IEEE Access
Multidisciplinary | Rapid Review | Open Access Journal

Received August 12, 2019, accepted August 26, 2019, date of publication September 4, 2019,
date of current version September 23, 2019.

Digital Object Identifier 10.1109/ACCESS.2019.2939404

Effects of Information and Communication Technology Usage by Individuals, Businesses, and Government on Human Development: An International Analysis

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ABSTRACT The effects of information and communication technology (ICT) on development have been studied primarily from the perspective of their contributions to a country's economic growth. However, ICT can offer individuals much more than just monetary income—it can improve many aspects of their quality of life. In fact, according to the human development paradigm, income is only one resource that helps individuals to satisfy their economic needs. Using the capabilities approach as a theoretical framework, this study applied data panel technique to a sample of 145 countries to investigate how the use and adoption of ICT, by individuals, enterprises, and governments, affects human development, as measured by the Social Progress Index and Human Development Index (HDI). The results show that regardless of a country's level of development, the individual use of ICT has a positive impact on human development; especially on the dimensions measured by HDI (having a long and healthy life, being knowledgeable, and having a decent standard of living). Furthermore, the use of ICTs for commercial purposes has a positive impact on human development at the global level, but if we make the analysis considering only developed countries, the relationship of this variable with human development is no longer significant. Regarding the impact of government use of ICT on human development, it has been verified that it is significant on developed countries. This study can be used as a tool by policymakers, especially in developing countries, to reinforce their intentions to support the use and implementation of ICTs.

INDEX TERMS Information society, information and communication technologies, innovative entrepreneurship, social progress, theory of human development.

I. INTRODUCTION

Since the second half of the 20th century, the discussions about countries' development have been guided by different perspectives [1], that include: theories aligning development and economic growth [2]–[4], theories arguing that the origin of dependency and inequalities are characteristic to the capitalist system [5], and alternative approaches to development that recognize ecological, economic, and social goals [6]. One of most influential theories that counteracts the view of development focused on economic growth is the capabilities approach (CA) proposed by Amartya Sen [1], [7], which defines development as "a process of expanding the freedoms that people enjoy" [8, p. 3] to lead the type of life they have reason to value [8]. Under this theory, economic growth and technologies are important as means for people to achieve and live a life they value [7], [9].

Sen [10] argued that information technology is responsible for creating an interactive global culture. The positive use of IT, such as to expand human freedoms, leads to both greater efficiency in various human activities and a stronger ability to fight government repression of individual

The associate editor coordinating the review of this manuscript and approving it for publication was Saqib Saeed.

freedoms. However, Kleine [1] argued that the discourse on information and communication technology (ICT) for development continues to be overly focused on economic growth, with severe limitations in capturing the impacts of these resources. on an improved quality of life at a comprehensive level.

As such, the 2012 study by Oosterlaken [11] indicated a significant increase in research since 2006, from different disciplinary perspectives that use the CA framework to explain the impact of ICT on improving the quality of life. Furthermore, this author recommended performing empirical studies to analyze the relationship between ICT at the micro and macro levels for politicians, professionals, and activists responsible for development. Similarly, Heeks [12] indicated the need for more evidence regarding the impact of ICT on development, especially studies based on theories supporting human development (HD). Additionally, Thapa and Saebø [13] argued the need for quantitative research that enables us to better understand the effects of the relationship between ICT and development.

Moreover, Lwoga and Sangeda's [14] analysis of ICT's impact on development in developing countries provided limited evidence of the contribution of ICT tools. Finally, Johnston *et al.* [15] found that not enough studies evidence ICT's contribution to solving social problems. In this sense, the first goal of this study is to contribute to filling this literature gap by providing new evidence about the relationship between ICT and HD.

In this study, CA was used as theoretical framework and empirical econometric analysis was carried out by means panel data technique. The results provide new evidence on the effects of ICT on HD. The findings suggest that the individual use ICT have positive effects on HD, as measured by the Human development Index (HDI), and Social Progress Index (SPI), which is calculated from 53 indicators classified into three dimensions of social progress: basic human needs, foundations of wellbeing, and opportunity.

The paper continues as follows. The next section presents the conceptual framework and develops the research hypotheses. Section 3 outlines the data sources and the method. Section 4 presents the findings. The final section concludes with recommendations and policy implications.

II. CONCEPTUAL FRAMEWORK AND HYPOTHESES DEVELOPMENT

A. CAPABILITY APPROACH

The theory of social choice developed by Sen during the 1970s concludes there are regulatory reasons for modifying welfare economics and the exclusive dependence on income and wealth as HD indicators. Based on this, Anand and Sen [16] argued that focusing on variables such as GDP per capita or national wealth to measure development levels perpetuates the traditional approach oriented toward opulence, whereas the search for wellbeing should focus on improvement in positive freedoms or capabilities [8].

Similarly, Atkinson [17] and Bourguignon and Chakravarty [18] reached a broad consensus that multiple factors cause deprivation of goods and services. Therefore, addressing poverty through people's income levels is insufficient, and other attributes associated with the expansion of capabilities should be analyzed. In this sense, CA provides tools to analyze inequality based on its multidimensionality. Sen's contribution to creating an alternative measure for the improvement in the quality of life has made him one of the main theoreticians of HD. For Sen, development is associated with people's capabilities to live the type of life they have reason to value [8].

The philosophy of CA provides the basis for creating a paradigm that seeks to redirect the discussion on the concept of wealth to what people are able to do or be. CA differs from the utilitarian approach, which explains people's level of satisfaction based on the amount of goods and services that enable them to have a particular lifestyle [19], [20], by basing its analysis on the concepts of capabilities, functioning, achieved functioning, and agency [8], [21]–[28]. Capabilities are what individuals are free to do, functioning is what they actually do [29], achieved functioning is the result of the actions that a person enjoys at a certain point in time, and agency refers to the ability of a person to pursue goals they have voluntarily set. A person without agency is one who performs crucial activities in his/her life as an obligation [30].

B. ICT AND THE CAPABILITY APPROACH

Understanding development as expansion of capabilities does not mean denying the importance of the resources [20] proceeding from economic growth or technological progress as tools that encourage HD. The effectiveness of income and technology should therefore be evaluated according to their impact on capabilities expansion [9]. Sen recognized IT as ''an interactive culture across the world'' [10] that transcends the debate on local vs. global knowledge. IT is equally absorbed by both people who defend modernity and globalization and people who defend local culture. Sen also argued that the question we should ask about ICT usage should focus on how IT can help people to be more efficient in their work, and how ICT usage can be important in expanding capability to win battles for freedom and against the continuity of repressive governments.

According to a literature review on the impact of ICT on development [11], there is growing interest in demonstrating the role of ICT in HD with the CA, since ICT can contribute directly and simultaneously to the expansion of human capabilities in different areas (health, education, recreation, and means of subsistence, among others). Oosterlaken also showed that ICT ''might thus be seen as the ultimate embodiment of the ideal of the capability approach, that we ought to promote a variety of capabilities and leave it up to empowered individuals which functioning to realize, depending on their idea about the good life'' [11, pp. 12–13].

Similarly, Kleine [1] stated that ICT is a useful tool for improving people's capabilities to make effective decisions

that enable them to achieve the desired results. Given the potential to expand opportunities and facilitate the choice process, CA is especially interesting for those who study or work in the field of ICT and development.

Additionally, the literature review by Lwoga and Sangeda [14] regarding the impact of ICT on quality of life enhancement in developing countries highlighted CA as one of the main reference frameworks used since the 1990s to explain this relationship. The prevalence of CA stems from its broader view, includes the social dimensions of development, where ICT usage can improve living conditions. Despite multiple evaluations, the review showed that the contribution of ICT to HD remains debatable. Further, in an extensive review on the relationship between ICT and development using the CA approach, Thapa and Saebø [13] found that ICT may contribute to expanding capabilities, particularly what Sen [31] called instrumental freedom related to guarantees of transparency.

From the perspective of international organizations oriented toward development, the UN uses its Human Development Reports to recommend that national governments create or strengthen the institutional frameworks that encourages the use and adoption of ICT as tools to foster the expansion of capabilities [32]–[35]

Moreover, the UN has promoted the information society. During the 2002 summit [36], the representatives of 174 countries approved the creation of the information society, considering the Universal Declaration of Human Rights, especially the fundamental right of every individual to freedom of opinion and expression. The information society was thus born as a comprehensive and development-oriented institution, whose main goal is to improve people's quality of life by promoting ICT adoption and use [37].

Within the information society, the Internet is a global facility available to the public. The UN Human Rights Council also recognizes ''the global and open nature of the Internet as a driving force in accelerating progress towards development in its various forms'' [38], and access to this medium is seen as an extension of the fundamental right to freedom of expression. Based on International Telecommunication Union (ITU) statistics, 48.6% [39] of the global population had access to and used the Internet by 2017.

In 2015, the UN General Assembly [40] approved a general examination of information society's global reach, the UN recognizing the importance of ICT in achieving the 17 Sustainable Development Goals (SDG) by 2030. The evaluation also highlights the digital economy as an important and growing part of the world economy [40].

Similarly, given the growing importance of the digital economy, the 28 member countries of the European Union (EU) approved the creation of a digital single market in 2015 to create digital opportunities for both individuals and companies by using the Internet and digital technologies. According to studies performed by the EU, the creation of the digital single market would topple regulatory barriers, enabling a transition from 28 national markets to a single market, which, when fully functional, could contribute EUR 415 billion to the EU economy and create hundreds of thousands of new jobs [41].

Additionally, another international organization that advocates the importance of ICT in development—the World Economic Forum (WEF)— argues in its 2016 Global Information Technology Report [42] that ICT constitutes the backbone of the developments of the fourth industrial revolution, that has fostered an exponential increase in capabilities for processing and storing information and for making this knowledge accessible to people as never before in the history of humanity, thus creating a better future for HD.

Since 2001, the Global Information Technology Report series published by the WEF, INSEAD, and Cornell University has measured drivers of the ICT revolution globally by means of the Networked Readiness Index (NRI). The NRI has evolved over time and currently evaluates the state of network preparation using 53 individual indicators. For each of the 139 studied economies, the NRI enables identification of areas of priority for the use of ICTs for better socioeconomic development [42]. The NRI delivers information on individual, family, business, and public adoption and use of the Internet, cell phones, personal computers, telephony network infrastructure, and Internet servers with secure access, as well as virtual networks [42].

Based on the above, we propose the following hypothesis on the virtues of ICT as an instrument that fosters improvement in the quality of life:

HYPOTHESIS 1 (H1): ICT adoption/use is positively related to HD, especially on the dimensions measured by HDI and SPI.

The conceptual framework of the CA suggests that the impact of the use of a resource must be evaluated according to its potential to expand the capabilities and functioning that would allow individuals to lead the life they desire. From the normative perspective, access to a resource must improve the quality of life for the people who use it. Similarly, the actions related to the use of a resource must generate positive effects for both the person who carries out an action and the society affected by it [20]. Sen [8] suggested that the quality of people's lives depends on what they are capable of doing or being given the resources they have access to. Regarding the use of ICT, as mentioned, Sen [10] argued that the question we should ask is how these resources can help people be more efficient in their work and how its usage can expand capabilities.

From the perspective of the individual impact of ICT on HD, the literature review carried out by Thapa and Saebø [13] showed that seven studies corresponding to the micro level, two macro-level studies, and one study at the meso level conclude that access to information and communication services can be useful in creating social and human capital in remote communities. Likewise, in the literature review conducted by Johnston *et al.* [15], over 26 micro-level studies suggested that ICT has been a key tool for improving health care systems and agricultural supply chains in some African countries.

For instance, the use of mobile phones has had a positive socioeconomic impact in rural Nigeria [43]. Similarly, micro-level studies found that ICT has had a positive impact on the standard of living in rural China [44], Colombia [45], Ghana [46], Tanzania [47], and Uganda [48]. It has also been verified that through access and use of computers and the Internet, people living in remote areas of Thailand can increase their probability of accessing different types of livelihoods [49].

The literature review by Zaremohzzabieh *et al.* [50] on 15 qualitative studies conducted in different countries concluded that use of ICT at the individual level has a positive impact on people's quality of life, especially in terms of access to education and training.

Similarly, use of these resources facilitates access to information that allows people to increase their skills and knowledge. From the social point of view, ICT allows an increase in communication between family and friends and participation in social networks, thus generating personal satisfaction.

The 2016 NRI report indicates that individual use of ICTs is one of the highest-growing indicators in all the countries studied [42]. Considering the results of the aforementioned qualitative and quantitative studies, it is inferred that individual use of ICTs allows people to expand their capacity and improve their quality of life. Therefore, the following hypothesis is suggested:

HYPOTHESIS 1.1 (H1.1): Individual use of ICT (mobile telephone, Internet, personal computer, and virtual social networks) is positively related to HD, especially on the dimensions measured by HDI and SPI.

From the perspective of improving people's quality of life as a result of actions undertaken by entrepreneurs based on ICT use, several studies found that small and medium enterprises' usage of ICT reduces multidimensional poverty through the creation of new jobs and facilitation of enterprise subsistence [15], [51]–[55].

Similarly, the US government has recognized that ICT usage in nascent enterprises is important for ensuring social progress, = so it created the Digital Freedom Initiative to help entrepreneurs and small businesses make better use of ICT to create jobs and improve the locals' standard of living [56].

Mathew [57] argued that ICT allows women entrepreneurs to increase their participation in the growth and development of their country's economy. ICT is thus a driving force in the creation and dissemination of new products and services [58].

A study conducted in Indonesia reported that the use of cell phones by blind microentrepreneurs played a fundamental role in their perceived well-being [59]. This study also concluded that cell phones facilitated functions that the participants valued greatly. The authors reached the same conclusion regarding cell phone use for a sample of religious women and microentrepreneurs in Indonesia [60]. Kemal [61] argued that the use of ICT allows microentrepreneurs to obtain sustainable livelihoods, such as increased income and profits, access to new markets and market information, less dependence on physical/natural resources, and risk reduction. Considering the results at the micro level, it is inferred that the use of ICTs for commercial use promotes the expansion of human capacities. Therefore, the following hypothesis is suggested:

HYPOTHESIS 1.2 (H1.2): Business use of ICT is positively related to HD, especially on the dimensions measured by HDI and SPI.

According to the UN e-Government Knowledgebase [62], e-government is defined as the use of ICT to provide government services to citizens and businesses more effectively and efficiently. It is the application of ICT in government operations for achieving public ends through digital means.

The principle of e-government, supported by an effective e-governance institutional framework, involves the improvement of internal functioning of the public sector by reducing financial costs and transaction times to better integrate workflows and processes and enable the effective use of resources. It is utilized by various public sector agencies that seek sustainable solutions. Through innovation and e-government, governments around the world can become more efficient, be service-backed, respond to citizens' demands for transparency and accountability, and thus restore citizens' confidence in their governments.

E-governance represents an era of modernity, innovation, and flexibility for the provision of efficient and quality public services. Academics from both developed and developing economies argue that e-government strengthens citizens' participation in the decision-making process and makes governments more transparent, accountable, and effective while improving the quality of service delivery [63], [64].

Furthermore, e-government offers opportunities to the public sector in emerging economies. Specifically, it can help control the government's procurement risks as well as promote favorable environmental and social benefits that are considered sustainable [65]–[67]. Based on the above, we propose the following hypothesis:

HYPOTHESIS 1.3 (H3): Government use of ICT is positively related to HD, especially on the dimensions measured by HDI and SPI.

III. MATERIALS AND METHODS

A. MATERIALS

1) DEPENDENT VARIABLES

Following the theoretical framework of Sen's approach, the United Nations Development Program (UNDP) adopted the concept of HD in 1990, which is now measured globally by the Human Development Index (HDI) [34]. This index has three dimensions: a long and healthy life, access to knowledge, and a decent standard of living [33], [68]. Therefore, HDI is used in this study as a dependent variable. HDI was also used by Dhahri and Omri [69] to identify the contribution of entrepreneurship to sustainable development. Similarly, it was used by Costantini and Monni [70] to analyze the relationship between the environment, human development, and economic growth.

Another dependent variable used in this study is SPI, created by the Social Progress Imperative Foundation and guided by the studies of Sen, Douglas North, and Stiglitz [71], among others. SPI is defined as ''the capacity of a society to meet the basic human needs of its citizens, establish the building blocks that allow citizens and communities to enhance and sustain the quality of their lives, and create the conditions for all individuals to reach their full potential'' [71, p. 3]. This index is thus considered an internally consistent approach for measuring HD [72], [73].

The SPI is structured into three elements: dimensions, components, and indicators. The dimensions are the three sub-indexes (Basic Human Needs, Foundations of Wellbeing, and Opportunity). Each dimension is composed of four components and each component of several indicators. The indicators are aggregated to each component through exploratory factor analysis, using the principal component analysis technique [74]. Appendix A presents the structure of this index.

SPI has been subject to validation analysis. The results indicated that it has the highest number of indicators for measuring improvement in people's life quality from different dimensions. Further, its calculation method rests on a strong theoretical foundation. The main limitation is the short period of time analyzed, which prevents comparative studies from identifying changes in countries in the medium and long term [73]. The SPI has been used in other studies to explain the causes and effects of various processes of human interaction in improving the quality of life [75]–[78].

2) INDEPENDENT VARIABLES

We divide the independent variables into two groups. The first group measures the use and adoption of ICT at country level, and the second group the adoption and usage by social sector, this is personal, business, or government. The variables in each group are detailed below.

Countries use/adoption of ICT. The NRI measures a country's capacity to capitalize ICT to increase competitiveness and welfare. The NRI is structured into four sub-indexes (Environment, Readiness, Usage, and Impact), with 10 pillars distributed across the sub-indexes and 53 indicators distributed across the pillars. The Environment sub-index is composed of laws and public policies impacting ICT implementation, innovation, and development of entrepreneurial activities. The Readiness sub-index measures a society's willingness to use ICT, the Usage sub-index measures the use of ICT in all sectors of the society, and the Impact (economic and social) sub-index is associated with ICT use [79]. Appendix B presents the full structure of this index.

Detailed information on the method used to calculate the NRI is found in the Global Information Technology Report 2016 [42, p. xi]: ''The computation of the overall NRI score is based on successive aggregations of scores: individual indicators are aggregated to obtain pillar scores, which are then combined to obtain sub-index scores. Sub-index scores are in turn combined to produce a country's overall NRI score'' [42, p. xi]. As each aggregation step in the NRI uses equal weights, each sub-index has a weight of 25%.

To evaluate the weighting scheme for NRI, Maricic *et al.* [80] applied the enhanced scatter search (eSS) metaheuristics technique to obtain a weighting scheme that would increase the stability of the composite indicator. The objective function is based on the relative contributions of indicators, whereas the problem constraints rely on the bootstrap Composite I-Distance Indicator (CIDI) approach. The eSS-CIDI approach combines the exploration capability of eSS with the data-driven constraints devised from the bootstrap CIDI. The results obtained by Maricic *et al.* [80] initially suggested that the equal weightings for each sub-index of the NRI could change when the eSS-CIDI is applied. However, the proposed model does not guarantee a more stable solution than the official estimation method and should thus not be changed. Maricic *et al.* [80] suggested that the results of the proposed method can be interpreted as a means to verify the official weighting schema.

As an additional measure of the reliability of the NRI scales, we calculated Cronbach's α for the published results for each of the 10 pillars. The value obtained was 0.946, indicating that the grouping of the variables is valid, since it is above 0.7 [81].

Because of the importance of the NRI as a measurement for the use and adoption of ICT in 151 countries, several researchers have used this index to demonstrate the relationship of ICT with different aspects of human life [82]–[92].

Individual use of ICT (INUICT), was obtained by NRI; this variable has seven indicators, measures ICT penetration and diffusion at the individual level, using indicators such as the number of mobile phone subscriptions, individuals using the Internet, households with personal computers, households with internet access (both fixed and mobile), broadband subscriptions, or the use of social networks [79].

Business use of ICT (BUICT), was obtained by NRI; this variable has five indicators, captures the extent of business internet use as well as the efforts of the firms in an economy to integrate ICT into an internal technology savvy, innovation conducive environment that generates productivity gains. Consequently, this variable measures a firm's technology absorption capacity, as well as its overall capacity to innovate, the production of technology novelties measured by the number of patent applications or the proportion of staff trained, so that management and employees are better capable of identifying and developing business innovations [79].

Similarly, as a measure of the business usage of ICT the total entrepreneurial activity rate of innovation (TEAIN) was used, which is measured as a percentage of all people surveyed who are involved in total entrepreneurial activity. This type of entrepreneur is reported to provide new products or services for many of their customers and has few or no competitors. TEAIN is obtained from the adult population survey published by GEM. This survey is administered in approximately 100 countries through stratified sampling by gender and age, considering the active population (people

aged 18 to 64). GEM usually provides 95% confidence intervals for the estimates reported in its global reports [93].

The GEM is ranked as the most important study on global entrepreneurship. Organizations such as the UN, World Bank, Organisation for Economic Co-operation and Development, and WEF use its information to propose policies to support entrepreneurship worldwide [94], [95]. GEM data currently constitute the main source of information for conducting empirical studies that explain the causes and effects of entrepreneurship [96].

Researchers have used the TEAIN to determine the relevance of innovative entrepreneurship for economic growth and development [97], the relationship between entrepreneurship and the business cycle [98], the influence of social progress on innovative entrepreneurship [99], and the relationship between leadership styles and innovative entrepreneurship [100].

Government use of ICT (GUICT), was obtained from the NRI; this variable has three indicators, provides insights into the importance that governments place on developing ICT policies for competitiveness and wellbeing and their efforts for implementing these visions for ICT development and the number of government services they provide online [79].

3) CONTROL VARIABLES

As previously mentioned, CA bases its analysis principally on functioning and capabilities, which is why this study analyzes innovative and necessity entrepreneurial activities. According to Sen [8], capabilities depend fundamentally, among other things, on the instrumental freedoms associated with political freedoms, economic services, social opportunities, guarantees of transparency, and protective security. Therefore, it is important to consider a measurement of real individual freedoms.

Economic freedom is mainly measured by two indexes, developed by the Heritage Foundation and the Fraser Institute, respectively. The use of one or the other for a particular study depends on the time and space analyzed [101]. In this study, to measure economic freedom, we use the Heritage Foundation's index, which has been widely used since its creation in | 1995 as a valid measure of economic freedom [102]–[107]. The Heritage Foundation defines economic liberty as the fundamental right of every human being to control his or her own work and property. Individuals are free to work, produce, consume, and invest in any way they wish. Further, governments allow work, capital, and goods to move freely, and refrain from exercising the coercion of freedom beyond what is necessary to protect and maintain freedom [108].

The Economic Freedom Index (EFI) is measured by quantitative and qualitative indicators grouped into four categories: rule of law (property rights, governmental integrity, and judicial integrity); size of government (government spending, taxation, and financial health); normative efficiency (commercial freedom, freedom of labor, and monetary freedom); and open markets (freedom of trade, freedom of investment, and financial freedom). Each indicator is measured on a scale of 0 to 100. The overall score of a country is obtained by averaging all indicators, giving each the same weight [108].

TABLE 1. Description of variables.

Type of variable	Name	Description	Source
Dependent Variables	Human Development Index (HDI)	Measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living	United Nations Development Programs
	Social Progress Index (SPI)	Measure of the extent to which countries meet the social and environmental needs of their citizens	Social Progress Imperative Foundation
Independent Variables	Total entrepreneurial activity rate of innovation (TEAIN)	Measure of a percentage of all people surveyed who are involved in the total entrepreneurial activity rate	GEM
	Networked Readiness Index (NRI)	Measures how well an economy is using information and communications technologies to boost competitiveness and well-being	
	Individual use of ICT (INUICT)	Measure of individual ICTs usage	WEF
	Business use of ICT (BUICT)	Measure of commercial ICTs usage	
	Government use of ICT (GUICT)	Measure of government ICTs usage	
Control Variables	Economic Freedom Index (EFI)	Measure of the degree of economic freedom in the world's nations.	Heritage Foundation and The Wall Street Journal
	Pillar Political and Regulatory Environment *(PRE)*	Measure of the Pillar Political and Regulatory Environment of NRI	WEF
	Development Level *(DL)*	Measure of the degree of a country's development, that is, whether it is developed or developing	United Nations

Source: Compiled by the authors

Considering that the EFI is an index composed of several indicators and that its calculation method entails that no evaluation is made for convergent validity, with reference to the consistency of its measurement, in this study, an evaluation of the reliability of this index was carried out using Cronbach's alpha, which is a good statistical measure of scale reliability [109]. The value obtained is 0.8931, indicating that the grouping of the indicators is valid, as it is above 0.7 [81].

Likewise, for testing hypothesis 2, the pillar of political and regulatory environment (PRE) from NRI is used to measure

the institutional capability variable. This pillar includes the effectiveness of law-making bodies, judicial independence, efficiency of the legal framework in settling disputes, efficiency of legal framework in challenging regulations, intellectual property protection, software piracy rate, number of procedures to enforce a contract, and time required to enforce a contract.

Sen [31] argued that HD should be understood as an improvement in capacities, which are limitless. Seen thus, the ranking of countries by level of development should only be considered as an indicator of the coverage of basic instrumental capacities or freedoms. This argument was considered by the UN in the formal definition of HD, on which it bases its policy recommendations. Thus, all countries are encouraged to continuously improve their quality of life [68].

From the perspective of economic development, the UN [110] categorizes countries as developed or developing. The countries in the sample selected for this study are heterogeneous in terms of economic development, and so the mean, maximum, and minimum values for the selected variables are at different intervals. Therefore, to have a measure of the obtained results' robustness, a third qualitative control variable, called development level (DL), was included, which takes the value of 1 when the country is developed and 0 when the country is developing.

B. METHOD

For this study, six different samples were used, considering, as a first criterion of classification, the availability of information on the independent variables, NRI and TEAIN, and HD (that is, SPI and HDI). The models used are summarized in Table 2. Appendix C presents the list countries used in each sample.

According to Gujarati and Porter [111], when information exists in the same cross-sectional units over time, it is possible to design models in which the combination of both types of data is used, which can then be evaluated by means of panel data. Wooldridge [112] argued that one of the main advantages of using the panel data technique is that it allows non-observable factors, which influence the dependent variable, to be classified into two types: those that are constant and those that vary over time. The same argument is put forward in [113], [114].

Evaluations with panel data can be carried out in two ways: the fixed-effects model, which considers that the differences between the units can be captured through the differences in the constant term, where each intercept must be evaluated; and the random-effects model, which assumes that each cross-sectional unit has a different intercept [115]. On estimating the regressions, in Stata 14, by means of the fixed- and random-effects methods, F and Breusch–Pagan tests confirm that, in the selected samples, the panel data technique is more accurate than the pooled Ordinary Least Squares method.

According to the above procedure, to determine which is the better model, fixed- or random-effects, the Hausman [116] test is applied, and the result supports the use of fixed effects. Subsequently, tests are performed to validate the Gauss–Markov assumptions relating to the independence between errors and a distribution with constant variance. The Wooldridge [115] test is then applied, indicating the existence of autocorrelation, while the modified Wald test reveals the presence of heteroscedasticity [117].

TABLE 2. Summary of samples.

No.	Period	Variables	Obs.	Developed Countries	Developing Countries	Total
1	2012–2016	HDI, NRI, EFI, DL	689	36	109	145
2	2012–2012	HDI, INUICT, BUICT, GUICT, EFI, DL	689	36	109	145
3	2012–2016	HDI, TEAIN, PRE, EFI, DL	314	33	58	91
4	2012–2016	SPI, NRI, EFI, DL	366	35	91	126
5	2012–2012	SPI, INUICT, BUICT, GUICT, EFI, DL	366	35	91	126
6	2012–2016	SPI, TEAIN, PRE, EFI, DL	175	32	44	76

Source: The authors

Evaluations using panel data often present serial autocorrelation problems, heteroscedasticity, and even contemporary correlation [118]. According to Jönsson [119], these problems arise when errors are dependent on the cross-sections in the panel data model. This problem can be solved by applying the feasible generalized least square (FGLS) technique.

However, Beck and Katz [120] demonstrated that FGLS produces standard errors coefficients that are seriously underestimated. Moreover, the authors describe Monte Carlo experiments in which the evaluation of panel corrected standard errors (PCSE) allows the correction of the presence of serial autocorrelation, heteroscedasticity, and even contemporary correlation with precise evaluations of standard error, with little or no loss of efficiency as compared with FGLS. Similarly, Beck and Katz [120] suggested that the PCSE evaluation has the advantage that it can easily be used even when $T < N$, which is the case with the samples selected in this study. Therefore, the results of the evaluations correspond to PCSE, which is represented in the following equations:

$$HD_{it} = v_i + \beta_1 ICT_{it} + \beta_2 EFI_{it} + e_{it} \quad (1)$$

$$HD_{it} = v_i + \beta_1 TEAIN_{it} + \beta_2 EFI_{it} + \beta_3 PRE_{it} + e_{it} \quad (2)$$

where i means the i-th transversal unit (country); t is the time (year); HD is a variable measuring human development (SPI, HDI); ICT is a measure of ICT usage (NRI, INUICT, BUICT, and GUICT); TEAIN measures the rate of innovative entrepreneurial activity; EFI is the Economic Freedom Index; and PRE measures the political and regulatory environment.

IV. RESULTS AND DISCUSSION

Tables 3 and 4 summarize the descriptive statistics of the variables used (minimum and maximum values, average, and standard deviation). The maximum and minimum values indicate that the sample selection is unbiased, owing to

TABLE 3. Descriptive statistics and correlation matrix: Samples 1–3.

Variable	Mean	Std. Dev.	Min	Max	HDI	TEAIN	NRI	PRE	EFI	INUICT	BUICT	GUICT
HDI	69.99	15.37	33.6	95.1	1							
TEAIN	25.57	10.39	0.76	58.7	0.109**	1						
NRI	57.51	12.93	31.39	86.23	0.879***	0.375***	1					
PRE	55.11	12.69	30.99	85.33	0.624***	0.366***	0.855***	1				
EFI	60.50	10.41	26.3	90.1	0.290***	0.375***	0.780***	0.757***	1			
INUICT	53.70	22.03	18.58	98.05	0.914***	0.341***	0.931***	0.722***	0.713***	1		
BUICT	53.57	12.00	30.71	88.83	0.710***	0.354***	0.900***	0.860***	0.698***	0.798***	1	
GUICT	57.18	12.29	25.98	89.79	0.648***	0.257***	0.858***	0.806***	0.695***	0.709***	0.757***	1

Note. *** $p < 0.01$, ** $p < 0.05$. Source: Authors' calculations.

TABLE 4. Descriptive statistics and correlation matrix: Samples 4–6.

Variable	Mean	Std. Dev.	Min	Max	SPI	TEAIN	NRI	PRE	EFI	INUICT	BUICT	GUICT
SPI	64.07	16.78	23.99	89.62	1							
TEAIN	25.57	10.39	0.76	58.7	0.402***	1						
NRI	57.51	12.93	31.39	86.23	0.901***	0.375***	1					
PRE	55.11	12.69	30.99	85.33	0.677***	0.366***	0.855***	1				
EFI	60.50	10.41	26.3	90.1	0.726***	0.385***	0.780***	0.757***	1			
INUICT	53.70	22.03	18.58	98.05	0.926***	0.341***	0.931***	0.722***	0.713***	1		
BUICT	53.57	12.00	30.71	88.83	0.747***	0.354***	0.900***	0.860***	0.698***	0.798***	1	
GUICT	57.18	12.29	25.98	89.79	0.657***	0.257***	0.858***	0.806***	0.695***	0.709***	0.757***	1

Note. *** $p < 0.01$. Source: Authors' calculations.

the heterogeneity of the studied countries in their levels of entrepreneurship, social progress, and human development. Tables 3 and 4 also show the results of bivariate correlation, which are consistent with the proposed theory, providing initial evidence for the testing of the hypotheses. According to these results, a positive and significant correlation exists between all the variables that measure human development, that is, the IPS and HDI with ICT usage. Similarly, the correlation of TEAIN with SPI and HDI is positive and significant. The correlation of SPI and HDI with the control variables (EFI and PRE) is also positive and significant.

Figure 1 shows that regardless of the level of development, there is a positive relationship between the ICT variables and the variables that measure HD.

Figure 2 shows countries classified by their level of economic development along with information on the HD variables (HDI and SPI), and NRI for 2016. These maps show that regardless of a country's level of development, there is a direct link between the use and adoption of ICT and HD. However, it should be noted that in developed countries such as Bulgaria, Croatia, Cyprus, Czech Republic, Greece, Hungary, Italy, Poland, Romania, Slovakia, Slovenia, and Spain, the level of use and adoption of ICT is at the middle level; in contrast, in developing countries such as Bahrain, Hong Kong-China, Israel, Malaysia, Qatar, Saudi Arabia, Singapore, South Korea, and, United Arab Emirates, this level is high.

Table 5 summarizes the regressions calculated by PCSE. The results of the evaluations indicate, for all cases, that the independent variables jointly explain the dependent variable. Moreover, the results allow for the verification of the proposed hypotheses, as described in the following.

Hypothesis 1 proposed that countries' adoption/use of ICT is positively related to HD, especially on the dimensions measured by HDI and SPI. Model 1 shows that the variable measuring a country's capacity to use ICT to increase competitiveness and welfare (NRI) has a positive and significant relationship with the HDI (0.88; $p < 0.01$). As a validation measure of Model 1's robustness, Model 6 was estimated, and the results indicate that NRI has a positive and significant relationship with SPI (0.93; $p < 0.01$).

Similarly, in Models 2 and 7, the level of economic development was included as a control variable, and the results indicate that regardless of a country's level of development, the adoption of ICTs has a positive and significant impact on HD. As a third measure of robustness of the results obtained in Model 1, Models 13, 14, 19, 20, 25, and 26 (Appendix D) were estimated. In these models, the dimensions of the HDI—having a long and healthy life, being knowledgeable, and having a decent standard of living—were taken as dependent variables. In addition, level of development was included as a control variable. The results of these estimates are summarized in Table 6. They indicate that adopting ICTs has a positive and significant impact on each HDI dimension, which validates H1. Similarly, this result is consistent with the proposed theoretical approach, which adds evidence to prior studies that have attempted to explain ICT use as a tool that facilitates functioning that potentially enables people to achieve their goals [10], [11], [13], [37], [41], [42], [121]–[130].

The results on the positive relationship between NRI and HD provide new evidence, suggesting that ICT facilitates people's lives, regardless of their socioeconomic status, as well as their access to basic goods and services to expand capabilities and opportunities [124].

H1.1 indicates that individual use of ICT (mobile telephone, Internet, personal computers, and virtual social networks) is positively related to HD, and especially on the

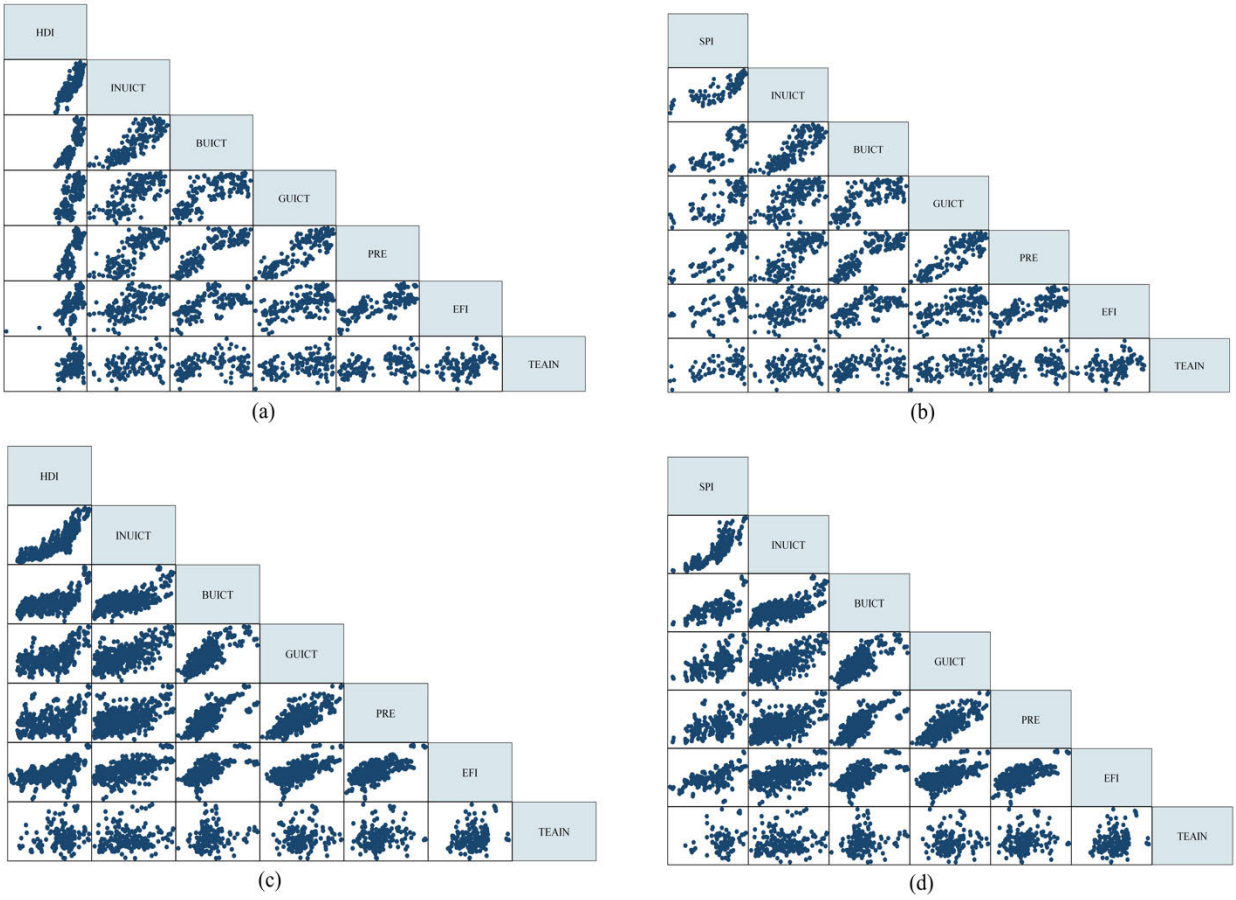

FIGURE 1. Relationship between the human development (HD), information and communication technology (ICT), and institutional indicators, by economic development level. In all figures, the first column represents the HD indicator, social progress index (SPI) or human development index (HDI); the adjacent columns represent: The ICT indicators, individual ICT use (INUICT), business use of ICT (BUICT) and government use of ICT (GUICT); institutional indicators, economic freedom index (EFI) and pillar political and regulatory environment (PRE); and the last indicator is the total entrepreneurial activity rate of innovation (TEAIN). Each cloud point represents the relationship between the intersecting variables. (a) and (b) represent developed countries. (c) and (d) represent developing countries.

dimensions measure by HDI and SPI. Model 3 shows that the variable measuring the individual use of ICT (INUICT) has a positive and significant relationship with the HDI (0.47; $p < 0.01$). As a validation measure of Model 2's robustness, Model 9 was estimates, the results showing that INUICT has a positive and significant relationship with SPI (0.47; $p < 0.01$). Similarly, in Models 4 and 10, the level of economic development was included as a control variable, and the results indicate that regardless of a country's level of development, individual use of ICTs has a positive and significant impact on HD.

As a third measure of robustness of the results obtained in Model 3, Models 15, 16, 21, 22, 27, and 28 (Appendix D) were estimated. In these models, each HDI dimension was taken as a dependent variable, and the level of development was considered as a control variable. The results of estimates are summarized in Table 6. They indicate that individual use of ICTs has a positive and significant impact on each HDI dimension, which validates H1.1. This result was obtained from a significant sample of countries and reinforces the findings of micro-level studies that concluded that individuals' use of ICT contributes to improving the quality of life [13], [15], [42]–[46], [49], [50].

Individual ICT usage helps human capabilities expand, as measured by HDI and SPI; this can be explained through the analysis of Internet usage, as main means of information and communication. The Internet enables access to technical and specialized knowledge. The best universities in the world have a wide range of open courses through platforms such as Coursera and edX, allowing people to gain access to knowledge. Development of innovations with a technological component has also been promoted by open access to specialized research and open source software [131]. Similarly, the virtual platforms of a collaborative economy foster activities from satisfying needs for food and leisure, to obtaining financial capital to start entrepreneurial activities [131], [132].

H1.2 indicates that business use of ICT is positively related to HD, especially on the dimensions measured by HDI and SPI. Model 3 shows that the variable measuring the business use of ICT (BUICT) has a positive and significant relationship with HDI (0.06; $p < 0.05$). In the field of entrepreneurship, expanding Internet usage is

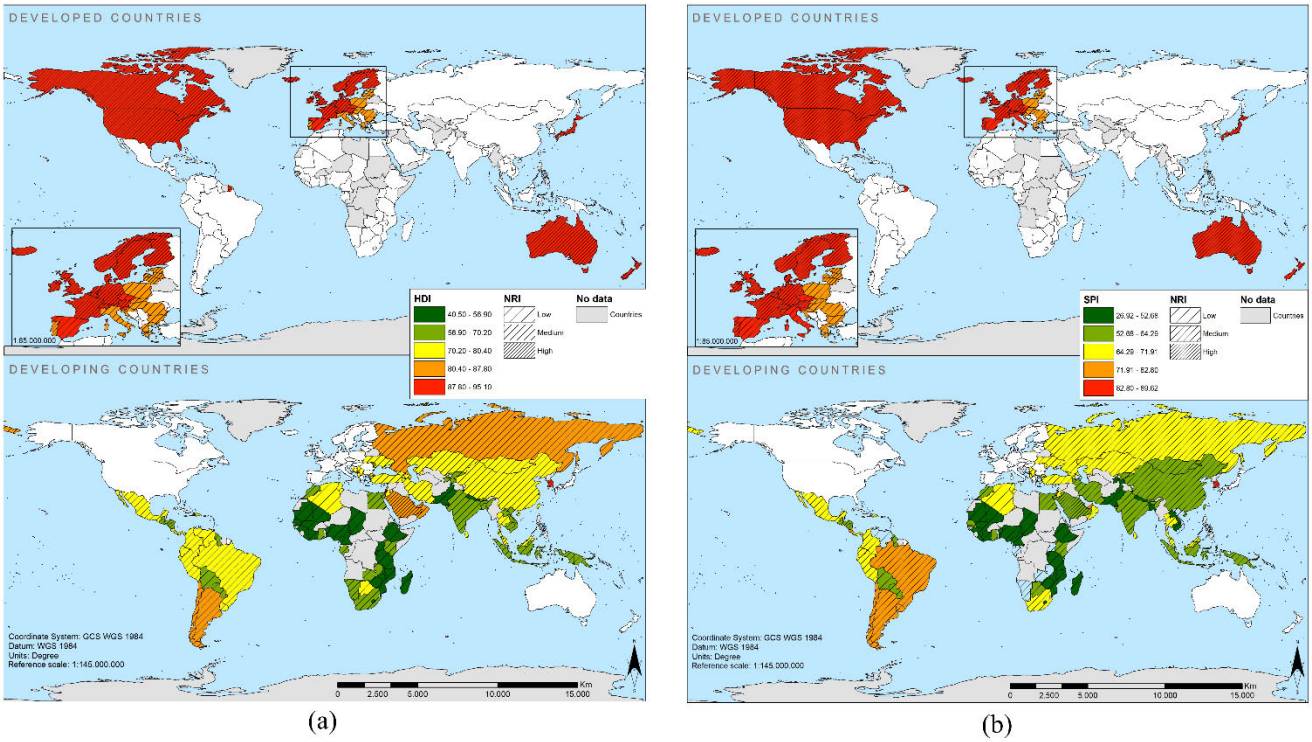

FIGURE 2. (a) Human development index (HDI) and networked readiness index (NRI), by economic development level. (b) Social progress index (SPI) and networked readiness index (NRI), by economic development level.

an input for creating successful start-ups available online. Crowdfunding, MOOCs, and open source computer developments eliminate entry barriers to markets that can restrict entrepreneurs [124], [131]. Using the Internet as a platform for business enables the entrepreneur to overcome financing obstacles through crowdfunding [133]. Massolution's annual Crowdfunding Industry Report (2015) [134] shows that the crowdfunding platforms worldwide raised USD 16.2 billion in 2014, an increase of 167% over 2013. Of the total collected in 2014, 41.3% (equivalent to USD 6.7 billion) correspond to investments in business and entrepreneurship.

The most visible impact of Internet usage on entrepreneurship activities is associated with creating new market segments through online start-ups, targeting 45.9% of the Internet users worldwide. New start-ups have fewer operational costs because the network aids with the distribution of their product or services and provides access to raw materials. The largest of these companies are currently ranked among the most profitable in the world: Google, Facebook, Amazon, and eBay [79], [131].

According to Sen [10], ICT fundamentally helps establish human interaction in all social spheres, regardless of the economic paradigm or philosophical thinking involved. ICTs are used by the most rudimentary economies to the most developed ones to facilitate exchanges of goods and services. The information society, especially open Internet access, are enabling the expansion of the collaborative economy, aiding a paradigm change in the exchange of goods and services and in turn improving the quality of people's lives and the implementation of sustainable development theories. Collaborative economy platforms and open access to codes and data on the Internet encourage highly innovative scientific development [105].

Similarly, Model 5 shows that TEAIN has a positive and significant relationship with the HDI (0.047; $p < 0.1$), and Model 6 shows TEAIN has a positive and significant relationship with the SPI. However, considering the level of development as a control variable, it is observed in Models 4 and 10 that when countries are economically developed, the use of ICT for doing business does not have a significant impact on HD. Similarly, by introducing the level of development as a control variable in the relationship between innovation entrepreneurship and HD in Models 6 and 12, it is noted that when countries are developed economically, the impact of innovation entrepreneurship on HD is not significant. These results are consonant with those obtained by previous studies, which have indicated that innovation entrepreneurship has a U-shaped relationship with economic development [135]–[137]. In the same way, Hessels *et al.* [138], suggests that entrepreneurship rates are lower in countries with high levels of social security.

Similarly, by linking HDI components to the use of ICT in commercial activities (Appendix D: Models 15, 16, 21, 22, 27, and 28), as shown in Table 6, the use of ICT to do business has a positive relationship with each

TABLE 5. Regression analysis.

Variable	*HDI*						*IPS*					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
CONS	16.37***	22.00***	31.84***	34.42***	28.24***	38.21***	2.35***	11.50***	20.66***	24.51***	25.05***	38.22***
	(2.15)	(2.28)	(2.16)	(2.16)	(4.76)	(4.54)	(2.80)	(3.05)	(2.92)	(2.93)	(5.67)	(5.37)
EFI	0.08*	0.08*	0.14***	0.13***	0.42***	0.34***	0.15**	0.14**	0.23***	0.20***	0.34***	0.25***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.08)	(0.08)	(0.06)	(0.06)	(0.06)	(0.06)	(0.09)	(0.07)
PRE					0.35***	0.22***					0.40***	0.22***
					(0.04)	(0.04)					(0.06)	(0.04)
NRI	0.88***	0.76***					0.93***	0.75***				
	(0.03)	(0.03)					(0.04)	(0.04)				
INUICT			0.47***	0.44***					0.51***	0.45****		
			(0.02)	(0.02)					(0.02)	(0.02)		
BUICT			0.06**	0.02					0.03	0.02		
			(0.02)	(0.02)					(0.04)	(0.03)		
GUICT			0.04	0.06**					0.01	0.06		
			(0.02)	(0.02)					(0.04)	(0.03)		
TEAIN					0.045*	0.02					0.10**	0.01
					(0.035)	(0.02)					(0.04)	(0.02)
DL.		5.81***		3.70***		10.13***				5.85***		12.83***
		(0.65)		(0.65)		(0.92)				(0.93)		(0.97)
N	689	689	689	689	314	314	366	366	366	366	175	175
Groups	145	145	145	145	91	91	126	126	126	126	76	76
Wald Chi2	1,670.93	1,921.49	2,256.76	2,527.07	229.49	456.59	1,500.92	1,829.03	2,054.08	2,497.89	129.53	354.44
Chi2 Prob.	0	0	0	0	0	0	0	0	0	0	0	0
R2	0.95	0.96	0.95	0.95	0.95	0.96	0.95	0.96	0.95	0.96	0.93	0.97

*** $p < 0.01$, ** $p < 0.05$; standard errors in parentheses. Source: Authors' calculations.

TABLE 6. Regression analysis of human development index components.

Variable	HDI	HDI	INCOME-HDI	INCOME-HDI	EDU-HDI	EDU-HDI	LIFE-HDI	LIFE-HDI
NRI	+***	+***	+***	+***	+***	+***	+***	+***
INUICT	+***	+***	+***	+***	+***	+***	+***	+***
BUICT	+**	+	+	+	+***	+	+**	+
GUICT	+	+**	+***	+***		+	+	+*
TEAIN	+*	+	+**	+	+*		+*	+
EFI	+*	+***	+***	+***	+**	+***		+***
PRE	+***	+***	+***	+***	+***	+***	+***	+*
DL.		+***		+***				+***

Note. *** $p < 0.01$, ** $p < 0.05$. INCOME-HDI: Measure of having a decent standard of living; EDU-HDI: Measure of being knowledgeable; EDU-HDI: Measure of having a long and healthy life. Source: Authors' calculations.

HDI component, but this relationship is not significant. Meanwhile, *TEAIN* has a positive and significant relationship with each component of HD (Models 17, 23, and 29); however, by introducing the level of development as a control variable, the *TEAIN* ratio remains positive but not significant (Models 18, 24, and 30).

The results of each model allow the inference that the use of ICTs for commercial purposes has a positive impact on HD at the global level. However, if the analysis considers only developed countries, the relationship between this variable and HD is no longer significant. Therefore, H1.2 can only be partially accepted.

H1.3 indicates that government use of ICT is positively related to HD, especially on the dimensions measured by HDI and SPI. The results for the coefficient measuring the government usage of ICT in Models 3 and 9, despite being positive, is not statistically significant on HD. This result validates the approaches of the WEF and UN, in that all public sectors (especially in developing countries) should intensify the adoption and use of ICT by implementing online government

programs that allow people to interact with the public administration in an agile and reliable way. Similarly, these organizations suggesting that public administrations should report online the management and execution of public resources for a greater citizen control to occur [32], [34], [79], [131], [139]. This result is verified through Model 4, wherein, upon considering developed countries as a control variable, the impact of governments' use of ICT on HD is positive and significant.

Similarly, by linking government use of ICT with each HDI component (Appendix D: Models 15, 16, 21, 22, 27, and 28), as seen in Table 6, the use of ICT by the government has a positive and significant impact on the "decent standard of living" dimension. In addition, the use of ICTs by the government has a positive and significant impact on the "long and healthy life" dimension when controlled for developed countries.

In all estimations, EFI and PRE have positive and significant effects on the HD variables. These results validate Sen's approach [31] in that the freedom to participate in markets can contribute in a significant way to HD, independently of what the market mechanism may contribute to promote economic growth or industrialization. The freedom to carry out economic exchanges thus plays an essential role in social life. In addition, economic and political freedom complement or reinforce each other, in that social opportunities for education and health care, which may require state intervention, complement individual opportunities to participate to the economy and policy and contribute to foster our own initiatives in overcoming our respective deprivations.

V. CONCLUSION

The main goal of this study was to present new evidence about the relationship between ICT and innovative entrepreneurship for HD. To achieve this goal, we took the CA as a theoretical framework of reference. The first conclusion is that the CA helps us understand how a human activity or resource can enhance the quality of life.

We conclude that ICT is a resource that may expand people's capabilities, allowing them to lead the lives they desire. This result provides new evidence regarding the influence of ICT on HD, as increases in ICT usage and adoption, measured by the NRI, correspond to increases in HD, measured by the SPI and HDI.

Upon conducting analysis that considered the level of economic development of countries included in the sample, it was observed that, regardless of the level of development, individual use of ICTs has a positive impact on HD. However, the use of ICTs for commercial purposes does not have a significant positive impact on HD when controlled for developed countries, because there is a U-shaped relationship between development and entrepreneurship innovation. Similarly, the government's use of ICTs was found to have a positive and significant impact on HD when developed countries are controlled for.

The use of ICTs at the individual, commercial, and government levels, when controlled for the level of economic development, has a very similar impact on the HDI and each of its dimensions.

We are convinced that stable support to encourage widespread ICT use in all dimensions of people's lives can contribute to their wellbeing, especially if applied to optimize work activities so people can spend extra time on hobbies or other ludic activities.

The results of this study can be used as a tool by public policymakers, especially in developing countries, to reinforce their intentions to support the use and implementation of ICTs at the individual, commercial, and government levels. Supporting the use of ICT at the individual level makes it easier for people to do and be what they really desire. This is because, through the use of tools such as the Internet, it is possible to access multiple sources of information related to most activities that people perform.

Similarly, it is important that policymakers promote policies that support the use of ICTs for doing business in developing countries. This is because these tools improve efficiency in the production and distribution of goods and services, which increases sales and results in higher profitability. The increase in the supply of goods and services reduces prices and makes it easier for people to meet needs they could not before.

Support for the implementation of e-government may also result in improved efficiency in the provision of public services. Especially in developing countries, it could provide an alternative path to information related to public services and government spending, allowing citizens to exercise greater control over public resources, and it could prevent corruption, which is one of the main challenges in developing countries.

We also suggest that public programs that encourage the adoption and use of ICT, especially the Internet, should be created and strengthened in all sectors of society, since these tools make it easier for people to improve their quality of life. In many countries, programs exist to support the adoption and use of ICTs. However, there is a growing trend, in both developed and developing countries, to establish barriers to access the Internet, which can threaten the fundamental right to freedom of expression and weaken the information society. It is therefore essential, that public policies in each country and international agreements continue to defend free and secure access to the Internet globally, as the main means of communication and information.

The main limitation of this study is the scarcity of secondary information to apply causality statistical techniques to, such as Granger, as well as the lack of estimations using other techniques related to time series. Our results are thus an approximation of the influence of entrepreneurship and ICT on HD.

Finally, concerning the above methodological limitations, future research should continue to explore the impact of entrepreneurship and ICT on HD. To this end, multidimensional synthetic indexes of HD could be created using information on cities or regions to determine its relationship to the creation of new firms in specific territories.

APPENDIX A

TABLE 7. Structure of social progress index (SPI).

Dimensions	Components	Indicators
Basic Human Needs	Nutrition and basic medical care	Undernourishment, Depth of food deficit, Maternal mortality rate, Child mortality rate and Deaths from infectious diseases
	Water and sanitation	Access to piped water, Rural access to improved water source and Access to improved sanitation facilities
	Shelter	Availability of affordable housing, Access to electricity, Quality of electricity supply and Household air pollution attributable deaths
	Personal safety	Homicide rate, Level of violent crime, Perceived criminality, Political terror and
Foundations of Wellbeing	Access to basic knowledge	Adult literacy rate, Primary school enrolment, Secondary school enrolment and Gender parity in secondary enrolment
	Health and wellness	Life expectancy at 60, Premature deaths from noncommunicable and disease suicide rate
	Access to information and communications	Mobile telephone subscriptions, Internet users and Press Freedom Index
	Environmental quality	Wastewater treatment, Outdoor air pollution attributable deaths, Biodiversity and habitat and Greenhouse gas emissions
Opportunity	Personal rights	Political rights, Freedom of expression, Freedom of assembly and Private property rights
	Personal freedom and choice	Freedom over life choices, Freedom of religion, Early marriage, Satisfied demand for contraception and Corruption
	Tolerance and inclusion	Tolerance for immigrants, Tolerance for homosexuals, Discrimination and violence against minorities, Religious tolerance and Community safety net
	Access to advanced education	Years of tertiary schooling, Women's average years in school, Inequality in the attainment of education, globally ranked universities and Percentage of tertiary students enrolled in globally ranked universities

Source: Methodology Report, Social Progress Index [112].

APPENDIX B

TABLE 8. ICT usage sub-index of the networked readiness index (NRI).

Subindex	Pillar	Indicators
Environment	Political and regulatory environment	Effectiveness of law-making bodies, Laws relating to ICTs, Judicial independence, Efficiency of legal framework in settling disputes, Efficiency of legal framework in challenging regulations, Intellectual property protection, Software piracy rate, Number of procedures to enforce a contract, Time required to enforce a contract
	Business and innovation environment	Availability of latest technologies, Venture capital availability, Total tax rate, Time required to start a business, Number of procedures required to start a business, Intensity of local competition, Tertiary education enrolment rate, Quality of management schools, Government procurement of advanced technology products
Readiness	Infrastructure	Electricity production, Mobile network coverage rate, International Internet bandwidth, Secure Internet servers
	Affordability	Prepaid mobile cellular tariffs, Fixed broadband Internet tariffs, Internet and telephony sectors competition index
	Skills	Quality of education system, Quality of math and science education, Secondary education enrolment rate, Adult literacy rate
Usage	Individual usage	Subscriptions to mobile phones, Percentage of individuals using Internet, Households with personal computer, Households with Internet access, Fixed broadband Internet subscriptions, Mobile broadband Internet subscriptions, Use of virtual social networks
	Business usage	Firm-level technology absorption, Capacity for innovation, Patent applications, ICT use for business-to-business transactions, Business-to-consumer Internet use, Extent of staff training
	Government usage	Importance of ICT for government vision, Government Online Service Index, Government success in ICT promotion
Impact	Economic impacts	Impact of ICTs on business models, ICT PCT patent applications per million population, Impact of ICTs on organizational models, Knowledge-intensive jobs, % workforce
	Social impacts	Impact of ICTs on access to basic services, Internet access in schools, ICT use and government efficiency, E-Participation Index

Source: The Global Information Technology Report [54].

APPENDIX C

TABLE 9. Countries. Sample model 1, 2,3, 4, 13, 14, 15, 16, 19,20,21,22,25, 26,27 and 28.

No.	Country	No.	Country	No.	Country	No.	Country
1	Albania	38	Dominican Republic	74	Latvia	110	Russian Federation
2	Algeria	39	Ecuador	75	Lebanon	111	Rwanda
3	Angola	40	Egypt	76	Lesotho	112	Saudi Arabia
4	Argentina	41	El Salvador	77	Liberia	113	Senegal
5	Armenia	42	Estonia	78	Lithuania	114	Serbia
6	Australia	43	Ethiopia	79	Luxembourg	115	Seychelles
7	Austria	44	Finland	80	Madagascar	116	Sierra Leone
8	Azerbaijan	45	France	81	Malawi	117	Singapore
9	Bahrain	46	Gabon	82	Malaysia	118	Slovakia
10	Bangladesh	47	Georgia	83	Mali	119	Slovenia
11	Barbados	48	Germany	84	Malta	120	South Africa
12	Belgium	49	Ghana	85	Mauritania	121	Spain
13	Belize	50	Greece	86	Mauritius	122	Sri Lanka
14	Benin	51	Guatemala	87	Mexico	123	Suriname
15	Bhutan	52	Guinea	88	Moldova	124	Sweden
16	Bolivia	53	Guyana	89	Mongolia	125	Switzerland
17	Bosnia	54	Haiti	90	Montenegro	126	Syrian Arab Republic
18	Botswana	55	Honduras	91	Morocco	127	Tajikistan
19	Brazil	56	Hong Kong	92	Mozambique	128	Tanzania
20	Brunei	57	Hungary	93	Namibia	129	Thailand
21	Bulgaria	58	Iceland	94	Nepal	130	Macedonia
22	Burkina Faso	59	India	95	Netherlands	131	Timor-Leste
23	Burundi	60	Indonesia	96	New Zealand	132	Trinidad and Tobago
24	Cabo Verde	61	Iran	97	Nicaragua	133	Tunisia
25	Cambodia	62	Ireland	98	Nigeria	134	Turkey
26	Cameroon	63	Israel	99	Norway	135	Uganda
27	Canada	64	Italy	100	Oman	136	Ukraine
28	Chad	65	Jamaica	101	Pakistan	137	United Arab Emirates
29	Chile	66	Japan	102	Panama	138	United Kingdom
30	China	67	Jordan	103	Paraguay	139	United States
31	Colombia	68	Kazakhstan	104	Peru	140	Uruguay
32	Costa Rica	69	Kenya	105	Philippines	141	Venezuela
33	Croatia	70	South Korea	106	Poland	142	Viet Nam
34	Cyprus	71	Kuwait	107	Portugal	143	Yemen
35	Czechia	72	Kyrgyzstan	108	Qatar	144	Zambia
36	CÙte d'Ivoire	73	Lao	109	Romania	145	Zimbabwe
37	Denmark						

TABLE 10. Countries. Sample model 5,6, 17, 18,23, 24, 29 and 30.

No.	Country	No.	Country	No.	Country	No.	Country
1	Algeria	24	Ecuador	47	Kazakhstan	70	Saudi Arabia
2	Angola	25	Egypt	48	South Korea	71	Senegal
3	Argentina	26	El Salvador	49	Latvia	72	Singapore
4	Australia	27	Estonia	50	Lebanon	73	Slovakia
5	Austria	28	Ethiopia	51	Lithuania	74	Slovenia
6	Barbados	29	Finland	52	Luxembourg	75	South Africa
7	Belgium	30	France	53	Malawi	76	Spain
8	Bolivia	31	Georgia	54	Malaysia	77	Suriname
9	Bosnia	32	Germany	55	Mexico	78	Sweden
10	Botswana	33	Ghana	56	Morocco	79	Switzerland
11	Brazil	34	Greece	57	Namibia	80	Thailand
12	Bulgaria	35	Guatemala	58	Netherlands	81	Macedonia
13	Burkina Faso	36	Hong Kong	59	Nigeria	82	Trinidad and Tobago
14	Cameroon	37	Hungary	60	Norway	83	Tunisia
15	Canada	38	India	61	Pakistan	84	Turkey
16	Chile	39	Indonesia	62	Panama	85	Uganda
17	China	40	Iran	63	Peru	86	United Arab Emirates
18	Colombia	41	Ireland	64	Philippines	87	United Kingdom
19	Costa Rica	42	Israel	65	Poland	88	United States
20	Croatia	43	Italy	66	Portugal	89	Uruguay
21	Cyprus	44	Jamaica	67	Qatar	90	Viet Nam
22	Czechia	45	Japan	68	Romania	91	Zambia
23	Denmark	46	Jordan	69	Russian Federation		

TABLE 11. Countries. Sample model 7,8,9 and 10.

No.	Country	No.	Country	No.	Country	No.	Country
1	Albania	33	Dominican Republic	65	Lebanon	97	Romania
2	Algeria	34	Ecuador	66	Lesotho	98	Russian Federation
3	Angola	35	Egypt	67	Liberia	99	Rwanda
4	Argentina	36	El Salvador	68	Lithuania	100	Saudi Arabia
5	Armenia	37	Estonia	69	Luxembourg	101	Senegal
6	Australia	38	Ethiopia	70	Madagascar	102	Serbia
7	Austria	39	Finland	71	Malawi	103	Sierra Leone
8	Bangladesh	40	France	72	Malaysia	104	Singapore
9	Barbados	41	Georgia	73	Mali	105	Slovakia
10	Belgium	42	Germany	74	Mauritania	106	Slovenia
11	Benin	43	Ghana	75	Mauritius	107	South Africa
12	Bhutan	44	Greece	76	Mexico	108	Spain
13	Bolivia	45	Guatemala	77	Moldova	109	Sri Lanka
14	Botswana	46	Guinea	78	Mongolia	110	Suriname
15	Brazil	47	Guyana	79	Montenegro	111	Sweden
16	Bulgaria	48	Honduras	80	Morocco	112	Switzerland
17	Burkina Faso	49	Hungary	81	Mozambique	113	Tajikistan
18	Burundi	50	Iceland	82	Nepal	114	Tanzania
19	Cabo Verde	51	India	83	Netherlands	115	Thailand
20	Cambodia	52	Indonesia	84	New Zealand	116	Macedonia
21	Cameroon	53	Iran	85	Nicaragua	117	Timor-Leste
22	Canada	54	Ireland	86	Nigeria	118	Tunisia
23	Chad	55	Israel	87	Norway	119	Turkey
24	Chile	56	Italy	88	Oman	120	Ukraine
25	China	57	Japan	89	Pakistan	121	United Arab Emirates
26	Colombia	58	Jordan	90	Panama	122	United Kingdom
27	Costa Rica	59	Kazakhstan	91	Paraguay	123	United States
28	Croatia	60	Kenya	92	Peru	124	Uruguay
29	Cyprus	61	South Korea	93	Philippines	125	Yemen
30	Czechia	62	Kyrgyzstan	94	Poland	126	Zimbabwe
31	CÙte d'Ivoire	63	Lao	95	Portugal		
32	Denmark	64	Latvia	96	Qatar		

TABLE 12. Countries. Sample model 11 and 12.

No.	Country	No.	Country	No.	Country	No.	Country
1	Angola	20	Denmark	39	Jordan	58	Russian Federation
2	Argentina	21	Ecuador	40	Kazakhstan	59	Saudi Arabia
3	Australia	22	Egypt	41	South Korea	60	Senegal
4	Austria	23	El Salvador	42	Latvia	61	Singapore
5	Barbados	24	Estonia	43	Lebanon	62	Slovakia
6	Belgium	25	Finland	44	Lithuania	63	Slovenia
7	Bolivia	26	France	45	Luxembourg	64	South Africa
8	Botswana	27	Georgia	46	Malaysia	65	Spain
9	Brazil	28	Germany	47	Mexico	66	Suriname
10	Bulgaria	29	Greece	48	Morocco	67	Sweden
11	Burkina Faso	30	Guatemala	49	Netherlands	68	Switzerland
12	Cameroon	31	Hungary	50	Norway	69	Thailand
13	Canada	32	India	51	Panama	70	Macedonia
14	Chile	33	Indonesia	52	Peru	71	Tunisia
15	China	34	Iran	53	Philippines	72	Turkey
16	Colombia	35	Ireland	54	Poland	73	United Arab Emirates
17	Costa Rica	36	Israel	55	Portugal	74	United Kingdom
18	Croatia	37	Italy	56	Qatar	75	United States
19	Cyprus	38	Japan	57	Romania	76	Uruguay

APPENDIX D

TABLE 13. Regression analysis.

Variable	*INCOME-HDI*						*EDU-HDI*						*LIFE-HDI*					
	Model 13	Model 14	Model 15	Model 16	Model 17	Model 18	Model 19	Model 20	Model 21	Model 22	Model 23	Model 24	Model 25	Model 26	Model 27	Model 28	Model 29	Model 30
CONS	7.04	11.42***	23.45***	24.69***	24.24***	33.30***	8.76***	17.65***	24.53***	29.95***	16.07***	30.24***	38.82***	42.67***	48.87***	50.64***	47.91***	54.76***
	(2.81)	(3.07)	(2.74)	(2.76)	(5.08)	(5.07)	(2.49)	(2.53)	(2.60)	(2.55)	(6.09)	(5.59)	(2.06)	(2.25)	(2.10)	(2.18)	(4.08)	(4.12)
EFI	0.17***	0.17***	0.18***	0.17***	0.36***	0.30***	0.04	0.02	0.14***	0.11**	0.48***	0.37***	0.11***	0.11***	0.15***	0.15***	0.38***	0.33***
	(0.06)	(0.06)	(0.05)	(0.05)	(0.09)	(0.09)	(0.05)	(0.05)	(0.05)	(0.05)	(0.11)	(0.10)	(0.04)	(0.04)	(0.04)	(0.04)	(0.07)	(0.07)
PRE					0.48***	0.35***					0.40***	0.21***					0.18***	0.08*
					(0.05)	(0.06)					(0.06)	(0.06)					(0.04)	(0.04)
NRI	0.92***	0.83***					0.96***	0.78***					0.60***	0.52***				
	(0.04)	(0.05)					(0.04)	(0.04)					(0.03)	(0.03)				

INUICT			0.51***	0.50***					0.48***	0.41***					0.31***	0.29***		
			(0.02)	(0.03)					(0.02)	(0.02)					(0.01)	(0.01)		
BUICT			0.06	0.03					0.13***	0.05					0.05**	0.02		
			(0.04)	(0.04)					(0.03)	(0.03)					(0.02)	(0.02)		
GUICT			0.09***	0.10***					0.00	0.04					0.03	0.04*		
			(0.03)	(0.03)					(0.03)	(0.03)					(0.02)	(0.02)		
TEAIN					0.05**	0.02					0.05*	0.00					0.03*	0.02
					(0.02)	(0.02)					(0.03)	(0.03)					(0.02)	(0.02)
DL.		4.57***		1.36		9.16***		9.40***		8.06***		14.00***		4.01***				7.41***
		(0.94)		(0.95)		(1.37)		(0.81)		(0.81)		(0.99)		(0.65)				(1.01)
N	689	689	689	689	314	314	689	689	689	689	314	314	689	689	689	689	314	314
Groups	145	145	145	145	91	91	145	145	145	145	91	91	145	145	145	145	91	91
Wald Chi2	1,149.02	1,374.04	1,687.79	1,885.72	278.54	453.64	1,300.81	1,661.34	1,526.47	1,917.50	164.29	379.72	889.52	1,027.26	1,152.78	1,248.41	122.77	212.96
Chi2 Prob.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R2	0.93	0.93	0.93	0.93	0.94	0.95	0.92	0.93	0.92	0.93	0.92	0.93	0.96	0.97	0.96	0.96	0.96	0.97

Note. *** $p < 0.01$, ** $p < 0.05$. Standard errors in parentheses. Source: Authors' calculations.

ACKNOWLEDGMENT

The authors would like to thank the anonymous reviewers for their constructive comments, which helped improve the quality and presentation of this paper.

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