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## Assessing the nexus of sustainability and information & communications technology

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### ABSTRACT

The link between information and communications technology and sustainability has been discussed by many authors, yet a macro-level analysis of the link coupled with an examination of the link between new technology areas, human development and the interaction between all of these measures has not been fully explored. In this paper, we hypothesize the link between environmental sustainability, information and communication technology, and human development. We find that information and communications technology and human development have significant main and interactive effects on environmental sustainability. Our discussion section proposes further research into these areas to understand some of the micro-level interactions.

### 1. Introduction

Access, adoption, and diffusion of modern technologies and innovations are the driving forces behind a nation's knowledge-driven economic growth and development strategy. Information and communications technology (ICT) currently permeates the economic, social, and environmental dimensions of many nations around the globe. ICT has become an intrinsic dimension of a nation's drive for a more equitable, inclusive, sustainable and competitive economy and society. In addition, ICT has the potential to also enhance the rate of diffusion of innovations and technologies across economies and societies (Hanclova et al., 2015; OECD, 2014a, 2014b; UN, 2015; World Bank, 2012).

The availability and implementation of information and communication technologies (ICT) and innovations are increasingly vital to all dimensions of a nation's inclusive, equitable and sustainable economic development and growth agendas and strategies. ICT is fundamentally changing the nature of economic, environmental, and social relationships global wide; functioning as a vector of economic, social and environmental changes (Mardikyan et al., 2015; OECD, 2004, 2015; Parthasarathy and Bass, 2015; UNCTAD, 2015).

In the past decades, knowledge as an input into an economic system has surpassed natural resources in determining and shaping a nation's path towards economic development and growth. The generation and diffusion of knowledge is at the core of knowledge-driven economies, becoming a very important component in a nation's quest for economic competitiveness and sustainable growth. In this regard, investments in ICT have substantial impacts on an economy's productivity rates, competitiveness, and on its economic complexity. In order to further

promote the increasing importance of ICT in a nation's quest towards deepening its knowledge complexity, a nation needs to balance and coordinate a number of functional dimensions of its economy such as: a) R & D and innovation agents; b) human capital system; c) macro-economic and microeconomic policies, and d) ICT infrastructure (El-Sherbiny, 2005; European Commission, 2015).

Moreover, the pervasive dissemination of ICT also facilitates addressing the full innovation chain embedded in addressing societal and sustainability challenges in areas such as health, energy, and transportation, fostering excellence in the science base (Research Infrastructures), and promoting leadership in manufacturing of traditional and high-tech sectors (robotics, photonics, micro- and nano-electronics) (European Commission, 2015).

Many nations around the globe are going through severe digital disruptions. ICT is driving the change in the utilization of technology and innovation by all nations and regions. It is clear, however, that without the diffusion and dissemination of ICT; countries cannot garner the full environmental benefits and the positive externalities that are generated as a result. Thus, the development of an ICT ecosystems is of paramount importance to policy-makers and the local business community in a true public-private partnership arrangement. Such ecosystem, for instance, will allow the fostering of entrepreneurship and new models of economic cooperation and fund raising utilizing innovative financing models, resulting in further economic development and economic growth. Furthermore, countries' ability to further capitalize on the social, economic and environmental impacts of ICTs are driven by the usage of individual, businesses and government, and by their capabilities in areas such as infrastructure, affordability and skills

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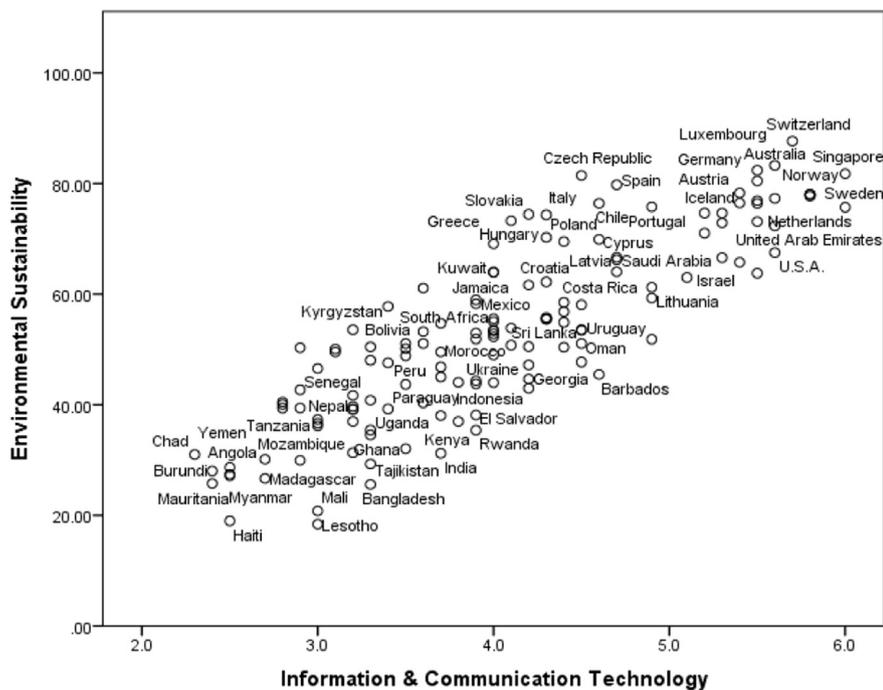


Fig. 1. Scatterplot of countries showing relationship between information & communication technology and environmental sustainability.

Note: For the sake of legibility not all data points are labeled.  
Source: Constructed by the authors.

(Pick and Azari, 2008; World Bank, 2012; World Economic Forum, 2015; Zheng, 2009).

ICT's Digital Quadruple Helix, or the interdependent components of the ICT diamond model, need to be balanced, in order for ICT to have a successful establishment and implementation (Ericsson, 2015). A country needs to balance its endeavors in ICT Infrastructure, development of human capital, development of dynamic ICT industry (services and manufacturing), and the embrace and the metamorphosis of industries towards increasing the use and penetration of digital innovations and technologies in order for it to reap the full benefits of these implementations. This digital quadruple helix will foment and foster government's policies and incentives towards the further adoption and dissemination of ICT helping the private sector in its business activities. The successful impact of ICT on sustainability is also deeply related to the existence and success of these Digital Quadruple Helixes.

## 2. Sustainability & ICT

The global knowledge-driven economy is built on three basic tenets: knowledge flow, economic development, and environmental sustainability. Policy-makers study and implement strategies that foster innovation and stimulate local institutions, agencies, and companies to participate in the innovation process. Innovation is at the core of the new knowledge economy. It is more vital than ever for nations and companies to develop an infrastructure and policies to foster the innovation process and to absorb knowledge (Castaldi et al., 2004; IDB, 2004; Bate, 2005; Blejer, 2004; Kozmetsky et al., 2004).

The link between these three components (knowledge flow, economic development, and environmental sustainability) has always been described in terms of building the information pipeline that will lead to development through better education, R&D, innovation, wealth creation, and poverty elimination (Steinmueller, 2001; Corea, 2007; Kottemann and Boyer-Wright, 2009; Jaruzelski et al., 2006).

The 2015 adoption of the 2030 Agenda for Sustainable Development, with its 17 goals and 169 targets, address the role of ICT as a vital component in fostering sustainable economic development, and in promoting the achievement of sustainable development goals (SDGs).

ICT has a number of applications and services for sustainable

economic development and growth. These applications, for instance, extend from: a) the internet of things allowing for remote sensing and management and control of connected devices with a number of environmental applications, b) green use of robots and drones for environmental surveillance, monitoring, and protection, c) smart grids, d) ICT support for smart infrastructure, and cities; e) impact of cloud computing services and “big data” on the environment, f) circular and sharing economies, and g) urban transportation management systems.

Thus, ICT has a number of impacts, implications and applications for nations' abilities to green their economies. The delivery of public and private goods and services are changing radically. ICT is also impacting climate change and permeating environmental policies across the globe. As an example of these impacts, the role of ICT in GHG abatement solutions have affected areas in the global economies, such as transportation, land use, buildings, manufacturing and energy (Gouvea, 2015; Forge et al., 2009; ITU, 2014; Manyika et al., 2015; Neves and Krajewski, 2012; Nipo et al., 2014; World Economic Forum, 2015).

Other impacts are felt on the transportation side with recent trends in smart and green transportation that relies on green innovations such as automated road transport (ART). On the energy side, ICT has a considerable contribution on the design of smart grids. ICT also has a vital role in energy efficiency (EE) and “Competitive Low Carbon Energy – LCE” strategies in areas such as: a) behavioral modifications towards energy conservation via ICT; b) buildings with green infrastructure and LEED certifications, and c) in several industries such as manufacturing, services, and agriculture. On the agriculture side, for instance, ICT plays a key role in sustainable food security via the utilization of robotics for precision farming (European Commission, 2016).

But does information and computer technology (ICT) lead to higher levels of environmental sustainability? Fig. 1 shows how the relationship is between ICT and environmental sustainability for many countries in the world.

Whereas Fig. 2 shows the relationship between human development and environmental sustainability. The next sections will address and assess this intriguing question.

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