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THE EXPLORATION OF THE RELATIONSHIPS BETWEEN THE GLOBAL COMPETITIVENESS, THE ICT AND EDUCATION

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Abstract. Information and Communication Technology (ICT) is a key element for development and economic expansion. However, many of the developing countries appear to gain only small fraction of the advantages from the ICT sectors. Indeed, developed countries are taking the most of the advantages and opportunities brought by the use of ICT. Therefore, it is necessary to highlight the essential role and the significant relationship of ICT and education for gaining the competitive advantage. In this regard, this study investigates the complex relationships of some of the global competitiveness indicators of the ICT, education and the business sophistication and innovation factors. In this study, several statistically significant relationships are explored by applying canonical correlation analysis. These findings and significant statistical results are highlighted.

Keywords: ICT, education, competitiveness, technological readiness, business sophistication, innovation, canonical correlation.

JEL Classification: I25, I21, L2, N70.

1. Introduction

Knowledge and learning are widely regarded as the key not only to sustained development and growth of economies but also societies (Baskaran, Muchie 2007). As information and communication technologies (ICT) has become one of the main driving forces of globalization, it has been increasingly perceived as a major factor determining the comparative advantage of nations and the competitiveness of their economies because of its potential to bring about socio-economic transformation (Baskaran, Muchie 2007).

ICT is believed to be an essential driver for development and it can expand economic opportunities. Indeed, developed countries tend to gain more advantages from ICT sectors than developing countries (Pham 2014). Some newly industrialized countries back in 1980s became more developed because of ICT development (Pham 2014). Policy makers at national and international levels believe that ICT provide a key opportunity for particularly developing countries to address problems in the field of education, health, rural development, poverty alleviation and employment (Baskaran, Muchie 2007).

In this regard, the current research was undertaken to highlight the key points of the relationships between the global competitiveness, the ICT and education. More specifically, the association between the ICT and education, in terms of technological readiness, quantity and quality of educational indicators are investigated by applying statistical methods. Additionally, the relationships between education-related indicators and business sophistication and innovation factors are investigated. Statistically significant associations are highlighted.

The remainder of this paper is organized as follows. Section 2 reviews the literature on ICT in general and education-related issues in particular. Section 3 introduces the data and methods used for the canonical correlation analyses of the perceptions of countries' ICT and educational scores by using various measures drawn from the Global Competitiveness Index (GCI) of the World Economic Forum (WEF) database. Specifically, this section investigates the associations among technological readiness, business sophistication, innovation indicators and education-related scores derived from the WEF. Section 4 presents the empirical findings. The study is briefly concluded in Section 5.

2. Literature review

The ICT is unique mainly in two aspects. Firstly, it affects almost every developed and developing countries and almost every aspect of life – economic, social, and cultural, as stated by Baskaran and Muchie (2007). Therefore the dynamics of technological change in ICT is a global issue rather than being national or regional issue. Secondly, unlike other technologies, ICT has significant potential to build both social and technological capabilities in developing countries (Baskaran, Muchie 2007).

ICT is perceived to be an essential facilitator for information transparency, good governance, empowerment, participatory management and grass-root democracy (Baskaran, Muchie 2007). As empowerment requires complete transparency in functioning of government as well as corporations, ICT has an essential role to make it possible through extensive use of electronic governance (Baskaran, Muchie 2007).

Researchers have examined the connections among ICT, education and competitiveness. For instance, Ozmen (2013) performed a study on the virtual communities of practices for ensuring innovation at universities. The findings revealed that virtual communities of practices were thought to be important for ensuring improvement and innovation by the majority of the administrators; however, some barriers, such as distrust and insecurity, lack of leadership, and lack of knowledge and skills existed. Selwyn (2008) examined the realization of the potential of new technology by assessing the legacy of ICT agenda. The study stated that the ICT agenda may well have had the short term impact of increasing the physical presence of ICT resources in all education institutions, its longer-term educational legacy was compromised by the wider macro-level issues it purported to address.

Studies of ICT in relation to the education have been made by numerous researchers. The most recent research reflects the significant amount of international literature in the area based on many different viewpoints. For example, Bankole *et al.* (2015) explored the impact of ICT infrastructure and complementary factors on intra-African trade. Their research used structural equation modeling to analyze data. The analysis showed that the telecommunications infrastructure has a major impact on intra-African trade and taking into account other relevant factors that also influence trade such as Institutional Quality and Educational Attainment. Interacting factors such as Institutional Quality and Educational Attainment also play a role in influencing intra-African trade. Anyanwu (2013) performed a study on the characteristics and macroeconomic determinants of youth employment in Africa with a view to proffering some solutions. The author's estimates show that a nation's domestic investment rate is found to be positively and significantly associated with youth employment in the overall Africa and sub-Saharan estimations. The study also included variables as such ICT infrastructure, education others into their study. The author stated key policy implications.

Antlova *et al.* (2011) studied the long term growth of small and medium enterprises (SME) from the view of ICT competencies and web presentations. They explored the correspondence between ICT competencies of SME by using employed decision tree classifiers and association rules as well as class outlier detection methods and hierarchical cluster analysis. They found that some companies had developed significantly more ICT competencies than the others and these competencies help them to be more successful and competitive. Taylor *et al.* (2008) outlined an initiative to support and encourage capacity building in remote desert centers and to create networks to overcome the isolation experienced by desert-based small and medium-sized enterprises. Building on existing local initiatives and seizing the opportunities offered by a range of new information and communication technologies (ICT), businesses are linked together to explore the benefits of networking, to identify possible synergies and opportunities for collaboration, to gain practical ICT and networking skills and confidence in the processes, and create real outcomes for their business. Torrent-Sellens and Ficapal-Cusi (2010) investigated new co-innovating sources of business productivity. Their results for Catalan companies indicate that evidence has not been found for the great majority to corroborate the existence of new sources of productivity and thus the results also show the adaptation to enable them to compete in global knowledge markets.

Rodriguez *et al.* (2012b) developed a conceptual framework for the sustainable adoption of technology-enhanced learning environments. Rogosic (2015) focused on the construct validity of the questionnaire measuring technical and socio-psychological factors which affect successful integration of ICT into education. Rodriguez *et al.* (2010) developed a monitoring and evaluation scheme for an ICT-supported education program in schools. Chen (2011) examined the fostering Taiwanese EFL teachers' constructivist instructional beliefs through teaching goals and ICT use. The results show that higher education EFL teachers, who are constructivist-oriented, tend to use ICT more. Chikasa *et al.* (2014) studied ICT integration in teaching as an uncomfortable zone for teachers with a case of schools in Johannesburg, South Africa. They found that teachers who are more likely to integrate ICT into their teaching if they believe it have potential to enhance teaching and learning.

Berrio-Zapata and Rojas (2014) explored the digital divide in university in Bogota, Colombia. Their results show that the variables of the model link causally, with the strongest relations between education, attitude towards ICTs and ICT application. Hadfield and Jopling (2014) discussed the development of an implementation model for ICT in education as an example of the interaction of affordances and multimodality. The study argues that the perceived status of technologies is a key factor in the success of an innovation. Song *et al.* (2013) performed the development and pilot test of ICT in education readiness indicators in the global context. Rezaei *et al.* (2011) investigated challenges of ICT in education. Gewerc and Montero (2013) explored cultures, training and career development and the integration issues of ICT in educational institutions. Their results showed abundant evidence of teachers' career development and changes in professional and institutional culture through the collaborative action research process. Hashim *et al.* (2010) assessed antecedents of ICT attitudes of distance education students. Melero *et al.* (2012) reviewed the constructivist learning methods with supporting tooling in ICT higher education. Devolder *et al.* (2010) explored identifying multiple roles of ICT coordinators. This study reports on the development and validation of measurement scales to study the different roles fulfilled by ICT coordinators.

Kolodziejczyk (2015) performed mixed methods for study of gender issues in access, application, and attitudes toward ICT in higher education institutions in Papua New Guinea. Aesaert and van Braak (2015) investigated the gender and socioeconomic related differences in performance based ICT competences. Their results show that girls have better technical ICT skills and higher-order ICT competences than boys. Additionally, the results reveal that the educational level of the mother is positively related to both students' technical ICT skills and higher-order ICT competences. Lau and Yuen (2015) studied factorial invariance across gender of a perceived ICT literacy scale. Sang *et al.* (2010) explored student teachers' thinking processes and ICT integration as the predictors of prospective teaching behaviors with educational technology. Their results show that prospective ICT integration significantly correlates with all teacher related variables, excluding gender.

Kerckaert *et al.* (2015) explored the role of ICT in early childhood education as a scale development and research on ICT use and influencing factors. Aftab and Ismail (2015) researched the defeating poverty through education by exploring the role of ICT. The authors of the paper focus on issues in forming ICT based educational and socio development initiatives. Kokkalia and Drigas (2015) investigated the working memory and attention deficit hyperactivity disorder in preschool education. They investigated the role of ICT's as a diagnostic and intervention tool. Ott and Pozzi (2011) performed a research on the new era for cultural heritage education by discussing the role of ICT.

Parvin *et al.* (2011) investigated the role of ICT in business ethics courses by exploring the evidences from Bangladesh. Kim *et al.* (2014) studied ICT ethics of college students in Korea. The study investigates factors affecting ICT ethics (IE) behavior intent and presents their implications for IE education. Hoque *et al.* (2012) explored the role of ICT in school management of Maldives. Lu *et al.* (2015) explored the role of ICT infrastructure in its application to classrooms for middle and primary schools in China. Doucek *et al.* (2014) examined the requirements of the competence of ICT managers and their coverage by the educational system in the Czech Republic. The presented results indicate the requirements on knowledge and skills for the role of ICT manager in the Czech education market.

Palmero and Rodriguez (2012) explored advantages and drawbacks of the impact of education policies to incorporate ICT as innovative agents in the classroom. Vanderlinde *et al.* (2012b) studied ICT policy planning in a context of curriculum reform. Their results indicate that ICT policy planning in schools should be considered as a multifaceted phenomenon grounded in school culture. Austin and Hunter (2013) examined ICT policy and implementation in Education with some cases in Canada, Northern Ireland and Ireland. Shaikh and Khoja (2011) examined the role of ICT in shaping the future of Pakistani higher education system. Their findings suggest that an effective and robust ICT policy could greatly improve the status of the Pakistani knowledge-based economy, therefore helping establish ICT policy and planning, administration, and integration at the higher education level.

Savage (2010) performed a survey of ICT usage across English secondary schools. The findings show that music education is dominated by conservative uses of ICT that reinforce traditional subject content. Quintana *et al.* (2012) investigated the internet navigation and information search strategies about children who are influenced by their participation in an intensive ICT project. Their results reveal that students of elementary and secondary education, who have an interaction with ICT, but not specifically introduced to searching for information on the Internet, know how to benefit from the technology.

Tondeur *et al.* (2010) studied teacher and school characteristics that are associated with the use of ICT in primary education. Aesaert *et al.* (2014) investigated the direct measures of digital information processing and communication skills in primary education. Vanderlinde *et al.* (2014) investigated the institutionalized ICT use in primary education as a multilevel analysis. Vanderlinde *et al.* (2012a) explored school-based ICT policy plans in primary education. Vanderlinde and van Braak (2011) explored a new ICT curriculum for primary education in Flanders. Vanderlinde *et al.* (2010) examined the use of an online tool to support school-based ICT policy planning in primary education.

Baytak *et al.* (2012) examined parents' perception over use of ICT in education. Their results showed that parents had neutral attitudes towards use of ICT in education but they were against to unrestricted use of ICT by their children. Belando-Montoro and Bedmar (2015) analyzed ICT and education in studies on frailty in elderly. Their conclusions are focused on two proposals; one is related to the necessity for specific trainers for the use of ICT by the elderly, and the other one about the solidarity and intergenerational learning. Dukic *et al.* (2012) analyzed students' ICT usage in Croatian higher education development management. Isiyaku *et al.* (2015) developed an empirical modeling of ICT usage behavior among business education teachers in tertiary colleges of a developing country.

Ottestad (2010) explored the innovative pedagogical practice with ICT in three Nordic countries. The findings imply that Finnish teachers are either not differing or they are scoring significantly lower on the two indicators than teachers from Denmark or Norway. Sang *et al.* (2011) studied the prediction of ICT integration into classroom teaching in Chinese primary schools. Their results reveal that classroom use of ICT directly depends on teachers' computer motivation and the supportive use of ICT. Akbiyik (2010) researched the affective computing, which lead to more effective use of ICT in education. The main purpose of the study was to make an inquiry on affective computing with an educational viewpoint. Hu and McGrath (2011) examined the innovation in higher education in China by exploring the readiness of teachers to integrate ICT in English language teaching. The findings indicate that limited ICT skills and pedagogic expertise are obstacles to the use of ICT in English language teaching. Player-Koro (2013) studied hype, hope and ICT in teacher education. The main finding is that, contrary to the intentions to renew and revitalize education, ICT in use operate as a relay in the reproduction of traditional ways of teaching and learning. Solar *et al.* (2013) examined a maturity model for assessing the use of ICT in school education. Rogers and Twidle (2013) explored a pedagogical framework for developing innovative science teachers with ICT.

Ricoy and Rodriguez (2013) researched contributions and controversies generated by the use of ICT in higher education. Wastiau *et al.* (2013) explored the use of ICT in Education with a survey of schools in Europe. Baelo and Canton (2010) examined the use of information and communication technologies in Castilla Leon Universities. Peric (2011) investigated the ICT and the new generations of professionals. The research performed to determine the students' use of ICT in the learning process, their primary requirements and the level of satisfaction with the existing faculty website. Khodamoradi *et al.* (2011) performed a research on the utilization of ICT in education.

Aoki *et al.* (2013) examined the factors influencing in the ICT composite index at the school level. Their findings provide suggestions to other nations that are endeavoring to enhance the ICT levels of schools. Alexandru *et al.* (2013) analysed ICT challenges and issues in climate change education. Fauville *et al.* (2014) examined ICT tools in environmental education by reviewing two newcomers to schools. A key finding is that there is far less research on the fit with and implications for student learning, though the existence of a rich variety of tools and applications.

Bostan and Akman (2015) explored the impact of education on security practices in ICT. Results indicate that education level has significant impact on all security issues included in the analysis regarding computer usage, web usage and e-mail usage. De Witte and Rogge (2014) investigated the ICT matter for effectiveness and efficiency in mathematics education. Viseu and da Ponte (2012) explored mathematics teacher education, supported by ICT in the teaching internship. Peltenburg *et al.* (2010) researched ICT-based dynamic assessment to reveal special education students' potential in mathematics.

Bocconi *et al.* (2013) discussed framing ICT-enabled innovation for learning with the case of one-to-one learning initiatives in Europe. Cifuentes and Vanderlinde (2015) analyzed the ICT leadership in higher education with a multiple case study in Colombia. Their findings are of particular relevance for the work of policy makers, ICT coordinators and leaders in higher education around the world.

Tondeur *et al.* (2015) focused on integrating ICT in Kenyan secondary schools with an exploratory case study of a professional development programme. Rodriguez *et al.* (2012a) investigated evolutionary development with a model for the design, implementation, and evaluation of ICT for education programmes. Egea (2014) explored neoliberalism, education and the integration of ICT in schools.

Oshima and Muramatsu (2015) investigated current situation and issues related to ICT utilization in primary and secondary education. Their research describes the government's policy for the introduction of ICT in education and the efforts that Fujitsu is making in this regard. Garcia-Valcarcel *et al.* (2014) researched ICT in collaborative learning in the classrooms of primary and secondary education. The results indicate that teachers think that ICT have great potential for enhancing collaborative activities among students and for developing highly relevant generic skills. Heemskerk *et al.* (2012) investigated the inclusiveness of ICT in secondary education by taking into account of students' appreciation of ICT tools.

Demirli (2013) examined the ICT usage of pre-service teachers as part of a cultural comparison for Turkey and Bosnia and Herzegovina. The results reveal the need to take into account the cultural differences in ensuring the integration of ICTs. Xiong and Lim (2015) researched curriculum leadership and the development of ICT in education competencies of pre-service teachers in South China. Tezci (2011) studied factors that influence pre-service teachers' ICT usage in education. The results reveal that Turkey is in the early phase of ICT integration in education. Szeto and Cheng (2014) studied exploring the usage of ICT and YouTube for teaching as a case of pre-service teachers in Hong Kong. Martin *et al.* (2010) studied school teacher training and ICT integration in education. Yurdakul (2011) examined techno-pedagogical knowledge competencies of pre-service teachers based on ICT usage. Koh *et al.* (2013) examined the understanding of the relationship between Singapore pre-service teachers' ICT course experiences and technological pedagogical content knowledge through ICT course evaluation.

Kuskaya Mumcu and Kocak Usluel (2010) investigated ICT in vocational and technical schools by taking into consideration of teachers' instructional, managerial and personal use matters. Moreno *et al.* (2013) studied engineering education for sustainability with a multi-stakeholder case study on ICT and transportation. Munoz-Repiso and Tejedor (2012) researched the incorporation of ICT in higher education. Munoz-Repiso and Tejedor (2011) explored ICT variables related to the generation of new scenarios of learning in higher education. Rosman and Burita (2014) focused on the concept of the computer science course and some aspects of ICT integration into education. The analysis of the research results makes possible to suggest options for further development of the course.

Blignaut *et al.* (2010) analyzed ICT in education policy and practice in developing countries. Nachmias *et al.* (2010) studied ICT use in education with different uptake and practice in Hebrew-speaking and Arabic-speaking schools in Israel. The conclusions imply that further effort is needed to close the gaps between Hebrew and Arabic-speaking schools as well as collaboration and exchange of ideas, information and educational experience between staff members from sectors. Uslu and Bumen (2012) investigated the effects of the professional development program on Turkish teachers. Zhang *et al.* (2010) researched the latest progress report on ICT application in Chinese basic education. Zlamanski and Ciccarelli (2012) explored the teachers' belief about their competency to promote healthy ICT use among their students. Wiseman and Anderson (2012) studied ICT-integrated education and national innovation systems in the Gulf Cooperation Council countries. Sanchez *et al.* (2011) studied education with ICT in South Korea and Chile. Rubagiza *et al.* (2011) studied introducing ICT into schools in Rwanda by considering educational challenges and opportunities. Peeraer and van Petegem (2011) explored ICT in teacher education in an emerging developing country with Vietnam's baseline situation at the start of "The Year of ICT". Their analysis reveals the teacher educators' access to ICT, their intensity of use, their related skills, and their confidence in using ICT, as well as their conceptions of learning. Jun *et al.* (2014) assessed the computational literacy of elementary students on a national level in Korea.

Hismanoglu (2012) investigated prospective EFL teachers' perceptions of ICT Integration with a study of distance higher education in Turkey. The results imply that training that will enable teachers to become competent in and receptive to ICT is quite critical in distance education realms. Hammond *et al.* (2011) examined how and why do student teachers use ICT. Jordan (2011) studied framing ICT, teachers and learners in Australian school education ICT policy. Kreijns *et al.* (2013) studied adopting the integrative model of behavior prediction to explain teachers' willingness to use ICT as a perspective for research on teachers' ICT usage in pedagogical practices. Brun and Hinostroza (2014) present a study about learning to become a teacher in the 21st century by considering the ICT integration in initial teacher education in Chile. Espinosa *et al.* (2010) studied ICT competences of future teachers. Martinovic and Zhang (2012) examined situating ICT in the teacher education program. Voogt *et al.* (2013) investigated conditions of ICT which have a positive effect on teaching and learning. Khan (2015) investigated the emerging conceptions of ICT-enhanced teaching within the Australian TAFE context. Hinostroza *et al.* (2011) analyzed teaching and learning activities in Chilean classrooms by exploring the ICT-made differences. Their results contribute to the discussion regarding the specific role of ICT in teaching and learning activities.

Based on the foregoing, the present study adds another dimension to the existing literature. In this regard, by using statistical methods, this paper provides an additional viewpoint for policymakers in the field. Specifically, it differs from previous works in that it investigates significant relationships and connections between competitiveness, ICT and education and competitiveness.

3. Data and method description

The GCI (2014–2015) measured national competitiveness by using a complex methodology involving raw data and executive opinions. The index rests on 12 pillars categorized into three groups, namely *basic requirements* (four pillars), *efficiency enhancers* (six pillars), and *innovation and sophistication factors* (two pillars). Countries are rated on a seven-point scale, with a higher score indicating more competitiveness. In this research, the fifth pillar, which concerns *higher education and training*, is taken into consideration. This pillar has three sub indicators: *quantity of education*, *quality of education*, and *on-the-job training*. The ninth pillar, which concerns *technological readiness*, is also taken into the analysis. This pillar has two sub indicators: *technological adoption* and *ICT use*. Finally the eleventh and twelfth pillars, which measure *business sophistication and innovation factors*, are taken into consideration.

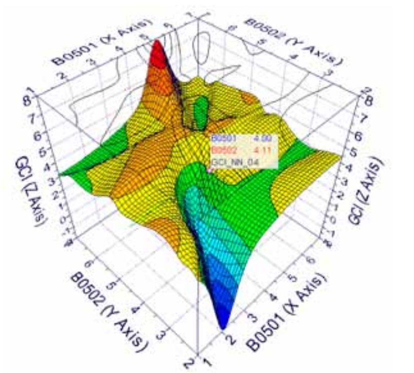
In this study, one main type of data source is used, which is drawn from the Global Competitiveness Index (GCI) of the World Economic Forum (WEF) database. The data source is the fifth pillar from the GCI (GCI–5) the ninth pillar from the GCI (GCI–9), the eleventh and twelfth pillars of the GCI (GCI–11 and GCI–12), which measures *higher education and training*, *technological readiness*, *business sophistication*, *innovation indicators* (see Appendix Tables A1 through A4).

The GCI is a comprehensive database of the competitiveness of nations. Global competitiveness is an area of economic theory that analyzes the facts and policies that shape the ability of a nation to create and maintain an environment that sustains more value creation for its enterprises and more prosperity for its people.

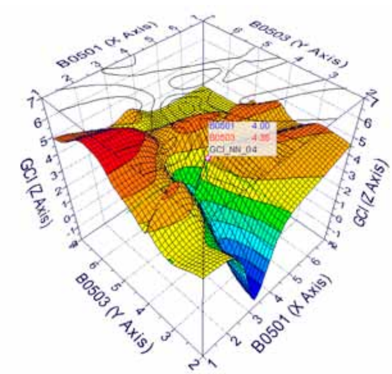
Firstly, for data investigation and depiction purposes, Response Surface Method (RSM) is applied to visualize the data in three dimensions. Then, Self-Organizing Maps (SOM) are generated on the clustered data for detecting cluster structures.

Finally, canonical correlation procedures are applied. This procedure finds the linear combinations of two sets of variables which have the highest correlation between them. Before beginning the analysis, all the variables have first been standardized by subtracting their means and dividing by their standard deviations. Technically, the canonical correlation is a generalization of principal component analysis, which is developed by Hotelling back in the year 1936. The canonical correlation analysis is concerned with the amount of linear relationship between two sets of variables. The method was developed for studying the relationship between two sets of variables with one or more sets of variables. Indeed, the canonical correlation analysis is a complicated method of analysis based on the largest number of matrix algebra tools, which include elements such as the Cholesky decomposition, matrix inversion, eigenvalues and eigenvectors and decomposition singular values.

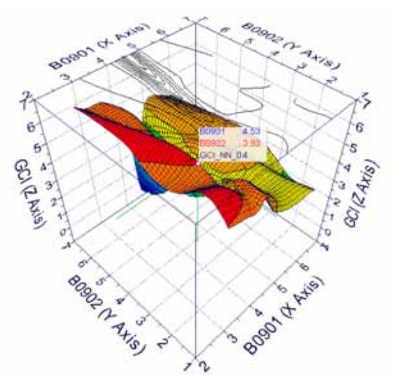
Response Surface Method (RSM) and Self-Organizing Maps (SOM). The RSM figures depict the relationships among the competitiveness variables (Fig. 1).



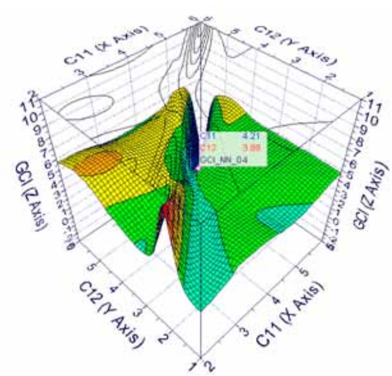
Quantity of education (B.05.01), *Quality of education* (B.05.02) and *Global competitiveness* (GCI)



On-the-job training (B.05.03), *Quantity of education* (B.05.01) and *Global competitiveness* (GCI)



Technology adoption (B.09.01), *ICT Use* (B.09.02) and *Global competitiveness* (GCI)



Business sophistication (C.11), *Innovation* (C.12) and *Global competitiveness* (GCI)

Fig. 1. 3D visualization of the data (Response Surface – Algorithm: Neural Networks)

Figure 2 shows the Davies-Bouldin (DB) Index, which is useful for determining the appropriate number of clusters to be applied to the source dataset (sum ratio of internal variance for each cluster, with inter-cluster distance) for the Partitive Clustering.

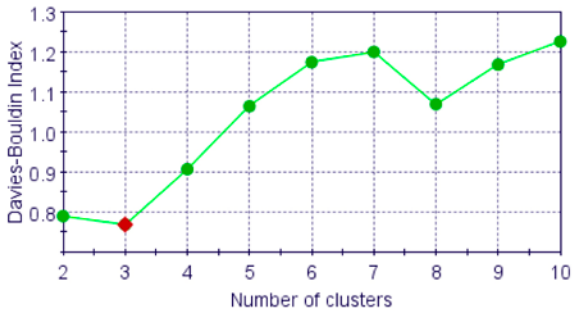


Fig. 2. Davies-Bouldin (DB) Index of clustering

In this case, three clusters are generated as the DB Index suggested. See Figure 2. Based on the clustered data, SOM analyses are performed.

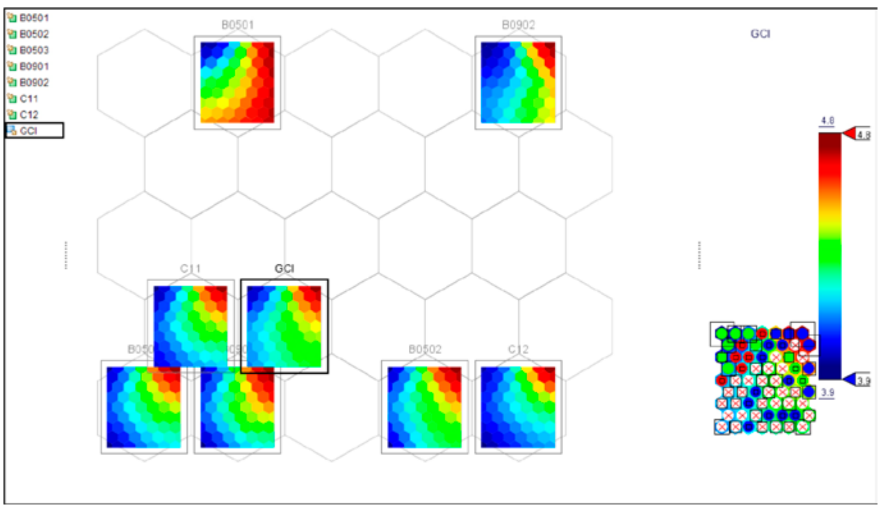


Fig. 3. SOM components

The Figure 3 shows how different components are distributed on the SOM hexagonal grid. Similar component maps are placed in adjacent positions in order to spot correlations. In this case, *Quality of education* (B.05.02) and *Innovation* (C.12) components are placed on down right corner. *Quantity of education* (B.05.01) and *ICT Use* (B.09.02) components are placed upper left and upper right corners, whereas all together *Business Sophistication* (C.11), *On-the-job training* (B.05.03), *Technology adoption* (B.09.01) and *Global Competitiveness Index* (GCI) components are placed down left corner. See Figure 3.

Fig. 4. SOM D-Matrix

Figure 4 puts on the top of each unit *the mean value of the distances* from its six nearest neighbors. Peaks of far of units separate valleys of nearest ones. This chart shows the detected cluster structure in input data.

Fig. 5. SOM P-Matrix

Figure 5 displays *the probability density* of input data. Each unit displays the relative number of input data for which it and its six nearest neighbors is the best matching unit (BMU). The peaks of dense zones of the input space separate valleys of sparse ones. It is useful for detecting *density-based* cluster structures. See also D-Matrix of Figure 4.

Canonical correlations – Education and Technological Readiness. This procedure finds the linear combinations of two sets of variables, which have the highest correlation between them. The numbers of complete cases are 156. In this case, 4 significant sets of linear combinations have been formed (Table 1).

The Table 1 shows the estimated correlation between each set of canonical variables. Since 4 of the P-values are less than 0.05, those sets have statistically significant correlations at the 95.0% confidence level.

Table 1. Canonical correlations – Education, and Technological Readiness

Number	Eigenvalue	Canonical Correlation	Wilks Lambda	Chi-Square	D.F.	P-Value
1	0.919	0.959	0.0245	545.0	56	0.0000
2	0.489	0.699	0.303	175.0	42	0.0000
3	0.218	0.467	0.594	76.7	30	0.0000
4	0.155	0.393	0.759	40.5	20	0.0043
5	0.0627	0.25	0.898	15.8	12	0.2029
6	0.0298	0.172	0.959	6.23	6	0.3984
7	0.0121	0.11	0.988	1.79	2	0.4095

Since p values are less than 0.05 in the Wilks (the Wilks' lambda) tests, the null hypothesis is rejected. Therefore, the alternative hypothesis that there is a linear relationship between the "Education and Technological Readiness" variables is accepted.

The variables have first been standardized by subtracting their means and dividing by their standard deviations. Tables 2 and 3 show the estimated correlation between each set of canonical variables.

Table 2. Coefficients for canonical variables of the first set (Higher education and training – 5th pillar)

Set:	1	2	3	4
Secondary education enrollment (5.01)	0.164	0.291	–0.795	0.909
Tertiary education enrollment (5.02)	0.112	0.706	0.289	–1.31
Quality of the education system (5.03)	–0.0888	0.276	0.296	–0.611
Quality of math and science education (5.04)	0.00308	0.0986	–0.215	–0.431
Quality of management schools (5.05)	0.0311	–0.394	1.47	0.873
Internet access in schools (5.06)	0.39	–0.0106	0.0291	1.19
Avail. of research and training services (5.07)	0.376	0.0715	0.0162	–0.193
Extent of staff training (5.08)	0.125	–0.99	–1.08	–0.739

Table 3. Coefficients for canonical variables of the second set (Technological readiness: Technological adoption and ICT use – 9th pillar)

Set:	1	2	3	4
Availability of latest technologies (9.01)	–0.131	–0.198	2.95	2.39
Firm-level technology absorption (9.02)	0.479	–1.24	–1.61	–2.66
FDI and technology transfer (9.03)	0.112	–0.00371	–0.657	0.519
Individuals using Internet (9.04)	0.383	0.593	–0.98	1.18
Fixed broadband Internet subscriptions (9.05)	0.27	0.733	0.783	–1.03
Int'l Internet bandwidth (9.06)	–0.0557	–0.315	–0.236	0.305
Mobile broadband subscriptions (9.07)	0.0225	0.244	–0.706	–0.476

In this case, seven sets of linear combinations have been formed. However, only four sets of linear combinations are statistically significant $p < 0.05$ (See Table 1 and see Table 2, 3 and Fig. 6a). The first set forms the strongest correlations and R equals to 0.96. The first set of linear combinations with the highlighted highly contributing variables is

U_1 = 0.164 × [Secondary education enrollment (5.01)] + 0.112 × [Tertiary education enrollment (5.02)] – 0.0888 × [Quality of the education system (5.03)] + 0.00308 × [Quality of math and science education (5.04)] + 0.0311 × [Quality of management schools (5.05)] + **0.39** × **[Internet access in schools (5.06)] + 0.376** × **[Avail. of research and training services (5.07)]** + 0.125 × [Extent of staff training (5.08)]

and

L_1 = – 0.131 × [Availability of latest technologies (9.01)] **+ 0.479** × **[Firm-level technology absorption (9.02)]** + 0.112 × [FDI and technology transfer (9.03)] **+ 0.383** × **[Individuals using Internet (9.04)] + 0.27** × **[Fixed broadband Internet subscriptions (9.05)]** – 0.0557 × [Int'l Internet bandwidth (9.06)] + 0.0225 × [Mobile broadband subscriptions (9.07)].

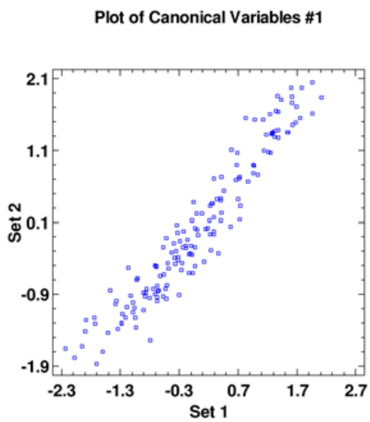
In addition, the second set of linear combinations, which is the next correlation and is less strong (R equals to 0.7) amongst all combinations that are uncorrelated with the first set (See table 1 and see table 2, 3 and figure 6b), with the highlighted highly contributing variables is,

U_2 = 0.291 × [Secondary education enrollment (5.01)] **+ 0.706 × [Tertiary education enrollment (5.02)]** + 0.276 × [Quality of the education system (5.03)] + 0.0986 × [Quality of math and science education (5.04)] – 0.394 × [Quality of management schools (5.05)] – 0.0106 × [Internet access in schools (5.06)] + 0.0715 × [Avail. of research and training services (5.07)] **– 0.99 × [Extent of staff training (5.08)]**

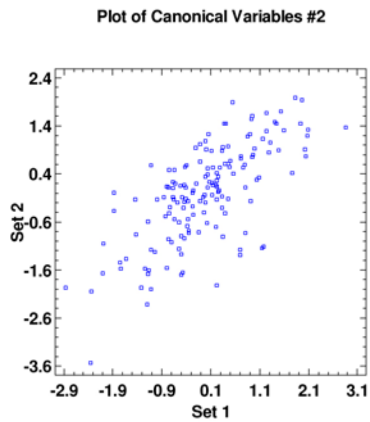
and

L_2 = – 0.198 × [Availability of latest technologies (9.01)] **– 1.24 × [Firm-level technology absorption (9.02)]** – 0.00371 × [FDI and technology transfer (9.03)] **+ 0.593 × [Individuals using Internet (9.04)] + 0.733 × [Fixed broadband Internet subscriptions (9.05)]** – 0.315 × [Int'l Internet bandwidth (9.06)] + 0.244 × [Mobile broadband subscriptions (9.07)], where the variables have first been standardized by subtracting their means and dividing by their standard deviations. Table 1 shows the estimated correlation between each set of canonical variables.

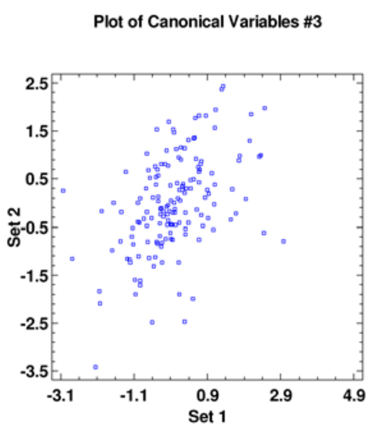
For the other sets, third set (R equals to 0.47) and fourth set (R equals to 0.39), of linear combinations, please refer to Tables 2, 3 and Figure 6c, 6d.



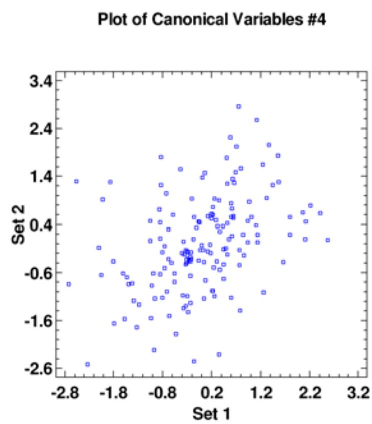
(a) Linear combination 1 (R = 0.96)



(b) Linear combination 2 (R = 0.70)



(c) Linear combination 3 (R = 0.47)



(d) Linear combination 4 (R = 0.39)

Fig. 6. Canonical correlations – Education and Technological Readiness

Canonical correlations – Education, Business Sophistication and Innovation. Again, this procedure finds the linear combinations of two sets of variables, which have the highest correlation between them. The numbers of complete cases are 163. In this case, 2 significant sets of linear combinations have been formed (Table 4).

The Table 4 shows the estimated correlation between each set of canonical variables. Since two of the p-values are less than 0.05, those sets have statistically significant correlations at the 95% confidence level.

Table 4. Canonical Correlations – Education, and Business Sophistication and Innovation

Number	Eigenvalue	Canonical Correlation	Wilks Lambda	Chi-Square	D.F.	P-Value
1	0.922	0.96	0.0704	422.0	6	0.0000
2	0.0931	0.305	0.907	15.5	2	0.0004

Since p values are less than 0.05 in the Wilks (the Wilks' lambda) tests, the null hypothesis is rejected. Therefore, the alternative hypothesis that there is a linear relationship between the "Education, and Business Sophistication and Innovation" variables is accepted.

The variables have first been standardized by subtracting their means and dividing by their standard deviations. Table 5 and 6 show the estimated correlation between each set of canonical variables.

Table 5. Coefficients for canonical variables of the first set (Higher education and training – 5th pillar)

Set:	1	2
A. Quantity of education (B.05.01)	0.104	0.732
B. Quality of education (B.05.02)	0.00712	–2.15
C. On-the-job training (B.05.03)	0.931	1.45

Table 6. Coefficients for canonical variables of the second set (Business sophistication and Innovation)

Set:	1	2
11th pillar: Business sophistication (C.11)	0.9	2.8
12th pillar: Innovation (C.12)	0.106	–2.94

In this case, two sets of linear combinations have been formed and the two sets of linear combinations are statistically significant $p < 0.05$ (See Table 4 and see Table 5, 6 and Fig. 7a). The first set forms the strongest correlations and R equals to 0.96. The first set of linear combinations with the highlighted highly contributing variables is

K_1 = 0.104 × [A. Quantity of education (B.05.01)] + 0.00712 × [B. Quality of education (B.05.02)] **+ 0.931 × [C. On-the-job training (B.05.03)]**

and

M_1 = **0.9 × [11th pillar: Business sophistication (C.11)]** + 0.106 × [12th pillar: Innovation (C.12)]

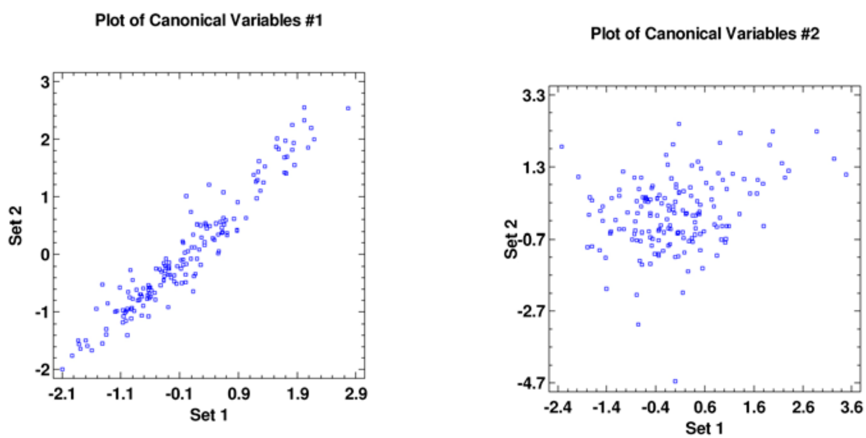
In addition, the second set of linear combinations, which is the next correlation and is substantially less strong (R equals to 0.30) amongst all combinations that are uncorrelated with the first set (See Tables 4, 5, 6 and Fig. 7b), with the highlighted highly contributing variables is,

K_2 = 0.732 × [A. Quantity of education (B.05.01)] **– 2.15 × [B. Quality of education (B.05.02)] + 1.45 × [C. On-the-job training (B.05.03)]**

and

M_2 = **2.8 × [11th pillar: Business sophistication (C.11)] – 2.94 × [12th pillar: Innovation (C.12)]**

where the variables have first been standardized by subtracting their means and dividing by their standard deviations. Table 4 shows the estimated correlation between each set of canonical variables. Since two of the p values are less than 0.05, those sets have statistically significant correlations at the 95% confidence level.



(a) Linear combination 1 (R = 0.96) (b) Linear combination 2 (R = 0.30)

Fig. 7. Canonical correlations – Education and Business Sophistication and Innovation

4. The empirical findings

The results of the first sets (Tables 3 and 4, set columns 1), the canonical correlation is strong with a magnitude of 0.96 and statistically significant at $p < 0.05$ (Table 1, Fig. 6a). There are primarily relationships between the *higher education and training* variables of *internet access in schools* and *availability of research and training services*, on the one hand, and the technological readiness variable of *firm-level technology absorption* with some contribution from *individuals using internet* and *fixed broadband internet subscriptions*, on the other. In addition, all other findings that are highlighted on Table 3 and Table 4 indicate the significant importance of variables in each respective set (Fig. 6).

By looking at the results of the first sets (Tables 5 and 6, set columns 1), the canonical correlation is strong with a magnitude of 0.96 and statistically significant at $p < 0.05$ (Table 4, Fig. 7a). There are primarily relationships between the *higher education and training* variables of *on-the-job training*, on the one hand, and the *business sophistication and innovation* variable of *business sophistication*, on the other. In addition, all other findings that are highlighted on Table 5 and Table 6 show the significant importance of variables in each respective set (Fig. 7).

5. Conclusions

In this study, the relationship between ICT indicators and education-related indicators are examined and their associations are identified. The presented results indicate that certain indicators, as evidenced by the canonical correlation analyses, contribute much more to improving competitiveness than do other variables. Additionally, there is an apparent link between economic development, competitiveness and education related variables. Thus, it is essential for policymakers in the field, especially those in developing countries, to take account of specific decisions based on the highlighted significant indicators in this study. The broad areas for improvement include increasing the quality of ICT services, developing and improving ICT infrastructure, promoting cooperation and coordination among service providers, investing into ICT, reducing costs and increasing training on all aspects of ICT and education.

ICT is a key element for development and economic expansion. However, many of the developing countries appear to gain only small fraction of the advantages from the ICT sectors. Indeed, developed countries are taking the most of the advantages and opportunities brought by the use of ICT. Because, these countries have well-developed ICT infrastructure, expertise, and enough capital to finance and thereby provide the best education opportunities, whereas developing countries are faced with numerous challenges to fully exploit the opportunities offered in the ICT. On the other hand, the governments of developing countries might be aware of these disadvantages; however, they usually have insufficient funds and expertise to bring life the necessary significant improvements.

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APPENDIX

Table A1. Higher education and training (5th pillar)

B.05.01	**A. Quantity of education**
5.01	Secondary education enrollment, gross %
5.02	Tertiary education enrollment, gross %
B.05.02	**B. Quality of education**
5.03	Quality of the education system, 1–7 (best)
5.04	Quality of math and science education, 1–7 (best)
5.05	Quality of management schools, 1–7 (best)
5.06	Internet access in schools, 1–7 (best)
B.05.03	**C. On-the-job training**
5.07	Availability of research and training services, 1–7 (best)
5.08	Extent of staff training, 1–7 (best)

Table A2. Technological readiness (9th pillar)

B.09.01	**A. Technological adoption**
9.01	Availability of latest technologies, 1–7 (best)
9.02	Firm-level technology absorption, 1–7 (best)
9.03	FDI and technology transfer, 1–7 (best)
B.09.02	**B. ICT use**
9.04	Individuals using Internet, %
9.05	Fixed broadband Internet subscriptions/100 pop.
9.06	Int'l Internet bandwidth, kb/s per user
9.07	Mobile broadband subscriptions/100 pop.

Table A3. Business sophistication factors (11th pillar)

C.11	**11th pillar: Business sophistication**
11.01	Local supplier quantity, 1–7 (best)
11.02	Local supplier quality, 1–7 (best)

11.03	State of cluster development, 1–7 (best)
11.04	Nature of competitive advantage, 1–7 (best)
11.05	Value chain breadth, 1–7 (best)
11.06	Control of international distribution, 1–7 (best)
11.07	Production process sophistication, 1–7 (best)
11.08	Extent of marketing, 1–7 (best)
11.09	Willingness to delegate authority, 1–7 (best)

Table A4. Innovation factors (12th pillar)

C.12	**12th pillar: Innovation**
12.01	Capacity for innovation, 1–7 (best)
12.02	Quality of scientific research institutions, 1–7 (best)
12.03	Company spending on RD, 1–7 (best)
12.04	University-industry collaboration in RD, 1–7 (best)
12.05	Gov't procurement of advanced tech products, 1–7 (best)
12.06	Availability of scientists and engineers, 1–7 (best)
12.07	PCT patents, applications/million pop.

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