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Assessment of information and communications technology maturity level

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ABSTRACT

The use of information and communications technology (ICT) turned out to be a key factor in the process of the wider development of a country. It is therefore very useful to estimate ICT evolution by the means of an appropriate metric. Based on statistical data from 159 countries, the ICT maturity level index (IMLI) is proposed and estimated by using structural equation modelling (SEM). This index is a metric measuring the information society in a country and consists of three sub-indices which are access, use and skills. It is an improvement of the ICT development index, proposed by the ITU in 2009. The analysis divides the countries into two groups, the developed and the developing, due to major disparities in their statistical data. The criterion used to define the groups was the income, as expressed by the Gross National Income per capita. The impact of a number of influential parameters on the ICT maturity level is evaluated and it becomes obvious that there is a substantial difference in their impact between developed and developing countries. Finally, a procedure that allows the ranking of the countries, based on IMLI, is presented.

1. Introduction

Despite the fact that during the last years information and communications technology (ICT) follows a growing diffusion process, differences in the level of access, use and skills of ICT can be detected, both among countries as well as within them. Decision and policy makers have pointed out that these differences cause ICT gap and thus strategies targeting to the development of ICT have been applied to many countries. Measuring and analyzing of the digital divide among countries is consequently of paramount importance for managers and researchers. Their attention is given particularly to the understanding of the causes driving ICT adoption, which in turn boost ICT development. Many studies reveal a number of barriers or drivers in this development. Income level, PCs penetration level, education level etc., could be either accelerators or decelerators, with respect to ICT increase (Weber & Kauffman, 2011).

Not only identifying the factors that affect ICT adoption but also estimating their impact is of major importance. Apart from useful information, for both the demand and the supply sides of the market, relevant analysis is expected to provide key factors to policy makers, regulators and telecom operators, to rethink their strategies and goals. Towards this direction, the use of statistical or econometrical methodologies is able to provide accurate and precise results, based on appropriate

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data. Thus, a number of economic, social, educational, demographic, technological and other parameters can be included in a simple regression model in order to determine the significance of each factor over ICT diffusion level. However, since ICT development is a dynamic process, monitoring its influential factors on a regular basis remains crucial.

In addition, during the last decade telecommunications adoption provoked a rapid economic growth. According to Gupta's (2000) findings, for one percent increase in telecommunications services there was a three percent growth in economy. Therefore, ICT should be used by developing countries as a means to enhance their economic growth, while for developed countries, ICT offers new challenges and opportunities making them more competitive (Sridhar & Sridhar, 2009).

Following the above considerations, this work aims to express the level of ICT development in each country, through an adequate conceptual model. To do this, a latent variable is defined, the ICT maturity level, in the context of structural equation modeling (SEM). The ICT maturity level is determined by three elements (sub-indices), Access, Use and Skills, which are also latent variables and which in turn are described by observed factors. These factors are indicators which derive by the countries' statistical data. Since the estimation of ICT evolution by the means of an appropriate metric is important, the ICT maturity level index (IMLI) is introduced, to improve the ICT development index (IDI) proposed by ITU (2009b). Structural equation modeling allows for the precise estimation of the sub-indices and indicators' weights, which are different from those set by ITU, especially when applied to developing countries. Calculation of the IMLI was based on statistics from 159 countries. Due to their huge differences in the corresponding economic wealth, the considered countries were grouped according to their income level, as expressed by the GNI per capita, in order to avoid bias in estimations. The common approach to do this is the clustering of countries into developed and developing. This separation, proposed in the present work, proved very important according to the results.

It could be probably expected that the impact of sub-indices and their indicators over the ICT maturity level would change slowly over time. However, within short periods of time, significant changes are observed on indicators statistics describing Access, Use and Skills led to the examination of their dynamic nature. Therefore, the analysis was performed for two consecutive years, revealing marginal changes regarding the sub-indices but significant for their indicators. Thus, a different ranking of the countries with respect to IMLI, from year to year, was apparently obtained. In this way, the time behavior of the model was highlighted.

The rest of the paper is structured as follows: a literature review is performed in Section 2, whereas Section 3 contains the presentation of the methodology used, together with the conceptual model of the analysis. A clustering of the countries is performed in Section 4, and in Section 5 the results together with discussion are presented. Finally, Section 6 concludes with the main findings of this work.

2. Background and literature review

ICT diffusion is a main subject of study across a number of different scientific fields, as new technologies have an immense impact on all aspects of social and economic activities. Economists, statisticians and even sociologists and psychologists developed their approaches regarding ICT adoption. Besides, technological evolution with the excess usage of ICT was the cornerstone of the new knowledge-based society (Castells, 2000). Forecasting of the telecommunications diffusion process has been widely studied, with the majority of approaches to be based on aggregate diffusion models (Bass, 1969; Rogers, 1995).

Apart from the necessity to forecast ICT diffusion, researchers additionally focused on the further understanding of the reasons that lead to success or failure of ICT development (Valletti, 2003). The driving factors for broadband penetration were studied using statistical data from OECD countries (Ford, Koutskya, & Spiwaka, 2011). The aim of this work was to reveal the impact of each considered parameter on broadband subscriptions. The analysis concluded that the most important parameter is wireline telephony. Moreover, Age (the number of persons over the age of 65 as a percentage of the labor force), GINI (income inequality) and GNI also seem to affect broadband adoption but to a lesser extent.

Apart from the diffusion analysis of new technologies and the study of driving factors that accelerate their adoption, the analysts also consider the development of measures in order to monitor progress towards information society. In ITU (1998) the ITU Secretary-General was instructed to propose the World Summit on the Information Society (WSIS) to the United Nations Administrative Committee on Coordination. The WSIS was divided in two phases. In the first phase of WSIS, in year 2003, experts concluded that ICT exclusion was an obstacle to economic development and it was decided to put that issue to high priority (WSIS, 2003). More specifically, they highlighted the necessity to capture the evolution of ICT through measurable terms. Into this context, a number of indices were developed by ITU, such as digital access index—DAI (ITU, 2003), the ICT opportunity index (ICT-OI) (ITU, 2005) and the digital opportunity index (DOI) (ITU, 2006). The first index, DAI, introduced in 2003, consisted of 5 groups of indicators that is, usage, quality, infrastructure, affordability and knowledge, and allowed for the classification of countries into high, upper, medium and low, in terms of access to information society. The calculation of the index used data of 8 indicators, whose weights were based on experts' opinions.

The second index, ICT-OI, derived from the merging of DAI and Orbicom's digital divide index (Orbicom, 2005). During the first year of its publication, 2005, it was applied in a number of 139 countries. The aim of ICT-OI was to measure access to and usage of ICT by individuals and households. Its assessment was based on a time-series dataset of ten indicators where a reference country (the average of all countries) and a reference year (the year with the largest number of available data) allow the comparison of countries regarding information society. The indicators were grouped in two categories, info-density and info-use, providing a dynamic index, as reference values change over time.

In year 2006 ITU presented DOI which consisted of 11 indicators with equal weights, grouped in three dimensions (Opportunity, Infrastructure and Utilization). The index provides a straightforward analysis and ease of use. A large number of countries were included in the research, 181 in total, and they were ranked according to their DOI score.

In 2009, ITU launched ICT development index (IDI) as a response to members' request from the second phase of WSIS, in 2005, for a single index regarding ICT development (ITU, 2009b). IDI is a composite index and allows the grouping of key performance indicators, which are comparable statistical indicators. According to ITU, IDI resulted from a three-component conceptual model, which includes ICT readiness, intensity and impact. The first two elements reflect Access and Use sub-indices, while the maximization of the IDI depends on the third component, that is, Skills sub-index, which determines the effective use of ICTs.

The above indices were the basis for a number of studies where researchers tried to provide more accurate results. Hanafizadeh, Saghaei, and Hanafizadeh (2009) proposed a composite index for measuring the two main components of ICT diffusion, that is, infrastructure and access, as the potent indicators of ICT development. They questioned the empirical development of digital opportunity index (DOI) (ITU, 2006) and proposed a statistical index, aiming to present more accurate results, which would in turn allow cross-country comparisons, related to the diffusion of the above ICT components. In this way they succeeded to highlight the importance of using statistical methodologies, in order to avoid misleading results and errors. Furthermore, they used economic and demographic criteria to provide additional insights by comparing their results. In a similar analysis, data envelopment analysis (DEA) was used to estimate DEA-opportunity index (DEA-OI), which is a useful tool for measuring progress toward information society (Emrouznejad, Cabanda, & Gholami, 2010). According to this alternative approach of measuring ICT, findings were in line with ICT-opportunity index that was developed by ITU (2005).

In a similar way the present work improves the IDI ITU index, especially as far as the estimated weights of sub-indices and indicators are concerned. However, this work has also some differences, as compared to all the above presented indices. More specifically the evaluation of information society is not considered as a uniform procedure for all countries, because of the important differences that exist among them. Thus, countries were grouped according to their GNI per capita, which was included in the model, in order to highlight the necessity to consider each country's development level, as expressed by its income.

Indeed, it seems that there is a causal relationship between new technologies and per capita income. In the study of Lam and Shiu (2010) it was proved that GDP per capita does not Granger-cause teledensity for a number of countries (105 in total) with different development levels. On the contrary, when countries were divided into income and regional categories, it was proved that there is a unidirectional or bidirectional relationship between real GDP and teledensity. Furthermore, a cluster analysis, based on income level, was conducted in order to determine the *S*-curve of each considered group of countries (Andrés, Cuberes, Diouf, & Serebrisky, 2010). Not-surprisingly, there was a substantial difference between the adoption patterns of high and low income countries. In addition, a number of different statistical methodologies were used, seeking to assess the impact of income level on technological adoption (Bohman, 2008). Results indicated the necessity of policy intervention in geographic areas of unequal income distribution. Policy makers should encourage the adoption of technology, even in poor regions, as it constitutes an important economic growth accelerator. Moreover, Vu (2011) conducted an analysis over 102 countries for the period of time between years 1996 and 2005, in order to determine the impact of ICT on economic growth. Findings indicated positive and significant relationship between ICT development and economic growth. Finally, economic welfare and growth, as expressed by the GNI, seem to be affected by ICT development in a number of works (Jalava & Pohjola, 2002; Jorgenson, 2001; Oliner & Sichel, 2000; Roller & Waverman, 2001; Seo, Lee, & Oh, 2009).

3. Problem approach

The main outcome from the World Summit on the Information Society was the enhancement of Information Society worldwide, as the key factor for further development. For this reason, the necessity of measurable trends and agreed implementation methodologies has been arisen, in order to monitor the progress on the WSIS targets. An adequate index should be based on a conceptual framework, while the choice of indicators used for its evaluation should be driven by the availability and quality of data. Moreover, the chosen indicators should reflect the purpose of indices' concept. More specifically, indicators' grouping into sub-indices corresponds to general dimensions of information society, such as access or use, consent to the identification of relative strengths and weaknesses, which allows the implementation of more effective policies. ICT development is a dynamic procedure and the key performance indicators can be changed over time. In this case, grouping the indicators is particularly useful as proposed indices can be tracked over time without the index values changing their meaning. Moreover, based on their statistical data, countries can be sorted according to their level of Information Society, allowing the evaluation of policy practices.

As it was mentioned earlier, in ITU (2009b) introduced an new sophisticated index, ICT development index—IDI, which is a composite index that integrates prior experience (ITU, 2009b). Through IDI experts can monitor digital divide and benchmarking information society developments (ITU, 2009a). The methodology chosen by ITU in order to evaluate the ICT development index (ITU, 2009b) is the principal component analysis (PCA). Based on this method, a dimension reduction was conducted before concluded to the most important indicators of ICT. More specifically, twenty indicators were initially analyzed. According to outputs derived from PCA and in particular based on the highest eigenvalues, ITU concluded to specific indicators which explain the maximum variance of the sub-indices. ITU decided to provide a simple methodology for IDI computation by taking the simple average of the normalized weights values. Hence, equal weights were used in order to compute the final index by summing up the weighted sub-indices and their relative indicators. Although the simplification of an index remains a challenge, the computation of an index value could lead to a quite different ranking due to simplified equal weighting. The most important problem with this simplification, however, is that it cannot point out the important differences regarding the sub-indices' and indicators weights, between the developed and the developing countries.

The index proposed in the present work, ICT maturity level index (IMLI), is based on ITU's IDI, in the way that it derives from an entity, the ICT maturity level, consisting of three key elements for information society, that is, access, use and skills. Each one of these elements (or sub-indices), which are latent variables, is described by measurable indicators. However, as income level can cause variations in ICT development (Lam & Shiu, 2010), IML incorporates the relationship with GNI per capita. Furthermore, Granger causality test (Granger, 1969) was applied in both groups of countries, developed and developing, in order to examine the causal relationship between GNI per capita and broadband penetration, which was chosen among other variables, as a significant feature of ICT maturity in a country. Results indicated that there is a causal relationship between these two variables, which runs from GNI per capita to broadband penetration. More specifically, the corresponding *F*-statistics were estimated at 4.11 for developed countries and at 3.31 for developing ones. According to the above results, the causal relationship is accepted at the 0.01 and 0.05 level of significance in both developed and developing countries, respectively.

The proposed analysis should be able to estimate the relative weights of all variables (sub-indices and indicators) that were involved in the model, if applied in different groups of countries. Moreover, it is desirable that the analysis would provide the means to confirm the proposed model and, consequently, the conceptual hypothesis. Therefore, both the proposed model and the results can be evaluated in terms of their reliability.

The conceptual model of this analysis is depicted in Fig. 1.

As it is mentioned above, countries were divided in two groups based on their GNI per capita. The analysis was applied separately on developed and developing countries, which in turn leads to the expectation of different outcomes and allows the comparison among countries.

3.1. Methodology

The methodology used in this work is based on structural equation modeling (SEM), an alternative multivariate technique launched by Wright (1921, 1934), aiming to explain natural sciences' issues. Since then, the original method was extended and improved, providing a useful tool to scientists, especially those from social and behavioral sciences (Bollen, 1989; Jöreskog & Sörbom, 1982). The main characteristic of these sciences is the variety of unobserved variables. Studies in these fields are commonly based on questionnaires and objective opinions, trying to approach and explain attitudes, such as willingness to adopt a service, usefulness, ease of use etc.

Structural equation modeling is a technique that combines the benefits of multiple regression and principal components analysis (Verleye, Ireton, Cesar, & Hauspie, 2004). On the contrary to the principal components analysis where all variables score on each factor (either component or latent variable), structural equation modeling allows to decide about the set of variables that will explain a specific latent variable, as well as which paths of relationship between observed and latent variables should be investigated by the model and which ones should not. The procedure of using the structural equation modeling consists of two phases. The first one is explorative and it is based on principal components analysis of the data. It allows the identification of the structure of the latent variables or constructs that can better explain the various interrelationships. The second phase corresponds to the testing of a number of several possible models, seeking

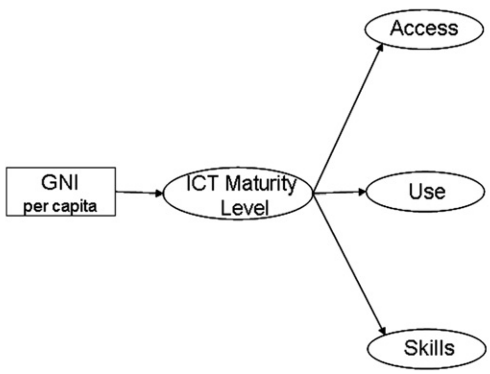

Fig. 1. Conceptual model.

for an optimal solution, able to explain the interrelationships between the explanatory variables and the dependent variables.

The benefit from using SEM to perform an analysis is that many important variables are latent and analysts often try to estimate them with only a single observed measurement, usually with an unknown reliability. The lower the measurement reliability, the less likely are the relationships between the latent variable and other variables to be observed. SEM is designed in a way that it can incorporate the unreliability of the indicators in the process of modeling important latent variables. SEM can also be a powerful method to face multicollinearity problems in sets of predictor variables. Multicollinearity appears when two or more variables are not independent. As a result, when the variables are used as predictors, and their interdependence is strong enough, model outcomes are poor and misleading.

As mentioned above, the evaluation of IDI is based on PCA, where the loadings of any observed variable on any factor can assume any value and they are allowed to load on any factor. In other words, which variables load on which factors is not fixed, or constrained, in any way. What is constrained is the number of factors, and often the correlations between the factors are constrained to zero.

Although exploratory factor analysis (EFA), such as PCA, is a common practice in research studies, the best practice always depends on researcher's point of view. PCA's main advantage is the dimension reduction which can be revealed through simple calculations. Moreover, no index of the goodness of the model fit is applied in order to validate the results. The popularity of this method lies in the availability of PCA in widely used statistical packages such as SPSS and SAS (Costello & Osborne, 2005; Ford, MacCallum, & Tait, 1986; Gorsuch, 1990; McArdle, 1990).

When using SEM, on the contrary, the loadings and path coefficients that are free to vary can be specified, together with those that are assumed to be fixed at particular values. Furthermore, it can be also specified whether variables are independent or they co-vary.

In addition, SEM is unlike to other approaches, for example, hedonic models, which are applied to observed data, requiring a set of independent variables (regressors) to describe a dependent variable. These approaches rely on observed variables and time series and they cannot accommodate latent variables, which can describe the underlying mechanism of adoption. Classical regression techniques assess such kind of problems by applying separate regression analyses. Unlike, SEM methodology allows the concurrent construction of flexible assumptions and estimation of correlations between considered parameters.

There are some basic steps regarding the application of SEM. First, the conceptual model must be developed, in order to describe the relationships among variables, which are based on a number of hypotheses. These relationships are usually illustrated by the means of a path diagram (Bentler & Bonett, 1980; Goldberger, 1972). Eq. (1) presents the null hypothesis of a SEM:

$$H_0 : \Sigma = \Sigma(\theta) \tag{1}$$

where Σ refers to the sample covariance matrix, $\Sigma(\theta)$ to the model-implied covariance matrix and θ to the estimated model parameters. According to the methodology, an error of measurement is included in each indicator, for example, independent variable, in order to remove bias and distortions from the outputs (Iriondo, Albert, & Escudero, 2003).

The challenge in SEM is not only the determination of the impact factor between parameters but also the confirmation of the initial assumptions and the proposed model itself. SEM methodology provides, apart from exploratory factor analysis a confirmatory analysis as well. Consequently, acceptance or rejection of the model and its results depends on the values of appropriate goodness-of-fit measures (Bagozzi & Yi, 1988; Brwone & Cudeck, 1992). Thus, results' validation is achieved by the comparative fit index (CFI), the incremental fit index (IFI), the Tucker–Lewis index (TLI) and the root mean square error of approximation (RMSEA)[1]. Moreover, the values of chi-square (χ^2), degrees of freedom (df) and probability value (p) are also calculated, as they reflect the sensitivity of the sample size. Statistical findings beyond the expected values indicate the revision of the initial model, such as for example, dimension reduction, where variables with low impact are excluded from the revised model.

3.2. IMLI definition

In line with IDI (ITU, 2009b), ICT maturity level depends on three elements, that is, Access, Use and Skills. In the context of SEM these elements are the latent variables, described by a number of observed factors. SEM is considered as an appropriate method to face this kind of problems, where latent variables are contained in the modeling. Thus, SEM provides a means for determining the relationships between multiple dependents including latent variables.

In this work, the proposed model is based on four main hypotheses (H1–H4), which are presented below. These hypotheses describe, on the one hand the relation between GNI per capita and IML (ICT maturity level) and on the other the link between IML and the considered elements that is, Access, Use and Skills.

[1] The threshold, or the critical value of acceptance is over 0.90 for CFI, IFI and TLI, whereas RMSEA should not exceed 0.08 (Curran & Hussong, 2002).

Table 1
Sub-indices' indicators

Access sub-index	Main fixed telephone lines per 100 inhabitants (A_1)
	Mobile cellular subscriptions per 100 inhabitants (A_2)
	International internet bandwidth Bit/s per internet user (expressed in logarithmic scale) (A_3)
	Proportion of households with computer (A_4)
	Proportion of households with internet (A_5)
Use sub-index	Internet users per 100 inhabitants (U_1)
	Fixed broadband internet subscribers per 100 inhabitants (U_2)
	Mobile broadband subscribers per 100 inhabitants (U_3)
Skills sub-index	Secondary (S_1)
	Tertiary (S_2)
	Adult literacy rate (S_3)

H1. *There is a link between GNI per capita and ICT maturity level.*

GNI per capita is included in the proposed model as an important indicator. Indeed, and according to the literature, the GNI per capita has an impact on ICT adoption. Furthermore, since this impact seems to be noticeably different between the groups of developed and developing countries, the analysis was conducted separately for each group. The existence of a strong relationship between GNI per capita and ICT development would probably indicate regulatory interventions, re-assess of pricing policy, redefinition of the strategic decisions etc.

H2. *ICT maturity level is related with Access.*

Access describes the availability of the required infrastructures for broadband adoption. It consists of the basic wireline and the cellular components. Apart from the network infrastructure an additional dimension also exists, which refers to the offered services. The main parameter describing the quality of services is bandwidth per user and therefore network operators tend to upgrade their capacity to satisfy their customers.

H3. *ICT maturity level is related with Use.*

In this context, fixed and mobile broadband usage are both considered, describing what is called Internet usage and having its own advantages and disadvantages. For example, fixed broadband offers higher speed connectivity than mobile broadband. On the other hand and despite of the lower bandwidth, the mobility and the low cost of gaining a device capable of accessing the Internet provide alternative advantages to mobile end-users. In addition, fixed and mobile broadband subscriptions are neither substitute nor complementary and it can be assumed that they meet the needs of different end-users' requirements.

H4. *ICT maturity level is related with Skills.*

The usage of ICT clearly depends on the availability of infrastructures and terminals, such as PCs, but it is not limited to them. It can be assumed that the educational level is also essential. A low education level could be a barrier to technological adoption. Unfortunately, ICT adoption seems problematic in many developing countries that still have significant literacy problems. On the contrary, in the developed countries, where education indicators are clearly higher, the uptake of ICT is more intimate, without implying that people fully understand the advantages of ICT usage.

According to the above hypotheses, the new entity that evaluates the ICT maturity level (IML), is described by the following Eq. (2):

$$\mathrm{IML} = w_{\mathrm{Access}} \times \mathrm{Access} + w_{\mathrm{Use}} \times \mathrm{Use} + w_{\mathrm{Skills}} \times \mathrm{Skills} \tag{2}$$

where the considered sub-indices (Access, Use and Skills) participate with a corresponding weight (w_{Access}, w_{Use} and w_{Skills}). The sub-indices are described by a number of observed indicators, presented in Table 1. These indicators are five for Access, three for Use and three for Skills sub-index, respectively. They were chosen among 20 candidate indicators, so that their variability in the dataset approached 99% (ITU, 2009b).

As far as the above indicators are concerned, it must be stated that fixed broadband and telephone subscriptions provide services to a particular location and not to a particular end-user. Thus, the most appropriate indicator would be the percentage of households and businesses with a broadband connection, instead of the percentage of subscribers over population (Ford, 2009; Wallsten, 2009). However, this indicator is usually converted to the number of subscriptions per 100 inhabitants in the most credible datasets. Furthermore, one can claim that Primary schooling level, perhaps not even that, may be enough for ICT usage. In this sense, the indicator Adult literacy rate reflects a basic capability of using new technologies. However, the ICT use derives not only from the required capabilities but also from the necessity of ICT using and the understanding of the benefits gained by their use, especially in a knowledge-oriented society where ICT can be a development enabler. For this, the indicators Secondary and Tertiary education levels are also included. Indeed, according to ITU the considered indicators (S_1–S_3) retained the most important information regarding Skills.

The proposed model of the analysis based on the above hypotheses is presented in detail in Fig. 2.

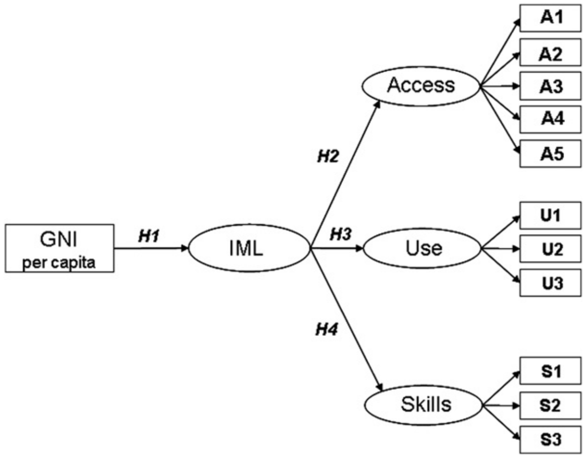

Fig. 2. The proposed structural equation model.

In the above model, A_i, $i=1,\ldots,5$; U_i, $i=1,\ldots,3$; S_i, $i=1,\ldots,3$ and GNI per capita are observed variables, whose values were extracted from the ITU and the World Bank, while IML, Access, Use and Skills are latent variables. The evaluation of the model based on the SEM methodology allows for the estimation of the corresponding weights (w) of the links (relationships) appearing in Fig. 2. However, it must be stated that there are some disadvantages regarding the SEM methodology. The most important is that findings are driven by the conceptual model. Thus, an inadequate model is possible to lead to misleading results. In addition, apart from the estimation of the goodness of fit indices, the accuracy of the results also depends on the sample size. In these cases researchers have to deal with an additional difficulty which is data collection.

Based on Eq. (2) an index written in the following form can be calculated for each country. The formulation of the ICT maturity level index is described by Eq. (3).

$$\begin{aligned} \text{IMLI} = {} & w_{\text{Access}} \times (w_{A1} \times A_1 + w_{A2} \times A_2 + w_{A3} \times A_3 + w_{A4} \times A_4 + w_{A5} \times A_5) \\ & + w_{\text{Use}} \times (w_{U1} \times U_1 + w_{U2} \times U_2 + w_{U3} \times U_3) \\ & + w_{\text{Skills}} \times (w_{S1} \times S_1 + w_{S2} \times S_2 + w_{S3} \times S_3) \end{aligned} \quad (3)$$

In the above expression of IMLI, A_i, U_i and S_i are the corresponding observed variables, for each country, while w_{Access}, w_{Use}, w_{Skills}, wA_i, wU_i and wS_i are the estimated weights resulting from SEM approach. The implementation of the proposed model was performed by using ordinary least squares (OLS).

4. Countries clustering

According to the World Bank (http://www.worldbank.org) countries are separated in two groups, developed and developing. The main criterion for this distinction is the income level. There are four categories of income that is, high, upper-middle, low-middle and low. More specifically, for years 2007 and 2008, high income is over 9206$, upper-middle income between 2976$ and 9206$, low-middle income between 746$ and 2975$ and a low income is less than 745$. The classification is based on Gross National Income per capita in US dollars ($), a commonly used indicator which echoes social welfare and can be associated with the expected public and private actions for example, ICT investments, literacy rate, usage of telecommunication services. According to the available data from 159 countries, 75 of them correspond to the high income group, 38 to upper-middle, 42 to low-middle and 4 to low. The countries belonging to the high income group are addressed as the developed countries, while those belonging to the other three groups are considered as the developing countries. Developed countries are characterized by extensive infrastructures, urbanization and competence in science and technology. Shortly, it can be stated that these countries have already reached ICT maturity. On the contrary, developing countries are at the beginning of their development process and there is still room for improvements (Adams, 2002). The following Table 2 contains the number of countries in each income category and geographic region.

Europe seems to be the most prosperous region in terms of GNI per capita, as there are no low-middle or low income countries. In addition, all European countries but Albania and Bosnia & Herzegovina belong to high income category. Not surprisingly, the majority of African countries belong to the unprivileged, low-middle income category and it is the only region with low income countries.

In this analysis all the participating countries were clustered according to their development level into two groups, that is, the developed and the developing, based on their income level. Clustering based on income level reveals that differences among countries within the same cluster are blunted, therefore is considered more appropriate than geographical region grouping. These differences in both cases (geographical and development level clustering) are shown in Table 3 and Table 4, respectively, where basic statistical measures are presented.

Table 2
Number of countries based on income level and geographic region.

	High	Upper-middle	Low-middle	Low	Total
Africa	5	5	23	4	37
America	12	11	2	0	25
Arab States	8	6	5	0	19
Asia & Pasific	10	10	8	0	28
Europe	36	2	0	0	38
CIS	4	4	4	0	12
Total	75	38	42	4	159

Table 3
Basic statistical measures for each geographical region (in US $).

	Africa	America	Arab States	Asia & Pasific	Europe	CIS
Average	3,472	12,093	17,212	14,019	28,180	7,195
Median	1,431	9,167	8,184	4,949	27,339	5,807
Standard Deviation	4,616	10,438	20,982	16,166	14,746	5,141
Max	19,615	46,436	78,260	50,705	84,003	18,945
Min	320	1,153	1,306	1,156	8,245	1,975

Table 4
Basic statistical measures for each development level (in US $).

	Developed countries	Developing countries
Average	26,764	3,574
Median	24,021	2,645
Standard deviation	15,328	2,560
Max	84,003	9,167
Min	9,652	320

In fact, according to the above Table 3, the calculated standard deviations are higher than the corresponding medians and in some cases higher than the average as well. This does not hold for the calculations referring to Europe and borderline to CIS. However, in all cases there is a huge gap between maximum and minimum values, which in turn indicates important differences among countries. For example, in the case of Africa, the maximum GNI per capita is 19,615$, while the minimum value is only 320$.

As Table 4 shows, statistical results indicate a higher homogenization, in terms of income. Standard deviation is below the average and median measures in all cases. Moreover, the income gap between the maximum and minimum values is closing.

Following the above, using the available statistics regarding the parameters used in the proposed model, the results for both groups of countries are presented and discussed.

5. Results

Following the methodology described above and according to the conceptual model presented in Fig. 2, the corresponding weights for the sub-indices w_{Access}, w_{Use} *and* w_{Skills}, as well for the indicators w_{Ai}, $i=1,2,\ldots,5$, w_{Ui}, $i=1,2,3$, and w_{Si}, $i=1,2,3$ can be estimated using the SEM approach. Based on these weights, the index IMLI can be calculated for each country, according to Eq. (3), assuming that within the same cluster they do not vary significantly among the countries. The above weights were calculated using two different datasets, one formed by the data of the 75 developed countries and the other formed by the data of the 84 developing countries.

The weights of the three considered sub-indices are presented in Table 5 for developed and developing countries and for years 2007 and 2008. In the first column the estimated values of the weights, as given by the SEM approach, are presented while the second column contains the normalized percentage. This normalization was conducted in order to make easier the comparison of the corresponding impact among sub-indices and indicators (presented below in Table 6). It is obvious that the weights provided by the proposed model are in general quite different for the two clusters, proving the value of the specific clustering, because it allows more targeted practices and polices in different economic situations. In the case of developing countries, the sub-index Skills turned out to be more significant than Use. This output indicates that

Table 5
Estimated weights of sub-indices.

	Developed countries				Developing countries			
	2007		2008		2007		2008	
	Estimated weights	Normalized (%)	Estimated weights	Normalized (%)	Estimated weights	Normalized (%)	Estimated weights	Normalized (%)
Access	87	44.2	.86	44.3	87	38.3	87	37.0
Use	75	38.0	.76	39.2	63	27.8	69	29.4
Skills	35	17.8	.32	16.5	77	33.9	79	33.6

Table 6
Estimated weights of sub-indices indicators.

	Indicators	Developed countries				Developing countries			
		2007		2008		2007		2008	
		Estimated weights	Normalized (%)	Estimated weights	Normalized (%)	Estimated weights	Normalized (%)	Estimated weights	Normalized (%)
Access	A_1	0.048	11.59	0.039	8.26	0.142	35.50	0.120	34.98
	A_2	0.005	1.20	0.002	0.42	0.042	10.50	0.035	10.20
	A_3	0.197	47.58	0.240	50.84	0.084	21.00	0.100	29.15
	A_4	0.005	1.20	0.038	8.05	0.107	26.75	0.082	23.90
	A_5	0.159	38.40	0.153	32.41	0.025	6.25	0.006	1.74
Use	U_1	0.101	31.26	0.136	35.32	0.001	8.33	0.004	10.25
	U_2	0.205	63.46	0.230	59.74	0.008	66.66	0.030	76.92
	U_3	0.017	5.26	0.019	4.93	0.003	25.00	0.005	12.82
Skills	S_1	0.004	23.52	0.010	38.00	0.093	36.61	0.084	38.00
	S_2	0.002	11.76	0.003	6.81	0.105	41.33	0.090	40.72
	S_3	0.011	64.70	0.031	70.45	0.056	22.04	0.047	21.26

in developing countries the lack of education remains an obstacle for ICT development. Policies should target to the enhancement of the education level of their citizens, which will in turn foster the diffusion of new technologies. It is important to notice that Access remains the most important element related with ICT maturity level, in both developed and developing countries. Public initiatives regarding the implementation of infrastructures, probably through subsidization, could have a positive impact on ICT maturity level. In addition, regulatory framework related with Access should be adapted to the needs of the market so as to meet the demand of the end users.

For comparison reasons, the methodology was applied to the whole dataset, as well. The corresponding results are presented in Appendix A and it is interesting to notice that they are closer to those of the developed countries. Yet, it is worth mentioning that the weights for the whole dataset (resulting from all developed and developing countries) are close to those used by the ITU to calculate the ICT development index (ITU, 2009b). According to ITU's approach, which uses ideal values and proxy indicators, Access, Use and Skills are assumed to affect IDI by 40%, 40% and 20%, respectively.

Additionally to the weights of each sub-index presented above, indicator score weights for each of the observed parameters are also estimated. Corresponding results are presented in Table 6 and it is obvious that the weights are not equally distributed among the sub-indices' indicators. In ITU's approach the indicators of Access, Use and Skills were given equal weights that is, 20% for the w_{Ai}, 33% for the w_{Ui} and 33% for the w_{Si}.

The sub-index Access seems to be strongly affected by the international Internet bandwidth (A_3), especially in the developed countries. As the offered services increase in number and become more resource demanding, end users need more bandwidth to maximize their benefits from ICT usage. On the contrary, the analysis reveals that basic infrastructures, such as telephone lines (A_1) and computer possession (A_4) are the dominant driving indicators for further ICT growth in developing countries. Moreover, fixed broadband penetration (U_2) seems to be the potent driving indicator for further Use growth. Though, in developing countries where ICT development is significantly lower than in developed world, the impact of the observed parameters is significantly low as well. However and in both cases, fixed broadband penetration plays the most crucial role for the development of ICT maturity level, revealing the strong connection between new technologies and broadband. Finally and according to the sub-index Skills indicators, it seems that developed countries have already reached an education level that facilitates ICT development. It seems that in developed countries, the acquisition of the basic education, as it is reflected by adult literacy rate (S_3), is sufficient for ICT adoption. In these cases, decision makers could focus their actions to the improvement of ICT skills such as Internet usage. Furthermore, the provision of additional e-government services would enhance ICT maturity level. On the other hand, Skills indicators in developing countries play a crucial role to ICT growth. In this case, actions should provide easy access to knowledge and encourage citizens to turn to education. In developing countries, tertiary education (S_2) is the most related indicator with ICT maturity level, highlighting the significant differences with developed countries.

ICT maturity level is influenced by many statistical parameters and therefore cannot be described by an index which is static. For this reason, the evaluation of the IML Index should be performed regularly. Significant differences in the descriptive statistics between two consecutive years indicated that it would be interesting to consider, for example, years 2007 and 2008 in the analysis, in order to evaluate the effect of these differences on country ranking. According to the results, the estimated impacts of Access, Use and Skills on IMLI, as expressed by their relative weights, are changed only slightly between 2007 and 2008. On the contrary, the estimated weights of sub-indices indicators vary significantly, in some cases. For example, in developed countries, the indicator A_4, Proportion of households with computer, affects Access by 8.05% in 2008 while the corresponding impact in 2007 was 1.20%. Similarly, important differentiations are also observed in the estimated weights for developing countries. For instance, the indicator A_3, International Internet bandwidth Bit/s per Internet user, affects Access by 29.15% in 2008, when the corresponding value in 2007 was 21.00%. Despite the changes of the estimated weights of indicators between years, resultant ranking of countries according to IMLI (presented in Tables 7 to 9) is not significantly affected. To a large extent, this fact arises due to the grouping of indicators in three latent variables, the estimated weights of which remain almost stable. Therefore, it seems that based on SEM approach, the proposed model allows the smoothing of IMLI variations in consecutive years. Of course, there are some exceptions, such as Sweden, which is ranked first in 2008 from fifth in 2007. Based on the above, it is assumed that IMLI could reveal general tendencies if applied regularly on a larger time period.

5.1. Assessment for the developed countries

Following the calculations of the ICT maturity level (IML), as they were derived from the proposed model, the relationship between GNI per capita on one and IML on the other is examined, aiming to reveal the link between these two variables in both years. The results are presented in Table 10 and findings indicate that there is a positive and significant relationship.

Overall, statistical measures indicate that the conceptual model provides good fit to the data. More specifically, for developed countries and for both years, goodness of fit indices are above acceptance threshold, having values of $\chi^2/df=2.755$ (2.626), CFI=0.901 (905), IFI=0.902 (0.908), TLI= 0.902 (0.905), RMSEA=0.072 (0.070), $p=0.000$ (0.000), where values in parentheses refer to year 2007. The obtained ranking of developed countries based on their estimated IMLI is presented in Table 7.

According to the results shown in Table 7, it is obvious that Europe is the leading area regarding ICT development. The majority of the first twenty places are occupied by European countries (thirteen out of twenty). The Scandinavian countries lead the ranking illustrating their superiority in relation with ICT maturity level. Apart from European countries, there are six countries from Asia and Pasific, that is, Korea, Japan, Hong Kong, Singapore, Australia and New Zealand. All these countries register high growth rates and it seems that new technologies foster their economies. The only country from America is Canada, while U.S.A took the twenty-first position. IMLI values range from 4.17 to 36.64 in 2008, while the corresponding values in 2007 were from 2.61 to 28.79. According to these values, some differences are observed in terms of ranking of countries. In addition, ranking based on IMLI is slightly different than the one estimated by ITU's IDI. Moreover, it is worth mentioning that in all cases IMLI values were improved in 2008, in comparison with IMLI values in 2007. This improvement could indicate that developed countries enhance their ICT maturity level which is in line with an information society.

5.2. Assessment for the developing countries

As mentioned above, the second group of countries consists of those with upper-middle, low-middle and low income. The same methodology is applied over the corresponding data, revealing the potential of growth due to the low rates of ICT development. Thus, the developing world should be considered as an emerging telecommunications market. Of course rates of development are extremely low, as compared to those of developed countries, and decisions makers should focus on their increase through targeted actions. Not surprisingly, the relationship between GNI per capita and IML for both years is significantly high. In fact, it is stronger than the corresponding relationship for the developed countries.

Goodness of fit indices are also calculated for developing countries, which indicate that the model can be accepted, since $\chi^2/df=2.361$ (2.954), CFI=0.913 (0.903), IFI=0.914 (0.903), TLI=0.907 (0.905), RMSEA=0.061 (0.065), $p=0.000$ (0.000). Values in parentheses refer to year 2007. Table 9 shows the resulting ranking of developing countries based on IMLI.

In Table 9 the corresponding IMLI values from the 84 developing countries is depicted. Not surprisingly, the last places of the aforementioned ranking are taken by African countries. IMLI values range from 2.99 to 24.61 in 2008, while in 2007 these values are 2.99 up to 27.26. Hence, it becomes obvious that the maturity level of these countries does not increase

Table 7
ICT maturity level index for developed countries.

Region	List of countries	Rank 2008	IMLI value 2008	Rank 2007	IMLI value 2007
Europe	Sweden	1	36.64	5	27.73
Europe	Iceland	2	35.27	1	28.79
Europe	Netherlands	3	35.21	3	28.49
Europe	Denmark	4	34.67	4	28.11
Europe	Luxembourg	5	34.64	6	27,37
Asia & Pasific	Korea (Rep.)	6	34.43	2	28.60
Europe	Norway	7	33.70	8	26.41
Europe	Switzerland	8	33.34	7	27.21
Europe	Germany	9	31.35	12	25.02
Europe	Finland	10	31.15	13	24.92
America	Canada	11	30.98	11	25.03
Asia & Pasific	Japan	12	30.96	10	25.05
Europe	United Kingdom	13	30.90	14	24.47
Asia & Pasific	Hong Kong, China	14	30.53	9	25.45
Asia & Pasific	Singapore	15	29.99	15	24.03
Asia & Pasific	Australia	16	28.81	16	22.93
Europe	France	17	28.55	21	21.11
Europe	Austria	18	28.36	20	21.55
Asia & Pasific	New Zealand	19	28.34	18	22.50
Europe	Belgium	20	28.07	19	22.39
America	United States	21	27.96	17	22.72
Europe	Ireland	22	26.59	22	20.51
Europe	Estonia	23	26.25	24	20.05
Arab	United Arab Emirates	24	25.32	30	16.62
Europe	Israel	25	25.30	23	20.26
Europe	Slovenia	26	25.00	26	19.46
Europe	Malta	27	24,78	27	19,26
Asia & Pasific	Macao, China	28	24.33	25	19.53
Europe	Spain	29	24.02	28	18.17
Europe	Slovak Republic	30	23.06	34	15.78
Europe	Hungary	31	22.15	35	15.70
Arab	Bahrain	32	21.78	40	14.71
Europe	Lithuania	33	21.70	32	16.21
Asia & Pasific	Brunei Darussalam	34	21.57	31	16.46
Europe	Czech Republic	35	21.43	38	14.79
Europe	Italy	36	21.30	29	16.85
Europe	Latvia	37	21.28	33	16.12
Europe	Croatia	38	20.42	37	15.00
Europe	Portugal	39	20.25	36	15.54
Europe	Poland	40	19.99	41	14.71
Arab	Qatar	41	19.78	42	13.90
Europe	Cyprus	42	19.66	39	14.74
Europe	Greece	43	18.46	43	12.73
Europe	TFYR Macedonia	44	15.31	57	8.59
Europe	Romania	45	15.03	50	10.06
Europe	Bulgaria	46	15.02	45	10.57
Arab	Saudi Arabia	47	14.75	47	10.45
Europe	Montenegro	48	14.65	44	11.47
Asia & Pasific	Malaysia	49	14.39	51	9.98
CIS	Russia	50	14.10	53	9.73
America	Argentina	51	13.88	46	10.50
America	Chile	52	13.65	49	10.17
Europe	Serbia	53	13.59	48	10.27
America	Uruguay	54	13.51	55	9.16
Europe	Turkey	55	13.48	54	9.36
America	Brazil	56	12.85	56	8.91
Arab	Kuwait	57	12.59	52	9.81
CIS	Belarus	58	11.53	61	7.75
Africa	Seychelles	59	11.39	58	8.33
Africa	Mauritius	60	11.01	59	8.25
America	Costa Rica	61	10.86	62	7.74
America	Trinidad & Tobago	62	10.80	60	7.81
Arab	Lebanon	63	10.08	65	7.02
America	Panama	64	10.06	63	7.10
Arab	Oman	65	9.91	64	7.08
America	Mexico	66	9.57	66	6.67
CIS	Azerbaijan	67	9.02	70	5.50
America	Venezuela	68	8.93	67	6.01
CIS	Kazakhstan	69	8.78	68	5.73

Table 7 (*continued*)

Region	List of countries	Rank 2008	IMLI value 2008	Rank 2007	IMLI value 2007
Asia & Pasific	Iran (I.R)	70	8.64	69	5.68
Africa	South Africa	71	5.56	71	3.90
Arab	Libya	72	5.23	72	3.80
America	Cuba	73	4.34	74	2.81
Africa	Gabon	74	4.31	73	3.16
Africa	Botswana	75	4.17	75	2.61

Table 8
GNI per capita and IML relationship for developing countries.

	IML	
	2007	2008
GNI	0.833*	0.851*

* Indicates statistical significance at the 1% level.

Table 9
ICT maturity level index for developing countries.

Region	List of countries	Rank 2008	IMLI value 2008	Rank 2007	IMLI value 2007
America	St. Vincent and the Grenadines	1	24.61	2	25.66
CIS	Ukraine	2	24.31	1	27.26
Europe	Bosnia and Herzegovina	3	20.05	3	22.62
America	Colombia	4	18.98	4	20.99
Arab	Jordan	5	18.81	7	20.67
Asia & Pasific	Thailand	6	18.71	5	20.90
Asia & Pasific	Maldives	7	18.34	13	19.24
CIS	Armenia	8	18.31	9	19.90
CIS	Moldova	9	17.84	6	20.85
America	Peru	10	17.67	12	19.31
Asia & Pasific	China	11	17.33	8	19.94
Europe	Albania	12	17.27	17	18.40
CIS	Georgia	13	17.23	11	19.68
America	Jamaica	14	16.89	10	19.88
Arab	Tunisia	15	16.77	15	18.62
Asia & Pasific	Mongolia	16	16,59	14	18,82
America	Ecuador	17	16.03	16	18.58
Asia & Pasific	Fiji	18	15.88	18	18.12
Asia & Pasific	Philippines	19	15.70	19	17.82
America	Bolivia	20	15.66	22	17.52
America	Dominican Rep.	21	15.58	24	17.48
America	El Salvador	22	15.43	23	17.50
Arab	Algeria	23	15.23	25	16.96
Arab	Syria	24	15.19	20	17.79
CIS	Kyrgyzstan	25	15.10	21	17.62
America	Paraguay	26	15.06	27	16.50
Arab	Egypt	27	14.91	28	16.49
CIS	Turkmenistan	28	14.63	29	16.09
Asia & Pasific	Sri Lanka	29	14.35	30	15.56
Asia & Pasific	Viet Nam	30	14.30	26	16.76
Asia & Pasific	Indonesia	31	14.16	35	14.78
Africa	Cape Verde	32	14.13	32	15.13
America	Guatemala	33	14.01	31	15.22
America	Honduras	34	13.79	34	14.91
CIS	Uzbekistan	35	12.87	33	14.94
Arab	Morocco	36	12.63	38	13.23
CIS	Tajikistan	37	12.50	36	14.52
Africa	Namibia	38	11.74	39	12.96
America	Nicaragua	39	11.72	37	13.62
Africa	Swaziland	40	10.28	40	11.43
Asia & Pasific	India	41	9.40	41	10.28

Table 9 (*continued*)

Region	List of countries	Rank 2008	IMLI value 2008	Rank 2007	IMLI value 2007
Africa	Congo	42	8.97	42	9.78
Asia & Pasific	Bhutan	43	8.42	51	8.57
Asia & Pasific	Lao P.D.R.	44	8.33	43	9.70
Africa	Ghana	45	8.29	44	9.61
Asia & Pasific	Myanmar	46	8.17	45	9.46
Africa	Kenya	47	8.08	46	9.44
Africa	Gambia	48	7.73	47	8.93
Arab	Yemen	49	7.54	49	8.71
Africa	Lesotho	50	7.54	48	8.83
Africa	Zimbabwe	51	7.52	50	8.62
Asia & Pasific	Cambodia	52	7.35	53	8.52
Arab	Comoros	53	7.35	52	8.55
Africa	Nigeria	54	7.07	54	8.36
Africa	Cameroon	55	7.03	55	8.20
Asia & Pasific	Pakistan	56	6.95	56	8.11
Africa	Zambia	57	6.80	58	7.91
Africa	Togo	58	6.79	57	7.91
Asia & Pasific	Bangladesh	59	6.79	60	7.81
Asia & Pasific	Nepal	60	6.78	59	7.84
Africa	Côte d'Ivoire	61	6.57	61	7.56
Africa	Angola	62	6.46	65	7.00
Arab	Sudan	63	6.44	62	7.40
Arab	Djibouti	64	6.29	63	7.39
Arab	Mauritania	65	6.27	64	7.22
Africa	Congo (Dem. Rep)	66	5.99	70	6.58
Africa	Senegal	67	5.85	66	6.72
Africa	Benin	68	5.79	68	6.63
Africa	Madagascar	69	5.79	67	6.70
America	Haiti	70	5.69	69	6.62
Africa	Malawi	71	5.60	71	6.51
Africa	Uganda	72	5.57	72	6.48
Asia & Pasific	Papua New Guinea	73	5.50	73	6.44
Africa	Eritrea	74	5.27	74	5.92
Africa	Guinea	75	4.97	75	5.78
Africa	Mali	76	4.74	76	5.36
Africa	Rwanda	77	4.65	77	5.34
Africa	Tanzania	78	4.40	78	5.17
Africa	Ethiopia	79	4.39	79	4.95
Africa	Mozambique	80	4.23	81	4.90
Africa	Guinea-Bissau	81	4.21	80	4.94
Africa	Burkina Faso	82	3.42	82	3.83
Africa	Chad	83	3.30	83	3.82
Africa	Niger	84	2.99	84	2.99

Table 10
GNI per capita and IML relationship for developed countries.

	IML	
	2007	2008
GNI	0.708*	0.720*

* Indicates statistical significance at the 1% level.

with time. The strong relationship between GNI per capita and IML restrict their ICT development in this group of countries, due to their low income level.

6. Conclusions

ICT development and the analysis of its influential factors gained substantial attention during the last years. A number of these factors were detected and decision makers have taken them into account in applying effective policies. However, important differences among countries make the implementation of common strategies quite difficult. Thus, it seems that countries should face the increase of ICT usage by applying particular policies based on their own characteristics and distinctiveness.

In this work, the majority of developed and developing countries were taken under consideration, in order to estimate each country's ICT maturity level. Through ICT maturity level index measurable results are provided, based on three main elements, Access, Use and Skills. The impact of GNI per capita on IML is also included in the model, together with the aforementioned elements. In the performed analysis, countries were split based on their GNI per capita to ensure homogeneity in statistics.

According to the results, income level has a significant effect on ICT development, which is more intense for countries with low incomes. Furthermore, it is important to notice that the estimated weights of the three sub-indices of the model have quite different values between the developed and the developing countries. Access turned out to be the dominant component regarding IML for both groups of countries. These findings indicate that access availability has a substantial influence on ICT development and are in line with the idea of build it and they come (Msimang, 2011). More specifically, access speed in developed countries is the most important indicator affecting IML. On the contrary, in developing countries the impact of telephone lines on IML reflects the lack of the required infrastructures.

The Use element is significantly more important for developed countries than for developing. In particular, fixed broadband connections are the dominant indicator for further ICT growth. Not surprisingly, the importance of Skills is lower in developed countries, indicating the sufficient educational level they have reached. On the other hand, in developing countries Skills exert great influence on IML. Hence, it is proved that educational level is directly related to the ICT development. Therefore, targeted actions should take place, especially in developing countries, where even nowadays literacy rates remain in extremely low levels.

Europe is the leading area, in terms of ICT development, as the great majority of the countries belonging to the first 20 places in world ranking are European. This conclusion is in line with ITU (2009b), indicating that ICT uptake in Europe is faster than in other areas, probably due to common regulatory framework and orchestrated policies implemented in all countries. There is an observable improvement each year with respect to ICT development, especially for the developed countries. Further, best practices could be analyzed and adapted to other countries' increasing ICT diffusion.

According to the results, the proposed index (IMLI) reflects a dynamic process and thus the systematic monitoring of the present situation is extremely important. The evaluation of the ICT maturity level provides useful information to both supply and demand sides. However, factors affecting all aspects of ICT development should be continually renewed. In many developed countries ICT diffusion has already reached a critical mass. Therefore, researchers should include other aspects that can affect the process, such as safety. In this case, decision makers could decide policies aiming to the limitation of disbelief against ICT usage which in turn could lead to the upgrade of the ICT maturity level.

Appendix A. Results for the whole dataset

See Table A1.

Table A1
Estimated weights for the whole dataset.

	Sub-indices estimated weights	Normalized (%)	Indicators	2007		2008	
				Estimated weights	Normalized (%)	Estimated weights	Normalized (%
Access	0.856 (0.874)*	38.01 (38.64)*	A_1	0.023	6.65	0.034	6.51
			A_2	0.002	0.58	0.001	0.19
			A_3	0.187	54.05	0.252	48.28
			A_4	0.016	4.62	0.058	11.11
			A_5	0.118	34.10	0.177	33.91
Use	0.915 (0.885)*	40.69 (39.12)*	U_1	0.068	17.48	0.171	34.20
			U_2	0.301	77.38	0.290	58.00
			U_3	0.020	5.14	0.039	7.80
Skills	0.481 (0.503)*	21.36 (22.14)*	S_1	0.006	25.00	0.009	25.00
			S_2	0.001	4.17	0.001	2.78
			S_3	0.017	70.83	0.026	72.22

* Values in parentheses refer to year 2007.

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