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# Environmental degradation, ICT and inclusive development in Sub-Saharan Africa

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ABSTRACT

This study examines how information and communication technology (ICT) complements carbon dioxide ($CO_2$) emissions to influence inclusive human development in forty-four Sub-Saharan African countries for the period 2000–2012. ICT is measured with internet penetration and mobile phone penetration. The empirical evidence is based on Generalised Method of Moments. The findings broadly show that ICT can be employed to dampen the potentially negative effect of environmental pollution on human development. We establish that: (i) ICT complements $CO_2$ emissions from liquid fuel consumption to increase inclusive development; (ii) ICT interacts with $CO_2$ intensity to negatively affect inclusive human development and (iii) the net effect on inclusive human development is positive from the complementarity between mobile phones and $CO_2$ emissions per capita. Conversely, we also establish evidence of net negative effects. Fortunately, the corresponding ICT thresholds at which these net negative effects can be completely dampened are within policy range, notably: 50 (per 100 people) mobile phone penetration for $CO_2$ emissions from liquid fuel consumption and $CO_2$ intensity. Theoretical and policy implications are discussed.

## 1. Introduction

Four tendencies motivate the positioning of this inquiry, namely: the increasing information and communication technology (ICT) penetration trend in Sub-Saharan Africa (SSA); growing exclusive development in the sub-region; increasing environmental concerns in the light of the sustainable development agenda and gaps in the literature. The tendencies are substantiated in chronological order. First, recent ICT literature is consistent with the perspective that the greatest room for ICT penetration is in SSA, compared to other high-end economies in North America, Asia and Europe where the penetration of ICT has reached levels of saturation (see Penard et al., 2012; Asongu, 2013; Murphy and Carmody, 2015; Tchamyou, 2016). Such a high penetration opportunity naturally represents a policy instrument that can be leveraged by policy makers to address sobering sustainable development concerns like environmental pollution and global warming.

Second, in the transition from the Millennium Development Goals (MDGs) to Sustainable Development Goals (SDGs), many positions are consistent with the view that extreme poverty has been decreasing in all regions of the world with the exception of SSA, where close to half the countries in the sub-region have been substantially off-course from achieving the MDG extreme poverty threshold (World Bank, 2015; Asongu and Le Roux, 2017). Evidence of this extreme poverty trend substantially contrasts with the fact that the sub-region has been enjoying more than two decades of economic growth resurgence which began in the mid-1990s (Asongu and Nwachukwu, 2016a). It is therefore logical to infer that the fruits of economic prosperity are not substantially trickling down to unprivileged factions of the population in order to address absolute poverty. Moreover, it is also logical to associate the corresponding economic prosperity to green house gas emissions which have been documented to considerably represent a challenge to environmental sustainability in the post-2015 development era (see Akinyemi et al., 2015).

Third, there is consensus today that environmental sustainability is a key theme in the post-2015 development agenda (Akpan and Akpan, 2012; Asongu et al., 2016a). The relevance of this theme to SSA can be articulated along four constructive lines, notably: the comparatively high economic growth record in the sub-region; growing energy crisis; poor management of energy crisis and negative externalities from global warming. Considering these points in detail, we can note that SSA has recently experienced over two decades of growth resurgence after decades lost in the quest for economic development (see Fosu, 2015), partly due to the ineffective formulation and failed implementation of Structural Adjustment Programmes. With more evidence that the continent has recently hosted seven

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of the ten fastest growing economies in the world (see Bradley, 2016), it is logical to assert that the underlying burgeoning economic prosperity has been associated with environmental degradation and pollution as well as emissions of green house gases.

While the energy crisis has been documented as another critical challenge in the post-2015 sustainable development agenda (Akinyemi et al., 2015), the crisis is most apparent in SSA, because the privileged part of the population in the sub-region with access to energy is about 5% (see Shurig, 2015). The narrative maintains that the total energy that is consumed in the sub-region is equivalent to that consumed in some states in more advanced economies like the state of New York, United States of America (USA). Furthermore, consumption of energy by the sub-region accounts for just about 17% of the global average.

Moreover, inefficiency is a common feature in the management of energy in most African countries (Soumoni and Sounmoni, 2011; Anyangwe, 2014). This perspective can be substantiated by considering Nigeria, the continent's most populous nation, where shortages of and outages in electricity are addressed with government subsidised petroleum fuel, which is used by electricity generators to compensate for underlying outages and shortages (see Apkan and Apkan, 2012). Conversely, comparatively less investment has been allocated for renewable sources of energy in the country (Babatunde, 2011; Nigeria Electricity, 2017). Finally, the consumption of fossil fuels which is a direct cause of climate change and global warming represents a great challenge to sustainable development in the post-2015 development era (see Huxster et al., 2015). According to Kifle (2008), the most negative consequences of global warming will be borne by Africa. Carbon dioxide ($CO_2$) emissions represent about 75% of global greenhouse gas emissions (Akpan, 2012).

This inquiry assesses how ICT can be tailored to reduce the effect of $CO_2$ emissions on sustainable development in the perspective of inclusive human development. It is important to note that inclusive development is part of sustainable development because for inclusive development to be sustainable it has to be sustained and in order for sustained development to be sustainable, it must be inclusive (see Amavilah et al., 2017). Hence, building on the intuition that $CO_2$ emissions, ICT and human development are connected, we argue that ICT could reduce $CO_2$ emissions by, inter alia: (i) preventing unnecessary transportation costs and (ii) consolidating the efficient management of households and corporations. For instance, transport costs could be saved by the availability of a mobile phone, that can be used to pay health bills and make other transactions which can improve the financial standing of a household. These corresponding human development dimensions are components of the inequality adjusted human development index (IHDI) used in this study as the outcome variable.

In the light of the above, the intuition underlying the current study falls within a scholarly framework of theory-building and provides consistency with recent empirical literature (see Narayan et al., 2011) in arguing that applied econometrics should not be exclusively based on the acceptance or rejection of existing theoretical underpinnings. This is essentially because an empirical exercise that is founded on a logically substantiated intuition could pave the way to theory-building, especially in the light of interactions between relevant phenomena like $CO_2$ emissions, ICT and inclusive human development. Therefore, we aim to provide both theoretical and practical implications.

The positioning of the inquiry is not in the same vein as recent literature on $CO_2$ emissions and ICT. With regard to $CO_2$ emissions, recent environmental degradation literature has largely focused on nexuses between energy consumption, $CO_2$ emissions and economic growth. The existing literature has been dominated by a discussion of the relationship between environmental pollution and economic growth, with a fundamental emphasis on the Environmental Kuznets Curve (EKC) hypothesis (see Akbostanci et al., 2009; Diao et al., 2009; He and Richard, 2010).[1] Existing literature also considers the nexus between economic growth, environmental pollution and energy consumption (Jumbe, 2004; Ang, 2007; Odhiambo, 2009a, 2009b; Apergis and Payne, 2009; Menyah and Wolde-Rufael, 2010; Ozturk and Acaravci, 2010; Bölük and Mehmet, 2015; Begum et al., 2015) and connections between energy consumption and economic growth (Mehrara, 2007; Esso, 2010).

A shortcoming that is largely shared by the highlighted literature is the collective failure to engage a policy variable with which $CO_2$ emissions can be reduced, in order to enhance human development and environmental sustainability. We argue that findings based on nexuses between energy consumption, $CO_2$ emissions and economic growth have limited practical significance for policy makers, unless policy makers are provided with instruments with which to address corresponding policy syndromes in order to improve human/economic development. Hence, this inquiry addresses the highlighted shortcoming by employing ICT as a policy variable with which $CO_2$ emissions can be dampened in order to improve human development. In order to make this assessment, ICT (mobile phone and internet penetrations) is interacted with $CO_2$ emissions indicators and the net effects on inclusive human development are subsequently computed from both conditional and unconditional effects.

The study also deviates from recent ICT inquiries which have largely focused on inter alia: economic prosperity (Qureshi, 2013a; Levendis and Lee, 2013); living standards (Chavula, 2013); externalities in welfare (Qureshi, 2013b, 2013c; Carmody, 2013); banking sector progress (Kamel, 2005); Africa's information revolution from the perspectives of production networks and technical regimes (Murphy and Carmody, 2015); life for all (Ponelis and Holmner, 2013a, 2013b; Kivuneki et al., 2011) and sustainable development (Byrne, 2011) in developing nations. Thus, while these studies consider the human and socioeconomic rewards from ICT, we know very little about the relationships between ICT, $CO_2$ emissions and human development.

In the light of the above, the two main hypotheses tested of this study are as follows.

**Hypothesis 1:.** The mobile phone modulates the potentially negative effect of $CO_2$ emissions on human development.

**Hypothesis 2:.** The internet modulates the potentially deleterious impact of $CO_2$ emissions on human development.

For each of the hypotheses to be valid, the net effect from the association between ICT and $CO_2$ emissions on human development should be positive. The positioning of this inquiry steers clear of recent energy policy studies on $CO_2$ emissions which have largely focused on:

Recalculating $CO_2$ emissions from an added value perspective (Xu et al., 2017); examining $CO_2$ emissions and economic effects of implementing energy efficient programs (Martinez et al., 2017); renewable energy and $CO_2$ abatement (Marcantonini and Valero, 2017); acceptance of $CO_2$-utilisation for plastic products (Van Heek et al., 2017) and decomposing inequality in energy-oriented $CO_2$ emissions (Chen et al., 2017). The last study is closest to the present paper because it directly engages inclusive development.

The rest of the paper is structured as follows. Section 2 engages the data and methodology. The empirical results are presented in Section 3 and Section 4 concludes with implications and future research directions.

## 2. Data and methodology

### 2.1. Data

This study investigates a panel of forty-four Sub-Saharan African (SSA) countries with data from: (i) African Development Indicators (ADI) of the World Bank and (ii) the United Nations Development Program (UNDP) for the period 2000–2012. The adopted periodicity is based on constraints in data availability and the motivation discussed in

[1] According to the EKC hypothesis, in the long term, there is an inverted U-shaped relationship between per capita income and environmental degradation.