The Effect Of Information Systems Capabilities On Sustainability: A Country-Level Analysis

Satish Krishnan  
National University of Singapore, satishk@comp.nus.edu.sg

Thompson S.H. Teo  
National University of Singapore, bizteosh@nus.edu.sg

ISBN: [978-1-86435-644-1]; Full paper

Recommended Citation
http://aisel.aisnet.org/pacis2011/101

This material is brought to you by the Pacific Asia Conference on Information Systems (PACIS) at AIS Electronic Library (AISeL). It has been accepted for inclusion in PACIS 2011 Proceedings by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact elibrary@aisnet.org.
THE EFFECT OF INFORMATION SYSTEMS CAPABILITIES ON SUSTAINABILITY: A COUNTRY-LEVEL ANALYSIS

Satish Krishnan, Department of Information Systems, School of Computing, National University of Singapore, Singapore, satishk@comp.nus.edu.sg

Thompson S.H. Teo, Department of Decision Sciences, School of Business, and Department of Information Systems, School of Computing, National University of Singapore, Singapore, bizteosh@nus.edu.sg

Abstract

Using the Source-Position-Performance (SPP) framework and the literature on information and communication technology (ICT) impact, we posit that the IS capabilities owned by citizens (i.e., source of advantage) lead to ICT penetration among them (i.e., positional advantage), which in turn affects the sustainability of the country (i.e., national performance). Based on secondary data from 120 countries, our results supported the hypothesized model. Specifically, IS capabilities owned by citizens in a country appears to be a significant enabler of ICT penetration among them, which in turn lead to the management of national performance in terms of economic, environmental, and social sustainability. Post hoc analysis indicates that ICT penetration among citizens partially mediated the relationships of IS capabilities owned by citizens with economic and social sustainability. In addition, the relationship of IS capabilities owned by citizens with environmental sustainability is not mediated by ICT penetration among citizens. Our findings contribute to the theoretical discourse on ICT impact by identifying the role of IS capabilities owned by citizens in a country and provide indications to practice on enhancing its sustainability by managing ICT penetration among citizens.

Keywords: IS capabilities, sustainability, ICT penetration, SPP framework, secondary data.
1 INTRODUCTION

There has been much debate over the phenomenal growth of information technology (IT) investments by organizations, and the ability of these investments to engender value (in terms of innovative and competitive strategies) at both organizational (Barua and Mukhopadhyay 2000) and national levels (Srivatsava and Teo 2010). Concurrent with this rise in arguments on IT investments and capabilities, an equally important debate has been taking place regarding the need for stakeholders in a country (i.e., citizens, businesses, and governments) to engage in sustainability practices (Dunphy et al. 2003; McIntyre 2003). The growing requirement for nations to engage in sustainability practices and the role of IT in causing and resolving sustainability issues is attracting the interest of academic researchers and managers (including policy makers). Sustainability refers to meeting the needs of present generation without compromising the ability of future generations to meet their needs (Hart 1997).

The three pillars of sustainability are (1) Economy; (2) Environment (or ecology); and (3) Social (or community). The concept of three pillars pertaining to profit, planet, and people respectively is called as the “Triple-Bottom-Line” (TBL) (Elkington 1998).

Existing studies examining the “IT-sustainability” linkage has evolved over three streams. First, descriptive and anecdotal studies, while offering benchmarks for practitioners to assess and evaluate their sustainability practices and to progress against their peers, provide limited value to theory. Second, studies that focuses on “particular aspects” of sustainability in reference to “particular IT innovation”. For instance, a study by Haigh (2004) focused only on the environmental aspect of sustainability in reference to e-business innovation and ignored the other two bottom lines (i.e., economic and social sustainability). Similarly, a study by Srivatsava and Teo (2010) focused only on the economic sustainability pertaining to e-business and e-government innovation in a country and ignored the other two aspects (i.e., environmental and social sustainability). A third related stream is the case studies that are micro in orientation or studies that are conceptual in nature. Case studies capture the richness of context in which the researched object is embedded and conceptual studies lay the theoretical foundations for future empirical exploration (Srivatsava and Teo 2010). While such studies address important aspects of academic research, they cannot possibly address the broad macro-level issues pertaining to sustainability. Although the need for macro-level studies (i.e., studies looking at global or cross-country level) looking at all the three aspects of sustainability is largely emphasised in past literature (e.g., Watson et al. 2010), researchers often ignore or overlook them. Hence, the prime motivation of this research is to fill these voids by examining the impact of IS capabilities on sustainability at the country-level.

The critical role of individuals in dealing with sustainability issues is often emphasized in past literature. For instance, Gifford (2008) indicates that individuals are the “ultimate key” to respond to environmental threats, and human ingenuity is the “ultimate resource” to reframe aspiration toward climate-change betterment. Specifically, he states that “I maintain that individuals truly are the ultimate key to climate-change amelioration: policies, programmes, and regulations themselves do not change anything” (p. 274). In similar vein, Melville (2010) in his research agenda emphasizes the importance of individuals’ beliefs in managing economic and environmental sustainability. While the significance of individuals’ role in managing sustainability is evident in the literature, most studies focus only on firm-level IT investments, and often ignore the impact of IS capabilities available with citizens on sustainability. Our study strives to fill this void by exploring the linkage between IS capabilities owned by citizens in a country and its sustainability. Specifically, by utilizing the Source-Position-Performance framework (Day and Wensley 1988) and by drawing from the literature on ICT impact, we argue that IS capabilities owned by citizens in a nation, defined as citizens’ readiness to use ICTs are sources of advantage, offering inimitable differentiation in ICT penetration among them (i.e., positional advantage), which in turn is a key to manage sustainability of nations (i.e., national performance). We examine theses linkages empirically based on secondary data from 120 countries. In sum, the specific research questions we strive to address in this study are:

*RQ1*: How does IS capabilities owned by citizens in a nation affect ICT penetration among them?
**RQ2:** How does ICT penetration among citizens in a country contribute to its performance (in terms of economic, environmental, and social sustainability)?

The rest of the paper is organized as follows. First, we present the conceptual framework that underlies our rationalization of the effects of IS capabilities owned by citizens in a country on its ICT penetration and national performance (in terms of economic, environmental and social sustainability) with the range of hypotheses that flow from those rationalizations. Thereafter, using secondary data from 120 countries (see Appendix A for the list of countries), we test the hypothesized model. Lastly, we discuss the findings and their contributions to the knowledge base in IS capability and sustainability development. Then, we highlight the major limitations of our study and offer future research directions.

## 2 CONCEPTUAL FRAMEWORK AND HYPOTHESES

Capabilities are socially complex routines that determine the efficiency with which firms transform inputs into outputs (Collis 1994). While resources are seen as basic inputs into gaining and maintaining competitive advantage, organizational capabilities are the firm’s capacity in acquiring and utilizing its resources to perform tasks and activities for competitive gain (Barney 1996; Bharadwaj 2000). In their seminal paper on competitive advantage, Day and Wensley (1988) argue that “the creation and sustenance of a competitive advantage are the outcomes of a long-run feedback or cyclical process” (p. 2). This is underpinned by a simple, yet elegant sequential framework called the “Source-Position-Performance” framework as shown in Figure 1.

![Figure 1. Conceptual model.](image)

According to this framework, superior skills are sources of advantage. In our context, we propose IS capabilities owned by citizens (in terms of their readiness to use ICTs) as the source of advantage for three reasons: (1) readiness is an indicator of the agility of a business and a capability that needs constant building, re-building and upgrading (Clark and Cavanaugh 1997); (2) the emphasis on IS capabilities owned by citizens is consistent with prior research in strategy, where Grant (1991) observed, “capabilities can be identified and appraised using a standard functional classification of the firm’s activities” (p. 120); (3) despite their strategic value, IS capabilities owned by citizens have not been the focus of prior IT—national performance research (e.g., Srivatsava and Teo 2010).

IS capabilities of a firm mobilize and deploy IT-based resources in combination or copresent with other resources and capabilities (Bharadwaj 2000). These routines available within IS department enable it to deliver IT services to the organization (Ravinchandran and Lertwongsatien 2005). Such capability differentiates an organization from its competitors and can affect its operational and market performance (Bhatt and Grover 2005). Likewise, a nation’s ability to discriminately invest and build IS capabilities (via its citizens) not only enable it to operate differently from its neighbouring countries (or competitors) but also make it harder for them to imitate. Further, these skills will allow the nations to develop their IS that could integrate its nation-wide activities in a coordinated manner. Hence, an economy whose citizens are more ready and show a greater interest toward ICT advances will be likely to use it more effectively and extensively (WEFGIT Report 2007-2008; 2008-2009). In other words, ICT penetration among them will be higher.

According to Day and Wensley (1988), positional advantages (i.e., first-order benefit) are the key business attributes that either deliver a lower cost position or value-add to a firm’s activities and...
operations. Extending this rationale to our context, we argue that an inimitable differentiation in ICT penetration among citizens is a positional advantage that differentiates a country from its neighbours and competitors. In the context of achieving national outcomes, ICT penetration among individuals is crucial to manage sustainability (e.g., Gifford 2008; Melville 2010), a key national performance indicator (i.e., second-order benefit). This forms the premise of our conceptual model depicted in Figure 1. The proposed research model is shown in Figure 2.

![Figure 1. Conceptual Model](image)

**Figure 1. Conceptual Model.**

### 2.1 Effect of IS Capabilities on ICT Penetration

Existing studies on ‘technology readiness’ defines readiness in either one of the following forms: (1) readiness is an antecedent condition necessary for implementation of initiatives such as IT-enabled change or innovation (e.g., Guha et al. 1997); and (2) readiness is an indicator of agility of a business and a capability that needs constant building, re-building and upgrading (e.g., Clark and Cavanaugh 1997). Parasuraman (2000) defines technology readiness as people’s propensity to embrace and use new technologies for accomplishing goals in home life (and at work). Such a tendency is likely to occur only when profound facilitators in form of IS capabilities are available with them. Given this, and by building on the notion that capabilities are determined by organizational routines (Collis 1994), we adopt a process focus and define IS capabilities owned by citizens as their readiness to use ICTs. Specifically, following Clark and Cavanaugh’s (1997) conceptualization of technology readiness as capabilities, we argue that a nation’s ability to increase penetration of ICTs among citizens is likely to be contingent on IS capabilities owned by them. That is, an economy whose citizens are more ready and show a greater interest towards ICT advancements will be likely to use them more effectively and extensively (WEFGIT Report 2007-2008; 2008-2009). Hence, penetration and diffusion of ICTs among them will be higher. This leads to the following hypothesis:

**H1:** The level of IS capabilities owned by citizens in a country is positively associated with the level of ICT penetration among them.

### 2.2 Effect of ICT Penetration on Sustainability

Managing sustainability implies seeking a balance between short- and long-term considerations (Raynard and Forstarter 2002), and often involves large group of stakeholders (i.e., citizens, businesses, governments). While the three dimensions of sustainability (economic, environmental, and social) are distinct spheres, they sometimes overlap (Petrini and Pozzebon 2009). Figure 3 shows the definition of different components of sustainable development (Harris et al. 2001; Holmberg 1992; Reed 1996; Brundtland 1987).
Figure 3. Definition of components of sustainable development.

The significance of the link between ICT penetration (i.e., usage) and organizational performance has long been discussed in the literature (Devaraj and Kohli 2003). Doll and Torkzadeh (1998) note that ICT use is a pivotal construct in the system-to-value chain that links upstream research on the causes of ICT success with downstream research on the organizational impacts of ICT. In similar vein, the relationship between ICT utilization and organizational performance has been proposed as pivotal by Delone and McLean (1992). Extending this argument to the country-level, we reason that for national-level ICT impacts to occur, it is necessary that ICT penetration among citizens is tied to national performance metrics. That is, at the national-level, countries derive competitive advantage by “effectively utilizing” their resources and capabilities (Farhoomand et al. 2001; Porter 1990). Hence, the degree of ICT penetration among citizens will impact the performance at the country-level (Dewan and Kraemer 2000). To measure the impact of IT investments and usage, researchers have used multifarious measures of organizational performance, such as productivity enhancement, inventory reduction, cost reduction, and competitive advantage (Devaraj and Kohli 2003; Hitt and Brynjolfsson 1996). In this research, we define national performance metrics in terms of a country’s economic, environmental, and social sustainability development. Extending Day and Wensley’s (1988) argument that positional advantages are the key attributes that deliver a lower cost position or value-add to a firm’s activities and operations, we argue that an inimitable differentiation in ICT penetration among citizens (as positional advantage) will differentiate their country from its neighbours and competitors, and consequently, impact sustainability outcomes.

2.2.1 Relationship between ICT Penetration and Economic Sustainability

ICT enables economic sustainability by widening the reach of technologies such as high-speed Internet, mobile broadband, and computing (WEFGIT Report 2009-2010). Statistics indicate that bringing mobile broadband levels in emerging markets up to those of more mature markets could add between US$300 and US$420 billion to the world’s GDP and 10 to 14 million direct and indirect jobs in areas such as equipment manufacturing and outsourcing/offshoring services (WEFGIT Report 2009-2010). Research indicates that ICT’s role in enabling economic growth has become more significant. For instance, Clark et al. (2002) highlights how the use of Internet technologies at the local government level leads to proliferation of e-government resulting in economic welfare of the country. Similarly, Moynihan (2004), Von Haldenwang (2004) and West (2004) indicate that e-government development and usage impacts the efficiency of a country in a number of ways, thereby improving
The national performance. Further, recent studies by Srivatsava and Teo (2008; 2010) indicate that national economic performance and business competitiveness of a nation are dependent on the development and use of online public services. Another study by Dutta and Jain (2005) in the context of e-business development, indicate that the greater usage of e-business in a country will increase its productivity, leading to enhanced economic performance. Consistent with the extant studies, and by taking a proxy view of ICT usage and impact, we argue that ICT penetration among citizens will affect a nation’s economic sustainability in terms of GDP per capita adjusted for purchasing power parity (PPP). This is noted in WEFGIT Report (2009-2010) which indicates that investing in ICT can help countries increase their annual GDP growth by 0.6-0.7 percent on average, on an annual basis, for each increase of 10 percent in household penetration. Hence, we posit:

**H2a:** The level of ICT penetration among citizens in a country is positively associated with its economic sustainability in terms of GDP per capita (adjusted for PPP).

### 2.2.2 Relationship between ICT Penetration and Environmental Sustainability

Environmental sustainability of IT is defined as “activities to minimize the negative impacts and maximize the positive impacts of human behaviour on the environment through the design, production, application, operation, and disposal of IT and IT-enabled products and services throughout their lifecycle” (Elliot 2011, p. 208). The environmental scope of ICT is related to three aspects namely climate change, energy use, and waste. Among the three aspects, ‘climate change’ is the most important one at this point in the human history. Climate change is defined as “a change in climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere” (UNFCCC 1992, p. 3).

Gifford (2008) argues that citizens (i.e., individuals) are the “ultimate key” to respond to environmental threats, and human ingenuity is the “ultimate resource” to reframe aspiration towards climate change betterment. They may adopt and make use of initiatives such as (1) paperless technologies (e.g., e-bill, e-cards, e-news, e-book); (2) energy saving practices when using ICTs; and (3) ICTs for reduction of transportation. For instance, when individuals make use of paperless technologies, it is estimated that (1) the emission of greenhouse gases (GHGs) is reduced; (2) the usage of industrial wood (which causes deforestation) is cut down; (3) human-based methane gas emissions are lowered. As a result, the annual material usage of a typical semiconductor (an electronic component that is essential in many electrical devices from computers to mobile phones) facility will increase. This in turn leads to negative effects such as (1) 832 million ft³ of bulk gases; (2) 5.72 million ft³ of hazardous gases; (3) 591 million gal of deionized water; (4) 5.2 million lb of chemicals; and (5) 8.8 million kWh of electrical power (Yi and Thomas 2007). Taken together, these statistics indicate that the negative impacts created by physical existence of ICT, the infrastructure and the processes involved are higher in comparison with the beneficial impacts created by the ongoing use and application of ICT. Hence, as the higher ICT penetration among citizens will degrade the climate change betterment, we propose:

**H2b:** The level of ICT penetration among citizens in a country is negatively associated with its environmental sustainability in terms of climate change betterment.

### 2.2.3 Relationship between ICT Penetration and Social Sustainability

Enhancement of social sustainability is brought about by improving the way societies and governments provide education, healthcare, and online public services to citizens (WEFGIT Report 1http://www.caricomict4d.org/stats/2009/OECD%20Measuring%20the%20Relationship%20between%20ICT%20and%20the%20Environment%202009.pdf (accessed on March 5, 2011)

2http://www.environmentalpaper.org/stateofthepaperindustry/ (accessed on March 5, 2011)
In education sector, ICTs has dramatically changed the way people study. The use of email, websites, and virtual classrooms and libraries has proliferated, facilitating the sharing of information on a large scale. Further, in health sector, the use of ICTs (e-health) has transformed healthcare by efficiently connecting people and improving information sharing. For instance, a major hospital chain in India, Apollo Hospitals, in collaboration with Ericsson\(^3\), a leading provider of telecommunications and data communications systems, is providing basic diagnostics (blood pressure), medical check-ups, and consultation via mobile services. This has enabled (and is enabling) the provision of affordable and accessible healthcare to millions of people in remote areas. Similarly, in government sector, the use of ICTs to provide and improve public services has enabled government agencies to deliver better services more efficiently because of which citizens have a much easier and faster access to government services. In addition, rapid proliferations of social media applications has changed the way people access information and interact with each other, thereby creating long term and largely positive changes in a variety of areas. For instance, usage of Internet technologies by individuals has increased societal cohesiveness, defined as “the processes of building shared values and communities of interpretation, reducing disparities in wealth and income, and generally enabling people to have a sense that they are engaged in a common enterprise, facing shared challenges, and that they are members of the same community” (Maxwell 1996, p.13). In sum, the above services (provided by education, health, and government sectors) can be assessed by citizens only when there is a higher degree of ICT penetration among them. In other words, when there is a lower degree of ICT penetration among nationals, the lower will be the chance for them to use and benefit from the above services. This is noted by Castells (1996; 1998) who emphasize the significant usage of information networks in supporting the development of policies and procedures for promoting social sustainability. This leads to the following hypothesis:

\(H2c:\) The level of ICT penetration among citizens in a country is positively associated with its social sustainability in terms of improvements in accessing basic services (e.g., health and education services) by citizens.

### 2.3 Control Variable(s)

As national performance in terms of economic, environmental, and social sustainability are likely to differ across different countries (Vachon and Mao 2008), we controlled for country’s size in our study. We measure country’s size using its population scores. In addition, as population density gives the direct measurement of a country’s population pressure on its national performance (Vachon and Mao 2008), we also controlled for its effects in our study. The values for these two variables (for year 2007) are obtained from the Yale Report (2010).

### 3 RESEARCH METHOD

#### 3.1 Data

In this research, to test the formulated hypotheses, we used reliable secondary sources of country level data for two reasons. First, collecting large scale primary data from over hundred countries is restrained by the amount of resources and time available for conducting such research (Srivastava and Teo 2008; 2010). Second, secondary data, as indicated by some researchers (e.g., Jarvenpaa 1990), delivers a variety of untapped opportunities in IS research and provides several advantages like easy reproducibility, ability to generalize the results arising from larger datasets, etc (Kiecolt and Nathan 1985).

\(^3\)http://www.ericsson.com/thecompany/press/releases/2008/06/1225191 (accessed on March 5, 2011)
After exploring several secondary data sources, we selected three sources that conform to our research objectives. The data sources are: (1) the World Economic Forum Global Competitiveness Report (WEFGC Report 2010-2011); (2) the World Economic Forum Global Information Technology Report (WEFGIT Report 2007-2008; 2008-2009; 2010-2011); and (3) the 2010 Environmental Performance Index Report (Yale Report 2010). All the three sources are considered to be reliable reports and have been widely used in past academic research. For instance, data from the Global Competitiveness Report have been used in studies such as Delios and Beamish (1999), Gaur and Lu (2007), and Srivastava and Teo (2008;2010). Similarly, data from the Global Information Technology Report have been used in studies such as Katos (2010) and Katsouli (2006). And, data from the Yale Environmental Performance Index Report have been used in studies such as Feroz et al. (2009) and George (2007).

Although WEF has been publishing the Global Competitiveness Report and the Global Information Technology Report for a number of years now, Yale started publishing the Environmental Performance Index Report only in 2006. Consequently, consistent with extant studies (e.g., Srivastava and Teo 2008; 2010), we used cross-sectional data from the above reports for our analysis. In addition, to cope with the endogeneity issue and to obtain consistent estimates, we lagged the independent and intermediate variable prior to the base-year (see Appendix B for more details). While the data from Global Competitiveness Report (WEFGC Report 2010-2011) covered 139 countries, the data from Global Information Technology Report covered 134, 129, 138 countries for year 2007-2008, 2008-2009, and 2010-2011 respectively. And, the data from Yale Environmental Performance Index Report (Yale Report 2010) covered 163 countries. Combining the datasets from these reports, we have a sample size of 120 countries (see Appendix A for the list of countries) for this research.

### 3.2 Variables and Measures

As depicted in our research model (Figure 2), there are five main constructs in this study: IS capability with citizens, ICT penetration among citizens, and national performance (economic, environment, and social sustainability). While the ‘IS capability with citizens’ construct is indicated by citizens’ readiness to use ICTs obtained from the Global Information Technology Report 2007-2008, the ‘ICT penetration’ construct is indicated by diffusion of ICTs at the individual level, the values for which are obtained from the Global Information Technology Report 2008-2009. We operationalized national economic sustainability using Porter’s productivity paradigm, which is measured by the GDP per capita adjusted for PPP, the values for which are obtained from the Global Competitiveness Report 2010-2011. The environmental sustainability construct is indicated by climate change, and is measured by three indicators: (1) GHG emissions per capita (including land use emissions); (2) CO₂ emissions per electricity generation; and (3) industrial greenhouse gas emissions intensity. The values for these indicators are taken from the Yale Environmental Performance Index Report (Yale Report 2010). The social sustainability construct is indicated by the impact of ICT on access (for all citizens in a country) to basic services (health, education, financial services, etc.), the values for which are obtained from the Global Information Technology Report 2010-2011.

While forming the above specified indices which are based on a mix of hard objective data and survey data, the reputed reporting agencies carried out suitable statistical procedures to ensure reliability and validity. These involved use of multiple respondent expert surveys in each nation, correcting the internal consistency before index calculation and so forth. The details of variables and a brief note on the measures taken by reporting agencies are described in Appendix B and C.

---

4Previous versions of the Environmental Performance Index Report are available as the Environmental Sustainability Index Report for years 2000-2002.
4 DATA ANALYSIS

4.1 Descriptive Statistics and Correlations

Figure 4 presents the descriptive statistics and correlations for variables in the research model. From the figure, we see that most of the correlations among variables are significant at p<0.001.

![Figure 4. Descriptive Statistics and Correlations.]

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Country Size</td>
<td>16.29</td>
<td>1.57</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2. Population Density</td>
<td>4.13</td>
<td>1.43</td>
<td>0.71</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.23</td>
<td>0.33</td>
<td>-</td>
</tr>
<tr>
<td>3. IS Capability with Citizens</td>
<td>5.03</td>
<td>1.06</td>
<td>-0.13</td>
<td>0.13</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4. ICT Penetration</td>
<td>2.52</td>
<td>1.37</td>
<td>-0.17</td>
<td>0.14</td>
<td>0.76***</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5. Economic Sustainability</td>
<td>8.64</td>
<td>1.54</td>
<td>-0.22**</td>
<td>0.06</td>
<td>0.88***</td>
<td>0.86***</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6. Environmental Sustainability</td>
<td>53.36</td>
<td>16.09</td>
<td>0.17</td>
<td>0.01</td>
<td>-0.55***</td>
<td>-0.38***</td>
<td>-0.56***</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7. Social Sustainability</td>
<td>4.49</td>
<td>0.74</td>
<td>-0.14</td>
<td>0.17</td>
<td>0.61***</td>
<td>0.63***</td>
<td>0.60***</td>
<td>-0.26***</td>
<td>-</td>
</tr>
</tbody>
</table>

N = 120  *p < 0.05  **p < 0.001  (2-tailed)  "log-transformed Variables"

4.2 Hypotheses Testing

Structural equation modeling (SEM) analysis was chosen over regression analysis as SEM can simultaneously analyze all of the paths in one analysis (Chin 1998). Within SEM, we employed Partial Least Squares (PLS) over covariance-based SEM techniques (such as LISREL, EQS, or AMOS) for four reasons. First, PLS places minimal restrictions on measurement scales, sample size, and residual distributions (Chin 1998). Second, PLS analysis is distribution free and does not assume true independence of the variables, leading to more reliable results (Tobias 1999). Third, PLS is robust against other data structural problems such as skew distributions and omissions of regressors (Cassel 1999; Gefen et al. 2000). And fourth, the exploratory theory development stage that ‘IT and sustainability’ research is currently in makes PLS a suitable choice for analyzing data in our study (Barclay et al. 1995; Gefen et al. 2000). As regards the measurement model, the issues were mostly related to the content and face validity of the constructs (see Appendix B and C). In the model tested, all constructs were modeled as reflective as their measurement items were manifestations of intended constructs (Barclay et al. 1995). SmartPLS (version 2.0.M3) was used to analyze the data in this study (Ringle et al. 2005). The results of PLS analysis for the structural model are shown in Figure 5.

![Figure 5. Results.]

<table>
<thead>
<tr>
<th>Control Variables</th>
<th>Economic Sustainability</th>
<th>Environmental Sustainability</th>
<th>Social Sustainability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country Size</td>
<td>-0.08</td>
<td>0.10</td>
<td>-0.03</td>
</tr>
<tr>
<td>Weighted</td>
<td>[t=-1.44]</td>
<td>[t=1.02]</td>
<td>[t=-0.32]</td>
</tr>
<tr>
<td>Population Density</td>
<td>-0.05</td>
<td>0.02</td>
<td>0.09</td>
</tr>
<tr>
<td>Weighted</td>
<td>[t=-1.28]</td>
<td>[t=0.31]</td>
<td>[t=0.36]</td>
</tr>
</tbody>
</table>

Note: Control variables were entered simultaneously with model variables  **p < 0.001  (2-tailed)
As shown in Figure 5, there is a positive association between IS capability available with citizens in a nation and ICT penetration among citizens ($\beta=0.76$, $t=33.90$, $p<0.001$). Hence, H1 is supported. Also, as expected, while there is a positive association between ICT penetration among citizens and economic ($\beta=0.86$, $t=39.12$, $p<0.001$) and social sustainability ($\beta=0.61$, $t=11.84$, $p<0.001$); there is a negative association between ICT penetration among citizens and environmental sustainability ($\beta=-0.37$, $t=4.08$, $p<0.001$). Hence, H2a, H2b, and H2c are supported. The effects of the control variables (i.e., country size and population density) on sustainability outcomes were not significant as expected.

4.3 Post Hoc Analysis

4.3.1 Mediating Effect of ICT Penetration on IS Capabilities and Performance

Drawing on the resource-based-view of a firm, several researchers argue that organizational capabilities (which include IS capability) can lead to competitive advantage (e.g., Bharadwaj 2000) and superior business performance (e.g., Wade and Hulland 2004). Further, research indicate that there is an association between IS capability and firm performance (e.g., Bhatt and Grover 2000; Dehning et al. 2003). It should be noted that we have purposefully avoided the direct linkages between IS capability with citizens and performance (in our original research model) because this association is neither necessary for the definition of capabilities (Ravinchandran and Lertwongsatien 2005) nor required for theorizing about how IS capabilities with citizens can lead to ICT penetration among citizens. We note that a similar procedure has been adopted by Gold et al. (2001) and Ravinchandran and Lertwongsatien (2005). Now that we have assembled each of the piecewise elements and associations among the constructs in our research model, we conducted PLS analysis again (by adding direct paths from IS capability with citizens and sustainability) to see if the relationship of IS capability owned by citizens in a country with its national performance is mediated by ICT penetration among citizens. Otherwise stated, we assessed if ICT penetration among citizens serves as an intervening mechanism or, at the least, partial conveyors of the effect of IS capabilities owned by citizens onto national performance. The results are shown in Figure 6.
capability with citizens and environmental sustainability ($\beta = -0.62, t = 6.46, p < 0.001$) is significant, the path between ICT penetration and environmental sustainability ($\beta = 0.10, t = 0.72, \text{n.s.}$) is not significant. Therefore, the effect of IS capability with citizens on environmental sustainability is not mediated by ICT penetration among citizens. Further, the paths between IS capability with citizens and social sustainability ($\beta = 0.30, t = 2.98, p < 0.01$) and between ICT penetration and social sustainability ($\beta = 0.37, t = 3.98, p < 0.001$) are significant. Hence, the effect of IS capability with citizens on social sustainability is partially mediated by ICT penetration among citizens.

Further, we compared the modified model (Figure 6) with the original model (Figure 5) in terms of $R^2$ change for the three final dependent variables—“economic sustainability”, “environmental sustainability”, and “social sustainability.” For $R^2$ comparison, we used Cohen’s (1988) formula for calculating $f^2$ as, $f^2 = (R^2_{\text{included}} - R^2_{\text{excluded}}) / (1 - R^2_{\text{included}})$. The value of $f^2$ captures whether the impact of a particular independent construct on a dependent construct is substantive. We assessed the significance of $f^2$ based on a pseudo F test. The pseudo F statistic is calculated as $f^2(n-k-1)$, with 1, $(n-k)$ degrees of freedom where $n$ is the sample size and $k$ is the number of constructs in the model (Subramani 2004). For the modified model, $R^2$ for “economic sustainability” increased from 0.75 to 0.88 ($f^2 = 1.08$). Similarly, for “environmental sustainability”, $R^2$ increased from 0.16 to 0.32 ($f^2 = 0.23$), and for “social sustainability”, $R^2$ increased from 0.41 to 0.42 ($f^2 = 0.01$). The $f^2$ values suggest that the modified model does not have significantly better predictive power than the original model (Chin 1998). We also tested the significance of the indirect effects by means of the formula $z = A*B/\sqrt{(B^2*SA^2 + A^2*SB^2)}$ developed by Sobel (1982) and noted that there were no significant changes or improvements in the results, thus confirming our findings from PLS mediation analysis. In sum, the above results provide support for the original model.

5 DISCUSSION

Findings from this investigation raise several issues that deserve mention. First, the higher the level of IS capabilities owned by citizens in a country, the higher is the ICT penetration among them. This result emphasize the significance of citizens’ IS capabilities in increasing ICT penetration among them. That is, nationals who lack IS capabilities will be unable to embrace and use ICTs for accomplishing goals in home life. This result is consistent with Parasuraman (2000), who highlights the importance of profound facilitators (in form of IS capabilities) to increase the penetration and diffusion of ICTs among individuals. Hence, an economy whose citizens are more ready and show a greater interest towards ICT advancements will be likely to use them more effectively and extensively (WEFGIT Report 2007-2008; 2008-2009). That is, countries whose citizens have access to ICTs are the winners and those without access face a spiral of decline.

Second, the higher the level of ICT penetration with citizens in a country, (1) the higher is the level of economic sustainability (in terms of GDP per capita adjusted for PPP) and social sustainability (in terms of improvements in access to basic services by citizens); and (2) the lower is the level of environmental sustainability (in terms of climate change betterment). This result highlight that in a cross-country setting, economic and social sustainability development are top driven initiatives compared to environmental sustainability development. Third, results of mediation hypotheses (examined in post hoc analysis) indicate that ICT penetration among citizens (1) partially mediated the relationships of IS capabilities owned by citizens with economic and social sustainability; and (2) did not mediate the relationship of IS capabilities owned by citizens with environmental sustainability. One possible reason for this difference in results in a cross-country setting (as suggested by social dilemma theory) could be the fact that citizens (or individuals) may perceive a discrepancy between

In this formula, $A$ is the unstandardized regression coefficient for the relationship between the independent variable and the mediator, $SA$ is the standard error of $A$, $B$ is the unstandardized regression coefficient for the relationship between the mediator and the dependent variable when controlled for the independent variable, and $SB$ is the standard error of $B$ (Preacher and Leonardelli 2005).
the personal benefits they would receive and collective costs of their attitudes and behaviour towards environmental decision making (Uzzell et al. 2002). As noted by John Drummond, CEO of Corporate Culture, a corporate social responsibility consultancy, “there is a gap between what people say and what they do.” Further, as environmental problems are neither invariably caused nor solved by single individuals, the extent to which people believe that others are willing to help solve environmental problems will influence on their own willingness to change. In other words, collective social processes are a key ingredient to understanding environmental attitudes and behavioural change.

6 CONCLUSION

6.1 Limitations

This study has two limitations. First, we used secondary data obtained from three different sources, and hence, we have to depend on the indices as formulated by the reporting agencies. While primary data might have given us a better control over the definition of variables, it is less feasible for small group of researchers to undertake a large scale cross-country data collection given the limited amount of resources and time. But, taking into consideration that these indices have been (1) formulated by reputable and authorized organizations; and (2) by using several suitable statistical procedures (e.g., use of multiple respondent expert surveys in each nation and correcting the internal consistency before index calculation) for assessing validity and reliability of the instrument, relying upon these secondary sources provides a cost-effective way for conducting our study. Second, we analyzed data only from the countries commonly available in all the three sources. For instance, we could not include countries like Afghanistan, Cuba, Hong Kong, Taiwan, and so on as these countries were not commonly available in all the three sources. Given that we have only 5 main variables and sample size is 120, discarding few countries may not make a significant difference in the results because PLS places minimal restrictions on sample size, and residual distributions (Chin 1998). Despite these two potential limitations, our study is one among the few studies with macro-level orientation to examine all the three pillars of sustainability cohesively in a unified theoretical framework.

6.2 Implications and Future Research

6.2.1 Theoretical Implications

Our study makes several important theoretical contributions. First, our study is among the few studies to examine all three aspects of sustainability (economic, environmental, and social) under a unified theoretical framework in a cohesive manner. Second, while existing studies examining the “IT-sustainability” linkage are either conceptual or case studies, our study is amongst the few large scale empirical research, which makes innovative use of publicly available reliable secondary sources of data. In addition, while most extant studies examining the effect of IS capabilities on performance are at organizational level (e.g., Ravinichandran and Lertwongsatien 2005); our study examined the effect from a macro perspective (i.e., country-level). By doing so, we heed to consistent calls from researchers (1) to simultaneously examine all the three aspects of sustainability; and (2) to understand the critical roles of citizens’ IS capabilities in managing a country’s sustainability. Third, by approaching the issue of managing sustainability from not only the perspectives offered by SPP framework, but in particular, ICT impact, our study aims to further our understanding as to why differing levels of economic, environmental, and social sustainability among nations continues to prevail, despite the presence of wide range of IS capabilities with citizens in a country. Fourth, our

results not only highlights the association between IS capabilities available with citizens, ICT penetration among citizens, and national performance but also reiterates the synergistic connection between source of advantage, positional advantage (i.e., first-order benefit) and competitive advantage of a nation (i.e., second-order benefit). Fifth, while SPP framework has emerged as a useful theoretical lens for understanding IS capability—organizational performance linkage in the context of business firms; we apply it in cross-country setting for understanding the issue of managing sustainability, and hence, demonstrate its usefulness in the global context.

6.2.2 Practical Implications

Our research also has three important implications for practitioners. First, by examining the effect of IS capabilities possessed by citizens on ICT penetration among citizens and national performance, our study not only helps them to understand why differing levels of ICT penetration among citizens and sustainability continue to prevail but also shows directions to manage the levels of ICT penetration among citizens and to enhance sustainability outcomes in a country. Second, our study suggests that ICT penetration among citizens have an association with national performance. That is, increase in the levels of ICT penetration among citizens in a country will increase the levels of economic and social sustainability. Hence, governments and policy makers should make concerted efforts to manage ICT penetration among citizens, which in turn will enhance the national performance. Third, our results may also serve as a guide to countries striving to elevate and manage their sustainable development on what to focus their resources and capabilities on.

6.2.3 Future Research

Future research may focus on several directions. First, researchers may consider extending our cross-sectional study to a longitudinal (panel) study. This would help to examine the issues of temporal precedence (leads/lags between independent and dependent variables), as well as the evolution of sustainability as a function of the levels and trends in the independent and intermediate variables. In regards to this, as the data pertaining to environmental sustainability is available only for 3 years (2006, 2008 and 2010) from the Yale Center for Environmental Law and Policy, researchers may consider using other indices like environmental vulnerability index and green stickered energy consumption indexes. Second, while our study has mainly focused on the IS capabilities owned by citizens in a country on its sustainability, future studies may consider examining the effect of IS capabilities possessed by businesses and governments in country on its sustainability. Third, given the association between ICT penetration among citizens and national performance in terms of economic, environmental, and social sustainability, future research may also test how the relationship is affected by introducing several contingency variables such as public institutions, human capital, and macro-economy. Fourth, future studies may also examine the relationships between different dimensions of sustainability. For instance, they may consider examining how environmental and social sustainability in a country would affect its economic sustainability.

In conclusion, despite an extensive recognition on the importance of IT in causing and resolving issues surrounding sustainability, both research and practitioner communities knows relatively little on how IT can be effectively utilized to bridge the balance between different aspects of sustainability. As an initial step to be taken towards raising awareness for pivotal role of ICT penetration in managing sustainability, we have constructed and validated a theoretical model that examines the role of IS capabilities owned by citizens on ICT penetration among citizens and national performance in terms of economic, environmental, and social sustainability. In addition, we reasoned and demonstrated empirically the relationship between ICT penetration among citizens and sustainability, and the mediating role of ICT penetration among citizens on the relationship between IS capabilities owned by citizens in a country and its sustainability. Our study, in sum, reiterates the synergistic connection between source of advantage, positional advantage (i.e., first-order benefit) and competitive advantage of a nation (i.e., second-order benefit).
References


APPENDIX A: COUNTRIES ANALYZED

| Albania, Algeria, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Belgium, Benin, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Chad, Chile, China, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Ethiopia, Finland, France, Gambia, Georgia, Germany, Greece, Guatemala, Guyana, Honduras, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kuwait, Kyrgyzstan, Latvia, Libya, Lithuania, Luxembourg, Macedonia, Madagascar, Malaysia, Mali, Malta, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Morocco, Mozambique, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Nigeria, Norway, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russia, Saudi Arabia, Senegal, Singapore, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Syria, Tajikistan, Tanzania, Thailand, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States of America, Uruguay, Venezuela, Viet Nam, Zambia, Zimbabwe. |

Total number of countries included for data analysis = 120.

APPENDIX B: DESCRIPTION OF MEASURES EMPLOYED

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS Capability with Citizens</td>
<td>The construct, IS capability with citizens is indicated by individual readiness index, the values for which are taken from the Global Information Technology Report (WEFGIT 2007-2008). As citizens’ readiness to use ICT is a measure of IS capabilities possessed by citizens (Clark and Cavanaugh 1997; WEFGIT 2007-2008), it is appropriate to use individual readiness index values. This index is a composite measure of eight variables: (1) quality of math and science education; (2) quality of the educational system; (3) buyer sophistication; (4) residential telephone connection charge; (5) residential monthly telephone subscription; (6) fixed broadband tariffs; (7) mobile cellular tariffs; and (8) fixed telephone tariffs. All the cost variables (used to form this index) are valued at PPP to account for differences in the cost of living across countries.</td>
</tr>
<tr>
<td>ICT Penetration</td>
<td>The construct, ICT penetration among citizens is indicated by diffusion of ICTs at the individual level and is assessed by five indicators: (1) mobile telephone subscriptions; (2) personal computers; (3) broadband Internet subscribers; (4) Internet users; and (5) Internet access in schools. The values for these indicators are taken from the Global Information Technology Report (WEFGIT 2008-2009).</td>
</tr>
<tr>
<td>Economic Sustainability</td>
<td>The economic sustainability of a nation is an indicator of the micro-economic capabilities of its constituents and is measured by the GDP per capita adjusted for PPP, the values for which are taken from the Global Competitiveness Report (WEFGC Report 2010-2011). This measure is used in past studies like Srivatsava and Teo (2008; 2010).</td>
</tr>
<tr>
<td>Environmental Sustainability</td>
<td>The environmental sustainability construct captures three main aspects of environmental performance on climate change: (1) GHG emissions per capita (including emissions from land use change); (2) CO₂ emissions per unit of electricity generation; and (3) Industrial greenhouse gas emissions intensity. The GHGs in this calculation include CO₂ from fossil fuels, land use change emissions, and non-CO₂ gasses like methane and nitrous oxide (NOX), and are measured in metric tons of carbon dioxide equivalents. The lower the per capita emissions, the less the average person in a given country contributes to climate change. The values for these are taken from the Yale Environmental Performance Index Report (Yale Report 2010).</td>
</tr>
<tr>
<td>Social Sustainability</td>
<td>The social sustainability construct is indicated by ‘impact of ICT on access to basic services’, the values for which are taken from the Global Information Technology Report (WEFGIT 2010-2011). This variable was measured by asking the respondents, ‘To what extent are information and communications technologies improving access for all citizens to basic services (health, education, financial services, etc.) in your country?’ This item was anchored on a 1-to-7 scale with ‘1’ representing ‘do not improve access at all’ and ‘7’ representing ‘improve access significantly’.</td>
</tr>
</tbody>
</table>
APPENDIX C: NOTE ON RELIABILITY AND VALIDITY OF DATA

The secondary sources of data reports were prepared by two leading organizations namely World Economic Forum and Yale Center for Environmental Law and Policy, which in turn have a long experience and expertise in gathering and understanding global data. While the WEF prepared the Global Competitiveness Report 2010-2011 and the Global Information Technology Reports (2007-2008; 2008-2009; 2010-2011), the Yale Center for Environmental Law and Policy prepared the Environmental Performance Index Report 2010. The data from these reports had two components—hard data and survey data. While some indices like GDP per capita adjusted for PPP rely completely on hard data; other indices, like IS capability with citizens and ICT penetration emerge from a mix of survey as well as from hard data. For ensuring reliability and validity of all the constructs, it is important to have a brief overview of the methods undertaken by the two agencies.

The country-level data was collected by WEF through a number of partner institutes who were given a uniform set of guidelines which were strictly followed. Some of these guidelines included taking responses only from CEOs or equivalent rank company officials, facility for the respondents to answer in their preferred language, etc. The survey was administered in several forms such as face-to-face interviews with business executives, mailed or telephone interviews, and a version administered online as an alternative (WEFGC 2010-2011). To minimize chances of perception bias\(^7\), two techniques were adopted. First, the questions were framed in a way that asks the respondents to compare their own country to world standards, rather than thinking in absolute national terms. Second, wherever possible, the survey data was compared with hard data on similar issues (WEFGIT 2007-2008; 2008-2009; 2010-2011). The collected respondent-level data were subjected to a careful editing process following several rules such as excluding the surveys with a completion rate inferior to 50 percent. Then, multivariate and univariate outlier analyses were performed the data. Once the data have been edited, individual answers were aggregated at the country level. Then, sector weighted country averages were obtained for analyses.

Yale center also followed similar procedures for ensuring validity and reliability. The data sources included, (1) official statistics that are measured and formally reported by governments to international organizations; (2) spatial data compiled by research or international organizations; and (3) observations from monitoring stations. All potential datasets were reviewed for quality and verifiability. Those that did not meet baseline quality standards were discarded. The raw data was transformed to proximity-to-target scores ranging from zero (worst performance) to 100 (at target). To compute the composite index, data aggregation and weighting were performed. For instance, to compute the climate change index, three indicators were used: (1) GHG emissions/capita, (2) carbon intensity of electricity generation, and (3) industrial GHG emissions. Since the two agencies (i.e., WEF and Yale Center for Environmental Law and Policy) followed rigorous procedures, as described above, for ensuring the reliability and validity of the indices, data from these reports was used directly for analyses. Moreover as highlighted earlier, data from these reports have been used by several past studies.

\(^7\)A systematic positive or negative bias found among all respondents in a given country. For instance, some might believe that people in a certain country are generally more positive about their own economic environment than people in another country, who might be pessimistic.