Exploring the nonlinear effect of shadow economies on sustainable development in Africa: does the level of financial market development matter?

Received 6 June 2023
Revised 5 September 2023
Accepted 5 September 2023

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Abstract

Purpose – This study aims to examine the nonlinear threshold effect of shadow economy on sustainable development in Africa while providing additional evidence on how this nonlinear threshold effect play out in economies with high and low developed financial/credit markets.

Design/methodology/approach – This study uses 37 African economies between 2009 and 2017 in a dynamic GMM panel model that controls for country, year and technological effects to ensure consistency and reliability of results and findings.

Findings – The results reveal that there is an inverted nonlinear U-shape nexus between the size of shadow economy and sustainable development in both short run and long run in Africa and across economies with high and low developed credit/financial market. Also, the threshold points beyond which the size of shadow economies dampens sustainable development is lower for economies with high financial/credit market development and higher in the long run.

Practical implications – These results have policy implications and recommendations and suggest that shadow economies can be beneficial to sustainable development particularly when the size of shadow economies are restrained from increasing beyond certain thresholds/levels. Moreso, to restrict the adverse effect of shadow economies on sustainable development, policymakers can rely on developing their financial/credit markets to tame the destructive nature of shadow economies on sustainable development. These results are robust to technological, year/time and country effects.

Originality/value – To the best of the author's knowledge, this study examines for the first in the context of Africa, the nonlinear effect of shadow economies on sustainable development under low and high developed financial markets.

Keywords Financial markets, Sustainable development, Shadow economy

Paper type Research paper

JEL classification – E26, G1, G2, O470

Data availability statement: 1. Data is available on Global Financial Development (www.databank.worldbank.org/reports.aspx?source=global-financial-development); 2. World Development Indicators (www.databank.worldbank.org/source/world-development-indicators); and 3. Medina, L., and Schneider, M. F. (2018). *Shadow economies around the world: what did we learn over the last 20 years?*. International Monetary Fund.

Conflict of interest statement: The author states that there is no conflict of interest.

Declarations – Availability of data and materials: Data will be made available on request.

Funding: No funding has being received for this paper.

Journal of Financial Economic Policy

1757-6385
DOI 10.1108/JFEP-06-2023-0146

Introduction

Sustainable development has recently emerged as one of the key and important economic indicators that comprehensively captures the current consumption of the present generation and that of the future generations in a manner that is economically, financially, environmentally and socially friendly or sustainable (Boos, 2015; Kaimuri and Kosimbei, 2017; Arrow *et al.*, 2003). Unlike economic growth/development which is short-term oriented, considers only current consumption, do not take into account environmental sustainability (depletion/damage) and future consumption of the next generation (Koirala and Pradhan, 2020; Kaimuri and Kosimbei, 2017; Pardi *et al.*, 2015), sustainable development measured with adjusted net savings (ANS) reflects "a development that meets the needs of the present without compromising the ability of the future generations to meet their own needs" (UNWCED, 1987, p. 17). Thus, sustainable development shows massive concern for long run and continuous/intergenerational development that comprehensively encompasses the "true rate of savings in an economy after taking into consideration investments and human capital, depletion of natural resources and damage the environment caused by pollution" (World Bank, 2012, p. 1). In essence, sustainable development has become the economic variable of interest for most economic policymakers and analysts who assess intergenerational long-run developmental achievement of economies.

As such, many empirical studies have investigated sustainable development to understand how to improve sustainable development. One factor that is recently gaining attention in the economic literature is the shadow economy, which reflects informal economic activities that are not captured in the computation of the official/national gross domestic product of an economy (Medina and Schneider, 2020, 2018; Putniņš and Sauka, 2015; Williams and Schneider, 2016; Orviska *et al.*, 2006; Fleming *et al.*, 2000; Schneider, 1994). Feige (1996, 1979) defines shadow economy as economic activities that circumvent costs and are excluded from the benefits and rights incorporated in laws and administrative rules covering property relationships, commercial licensing, labor contracts, torts, financial credit and social systems. Interestingly, shadow economy activities directly or indirectly influence the economic, social and environmental dimensions of an economy but empirical evidence in the report on how shadow economy influences sustainable development is limited to using environmental sustainability indicators (Tran, 2022; Dada *et al.*, 2022, 2021; Zhao *et al.*, 2022; Sohail *et al.*, 2021) as sustainable development although environmental sustainability is just one aspect/dimension of sustainable development. Beyond this, prior studies focus on comparing the effects of shadow economies on income inequality (Huynh and Nguyen, 2020), economic growth (Baklouti and Boujelbene, 2020) and globalization (Datsii *et al.*, 2023) in developed and underdeveloped economies.

Again, the literature shows that although the dark side of shadow economies, which includes reduced government revenues and disguised/understated national productivity, has loudly been projected in the literature, the bright side of shadow economies as providing a safety net for creating employment and generating income for citizens have gained little recognition (Medina and Schneider, 2020, 2018; Putniņš and Sauka, 2015). The existence of both dark and bright sides of shadow economies presents a possibility of nonlinear effects of shadow economies on sustainable development, implying that there would be a certain level/size of shadow economies that may promote and or derail sustainable development. However, empirical evidence examining shadow economies' nonlinear effects is nonexistent, especially in Africa. Interestingly, the few non-African studies on the nonlinear effect of shadow economies on sustainable development (Saafi *et al.*, 2022; Wu and Schneider, 2019) use environmental sustainability indicators as measures for sustainable development, but environment sustainability is just one dimension of sustainable development.

Interestingly, following prior studies on financial/credit market development within the shadow economies literature (Dada *et al.*, 2022; Khan *et al.*, 2021; Gharleghi and Jahanshahi, 2020; Canh and Thanh, 2020; Berdiev and Saunoris, 2016), it is clear that financial/credit market development lowers shadow economies through several ways (Berdiev and Saunoris, 2016; Capasso and Jappelli, 2013; Blackburn *et al.*, 2012; Bose *et al.*, 2012). First, the financial/credit sector/market, through its function of lending primarily/strictly lends to formal business entities, which raises that opportunity cost for informal entities operating in the shadow economy (Berdiev and Saunoris, 2016), and this pressurizes informal entities to formalize and obtain legitimacy to gain access to credit (Berdiev and Saunoris, 2016; Capasso and Jappelli, 2013; Blackburn *et al.*, 2012). Second, the financial/credit sector allows governments to monitor, supervise and implement policies and tax transactions successfully. The financial/credit market/sector function helps lower the occurrence/frequency and magnitude of tax evasion and other shadow economy activities (Capasso and Jappelli, 2013; Blackburn *et al.*, 2012). Clearly, these functions of the credit/financial market toward the economy/government facilitate the formalization of businesses/enterprises, increase the cost of remaining in the shadow/informal economy and therefore reduce the activities/size of the shadow economy. Yet, empirical evidence to substantiate this logical and intuitive claim is not documented in the empirical literature.

In addition, empirical studies that examine/show how shadow economies nonlinearly affect sustainable development in economies with high and low development financial markets are nonexistent. This study focuses on Africa because Africa is reported to have the highest share of shadow economies (Medina and Schneider, 2020). Hence, this study takes advantage of the measurement gap (using ANS as a comprehensive proxy for sustainable development), issue gap (exploring the nonlinear effect of shadow economy on sustainable development under economies with high and low credit/financial market development indicators) and context gap (presenting African context evidence of a nonlinear effect of shadow economy on sustainable development) to contribute to the "shadow economy-sustainable development nexus" by:

- presenting first-time nonlinear effects of shadow economies on sustain development in Africa;
- estimating the nonlinear effects (short run and long run) of shadow economies on sustainable development in economies with developed and less developed financial/credit markets in Africa; and
- obtaining the threshold nonlinear (short run and long run) turning points of shadow economies on sustainable development under developed and less developed credit/financial markets in Africa.

The rest of the study is organized into an overview, literature review, methodology, results and discussions, conclusions, implications and recommendations.

Literature review: theoretical and conceptual

The literature on sustainable development posits that sustainable development has no theories but rides on economic growth theory (Seiko, 2018; Steer and Wade-Gery, 1993). Beyond using the economic theory to explain sustainable development, the modern theory of financial intermediation is used in this study to explain the economic importance/relevance of financial/credit markets to economies. Following economic theories, where sustainable development is argued to derive its roots, it is clear that sustainable development is a recent economic growth concept that has emerged as a result of the increasing importance of the

social and environmental sustainability/protection aspects of pursuing economic growth activities (Castro and Lopes, 2022; Koirala and Pradhan, 2020). Arguably, the traditional economic growth approach neglects the social and environmental implications of the quest to pursue economic growth (Rutherford, 1997; Hardi *et al.*, 1997). Specifically, pursuing economic growth is argued to be short-term oriented on present consumption without considering the social and environmental damages it poses to future generations' ability to meet their consumption (Castro and Lopes, 2022; Koirala and Pradhan, 2020). Therefore, sustainable development arises to augment the failures/weaknesses of the traditional pursuit of economic growth by incorporating social concerns and environmental damages caused by pursuing economic growth. Put differently, how current consumption of human and natural resources are carefully/adequately conserved without compromising the future generation's consumption can be conceptualized as sustainable development (Castro and Lopes, 2022; Koirala and Pradhan, 2020).

In the conceptualization and computation of sustainable development (SUSDEV), the World Bank advances that sustainable development can be measured with ANS because it represents the "true rate of savings made by an economy after that economy has accounted for investment in human capital, depletion of natural resources and damage caused by pollution" (World Bank, 2012, p. 1). Thus, net national savings (NNS) adjusts for intergenerational tradeoff between current and future consumptions through investment in human capital, depletion of natural resources and damages caused by pollution. In practice, higher current consumption reflects lower savings and capital stock accumulation and hence lower future productivity, growth and standard of living (Koirala and Pradhan, 2020; Boos, 2015; Kaimuri and Kosimbei, 2017; Arrow *et al.*, 2003). Hence, the computation of sustainable development is obtained by adjusted gross national savings (GNS) with investment capital consumption (ICC) (fixed capital consumption), human capital (educational expenditure), natural resource depletion (NRD) (minerals, forestry and energy) and environmental depletion (ED) (CO_2 and particulate emissions). Hence, sustainable development is obtained and expressed as follows:

$$\mathrm{SUSDEV}_{i,t} = \mathrm{ANS}_{i,t} \tag{1}$$

$$\mathrm{NNS}_{i,t} = \mathrm{GNS}_{i,t} - \mathrm{IC}_{i,t} \tag{2}$$

$$\mathrm{ANS}_{it} = \mathrm{NNS}_{i,t} + \mathrm{HC}_{it} - \mathrm{NRD}_{it} - \mathrm{ED}_{i,t} \tag{3}$$

or

$$\mathrm{ANS}_{it} = \mathrm{GNS}_{i,t} - \mathrm{IC}_{i,t} + \mathrm{HC}_{it} - \mathrm{NRD}_{it} - \mathrm{ED}_{i,t} \tag{4}$$

Equation (1) projects that sustainable development (SUSDEV) is represented by ANS. To obtain ANS, ICC is first deducted from GNS, which results in NNS in equation (2), then in equation (3) human capital is added to NNS while natural resource and environmental depletions are deducted from NNS to obtain ANS. Alternatively, equations (2) and (3) could be combined immediately to obtain equation (4), where ANS is obtained by deducting IC, NRD, ED and HC to GNS.

Focusing on the financial market development literature, the modern theory of financial intermediation advances that financial intermediation activities undertaken by financial institutions are aimed at facilitating economic activities and efficiency, implementing

government policies and granting creating credit to real economy for economic growth (Gyeke-Dako *et al.*, 2021; Allen and Santomero, 1997). Thus, a modern theory of financial intermediation is focused on justifying economy-wide functions of financial institutions, which include:

- providing a system for monitoring economic activities;
- executing government policies;
- collecting tax revenue for the government; and
- granting credit/loans to formal enterprises (Kusi *et al.*, 2022; Lay, 2020; Cooray, 2009).

Interestingly, for financial markets and institutions to recognize and perform these functions for economic agents (households, businesses and governments), the economic agents must be legally formalized to enjoy such intermediation functions. Hence, developing/having strong financial/credit markets can help formalize businesses and economic activities and reduce shadow/black market activities. Thus, through the performance of these economy-wide functions by financial institutions, the financial/credit market activities can suppress informal/shadow economy activities, operations and size (see Dada *et al.*, 2023; Ajide, 2021; Canh and Thanh, 2020; Berdiev and Saunoris, 2019). Beyond the modern theory of financial intermediation, the finance–growth nexus theory (Stolbov, 2013; Gurley and Shaw, 1955) shows that the interaction between economic activities and financial activities, institutions, markets and systems is critical for sustained economic growth and development. Thus, financial institutions enforce environmental-friendly policies that can lower environmental degradation and pollution to encourage sustainable development. Hence, financial institutions and markets can suppress the effects of shadow economy activities.

Literature review: empirics

The empirical literature on how the shadow economy affects sustainable development exists abundantly. However, such studies focusing on Africa and exploring the nonlinear effect of shadow economies on sustainable development under developed and less developed credit/financial markets are nonexistent. Arguably, most existent empirical studies use environmental sustainability indicators (energy efficiency, energy consumption and air pollution) as sustainable development measures. Meanwhile, environmental sustainability is just one aspect of sustainable development. Given this discussion, the literature review focuses on:

- studies on the effect of the shadow economy on sustainable development;
- studies that explore the nonlinear effect of the shadow economy on sustainable development; and
- studies that use moderators on the nexus between shadow economy and sustainable development.

Considering studies exploring the shadow economy's effect on sustainable development, Sohail *et al.* (2021) examined the effect of the shadow economy on sustainable development in the form of environment sustainability (clean energy and air pollution). The study focuses on South Asian economies between 1999 and 2019 and reports using ARDL models that shadow economies increase clean energy consumption in Sri Lanka and Pakistan while reducing clean energy consumption in India. These findings show that the effect of the shadow economy on environmental sustainability is context-dependent. In addition,

institutional quality and tax revenue were identified to have critical effects on environmental sustainability quality. Likewise, Hoinaru *et al.* (2020) investigated how shadow economies and corruption affect sustainable development using 185 economies between 2005 and 2015. The results show that while low-income economies have higher thresholds of the shadow economy and corruption, corruption and shadow economies are reported to have destructive effects on economic and sustainable development. These effects are reported to be higher and stronger for high-income economies.

At the single-country level, Zhao *et al.* (2022) studied how shadow economy competition influences sustainable development measured with environmental sustainability quality in China using 2,848 public and private sector firms from 25 cities. The study uses instrumental variable models and propensity score matching methods and reported that shadow economy competition lowers energy intensity, reflecting environmental quality sustainability improvement. Similarly, Pang *et al.* (2020) explored how the size of the shadow economy in China affected sustainable environmental quality in three provinces of China between 2000 and 2016. The dynamic models used reveal that shadow economy directly and significantly contributes to pollution levels, whereas the larger pollution level significantly impacts the size of shadow economies. Also, Benkraiem *et al.* (2019) examined the asymmetric effect of the shadow economy on energy growth or energy consumption in Bolivia, covering periods between 1960 and 2015. The study uses ARDL cointegration method and the asymmetric causality test in a quarterly data structure and observes that the shadow economy in Bolivia positively influences energy consumption, indicating that the existence of a shadow economy lowers sustainable environmental quality.

Furthermore, Popescu *et al.* (2018) studied the determinants of the Romanian shadow economy and additionally examined how it influenced sustainable development goals 8 (decent work and economic growth) and 16 (peace, justice and strong institutions). In examining the drivers of the shadow economy, the study used multiple causes and multiple indicator specification models and reported that tax avoidance, lack of trust in public officials, bribery, poor business ecosystem, corruption and regulation uncertainties determined the shadow economy at the micro level. In contrast, self-employment, unemployment, part-time employment and lack of trust in institutions determined the shadow economy. Their second stage results show that an increase in the shadow economy has detrimental effects on sustainable development goals 8 and 16.

Focusing on the scanty empirical studies that examine the nonlinear threshold effect of shadow economy on sustainable development, Saafi *et al.* (2022) studied the nonlinear impact of shadow economies on sustainable development using 83 developing and developed economies between 1996 and 2017. They use dynamic and static panel threshold models and report that the size of the size economy initial has a positive effect on sustainable development. Beyond a certain threshold, shadow economy size dampens sustainable development. Thus, while this suggests an inverted U-shape effect between shadow economy size and sustainable development, it simply implies that the growth and expansion of shadow economies beyond certain thresholds is injurious/harmful to sustainable development and results are consistent across both developed and developing economies. This study measures sustainable development using individual aspects/dimensions of sustainable development. Similarly, Wu and Schneider (2019) studied the shadow effect's nonlinear effect on development levels. The study uses an international sample consisting of 158 economies covering periods between 1996 and 2015. Using panel regression strategy, the results show that the shadow economy has a direct U-shape effect on gross domestic product per capita, implying that beyond a certain threshold of the shadow economy, shadow economy can positively contribute to gross domestic product per capita.

Furthermore, in the light of studies that use moderators in the nexus/relation between shadow economy and sustainable development, Dada *et al.* (2022) used 30 economies in Africa between 1991 and 2017 to investigate the effect of shadow economy on environmental sustainability using financial development as a moderator. Using both static and dynamic panel models their results show that, although shadow economy and other variables, including financial development, urbanization and economic growth and enhanced ecological footprint, the interaction between shadow economy and financial development had an adverse effect on sustainable development represented with environmental sustainability indicator implying that shadow effect reduced sustainable development through financial development. Similarly, Dada *et al.* (2021) examined the effect of the shadow economy on environmental sustainability while focusing on how institutional quality moderates the nexus between the shadow economy and environmental sustainability. Using an array of estimation strategies of African economic between 1991 and 2015, the results show that while the shadow economy in Africa reduces environmental sustainability, the weak institutional quality framework in Africa increases the reducing effect of the shadow economy on environmental sustainability.

Likewise, Chen *et al.* (2021) investigated the interrelationship between technological innovations and shadow economy on sustainable development in the form of energy efficiency. The study used a sample of MENA economies between 1990 and 2016 and reported using second-generation methodological approaches that technological innovations promote energy efficiency while the shadow economy is detrimental to energy efficiency. Furthermore, the results show that the shadow economy lowers technological innovations' positive effect on energy efficiency. Furthermore, Canh and Thanh (2020) examined the effect of shadow economies on energy use and renewable energy use as sustainability indicators in 115 economies between 1991 and 2014. Applying dynamic models, their results reveal that shadow economies increase the use of energy and renewable energy, comprising environmental sustainability. However, it is observed that the official national income lowers the comprising nature of the shadow economy on environmental sustainability by lowering energy usage.

Literature review: gaps development

From the literature review, it is clear that while sustainable development is a recent economic growth approach and has four main aspects/dimensions (investment consumption, human capital development, environmental depletion and NRD), the development of a comprehensive sustainable development indicator that captures all these aspects/dimensions (ANS) is also new and less represented/used in the empirical literature. Interestingly, most empirical studies have used environment-sustainable indicators (energy efficiency, energy consumption and air pollution), which capture only one dimension/aspect of sustainable development. Relying on ANS as a good and comprehensive indicator of sustainable development (Castro and Lopes, 2022; Medina and Schneider, 2020; Koirala and Pradhan, 2020), this study presents new perspectives on sustainable development using a more comprehensive sustainable development indicator.

Again, despite the intuitive reasoning/argument that the shadow economy may have nonlinear effects by serving as a safety net (by creating employment/income) for vulnerable citizens and at the same time impeding tax revenue (for the government), there are limited studies that explore this nonlinear effect of shadow economy on sustainable development especially in Africa. Besides the limited African evidence, the few existing cross-country studies (see empirical review section) fail to use the comprehensive measure of sustainable development and ignore examining how shadow economies' nonlinear effects play out in

economies with high and low credit markets in Africa. In effect, this study identifies measurement gap (using ANS as a proxy for sustainable development), issue gap (exploring the nonlinear effect of shadow economy on sustainable development under economies with high and low credit/financial market development indicators) and context gap (presenting African context evidence of the nonlinear effect of shadow economy on sustainable development) that needs to be addressed. Hence, this study takes advantage of the gaps identified to explore how the nonlinear effect of shadow economies in Africa affects sustainable development in economies with high and low credit market development in Africa.

Methodology and data

This study uses a panel data strategy to shed insights on the link between shadow economies and sustainable development in Africa's high and low financial/credit market development economies. It is advanced that the panel data strategy provides more convincing and robust results compared to the traditional time series and cross-sectional data because the panel structure allows it to capture both time and entity variations (Baltagi, 2015; Baltagi and Baltagi, 2008). Furthermore, Imbens and Wooldridge (2009) posit that the panel data strategy can control for omitted variable biases and its form/structure is expressed as:

$$Y_{it} = \alpha_i + \gamma_t + \beta X_{it} + \varepsilon_{it} \ldots\ldots\ldots \quad (5)$$

where Y is the dependent variable, α and γ are the country's fixed and time-specific effects, respectively, X is a vector of control variables and β is also the sensitivity of the vector of control variables. Data for this study is obtained from two different sources, including world development indicators (WDI) and Medina and Schneider (2019). Specifically, data on the shadow economy is obtained from Medina and Schneider (2019), while other macroeconomic data is obtained from WDI. For the purpose of this study, the modeling approach follows that of Koirala and Pradhan (2020), who focused on the determinants of sustainable development. However, the modeling of sustainable development in this study deviates from that of Koirala and Pradhan (2020) in two main ways, which include:

(1) the inclusion of shadow economy in the modeling; and

(2) the use of dynamic GMM model instead of static models.

The structure of the dynamic GMM is expressed as:

$$Y_{it} = \alpha Y_{it-1} + \gamma_t + \beta X_{it} + \varepsilon_{it} \ldots\ldots\ldots \quad (6)$$

Y_{it} is sustainable development, *the past value of sustainable development determines* $Y_{it\text{-}1}$, γ_t is the time dimension and X_{it} is a set of variables which include shadow economy and control variables, α *and* β are the sensitivities of lag values of sustainable development and control variables, respectively, and ε_{it} is the error term. The GMM panel data framework is used for a number of data structures and econometric reasons. First, the literature advances that the GMM is appropriate and yields robust results when there is high persistence between the dependent variable (see Appendix 1) and its lag and the number of entities/countries (37) is greater than the number of time series dimension (8 years) (Tchamyou, 2020; Asongu, le Roux *et al.*, 2019). Similarly, there is evidence of a weak presence of cross-sectional dependence (see Appendix 2) and the GMM is argued to control for cross-sectional dependence (Tchamyou *et al.*, 2019). Again, the GMM is used because it can control for

endogeneity, which has been shown to be present in sustainable development models (Zakari *et al.*, 2022; Ahmed *et al.*, 2021). Furthermore, in line with estimating long-run effects, which happens to be one of the objectives, the GMM offers the opportunity to estimate long-run effects and hence the use of the GMM (Qudrat-Ullah and Nevo, 2021; Canh *et al.*, 2019). The dynamic GMM models to be estimated as expressed as:

$$SUSDEV_{i,t} = \beta_1 SUSDEV_{i,t-1} + \beta_2 SHAECO_{i,t} + \beta_3 SHAECO * SHAECO_{it} + \beta_4 LNGNIPC_{it} + \beta_5 INFL_{i,t} + \beta_6 LNMINREV_{i,t} + \beta_7 FINDEV_{i,t} + \varepsilon_{i,t} \ldots\ldots\ldots \quad (7)$$

$$SUSDEV_{i,t} = \beta_1 SUSDEV_{i,t-1} + \beta_2 SHAECO_{i,t} + \beta_3 SHAECO * SHAECO_{it} + \beta_4 LNGNIPC_{it} + \beta_5 INFL_{i,t} + \beta_6 LNMINREV_{i,t} + \beta_7 FINDEV_{i,t} + \alpha_t + \varepsilon_{i,t} \ldots\ldots\ldots \quad (8)$$

$$SUSDEV_{i,t} = \beta_1 SUSDEV_{i,t-1} + \beta_2 SHAECO_{i,t} + \beta_3 SHAECO * SHAECO_{it} + \beta_4 LNGNIPC_{it} + \beta_5 INFL_{i,t} + \beta_6 LNMINREV_{i,t} + \beta_7 FINDEV_{i,t} + \pi_i + \varepsilon_{i,t} \ldots\ldots\ldots \quad (9)$$

$$SUSDEV_{i,t} = \beta_1 SUSDEV_{i,t-1} + \beta_2 SHAECO_{i,t} + \beta_3 SHAECO * SHAECO_{it} + \beta_4 LNGNIPC_{it} + \beta_5 INFL_{i,t} + \beta_6 LNMINREV_{i,t} + \beta_7 FINDEV_{i,t} + \alpha_t + \pi_i + \varepsilon_{i,t} \ldots\ldots\ldots \quad (10)$$

$$SUSDEV_{i,t} = \beta_1 SUSDEV_{i,t-1} + \beta_2 SHAERCO_{i,t} + \beta_3 SHAECO * SHAECO_{it} + \beta_4 LNGNIPC_{it} + \beta_5 INFL_{i,t} + \beta_6 LNMINREV_{i,t} + \varepsilon_{i,t} \ldots\ldots\ldots \quad (11)$$

$$SUSDEV_{i,t} = \beta_1 SUSDEV_{i,t-1} + \beta_2 SHAECO_{i,t} + \beta_3 SHAECO * SHAECO_{it} + \beta_4 LNGNIPC_{it} + \beta_5 INFL_{i,t} + \beta_6 LNMINREV_{i,t} + \alpha_t + \varepsilon_{i,t} \ldots\ldots\ldots \quad (12)$$

$$SUSDEV_{i,t} = \beta_1 SUSDEV_{i,t-1} + \beta_2 SHAECO_{i,t} + \beta_3 SHAECO * SHAECO_{it} + \beta_4 LNGNIPC_{it} + \beta_5 INFL_{i,t} + \beta_6 LNMINREV_{i,t} + \pi_i + \varepsilon_{i,t} \ldots\ldots\ldots \quad (13)$$

$$SUSDEV_{i,t} = \beta_1 SUSDEV_{i,t-1} + \beta_2 SHAECO_{i,t} + \beta_3 SHAECO * SHAECO_{it} + \beta_4 LNGNIPC_{it} + \beta_5 INFL_{i,t} + \beta_6 LNMINREV_{i,t} + \alpha_t + \pi_i + \varepsilon_{i,t} \ldots\ldots\ldots \quad (14)$$

In models 7–10, the study estimates the nonlinear effects of shadow economies on sustainable development while including financial development in the models. However, in models 11–15, the effect of shadow economies on sustainable development under high and low developed credit/financial markets in Africa. Thus, in models 11–15, we use the median of financial development to split the sample into high and low developed financial/credit markets, where those above the median are considered to be high developed credit/financial market economies and those below are considered to be low developed credit/financial market economies. Models 7 and 11 fail to control for time and country effects, while 8 and 12 and 9 and 13 control for time and country effects, respectively. However, in models 10 and 14, both time and country effects are controlled for. Thus, time and country effects are controlled for to ensure the results' reliability, accuracy and robustness. While the estimates generated from these models represent the short-run effects, the long-run effects/estimates are obtained following Qudrat-Ullah and Nevo (2021) and Canh *et al.* (2019), who expressed the dynamic GMM approach of long-run estimates as:

$$\beta_k/[1-\phi], \quad (15)$$

where β_k is the significant coefficient of shadow economy at linear or nonlinear level for each estimated model and ϕ is the coefficient of the lagged dependent variable for each estimated model. To apply the long-run computation, both the variable of interest (in this case, shadow economy) and the lag of the dependent variable must all be significant.

In testing for the U-shape nonlinear threshold, the approach of Lind and Mehlum (2010) is used in which the computation of the nonlinearity threshold is computable only if both the linear and nonlinear terms of the variable in question are significant. To obtain the nonlinear threshold point, partial derivatives of equations (8)–(14) are taken for shadow economy and set to zero. The formula for computing the threshold point is expressed as: $-[\beta 2] \div [2*\beta 3]$. While the coefficient of the short-run and long-run effects may all be significant, the study is interested in estimating whether the difference in the short-run and long-run coefficients is significant. This is relevant for policy because it indicates the regime (short run or long run) with which shadow effects have the most effect. Thus, in terms of testing for significant differences in the short-run and long-run coefficients, the approach of Clogg *et al.* (1995) and Paternoster *et al.* (1998) $[(|\beta_m - \beta_j|)/\text{sqrt}((\text{Standard Error of } \beta_m)^2 + (\text{Standard Error of } \beta_j)^2)]$ is used.

From the models estimated, sustainable development ($SUSDEV_{it}$) is used as the dependent variable and computed as adjusting net national saving with human capital development (expenditure on education), mineral resource depletion (minerals, energy and forest depletion) and environmental damages (particulate emission and CO_2 damages) following prior studies (Castro and Lopes, 2022; Koirala and Pradhan, 2020). $SUSDEV_{it-1}$ represents the lag of sustainable development and from a theoretical perspective, it is argued the past values of sustainable development inform/determine its current values. Shadow economy (SHAECO) represents the value of informal activities scaled over gross domestic product. It is the linear form of the shadow economy, while the extreme/nonlinear form of the shadow economy is represented as (SHAECO*SHAECO or $SHAECO^2$). It is argued that the linear/initial level of shadow economy would promote sustainable

development because small-sized shadow economy serves as a safety net creating employment and generating income while large-sized shadow economies create more avenues for tax invasion and environment depletion/damage and hence impeding sustainable development (Castro and Lopes, 2022; Koirala and Pradhan, 2020). Thus, an inverted U-shape relationship is expected from the shadow economy to sustainable development. Formal economy size is measured as the natural gross national income per capital log. It is expected to promote sustainable development because the formal economy generates more positive outcomes, including creating employment, generating income for the citizenry and generating tax revenue for developmental projects.

Inflation (INFL) measures price stability and is measured with the consumer price index. It is anticipated that inflation would lower sustainable development because inflation reduces the purchasing value/power of savings and is consistent with the new economic theory (Bruno and Easterly, 1998; Barro, 1995). Revenue from natural resources is measured as the natural log of mining revenue and contributes to sustainable development. Following prior studies, the effect of mining revenue on sustainable development depends on whether the mining revenue exceeds its cost (Koirala and Pradhan, 2020). Thus, when mining revenue exceeds its cost, a positive effect is expected, while if the mining cost exceeds its revenue, a negative effect is expected. Financial development is measured as credit to the private sector to gross domestic product. Following prior studies (Dada *et al.*, 2022; Khan *et al.*, 2021; Gharleghi and Jahanshahi, 2020; Canh and Thanh, 2020; Koirala and Pradhan, 2020), financial/credit development has a positive effect on sustainable development. However, if the credit advanced to the private is not efficiently used, it may lead to a reduction in sustainable development. In addition, under a highly developed financial/credit market, it is expected that financial development will force informal entities to formalize to have access to credit. This reduces the size of the shadow economy and hence lowers the threshold at which shadow economies impede/hurts sustainable development.

Empirical results and discussion

In estimating the results, the summary statistics table, correlation matrix table, ratios and natural logs are used to ensure the results are accurate and robust. Using the summary statistics (see Table 1), the mean, minimum, maximum and standard deviation values show no evidence of outliers. Following econometric literature (Osborne and Overbay, 2004; Yuan and Bentler, 2001), outliers can influence the reliability and accuracy of the results, but no evidence of outliers is observed. Similarly, ratios and natural logs are used to control for outliers and normality of variables. In Table 2, the correlations are used to screen for

Variable	Obs.	Mean	SD	Min	Max
SUSDEV	236	41.647	2.648	33.789	49.704
SHAECO	306	35.363	7.568	21.9	56.7
LNMINREV	273	11.235	1.069	7.753	13.772
INFL	274	5.817	5.667	−2.431	30.695
FORECO	274	7.168	0.949	5.394	9.549
FINDEV	274	29.605	16.425	0	104.626

Source: Computed using Stata 14 based on data from World Development Indicators (WDI) and Medina and Schneider (2019) – SUSDEV (sustainable development), SHAECO (shadow economy), $SHAECO^2$ (squared term of shadow economy), LNMINREV (log of mineral revenue), INFL (inflation rate), FORECO (log of GNI per capita), FINDEV (financial development)

Table 1. Descriptive statistics

multicollinearity. Following prior studies (York, 2012; Wichers, 1975) that set the multicollinearity threshold to 0.5, there is no evidence of multicollinearity.

Table 3 presents the main results of this study. In all, 12 models are reported, where the first four models capture results for the full sample, and the next two of four models capture results for less and highly developed financial/credit market economies. As indicated earlier, models 1, 5 and 9 fail to control for year and country effects, while models 4, 8 and 12 control for both year and country effects concurrently. Also, models 2, 6 and 10 control for only year effects, while models 3, 7 and 11 control for only country effects.

In the context of reliability and robustness of the results, the number of instruments, AR(2) and Hansen tests provide evidence of reliability, validity and robustness (Roodman, 2009; Love and Zicchino, 2006; Arellano and Bond, 1991) and these are reported in Table 3. Thus, in a two-step dynamic GMM, the number of internally generated instruments must be lower than the number of groups (countries), which is confirmed in Table 3. Similarly, the two-step dynamic GMM controls assume the presence of autocorrelations, and the AR(2) is used to test for autocorrelation (Windmeijer, 2005; Blundell and Bond, 1998). Given the AR(2) results and the desirable outcome that there should not be autocorrelation present in the data, the hypothesis that no autocorrelation is not rejected implies that autocorrelation is not present. In addition, the Hansen test shows evidence of robustness and validity of the internally generated instruments, confirming the Hansen test hypothesis that instruments generated are robust and valid (Arellano and Bover, 1995). The results on the number of instruments, AR(2) and Hansen tests are evidence of the reliability, validity and robustness of the results of this study.

From the main results in Table 3, the past value of sustainable development is persistent on the current value of sustainable development, implying that the current level of sustainable development is highly dependent on its previous values. This finding is consistent with prior studies showing that sustainable development depends on previous values (Zakari *et al.*, 2022; Khan *et al.*, 2019).

The results on the effect of the shadow economy on sustainable development show that the shadow economy initially promotes sustainable development in both the short and long runs. Still, the shadow economy impedes sustainable development in both the short and long runs when the size of the shadow economy is doubled. Clearly, the results suggest an inverted U-shape nonlinear short-run and long-run nexus from shadow economy to sustainable development in Africa, implying that when shadow economy grows beyond a certain threshold, it lowers/dampens sustainable development now and in the future (long run). This finding is consistent across the full sample (Models 1–4), weak institutional economies sample (Models 5–8) and strong institutional economies sample (Models 9–12).

Table 2.
Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) SUSDEV	1.000					
(2) SHAECO	0.259	1.000				
(3) LNMINREV	0.216	−0.180	1.000			
(4) INFL	0.177	0.059	0.039	1.000		
(5) FORECO	0.319	−0.163	0.307	−0.148	1.000	
(6) FINDEV	−0.101	−0.400	0.297	−0.084	0.379	1.000

Source: Computed using Stata 14 based on data from World Development Indicators (WDI) and Medina and Schneider (2019) – SUSDEV (sustainable development), SHAECO (shadow economy), $SHAECO^2$ (squared term of shadow economy), LNMINREV (log of mineral revenue), INFL (inflation rate), FORECO (log of GNI per capita), FINDEV (financial development)

Table 3. Nonlinear effect of shadow economy on sustainable development in Africa

VARIABLES	Full sample				Low developed financial/credit market	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
L.SUSDEV	0.4440** (0.2107)	0.2645** (0.1068)	0.4377** (0.2088)	0.2551** (0.1009)	0.7116*** (0.1431)	0.7476*** (0.1349)
SHAECO	0.7057*** (0.2419)	0.9740*** (0.1918)	0.6993*** (0.2368)	0.9822*** (0.1898)	0.5855*** (0.1716)	0.5126*** (0.1733)
$SHAECO^2$	−0.0086*** (0.0031)	−0.0121*** (0.0029)	−0.0086*** (0.0030)	−0.0122*** (0.0028)	−0.0068*** (0.0020)	−0.0060*** (0.0020)
LNMINREV	0.1710 (0.2190)	0.2525 (0.2908)	0.1610 (0.2134)	0.2330 (0.2845)	−0.1708 (0.1473)	−0.1115 (0.1327)
INFL	0.0107 (0.0308)	0.0103 (0.0390)	0.0124 (0.0296)	0.0105 (0.0377)	0.0072 (0.0533)	0.0108 (0.0410)
FORECO (LNGNICAP)	1.1505** (0.5610)	1.4418** (0.7029)	1.1895** (0.5538)	1.4558** (0.6835)	0.3088 (0.3341)	0.2619 (0.2964)
FINDEV	−0.0212* (0.0114)	−0.0265 (0.0168)	−0.0209* (0.0113)	−0.0257 (0.0171)		
Year effects	No	Yes	No	Yes	No	Yes
Country effects	No	No	Yes	Yes	No	No
Short-run thresholds	41.029	40.248	40.657	40.254	43.051	42.717
Long-run thresholds	40.673	41.375	41.467	41.219	42.292	42.217
SHAECO long-run	1.269*** (0.201)	1.324*** (0.237)	1.244*** (0.180)	1.319*** (0.221)	2.030*** (0.531)	2.031*** (0.552)
$SHAECO^2$ long-run	−0.016*** (0.003)***	−0.016*** (0.004)	−0.015*** (0.003)	−0.016*** (0.004)***	−0.024*** (0.007)	−0.024*** (0.007)
Observations	205	205	205	205	88	88
Number of codes	30	30	30	30	20	20
Instruments	11	13	12	14	9	10
F-Stats	−2.65 (0.01)	−3.16 (0.00)	−2.65 (0.01)	−3.19 (0.00)	−2.58 (0.01)	−2.62 (0.01)
AR(1)	0.44 (0.66)	0.18 (0.86)	0.43 (0.67)	0.17 (0.86)	0.41 (0.65)	0.43 (0.66)
AR(2)	1.70 (0.79)	5.27 (0.38)	1.70 (0.79)	4.90 (0.43)	0.80 (0.85)	0.23 (0.97)
Hansen	2.83 (0.59)	4.58 (0.49)	2.80 (0.59)	4.41 (0.49)	0.92 (0.82)	0.20 (0.98)

Notes: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$ L.SUSDEV (lag of sustainable development), SHAECO (shadow economy), $SHAECO^2$ (squared term of shadow economy), LNMINREV (log of mineral revenue), INFL (inflation rate), FORECO (log of GNI per capita), FINDEV (financial development); standard errors in parentheses

Source: Computed using Stata 14 based on data from World Development Indicators (WDI) and Medina and Schneider (2019)

(*continued*)

Table 3.

VARIABLES	Low developed financial/credit market		High developed financial/credit market			
	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
L.SUSDEV	0.6886*** (0.1522)	0.5827*** (0.1527)	0.5853* (0.2841)	0.4104* (0.2329)	0.6052** (0.2811)	0.7011** (0.2714)
SHAECO	0.5605*** (0.1626)	0.7744** (0.2808)	0.5165* (0.2799)	1.0943** (0.4705)	0.4870* (0.2793)	0.4127** (0.1803)
$SHAECO^2$	−0.0066*** (0.0018)	−0.0093** (0.0035)	−0.0066* (0.0035)	−0.0149** (0.0072)	−0.0062* (0.0035)	−0.0054** (0.0023)
LNMINREV	−0.0969 (0.1707)	−0.0114 (0.2320)	0.1896 (0.2265)	0.3826 (0.5208)	0.2371 (0.2513)	0.1715 (0.2910)
INFL	−0.0013 (0.0555)	−0.0232 (0.0426)	0.0074 (0.0441)	−0.0566 (0.0665)	0.0015 (0.0450)	−0.0130 (0.0622)
FORECO (LNGNICAP)	0.3149 (0.3304)	0.2637 (0.3173)	0.7450 (0.6249)	−0.3856 (1.1142)	0.6673 (0.6088)	0.4682 (0.5833)
FINDEV						
Year effects	No	Yes	No	Yes	No	Yes
Country effects	Yes	Yes	No	No	Yes	Yes
Short-run thresholds	42.460	41.634	39.129	36.721	39.274	38.274
Long-run thresholds	42.857	42.182	38.938	37.12	38.563	
SHAECO long-run	1.800*** (0.470)	1.856*** (0.249)	1.246*** (0.298)	1.856** (0.733)	1.234*** (0.318)	1.381 (0.776)*
$SHAECO^2$ long-run	−0.021*** (0.006)	−0.022*** (0.004)	−0.016*** (0.005)	−0.025* (0.013)	−0.016*** (0.005)	−0.018 (0.012)
Observations	88	88	117	117	117	117
Number of codes	20	20	24	24	24	24
Instruments	10	13	9	13	10	9
F-Stats	−2.56 (0.01)	−2.21(0.03)	−2.45 (0.01)	−2.21 (0.03)	−2.43 (0.02)	−2.21 (0.03)
AR(1)	0.42 (0.68)	0.30 (0.77)	0.45 (0.65)	0.38 (0.70)	0.47 (0.64)	0.52 (0.61)
AR(2)	0.77 (0.86)	6.93 (0.23)	1.70 (0.64)	3.79 (0.71)	1.76 (0.62)	1.17 (0.28)
Hansen	0.92 (0.82)	2.49 (0.78)	1.25 (0.74)	8.71 (0.19)	1.26 (0.74)	0.99 (0.32)

In an attempt to determine and understand the threshold point beyond which the shadow economy impedes sustainable development, the full sample exhibits a threshold between 40% and 41.7%, beyond which shadow economies dampen sustainable development (see Appendix 3). However, under economies with high financial/credit market development, shadow economy size beyond threshold points beyond 36.8%–39.3% results in a reduction in sustainable development (see Appendix 5), while under economies with low financial/credit market development, shadow economy size beyond threshold points beyond 41.6%–43.1% results into reduction in sustainable development (see Appendix 4). These results suggest that strongly developed financial/credit markets can lower/tame the size of shadow economies that suppress sustainable development in Africa, and this effect is observed in both the short-run and long-run. These results imply that the development of financial/credit markets can shrink the size of shadow economies that impedes sustainable development by:

- pressurizing informal businesses to formalize to gain access to credit (Berdiev and Saunoris, 2016; Capasso and Jappelli, 2013; Blackburn *et al.*, 2012); and
- providing the opportunity to monitor and supervise the shadow economy to reduce value and frequency tax invasion which happens in the shadow economy (Capasso and Jappelli, 2013; Blackburn *et al.*, 2012).

Evidently, the importance of financial development in taming the adverse effect of shadow economies on sustainable development cannot be overemphasized and demonstrated through this result and supported by prior studies that show the relevance of financial development between the nexus between shadow economies and sustainable development (Dada, Ajide and Arnaut, 2022; Khan *et al.*, 2021; Gharleghi and Jahanshahi, 2020; Canh and Thanh, 2020; Berdiev and Saunoris, 2016).

In terms of the control variables, formal economy size measured as the natural log of gross national income per capita has a significant positive effect on sustainable development (see Models 1–4), implying that income from the formal economy propels sustainable development in Africa. Similarly, financial development is reported to reduce sustainable development in Africa (Models 1 and 3). These findings on the control variables are consistent with prior studies.

Conclusions, policy implications and recommendations

The economic literature has long focused on evaluating, monitoring and reporting on the formal economy through economic growth measures/variables such as gross domestic product (growth or per capita) and gross national income (growth or per capita). However, in recent times, economists and policymakers have increased their interest in understanding, monitoring and reporting on the shadow/informal economy, given its positive and negative implications for economic outcomes such as sustainable development. Thus, prior studies show that shadow economies have both good and bad sides, providing a basis for a possible nonlinear nexus from shadow economies to sustainable development. Yet, evidence of the nonlinear effect of shadow economies on sustainable development is limited and scanty, especially in Africa. At the same time, policymakers and economists are interested in identifying and understanding the threshold point of shadow economies that yields destructive effects on sustainable development to deploy effect tools/mechanisms that can be used to tame the destructive threshold effects of shadow economies on sustainable development. In this study, we attempt to explore the possible nonlinear threshold effect of shadow economies on sustainable development in Africa while offering additional evidence

on how high and low financial/credit market development influences the threshold point of shadow economies that yields destructive effects on sustainable development.

The study uses about 37 African economies between 2009 and 2017 on a dynamic GMM panel model that controls for country, year and technological effects to ensure consistency and reliability of results and findings. The key results show that:

- there is an inverted U-shape nexus between shadow economy and sustainable development in both the short and long run;
- the threshold point beyond which shadow economies dampen sustainable development is higher in the long run; and
- the size of shadow economies that presents destructive effects on sustainable development is lower under economies with high financial/credit market development.

These results have policy implications and recommendations for policymakers and financial sector regulators. From the results, it is clear that shadow economies can benefit sustainable development, especially when the size of shadow economies remains within certain thresholds/levels. Similarly, it is clear from the results that policymakers and financial sector regulators can rely on financial/credit market development to tame the size of shadow economies, which creates destructive effects on sustainable development. Clearly, developing the financial/credit market can improve/enhance sustainable development by lowering shadow economies' destructive effects on sustainable development, especially in Africa. For future research direction, it will be insightful to understand how the development of insurance and stock markets can influence the nonlinear effect of shadow economies on sustainable development.

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Further reading

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Appendix 1

Variables	(1)	(2)
(1) lnans	1.000	
(2) L.lnans	0.735	1.000

Source: Computed using Stata 14 based on data from World Development Indicators (WDI) and Medina and Schneider (2019)

Table A1. Matrix of correlations

Appendix 2: Cross-sectional dependence

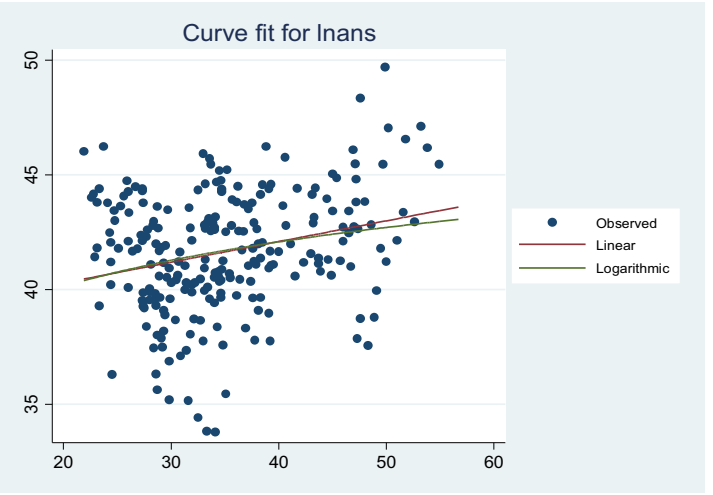
H0: Errors are weakly cross-sectional dependent.

CD = −0.784

p-value = 0.433

Source: Computed using Stata 14 based on data from World Development Indicators (WDI) and Medina and Schneider (2019)

Appendix 3



Source: Plotted using Stata 14 based on data from World Development Indicators (WDI) and Medina and Schneider (2019)

Figure A1. Model 4 – full sample

Appendix 4

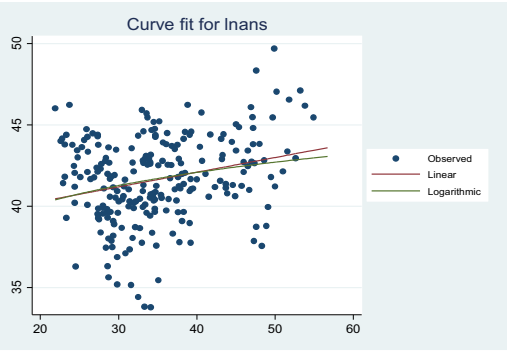


Figure A2.
Model 8 – low development financial/credit market sample

Source: Plotted using Stata 14 based on data from World Development Indicators (WDI) and Medina and Schneider (2019)

Appendix 5

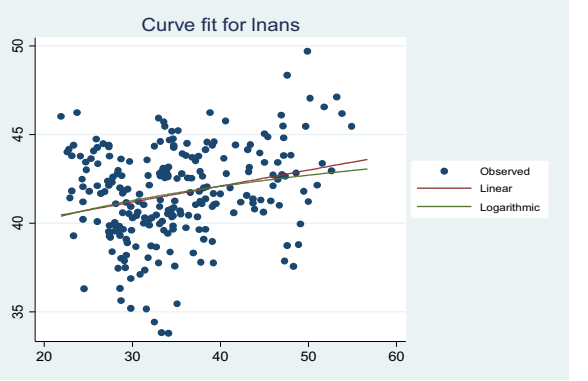


Figure A3.
Model 12 – high development financial/credit market sample

Source: Plotted using Stata 14 based on data from World Development Indicators (WDI) and Medina and Schneider (2019)

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