The Shadow Economy, Mobile Phone Penetration and Tax Revenue in Sub-Saharan Africa

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This study investigates the effect of the shadow economy on tax revenue and the moderating effect of mobile phone penetration in Sub-Saharan Africa. Using data on 26 SSA countries over 11 years and employing the system General Method of Moments (GMM) approach, the study reveals that the shadow economy has a significant negative effect on tax revenue in SSA, whereas mobile phone penetration has a significant positive effect on tax revenue. Again, mobile phone penetration plays a moderating role in the shadow economy–tax revenue nexus in SSA. Governments in the SSA region need to update their tax administration systems, construct and enhance infrastructure linked to emerging mobile technology, and implement best practices in tax regulations. Lastly, governments and telecommunications companies should implement some kind of consumer education in the informal sector to raise awareness of the advantages of using mobile phones for business transactions and the simplicity of paying taxes using a mobile device.

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Introduction

Every nation in the world aspires to economic development as a macroeconomic objective (Ayenew 2016). In most developing economies, there are still unresolved issues with economic development in particular. Despite having an abundance of natural resources, the majority

of developing nations have budget deficits that make it necessary for them to depend on foreign aid to pay for their development initiatives. Consequently, better control over the processes of economic development and poverty reduction as well as a reduction in the fiscal deficit may result from increased mobilization of domestic resources. Resource efficiency has remained poor in Less Developed Countries (LDCs), and these economies' governments are more actively involved in achieving economic stabilization using a range of policy tools, including fiscal policy (Ayenew 2016). Because economic resources are limited in society, an increase in government spending usually causes a drop in private spending. One way to transfer resources from the private to the public sector is through the implementation of fiscal policy, which involves raising tax revenue. Taxation is without a doubt the most significant source of government revenue; however, governments regularly raise money through a number of means, including borrowing, receiving aid, printing money, and taxing (Chaudhry and Munir 2010).

One of the most important tools that developing nations can use to mobilize their own resources for long-term development is taxation. It supports the core responsibilities of a functional state by allowing it to raise the funds required to carry out significant services and by creating an atmosphere that is favourable to economic expansion. It also acts as a catalyst for building state capacity and governments which are more responsive and responsible to their constituents (OECD 2008). In addition, to raise their tax revenues, several developing nations have implemented numerous reform initiatives during the past few decades, such as the implementation of value-added taxation (VAT). Even though tax revenue indicates how well the economy can support government spending, most developing nations still have low tax rates (Tanzi and Zee 2001).

In developing nations, tax revenue collection is still historically low, although being an essential tool for robust and inclusive state-building. Numerous authors have written about how developing nations perform poorly in terms of tax revenue. For instance, tax collection in developing nations is just 11 percent of GDP, while it is 20 percent in comparatively wealthy nations (Okunogbe and Santoro 2021). The Sustainable Development Goals specify a tax performance of 20 percent of GDP as the minimum required to build a strong state (to deliver on core citizens' rights and government promises), which raises significant development concerns in light of poor countries' low tax revenue. Numerous authors,

such as Okunogbe and Santoro (2023) and Basri et al. (2021), provide evidence of inadequate tax revenue mobilization in developing nations.

The majority of Sub-Saharan Africa (SSA) nations share a low tax-to-GDP ratio (Ayenew 2016). Many nations make great efforts but are unable to generate enough income to cover their governments' deficits and meet their development requirements. In order to meet the Sustainable Development Goals (SDGs), half of the SSA nations mobilized 16.8 percent of GDP from tax revenue, which is less than the 20 percent required by the UN. This information was reported by the United Nations Development Programme in 2013. However, less than 17 percent of GDP is collected in taxes by half of all SSA countries, and many Asian and Latin American nations fare little better (OECD 2014a). According to Coulibaly and Gandhi (2018), SSA has a large financing demand for investments, estimated at about $230 billion annually. The primary causes of this deficit are the low rates of savings inside the country and the persistent underperformance of tax revenue collection, even with the recent improvements. According to Coulibaly, Gandhi, and Senbet (2019), regional tax collections – aside from those pertaining to the natural resource sector – did in fact rise from 11 percent of GDP in the early 2000s to nearly 15 percent in 2015. Although the percentage has increased from 11 percent to nearly 15 percent, it still falls short of the desired level and is still lower than that of the OECD (24 percent) and other emerging and developing nations.

Official Development Assistance (ODA), a major source of funding for development in Africa, has been decreasing over time. This implies that for the continent to meet the SDGs, ways to improve internal resource mobilization must be found. The first SDG 17 target stresses the necessity for countries to improve internal resource mobilization and capacity building for tax and other revenue collection. The creation of tax income is vital to a nation's economic progress (OECD 2014b). In particular, higher revenue would fortify the fiscal capacity of the continent, allowing it to fund public goods and services that will lessen vulnerability, poverty, and inequality. Nonetheless, the average tax-to-GDP ratio in Africa is 17.1 percent, which is less than the 18.5 percent threshold needed to support growth and supply basic amenities like better public safety, healthcare, and road infrastructure in emerging countries (Aydin and Esen 2019). This contrasts sharply with the 34 percent of the OECD and the 22 percent of Latin America and the Caribbean, respectively (OECD 2019). The remaining 16 SDGs, as well as SDG 17, would be challenging to achieve if this problem is not fixed. Over time, low tax revenue mobilization in SSA

has been attributed to various factors, including poor economic development, the significant contribution of agriculture to economic activity, and the size of the informal economy, also known as the shadow economy (Coulibaly and Ghandi 2018). Since the informal sector generates less tax revenue than the formal sector, the governments of some states in the SSA region have implemented various mechanisms to curtail its large scale.

The informal sector's size has decreased over time in SSA, although not to the anticipated degree (Lum 2011; Medina and Schneider 2018). In SSA, 34 percent of GDP comes from the informal sector (Coulibaly and Ghandi 2018). Even while the informal sector is blamed for the region's low tax income, it does offer some job prospects. About 70 to 80 percent of non-agricultural workers are working in the informal sector, with the majority being self-employed people and micro-business owners, according to the International Labour Organization (2018). The bulk of these people who work for themselves and manage micro businesses have embraced using mobile phones for both daily tasks and company operations, according to Larsson and Svensson (2018). The informal economy is undergoing a shift, and this is reflected in the increasing use of mobile phones in this sector, which also serves as a means of raising taxes (Larsson and Svensson 2018).

Many lives have been transformed by the mobile revolution, which has made basic financial access and connectivity possible through phone-based money transfers and storage (Donner and Tellez 2008; Demombynes and Thegeya 2012). In order to accomplish some of the SDGs in the SSA region, mobile phones are essential due to their capacity to promote sustainable development and equitable growth. Theoretically, increases in a nation's tax revenue are the main indicators of growth and progress. According to the OECD (2014b), tax income is allocated to various projects, including but not limited to road construction, social amenities, and job creation, all of which contribute to growth and development.

Some studies have looked into how mobile phones affect economic development and growth (Aker and Mbiti 2010). Additionally, Asongu (2015) and Carabregu Vokshi et al. (2019) investigated the effect of the penetration of mobile phones on inequality. Furthermore, several studies conducted on mobile phones have been qualitative and theoretical in character (Donner and Tellez 2008; Maurer 2008; Merritt 2010; Thacker and Wright 2012). Research on the connection between taxes and mobile phones examined the impact of specific taxes and how the mobile

market is affected (Exelby 2011; Katz, Flores-Roux, and Mariscal 2011). For instance, Apeti and Edoh (2023) examine the effects of mobile money adoption on direct and indirect tax revenue in developing countries. Additionally, research on how the informal sector affects tax collection has been conducted in a number of different countries (Boltano and Abanto 2019; Mawejje and Munyambonera 2016).

As a result of the aforementioned literature, and to the best of our knowledge, no study has yet evaluated how widespread mobile phone use affects tax revenue and how it influences the tax revenue–informal sector nexus in SSA. The few empirical studies that are currently available rely on micro-level, nation-specific data that is primarily gathered through surveys (Demombynes and Thegeya 2012). Evidence from the literature shows that over time, actors in the informal sector have resorted to using mobile phones to run their businesses and also use them as a medium to pay their taxes, which in the long run increases the overall tax revenue; an examination of the moderating role of mobile phone penetration in the informal sector–tax revenue nexus is necessary for SSA (Larsson and Svensson 2018). Therefore, this gap in the literature offers a rare chance to enhance the body of work already done by adding a macroeconomic analysis of tax revenue, mobile phone penetration, and the shadow economy. Being one of the few, if not the only, empirical studies to look at the moderating effect of mobile phone penetration in the informal sector and tax revenue relationship in the SSA region, the study adds to the body of current literature.

The rest of the article is structured as follows. The literature is presented first, followed by the methodology and data in the third section, the results and discussions in the fourth section, and lastly, conclusions and policy recommendations in the fifth section.

Review of the Literature

A significant basis in the economics of taxes has been the optimal tax theory (see Atkinson and Stiglitz 1976; Mirrlees 1971). The idea of optimal taxation examines how taxes can be designed to produce the maximum social welfare outcomes (Opara 2014). In this sense, uniform vs differentiated taxation has dominated discussions over the best taxation policies. The literature on optimal taxes has grown quickly, although there is still disagreement in this area. Ramsey (1927) demonstrates in his groundbreaking work that, generally speaking, a uniform commodities tax system is not the best option because it does not alter relative

pricing. Feldstein (1978) supports the Ramsey tradition by pointing out that it is generally not ideal to tax some forms of capital evenly, as long as the revenue from those products is untaxed. Differentiated tax rates are therefore necessary for optimal taxation, according to these theoretical perspectives. However, according to Summers (1987), there is little potential efficiency gain from doing away with the differential taxation of different types of capital income. As a result, addressing this issue diverts attention from the overall level of capital income taxation, which is crucial for figuring out how efficiently the economy operates.

The macroeconomic applied tax models of Heller (1975) and Leuthold (1991) demonstrate the importance of the tax base's constituent parts, efficient institutional frameworks (such as those concerning corruption control), and affirmative economic policies (such as those aimed at luring foreign direct investment, or FDI) in terms of tax revenue performance. According to the models, measures aimed at increasing FDI will boost growth and hence broaden the tax base, opening up new avenues for increased tax collection. The economist Arthur Laffer has long proven the importance of tax rate (as a particular type of a general discretionary tax policy) to impact tax revenue (Kazman 2014; Trabandt and Uhlig 2011). Neoclassical supply-side economics, which is based on the Laffer curve, indicates that raising the tax rate first improves tax revenue; however, raising the rate further results in a decrease in tax revenue. According to supply-side economists, tax cuts boost the economy and raise tax receipts as a result. The curve's downward slope indicates that to increase total tax revenue, a tax rate reduction is required to broaden the tax base. These views are supported by theoretical studies by Mankiw, Weinzierl, and Yagan (2009) and Hines and Summers (2009), which emphasize how important it is to select the right revenue instruments or tax handles (tax bases) to affect tax performance.

Several authors have taken into consideration empirical research on the subject of the shadow economy and tax revenue. For example, Lukito and Adi (2023) use descriptive-exploratory and explanatory methodologies to empirically investigate the effects of the allocation, distribution, and stabilization variables on the shadow economy and their impact on tax revenues in Mojokerto City, Indonesia. Using a sample of 79 respondents, a population of 369 with a Slovin tolerance formula of 0.01 was identified. Version 3.3.7 of the SmartPLS software aided in data processing while a questionnaire was used for data collection. The outcomes demonstrate: (1) The shadow economy is significantly impacted by

allocations; (2) The shadow economy is significantly impacted by distribution; (3) Stabilization has no influence on the shadow economy; (4) Allocations have no effect on tax revenues; (5) Distribution significantly affects tax revenues; (6) Stabilization significantly affects tax revenues; (7) The shadow economy significantly affects tax revenues; (8) Allocations indirectly affect tax revenues through the shadow economy; (9) Distribution indirectly affects tax revenues through the shadow economy; (10) Stabilization indirectly affects tax revenues through the shadow economy. This study is, however, a micro-study of a city in Indonesia, the result of which cannot be used to generalize for the entire country. Furthermore, Ishak and Farzanegan (2020), for example, investigated the impact of the shadow economy on tax revenue and found that it had a negative influence on tax collection in both developed and developing nations.

The size of Peru's informal economy was examined in a Boltano and Abanto (2019) study concerning other Latin American countries and the Organization for Economic Cooperation and Development (OECD). The results showed that the average size of the informal economy in terms of tax collection as a percentage of GDP was projected to be 37.4 percent in Peru, 34 percent in Latin America, and 19.89 percent in OECD countries – less than half of the average for the region. The study's conclusions showed that tax revenue was negatively impacted by the unorganized sector. Additionally, Obara and Nangih (2017) looked into the effects of taxing Nigeria's informal sector, with a particular emphasis on Rivers State. The study's conclusions showed that taxing the informal sector improved revenue collection and benefited Nigeria's economic growth. Mawejje and Munyambonera (2016) looked into how public spending and sectoral growth affects tax revenue in Uganda. According to their results, the main obstacles to the performance of tax revenue are the dominance of the informal sector and agriculture. In his study of developing countries, Gnangnon (2023) investigated how tax reform was impacted by the shadow economy. The first category of tax reform is known as 'structural tax reform' (STR), which is defined by significant episodes of tax revenue mobilization. Akitoby et al. (2020) identified STR using the narrative approach, which enables the precise nature and timing of significant tax actions in a number of areas related to revenue administration and tax policy that actually resulted in increases in tax revenue. The term 'tax transition reform' (TTR) refers to the second kind of tax reform, which is a restructuring of the tax revenue structure that lessens reliance

on revenue from international trade taxes in favour of domestic tax revenue. The analysis, which made use of a variety of estimators, demonstrated that the shadow economy lowers the probability of STR (especially in low-income countries) in a number of domains related to tax policy and revenue management. In nations where the money from international trade taxes plays a significant role in the tax revenue system, the shadow economy also poses a threat to the TTR process. Lastly, it encourages the TTR process in nations with more liberalized trade.

The second approach in the literature looks at the factors that affect tax revenue. According to one body of research, the factors that statistically significantly explain the differences in the tax revenue-to-GDP ratio between nations are the per capita GDP, income level, foreign aid, share of agriculture, the structure of the economy, and the degree of openness (Addison and Levin 2012; Gupta 2007; Nnyanzi, Babyenda, and Bbale 2016; Zarra-Nezhad, Ansari, and Moradi 2016). The empirical research also focuses on the relationship between institutional characteristics and tax income. Research by Epaphra and Massawe (2017) shows that the creation of tax income is enhanced by governance indices such as government efficacy, regulatory quality, rule of law, voice, and accountability (see also Ngwakwe 2015; Lensink, Hermes, and Murinde 2000).

The third aspect of the literature looks at electronic commerce. Duke et al. (2013) investigated the barriers to Nigerian electronic commerce functioning as a conduit for tax revenue. The results show that Nigeria's total tax revenue is greatly impacted by e-commerce activities. A comparable study conducted in Nigeria by Effiong and Nwangu (2020) also discovered that while Point of Sales (PoS) and mobile phone transactions had a large impact on tax revenue income, e-commerce and ATM transactions had a big impact as well. Apeti and Edoh (2023) examine how the use of mobile money has affected tax collection performance over the 1990–2019 period in 104 developing countries. Estimates derived from the entropy balancing method demonstrate that, in comparison to non-mobile money countries, mobile money dramatically boosts tax collection in mobile money countries. This result holds up well to a number of robustness tests and may be influenced by time perspective, the kind of mobile money service, and a few structural elements such as the degree of corruption, the size of the rural population, the inflation rate, the education level, the sample 25th percentile and average of tax revenue, the effectiveness of revenue administration, and mature markets. Mobile money raises both types of tax revenue, having a greater

influence on direct tax revenue, according to a first level of tax revenue disaggregation into direct and indirect tax revenue. When these two components are broken down into separate subcategories at a second level, it becomes clear that while taxes on goods and services determine indirect tax revenue, personal and corporate income taxes have the biggest impact on direct tax revenue. Ultimately, the key ways that mobile money adoption improves tax performance in developing nations are through a wider tax base (measured by GDP per capita), improved institutional quality, and streamlined tax payment procedures. Hanrahan (2021) also applies both static and dynamic panel data analysis approaches to analyse the impact of the rise in digitalization on tax revenues. Panel data spanning OECD countries from 1995 to 2018 is used. The results suggest that a nation with strong digital dynamics may find it more difficult to earn larger tax returns as a result of digitalization. With propensity score matching, Wandaogo, Sawadogo, and Lastunen (2022) evaluate the causal relationship between tax income and Peer-to-Government (P2G) mobile payments adoption. The matching estimates indicate that P2G service adoption results in a 1.2 to 1.3 percentage point increase in direct tax collection as a proportion of GDP. The adoption of P2G enhances corporate and personal income tax collection, having a greater impact on the latter. The outcomes hold up well to comparable quality assessments and different estimate techniques such as the system generalized method of moments, function control, and two-stage least squares. The average treatment effects are highest in lower-middle-income nations and those with low levels of urbanization, domestic loans to the private sector, and limited tax compliance and corruption control. According to the research, developing nations should encourage the adoption and use of mobile money services for tax transactions, especially those with weak institutions and low levels of financial inclusion. Adegboye et al. (2022) also examine the effect of Information and Communication Technology on government revenue mobilization for 48 Sub-Saharan African countries from 2004 to 2020 using the Generalized Method of Moments (GMM). Internet penetration rate, telephone penetration rate, and mobile phone penetration rate are the three measures of Information and Communication Technology used in the study. The study also estimates the thresholds for two of the three measures and reveals thresholds of 21.125 internet penetration (per 100 people) for the income from the tax on non-resource income, 16.333 (per 100 people) internet penetration for

total income from tax, and 21.959 (per 100 people) telephone penetration for total income from tax revenue.

More recent studies such as Jemiluyi and Jeke (2023) and Okunogbe and Santoro (2023) have discussed the effect of the adoption of Information and Communication Technology on tax revenue in Africa. Jemiluyi and Jeke (2023), for instance, analysed the role of Information and Communication Technology in mobilizing tax revenue in the Southern African Development Community between 2001 and 2020 within the Fully Modified OLS framework. The results of the study indicate that measures of Information and Communication Technology, namely mobile cellular and internet usage, have a statistically significant positive effect on all categories of taxes such as total tax revenue, taxes on goods and services, and taxes on income, profit, and capital gains. Okunogbe and Santoro (2023) also look at how African nations might use the latest technological developments to enhance tax management. It gives a general summary of the advantages and disadvantages of the various tax types in Africa, including income taxes, trade taxes, real estate taxes, and consumption taxes. The use of technological solutions to help identify the tax base, monitor compliance, and ease compliance is then discussed as a means of addressing these issues.

It is evident from the literature that research on tax revenue that has already been done has concentrated on different factors. Furthermore, the majority of research on the shadow economy is done at the micro level (Olabisi et al. 2020; Mawejje and Munyambonera 2016; Obara and Nangih 2017). Lastly, research on the adoption of mobile phones relies primarily on micro-level, country-specific data gathered through surveys (Demombynes and Thegeya 2012). The research has mostly overlooked the empirical connection between mobile phone penetration and the creation of tax revenue as well as the moderating effect that mobile phone penetration plays in affecting tax revenue through the informal sector.

Methodology and Data

THEORETICAL MODEL SPECIFICATION

This study extends and adopts the well-known tax framework created by Heller (1975) as the foundation for the theoretical model specification to investigate the impact of the shadow economy on tax revenue and the moderating role of mobile phone penetration in the shadow economy–tax

revenue nexus in the SSA region. According to Heller's (1975) model, public decision-makers in developing nations make fiscal decisions based on maximizing a welfare function while adhering to budgetary constraints. The public decision-maker utility function is given as:

$$U = (Y - T, G, D, F + L), \tag{1}$$

where $U_{Y\text{-}T}$ and $U_g > 0$; U_D and $U_{F+L} < 0$, if D and $F+L > 0$; U_D and if D and $F+L < 0$. $Y\text{-}T$ (Y is GDP and T is tax revenue) is the disposable income of the private sector; G is total government spending, D is net domestic government borrowing (non-tax revenue), and $(F+L)$ is net foreign financing made up of grants (F) and loans (L), including the accumulation or decumulation of external arrears (net amortization). The first derivatives of U with respect to D and $(F+L)$ can be either positive or negative because the variables D and $(F+L)$ can have either one of these values. Every variable in the model is expressed in real terms per capita. The decision maker's budget constraint is given by:

$$G = T + (F + L) + D \tag{2}$$

To determine the desired tax revenue, (1) is maximized subject to (2). The utility function is assumed to take the following quadratic form:

$$U = \varnothing_1 (Y - T - Y_s) - \frac{\varnothing_2}{2}(Y - T - Y_s)^2 + \varnothing_3 (G - G_S) - \frac{\varnothing_4}{2}(G - G_S)^2 - \varnothing_5 D - \frac{\varnothing_6}{2} D^2 - \varnothing_7 (F + L) - \varnothing_8 (F + L)^2, \tag{3}$$

where the ∅ s are positive constants. G_s and Y_s are subsistence levels of government expenditure and income, respectively. Since G_s and Y_s are not observable, it is assumed that they are simple linear functions of income such that:

$$G_s = g_0 + g_1 Y \tag{4}$$

$$Y_S = y_0 + y_1 Y \tag{5}$$

The following reduced form for the desired equation for the tax revenue–GDP ratio $(T/Y)^*$ is obtained by simultaneously solving the optimal equations and maximizing (3) with regard to T, G, and D after substituting for G_s and Y_s subject to the budget constraint (2):

$$\left(\frac{T}{Y}\right)^{*} = \left(\frac{\mu + \varnothing_4 g_0 - \pi Y_0}{\pi + \varnothing_4}\right)\left(\frac{1}{Y}\right) - \left(\frac{\varnothing_4}{\pi + \varnothing_4}\right)\left(\frac{F+L}{Y}\right) + \left(\frac{\varnothing_4 g_1 - \pi Y_1}{\pi + \varnothing_4}\right), \tag{6}$$

where

$$\mu = \left(-\varnothing_1 + \varnothing_3 - \frac{\varnothing_1 \varnothing_4}{\varnothing_6} + \frac{\varnothing_4 \varnothing_5}{\varnothing_6}\right) \text{ and } \pi = \frac{\varnothing_2(\varnothing_4 + \varnothing_6).}{\varnothing_6}$$

Variable *D* disappears while solving for the desired tax revenue GDP ratio. We now suppose that certain tax bases, the desired tax revenue to GDP ratio $(T/Y)^{*}$, and the state of macroeconomic policies all influence the actual tax revenue to GDP ratio (T/Y). In this study, the tax base is captured by the shadow economy (SHADOW) and mobile phone penetration (MPP). Thus:

$$\left(\frac{T}{Y}\right) = f\left[\left(\frac{T}{Y}\right)^{*}, SHADOW, MPP, M\right] \tag{7}$$

The expression for the actual tax shares is given by combining equations (6) and (7) as:

$$\left(\frac{T}{Y}\right) = f\left[\left(\frac{1}{Y}\right), \left(\frac{F+L}{Y}\right), SHADOW, MPP, M\right] \tag{8}$$

Since π is positive and μ can be either positive or negative, the actual tax revenue to GDP ratio (T/Y) is a negative function of $(F+L)/Y$ and an uncertain function of the inverse of GDP $(1/Y)$. Equation (8) determines the country's tax bases captured by shadow economy (SHADOW) and mobile phone penetration (MPP) (often referred to as tax handles), macroeconomic policies (M), and foreign financing as a ratio of GDP$((F+L)/Y)$.

Finally, we can express the theoretical model as follows using the general determinants of the model:

$$\left(\frac{T}{Y}\right) = f(YP, \ Tax\ Base, M, \ Ext\ Env) \tag{9}$$

where *YP* is GDP per capita representing the size of the economy, *Tax Base* is the tax base of handles, captured by shadow economy (SHADOW) and mobile phone penetration (MPP), M is the macroeconomic policies captured by inflation with the reason that economic policies

that emphasize a prudent financial stance can be expected to raise tax revenue, and *Ext Env* denotes external environment factors that may affect tax revenue, such as control of corruption.

EMPIRICAL MODEL SPECIFICATION

The variables of interest, shadow economy and mobile phone penetration are added to equation (9) above in accordance with the literature (see, for instance, Feger (2014) and Terefe and Teera (2018)). Equation (10) specifies the baseline model, which is the empirical form of equation (9) above:

$$(T/Y)_{i,t} = \beta_0 + \beta_1 (T/Y)_{i,t-1} + \beta_2 SHADOW_{i,t} + \beta_3 MPP_{i,t} + \beta_4 X_{i,t} + \eta_i + \mu_t + \varepsilon_{i,t}$$

$$i = 1,2,3,\ldots,26;\ t = 1,2,\ldots,11, \tag{10}$$

where T/Y represents tax revenue as a percentage of GDP, SHADOW represents the shadow economy as a percentage of GDP, represents mobile phone subscriptions (per 100 people), which is a proxy for mobile phone penetration, and X is a vector of control variables. The control variables include TOT, which indicates Trade Openness as a percentage of GDP; AGRIC, which also represents the share of agriculture value added (% of GDP); INF, representing inflation, consumer price index (annual %); SER represents the share of service value added (% of GDP); and AID represents net Official Development Assistance (ODA) received (% of GNI). YP represents GDP per capita (constant 2015 US$), COC represents control of corruption, μ_t is a dummy for time-specific effects and is country-specific unobserved effect and $\varepsilon_{i,t}$ idiosyncratic error term. The subscripts t and i denote country and time period, respectively.

To examine the effect of the shadow economy on tax revenue in general, the model includes the lag of tax revenue which is specified below:

$$(T/Y)_{i,t} = \beta_0 + \beta_1 (T/Y)_{i,t-1} + \beta_2 SHADOW_{i,t} + \beta_3 X_{i,t} + \eta_i + \mu_t + \varepsilon_{i,t}$$

$$i = 1,2,3,\ldots,26;\ t = 1,2,\ldots,11, \tag{11}$$

where $(T/Y)_{i,\,t-1}$ is the lag of tax revenue as a percentage of GDP. The lag of T/Y is taken in order to assess whether the previous year's tax revenue has any impact on the current year's tax revenue. Moreover, since this is

a dynamic analysis, there is a need to specify the lag of the tax revenue in the model. All other variables remain as defined earlier.

To examine the effect of mobile phone penetration on tax revenue in general, the model includes the lag of tax revenue which is specified below:

$$\begin{aligned}(T/Y)_{i,t} &= \beta_0 + \beta_1 (T/Y)_{i,\,t-1} + \beta_2 MPP_{i,t} \\ &\quad + \beta_3 X_{i,t} + \eta_i + \mu_t + \varepsilon_{i,t} \\ \text{i} = 1,2,3,\ldots,26;\ \text{t} = 1,2,\ldots,11,\end{aligned} \tag{12}$$

To examine the moderating role mobile phone penetration plays in the shadow economy–tax revenue nexus, model (13) is specified as follows:

$$\begin{aligned}(T/Y)_{i,t} &= \beta_0 + \beta_1 (T/Y)_{i,\,t-1} + \beta_2 SHADOW_{i,t} \\ &\quad + \beta_3 MPP_{i,t} + \beta_4 X_{i,t} + \beta_5 (SHADOW_{i,t} * MPP_{i,t}) \\ &\quad + \eta_i + \mu_t + \varepsilon_{i,t} \\ \text{i} = 1,2,3,\ldots,26;\ \text{t} = 1,2,\ldots,11,\end{aligned} \tag{13}$$

where ($SHADOW_{i,t}$*$MPP_{i,t}$) denotes an interaction term between shadow economy and mobile phone penetration. All other variables remain as defined earlier, β_0 represents the intercept term, β_1, β_2, β_3, β_4, *and* β_5 are our parameters or coefficients of interest and is the error term in the model.

The study makes use of panel data from 26 SSA nations that spans the years 2009 through 2019. Data availability influenced the selection of the time period and the countries. The study uses a dynamic panel system GMM methodology proposed by Blundell and Bond (1998) to account for the autoregressive component dependent variable and address the endogeneity that could occur from regressors. The lagged dependent variable's presence and the correlation between it and the error term can cause various endogeneity issues. The system GMM can handle these issues, as well as omitted variable bias, measurement error correction, and the generation of effective internal instruments. Two requirements must be met in order to determine the consistency and validity of our system's GMM estimator: the instruments must be valid and the error term cannot be serially correlated. To meet these requirements, the Arellano-Bond test for serial correlation and the Hansen test for over-identifying restrictions were employed.

DATA, SOURCE AND EXPECTED SIGNS

Table 1 presents the summary of the descriptions of the variables and their expected signs as well as the data sources.

TABLE 1 Variables, Description, Expected Sign and Data Source

Variable	Description	Expected Sign	Data Source
Tax Revenue (T/Y)	Tax revenue as % of GDP		World Bank Database
Shadow Economy (SHADOW)	Size of the informal sector measured as a % of GDP	-	Medina and Schneider (2018)
Mobile Phone Penetration (MPP)	Mobile cellular subscriptions (per 100 people)	+	World Bank Database
Trade Openness (TOT)	Trade Openness, defined as the sum of imports and exports as a % of GDP	+/-	World Bank Database
Agriculture Sector (AGRIC)	Share of agriculture, value added as a % of GDP	-	World Bank Database
Inflation (INF)	Consumer price index (annual %)	-	World Bank Database
Service Sector (SER)	Share of service, value added as a % of GDP	+	World Bank Database
Aid (AID)	Net Official Development Assistance (ODA) received (% of GNI)	+/-	World Bank Database
GDP Per Capita (YP)	GDP per capita (constant 2015 US$)	+/-	World Bank Database
Control of Corruption (COC)	Index for the control of corruption [−2.5 (weak) to 2.5 (strong)]	+	World Governance Indicators

We anticipate seeing a negative relationship between tax revenue and the shadow economy once tax revenue has been regressed on the model's sets of control variables because the informal sector is thought to be difficult to tax and also evades taxes (Nnyanzi, Babyenda, and Bbale 2016; Mawejje and Munyambonera 2016). Tax revenue is anticipated to benefit from the increased use of mobile phones. Because there are several taxes associated with using mobile phones, their use provides a means of income generation for governments. Additionally, it is now a method for people to pay their taxes (Koyuncu, Yilmaz, and Ünver 2016; Effiong and Nwanagu 2020).

Theoretically, there is uncertainty about how GDP per capita affects tax revenue. A nation's share in the formal economy rises with its level of development, increasing tax revenue (Ángeles-Castro and Ramírez Camarillo 2014). The impact of GDP per capita level, a proxy for economic development, varies depending on the kind of tax. For example, while

a higher level of GDP per capita raises the indirect tax ratio, trade taxes are likely to decrease. Farhadian-Lorie and Katz (1989) state that trade tariffs were a significant source of funding for governments in both the pre-structural adjustment era and the early phases of development. In such cases, it is anticipated that rising GDP per capita will result in declining shares of total tax collection. Other control factors, such as trade openness, the agriculture and service sectors, inflation, aid, and the control of corruption are also included in the study with reference to the literature.

Results and Discussion

The findings from the econometric estimations are covered in this section. The study begins by summarizing the descriptive statistics of the variables it utilized. The impact of the shadow economy and the widespread use of mobile phones on tax revenue comes next. We then go on to discuss how mobile phones moderate the impact of the informal sector on tax revenue. The system GMM findings are shown for each case. However, two requirements must be met in order to determine the consistency and validity of the system GMM estimator: the instruments must be legitimate and the error term cannot be serially correlated. Due to this, the study must use the Arellano-Bond test for serial correlation AR (2), which measures second-order serial correlation with the null hypothesis that there is no second-order serial correlation. The second test is the Hansen test for over-identifying restrictions with the null hypothesis that the instrumented variables are exogenous and not correlated with the error term. Instrument validity is indicated by rejecting the null.

SUMMARY STATISTICS

According to table 2, the total tax revenue (T/Y) for the 26 sub-Saharan African countries is averaged at about 15 percent of GDP. The maximum and minimum values are approximately 39 percent and 4 percent, respectively, with a variance of 6.8 percent. When expressed as a share of GDP across the period, the informal sector (SHADOW) averages roughly 34 percent of GDP. With a minimum of roughly 18 percent of GDP, the maximum figure is roughly 54 percent of GDP. Within the region, the informal sector deviates from the mean by about 7.7 percent annually. The mean value of mobile cellular subscriptions (per 100 persons), which is used as a proxy for mobile phone penetration (MPP) over the period, is 78.86, with the regional variance being 38.85. In the SSA region, there are

TABLE 2 Summary Statistics of Variables from 2009 to 2019

Variable	Obs.	Mean	Std. Dev.	Min	Max
Tax Revenue (T/Y)	286	15.5880	6.7700	4.0985	39.2576
Shadow Economy (SHADOW)	286	33.5458	7.6600	17.8	54
Mobile Phone Penetration (MPP)	286	78.8562	38.8531	4.7536	173.811
Trade Openness (TOT)	286	79.2191	28.9353	28.8153	155.999
Agriculture Sector (AGRIC)	286	17.4960	12.8915	1.0535	58.0357
Inflation (INF)	286	6.1892	13.2135	−2.4096	200.367
Service Sector (SER)	286	47.4676	10.1024	22.1315	67.6503
Aid (AID)	286	6.7825	8.1905	0.0035	77.8681
GDP Per Capita (YP)	286	2690.469	3034.459	345.635	15906.5
Control of Corruption (COC)	286	−0.5375	0.6525	−1.8264	1.0269

173.81 mobile phone subscriptions at the greatest level (per 100 persons) and 4.75 at the lowest. Within the region, trade openness (TOT) as a percentage of GDP ranges from a minimum of 28.82 to a maximum of 156.0. As a percentage of GDP, trade openness has a mean value of 79.22 and a variation of 28.94. Agriculture's average GDP share (AGRIC) is 17.50, with a deviation of 12.89. Agriculture's GDP share ranges from a low of 1.05 to a maximum of 58.04.

The consumer price index (annual %), which is used to quantify inflation (INF), has a mean value of 6.19 percent and a deviation of 13.21 percent from the mean. For the SSA nations included in the study, the highest inflation rate is 200.37 percent, while the minimum inflation rate is −2.41 percent. Some countries such as Burkina Faso, Cameroon, Equatorial Guinea, Liberia, Mali, Togo, Zambia and Zimbabwe recorded negative inflation values and this may be as a result of a fall in prices of goods and services, supply exceeding demand, or reduction in money supply, among other factors. Zambia had the highest inflation rate of 200.37, which could be caused by a number of factors, including a rise in the money supply and a demand that exceeds supply. Within the region, the service sector's GDP share (SER) ranges from a minimum of 22.13 to a maximum of 67.65. As a percentage of GDP, the service sector's mean value is 47.47, varying by 10.10 from the mean. The net official development assistance received as a percentage of GNI is used in this analysis as

a proxy for (AID). The SSA region's mean value is 6.78, with a deviation of 8.19 from the mean for the member countries. The highest and lowest reported values are 77.87 and 0, respectively. Within the SSA region, the mean value of real per capita GDP (YP) is 2690.47 US dollars, with an average deviation of 3034.46 from the mean. Within the region, the highest and lowest recorded amounts are 15906.5 and 345.64 US dollars, respectively. The Control of Corruption measure has a mean of −0.54 and a standard deviation of 0.65. The values are 1.03 at the highest and −1.83 at the minimum, respectively. A low control of corruption score indicates that the region is not doing well in controlling corruption, whereas a high score indicates that the region is performing well. The mean score of −0.54 indicates that in general the region is not doing well in the fight against corruption.

THE SHADOW ECONOMY, MOBILE PHONE PENETRATION AND TAX REVENUE

The system GMM results for the effect of mobile phone penetration and the shadow economy on tax collection are displayed in table 3. In particular, Model 1 does not include mobile phone penetration and instead shows results for the effect of shadow economy on tax revenue with other control variables. Excluding shadow economy, Model 2 displays the effect of mobile phone penetration on tax revenue. The outcomes of Models 1 and 2 demonstrate that the lagged value of tax revenue is significant at the 10 percent and 1 percent alpha levels, respectively. This confirms that the tax revenue for the current period is influenced by that of the preceding period, necessitating the specification of a dynamic model. At the 10 percent alpha level, the primary variable of interest, the shadow economy, was shown to be statistically significant and negatively correlated as depicted in Model 1. Therefore, in the sub-Saharan Africa region, a percentage rise in the shadow economy will result in a 0.18 percent drop in tax revenue, all other things being equal. This outcome is in line with the research of Nnyanzi, Babyenda, and Bbale (2016) and Mawejje and Munyambonera (2016), who similarly discovered a negative correlation between tax revenue and the informal sector. This makes sense intuitively since the informal sector includes all activities not reported to tax authorities with the express purpose of evading payment of income taxes arising from legal or illegal activities, and that do not adhere to any laws. Because the informal sector's operations are not subject to legal regulation, it evades and avoids paying taxes, which

TABLE 3 Effects of the Shadow Economy and Mobile Phone Penetration on Tax Revenue

Variable	Model 1	Model 2
Tax Revenue (T/Y)−1	0.4353*	0.7611***
	(0.2434)	(0.1059)
Shadow Economy (SHADOW)	−0.1763*	
	(0.0966)	
Mobile Phone Penetration (MPP)		0.01922**
		(0.0090)
Trade Openness (TOT)	0.0364*	0.0208**
	(0.0197)	(0.0099)
Agriculture Sector (AGRIC)	−0.3127***	−0.0927**
	(0.1248)	(0.0457)
Inflation (INF)	0.0833	0.0354
	(0.1298)	(0.0990)
Service Sector (SER)	0.0144	0.0201
	(0.0721)	(0.0233)
Aid (AID)	−0.0932	−0.0414
	(0.0978)	(0.0325)
Log of GDP Per Capita (Log YP)	−4.9506***	−2.0318***
	(1.9009)	(0.7583)
Control of Corruption (COC)	2.2566**	0.7737**
	(1.0428)	(0.3890)
Constant	54.4205***	16.6587***
	(18.5783)	(6.5947)
Diagnostics		
F Stat	170.17	827.69
Prob > F	0.000	0.000
AR (1)	0.024	0.013
AR (2)	0.690	0.697
Hansen test	0.155	0.232
Number of Obs.	260	260

NOTE Robust standard errors are in parentheses. *$p<$ 0.1, **$p<$ 0.05, and ***$p<$ 0.01 indicates significance at 10%, 5% and 1% levels, respectively.

lowers tax revenue. In addition, the informal sector is one of the difficult sectors to tax because it is difficult to track its activities, which reduces tax revenue.

Model 2 indicates that the mobile phone penetration variable, another important variable of interest, was estimated to be positive and statistically significant at 5 percent. Therefore, in sub-Saharan Africa, a unit increase in the prevalence of mobile phones will result in approximately a 0.02 percent increase in tax revenue, all other things being equal. This outcome is in line with research by Effiong and Nwanagu (2020) and

Koyuncu, Yilmaz, and Ünver (2016), which demonstrated how increased mobile phone adoption raises overall sustainable tax revenue. This makes sense intuitively as mobile phone penetration is growing and it is also a means of mobilizing tax revenue, which will raise the total amount of tax revenue in sub-Saharan Africa. Additionally, there are various taxes levied on using mobile phones, and the amount of tax revenue rises along with the level of mobile saturation.

EFFECT OF OTHER CONTROL VARIABLES ON TAX REVENUE

In Models 1 and 2, trade openness was found to be positive and significant at the 10 percent and 5 percent alpha levels, respectively. Ceteris paribus, for Models 1 and 2, a rise in trade openness is linked to increases in tax revenue in SSA of about 0.04 and 0.02 percent, respectively. This outcome, as anticipated, agrees with the research by Nnyanzi, Babyenda, and Bbale (2016), and Terefe and Teera (2018). The positive coefficient for trade openness suggests that administrative complexity is low for import and export taxes, making them simple to collect and administer within the region. Sub-Saharan African nations, therefore, engage in open economies with one another, which has the knock-on effect of raising tax revenue from these trade interactions.

Moreover, agriculture was found to be significant and negative for Models 1 and 2, respectively, at the 1 percent and 5 percent alpha levels. Other things being equal, a percentage increase in the share of agriculture to GDP will result in approximately a 0.09 percent drop in tax revenue in the sub-Saharan Africa region and about a 0.31 percent decrease in tax revenue in Model 1. This conclusion is in conflict with the findings of Terefe and Teera (2018), but it is consistent with the investigations of Addison and Levin (2012), and Coulibaly, Gandhi, and Senbet (2019). Agriculture's negative coefficient suggests that this industry is sometimes referred to as 'the hardest sector to tax', owing to its prevalence of large-scale informal players and underground economies driven by subsistence farmers. Fiscal authorities are under pressure from inefficient tax administration, which increases the likelihood that enterprises would evade paying taxes and so lowers tax collection.

For both Models 1 and 2, the log of GDP per capita was likewise found to be significant and negative at the 1 percent alpha level. It shows that, in the sub-Saharan Africa region, a dollar rise in GDP per capita is linked, all other things being equal, to about a 0.05 and 0.02 percent decrease in tax revenue in Models 1 and 2, respectively. This conclusion

contradicts the findings of Ayenew (2016) and Besley and Persson (2013), but it is consistent with the work by Nnyanzi, Babyenda, and Bbale (2016). In theory, higher GDP per capita indicates development and increased taxability. But over the years, although most sub-Saharan African countries are growing and developing, they have been characterized by difficult-to-tax informal sectors and subpar tax administration systems, consequently causing the SSA region's tax revenue to decline.

With a coefficient of about 2.26 and 0.77 for Models 1 and 2, respectively, and at a significance level of 5 percent for all models, the control of corruption has a positive effect on tax revenue. This suggests that higher tax revenues in the SSA region follow improvements in the fight against corruption. This outcome agrees with Nnyanzi, Babyenda, and Bbale (2016)'s findings. The region's tax revenue will rise when measures to combat corruption are implemented, such as states using collected funds for their intended purposes, refraining from embezzlement, and punishing corrupt offenders. This is indicated by the positive coefficient of control of corruption.

The results of the Hansen over-identification test, which are also approximately 0.16 and 0.23 as well as AR (2), which are approximately 0.69 and 0.70 in Models 1 and 2, are not significant. The model is therefore valid and consistent.

MODERATING ROLE OF MOBILE PHONE PENETRATION

The study now proceeds by analysing the moderating role mobile phone penetration is playing in the shadow economy–tax revenue nexus in SSA. Finding the moderating effect of mobile phone penetration gives

$$\frac{\delta(T/Y)_{i,t}}{\delta SHADOW_{i,t}} = \beta_2 + \beta_5 MPP_{i,t}$$

$$\frac{\delta(T/Y)_{i,t}}{\delta SHADOW_{i,t}} = \beta_2 + \beta_5 \overline{MPP}.$$

From Model 3 in table 4, we get

$$\frac{\delta(T/Y)_{i,t}}{\delta SHADOW_{i,t}} = 0.2427 + (-0.0029)(\overline{MPP}).$$

Placing the mean value of mobile phone penetration of 78.8562 (from table 2) gives

$$\frac{\delta(T/Y)_{i,t}}{\delta SHADOW_{i,t}} = 0.2427 + (-0.0029)(78.8562)$$

$$= 0.2427 - 0.22868298$$

$$= 0.0140.$$

On the other hand,

$$\frac{\delta(T/Y)_{i,t}}{\delta MPP_{i,t}} = \beta_3 + \beta_5 SHADOW_{i,t}$$

$$\frac{\delta(T/Y)_{i,t}}{\delta MPP_{i,t}} = \beta_3 + \beta_5 \overline{SHADOW}$$

Placing the mean value of shadow economy of 33.5458 (from table 2) gives

$$\frac{\delta(T/Y)_{i,t}}{\delta MPP_{i,t}} = 0.1084 + (-0.0029)(33.5458)$$

$$= 0.1084 - 0.0973$$

$$= 0.0111.$$

The earlier result (0.0140) indicates that on average, with mobile phone penetration, a percentage increase in the informal sector would increase tax revenue by about 0.01 percent. This implies that with mobile phone penetration the effect of the informal sector on tax revenue changes from negative (−0.1763 as shown in Model 1) to positive. On the other hand, the estimated result of 0.0111 indicates that given the level of the shadow economy, an increase in mobile phone penetration increases tax revenue. These results show that mobile phone penetration, once increased, has a positive and significant impact on tax revenue as a variable on its own and even in the presence of the shadow economy. It also moderates the effect of the shadow economy on tax revenue, changing it from negative, as shown in Model 1, to positive. In other words, mobile phone penetration positively influences the informal sector to increase tax revenue. Hence, for the SSA region to achieve much in terms of the shadow economy impacting tax revenue positively, mobile phone penetration in the informal sector must be given greater attention.

Since the value of the AR (2) from the model is about 0.72, we fail to reject the null hypothesis that there is no second-order serial correlation,

TABLE 4 How Mobile Phone Penetration Moderates the Effect of Shadow Economy on Tax Revenue

Variable	Model 3
Tax Revenue $(T/Y)_{-1}$	0.8659***
	(0.0848)
Shadow Economy (SHADOW)	0.2427*
	(0.1396)
Mobile Phone Penetration (MPP)	0.1084**
	(0.0533)
Trade Openness (TOT)	0.0276*
	(0.0153)
Agriculture Sector (AGRIC)	−0.0017
	(0.0345)
Inflation (INF)	−0.0071**
	(0.0028)
Service Sector (SER)	0.0108
	(0.0212)
Aid (AID)	−0.0395*
	(0.0217)
Log of GDP Per Capita (Log YP)	−0.5935
	(0.4132)
Control of Corruption (COC)	−0.1703
	(0.3519)
SHADOW*MPP	−0.0029*
	(0.0015976)
Constant	−4.9806
	(6.5695)
Diagnostics	
F Stat	1798.07
Prob > F	0.000
AR (1)	0.017
AR (2)	0.721
Hansen test	0.628
Number of Obs.	260

NOTE Robust standard errors are in parenthesis. *p< 0.1, **p< 0.05, and ***p< 0.01 indicates significance at 10%, 5% and 1% levels, respectively.

leading to the conclusion that the model does not suffer from serial correlation. The value of the Hansen over-identification test is about 0.63, therefore we fail to reject the null hypothesis of no over-identification restrictions. From the post estimations, it can be concluded that the results are consistent and valid.

Conclusions and Recommendations

The Sustainable Development Goals emphasize the need to strengthen internal resource mobilization and enhance tax collection in relation to SDG 17's first target. However, because of the sizeable informal sector in each of the region's economies, sub-Saharan Africa is losing a substantial portion of its revenue. This study takes a look at how tax revenue in 26 SSA nations is affected by the shadow economy and the widespread use of mobile phones, in particular, the impact that the shadow economy has on tax revenue and the moderating function that the widespread use of mobile phones plays in the relationship between the shadow economy and tax revenue. The study analysed panel data on 26 African countries from 2009 to 2019 using the GMM methodology. The study's conclusions showed that in the SSA region, the shadow economy had a detrimental impact on tax revenue. As a result, tax revenue decreases as the size of the informal sector grows. Since the informal sector makes up a larger percentage of most sectors in emerging economies and is also one of the hardest sectors to tax, it cannot be disregarded when it comes to revenue collection. Additionally, the use of mobile phones increased tax collections. Therefore, higher rates of mobile phone adoption translate into higher tax receipts. Finally, in SSA, the effect of the shadow economy on tax income is positively moderated by the proliferation of mobile phones. This outcome is not unexpected because there has been an increase in the informal sector's usage of mobile phones over time, and some participants in the informal sector utilize them to conduct business and make payments of taxes.

The study suggests that to help the informal sector feel acknowledged and encourage voluntary compliance with regard to tax payment, governments should strengthen the special agencies that are tasked with identifying, registering, training, and advising all operators in this sector on how to market their goods, keep accurate records, and obtain affordable funding, among other things. Governments in the SSA region also need to update their tax administration systems and construct and enhance infrastructure linked to emerging mobile technology. To fully benefit from mobile phone usage, they must, however, also implement best practices in tax regulations. Lastly, the study suggests that governments and telecommunications companies implement some kind of consumer education in the informal sector to raise awareness of the advantages of using mobile phones for business transactions and the simplicity of paying taxes using a mobile device.

The study was based on 26 out of 46 countries in sub-Saharan Africa. The choice of the 26 countries was purely based on the availability of data for those countries. The results could have been more representative if all 46 sub-Saharan African countries had been used. However, the use of 26 out of 46 countries does not in any way render the findings and conclusions invalid.

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Appendix A: List of Selected Sub-Saharan African Countries

Angola, Botswana, Burkina Faso, Cabo Verde, Cameroon, Central African Republic, Congo Republic, Côte d'Ivoire, Equatorial Guinea, Ethiopia, Gabon, Ghana, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritius, Mozambique, Namibia, South Africa, Tanzania, Togo, Zambia and Zimbabwe

Appendix B: Pairwise Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) T/Y	1									
(2) SHADOW	−0.459*	1								
(3) MPP	0.433*	−0.201*	1							
(4) TOT	0.406*	−0.176*	0.158*	1						
(5) AGRIC	−0.412*	0.145*	−0.524*	−0.375*	1					
(6) INF	−0.0003	0.063	−0.064	−0.057	−0.020	1				
(7) SER	0.526*	−0.309*	0.292*	0.129*	−0.373*	0.114*	1			
(8) AID	−0.158	0.149*	−0.431*	0.072	0.598*	−0.010	−0.041	1		
(9) Log YP	0.244*	−0.240*	0.613*	0.321*	−0.803*	−0.084	0.205*	−0.579*	1	
(10) COC	0.606*	−0.515*	0.505*	0.215*	−0.251*	0.010	0.518*	−0.067	0.258*	1