0.920***	2.158***	1.878***	0.809***	1.162***	1.210***
	(0.329)	(0.696)	(0.626)	(0.267)	(0.325)	(0.363)
GDP per capita		-0.279**	-0.297**	-0.143*	-0.105**	-0.113**
		(0.109)	(0.109)	(0.074)	(0.042)	(0.047)
Natural resources			-0.047**	-0.005	0.020	0.005
			(0.022)	(0.038)	(0.027)	(0.042)

Table 6. *Continued*

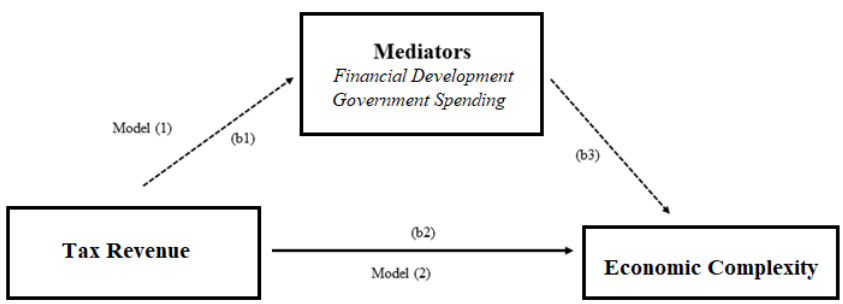
	Dependent variable: ECI+					
	(1)	(2)	(3)	(4)	(5)	(6)
Human capital				0.087**	0.132**	0.130**
				(0.042)	(0.058)	(0.062)
Population density					0.062***	0.063**
					(0.021)	(0.027)
Openness						-0.006
						(0.129)
Constant	-0.183**	1.624**	1.885**	0.733	-0.003	0.095
	(0.069)	(0.670)	(0.699)	(0.437)	(0.225)	(0.676)
Country fixed effects	No	No	No	No	No	No
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	197	197	197	197	197	197
Countries	29	29	29	29	29	29
Instruments	21	27	22	27	27	28
AR (1)	0.004	0.003	0.004	0.006	0.007	0.008
AR (2)	0.240	0.175	0.173	0.244	0.247	0.242
Hansen	0.591	0.737	0.882	0.662	0.535	0.449

Note. Robust standard errors are reported in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. ECI+, improved economic complexity index; L.ECI+, lag of improved ECI.
(Source) Authors' calculation.

C. Mediation analysis of the effect of tax revenue on economic complexity

In this subsection, we go into a thorough investigation by conducting a mediation analysis. As previously stated, we investigate two mediators: financial development and government spending. The method used in this study was inspired by Ang (2013) and, more recently, Avom and Ndoya (2022), as shown in Figure 4.

Figure 4. Modeling the mediation effect



(Source) Authors' construction.

This approach therefore involves the subsequent estimation of two regression equations as follows:

$$\text{Model 1: } Med_{it} = a_1 + b_1 TR_{it} + c'_1 X_{it} + u_{it} \quad (3a)$$

$$\text{Model 2: } ECI_{it} = a_2 + b_2 TR_{it} + b_3 Med_{it} + c'_2 X_{it} + v_{it} \quad (3b)$$

where Med_{it} represents mediation variables (financial development and government spending). The composition effect is derived from the two models as follows:

Indirect effect: $b_1 * b_3$; direct effect: b_2 and total effect: $(b_1 * b_3) + b_2$.

We begin by estimating Model (1), which is the effect of tax revenue on the mediators (financial development and government spending); $b_1$is the parameter describing this effect. The second step is to estimate Model (2), which involves regressing economic complexity on tax revenue while controlling for the mediators. The magnitude of this effect is provided by the coefficient of tax revenue (b_2). The indirect effect is therefore obtained from the product of $b_1$and b_3, where b_3 measures the strength of the correlation between tax revenue and the mediators in Model (2). This term also reflects the size of the mediation, which is primarily determined by the extent to which tax revenue affects the mediators (b_1) and the degree of mediators' influence on economic complexity (b_3).

Table 7 summarizes the results. Columns (1a) and (2a) present Model (1) estimates, with financial development and government spending serving as the mediators, respectively. Meanwhile, Model (2) estimates with mediators as controls are reported in columns (1b) and (2b), respectively. For convenience, we also report results for the baseline model in the last column of Table 7.

Overall, the findings indicate that: (i) tax revenue affects the two mediators, and the effects are statistically significant at the 1% level (columns 1a and 2a in Table 7). (ii) Each of the two mediators has a distinct effect on economic complexity (columns 1b and 2b in Table 7). (iii) Tax revenue significantly impacts economic complexity in the absence of mediators (column 3 in Table 7). (iv) The estimate coefficient of tax revenue on economic complexity decreases once a mediator is included in the model (columns 1b and 3b in Table 7, relative to column 3). Taken together, the results suggest that mediation may have occurred where some influences of tax revenue on economic complexity are carried through by financial development and government spending.

Furthermore, we conduct a formal assessment of the mediation effects on several statistical approaches, with the results reported in Table 8. Thus, several mediation tests are considered to analyze whether the indirect effect of tax revenue on economic complexity is statistically different from zero due to the influence of financial development and government spending.

Table 7. *The Mediation Effects of Financial Development and Government Spending*

Variables	(i) Mediator: Financial Development		(ii) Mediator: Government Spending		(iii) Baseline Regression
	(1a)	(1b)	(2a)	(2b)	(3)
	Financial Development	ECI	Government Spending	ECI	ECI
Tax Revenue	0.441***	0.110	1.258***	1.270***	1.6307***
	(0.053)	(0.322)	(0.132)	(0.299)	(0.290)
Financial Development		2.217***			
		(0.207)			
Government Spending				0.3871***	
				(0.076)	
Constant	0.079***	-1.251***	2.411***	-2.440***	-0.3585***
	(0.008)	(0.281)	(0.029)	(0.364)	(0.315)
Control variables	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	1234	1234	1234	1234	1234
Bootstrap replications	500	500	500	500	

Note. Robust standard errors are reported in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. ECI, economic complexity index
(Source) Authors's calculation.

Considering the mediation effect of financial development, for example, we estimated the estimated Sobel test statistic to be 0.977. Because the P-value is less than 5%, the null hypothesis of no mediation is rejected. The results are similar when using alternative mediation tests (Delta and Monte Carlo). Moreover, the usage of bootstrap confidence intervals does not alter the results. Indeed, the evidence presented implies that the mediation effect of financial development is material, with approximately 90% of the total effect of tax revenue on economic complexity.

Table 8. *Analysis of the mediation tests*

	(1) Mediating effect of Financial Development			(2) Mediating effect of Government Spending		
Mediation tests	Coeff.	Std. error	P-value	Coeff.	Std. error	P-value
Delta	0.977	0.142	0.000	0.487	0.115	0.000
Sobel	0.977	0.149	0.000	0.487	0.109	0.000
Monte Carlo	0.977	0.149	0.000	0.487	0.109	0.000
Composition tests						
Indirect effect (Sobel)		0.977			0.487	
Direct effect		0.11			1.27	
Total effect		1.077			1.757	
% of the total effect mediated		90%			28%	

V. Concluding Remarks

Difficulties in collecting tax revenue have sometimes been viewed as a barrier to economic development. Financing development necessitates the mobilization of substantial financial resources. Recent literature on economic complexity, which is defined by the amount of information entrenched in a country's industrial system, has emerged. Despite significant progress in understanding the drivers of economic complexity, tax revenue remains an unexplored topic. Hence, we investigate this possibility in this paper by examining the impact of tax revenues on economic complexity in 29 African countries from 1995 to 2018.

Applying the OLS, bootstrap, jackknife, and system GMM methods, we obtained empirical findings indicating that tax revenue increases economic complexity in Africa. Our findings are robust when accounting for the business cycle and using different tax revenue and economic complexity measures. Finally, we conducted a transmission channel analysis and found, without being exhaustive, that financial development and government expenditures are the primary channels through which tax revenue influences economic complexity.

The main implication of this study is the need for public policies to undertake strong tax reforms, which necessitate the implementation of effective tools to ensure efficient tax revenue mobilization and levers to facilitate the financing of the production and export of sophisticated and complex products.

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