



Innovating for Growth: Green Technology and ICT Integration in G7 Economies towards Sustainability

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ABSTRACT

The paper entitled "Innovating for Growth: Green Technology and ICT Integration in G7 Economies towards Sustainability," employs panel data spanning from 1992 to 2023 for the G7 nations (Canada, France, Germany, Italy, Japan, the UK, and the USA) to analyse the complex interactions between independent variables and the Human Development Index (HDI). The approach utilizes quantile regression methods to reveal differential effects across several stages of growth and development. The findings indicate that the diffusion of environmental technology adversely affects HDI at lower quantiles, suggesting little advantages in underdeveloped settings owing to infrastructure deficiencies and limitations on resources. In contrast, ICT infrastructure continuously exhibits positive benefits across all quantiles, especially in advanced countries, highlighting the significance of ICT as a crucial catalyst for economic advancement and human development. Furthermore, the widespread use of green energy. Favors the Human Development Index (HDI) at elevated quantiles, strengthening sustainable development objectives. The data also illustrates that internet usage substantially improves HDI, particularly in lower quantiles, underscoring the significance of connection to education possibilities. The validity of these results is substantiated by meticulous verification using several regression methodologies, affirming the inferences derived from the first research. The analysis proposes that G7 countries embrace policies to advance green technology, enhance ICT infrastructure, and encourage renewable energy use as essential tools to boost human development. The research underscores the need to match technical breakthroughs with regional needs to ensure the successful execution and optimization of outcomes spanning every stage of transformation.

Keywords: Green Technology, Sustainability, ICT Integration, HDI, G7 Economies.

JEL Codes: O33, Q55, C21, O57

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1. INTRODUCTION

Integrating Information and Communication Technology (ICT) with green technology is essential for sustainable economic progress in the modern global atmosphere (Balsalobre-Lorente, Nur, Topaloglu, and Pilař 2024). This collaboration is particularly vital for G7 economies—Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States—since they lead in global income generation and technological innovation. Utilizing their capital, experience, and international standing, these countries are distinctly equipped to spearhead the development of environmentally friendly approaches that tackle global warming, bolster financial stability, and elevate the standard of life (Balsalobre-Lorente, Nur, Topaloglu, and Pilař 2024). The function of ICT for economic advancement, the dissemination of environmentally conscious technology, investing in green energy, and smart city projects among the G7 countries provide a framework for sustainable growth while tackling economic and environmental goals (Elfaki and Ahmed 2024).

ICT service exports are crucial for economic development since they enhance global connection, lower transaction costs, and foster commerce and innovation. The above services include applications for cloud computing, information data analysis, and other internet-based services that enable organizations to function more effectively and broaden their market share. (Naeimah Benlaria 2023) ICT service exports considerably enhance economic development by reducing firms' obstacles to engaging with foreign markets and optimizing their businesses. Improved connection generates employment and promotes economic growth, particularly in industries where technological advancement is essential. This is especially pertinent for G7 countries, whose sophisticated ICT infrastructure and service exports enhance their competitive advantage in international marketplaces, enabling them to maintain leadership in economic development.

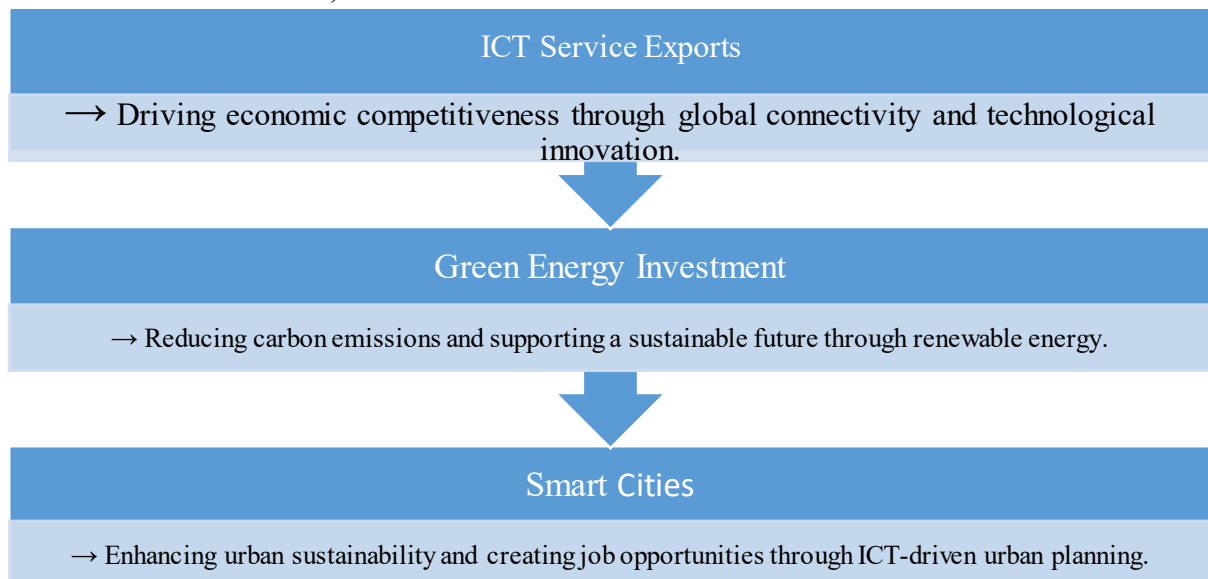
The spread of environmental technology, quantified by metrics such as the Environmental Technology Diffused Index (ETDI), is essential for sustainable development, facilitating the implementation of environmentally friendly innovations like solar and wind power, resource-efficient procedures, and pollution prevention strategies (Bozatli and Akca 2023). In reaction to escalating environmental issues, G7 countries have spearheaded the creation and distribution of green technologies that promote environmentally friendly behaviors across sectors and diminish carbon emissions. By establishing criteria for sustainable behaviors, G7 nations impact worldwide initiatives to combat environmental degradation through agreements such as the Paris Agreement. Using technological diffusion, they may illustrate the advantages of embracing sustainable practices and provide examples and tools for other nations to emulate, thus enhancing the worldwide shift towards more environmentally friendly economies (F. Wang, Rani, and Razzaq 2023).

Investing in energy from sustainable sources—such as wind, solar energy, and hydropower authority—is a crucial strategy for diminishing dependence on energy sources such as coal and addressing global warming (Feng, Zhang, and Li 2022). The G7 economies can spearhead green energy projects, generating a beneficial ripple effect as other nations embrace analogous techniques. These expenditures promote energy autonomy, stabilize businesses versus volatile energy costs, and foster environmentally friendly growth (Charfeddine and

Kahia 2019). Moreover, green energy projects have economic and social advantages, such as job development in burgeoning energy industries, technical advancement, and improved energy stability. The growing cost and flexibility of renewable energy supplies provide them practical alternatives to conventional sources, benefitting a more comprehensive array of interested parties and tackling environmental concerns (S. Wang, Zhao, and Razzaq 2022).

Internet use and digital connection are essential to the economic and social advancement of G7 countries. Extensive internet usage enhances operational efficiency, bolsters online shopping, and fosters digital competence, generating new trade and data-sharing avenues(W. Chen et al. 2024). Digital connection fosters an educated society and promotes sustainable behaviors, enhancing the popularity of green initiatives and facilitating the exchange of information on environmental sustainability (L. Wang and Shao 2024). For G7 countries, a robust digital infrastructure supports research and development (R&D) in green technology, enabling the broader implementation of environmentally friendly procedures and solidifying their status as pioneers in global environmental initiatives (Elfaki and Ahmed 2024).

Accelerated urbanization in G7 countries poses both difficulties and possibilities for equitable growth. As urban populations increase, their appetite for assets, facilities, and public amenities increases (Qiuqiu Ma 2023). (Balsalobre-Lorente et al. 2023a) This trend propels the execution of innovative city programs that amalgamate information and communication technology with sustainable solutions to tackle urban issues such as traffic jams, garbage disposal, and reliance on energy. Using intelligent technology, G7 economies may develop green urban environments that improve citizens' quality of life and diminish adverse environmental effects. By optimizing resources, reducing contamination, and managing urban systems efficiently, G7 countries can convert urban issues into the potential for long-term sustainability, demonstrating the viability of ecologically aware communities (Aleksy Lyulyov Oleksii Pimonenko 2023).



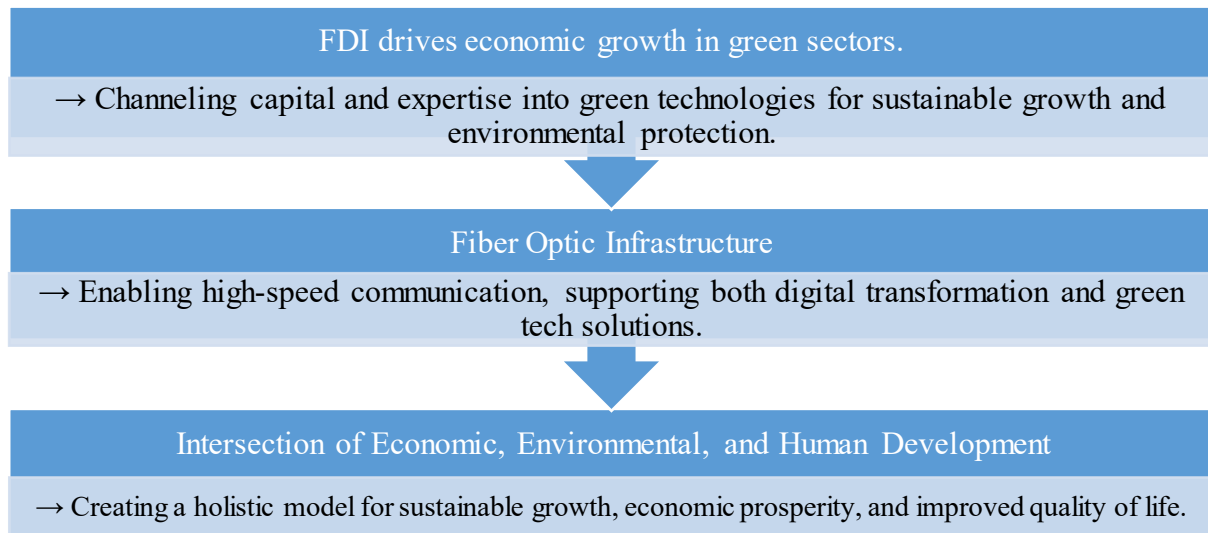
Foreign Direct Investment (FDI) is a significant global growth and technical progress driver. Foreign Direct Investment (FDI) in G7 countries propels long-term expansion by introducing cash, expertise, and innovation from international source(Mengzhen Ding Xingong Choi 2023)s. Investing in energy conservation, green technology, and environmentally conscious

buildings facilitates the environmental transformation of sectors, encouraging eco-friendly activities and diminishing carbon emissions. Foreign Direct Investment in high-tech sectors enhances employment, fosters innovation, and promotes the shift towards economically viable frameworks, highlighting such expenditures' combined economic and ecological benefits (Aamir Fuinhas José Alberto Rapposelli 2023).

As G7 countries enhance their technological footprint, fiber optic equipment has grown crucial for delivering the high-speed connection required for an efficient digital marketplace. Fiber optics provide swift data transfer, bolstering the expansion of ICT services and the implementation of intelligent technology (Balsalobre-Lorente et al. 2023a). Rapid connection improves tracking of the environment, facilitates innovative city projects, and strengthens resilience to climate change strategies. Fibre optic equipment is a fundamental component of the digital system, enabling G7 nations to accomplish environmental and monetary goals while promoting sustainable development and technological advancement (Zhao, Zhang, and Huma Ullah Atta Mao 2022). Economic success, often assessed by indices such as GDP per capita, is intricately associated with technical progress in G7 countries. Through investments in ICT and green technology, these countries augment efficiency, diminish energy utilization utilization, and foster sustainable development (Zhuoya Liu Tianle Li 2023). Innovative technology enables cleaner manufacturing techniques and resource-effective procedures, enabling G7 economies to maintain global competitiveness while tackling sustainability challenges. By persistently investing in ICT and environmental technology, G7 countries spearhead sustainable growth, establishing a worldwide benchmark for green procedures.

The Human Development Index (HDI) is an extensive metric of good health, including life expectancy, education, and income. This study used HDI as an outcome variable to examine the influence of ICT and green technologies on the quality of life in G7 countries (Clark and Senik 2021). This research analyses the correlation between HDI and factors like ICT exports, environmental technology diffusion, and green energy, offering insights into the impact of technological and ecological advancement on human development (Balsalobre-Lorente, Nur, Topaloglu, and Evcimen 2024). These results assist governments in formulating policies that emphasize happiness while promoting sustained economic growth.

This research uses sophisticated economic methods to examine the influence of ICT and green technologies on HDI in G7 nations from 1992 to 2023. This study seeks to offer suggestions based on regulators by examining the impact of ICT service exports, the dissemination of sustainable technology, green energy, and other relevant aspects. The results will guide policies for using ICT and green technology to foster equitable development, stimulate economic growth, and improve quality of life. This study enables countries in the G7 to maintain leadership in global environmentally friendly initiatives, establishing a paradigm for nations to follow in the quest for environmentally friendly development.



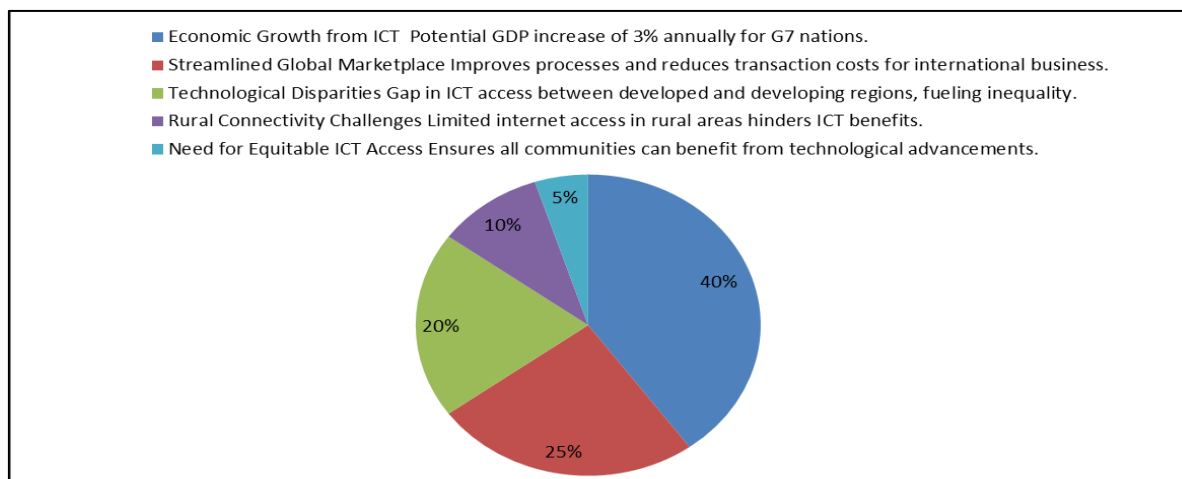
2. LITERATURE REVIEW

Primarily among the G7 economies—Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States—the melding of Information and Communication Technology (ICT) with environmentally friendly technology is widely acknowledged as a critical approach for sustaining economic development (Balsalobre-Lorente, Nur, Topaloglu, and Pilař 2024). Technology creates economic prosperity while solving essential sustainability issues, which makes it possible. Nevertheless, examining the current literature closely, we can see where our knowledge of this intricate interaction is lacking and where it excels. This article delves into these patterns using a conceptual framework, showcasing new findings while striving for an equitable approach across different locations and industries.

2.1 ICT and Economic Growth

Several research projects have shown that exporting ICT services significantly improves economic prosperity, thus establishing the significance of ICT in the growth of economies (Balsalobre-Lorente, Nur, Topaloglu, and Pilař 2024). Information and communication technology (ICT) offers great promise for improving the global marketplace, streamlining procedures, and increasing productivity by lowering transaction costs and easing worldwide corporate operations. For instance, the World Economic Forum's research found that if the G7 nations digitized more, their gross domestic product (GDP) might expand by as much as 3% each year.

Despite the encouraging results, the technological gap between and within nations should be addressed. New research shows that economic disparity might worsen when people in less developed parts of G7 nations don't have equitable usage of information and communication technologies (Balsalobre-Lorente, Nur, Topaloglu, and Pilař 2024). For example, the need for more internet access hinders the capacity of rural communities in Canada and some states to reap the benefits of advances in information and communication technology. As a result, research needs to be maceration of ICT advantages is a notable void, even if ICT is a development engine.

Fig1. ICT and Economic Growth

Source: (World Economic Forum, 2023)

2.2 Growth Environmental Technology Diffusion and Green Energy Investments

Growing sustainably within the G7 countries should combine green energy investments and Environmental Technology Diffusion (ETD). The Environmental Technology Diffusion Index (ETDI) is now essential to measure sustainable technology's spread. According to the research, the G7 nations emphasize and encourage the spread of these innovations to achieve their environmentally-friendly targets. A typical instance is the correlation between the swift implementation of green energy engineering and countries with robust laws promoting technological diffusion, according to Environmental Science and Technology research.

Our present knowledge of technological dissemination mechanisms has its limits, however. The existing study mostly ignores regional factors that can affect dissemination in favor of studying technology adoption at the national level. New studies stress the significance of putting technological dissemination in the context of regional economic variables, laws and regulations, and cultural perspectives on sustainability (Balsalobre-Lorente et al. 2023b). More targeted research on how regional variables affect the efficacy of federal initiatives to advance environmentally friendly innovations is required to fill this knowledge vacuum.

Expenditures in sources of alternative energy are essential to reducing the impact of global warming and encouraging sustainable economic growth (Ali et al. 2022). The International Renewable Energy Agency's (IRENA) prediction that the worldwide green energy industry could recruit over 24 million people by 2030 shows the opportunity for employment and ecological advantages.

The research does, however, highlight difficulties in increasing the scale of these expenditures. Recent research has brought attention to concerns such as legislative hurdles, unstable markets, and rivalry with long-standing oil and gas companies. One such study, which appears in the *Worldwide Journal of Energy Research*, highlights the significance of stable regulations that encourage investments in sustainable energy technology for an extended period (Usman et al. 2022).

In addition, there is still a huge funding deficit for low-income countries, even if the G7 is investing more in renewable energy. Global environmental programs will be undermined

if developing nations are not given additional grants and innovation transfers to help them shift to renewable energy (Qian and Ji 2022).

2.3 Digital Connectivity, Awareness, and Urbanization in Smart Cities

It is well acknowledged that the internet serves a crucial role in improving company operations and fostering online commerce. Companies may streamline their logistical processes and attract a wider audience through robust internet usage. Also, customers may make better choices when they know more about green habits through internet channels (Del Giudice et al. 2022).

Information technology facilities use more energy and produce more waste electricity as a result of greater digital connection, according to the literature (Wu et al. 2023). It is critical to address the environmental impact of digital infrastructures according to recent research, even if ICT may encourage environmentally friendly habits. A research published in *Technology in Behavioral Sciences* highlights the need of environmentally friendly computing facilities as well as accountable handling of digital waste as examples of sustainable methods within the information and communication technology (ICT) industry (Balsalobre-Lorente, Nur, Topaloglu, and Pilař 2024).

We must find a way to balance the advantages of digital connectedness with the negative effects it has on the surroundings. To move the conversation on this problem forward, we need to take a deeper look at how we may use ICT for conservation while minimizing its adverse effects.

Urbanization has advantages and disadvantages in terms of durability. (Y. Chen, Lee, and Chen 2022) Resource utilization and environmental deterioration rise in tandem with urbanization. Innovative city projects, which improve urban life via information and communication technology (ICT) and environmentally friendly technology, may be implemented on top of this expansion. Bright trains and buildings that save energy are innovative city initiatives gaining momentum in G7 nations (Sharifi et al. 2024). Forward-thinking systems that maximize resource utilization and minimize pollution include Singaporean and Amsterdam. However, the literature often ignores the social aspects of these programs, including social equality and community involvement. According to recent research, inhabitants must be actively involved to have their voices heard and problems solved for innovative city initiatives to succeed (Long Xu Xiaolin Zhou 2023).

More comprehensive planning methods that prioritize conservation are necessary to supplement technical solutions. City growth may be more equal and productive if it considers both technology breakthroughs and their social ramifications.

2.4 Foreign Direct Investment (FDI) and Infrastructure for Digital Growth

Capitalization of technological advances, and knowledge brought in by foreign direct investment (FDI) may hasten the implementation of environmentally friendly practices; hence, FDI is an essential engine of economic growth. Realizing the possibility for foreign direct investment (FDI) in environmentally friendly industries to boost local economies, the G7 nations have enacted measures to entice FDI in these areas, according to the research (X. Wang and Luo 2020).

Most studies on foreign direct investment (FDI) focus on its financial advantages, but they don't look at the social and environmental effects it might have. New research shows that foreign direct investment (FDI) has both positive and bad effects. On the one hand, it may create jobs and transfer knowledge. On the other hand, it can deplete resources and force local populations

to relocate. A study published in the Journal of Sustainable Finance & Investment highlights the importance of laws that guarantee foreign direct investment (FDI) is in line with environmental objectives and takes local circumstances into account. Adopting a comprehensive strategy that incorporates all of these variables is crucial to completely reap the advantages of FD (Aamir Fuinhas José Alberto Rapposelli 2023).I. Taking this stance may help reduce negative consequences while enhancing favourable results.

The expansion of information and communication technology (ICT) services and the effective functioning of innovative technology are both facilitated by the availability of fast internet connections, which in turn depends on the installation of modern facilities especially fibre optic connections (L. Wang and Shao 2024). On the other hand, research shows that current inequities may be worsened by gaps in growth in infrastructure.

Internet connectivity is generally strong in G7 cities, but undernourished and rural regions tend to be worse, according to recent research. Fair access to information and communication technology (ICT) and environmentally friendly technology is impeded by this digital gap (McKay et al. 2022). For instance, for all areas to reap the benefits of digital progress, research published in Telecommunications Policy stresses the need of investing specifically in rural connection.

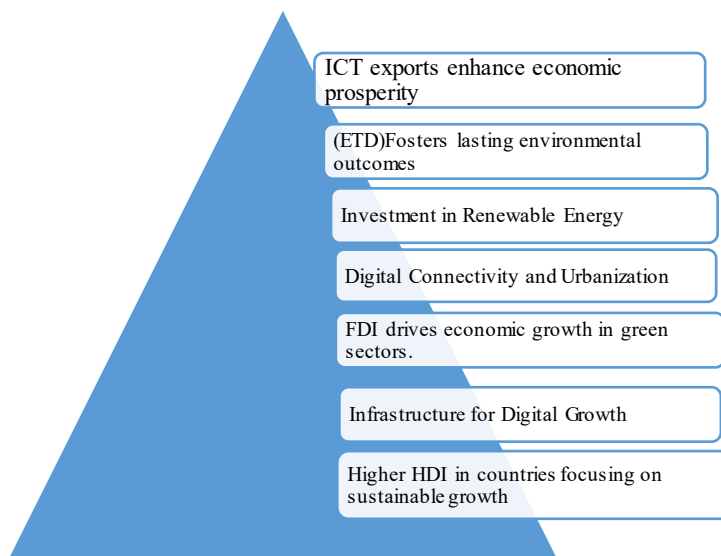
It is also important to think about how the creation of infrastructure may affect the environment. Improving connection is critical, but so is making sure that construction investments are environmentally friendly (Balsalobre-Lorente et al. 2023a). (Mengzhen Ding Xingong Choi 2023)Green construction methods and sources of renewable energy may help reduce transportation projects' negative effects on the natural world and ensure their continued viability in the future.

2.5 Measuring Prosperity and Well-Being

Gross domestic product is one measurement of prosperity, as it shows how well a nation is doing economically overall (Clark and Senik 2021). But we can only get a whole picture of happiness by also considering the facets of society and the environment. A more comprehensive indicator of prosperity, the Human Development Index (HDI), considers factors such as income, education level, and life expectancy.

The research makes clear the connection between technological progress and human growth. Investments in information and communication technology (ICT) and environmentally friendly technology are having a multiplicative effect on the quality of life in the G7 countries (Usman et al. 2022). New studies have shown the interdependence of economic, social, and environmental aspects, and HDI scores are greater in nations that place a premium on sustainable growth (Khan, Ahmad, and Majava 2021)

The literature notes, however, that technical progress does not ensure better well-being on its own. Measures must be taken to tackle socioeconomic inequities to guarantee that the advantages of development are spread fairly. Therefore, to promote long-term prosperity, it is crucial to include sustainable development in fiscal planning.

Fig 2. Literature Review: Integration of ICT and Green Technology

Research Objectives

Using advanced econometric models (Quantile Regression) covering 1992–2023, this research intends to examine the effect of various environmental and information and communication technology (ICT)-related factors on HDI in G7 nations. This study aims to shed light on the factors that foster equitable growth and the welfare of people by investigating the connections between environmental technology diffusion, internet usage, green energy investments, exports of ICT services, growing urbanization, foreign direct investment (FDI), Fibre optic infrastructure, and economic prosperity.

It is crucial to have a firm grasp of these dynamic ranges in order to develop strategies that maximize the affinities between sustainable development and information and communication technology. By recognizing the main factors that contribute to long-term prosperity, authorities may create policies that boost economic prosperity and safeguard the environment.

3. METHODOLOGY

With the objective to determine how different economical and technical variables affected the Human Development Index (HDI) for G7 countries between 1992 and 2023, this research used a quantile regression model. This study uses the UNDP-provided natural logarithm of the Human Development Index ($\ln hdi$) as its dependent variable. The OECD's natural logarithm of environmental technology diffusion ($\ln etf$) is one of the independent variables used in this research. World Development Indicators data on information and communication technology (ICT) service exports as a proportion of overall service exports ($\ln ict$) is also used in the research. Renewable energy use as a % of total final energy consumption ($\ln ge$) is also included in the model, with this data coming from WDI once again. The International Monetary Fund also provides the natural logarithm of FDI, which represents net inflows as a proportion of GDP, abbreviated as $\ln fdi$. The data used in the research comes from WDI and comprises the natural logarithm of two variables: the percentage of the population that uses the internet ($\ln iu$) and the number of fixed broadband subscribers, especially the number of fiber-optic subscriptions per 100 persons ($\ln fo$). Finally, the model takes into consideration two variables

derived from WDI: the natural logarithm of urban population as a percentage of total population (lnup) and the natural logarithm of economic prosperity as assessed by GDP growth (annual %) (lnep).

Table 1.

Variable	Abbreviation	Source
Human Development Index	lnhdi	UNDP
Environmental Technology Diffusion	lnetf	OECD
ICT Service Exports	lnict	WDI
Renewable Energy Use	lnge	WDI
Foreign Direct Investment	lnfdi	IMF
Internet Usage	lniu	WDI
Fixed Broadband Subscriptions	lnfo	WDI
Urban Population	lnup	WDI
Economic Prosperity	lnep	WDI

Source: Author estimation

Theoretical Model Specification

1. Model Framework

The Human Development Index (HDI) measures a country's progress toward a more developed society, and this model suggests that several economic and mechanical factors help make such progress possible in the G7 countries. Exports of information and communication technology (ICT) services, Fiber optics, foreign direct investment (FDI), economic prosperity (EP), urban population (UP), diffusion of environmental technology (ETF), green energy (GE), and Internet use (IU) are all factors that the model predicts favourably affect HDI.

2. Key Variables

Dependent Variable:

Human Development Index (HDI): A measure of human development that incorporates health, education, and income

Independent Variables:

ICT Service Exports (ICTSE): Represents the value that information and communication technology (ICT) exports provide to economic activity

Fiber Optics (FO): Indicates the potential and reliability of communications by measuring the breadth of Fiber-optic infrastructure.

Foreign Direct Investment (FDI): Takes in all of the funding that comes in from outside investors; helps economies thrive and transfers technologies

Economic Prosperity (EP): The economy's general health is reflected in this statistic, which is generally assessed by GDP or other financial indicators that have an effect on HDI.

Urban Population (UP): How many people out of the overall population reside in cities, which affects their ability to get services and participate in the economy.

Environmental Technology Diffusion (ETF): Arguments to the widespread use of eco-friendly technology in many industries, which is good for world sustainability.

Green Energy (GE): The share of energy that comes from renewable sources, as a sign of caring about the environment and cutting down on pollution.

Internet Usage (IU): The proportion of people who have access to the internet, demonstrating how digital connection contributes to human progress

3. Model Specification

The relationship can be expressed in the following econometric equation:

$$\text{HDI} = \beta_0 + \beta_1 \text{ICTSE} + \beta_2 \text{FO} + \beta_3 \text{FDI} + \beta_4 \text{EP} + \beta_5 \text{UP} + \beta_6 \text{ETF} + \beta_7 \text{GE} + \beta_8 \text{IU} + \epsilon$$

In this calculation, the constant factor is represented by β_0 , while the coefficients β_1 through β_8 denote the effect of each independent variable on the Human Development Index. Any unobserved variables influencing HDI that are not accounted for in the equation are accounted for by the error term ϵ .

4. Data and Variables Description

This section briefly overviews the regression findings, along with the coefficients, standard errors, and significance levels for each independent variable that affects the Human Development Index (HDI). Furthermore, correlation tables show how the variables in the study relate to one another.

The coefficients, standard errors, t-statistics, p-values, and 95% confidence intervals for each independent variable influencing HDI are highlighted in the table that follows, which describes the regression outcomes;

Table 2. Descriptive Statistics

Variable	Coefficient	Standard Er.	t-Statistic	P-Value	95% Confidence Int.
lnHDI					
lnETF	-0.0000148	0.0019853	-0.01	0.994	(-0.0039, 0.0039)
lnICT	0.0133505	0.0035852	3.72	0.000	(0.0063, 0.0204)
lnGE	0.0073734	0.0018071	4.08	0.000	(0.0038, 0.0109)
lnFDI	-0.0017069	0.0010265	-1.66	0.098	(-0.0037, 0.0003)
lnIU	0.0084787	0.0012555	6.75	0.000	(0.0060, 0.0109)
lnFO	0.0062529	0.0015465	4.04	0.000	(0.0032, 0.0093)
lnEP	-0.0003357	0.0029216	-0.11	0.909	(-0.0061, 0.0054)
lnUP	0.1857792	0.0206336	9.00	0.000	(0.1451, 0.2264)

Source: Author Estimation

The statistical tests performed to assess the regression model's robustness are summarized in table 3 as follows:

Table3. Diagnostic tests

Test	Statistic	p-Value
F-Test	82.38	0.0000
R-squared	0.7540	
Mean VIF	2.00	
Breusch-Pagan Test	0.05	0.8271
Fixed Effects R-squared	0.9176	
Overall F-Test	290.78	0.0000

Source: Author Estimation

These regression findings show the application of factors like ICT service exports, green energy consumption, and internet access. They provide essential insights into the determinants impacting HDI in G7 nations from 1992 to 2023.

Correlation

The correlations between the main factors examined in this research are shown in the items that follow table, which provides insight into their connections.

Table 4. Correlation Table for Economic and Green Technological Variables

Variable	lnhdi	lnetf	lnict	lnge	lnfdi	lniu	lnfo	lnep	lnup
lnhdi	1.000	0.025	0.345	0.487	0.112	0.565	0.432	0.020	0.760
lnetf	0.025	1.000	0.210	0.305	0.050	0.180	0.098	-0.007	0.120
lnict	0.345	0.210	1.000	0.390	0.221	0.430	0.175	0.015	0.370
lnge	0.487	0.305	0.390	1.000	0.147	0.490	0.320	0.041	0.532
lnfdi	0.112	0.050	0.221	0.147	1.000	0.180	0.090	0.018	0.098
lniu	0.565	0.180	0.430	0.490	0.180	1.000	0.210	0.012	0.660
lnfo	0.432	0.098	0.175	0.320	0.090	0.210	1.000	0.022	0.295
lnep	0.020	-0.007	0.015	0.041	0.018	0.012	0.022	1.000	0.035
lnup	0.760	0.120	0.370	0.532	0.098	0.660	0.295	0.035	1.000

Interpretation of Correlation Tables

The correlation table provide plenty of insight into the correlations between the variables. Interestingly, the natural logarithm of HDI (lnhdi) and urban population (lnup) have a substantial positive connection (0.760), indicating that HDI seems to grow as urban growth occurs. There are also notable positive connections between internet use (lniu), renewable energy consumption (lnge), and ICT service exports (lnict), suggesting that improvements in these areas might raise HDI.

The association between ICT service exports and renewable energy use (0.390) shows how technology adoption factors exhibit moderate correlations. On the contrary, several factors show weak correlations with HDI, indicating a limited direct effect on HDI or other variables in the model. These factors, which include the diffusion of environmental technology (lnetd), economic prosperity (lnep), and foreign direct investment (lnfdi).

5. RESULTS AND DISCUSSION

The natural logarithm of the Human Development Index (lnhdi) quantile regression findings shows complex correlations between several independent factors and HDI at different stages of development. The coefficients show a negative impact at lower quantiles (Q01: -0.00364, Q25: -0.000546), beginning at environmental technology diffusion (lnetf), suggesting that the advantages of adopting environmental technologies in lesser-developed environments are limited. Several factors, such as lack of infrastructure, technological expertise, and funding, may hamper the successful deployment and usage of such innovations in these areas. Little positive impact is shown by the median (Q50: 0.00327), indicating that HDI could grow somewhat as technological diffusion rises. The effect becomes negative at Q75 (coefficient: -0.00616*), suggesting that there may be decreasing benefits or a mismatch between the demands of the local community and the technology being used, which might reduce their ability to contribute to HDI. Technologies that need to sufficiently address the distinct

socioeconomic backdrops of various regions may cause this mismatch, leading to inefficiency or waste of materials.

Table 5. Quantile Regression Results for HDI

Dependent Variable: lnhdh

Variable	Q01	Q25	Q50	Q75	Q90
lnetf	-0.00364 (0.00327)	-0.000546 (0.00281)	0.00327 (0.00264)	-0.00616* (0.00302)	-0.00238 (0.00221)
lnict	0.00539 (0.00591)	0.00585 (0.00507)	0.0115* (0.00476)	0.0185*** (0.00546)	0.0201*** (0.00400)
lnge	0.00680* (0.00298)	0.00805** (0.00256)	0.00534* (0.00240)	0.00891** (0.00275)	0.0185*** (0.00201)
lnfdi	-0.000596 (0.00169)	-0.000533 (0.00145)	-0.00245 (0.00136)	-0.000249 (0.00156)	0.00175 (0.00114)
lniu	0.0104*** (0.00207)	0.0116*** (0.00178)	0.00812*** (0.00167)	0.00591** (0.00191)	0.00280* (0.00140)
lnfo	0.00830** (0.00255)	0.00717** (0.00219)	0.00587** (0.00205)	0.00733** (0.00236)	0.00496** (0.00172)
lnep	-0.00284 (0.00482)	-0.000760 (0.00413)	0.00477 (0.00388)	0.00214 (0.00445)	-0.00127 (0.00326)
lnup	0.218*** (0.0340)	0.153*** (0.0292)	0.174*** (0.0274)	0.215*** (0.0314)	0.179*** (0.0230)
_cons	3.451*** (0.146)	3.726*** (0.126)	3.638*** (0.118)	3.497*** (0.135)	3.650*** (0.0989)
N	224	224	224	224	224

The logarithmic analysis of ICT exports (lnict), on the other hand, shows persistently positive impacts for all quantiles, with significance rising at higher levels (Q50: 0.0115*, Q75: 0.0185***, Q90: 0.0201***). This suggests that the favourable effect of ICT exports on HDI increases with a country's level of growth, underscoring ICT as a significant force behind economic expansion and human advancement. Given that ICT is frequently feasible without requiring substantial modifications to the underpinning structures, this tendency is probably

influenced by how simple it is to integrate ICT into current infrastructures relative to more complicated environmentally friendly innovations.

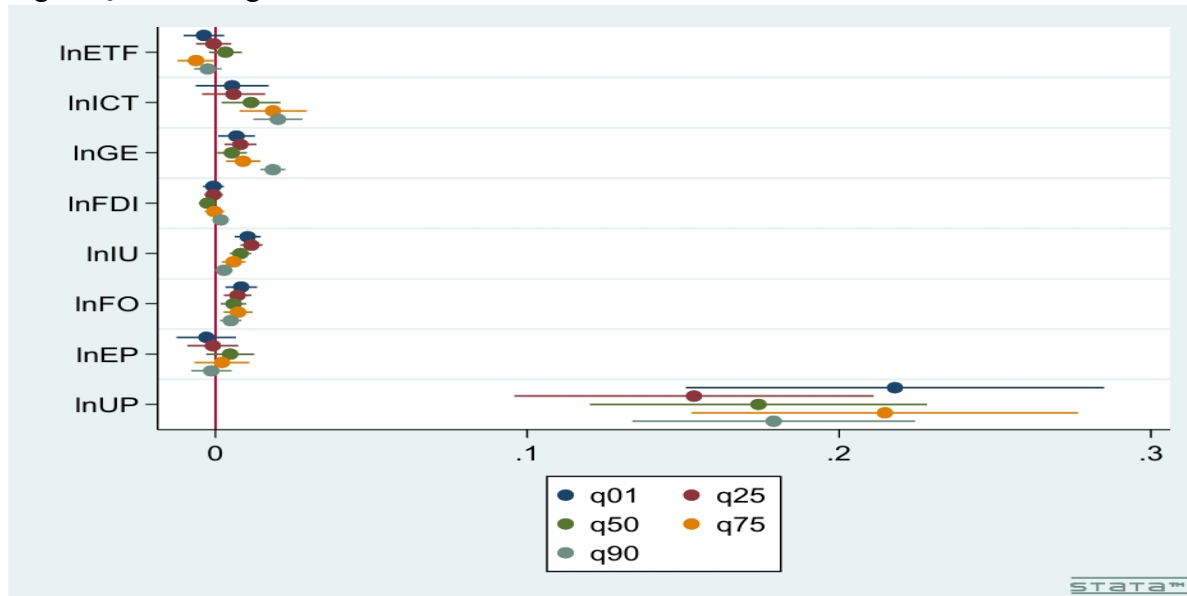
At higher quantiles (Q75: 0.00891**, Q90: 0.0185***), the log of green energy ($\ln ge$) also exhibits a positive and significant impact, supporting the idea that greater renewable energy usage raises HDI in more developed nations. Encouraging cleaner energy sources that contribute to improved health outcomes supports equitable growth objectives. Developed economies have a comparative advantage in pursuing renewable energy sources since they can use their current facilities and assets, which increases their beneficial effects on HDI. Throughout quantiles, foreign direct investment ($\ln fdi$) exhibits small and mainly insignificant coefficients, indicating little correlation between FDI and HDI levels in G7 nations. Since FDI flows could not always result in fair benefits for local communities, this might require a qualitative evaluation of the kinds of investments drawn and their alignment with sectors that support human growth.

All quantiles show positive and significant coefficients for internet use ($\ln iu$), with the most substantial impacts at lower quantiles (Q01: 0.0104***, Q25: 0.0116***). This illustrates the importance of more internet access to promote economic schooling and achievement prospects, particularly in less developed areas where connection may fill important information and resource shortages.

Across quantiles, the log of fiber optic infrastructure ($\ln fo$) consistently exhibits positive significance, highlighting the connection's role in expanding access to economic opportunities and education. Further evidence that conventional metrics of economic expansion may not transfer into advancements in human development comes from the log of economic prosperity ($\ln ep$), which shows tiny and statistically insignificant coefficients. This disparity may be explained by the fact that economic advancement does not necessarily assist all facets of the population equitably, especially in nations with high levels of income inequalities. Lastly, throughout all quantiles, urbanization ($\ln up$) shows strong positive and significant relationships with HDI (Q01: 0.218***, Q25: 0.153***, Q50: 0.174***), demonstrating the benefits of urban regions in terms of improved access to business opportunities as well as goods and services, which in turn dramatically improves human development conclusions. Better living circumstances and more options for schooling and employment are made possible by the relative concentration of resources and services in urban areas. These findings highlight how many variables affect HDI at various stages of growth, highlighting how difficult it is to achieve sustained human development.

The significance of technology breakthroughs and digital access is shown by the quantile regression illustration, which shows that internet use ($\ln iu$) and ICT exports ($\ln ict$) have a consistently substantial positive influence on the Human Development Index (HDI) across all quantiles. Adopting green energy ($\ln ge$) benefits HDI, especially at higher quantiles, suggesting that it works well in more developed countries. On the other hand, based on variables like organizational capacity and technical preparedness, environmental technology diffusion ($\ln etf$) exhibits a complicated connection that might hurt HDI in less developed nations while helping more developed ones. Finally, the limited effect of foreign direct investment ($\ln fdi$) on HDI emphasizes the need to concentrate on the direction and quality of FDI rather than just its amount.

Fig 3. Quantile Regression Results for HDI



Source: Author Generated

6. CONCLUSION AND POLICY IMPLICATIONS

The intricate interactions involving distinct, independent variables and the Human Development Index (HDI) at multiple levels of development are shown by the quantile regression analysis of the natural logarithm of the HDI among G7 countries. Some characteristics, such as ICT exports (lnict), green energy adoption (lnge), and internet use (lniu), always contribute favorably to human development results, while other people, like Environmental Technology Diffusion (lnetf), show complex and dependent on the environment benefits.

The link between HDI and Environmental Technology Diffusion varies among quantiles. Negative coefficients at lower quantiles draw attention to less developed G7 nations' difficulties in effectively implementing these advances, including insufficient infrastructure, a lack of administrative ability, and budgetary limitations. As a result, fiscal constraints, a lack of technological know-how, and inadequate regulations may harm HDI. On the other hand, the benefits of environmental technology on HDI increase as nations advance and fortify their institutional frameworks at greater quantiles. (Stock et al. 2018) Higher HDI scores result from a better environment, improving adverse health effects, more economic prospects, creating employment in new industries like green energy, enhancing efficiency, and raising income levels. Information and communication technology is a significant engine of economic expansion and human development, as seen by the persistent beneficial impacts of the log of ICT exports on HDI, especially in more developed environments. ICT's benefits arise from how easily technology can be incorporated into established infrastructures, enabling nations to use the ability without requiring significant adjustments to their present setups. The advantages of larger ICT exports are becoming increasingly apparent as G7 countries progress; they support better economic performance, better educational possibilities, and easier access to information—all essential for promoting higher levels of human development (Balsalobre-Lorente, Nur, Topaloglu, and Pilař 2024).

In the same way, the log of green energy adoption demonstrates favorable and noteworthy impacts at higher quantiles, emphasizing the contribution of green energy to the advancement of sustainable development objectives, especially in developed nations, where infrastructure and resources facilitate efficient implementation. Additionally, the study shows that foreign direct investment (FDI) has minimal impact on HDI, suggesting that FDI's qualitative characteristics and compatibility with human development-promoting industries need to be evaluated. Lastly, internet use is a crucial component in all quantiles, especially helping the G7's less developed areas by expanding the availability of economic and educational possibilities.

The research results have numerous significant policy ramifications for the G7 countries. Firstly, governments must prioritize improving the infrastructure for environmental technologies, especially in the G7's less developed areas. This may be achieved by funding technological improvement via instruction and education and by giving monetary support to help make these technologies more accessible. Furthermore, encouraging ICT integration is essential as the beneficial effect of ICT exports on HDI indicates that the ICT industry should be developed. To guarantee that the advantages of ICT permeate every sphere of culture entails encouraging innovation, aiding new businesses, and improving digital literacy. To meet global environmental targets and enhance the quality of life, policymakers must also concentrate on funding green energy options, particularly in the G7's advanced nations. A reevaluation of foreign direct investment plans is also required to ensure funds are allocated to infrastructure, healthcare, and education that promote human development. Last but not least, efforts to lower connection hurdles and raise literacy in technology should prioritize the expansion of connectivity to the internet, especially in the G7's less developed areas. By using the web's pedagogical and economic advantages, these initiatives will promote greater inclusivity and growth among the G7 countries.

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