ICT as a Determinant of Happiness

Cross-Country Evidence

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Abstract: This study aims to investigate ICT as a determinant of happiness. This study shifts its focus from traditional metrics to subjective assessments and extends the role of ICT to happiness research at the cross-country level. Due to innovations, the role of ICT may not be limited to productivity, consumption patterns, and consumer behaviour. A panel dataset for 40 countries with higher subjective wellbeing representing all continents from 2006 to 2019 is used. The pooled mean group (autoregressive distributed lag, ARDL) approach signifies that ICT is a determinant of happiness. Moreover, this research also investigates how effective governance negatively relates to happiness, and how human progress and economic development positively impact happiness. This research argues that policymaking should shift from the traditional economic development approach to socio-technical wellbeing.

Keywords: Innovation, Wellbeing, Governance, Human Development

Introduction

We are living in an era of transforming information due to the spread of information and communication technology (ICT). ICT governs various aspects of human life, including education, sports, engineering, management, health, tourism, and the economy. ICTs are used as an instrumental kit for solving problems. Nevertheless, humans underwent diverse technological transformations as a result of industrialization, yet the historical significance of ICT has emerged as complex, encompassing both its widespread adoption and its profound impact (Sala-I-Martín *et al.*, 2012).

Over the past three decades, innovation studies have evolved in diverse directions, with a consistent theme across various research areas: the pivotal role of innovation in fostering

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economic performance. Recently, ICT has improved economic results by increasing capital formation rates, export potential, and financial performance (Juster *et al.*, 1981). As a result of these factors, the GDP ought to be increasing. There are a lot of studies that capture the impact of ICT on economic growth, productivity, trade openness, and governance by using the proxy of investment in ICT (Goldfarb & Tucker, 2019; Dedrick *et al.*, 2011; Mačiulytė-Šniukienė & Gaile-Sarkane, 2014; Oulton, 2012). It is also playing a key role in socio-economic development. It has transformed human lives and left an everlasting impact on wellbeing.

In this context, two schools of thought investigated the impact of ICTs' diffusion. One of them is more optimistic, which builds supporting arguments. In the literature, the old arguments support the position of ICTs' diffusion by the "penalty of taking the lead" (Veblen, 1990). The last few decades showed that the catching-up countries need to invest in ICT-related infrastructure and skills. The diffusion of ICT is more complicated to catch up with developed countries due to the above reasons (Maiti *et al.*, 2020). A less optimistic stance is evident in development research regarding the current prospects for innovation and technology-based growth. Abramovitz (1986) investigated it in historically oriented studies on technological development, growth, and catching up.

Traditionally, wellbeing is measured by gross domestic product (GDP), which has been criticised as a weak indicator and claimed as an unsuitable tool for public policies (Fleurbaey, 2009). Therefore, other statistical tools were introduced for the measurement of wellbeing as complementary to GDP, which was observed by Stiglitz & Fitoussi (2009). Ben Martin (2016) investigated that wellbeing is the most important indicator for innovative research and highlights it in twenty challenges for future research: "Innovation scholars will need to shift the focus of our empirical work from innovation for wealth to innovation for wellbeing" (Martin, 2016).

At the same time, another problem arises: the widespread adoption of ICT necessitates both advanced skill levels and robust infrastructure. This leads to a scenario where affluent nations reap greater advantages from economic disparity, contributing to the widening digital divide (Maurseth, 2020). According to the economic point of view, happiness comes from richness. Research on happiness also indicates this paradox. But the Easterlin *et al.* (2010) paradox has proved that average happiness remains the same even with increasing income. The World Happiness Report (2021) also shows that many countries with high economic growth have a low happiness index.

Thus, the researcher's attention shifted from traditional measures to happiness because the true level of wellbeing is determined by intangible factors (Kyle, 2020). Research shows a positive GDP-happiness link in low-income nations, improving wellbeing. But, at a certain

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level of income, increase in GDP growth yields diminishing happiness gains (Easterlin *et al.*, 2010). At the same time, an elevated GDP can result in heightened income disparity, potentially exerting an adverse impact on the wellbeing of individuals with more modest earnings, irrespective of the nation's overall affluence (Zagorski *et al.*, 2014; Schneider, 2016). Heterogeneities like cultural values, social norms, and expectations can influence how individuals perceive and prioritize happiness. Consequently, these factors force researchers to make a transition from traditional measures to subjective measures. Pursuing economic growth should be balanced with policies that consider the broader aspects of human wellbeing, including social, environmental, and mental health factors.

Therefore, there is a dire need to conduct a study that would make a substantive contribution to the current body of knowledge across various dimensions. The empirical investigation into the ramifications of ICT on happiness using Subjective Well-Being (SWB) as a proxy remains in its nascent stage, primarily owing to a relatively limited emphasis on subjective indices of wellbeing. The previous studies investigating the impact of ICT on SWB used the earlier technologies and a single dimension of ICT, such as TV watching (Graham & Nikolova, 2013; Kavetsos & Koutroumpis, 2011), Internet use (Castellacci & Tveito, 2016; Castellacci & Viñas-Bardolet, 2019; Lohmann, 2015), or mobile phone penetration (Alhassan & Adam, 2021). The mentioned researchers used old happiness survey data that was collected in a low ICT diffused era to check the relationship between ICT and happiness.

To fill this gap, we combine four variables to construct an aggregate ICT index and show the relationship with happiness, which is determined by the ladder wellbeing index. This study addresses all these questions with the Pooled Mean Group (PMG) technique. Moreover, this research study also investigates the impact of effective governance, human progress, environmental development, and economic development on happiness.

The remaining study is structured as follows. The next section delineates a comprehensive literature review on ICT in the context of the transition from conventional measures to subjective wellbeing. The third section elucidates the theoretical underpinnings, while the following section delves into the methodology employed. The fifth section deals with a conclusion and policy implications. The last two sections encompass the research implications, limitations, and future suggestions.

Literature Review

The literature review comprises two distinct segments: the initial section delves into the determinants of subjective wellbeing, while the subsequent one deals with ICT as a path towards subjective wellbeing.

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Determinants of subjective wellbeing

The literature review aims to explore and synthesize the extensive body of research on the determinants of subjective wellbeing, by examining the diverse range of factors, including ICT, that influence this elusive concept. In this research, the determinants of SWB are corroborated by subsequent studies. The economic determinants of SWB are income (Easterlin *et al.*, 2010; Kahneman & Deaton, 2010), unemployment, inflation, GDP (El Ouardighi & Munier, 2019; Hongo *et al.*, 2020; Welsch & Kühling, 2016), and inequality (Delhey & Dragolov, 2014; Layte, 2012; Oishi *et al.*, 2011). Due to the Easterlin *et al.* (2010) paradox, the relationship between economic growth and SWB ought to be inconclusive.

Further, the effectiveness of the government also affects people's wellbeing and happiness (Shamsi *et al.*, 2018). Empirical evidence examined the positive as well as negative impact of good governance on SWB (Almatarneh & Emeagwali, 2019; Cárcaba *et al.*, 2022; Helliwell & Putnam, 2004). In addition, environment is very important for human beings and it can exert an influence on their wellbeing, as, for example, with climate change, pollution, and weather conditions (Frijters & Van Praag, 1998; Schmitt, 2013). Thus, this study uses a collective index for the environment, economic development, and ICT following the methodology of D'Acci (2011) to check their effect on SWB.

ICT as a path towards subjective wellbeing

Hardy (1980) initially investigated the contribution of ICT to productivity growth. He pointed out the direct impact of telephones on economic growth in 60 selected countries taking 13 years of data and using cross-lagged correlation techniques. In contrast, the Solow productivity paradox shows that the productivity of workers is not enhancing (Solow, 1987). This is the origin of the debate on ICT diffusion and economic growth, which raised the question: Does ICT affect economic growth and wellbeing? A study on the US economy also examined that there was no massive contribution to economic growth between 1970 and 1992 (Oliner & Sichel, 2000).

By contrast, Seo *et al.* (2009) showed the dynamic interdependent relationship between ICT investment and economic growth for a sample of 29 countries in the 1990s. Akinlo (2023) and Haftu (2019) pointed out that the effect of telecommunication infrastructure development has a positive impact on the economic growth of sub-Saharan African countries and the per-capita income of the region, while using panel data for the period 2006-2015. The debate regarding the relationship between ICT and economic growth remains inconclusive, with scholars and experts continuing to examine and evaluate the complex and multifaceted dynamics at play.

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Consequently, scholars have turned their attention to additional facets associated with the firm's behaviour and consumers' behaviour after economic growth, investment, and ICT nexus. Hjort & Poulsen (2019) used firm-level data from 12 African countries to examine how fast Internet connections enhanced exports, production, and firm entry. They also found that fast Internet connections increased income levels, which in turn raised satisfaction levels. Goldfarb & Tucker (2019) concluded that digital technology affects firms as well as consumers by lowering costs and saving time, respectively. They argued that online marketing (e.g., Flipkart, Amazon, Alibaba), job finding (e.g., Rozee, Jobbnore, Linkedin), and real-estate marketing (e.g., Zameen, Airbnb) leave a noticeable impact on human behaviour and wellbeing. At present, ICT innovations are increasing the productivity of ICT-intensive firms.

Subsequently, another avenue of scholarly inquiry delves into the trajectory of human advancement. A study undertaken by Lee *et al.* (2017) used a seemingly unrelated regression (SUR) model with panel data covering 14 years from 2000 to 2013, encompassing 102 countries, and showed that ICT diffusion is a determinant of global-level human progress. Elgin (2013) used panel data from 152 countries spanning the period from 1999 to 2007 to analyse how the Internet negatively affects the size of the shadow economy.

Recent researchers have investigated how the diffusion of ICT alters consumption patterns, yielding both positive and negative outcomes (Pea *et al.*, 2012). According to Pea *et al.* (2012), ICT catalyzes passive consumption but also exerts a detrimental impact. The advent of ICT has led to a significant upsurge in the consumption of cultural events. Furthermore, the utilization of ICT has been shown to elevate individuals' happiness levels when engaging with such products (Gui & Stanca, 2010). In contrast, it has brought about transformations in work patterns. In the recent past, the majority of people worked in physical offices, whereas today, due to ICT, remote work has become commonplace through various Internet platforms such as Fiverr, Toptal, Guru, and LinkedIn, which not only saves time but also allows individuals to remain close to their families instead of commuting, thereby influencing overall wellbeing.

ICT diffusion not only reshapes consumption and production paradigms but also exerts a profound influence on governance structures, accountability mechanisms, and institutional policies (Androniceanu *et al.*, 2021; Darusalam *et al.*, 2021; Gouvea *et al.*, 2022; Hartani *et al.*, 2020; Hussain, 2023; Kouladoum, 2022; Liu *et al.*, 2021; Mouna *et al.*, 2020; Suardi, 2021). Advancements in mobile device technology enable both businesses and individuals to communicate. These advancements increase transparency, enhance effective governance, and reduce the menace of corruption (Adam, 2020).

The scope of ICT also deepens different spheres of life, such as cultural, behavioural and social. Epstein *et al.* (2011) also concluded that the digital divide increases income inequality. Due to

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this evidence, Layard (2021) emphasized that income inequality could lead to increased anxiety, tension, stress, and mental depression, and policymakers need to prioritize wellbeing as a criterion. On the contrary, Zhang *et al.* (2014) argued that the Internet provides opportunities to use information in a better way with data availability and data sharing. They also claimed that ICT innovations help provide different services that positively affect individual satisfaction. Sellers and buyers can choose suitable matches by using search engines. People across the world can communicate and interact easily through email, messaging, video calling, texting, social media, and ICT innovations. These things change their feelings, emotions, and sentiments, which influence their subjective wellbeing. Thus, it encourages the use of ICT, which leads to an increase in life satisfaction.

Most research studies have brought attention to happiness and subjective wellbeing under the influence of ICT. Life satisfaction, subjective wellbeing, and material aspirations are also positively affected by TV consumption, as shown in a natural experiment in East Germany (Bruni & Stanca, 2008; Frey *et al.*, 2007; Hyll & Schneider, 2013). On the contrary, Lohmann (2015) argued that ICT has a negative effect, particularly Internet use, on subjective wellbeing. This study used the EU-SILC Survey and World Value Survey data for cross-country analysis. Maurseth (2018) concluded that average happiness is positively related to the ratio of the population of Internet users.

Castellacci & Viñas-Bardolet (2019) argued that Internet technologies increased job satisfaction by enhancing data access, generating new activities, and improving social interactions. They used a bivariate ordered probit model and a hierarchical ordered probit model for cross-country analysis. According to Gupta *et al.* (2019), the impact of ICT advancement on wellbeing is taken into account as the Human Development Index (HDI) using panel fixed-effect modelling. However, Alhassan & Adam (2021) indicated the effect of mobile penetration on the quality of life using data from 114 countries, and applied partial least squares structural equation modelling for results that are not significant on the quality of life.

Recent researchers from various fields, such as Economics and Management, Psychology and Computer Science, have elucidated both the positive and negative impacts of ICT (Internet use, mobile use, broadband use) on life satisfaction and wellbeing. However, the results are multifaceted due to regional, discipline-wise, and societal differences. Gigler (2011) used an alternative evaluation framework by applying Amartya Sen's Capability Approach to study the effects of ICT. He claimed that it enhances the informational capabilities, which improve the social, political, organizational, and cultural dimensions of life. Kavetsos & Koutroumpis (2011) concluded that people with mobile phones, PCs, or Internet access are happier than those who do not have access, based on their analysis of pooled cross-sectional data from

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European countries. Innovations in ICT have a positive relationship with subjective wellbeing (Dolan & Metcalfe, 2012). Katz & Koutroumpis (2013) constructed a digitization index using ICT dimensions and the World Dataset of Happiness for cross-country analysis. They argued that digitization is increasing wellbeing.

In the same stream of research, Graham & Nikolova (2013) explored the relationship between ICT and SWB by using the GWP survey panel data for 2009-2011. Ganju *et al.* (2016) examined the role of ICT on a nation's wellbeing with the inclusion of SWB. This empirical study used pooled data across the country and a fixed-effects model to analyse wellbeing through ICT. They argued that using ICT enhances the wellbeing of a country. Sabatini & Sarracino (2017) checked the relationship between social networking sites, and used SWB as a proxy of utility with instrumental variables. They suggested that a social network service has a positive effect on wellbeing. Kawai *et al.,* (2017) investigated national wellbeing by developing gross national happiness rather than gross national product. It was noticed that economic wellbeing is not capturing equal societal welfare.

A study that captured SWB and progress, undertaken by Maiti *et al.* (2020), used an index constructed by D'Acci (2011) and Stiglitz & Fitoussi (2009) to measure the wellbeing and progress in 67 countries, taking into account satisfaction, with six major variables: (1) economic wellbeing; (2) human wellbeing; (3) human progress; (4) cultural progress; (5) environmental wellbeing; and (6) subjective wellbeing through ICT exposure. They employed standard instrumental variable regression methods and simultaneous equation modelling to determine the relationship between them. Their findings showed that ICT exposure enhanced the aggregate level of wellbeing and progress during 2000-2014. The effects of ICT exposure were found to be lesser in developing countries than in developed countries. Contrarily, Aldieri *et al.* (2021) investigated the negative impact of social innovation on subjective wellbeing. They used the instrumental variables regression technique to analyze the results and utilized Veenhoven survey data as a measure of SWB.

The literature survey demands an empirical investigation of the impact of ICT by incorporating all aspects of wellbeing and development, due to its mixed findings. The above studies mostly covered only one dimension, either subjective or objective. Fewer studies in the literature analyse the overall impact of ICT empirically. Researchers reveal a significant role of ICT in economic progress, but the aspect of wellbeing in the context of ICT is often ignored, especially in the case of its subjective nature, and researchers did not use multiple dimensions of ICT.

Currently, various metrics of wellbeing have been examined in the literature for the impact of technologies, but the impact of ICT on SWB has not been explored at the cross-country level. Previous studies have primarily relied on past surveys that capture only one dimension of

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happiness, such as positive feelings, but they tend to overlook the adverse impact. Several indices have been developed by international organizations to measure subjective wellbeing but have failed to capture progress over time. Therefore, this study aims to fill this gap by addressing both dimensions of wellbeing using a proxy for subjective wellbeing and considering multiple dimensions of ICT.

Empirical Framework

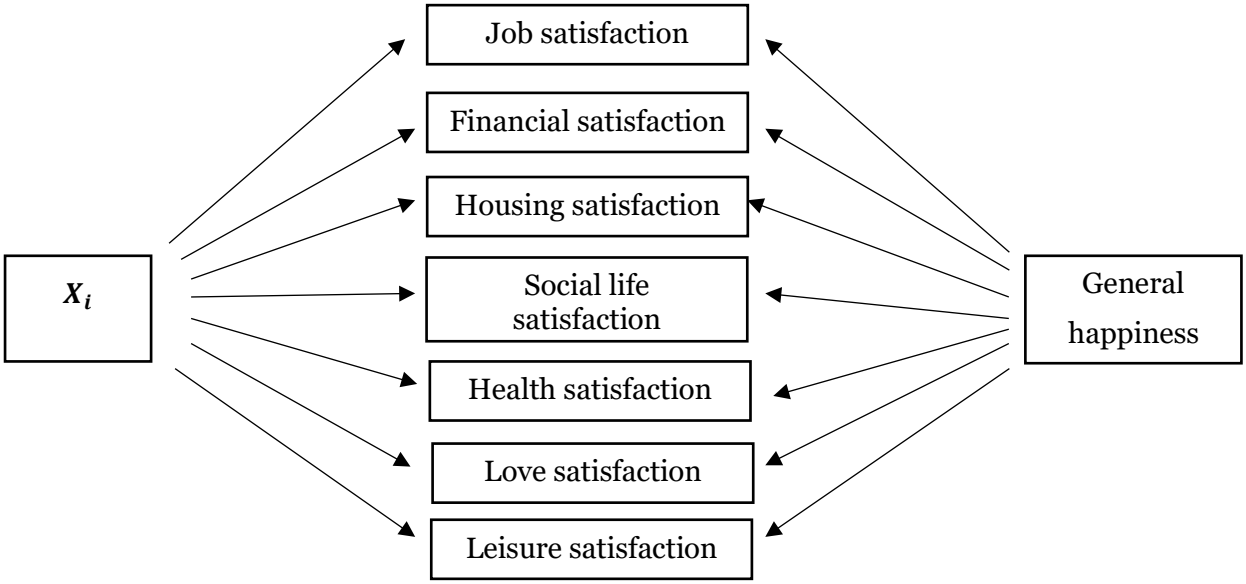

Figure 1. The nexus between observable factors and general happiness (Aldieri *et al.*, 2021)

In this section, we develop a theoretical framework that supports our empirical analysis. The various secondary analyses attempt to identify the factors that contribute to an increase or decrease in happiness, which econometricians refer to as explanatory variables. Various domains of life that are highlighted by Van Praag & Ferrer-i-Carbonell (2011) provide individuals with general happiness directly. When questions are asked to respondents about their life satisfaction, they go into a thought process as to "how satisfied I am with marriage, health, income, job, and social interaction". For overall evaluation, we have to sum the different dimensions of life with each other. In line with Van Praag & Ferrer-i-Carbonell (2011), SWB is chosen from the World Gallup Poll survey which includes different dimensions of life satisfaction. Figure 1 depicts the general happiness by observable factors X_i.

The utility function of individual j at time t is assumed to be the following:

$$U_{jt} = U\left(SWB_{jt}, SWB_{jt-1}, I_{jt}, \frac{I_{jt}}{I_t}, S_t, S_{t-1}\right) \quad (1)$$

The description of variables is as follows:

I_{jt}= Consumption of individual

$\frac{I_{jt}}{I_t}$=Average level of consumption of all individuals

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S_t = Socioeconomic measures in developed countries at a time

SWB_{jt} = Subjective wellbeing indicator derived from satisfaction factors

Due to the pro-cycling behaviour of consumption and economic development measures, we can conjecture that:

$$I_{jt} = I_{jt}\ (ICT_t) \tag{2}$$

$$S_t = S_t\ (ICT_t) \tag{3}$$

where ICT is the impact of ICTs on socio-economic measures, so equation (1) can be converted as follows:

$$U_{jt} = U\ [SWB_{jt}, SWB_{jt-1}, I_{jt}\ (ICT_t\ ), I_{jt-1}(ICT_t), S_t(ICT_t),\ S_{t-1}(ICT_t)] \tag{4}$$

From the above equation, we can easily derive the following equation:

$$D.SWB_{jt} = f(D.SWB_{jt-1};\ \mathrm{D}.ICT_t;\ D.ICT_{t-1}) \tag{5}$$

The relationship in equation (5), where "D." denotes change, we are going to test in the next section by using an econometric model.

Data and Methodology

Variables and data source

This study investigates panel data spanning 14 years, from 2006 to 2019, to analyse ICT as a determinant of happiness. This study includes 40 countries based on higher SWB; the list of countries is given in Appendix Table 1. Various international organizations, institutions, and scholars have presented different indicators measuring progress, development, and social wellbeing. Among the most famous indicators are the Human Development Index (HDI), the Genuine Progress Indicator (GPI), the Index of Sustainable Economic Welfare (ISEW), the Gross National Happiness (GNH), the Quality-of-Life Index, the Life Quality Index (LQI), and the Happy Planet Index (HPI), as well as the Economic Performance and Social Progress (OECD Index). We utilize world Gallup Poll survey data as a measure of subjective wellbeing. Variables are employed to construct indices with similar categorizations (D'Acci, 2011; Ganju *et al.*, 2016; Maiti *et al.*, 2020). This study examines the SWB of people at the cross-country level in five major areas: economic, institutional, human wellbeing, environmental, and ICT. Variables and data sources are provided in Table 2.

Construction of indices

Using the global min-max approach for the construction of indices, all the variables used here are first normalized, then combined, and given equal weights. There is no justification for not

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allocating equal weights, because a similar weighting approach is also used by the United Nations Development Programme (UNDP). Here, an effort is made to determine the elements that show the relationship among subjective wellbeing, human progress, environmental progress, governance, and economic wellbeing.

Economic Development: Economic development depends on a country's productivity and income, which, in turn, affects an individual's feelings and psychological wellbeing. A higher income enables a person to fulfil their desires in alignment with their preferences, fostering a happier attitude and a zest for life. This is why GDP per capita is used as a proxy. However, income distribution is not equal among people, leading to income inequality at the national level and heightened social tension. Consequently, social tension is determined by the Gini coefficient. Acemoglu & Restrepo (2018) argued that unemployment also contributes to social tension and inversely affects wellbeing. To combine these three variables reflecting economic development, a simple arithmetic average with equal weights is used.

Governance: The vital connection between happiness and government has been overlooked in the literature. Governments and institutions have a significant influence on individuals' lives. Therefore, the government effectiveness index, as taken by world governance indicators, is also included.

Human Progress: Health is the most prominent determinant of human wellbeing. People who lead healthier lives can move anywhere to enjoy their lives and feel better than those who are not physically or mentally fit. Life expectancy is considered a proxy for human wellbeing.

Environmental Progress: The environment is crucial for humans, and factors such as pollution, weather, and climate change can all impact how they feel. Environmental change also determines sustainable development, which increases individuals' satisfaction. The consumption of renewable resources as a percentage of total energy consumption is the most prominent indicator. Additionally, a large emission of CO2 leads to a worse and suffocating environment. Greenery also attracts human beings and creates a friendly environment, and forest cover is used as a proxy for the environmental index. It is constructed using the same methodology as an economic development index.

Information and Communication Technology: Today, ICT plays an important role in reducing anxiety and loneliness through its applications. It also has the power to change one's mood and overall quality of life, expanding the social circles of human beings. It connects people who are geographically separated and can even inspire societal unrest through privacy and cyber risks. SWB is determined through a questionnaire conducted by the World Gallup Poll, covering all aspects of an individual's life. The objective of these questions is to assess an individual's psychological wellbeing in comparison to their peers and the historical and

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contemporary contexts. The impact of ICT on subjective wellbeing is discussed in previous sections and, now, an empirical investigation is required. Due to the lack of long-term data availability, the ICT index is associated with and prepared using four variables, as follows:

1. Mobile Cellular subscriptions (per 100 people);
2. Internet users (per 100 people);
3. Fixed broadband subscriptions (per 100 people);
4. Fixed telephone subscriptions (per 100 people).

First, these variables were used to construct the ICT index. Ganju *et al.* (2016) used the same variables, and Maiti *et al.* (2020) also employed them, albeit without fixed broadband subscriptions. Further, the ICT exposure index was developed using Principal Component Analysis, as detailed in the work by Hanafizadeh *et al.* (2009) on ICT index construction.

Evidently, there is a significant disparity in all ICT indicators across countries over time in the above literature. Mobile cellular subscriptions substantially increased in all countries. Mobile cellular subscriptions in the UAE reached their peak in 2016. Fixed telephone subscriptions began to decline due to the increasing prevalence of mobile cellular subscriptions over time. The groups of Internet users and fixed broadband subscriptions have also witnessed significant improvements. An integrated index was developed by combining all these variables after normalizing them with the global min-max method and assigning equal weights. The scale of the ICT index ranges from 0 to 1, with a higher value indicating greater ICT exposure. It is worth noting that Switzerland reached its peak in 2016. Remarkably, ICT exposure is on the rise in all the data sets of sample countries.

Econometric model

We create the following function to undertake empirical estimation of the relationship between the variables:

$$SWB = f\ (Governance, Human\ wellbeing, Economic\ development, Environment, ICTs)$$

Here, subjective wellbeing is measured by the happiness index (ladder wellbeing), which is a function of ICT measured by mobile cellular subscriptions, fixed telephone subscriptions, fixed broadband subscriptions and Internet users, and other variables like life expectancy at birth, effective governance, economic development and environmental indices, which are expected to be linked to SWB. To analyze the relationship between SWB and its explanatory variables, the given generalized panel ARDL (p, q,..., q) model according to Pesaran *et al.,* (1999) is constructed:

$$SWB_{it} = \sum_{j=i}^{p} \delta_{it}\, SWB_{it-1} + \sum_{j=0}^{q} \gamma_{ij}\, X_{it-j} + \mu_i + \varepsilon_{it} \quad (6)$$

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where SWB_{it} indicates the dependent variable for group i and X_{it} $(K \times 1)$ is the vector of explanatory variables for group i, γ_{ij} are (k × 1) coefficient vectors, δ_{it} are the coefficients of the lagged dependent variables and scalars; groups are denoted by $i = 1, 2, \dots, 40$; time periods by $t = 2006 - 2019$; whereas μ_i represents the fixed effects and $\boldsymbol{\varepsilon_{it}}$ shows an error term. The following specified re-parameterized model in error correction form is convenient to work with to reduce heteroskedasticity and multicollinearity:

$$\Delta SWB_{it} = \theta_i\left(SWB_{it-1} + \beta'_i X_{it}\right) + \sum_{j=i}^{p-1} \delta_{ij}^{*} \Delta SWB_{it-j} + \sum_{j=i}^{p-1} \gamma'_{ij} \Delta X_{it-j} + \mu_i + \varepsilon_{it} \qquad (7)$$

where $\Delta SWB_{it} = (SWB_{it} - SWB_{it-j})$,

$$\theta_i = -\left(1 - \sum_{j=0}^{p} \delta_{ij}\right), \qquad \beta_i = \left(\sum_{j=0}^{q} \gamma_{ij}\right),$$

$$\delta_{ij}^{*} = -\left(\sum_{m=j+1}^{p} \delta_{m+1}\right), \qquad \gamma_{ij}^{*} = -\left(\sum_{m=j+1}^{q} \gamma_{m+1}\right).$$

This study uses Pesaran *et al.*, (1999) to construct an empirical model. The following Error Correction Model (ECM) is constructed based on variables using Equation (7).

$$\Delta SWB_{it} = \theta_i\left[SWB_{it-1} + \beta_{i,1} EG_{i,t-1} + \beta_{i,2} LEB_{i,t-1} + \beta_{i,3} EDI_{i,t-1} + \beta_{i,4} EI_{i,t-1} + \beta_{i,5} ICT_{i,t-1}\right] + \sum_{k=0}^{p-1} a_{ij}\, SWB_{it-j} + \sum_{k=0}^{p-1} b_{ij}\, EG_{it-k} + \sum_{k=0}^{p-1} c_{ij}\, LEB_{it-k} + \sum_{k=0}^{p-1} d_{ij}\, EDI_{it-k} + \sum_{k=0}^{p-1} e_{ij}\, EI_{it-k} + \sum_{k=0}^{p-1} f_{ij}\, ICT_{it-k} + +\mu_i + \varepsilon_{it} \qquad (8)$$

where $i = 1, 2, \dots, 40$; time periods by $t = 2006 - 2019$. The variables SWB, EG, LEB, EDI, EI, and ICT represent subjective wellbeing, effective governance, life expectancy at birth, economic development index, environmental index, and information and communication technology exposure index, respectively. The $\beta_{i,1}$, $\beta_{i,2}$, $\beta_{i,3}$, $\beta_{i,4}$, and β_{i5} are the long-run coefficients; a_{ij}, b_{ij}, c_{ij}, d_{ij}, $e_{ij,}$ and f_{ij} are the short-run coefficients; μ_i is the state effect; ε_{it} is the error term, and θ_i is the error correction term. As to the PMG technique and related theory of inference process, kindly refer to Pesaran *et al.* (1999).

Results and Discussions

To analyse the data, both descriptive and inferential techniques are used. The results of both techniques are included below with pertinent analysis.

Descriptive analysis

SWB is used as a dependent variable in these analyses. Independent variables are EG, LEB, EDI, EI, and ICT, respectively. A set of descriptive results are given in Table 3.

The mean value of SWB is 6.63, with an estimated standard deviation of 0.72 for all 40 countries over 14 years from 2006 to 2019. The minimum value of SWB was 4.38 for Serbia in

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2009, representing the lowest SWB in the entire dataset, while the maximum value was 7.99 for Malta in 2006, indicating the highest SWB within it.

The mean values of the variables used in the ICT index are 120.61, 34.1, 67.979, and 23.43, with estimated standard deviations of 25.049, 14.7, 21.897, and 11.656 for mobile cellular subscriptions, fixed telephone subscriptions, Internet users, and fixed broadband subscriptions, respectively. The minimum values for mobile cellular subscriptions, fixed telephone subscriptions, Internet users, and fixed broadband subscriptions are 33.224, 4.862, 3.268, and 0.196 in the countries Costa Rica (2006), Finland (2019) and Kazakhstan (2006), respectively. The maximum values for mobile cellular subscriptions, fixed telephone subscriptions, Internet users, and fixed broadband subscriptions are 212.64, 67.33, 99.15, and 46.82 in the countries UAE (2016), Switzerland (2006), UAE (2019), and Switzerland (2019), respectively.

The mean values of the variables used in the Economic Development Index are 31,397.862, 7.164, and 35.150, with estimated standard deviations of 23,406.188, 3.795, and 7.652 for GDP per capita, the unemployment rate, and Gini, respectively. The minimum values of GDP per capita, the unemployment rate, and Gini are 3,261.76, 1.64, and 23.20 in the countries of El Salvador (2006), the UAE (2016), which showed the lowest unemployment, and the Slovak Republic (2017), respectively. The maximum values of GDP per capita, the unemployment rate, and Gini are 112,37, 26.09, and 55.60 in the countries of Luxembourg (2007), Spain (2013), and Brazil (2006), which has the lowest income inequality, respectively.

The mean value of effective governance is 1.022 with an estimated standard deviation of .74 for all 40 countries over 14 years from 2006 to 2019. The minimum value of effective governance for the whole data set is -.76 for Guatemala in 2012, which has the lowest effective governance, and the maximum value is 2.35 for Denmark in 2007, which has the highest effective governance. The mean value of life expectancy at birth is 78.518 with an estimated standard deviation of 3.522 for all 40 countries over 14 years from 2006 to 2019. The minimum value of life expectancy at birth for the whole data set was 66.15 for Kazakhstan in 2006, which has the lowest life expectancy rate at birth, and the maximum value is 83.75 for Switzerland in 2018, which has the highest life expectancy at birth.

The mean values of variables used in the environmental index are 7.633, 31.477, and 20.420 with estimated standard deviations of 4.918, 18.117, and 16.256 for carbon dioxide emissions metric tons per capita, forest area to land area, and renewable energy consumption to total energy consumption, respectively. The minimum values of carbon dioxide emissions in metric tons per capita, forest area to land area, and renewable energy consumption to total energy consumption are 0.803, 1.094, and 0.1018 in countries Guatemala (2010), Malta (2006) and UAE (2012), respectively. The maximum values of carbon dioxide emissions in metric tons per

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capita, forest area to land area, and renewable energy consumption to total energy consumption are 24.834, 73.736, and 67.442 in countries Luxembourg (2006), Finland (2015), and Guatemala (2012), respectively.

Inferential analysis

In inferential analysis, statistical estimation is done on the pre-defined econometric model in this study, which is explained previously, and econometric results are appended below.

Econometric results and panel data estimation

The sequence of tests listed below is given for an estimate of the panel dataset. In this section, we compare the Pooled Mean Group (PMG), Mean Group (MG), and Dynamic Fixed Effects (DFE) estimation results.

Test for multi-collinearity

The primary concern of econometric analysis is to determine whether there is multicollinearity among the independent variables. To check for multicollinearity, we calculate the variance inflation factors (VIFs) for the independent variables. Table 4 displays the VIF results for investigating multicollinearity. The selected variables in the set indicate that there is no multicollinearity. According to Damodar Gujarati (2022), if the VIF value is less than 5, multicollinearity is not a problem. However, in general, it should not exceed 10.

Unit root test

Before examining the inferential relationships among the variables, it is essential to assess the time-series properties of these variables. This step ensures the accurate application of the panel ARDL method, which is appropriate for variables that are purely I(0) and I(1), but not for I(2) variables (Pesaran *et al.* 2001). The Im *et al.* (2003) panel unit root test was performed to check the stationarity properties of variables. The Im-Pesaran-Shin (IPS) unit-root test results show that LEB_{it} is stationary at level. Table 4, Panel (b) indicates that $SWB_{it}, EG_{it}, EDI_{it}, EI_{it}$, and ICT_{it} exhibit stationarity at the first difference, suggesting that they are I(1) variables based on the IPS panel unit root test.

Hausman test

The Hausman test is performed to select the best option between PMG and MG estimators and then also between PMG and DFE based on consistency and efficiency properties. The results are given in Table 5. PMG, MG, and DFE are compared having the null hypothesis for the final decision. The result shows that PMG is preferred, because the p-value is >0.05 and the null hypothesis is accepted. In this case, if we perform MG or DFE, it generates biased estimators.

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Comparison of PMG, MG, and DFE with long-run and short-run estimations

The methodologies of PMG, MG, and DFE are used for estimating and presenting the results, which are shown in Table 5. Among these three, the PMG technique examines the final results. The benefit of using this technique is its ability to determine both long-run and short-run results, as well as long-run equilibrium. It exhibits low collinearity, greater efficiency, and a higher degree of freedom. PMG accounts for a lower degree of heterogeneity and assumes homogeneity in the long-run coefficients.

However, it allows for short-run coefficients and error variances in the presence of heterogeneity. This flexibility permits long-run homogeneity for groups and explanatory variables. The MG approach is highly sensitive to outliers, but PMG is less sensitive. Based on these arguments, the PMG technique is considered the best for investigating the relationship between SWB and regressors in dynamic heterogeneous panel models. The results show that ICT diffusion, life expectancy at birth, economic development, and effective governance have statistically significant relationships with SWB in the long run with PMG estimation, but all regressors are insignificant except for effective governance in the DFE long-run model.

ICT_{it} affects subjective wellbeing (SWB_{it}) positively in the long run at a 1% significance level, as well as in the short run at a 10% significance level, and it is significant in the case of PMG. Social innovations increase ICT exposure day by day and influence various domains of life. Thus, ICT diffusion and exposure increase the happiness margin for the people in sample countries and the need to explore more forums of ICT. The reasons behind the positive relationship between ICT_{it} and SWB_{it} include connectivity, access to information, the ability to work remotely to improve living standards, and opportunities for entertainment and leisure.

The short-run results also affirm this. The reason is that those people who did not have ICT goods before experience a change in their standard of living as they gain access to the new ICT technology and goods. Consequently, ICT increases the happiness of people living in sample countries. To delve deeper, a 1% increase in ICT diffusion results in a SWB upsurge of around 125% in the long run and 255% in the short run. These results are consistent with previous studies (Castellacci & Tveito, 2016; Castellacci & Viñas-Bardolet, 2019; Ganju *et al.*, 2016; Maiti *et al.*, 2020; Rotondi *et al.*, 2017; Sabatini & Sarracino, 2017). Short-run results in Table 5 show that the error correction term(θ_i) is significant at a 1% level, but all variables in the three models are insignificant, except ICT_{it} and LEB_{it} at 10% and 5% level, respectively.

Estimations show that the environmental index (EI_{it}) is insignificant in both the short run and the long run. The reason is that all countries are capitalistic and do not focus on an environmental situation that has a very high opportunity cost for human beings (O'Mahony,

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2021). It also includes individual differences, cultural factors, and the specific aspects of the environment being considered (Diener *et al.*, 2009).

The slope coefficient of effective governance (EG_{it}) is negative, which means that effective governance restrains the happiness of individuals living in the sample countries. There are two types of arguments in the case of effective governance. First, the people in developed and higher SWB countries do not like government intervention. As the government becomes more effective, there will also be an upsurge in government intervention. This will decrease freedom and personal opinion, which is consistent with this study. Consequently, happiness decreases as effective governance rises. The contrary argument is that, as effective governance increases, it leads to higher GDP and societal welfare. Ultimately, it will lead to increased happiness (Cárcaba *et al.*, 2022; Helliwell & Putnam, 2004).

The most interesting aspect of the estimation is life expectancy at birth (LEB_{it}), which exerts a positive impact on SWB_{it} in the long run but harms SWB_{it} in the short run. The reason is an individual's expectation about their life when thinking about it in the long run. It will increase SWB_{it}, but life expectancy at birth has negative results in the short run due to short-term shocks, such as calamities, epidemics, and natural disasters.

Economic development (EDI_{it}) also has a positive impact on happiness. Income is the subject of debate due to the happiness paradox (Easterlin *et al.*, 2010; Stevenson & Wolfers, 2008). GDP yields positive results in this research due to high-income countries and also highlights the issue of inequality and the unemployment rate. However, economic development is insignificant in the short run. These results are consistent with previous studies (Delhey & Dragolov, 2014; Layte, 2012; Oishi *et al.*, 2011).

Conclusion and Policy Implications

The empirical relationship between happiness and ICT has not been explored extensively yet, but our research contributes to the literature. ICT diffusion is very complicated, both in terms of its spread and depth, due to its ubiquity. We demonstrate the positive impact of ICT on SWB resulting from an increase in mobile phone subscriptions, fixed broadband subscriptions, telephone subscriptions, and Internet use. Moreover, we also show the impact of effective governance on SWB, which follows an inverse direction due to an increase in government interventions. Estimates indicate that the environmental index has a negligible impact in both the short and long term due to the universal adoption of capitalism across all countries. This results from the prioritization of economic opportunities over environmental concerns, as highlighted by O'Mahony (2021).

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On the other hand, SWB is positively affected by economic development and human progress, as evidenced by an increase in GDP per capita and life expectancy at birth. We anticipate that the information systems research community will be able to gather an appropriate set of ICT knowledge to examine these issues.

The policy implications of the study, in line with the estimated results, are as follows: the results of this study are very beneficial to policymakers because they provide information on ICT diffusion leading to wellbeing. Therefore, policymakers should formulate policies that promote wellbeing instead of adopting a traditional approach. The governments of the sample countries should make decisions and rules that enhance the happiness of individuals through government effectiveness and minimal intervention in their lives. Sample countries should focus more on the health sector for human progress, because it increases individual happiness.

Research Implications

Since ancient Greek philosophy, the concept of wellbeing has been complex and has evolved in each era due to differences in the domains of life that are subject to change in the future, as discussed by philosophers, such as Aristotle, Plato, Socrates, and Kahneman *et al.* (1999). Because of this ambiguity, ICT could potentially play a significant role in research on information and wellbeing. This research explores the positive impact of ICT diffusion on subjective SWB. It is important to note that, in this study, the impact of ICT diffusion is found to be positive, but there is also the possibility of a negative effect on society. For instance, one argument is that ICT may lead to an increase in unemployment due to a reduced demand for unskilled workers. Additionally, it could contribute to increased wage inequality (Acemoglu & Restrepo, 2018). Moreover, it posits a negative effect stemming from differences in ICT diffusion.

Limitations and Suggestions for Future Research

ICT diffusion shows a direct relationship with subjective wellbeing but some limitations still exist. First, there may be some omitted variables that drive the results. Unobserved variables may be included in the research. In this study, we used the PMG (ARDL) technique, but the researcher can use additional econometric specifications, such as a slope homogeneity test and a cross-sectional dependence test. Second, we use only four dimensions of ICT, namely mobile cellular subscriptions, fixed broadband subscriptions, Internet use, and telephone subscriptions. But our ICT index does not include other dimensions of ICT, such as secure Internet servers. Future researchers could include the other dimensions of ICT in this innovative world.

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The other limitation is that the majority of countries in the sample are European. Europe's population constitutes less than 10% of the global population. We suggest that future researchers would increase the sample size based on population. We hope that this evidence of ICT as a determinant of happiness will pave the way for future researchers to show how ICT enhances the subjective wellbeing of people across countries. This study analyses the cross-country effects of ICT diffusion on SWB; a similar individual-level analysis is also possible.

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Appendix

Table 1. List of Sample Countries

Sr.	Country	Sr.	Country	Sr.	Country	Sr.	Country
1	Australia	11	Estonia	21	Malta	31	United Arab Emirates
2	Austria	12	Finland	22	Mexico	32	United Kingdom
3	Belgium	13	France	23	Netherlands	33	United States
4	Brazil	14	Germany	24	Norway	34	Uruguay
5	Canada	15	Guatemala	25	Panama	35	El Salvador
6	Chile	16	Ireland	26	Slovak Republic	36	Kazakhstan
7	Costa Rica	17	Israel	27	Slovenia	37	Poland
8	Cyprus	18	Italy	28	Spain	38	Romania
9	Czech Republic	19	Lithuania	29	Sweden	39	Serbia
10	Denmark	20	Luxembourg	30	Switzerland	40	Mauritius

Table 2. Measures and Indicators

Variable	Definition	Indicators/Scale/Source
EDI	Economic Development Index	GDP per Capita Unemployment rate Gini coefficient
		Source: World Development Indicators (WDI)
ICT	Information communication and technology exposure index	Mobile Cellular subscriptions (per 100 people) Internet users (per 100 people) Fixed broadband subscriptions (per 100 people) Fixed telephone subscriptions (per 100 people)
		Source: World Development Indicators (WDI)
EI	Environmental Index	a) Carbon dioxide emissions in metric tons per capita b) Forest Area to Land Area c) Renewable energy consumption to total energy consumption
		Source: World Development Indicators (WDI)
EG	Effective Governance	Scale: -2.5 to 2.5 (weak – strong) governance Source: The Worldwide Governance Indicators (WGI)
LEB	Life expectancy at birth, years	Source: World Development Indicators (WDI)
SWB	Subjective Wellbeing	Source: Gallup World Poll, shared in World Happiness Report (2021). Scale: 1–10

Table 3. Descriptive Statistics

Variable	Observation	Mean	Standard Deviation	Minimum	Maximum
Effective Governance	560	1.022	.74	-.76	2.35
GDP per capita	560	31397.862	23406.188	3261.764	112373
Unemployment rate	560	7.164	3.795	1.64	26.09
Gini	560	35.15	7.652	23.2	55.6
Life expectancy at birth	560	78.518	3.522	66.15	83.754
CO2 emissions metric tons per capita	560	7.633	4.918	.803	24.834
Forest area to land area	560	31.477	18.117	1.094	73.736
Renewable energy consumption	560	20.42	16.256	.102	67.442
Mobile cellular telephone subscription	560	120.61	25.049	33.224	212.639
Fixed telephone subscription	560	34.1	14.7	4.862	67.334
Internet users %	560	67.979	21.897	3.268	99.15
Fixed broadband subscription	560	23.43	11.656	.196	46.82
Subjective wellbeing	560	6.625	.7206	4.38	7.989

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Table 4. Diagnostic Tests

Panel (a): Investigating multicollinearity			**Panel (b): Im-Pesaran-Shin unit-root test stationary Test (IPS)**		
Variables	VIF	$1/VIF$	Statistics $W\text{-}t\text{-Bar}$		
EG_{it}	3.762	.266	Variables	At level	At first level
LEB_{it}	3.353	.298	SWB_{it}	-1.1438	-9.1378***
EDI_{it}	3.171	.315	EG_{it}	-1.2597	-7.2594***
EI_{it}	2.034	.492	LEB_{it}	-4.6447***	---
ICT_{it}	1.126	.888	EDI_{it}	-0.1436	-5.9349***
Mean VIF	2.689	-	EI_{it}	1.9502	-6.5082***
			ICT_{it}	0.9118	-8.6319***
*** shows the level of 1% statistical significance.					

Table 5. A Comparison of MG, DFE, and PMG

	Coefficients		
	MG	**DFE**	**PMG**
	Long Run Parameters		
$\boldsymbol{EG_{it}}$	2.145 (1.664)	.4654*** (0.196)	-.4139*** (.117)
$\boldsymbol{LEB_{it}}$	22.421 (1.664)	0.614 (0.728)	1.0501*** (.468)
$\boldsymbol{EDI_{it}}$	-7.141 (17.750)	-0.552 (0.590)	2.392*** (.352)
$\boldsymbol{EI_{it}}$	-10.392 (36.875)	0.781 (0.679)	.1503 (.3705)
$\boldsymbol{ICT_{it}}$	-31.725 (19.612)	0.008 (0.394)	1.256*** (.2484)
	Average Convergence Parameter		
$\boldsymbol{\theta_i}$	-1.165*** (0.306)	-0.495*** (0.040)	-.497*** (.0724)
	Short Run Parameters		
$\boldsymbol{\Delta EG_{it}}$	-0.188 (1.171)	-0.065 (0.132)	.0936 (.1817)
$\boldsymbol{\Delta LEB_{it}}$	-408.935 (403.750)	-1.260 (0.851)	-42.431** (20.3001)
$\boldsymbol{\Delta EDI_{it}}$	22740.260 (67157.680)	-0.064 (0.447)	-13234.58 (15305.41)
$\boldsymbol{\Delta EI_{it}}$	13.526 (18.469)	-0.439 (0.583)	-18.107 (16.7115)
$\boldsymbol{\Delta ICT_{it}}$	15.530 (19.867)	0.572 (0.484)	2.551* (1.4485)
C	25.215 (1956.978)	2.824*** (0.364)	-558.429 (610.105)
$(\text{Hausman})_{\text{PMG/MG}}$		**$(\text{Hausman})_{\text{PMG/MG}}$**	
H_0: PMG H_1: DFE	$\chi^2(5) = -154.15$	H_0: PMG H_1: DFE	$\chi^2(5) = 0.02$
Prob.>χ^2=0.7342		Prob.>χ^2= 01.000	
Remarks		**PMG is efficient & consistent**	
Note: Standard errors of parameters are given in parentheses. *** Significant at 1%, ** Significant at 5%, * Significant at 10%. θ_i is the error correction term			

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