Technological Forecasting & Social Change xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

Entrepreneurship and sustainability: The need for innovative and institutional solutions

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ARTICLE INFO

Keywords:
Entrepreneurship
Sustainability
Innovation
Institutional quality

ABSTRACT

The role of innovation and institutional quality for achieving sustainability are important issues tackled by current sustainable development debates, particularly in developing countries. Using a modified environmental Kuznets curve model, the present study improves our understanding of the critical roles of innovation, institutional quality, and entrepreneurship in structural change toward a sustainable future for Africa. Our empirical results show that formal and informal entrepreneurship are conducive to reduced environmental quality and sustainability in 17 African countries however informal entrepreneurship contributes more than formal entrepreneurship to this environmental degradation. The relationship between entrepreneurship and sustainable development turns strongly positive in the presence of high levels of innovation and institutional quality. This study contributes to this emerging research strand by clarifying the conditions that allow African countries to move toward more sustainable economies. Our results highlight the important roles played by innovation and institutions for achieving sustainability in Africa.

1. Introduction

Despite the promise entrepreneurship offers for sustainability and climate change reduction, its role and nature are uncertain. Work on sustainability within the general entrepreneurship literature is scarce (Hall et al., 2010). Accordingly, although entrepreneurship is recognized as allowing the achievement of a more sustainable economy, there are gaps in our knowledge about the conditions necessary to reach this objective. In this paper, we investigate innovation and institutional quality as necessary conditions for entrepreneurship to create economic growth and advance social and environmental goals.

To do so, we apply our methodology to examine the case of African countries. The ability of the African continent to tackle many of the serious challenges it faces, such as climate change, depends strongly on its ability to promote new kinds of entrepreneurs, adopt new technologies, and build institutions to manage those changes. Prior studies show that many of the major killers in Africa are climate sensitive. Without policy intervention, by 2030, climate change will increase the population at risk of malaria in Africa by 170 million (Foresight, 2006), and by the 2080s, will increase the global population vulnerable to dengue fever by 2 billion (Hales et al., 2002). Urban air pollution causes about 1.2 million deaths each year in Africa (WHO, 2009), mainly by increasing mortality from cardiovascular and respiratory diseases. The indirect effects of climate change are also significant. In sub-Saharan Africa where agriculture relies on precipitation, yields are expected to drop by up to 50% by 2020 (Parry et al., 2007), putting millions at risk of a food crisis and malnutrition (World Bank, 2010). Despite growing understanding of the effect of climate change, the region's capacity to address these risks is weak.

We consider 17 African countries during the period 2001–2014 for three main reasons. First, the selected sample of countries includes low income, middle income, and emergent countries – based on level of development. Thus, it accounts for the variety of situations found in Africa. Second, the countries in our sample account for a large share of Africa's GDP, making our conclusions valid for a large part of Continent.[1] Third, Africa is a fast growing continent; its population is expected to more than double over the next 30 years, increasing from 1 billion to 2.3 billion people by 2050. Development in African needs to follow a different path from that pursued in Europe and America. The sustainability of African economies will be a major challenge for future generations across the world.

Our paper makes three substantive contributions to the literature.

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[1] Note that data constraints do not allow us to work on a larger sample since many variables are missing for several countries.

https://doi.org/10.1016/j.techfore.2017.11.003
Received 31 December 2016; Received in revised form 6 October 2017; Accepted 1 November 2017

First, it incorporates entrepreneurship activity into the standard environmental Kuznets curve (EKC)[2] model and demonstrates that environmental quality in Africa is affected negatively by both forms of entrepreneurs, i.e. survival entrepreneurs, and innovative Schumpeterian entrepreneurs. Our paper takes into account various forms of entrepreneurship (formal and informal) given the fact that the size of the informal sector is important in Africa and more than one-third of small businesses are not legally registered. Second, it builds a modified EKC model to examine the contribution of entrepreneurship to sustainable development. Third, it appears that while entrepreneurship is currently being discussed as an important channel for fostering sustainability, there is much uncertainty regarding the conditions needed to move toward sustainable products and services. This study contributes by incorporating innovation and institutional quality as conditional variables to move toward sustainable entrepreneurship.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature; Section 3 describes the methodological approach; Section 4 presents and discusses the empirical results; and Section 5 discusses the study's main conclusions and policy implications.

2. Literature review and analytical discussion

The prior literature shows that entrepreneurship is considered important for the development of sustainable products and services and the implementation of new projects addressing various environmental and social concerns. The importance of entrepreneurs as vehicles of economic and societal transformation is not new in the economic literature. The three main strands of work that deal with this topic are the sustainable entrepreneurship literature, the “growth penalty” literature and the EKC literature.

2.1. Sustainable entrepreneurship literature

Sustainable entrepreneurship is a business creation process that links entrepreneurial activities to the achievement of sustainable value-related social and environmental goals (O'Neill et al., 2009). Many authors including Drucker (1985), and Matos and Hall (2007) among others, have examined this link. For instance, Cohen and Winn (2007), show that several types of market imperfections contribute to environmental pollution. They are considered sources of significant entrepreneurial opportunities to establish the foundations for an emerging model of sustainable entrepreneurship which slows degradation and gradually improves ecosystems. Similarly, York and Venkataraman (2010) propose entrepreneurship as a solution to rather than a cause of, environmental degradation. The authors develop a model that embraces the potential of entrepreneurship to augment regulation, corporate social responsibility (CSR), and activism related to resolving environmental problems. For Sheperd and Patzel (2011), entrepreneurial activity can reduce environmental pollution and deforestation, preserve the ecosystem, and improve freshwater supply and agricultural practices. As a result, entrepreneurship could be the solution to numerous environmental and social problems (Hall et al., 2010; Senge et al., 2007; Wheeler et al., 2005).[3]

2.2. Entrepreneurship and “growth penalty”

Another literature stream stresses three complementary arguments explaining the relationship between institutions, entrepreneurship, and sustainability in the specific context of less developed countries (LDCs).

First, most LDCs suffer from a “growth penalty” (Audretsch et al., 2002). In other words, a marginal increase in the rate of entrepreneurship in LDCs increases growth rates. Since the number of entrepreneurs in LDCs is suboptimal and these countries need to increase the number of entrepreneurs, promoting entrepreneurship especially among qualified workers population is fundamental for their economic growth. Institutions created for that purpose could foster the desired type of entrepreneurship and provide incentives for starting businesses in specific domains including “green” sectors.

Second, most LDCs have large numbers of self-employed people. Most entrepreneurs are “survival entrepreneurs” who create little added value. Several works, starting from the seminal paper by Acs (2006), show that “self-employment” is negatively correlated with per capita income. Increasing “self-employment” and the number of survival entrepreneurs has a negative impact on economic growth. The solution proposed is to foster “Schumpeterian” and innovator entrepreneurs. “Schumpeterian innovative entrepreneurs” coexist with “defensive and necessity entrepreneurs” (Baumol, 1990) - the latter term describing individuals who enter a new business not based on market opportunities and innovative ideas but merely because they need an income to survive. This kind of “survival-driven” self-employment is particularly diffuse in LDCs (Naudé, 2009), where poverty and lack of formal opportunities often push people into entrepreneurial activities ranging from street vending to traditional and personal services - in most cases within the informal sector (see, e.g., Stam and van Stel, 2011; Goedhuys and Sleuwaegen, 2010). Survival entrepreneurs can cause turbulence and negatively affect economic growth (Quatraro and Vivarelli, 2014). Moreover, increasing survival entrepreneurship can be counterproductive from both an environmental and an economic point of view (Vivarelli, 2013). In contrast, innovative entrepreneurs create jobs, transform the economy, and increase sustainability (Silvestre, 2015). Institutions, both public and private, can play an important role in promoting entrepreneurship among skilled students and workers. The promotion of entrepreneurship education for students and qualified people is the type of public policy that is likely to achieve better returns from entrepreneurship in LDCs. In its absence, the rate of entrepreneurship among students will remain low. These populations of “potential entrepreneurs” are good candidates for becoming “innovators” and “Schumpeterian” entrepreneurs and accelerating national economic growth and sustainability.

Finally, reforming institutions in order to decrease bureaucracy, cronyism, rent capture, and political patronage can increase the motivation of innovative entrepreneurs to create a business. Many are discouraged from business creation by the amount of time needed for non-productive (bureaucratic) activities, and the fear that they will be unable to capture value from their business because of a poorly developed innovation protection system. Establishing the necessary institutions can foster the efficacy and efficiency of new entrepreneurs in the context of LDCs. A one-stop shop, electronically enabled administration is an example of the type of institutional reform that could increase entrepreneurship and national sustainability.

The economic literature advocates innovation as a catalyst for change allowing institutions, organizations, and countries to move toward more sustainable products and services (Silvestre, 2015). Almeida et al. (2013) and Lozano et al. (2013) suggest that society should demand more initiatives and investment from enterprises, education institutions, and governments to adopt innovative solutions to solve current sustainability challenges. Thus, acknowledgment of entrepreneurship and innovation as solutions to, rather than causes of, social inequality and pollution (York and Venkataraman, 2010) will encourage reconsideration of their important role in establishing

[2] According to the Environmental Kuznets Curve (EKC) hypothesis, as income (GDP) increases, emissions increase as well until some threshold level of income is reached after which emissions begin to decline. There is in existence a plethoric empirical literature of EKC. For empirical and analytical surveys the reader can see Dinda (2004) and Stern (2004).

[3] Several peer-reviewed journals such as *Harvard Business Review*, *Journal of Business Venturing*, and *Entrepreneurship: Theory and Practice* have published special issues on this topic in recent years.

sustainable economies. Despite efforts to generate unifying theories on the role of entrepreneurship and innovation for achieving sustainable development, the ecological and the social embeddedness literatures urge us to rethink existing explanations and assumptions (Conen et al., 2012; Sheperd and Patzel, 2011). Policy makers can promote innovation and remove the barriers to national economic growth by fostering entrepreneurship (Litan et al., 2009). It is well known that increasing national "R&D capabilities" decreases the "growth penalty" due to lack of qualified entrepreneurs (Prieger et al., 2016). To increase national "R&D capabilities" requires a national innovation system and coordination among system actors (Lundvall, 1992). This requires the building of institutions such as those dedicated to technology transfer, innovation protection, laboratories and associated public policies (Lundvall, 1992). In the case of African countries, several papers show the link between establishing the right institutions and an increased rate of innovation and technology use (Arvanitis and M'henni, 2010; Kraemer-Mbula and Watu, 2010).

Promoting "opportunity entrepreneurship" is a plausible solution to environmental degradation and climate change. Entrepreneurs are aware of the existence of an important potential market for "environmentally friendly" products and services. Proposing new products and services initially captures "residual demand" with higher margins. Previous studies show that green labeling was successful in creating green products in developed countries, and this trend is being followed by developing countries. A new generation of entrepreneurs, helped by new technologies, is trying to capture these "niche" opportunities. In some cases, entrepreneurs may be subject to powerful regulation which induces them to use more sustainable methods of production. In this case, "opportunity entrepreneurs" will try to increase their market share and enter new markets – something not possible without a change in the regulation.

2.3. The environmental Kuznets curve literature and entrepreneurship

One of the most puzzling research questions is related to the EKC. The EKC describes a relationship where, in the early stage of economic development, environmental degradation increases with per capita income, and after a certain level of per capita income, environmental quality increases with a rise in per capita income. Despite the large body of work on the EKC, there is no clear answer to this question. The EKC literature has attracted much critique for its incompleteness in relation to sustainability analyses.

There is a new stream of research that proposes a more sustainability-oriented EKC model which may be able to connect new theoretical formulations with additional empirical specifications. For instance, Tamazian et al. (2009) argue that EKC is captured not only by analyzing the relationship between GDP growth, environmental degradation, and energy use but also by other important variables that affect environmental pollution. They argue that these should be included in the environmental function to avoid omitted variable bias in the econometric estimation. Many researchers are introducing other significant determinants of environmental degradation that improve representation of the EKC model, such as foreign trade (Omri, 2013; Al-Mulali et al., 2015; Omri et al., 2015), human development (Costantini and Monni, 2008; Gürlük, 2009), and financial development (Omri et al., 2015; Shahbaz et al., 2013). Others have focused on emerging entrepreneurship activity debates in environmental economics. For example, York and Venkataraman (2010) consider entrepreneurship as a solution to, rather than a cause of, environmental degradation. Sheperd and Patzel (2011) argue that entrepreneurship can protect the ecosystem, increase environmental quality, reduce deforestation, improve agricultural practices, and enhance freshwater supplies. Accordingly, we introduce entrepreneurship in the EKC model as a key determinant of sustainable development. One of our objectives is to show the relevance of entrepreneurial activity (formal and informal) in the EKC model.

Considering the EKC allows examination of how changes in microeconomic behavior affect national macroeconomic performance. At the same time, actors' behavior could be sensitive to the level of development of a given economy. For example, as the level of development increases, awareness of environmental degradation increases, inducing changes in the consumers' and entrepreneurs' behaviors.

Our paper links these three literatures and examines how the nature of entrepreneurship is sensitive to the macroeconomic variables (quality of institutions, innovation, export, etc.) in order to achieve sustainable goals.

3. Methodological approach

3.1. Model development

Based on the literature we can formulate the following EKC model:

$$P_{it} = \alpha_0 + \alpha_1 Y_{it} + \alpha_2 Y^2{}_{it} + \alpha_3 E_{it} + \alpha_4 T_{it} + \alpha_5 F_{it} + \alpha_6 MHDI_{it} + \alpha_7 FE_{it} + \alpha_8 IE_{it} + \mu_{it} \quad (1)$$

where P, Y, Y^2, E, T, F, MHDI, FE, and IE respectively indicate environmental pollution, per capita GDP, squared per capital GDP, energy consumption, trade liberalization, financial development, modified human development index, formal entrepreneurship, and informal entrepreneurship. In this equation, we use a modified human development index (HDI) that does not include GDP. Moreover, the absence of the income factor in the modified HDI avoids multicollinearity among per capita income and the HDI variables. Thus, our models use MHDI as an indicator of human development.

Since our objective is to analyze the relationship between entrepreneurship activity and sustainability using a modified EKC, we follow the methodology in Costantini and Monni (2008) which consists in replacing the environmental pollution-related dependent variable (P) with a negative Genuine Saving (− GS) as an indicator of non-sustainability. We also replace per capita GDP in the standard EKC with a more capability-oriented measure (i.e., HDI) to incorporate innovation (Franceschini et al., 2016) and institutional quality[4] as important determinants of sustainable development (Costantini and Monni, 2008).

According to Costantini and Monni (2008), the GS index is expressed as follows:

$$GS = \dot{K} - (F_R - f_r)(R - g) - b(e - d) \quad (2)$$

where K, FR, fr, R, g, b, e, and d indicate respectively economic capital formation, resource rental rate, marginal cost of extraction, resources extracted, natural growth rate of renewables, emissions, natural dissipation, and the marginal cost of abatement.

GS is based on the assumption of both the perfect and limit value of sustainability, where

- Sustainability (+ GS) → GS > 0
- Minimum level of sustainability → GS = 0
- Non-sustainability (− GS) → GS < 0

The relationship between economic growth and environmental degradation given by Eq. (1) can be reformulated using MEKC, introducing innovation and institutional quality as factors of sustainability, replacing the environmental pollution-related dependent variable (E) with –GS as an indicator of non-sustainability, and substituting per capita GDP with a more capability-oriented measure such as HDI. Considering that GS is computed in economic terms, the income dimension in the standard HDI could lead to multicollinearity and biased estimation. For this reason, MHDI is constructed as a simple average of life expectancy and the education index. Moreover, the absence of GDP

[4] Defined by the rule of law (RL).

in the MHDI mitigates multicollinearity concerns among GS and HDI.

Regarding the standard EKC model, the incorporation of additional control variables allows us to examine the contribution of entrepreneurship, innovation, and institutional quality toward achieving sustainable development goals. Accordingly, our final models representing the standard EKC (model 1) and MEKC (model 2) are given, respectively, by the following two equations:

$$P_{it} = \alpha_0 + \alpha_1 Y_{it} + \alpha_2 Y^2{}_{it} + \alpha_3 E_{it} + \alpha_4 T_{it} + \alpha_5 F_{it} + \alpha_6 MHDI_{it} + \alpha_7 FE_{it} + \alpha_8 IE_{it} + \mu_{it} \quad (3)$$

$$-GS_{it} = \beta_0 + \beta_1 MHDI_{it} + \beta_2 MHDI^2{}_{it} + \beta_3 FE_{it} + \beta_4 IE_{it} + \beta_5 IN_{it} + \beta_6 RL_{it} + \beta_7 T_{it} + \varepsilon_{it} \quad (4)$$

where i and t denote the country and the time period, respectively. α_0 and β_0 are fixed country effects. μ and ε are error terms. α_j (j = 1…8) are the elasticities of environmental pollution with respect to per capita GDP (Y), squared GDP per capita (Y^2), energy use (E), foreign trade (T), financial development (F), modified MHDI (MHDI), formal entrepreneurship (FE), and informal entrepreneurship (IE), respectively. In Eq. (3), we use per capita CO_2 emissions as a measure of environmental pollution (P).[5] The parameters β_k (k = 1…7) are the elasticities of –GS with respect to the linear (MDHI) and non-linear ($MDHI^2$) terms of the modified HDI, formal entrepreneurship (FE), informal entrepreneurship (IE), innovation (IN), rule of law (RL), and trade openness (T), respectively.

3.2. Data description

The present study uses annual data for 2001 to 2014[6] for 17 African countries, namely, Algeria, Angola, Botswana, Burkina Faso, Cameroon, Côte d'Ivoire, Egypt, Gabon, Ghana, Mozambique, Morocco, Nigeria, Senegal, South Africa, Togo, Tunisia, and Zambia. The data are from World Development Indicators, Global Entrepreneurship Monitor (GEM), the United Nations Education Science and Culture Organization (UNESCO), and the United States Patent and Trademark Office (USPTO) databases. Our data include the following variables:

3.2.1. CO_2 emissions

CO_2 emissions are releases of carbon into the atmosphere. This indicator is used to measure of environmental degradation. Data are in metric tons and collected from World Bank (WDI).

3.2.2. GS

According to the World Bank (2010), “Genuine saving index (also known as adjusted net saving) is a sustainability indicator building on the concepts of green national accounts. Genuine saving index measures the true rate of savings in an economy after taking into account investments in human capital, depletion of natural resources and damage caused by pollution” Costantini and Monni (2008) argue that the GS index “is the only available macroeconomic sustainability indicator calculated for a wide range of countries and for a consistent time series.”[7] Per capita GS is used as a measure of sustainability. Data are in constant U.S. dollars and collected from the World Development Indicators.

3.2.3. Gross Domestic Product (GDP)

GDP since the 1930s has been the most widely used measure of national growth worldwide (Lippman, 2009). The measure has been developed and has become the standard used by policymakers and is widely discussed in the public sphere (Bleaney and Nishiyama, 2002). It tells us how much a country's production has increased (total economic value added). Data are in constant U.S. dollars and collected from the World Bank Indicators.

3.2.4. Trade

The trade openness index is an economic metric calculated as the ratio of the a country's total trade (exports plus imports) to the country's GDP.

3.2.5. Energy

Energy consumption refers to the consumption of primary energy which refers to energy forms before transformation to other end-use fuels. Data are measured in metric tons of oil equivalent and collected from the World Development Indicators.

3.2.6. Financial development

Following Ang and Mckibbin (2007), we use principal component analysis to choose the best measure of financial development between the three indicators of financial development identified in the existing literature, namely, total credit to the private sector as a share of GDP, broad money as a share of GDP (M2), and liquid liabilities as a share of GDP (M3). The results of the principal components analysis are presented in Table 1. They show that the first principal component is total credit to the private sector as a percentage of GDP and is the best measure of financial development. This variable is collected from the World Bank Indicators.

3.2.7. Innovation

Several indictors are used to measure innovation activity, such as Global Innovation Index (e.g., Crespo and Crespo, 2016) and number of patents registered at the USPTO[8] (e.g., Anokhin and Schulze, 2009; Castellacci and Natera, 2016; Hudson and Minea, 2013). Since our study needs a large time-series dataset of both developed and developing countries, we use the number of patents per capita granted to residents of a given country each year to proxy for innovation. This variable is collected from the USPTO.

3.2.8. Institutional quality

Kaufman et al. (2004) argue that institutional quality could be described using political instability, rule of law, government effectiveness, regulatory framework, control of corruption, and property rights. Following Costantini and Monni (2008), we use rule of law to proxy for institutional quality. The World Bank considers rule of law to be an important dimension of governance in the control of corruption.

3.2.9. HDI

The human development index includes three dimensions of development: education, health, and income. An index is calculated for each of these three dimensions calculated using a simple average of the three indices: education, life expectancy (a proxy for health), and GDP (a proxy for national income). To calculate these indices, we use the World Development Indicators and UNESCO datasets. Table 2 presents formulae of the indices.

We use an MHDI that does not contain GDP to measure only the country's average achievements along two basic dimensions of human development (education index and life expectancy index). Moreover, excluding the income factor from the MHDI mitigates multicollinearity between per capita income and HDI. Data on education and life expectancy are from the World Bank Indicators.

3.2.10. Formal entrepreneurship

To measure formal entrepreneurship, we use the number of newly

[5] The choice of CO_2 emissions as the dependent variable in this study is driven mainly by data availability and also to maximize the number of observations.

[6] Selection of the period of study was driven by the availability of data on entrepreneurship.

[7] For more details on this index, see Hamilton and Clemens (1999).

[8] USPTO (2015).

Table 1
Results of the principal component analysis.

Component	Eigen value	Difference	Proportion	Cumulative
Comp 1[a]	2.018	1.374	0.673	0.673
Comp 2[b]	0.644	0.306	0.215	0.888
Comp 3[c]	0.338	–	0.112	1.000

Notes: a, b and c refer respectively to total credit to the private sector as a share of GDP, broad money as a share of GDP (M2), and liquid liabilities as a share of GDP (M3).

Table 2
HDI calculation.

$Dimension\ index = \frac{Actual\ value - Min\ \text{value}}{Max\ value - Min\ \text{value}}$	-	-
Indicator	Max value	Min value
Life expectancy at birth (years)	75	40
Combined gross enrollment ratio (%)	100	0
Adult literacy rate (%)	100	0
GDP per capita (constant US$)	7,628,722	175.887
Education index calculation		
Education index[a] = (ln(actual value) − ln(min value)) / (ln(max value) − ln(min value))		
GDP index calculation		
GDP index = (ln(actual value) − ln(min value)) / (ln(max value) − ln(min value))		
HDI calculation		
HDI = ((1/3 ∗ Education index) + (1/3 ∗ Life expectancy index) + (1/3 ∗ GDP index))		

[a] Education is measured as (2/3 adult literacy rate + 1/3 ∗ gross enrollment index). However, due to data availability, we consider only the combined gross enrollment ratio to calculate the education index.

registered businesses per 1000 working-age individuals aged between 15 and 64 years. This measure is provided by the World Bank and is designed to capture formal entrepreneurship. It provides well-established measures of formal entrepreneurship that cover > 103 countries during the period 2001–2014. We use the measure of formal entrepreneurship in Dau and Cazurra (2014):

$$Form.\ entrep. = \frac{Number\ of\ new\ registred\ \text{business}}{Working\ age\ population}$$

3.2.11. Informal entrepreneurship

Given the lack of extensive and ordered data on unregistered businesses, and difficulties related to sourcing reliable data, we generate an informal entrepreneurship index using cross-country data from the World Bank (WB - this index focuses on newly registered business) and from the GEM (GEM - this index includes registered and unregistered businesses per 1000 working-age individuals). GEM data are given as the total number of businesses, without differentiating between formal and informal enterprises. This provides a well-founded measure of entrepreneurship that covers 103 countries from 2001 to 2014. Therefore, we measure informal entrepreneurship by subtracting formal entrepreneurship from total entrepreneurship. Note that both variables are based on recent and inclusive datasets (2014). Following Dau and Cazurra (2014), we use this measure of informal entrepreneurship:

$$Infom.\ entrep. = \frac{Number\ of\ new\ registred\ \text{and unregistred business}}{Working\ age\ population} - \frac{Number\ of\ new\ registred\ \text{business}}{Working\ age\ population}$$

Table 3 reports the results of the Pearson correlation between all the panel series of variables. The correlation coefficients between the variables suggest that the reported regression panel models are not seriously distorted by multicollinearity. Table 3 shows that the CO_2 emissions variable is highly significantly correlated with per capita income, energy use, formal and informal entrepreneurship, innovation, and rule of law. The second dependent variable, namely, negative GS, is correlated positively with per capita income, human development, formal and informal entrepreneurship, and correlated negatively with innovation and rule of law. Overall, the pairs reveal high and significant correlation. The pair-wise relationship can change if we integrate the variables in a panel based on multivariate regression analysis.

3.3. Panel unit root tests

Several economic variables are characterized by stochastic trends that could result in spurious inferences. A variable is considered to be stationary if its autocovariances do not depend on time. Any variable that is not stationary has a unit root. The formal way to test the stationarity of variables is unit root tests (e.g., Breitung, 2000; Im et al., 2003; Levin et al., 2002; Maddala and Wu, 1999).

Table 4 reports the results of the several panel unit root tests. The Breitung unit root test includes individual linear trends and individual fixed-effects as regressors. The values in Table 4 show that the null hypothesis of a unit root cannot be rejected at the level of the variables, indicating that each time series is panel non-stationary. On the contrary, after application of these tests at the first difference level, the null hypothesis for each of the variables can be rejected at the 5% and 1% levels. All our variables series are stationary at first difference, indicating that they are integrated at first order (I(1)) in each panel.

3.4. Panel cointegration test

Engle and Granger (1987) indicate that a linear combination of two or more non-stationary series of variables may be stationary, and therefore are said to be cointegrated. These cointegrated series of variables may be interpreted as a long-run equilibrium relationship between the variables. According to Granger (1988), cointegration exists if two or more non-stationary variables have the same order of integration. To test the cointegration equations, Maddala and Wu (1999) recommend a Fisher cointegration test based on the multivariate framework proposed by Johansen (1991), rather than the Engle-Granger method, because the maximum likelihood procedure has significantly large and finite sample properties. To test the number of cointegration relationships, the Johansen (1991) method uses two ratio tests: (i) a trace test, and (ii) a maximum eigenvalue test. Both can be applied to determine the number of cointegrating vectors present, although they do not always indicate the same number of cointegrating vectors. In applying the Johansen method, if we find different results between the two ratio tests, the result from the maximum eigenvalue test is preferred in our context due to the benefit of separate tests on each eigenvalue.

The results of the Fisher-type Johansen panel cointegration test are reported in Table 5. For both models, they indicate that the assumption of the cointegration tests allows for individual effects but not individual linear trends in the vector autoregression. The null hypothesis of no cointegration is rejected at the 1% significance level. Furthermore, both the trace and the maximum eigenvalue statistics show strong support for and evidence of cointegration relationships among the variables in all models. Thus, we can conclude that there exists a panel long-run equilibrium relationship between the variables under consideration in both models, meaning that they move together over the long-run.

3.5. Testing panel-based multivariate regression models

Engle and Granger (1987) state that there are long-run equilibrium relationships between cointegrated non-stationary variables. Given this result, a panel-based error correction model (ECM) is applied to account for a long-run relationship using Engle and Granger's two-step procedure.

Accordingly, panel-based ECMs can be constructed as follows:

Table 3
Pearson correlations.

	P	− GS	Y	T	F	E	MHDI	FE	IE	IN	RL
P	1.000										
− GS	0.620	1.000									
Y	0.694**	0.702**	1.000								
T	0.421	0.456	0.436	1.000							
F	0.179	0.533*	0.329	0.159	1.000						
E	0.673*	0.622	0.624**	0.412**	0.256	1.000					
MHDI	− 0.352**	0.705**	0.168	0.239	0.417	0.426**	1.000				
FE	0.712*	0.782**	0.625**	0.387	0.669*	0.423	0.792**	1.000			
IE	0.794*	0.798*	0.714*	0.523	0.329	0.388	0.436	− 0.796*	1.000		
IN	− 0.788*	− 0.773*	0.692**	0.519**	0.408	0.530	0.788*	0.699**	0.586**	1.000	
RL	− 0.791*	− 0.768*	0.368**	0.432	0.389**	0.589**	0.711*	0.780*	− 0.703**	0.790*	1.000

Note: * and ** indicate correlation significance at 1% and 5% levels, respectively.

Table 4
Results of panel unit root tests.

Variables/ methods	Breitung		Levin et al.		Im et al.	
	Level	Δ	Level	Δ	Level	Δ
− GS	− 0.683	− 6.233*	− 0.217	− 8.210*	− 0.179	− 10.098*
Y	1.233	− 8.817*	1.009	− 11.023*	0.957	− 15.552*
T	− 1.128	− 5.025*	0.072	− 7.257*	0.355	− 6.521**
F	− 0.237	− 7.009*	− 0.836	− 5.241*	− 0.442	− 5.553*
E	− 0.389	− 6.118	− 0.920	− 8.019*	1.163	− 9.114*
MHDI	− 0.023	− 4.520**	− 0.055	− 5.413*	0.122	− 8.218*
FE	− 0.489	− 7.771*	0.283	− 6.837*	− 0.721	− 10.301*
IE	− 0.893	− 8.025*	− 0.624	− 7.092*	− 0.360	− 8.530*
IN	− 0.189	− 5.396*	0.117	− 6.142*	− 0248	− 12.231*
RL	− 0.026	− 6.124**	− 0.009	− 5.220*	0.177	− 8.473*

Notes: Δ denotes first differences. Significance levels: * (1%) and ** (5%).

Table 5
Fisher-type Johansen panel cointegration test.

Models	Model 1[a]		Model 2[b]	
Number of cointegrating equations	Trace test	Maximum-eigen test	Trace test	Maximum-eigen test
None	496.520*	412.119*	388.210*	352.443*
At most 1	318.008*	284.773*	305.791*	296.224*
At most 2	277.304*	199.263*	194.937*	155.408*
At most 3	168.566*	91.907*	111.005*	87.083*
At most 4	103.370*	74.075*	89.294*	59.360*
At most 5	66.449	51.883	41.030	28.651
At most 6	50.506	33.714	37.563	23.007
At most 7	46.012	26.913	21.174	21.174
At most 8	16.550	16.550	–	–

Notes: Probability values for rejection of the null hypothesis of no cointegration are employed at 1% level (*, p-value $<$ 0.01) based on the MacKinnon et al. (1999) p-values.
[a] Model 1: P = $f(Y, Y^2, E, T, F, MHDI, FE, IE)$.
[b] Model 2: − GS = $f(MHDI, MHDI^2, FE, IE, IN, RL, T)$.

$$\Delta \ln Y_{it} = \psi_{iY} + \sum_{j=1}^{n-1} \alpha_{ij} \Delta \ln X_{it-j} + \sum_{j=1}^{n-1} \beta_{1j} \Delta \ln Y_{it-j} + \lambda_i ECT_{t-j} + \varepsilon_{it} \quad (5)$$

where Y_{it} is observation of the dependent variable for country i at time t. t represents 1, 2, 3, …, n observations. Δ is the difference operator. Ψ, α, and β are the parameters of the regressors. ECT_{t-1} is the error correction term obtained from the cointegrating vectors. ε is a stationary random error with zero mean. j is the lag length. The panel-based ECM can be estimated using various types of panel data analytic models such as constant coefficient models, and fixed- and random-effects models. The Hausman test is used to choose between fixed-effects and random-effects models. If this hypothesis is rejected, the estimation results given by the fixed-effects models are found to be more robust than random effects. The result of this test rejects the null hypothesis of random-effects models as more efficient and suitable for the three models. Probability values rejecting the null hypothesis of no correlation are employed at the 5% significance level. Accordingly, the fixed-effects model results are more appropriate than the random-effects.

4. Regression results

Table 6 presents the results of panel-based ECM model using the fixed-effects estimator in model 1. The reported coefficients are statistically significant at the 1% or 5% levels. From the results of model 1, we find that 97.2% of the variation in CO_2 emissions in the African economies considered can be explained by the level of per capita GDP, energy use, trade openness, financial development, human development, and both formal and informal entrepreneurship. Therefore, we can see that informal and formal entrepreneurship are the highest contributors to environmental degradation in Africa, followed by financial development, energy consumption, and per capita GDP. The magnitudes of 0.551 and 0.276 imply that a 1% rise in informal and formal entrepreneurship increases environmental degradation in African countries by 0.55% and 0.28%, respectively. These results mean that entrepreneurship activity in Africa contributes positively to environmental degradation and are consistent with Riti et al. (2015) in the Nigerian case. We can see that the contribution of informal entrepreneurship to environmental degradation is much higher (0.551) compared to formal entrepreneurship (0.276). This result can be explained by the significant size of the informal sector in the African

Table 6
Fixed-effects results for model 1.

Independent variables	Model 1[a]	
	'**P**' as dependent variable	
	Coefficient	Probability
Y	0.220*	(0.007)
Y^2	− 0.123**	(0.043)
E	0.227*	(0.000)
T	0.061**	(0.031)
F	0.239*	(0.002)
MHDI	0.040	(0.149)
FE	0.276*	(0.001)
IE	0.551*	(0.000)
Constant	1.525*	(0.000)
R-squared	0.972	
Adj. R-squared	0.964	
F-Statistic	2118.420	

Notes: P-values are reported in parentheses. Significance levels: * (1%) and ** (5%).
[a] Model 1: P = $f(Y, Y^2, E, T, F, MHDI, FE, IE)$.

context,[9] where more than one-third of small businesses are not legally registered. Most African entrepreneurs seek to diminish costs by avoiding payment of taxes, social security contributions related to wages, retirement pensions, and other social benefits, and by avoiding legal labor market rules, such as safety and environmental standards, minimum legal age, minimum wages, and maximum working hours. Moreover, there is a significant cost attached to leaving the informal sector. Firms in the informal economy in most African countries, particularly small firms and the self-employed entities, may decide to continue to operate informally because the costs of formalization are higher than its benefits (Ihrig and Moe, 2001; Maloney, 2004).

Informal entrepreneurship has an important impact on environmental degradation. On the one hand, informal entrepreneurs use less efficient technologies and methods of production than those in the formal sector. On the other hand, since they are in the informal sector they do not comply with environmental standards and regulation, if they exist. Moreover, most informal entrepreneurs are survival entrepreneurs not taking account of the long-term. As a result, they do not consider the consequences of their production processes on the environment.

The second important finding presented in Table 6 is that the linear and non-linear coefficients of per capita GDP are respectively, positive and negative, which supports the inverted U-shaped relationship between income level and environmental pollution. This result supports the EKC theory that pollution levels increase as countries develop but begin to decrease as rising incomes pass a certain threshold. These results are in line with Orubu and Omotor (2011) for 47 African countries, Shahbaz et al. (2013) for South Africa, and Mensah (2014) for 6 African countries. Regardless of the presence of an EKC between economic growth and environmental degradation, since the coefficient of Y is much higher than the coefficient of Y^2, an increase in economic growth is expected to have a lower effect on reducing environmental degradation in the long-run. African economies have experienced rapid growth since the mid-2000s (AfDB, 2014). While the impact of this growth in the short term has been negative in terms of environmental quality, the picture will be reversed in the long-term after a certain threshold. Economic growth is a necessary but not sufficient condition for sustainability.

Another important finding is that a 1% increase in total credit to the private sector leads to a 0.24% increase in per capita CO_2 emissions, meaning that financial development contributes to environmental degradation in African countries. For this reason, there is a need to further increase the level of financial development to achieve lower CO_2 emissions. Financial systems are weak. While in a first stage, developing the financial sector can increase pollution, at higher levels of development the financial sector may reduce pollution by motivating firms to adopt new and advanced environmentally-friendly technologies for production processes. This means that a sound and stable financial system could reduce environmental pollution through use of new advanced technologies. In this context, Stiglitz (2016), among others, suggests these countries should not follow the pattern of western financial systems (especially the U.S. financial system). Africa should adopt more environmentally-friendly financial systems allowing for economic development and sustainability.

Moreover, consumption of energy exhibits a positive and statistically significant effect on carbon emissions at the 1% level. The coefficient magnitude of 0.227 implies that a 1% increase in energy use leads to an increase of 0.23% in per capita CO_2 emissions, indicating that an increase in the use of energy leads to increased environmental degradation. Similarly, we find that higher levels of trade openness are associated to higher levels of CO_2 emissions. This finding is consistent with Tiba and Omri (2017), which suggests that an increase in trade openness is accompanied by increased environmental pollution, particularly for less developed economies, due to delocalization of polluting industries, known as the pollution haven effect.

Table 7
Fixed-effects results for model 2 (without and with innovation and institutions variables).

Independent variables	Model 2 (" − GS as dependent variable)			
	Model 2a[a]		Model 2b[b]	
	Coefficient	*Probability*	*Coefficient*	*Probability*
MHDI	0.105**	(0.034)	0.161*	(0.002)
$MHDI^2$	− 0.098**	(0.011)	− 0.158**	(0.013)
FE	0.281*	(0.000)	− 0.204*	(0.000)
IE	0.424*	(0.000)	- 0.066	(0.104)
T	0.107**	(0.046)	− 0.170**	(0.037)
In	–	–	− 0.449*	(0.000)
RL	–	–	− 0.196*	(0.001)
Constant	0.866*	(0.000)	1.086*	(0.000)
R-squared	0.795		0.861	
Adj. R-squared	0.795		0.861	
F-Statistic	1497.913		3117.002	

Notes: P-values are reported in parentheses. Significance levels: * (1%) and ** (5%).
[a] Model 2a: $-GS = f(MHDI, MHDI^2, FE, IE, T)$.
[b] Model 2b: $-GS = f(MHDI, MHDI^2, FE, IE, IN, RL, T)$.

Finally, we focus on the key research gap addressed in this work, i.e., understanding whether innovation and institutional quality could improve the relationship between entrepreneurial activity and sustainability in African. Table 7 reports the estimation results of models 2a and 2b (MEKC). We obtain four important results. First, estimates of model 2a give results similar to the traditional EKC, with lower R-squared values. It appears that informal entrepreneurship is the highest contributor to the –GS, followed by formal entrepreneurship and trade openness. The magnitudes of 0.281 and 0.424 indicate that a 1% increase in formal and informal entrepreneurship in African countries increases sustainability by − 0.28% and − 0.42%, respectively. This result is in line with our previous findings. Informality and informal entrepreneurship are harming environmental quality in Africa.

Second, both models show a quadratic relationship between –GS and human development in African countries, since the coefficient of MHDI is much higher than the coefficient of squared MHDI; thus, an increase in human development is expected to have a lower effect on sustainability in the long-run. Therefore, the current efforts to reduce environmental degradation and to achieve sustainable development are unlikely to be very effective given the level of the problem.

Third, in estimating model 2a, in which we include innovation and institutional quality variables, we find that innovation and institutions have negative and significant effects on negative GS at the 1% level. The magnitudes of − 0.449 and − 0.196 indicate that a 1% increase in innovation activity and institutional quality reduces negative GS by 0.45% and 0.2%, respectively. These results highlight the important roles played by innovation and institutions for achieving sustainability in Africa. Adopting new technologies and innovation improves production methods and the efficiency of African firms (lower consumption of natural resources and less pollution). At the same time, better institutional quality implies an improvement in the management of economic and environmental resources and more effective environmental and natural resources regulation. Institutional quality also means more effective (environmental) law enforcement. While most African countries have adopted environmental regulations, they still suffer from corruption and lack of law enforcement. Taking actions that improve institutional quality could reverse the situation. Our result is in line

[9] According to Schneider et al. (2010), the informal sector contributes to > 50% of sub-Saharan Africa's GDP and 80% of its labor force. > 90% of rural workers have informal jobs in Africa, and most employees are women and youth. The informal sector in Africa offers to the most vulnerable populations such as the poorest, women, and youth, opportunities to generate reasonable incomes and to improve their chances to send their children to school and to access health services. However, workers involved in the informal economy often lack social protection, their incomes are not secure, and their employment conditions are poor.

with those in Costantini and Monni (2008), which show that institutional quality constitutes a conditional variable to build a sustainable development path. Similarly, Silvestre (2015) argues that innovation is an important goal to which countries and firms should aspire to achieve more sustainable products and services.

Fourth, after introducing innovation and institutional quality in the MEKC, the signs of coefficients related to formal and informal entrepreneurship and trade openness become negative, indicating that all these factors contribute positively to higher levels of GS (although informal entrepreneurship is not statistically significant). This result contrasts with results for the traditional EKC reported in model 1, and indicates that formal entrepreneurship, accompanied by a high level of innovation and institutional quality contributes positively to achieving sustainability goals in African countries. Thus, we can conclude that African governments need to address two challenges simultaneously to achieve sustainable entrepreneurship[10]: formalizing the informal sector by providing incentives for informal entrepreneurs to become formal, and encouraging formal entrepreneurship to adopt more innovative solutions and more environmentally-friendly technologies to produce more sustainable products and services. To deal with these challenges, governments should concentrate their efforts on informal entrepreneurship to help reduce its negative effect on the natural environment. Governments could encourage people to register their businesses, educate people to be oriented toward legal and regulated entrepreneurship, increase spending to stimulate markets, provide services to new firms to encourage them to comply with the formal market. Governments also need to improve their systems through solid laws, well-defined property rights, transparency, and good policies to encourage new entrepreneurs to enter the market. At the same time, there is a need for incentives for young entrepreneurs to join the formal economy, focusing especially on the burdens of the formal economy (e.g., fiscal policies). Building skills and easing access to financial markets could set the "gazelles free" and substantially increase the productivity of the informal economy (Arouri et al., 2014). In this context, De Soto (2003) argues that entrepreneurs resort to operating in the informal sector because of unclear rules for creating a formal enterprise, or bureaucratic barriers to legal property ownership and lack of legal structures that recognize and encourage ownership of assets. Similarly, Autio and Fu (2015) declare that a one standard deviation increase in the quality of economic and political institutions could double the rates of formal entrepreneurship and halve the rates of informal entrepreneurship. In addition, the emergence of innovative businesses is vital for a move toward sustainability. For this reason, it is necessary to reinforce the innovation capacity of firms by investing in education and training programs, credit and patent protection, reinforcing cooperation between research centers and industries, and stimulating applied research for innovative products and services. Lozano et al. (2013) suggest that society should call for more initiatives and investments from enterprises, education institutions, and governments to adopt innovative solutions to resolve current and future sustainability challenges.

5. Conclusions

Entrepreneurship has been cited as one of the solutions to meet future challenges such as climate change. Despite the fact that policy makers place great importance on entrepreneurship in promoting sustainable and inclusive development, the links between them are unclear. This paper sets out to explore the conditions where entrepreneurship can simultaneously achieve economic growth and advance social and environmental objectives in Africa. More precisely, we have tried to provide a better understanding of the central and critical roles of entrepreneurship, innovation, and institutions in moving toward a sustainable future in Africa. Using Genuine Saving (GS) as a measure of sustainability, we built an MEKC model to examine the interrelationship between innovation, institutional quality, entrepreneurship, and sustainable development in 17 African countries over the period 2001–2014.

Our empirical analyses provide interesting findings with regard to the sustainability process, which have important policy implications.

First, we found that both forms of entrepreneurship activity in Africa (i.e., formal and informal) contribute to environmental degradation, where the contribution of informal entrepreneurship to environmental degradation is much higher compared to formal entrepreneurship. However, after taking account of innovation and institutional variables in the analysis, the effects of both forms of entrepreneurship on sustainability turned positive, meaning that a higher level of innovation and better quality of institutions constitute a driving force to achieve a higher level of entrepreneurship and sustainability.

Our findings have important policy implications. Improved governance and law enforcement are needed in most of African countries to achieve sustainable development. Several international development agencies are encouraging such reforms. Most are providing loans to implement "governance" reforms including "law enforcement", "transparency", "participation," and "accountability". Setting up the right institutions can also improve the formality of the economy, and thus sustainability since formal entrepreneurs seem more able to move to sustainable development.

Second, we find that international trade could have positive effects in the countries considered. Our findings are in line with Stiglitz (2000) who argues that trade and inward FDI (globalization) positively affect institutional quality, and globalization could be a cause of institutional improvement. Economies positively influenced by globalization are those that do well in developing their institutions in a democratic way, and guarantee macroeconomic stability. Thus, the sustainability of such a process depends on how profits from the exploitation of existing resources are invested, and how the lack of resources is addressed.

Our findings suggest free trade policies are one way to improve the efficiency of the economy, catching up by acquiring new technologies and improving the sustainability of the economy. Most African countries are engaged in such processes. However, most lack economic diversification and are obliged to import many goods and services. However, there are new industries starting in Africa and there are the beginnings of a service economy.

Third, innovation and institutions are necessary conditions for the emergence of sustainable entrepreneurship in Africa. Our paper relies on previous findings such as those in Gerlach (2003) who addresses the need to approach an analysis of the role of sustainable entrepreneurs in implementing sustainable development, from the perspective of innovation. The focus is on innovation that improves sustainable development. Successful sustainable innovation is accomplished if entrepreneurial actors achieve competitive advantage, i.e., economic success through the application of innovative environmental and social practices.

Our findings suggest that promoting innovation and encouraging entrepreneurs to adopt new technologies should improve the sustainability of African economies. While innovation, measured in a narrow way (patents, etc.), suggests that Africa entrepreneurs are not very innovative, new evidence considering all aspects of innovation show that African firms are more innovative than has been expected and are benefitting from the technological revolution (especially information and communication technologies) (Lorenz, 2014). Information and communication technologies are fostering "innovation" in Africa and causing a paradigm shift in several economic sectors. They are used in ways that promote sustainable development. For example, their use in agriculture is "revolutionizing" this sector and causing improvement to

[10] Sustainable entrepreneurship can be described as innovation and entrepreneurship for sustainable development. It has been defined as "an innovative, market oriented and personality driven form of value creation by environmentally or socially beneficial innovations and products exceeding the start-up phase of a company" (Schaltegger and Wagner, 2011).

yields and sustainability of the resources used.

Overall, it appears that while entrepreneurship currently is discussed as an important channel for fostering sustainability, there remains substantial uncertainty regarding the conditions needed to move toward sustainable products and services. This study constitutes a contribution in this direction but more research is need on this emerging area. Among the several questions that remain, three are hot topics from a policy perspective: What characterizes sustainability-oriented entrepreneurship and how does it differ from traditional entrepreneurship? What prompts entrepreneurs to embrace a sustainable orientation? What are the roles of networks, partnerships, and other social and organizational ties in advancing sustainable entrepreneurship?

In addition to the insights and implications provided by this study, it has some important limitations. This study analyzes only the direct influences of innovation and institutional quality on the transition toward sustainable entrepreneurship. However, sustainable entrepreneurship is a complex process that could take place through several stages. For this reason, future work should extend this research framework by integrating moderating or mediating factors.

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