

## The impact of ICT on achieving Sustainable Development Goals (SDGs): A Cross-Country Analysis

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### Abstract:

This research investigates the influence of ICT usage on advancing the Sustainable Development Goals (SDGs), focusing on Goal 4, Goal 5, Goal 9, and Goal 17, in a selected country, from an econometric perspective. The data used in the study spans 13 years, from 2010 to 2022. This data was analyzed using the panel regression analysis model, adopting the Panel Corrected Standard Error (PCSE) method. The findings reveal that ICT play a positive role in fostering quality education, enhancing gender equality, promoting industry and innovation, and bolstering partnerships aimed at achieving the SDGs.

**Keywords:** Information and Communication Technologies (ICT), Sustainable Development Goals (SDGs), Cross-Country Analysis.

**JEL Classification Codes:** O33, Q01.

## **1. INTRODUCTION**

In recent years, the rapid advancement in information and communication technologies has significantly transformed many aspects of life. Communications have become faster and more efficient, greatly enhancing the transfer of information and knowledge in ways that were previously unattainable. This development was not limited only to technological innovations but numerous studies have highlighted that information and communication technology (ICT) plays as a key driver of economic growth and social advancement across nations. It is clear that ICT are not just tools for technical development but rather are major drivers of sustainable development. Thanks to the positive effects on economic growth, increased productivity, and job creation.

Moreover, the relationship between ICT and sustainable development has become increasingly undeniable. Information and communication technology serves as a catalyst, offering the essential resources and mechanisms to enhance economic, social, and environmental efficiency. Therefore, many countries are working hard to absorb ICT. In fact, adopting ICT-enhanced policies is one of the most important agendas and actions of governments today in most countries. In this context, we propose the following research question:

How does the usage of information and communication technology affect the achievement of sustainable development goals?

This research aims to assess the effect of ICT usage on achieving the SDGs from an econometric standpoint. It involves a cross-country analysis covering the period from 2010 to 2022.

The paper is organized in the ensuing manner: The subsequent part introduces the background on ICT and SDGs and examines their relationship. The third part presents the hypotheses and reviews the existing literature. The fourth third delves into the data, variables, and methodology employed in the study. The fifth part outlines the results. Lastly, the final part presents the paper's conclusion.

## **2. Background**

This section first introduces the background of the Information and Communications Technology (ICT) and Sustainable Development Goals

(SDGs), it then explores how ICT contributes to accelerating progress towards the SDGs. Lastly, the section categorizes the SDGs that specifically reference ICT.

### **2.1 Information and Communication Technologies (ICT)**

ICT is broadly acknowledged as a significant catalyst for transformation within economies and societies. It encompasses a wide array of communication technologies and devices. (Rouse, 2005). According to James (2011), information and communications technology extends the scope of information technology (IT) by emphasizing the integration of unified communications with telecommunications and computing (James, 2011). The OECD defines ICT as a comprehensive set of electronic technologies and strategies for managing information and knowledge (OECD, 2017). Furthermore, ICT generates new opportunities for technological knowledge and hence accelerates the dissemination process of information transformation, both worldwide and locally.

The ICT sector has grown significantly as a result to recent development in internet technology, the expansion of computer networks, and the high technology sector. ICT development has an impact on the infrastructure of the new economy; investment in this area will drive economic growth and create new jobs (Ioan, 2013). The ICT sector is recognized as a key engine of economic and social advancement, with a considerable impact on job creation, and technology transfer. In Africa, the ICT sector has been an important engine of economic transformation, breaking through conventional manufacturing and service differences (Ajakaiye & Wangwe, 2011). Many developing countries view the expansion of their domestic ICT industries as a strategic approach to achieve various development objectives. (UNESCO, 2002). Finally, ICTs help to create a more accommodating environment by being used in healthcare, public administration, and environmental management. By incorporating ICTs in these sectors, countries can promote transparency, improve service delivery, and support sustainable development practices.

### **2.2 Sustainable Development Goals (SDGs)**

In 2015, the global community endorsed the 2030 Agenda for Sustainable Development, embedding the Sustainable Development Goals (SDGs) as a fundamental aspect of their sustainability strategies. This agenda seeks to forge a balanced approach that integrates economic, social, and environmental dimensions. The SDGs consist of 17 goals, accompanied by 169 targets and 304 indicators, reflecting the scale and ambition of this new global framework and providing a dynamic, visionary roadmap for future advancement. (Mustajoki, et al., 2022). Figure (1) shows all 17 goals.

**Fig.1.** Sustainable Development Goals



**Source :** (UN, 2015)

The Sustainable Development Goals are considered as global and universal, supporting sustainable development in all countries. The report of Brundtland (1987) serves as the foundation for its concept of sustainable development: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UN, 1987). The 17 SDGs are a blueprint for shaping global economic growth in order to eliminate poverty, prosperity, promote equality, justice, and peace. The SDGs, often referred to as the Global Goals. Therefore, advancing one goal should not hinder progress towards others. (Ramos & Laurenti, 2020).

The SDGs, according to Sachs (2014), provide an ambitious roadmap for eradicating poverty, combating inequality, and addressing climate change. Despite their diversity, they are all dependent on the enabling potential of ICT (SACHS, 2014). The ICT and SDGs report highlights that

ICT has the potential to significantly lower service delivery costs. Additionally, it can enable low-income countries to leapfrog crucial developmental stages and enhance their economic growth. By advancing and proliferating a diverse range of sophisticated technologies, applications, and platforms across various sectors (The Earth Institute, 2016). According to Bello (2014), ICTs offer nations a chance to bridge the digital divide, eradicate poverty, and drive economic advancement. (BELLO & ADERBIGBE, 2014). Based on the ICT4D Report (2012), ICT serves as a driving force in the pursuit of sustainable development objectives and will continue to play this role (World Bank, 2012). However, achieving these worldwide "stretch" targets will necessitate a much faster and more significant restructuring of society than in the past.

ICTs are particularly mentioned in SDGs Specifically:

- SDG 4 emphasizes the importance of ICT training and education,
- SDG 5 highlights ICTs as a tool for advancing women's empowerment,
- SDG 9 focuses on improving access to ICTs, with affordable internet access being a key factor in achieving this goal,
- SDG 17 aims to boost the use of enabling technologies, including ICTs, to support overall development efforts.

The four SDGs that particularly refer to ICTs emphasize their empowering role. ICTs are displayed as a universal technology for sustainable development. Furthermore, ICT for sustainable development promotes social change through education, training, and public awareness, fostering values, behaviors, and lifestyles for a sustainable future. It educates individuals, communities, groups, businesses, and governments on environmental, moral, and economic issues (Adamu, 2014, p. 163).

### **3. Literature and hypotheses development**

ICT are transformative instruments that accelerate progress toward all SDGs by increasing access to information, fostering education, and promoting inclusivity. The UNCTAD Technology and Innovation Report 2021 highlights the potential of frontier technologies such as AI, robots, and biotechnology in promoting sustainable development (UNCTAD, 2021). Furthermore, ICTs have been identified as essential drivers of economic

growth, with developing countries experiencing a 2% rise in GDP for every 10% increase in broadband coverage. (UN, 2015).

The United Nations Development Programme underlines the connection between digital transformation and the Sustainable Development Goals (SDGs), particularly within the Arab region (UNDP, 2022). For example, the Arab region has undergone a substantial digital transition in the last two decades, with online users rising from 28.8% in 2012 to 70.3% in 2022. This digital boom has helped to alleviate inequities and create diversity, both of which are essential for achieving the SDGs.

### **3.1 ICT and Quality Education (SGD 4):**

ICT is spearheading a revolution in digital education, positioning it as one of the fastest-expanding sectors globally. The ICT sector has significantly transformed the quality of education globally. For example, in China, delivering high-quality lesson recordings to 100 million rural children boosted student performance by 32% and narrowed the urban-rural income disparity by 38% (UNESCO, 2023, pp. 11-15). In addition, a McKinsey report found that when teachers and students utilized gadgets, US students had a significant increase in learning outcomes, equating to an additional three-quarters of a year of academic progress, compared to those who did not use such devices (mckinsey, 2020). Based on this framework, We propose the following hypothesis:

**H1 :** The ICT Usage has a positive impact on ensuring quality education.

### **3.2 ICT and Gender Equality (SGD 5)**

Leveraging modern technology to promote gender equality and empower women is crucial not only for the well-being of women and girls but also for achieving the broader goals. According to the UNESCO 2024 Gender Report, technology can be a strong tool for girls' education. This can contribute to a more gender-balanced future in digital transformation (UNESCO, 2024, p. 62). Furthermore, a study published in Information Systems Frontiers indicates that ICT functions as an institutional actor that can promote gender equality, This aligns with SDG 5, which focuses on promoting gender parity (Shah & Krishnan, 2023). Statistics reveal notable

progress in digital gender parity within the Arab States region, where the score of gender parity is improving to 0.87 in 2023. After it was 0.79 in 2019 This indicates a reduction in the gender gap in internet usage, which is essential for accessing ICT opportunities (ITU, 2023). Based on this framework, We propose the following hypothesis:

**H2 :** The ICT Usage has a positive impact on promoting gender equality.

### **3.3. ICT and Industry, Innovation, and Infrastructure (SGD 9)**

The ICT sector has been instrumental to driving economic growth and fostering innovation across various industries. Recent research has found that the rapid development of ICT infrastructure over the last two decades has had a major positive influence on the economies of European Union countries. The Technology and Innovation Report 2021 underlines the importance of rapid growth in frontier technologies, which is assisted by ICT, for countries to catch up with technology trends and support equitable innovation (UNCTAD, 2021). In Arab nations, recent data shows that the ICT sector in Saudi Arabia was valued at SR154 billion (\$41.1 billion) in May 2023, representing 4.1% of the country's GDP. This growth mirrors a regional trend where digital technology is increasingly recognized as a driver of economic advancement (Oxford Business Group, 2022). Based on this framework, We propose the following hypothesis:

**H3 :** The ICT Usage has a positive impact on developing industry, innovation, and infrastructure.

### **3.4 ICT and Partnerships for The Goals (SGD 17)**

Public-private partnerships are regarded as critical to ensuring ICTs in all countries and communities. The ITU and the UN emphasize the importance of these partnerships. They are crucial for realizing universal and affordable internet access in LDCs, which is essential for the achievement of all SDGs (ITU, 2021). According to the European Commission's 2022 PREDICT Dataset, despite challenges like the COVID-19 pandemic, the ICT sector has shown extraordinary growth and resilience

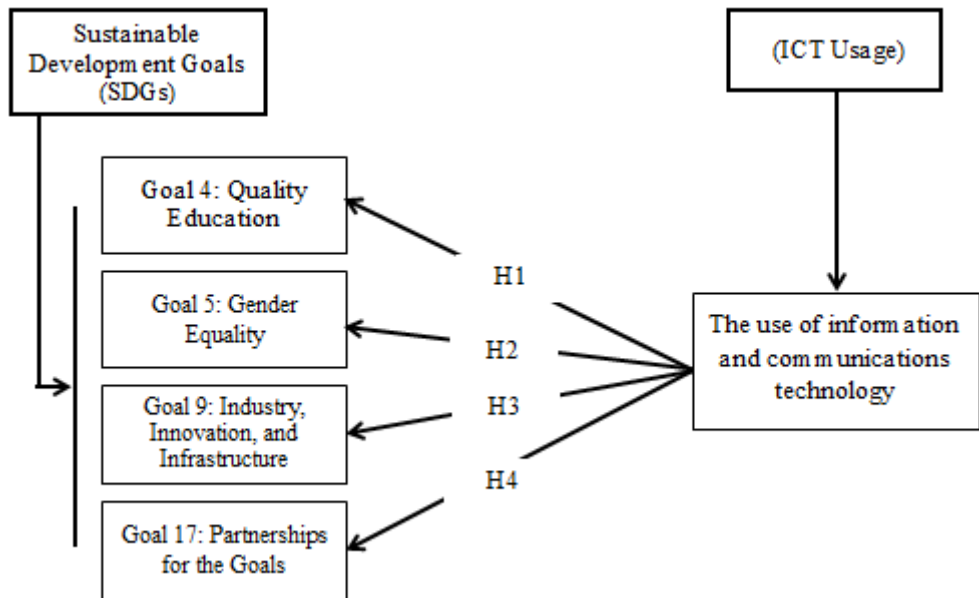
(European Commission, 2022). A research published in 2022 outlines how digitalization has led to increasing worldwide partnerships. It highlights that SDG-17, has played an essential role in promoting global partnerships and implementation tools for addressing social and environmental issues (Küfeoğlu, 2022). Based on this framework, We propose the following hypothesis:

**H4 :** The ICT Usage has a positive impact on strengthening partnerships for the Goals.

#### **4. Materials and methods**

The study focuses on how the usage of ICT impacts the achievement of Sustainable Development Goals. A comprehensive panel dataset was developed for the period 2010–2022. This study includes 75 countries that have data for related variables during the specified time frame Table (1). The theoretical model of the study is shown in Figure (2).

**Fig.2.** Theoretical model of the study



**Source:** Prepared by the researchers

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**Table 1:** Countries considered for the study

|                        |               |            |            |              |
|------------------------|---------------|------------|------------|--------------|
| Albania                | Bhutan        | Egypt      | Korea      | Pakistan     |
| Algeria                | Switzerland   | Estonia    | Kuwait     | Peru         |
| Andorra                | Chile         | Finland    | Lithuania  | Qatar        |
| Argentina              | Cote d'Ivoire | Fiji       | Luxembourg | Romania      |
| Austria                | Cameroon      | France     | Morocco    | Saudi Arabia |
| Azerbaijan             | Colombia      | Georgia    | Moldova    | Serbia       |
| Burundi                | Cabo Verde    | Gambia     | Madagascar | Slovak       |
| Belgium                | Costa Rica    | Greece     | Mexico     | Slovenia     |
| Burkina Faso           | Cuba          | Indonesia  | Malta      | Sweden       |
| Bulgaria               | Cyprus        | Iceland    | Mozambique | Seychelles   |
| Bahrain                | Czechia       | Italy      | Mauritius  | Togo         |
| Bosnia and Herzegovina | Djibouti      | Jordan     | Malaysia   | Tunisia      |
| Belarus                | Denmark       | Kazakhstan | Niger      | Turkiye      |
| Belize                 | Dominican     | Kyrgyz     | Norway     | Ukraine      |
| Bolivia                | Ecuador       | Cambodia   | Oman       | Uzbekistan   |

**Source:** Prepared by the researchers

## 4.1 Type and extent of the search

This search aims to explore whether there is a possible relationship between ICT usage and the attainment of SDGs in selected countries. To evaluate this potential relationship and test the hypotheses, the analysis will concentrate on four specific SDGs (4, 5, 9, and 17) as dependent variables.

The independent variable, ICT usage, will be assessed through three parameters: fixed-line telephone subscriptions, mobile/cell phone subscriptions, and fixed internet subscriptions.

## 4.2 Sample selection

For this research, we utilized data sourced from the Union Internationale des Télécommunications (ITU) through the World Telecommunication/ICT Indicators, as well as data from the SDG Transformation Center's, for the period from 2010 to 2022.

These observations are the lower secondary completion rate, women's representation in national parliaments, internet usage rates, and government expenditure on health and education, fixed-line telephone subscriptions, mobile/cell phone subscriptions, and fixed internet subscriptions.

### **4.3 Data Collection**

Upon reviewing the data from the International Telecommunication Union (ITU) and the SDG Transformation Center, we confirmed that our dataset for the period 2010–2022 is complete, with no missing values, and therefore no observations were excluded. For our analysis, we will work with a sample of 13 views and utilize the statistical program Stata 17 to conduct the statistical evaluation.

### **4.4 Measurement of variables**

This research encompasses two variables, which collectively comprise five dimensions. The first variable features a single independent dimension, while the second variable is associated with four dependent dimensions. These variables will be quantitatively assessed, as detailed in Table 2. This table provides descriptions for each variable dimension, along with the names and codes of the variables used for measurement.

#### **4.4.1 Independent variable**

The study's independent variable is ICT usage, which reflects the level of ICT usage in across countries. ICT Usage is operationalized by using the three parameters for generating an index, which are, subscriptions to fixed-line telephone service per 100 inhabitants, subscriptions to cell phone service per 100 inhabitants, and Internet subscribers per 100 people in the population (number of years). In accordance with OECD (2008) instructions for constructing an index, these parameters are normalized and averaged to get a synchronized score for the 13 years under study across 75 countries.

These basic data were collated from the Union internationale des télécommunications (ITU) for ICT-related indicators.

#### **4.4.2 dependent variables**

The percentage will be used to represent values for lower secondary completion rates, internet usage rates, the share of seats occupied by women in national parliaments, and government spending on health and education. These foundational data are sourced from the SDG Transformation Center's data hub.

Table (2) provides a summary of the sources and measures for both the dependent and independent variables.

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**Table 2:** Summary of sources and measures of dependent and independent variables

| Variable Name | Variable Description                            | Symbol | Data Source   | Measure                           |
|---------------|-------------------------------------------------|--------|---------------|-----------------------------------|
| (ICT Usage)   | -Fixed-line telephone                           | FLTE   | (ITU 2024)    | Quantitative<br>(number of years) |
|               | - Mobile/cell phone                             | MOBP   |               |                                   |
|               | - Fixed internet                                | FINT   |               |                                   |
| (SDGs)        | the lower secondary completion rate             | SDG 4  | (UNESCO 2024) | Percentage<br>(number of years)   |
|               | the seats held by women in national parliament  | SDG 5  | (IPU 2024)    | Percentage<br>(number of years)   |
|               | the population using the internet               | SDG 9  | (ITU 2024)    | Percentage<br>(number of years)   |
|               | The government spending on health and education | SDG 17 | (UNESCO 2024) | Percentage<br>(number of years)   |

**Source:** Prepared by the researchers

### e. Empirical model

This study employs panel regression models within a static framework to analyze the influence of ICT usage on achieving SDGs. The methodology includes:

$$SDG_{it} = \beta_0 + \beta_1 ICT_{it} + \beta_2 X_{it} + \varepsilon_{it}$$

Where:

- SDG<sub>it</sub>:denotes the four Sustainable Development Goals; i: country; t:time,
- ICT<sub>it</sub>: represents the index of ICT Usage,
- X<sub>it</sub>: Represents the control variables, such including INF (inflation rate); POPG (the population total); and LF (the labor force total),
- ε<sub>it</sub> is the error term.

Data for this analysis, covering 75 countries from 2010 to 2022, were sourced from the World Bank. Static panel models were applied using the Panel-Corrected Standard Errors (PCSE) method to account for potential issues with heteroscedasticity and autocorrelation.

### 5. Results

The data analysis comprises: a analysis descriptive of the model variables and a detailed examination using a panel regression model.

### 5.1 Data and descriptive

While the primary method for testing hypotheses is panel regression analysis, descriptive statistics play a crucial role by providing insights into the statistical characteristics of the sample. This preliminary analysis provides deeper insights into the distributional characteristics of the model's variables. Table (3) presents a descriptive summary of the variables.

**Table 3:** Descriptive statistics of the variables model

| Variables | Observations | Minimum  | Maximum  | Mean     | Std. Dev. | Skewness | Kurtosis |
|-----------|--------------|----------|----------|----------|-----------|----------|----------|
| ICT       | 75           | 0.072975 | 90.58586 | 40.10833 | 22.05237  | 0.123531 | 2.097754 |
| INF       | 75           | -25.9584 | 401.5912 | 5.483032 | 15.29698  | 18.54357 | 466.459  |
| LF        | 75           | 128753   | 1.38E+08 | 10291392 | 18100684  | 4.417947 | 26.73396 |
| POPG      | 75           | 70567    | 2.76E+08 | 23472382 | 42456971  | 3.842184 | 19.52262 |
| SDG4      | 75           | 9.79497  | 160.5816 | 83.13694 | 23.16369  | -1.22567 | 3.85122  |
| SDG5      | 75           | 0        | 53.41297 | 23.82917 | 12.12499  | 0.359133 | 2.410554 |
| SDG9      | 75           | 0.9      | 100.3472 | 59.80142 | 27.98073  | -0.50008 | 2.179116 |
| SDG17     | 75           | 0.141208 | 13.89092 | 4.004867 | 2.33487   | 0.770047 | 3.196434 |

**Source:** Prepared by the researchers. Stata outputs Version (17.0)

The table reveals that the value of variables inflation rate (INF), total labor force (LF), and total population (POPG) exhibit the highest volatility, with their coefficient of variation exceeding or approaching 100%. The considerable disparity between their minimum and maximum values is the cause of this pronounced volatility. In contrast, the variables ICT, SDG5, SDG9, and SDG17 show relatively lower volatility, while SDG4 is the most stable across the years. Additionally, Table (3) indicates that the study is based on 75 observations.

The distribution of model's variables is assessed using normality tests, with particular focus on skewness and kurtosis. Ideally, a normal distribution is characterized by a skewness coefficient close to zero (0) and

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a kurtosis coefficient near 3. As presented in Table (3), the skewness and kurtosis values for most variables suggest they are approximately normally distributed, albeit with minor deviations. However, the variables INF, LF, and POPG exhibit significant departures from normality. Therefore, to account for these deviations, we will apply a logarithmic transformation in the model estimation.

### 5.2 Main results

Table No. (4) presents the findings from the static panel regression analysis. These results enable the evaluation of the independent variable's significance using tests such as the (Sig z-Student,  $|P| > z$ ). Additionally, the standard beta coefficient is provided, this helps rank the impact of each variable on the dependent variables, indicating the strength and significance of their influence.

**Table 4:** Regression analysis result

| VARIABLES                 | SDG4                | SDG5                | SDG9                | SDG17              |
|---------------------------|---------------------|---------------------|---------------------|--------------------|
| <b>Constant</b>           | 59.57***<br>(2.008) | 20.55***<br>(1.360) | 41.62***<br>(2.852) | 2.60***<br>(0.399) |
| <b>INF</b>                | -0.002*<br>(0.011)  | -0.002*<br>(0.008)  | 0.002*<br>(0.010)   | -0.001*<br>(0.002) |
| <b>POPG</b>               | -1.66*<br>(9.130)   | -1.360*<br>(6.610)  | -3.94***<br>(1.090) | -1.25*<br>(7.230)  |
| <b>LF</b>                 | 4.170*<br>(2.160)   | 3.410*<br>(1.520)   | 8.27**<br>(2.750)   | 1.07*<br>(1.590)   |
| <b>ICT Use</b>            | 0.57***<br>(0.036)  | 0.79***<br>(0.027)  | 0.46***<br>(0.046)  | 0.41***<br>(0.007) |
| <b>Poolability F-test</b> | 48.609***           | 1003.25***          | 637.23***           | 104.86***          |
| <b>BP LM test</b>         | 3789.20***          | 3764.59***          | 970.14***           | 4193.94***         |
| <b>Hausman test</b>       | 52.15***            | 23.78***            | 40.28***            | 42.40***           |
| <b>AdjustedR-squared</b>  | 0.67                | 0.12                | 0.47                | 0.3453             |
| <b>Wald chi2(4)</b>       | 278.63***           | 14.29**             | 154.62***           | 79.62***           |
| <b>Prob &gt; chi2</b>     | (0.000)             | (0.002)             | (0.000)             | (0.000)            |

Source: Prepared by the researchers. Stata outputs Version (17.0)

(\*\*\* significance at  $p < 0.01$ ; \*\* significance at  $p < 0.05$ ; \* significance at  $p < 0.1$ )

The model estimation results presented in Table (4) indicate that the majority of variables are statistically significant, with p-values less than 0.05.

The static panel regression model results are as follows:

**SDG 4: Quality Education:** The coefficient for "ICT Use" is (0.5797603), at the "0.05" significance level, as evidenced by its p-value of "0.0000" ( $P > |z| = 0.000 < 0.05$ ). This finding demonstrates that ICT usage has a positive influences on quality education, with an effect strength quantified at 57.97%. In practical terms, a one-unit increase in ICT usage corresponds to a (0.5797603) unit rise in the level of quality education assurance per year.

**SDG 5: Gender Equality:** The coefficient for "ICT Use" is (0. 793377), at the "0.05" significance level, as evidenced by its p-value of "0.0030" ( $P > |z| = 0.003 < 0.05$ ). This finding demonstrates that ICT usage has a positive influences on promoting gender equality, with an effect strength quantified at 79.33%. In practical terms, a one-unit increase in ICT usage corresponds to a (0. 793377) unit rise in the level of promoting gender equality per year.

**SDG 9: Industry, Innovation, and Infrastructure:** The coefficient for "ICT Use" is (0. 4686083), at the "0.05" significance level, as evidenced by its p-value of "0.0000" ( $P > |z| = 0.000 < 0.05$ ). This finding demonstrates that ICT usage has a positive influences on developing industry, innovation, and infrastructure, with an effect strength quantified at 46.86%. In practical terms, a one-unit increase in ICT usage corresponds to a (0. 4686083) unit rise in the level of developing industry, innovation, and infrastructure per year.

**SDG 17: Partnerships for the Goals:** The coefficient for "ICT Use" is (0. 412884), at the "0.05" significance level, as evidenced by its p-value of "0.0000" ( $P > |z| = 0.000 < 0.05$ ). This finding demonstrates that ICT usage has a positive influences on strengthening partnerships for the Goals, with an effect strength quantified at 41.28%. In practical terms, a one-unit increase in ICT usage corresponds to a (0. 412884) unit rise in the level of strengthening partnerships for the Goals per year.

### **5.3 Additional tests**

Based on the results from the Panel-Corrected Standard Errors (PCSE) regression analysis, at the 5% confidence level, we will examine the

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variables. This includes the impact of ICT Usage on several dependent variables: (SDG 4), (SDG 5), (SDG 9), and (SDG 17). Table (5) illustrates these effects, detailing whether they are positive or negative according to the model.

**Table 5:** Study results summary

| hypothesis | Variable | P> z  | Decision    | Expected direction of the relationship | Direction of relationship according to the results | Test result of the hypothesis |
|------------|----------|-------|-------------|----------------------------------------|----------------------------------------------------|-------------------------------|
| H1         | SDG 4    | 0.000 | Significant | +                                      | +                                                  | Supported                     |
| H2         | SDG 5    | 0.003 | Significant | +                                      | +                                                  | Supported                     |
| H3         | SDG 9    | 0.000 | Significant | +                                      | +                                                  | Supported                     |
| H4         | SDG 17   | 0.000 | Significant | +                                      | +                                                  | Supported                     |

**Source:** Prepared by the researchers

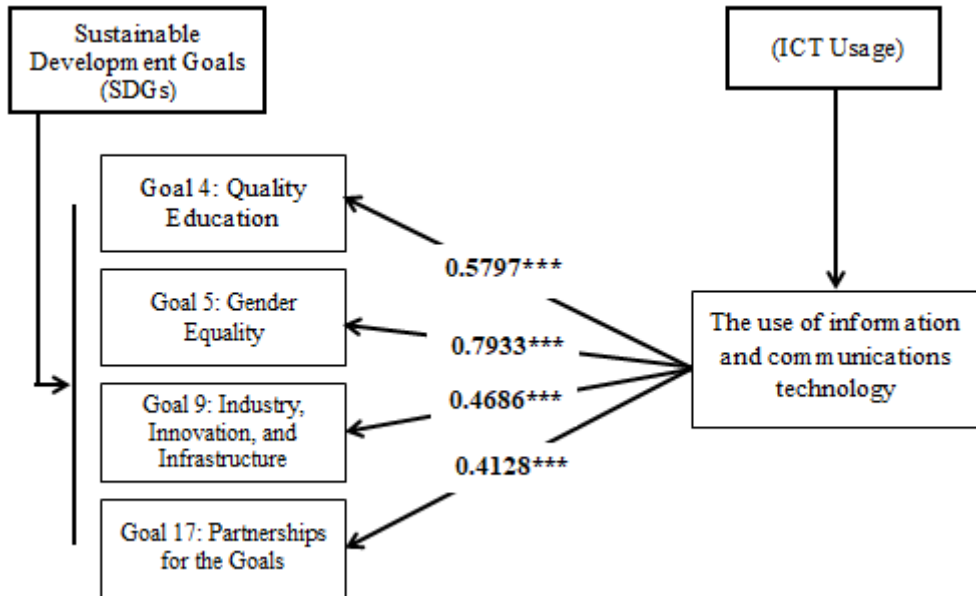
**6. Conclusion**

**6. 1 Discussion of the results**

It is evident that nations that invest significantly in the ICT sector have made notable strides in areas such as education, gender equality, industry, and innovation, while also enhancing international collaborations. They recognize that ICT is more than a mere instrument; it is a crucial catalyst for social and economic change. This insight compels them to make enduring investments in the sector, encourage digital advancement, and build technological infrastructure, all of which plays a vital role in advancing the SDGs.

To answer the study's question—“ How does the use of information and communication technology affect the achievement of sustainable development goals?”—and to verify the theoretical model through hypothesis testing , the findings reveal that ICT usage positively influences several SDGs. Specifically, ICT use enhances quality education (SDG4), promotes gender equality (SDG5), fosters industry, innovation, and infrastructure development (SDG9), and strengthens partnerships for the SDGs (SDG17) in selected countries from 2010 to 2022. Figure 3 below illustrates the empirical model derived from the study.

**Fig.3.** Empirical model of the study



**Source:** Prepared by the researchers

(\*\*\* significance at  $p < 0.01$ ; \*\* significance at  $p < 0.05$ ; \* significance at  $p < 0.1$ )

In examining the study's four hypotheses, the first one hypothesis is a positive impact of ICT usage on enhancing quality education (SDG4) in selected countries between 2010 and 2022. The findings confirmed a statistically significant correlation, demonstrating that ICT usage positively influences quality education, with an effect size of (0.5797603). This implies that a one unit increase in ICT utilization leads to a (0.5797603) unit rise in the level of educational quality assurance per year. Consequently, the hypothesis asserting that "The ICT Usage has a positive impact on ensuring quality education," is validated by the study's outcomes. The reasoning behind this is that ICT offers tools and platforms that enhance teaching and learning methods, such as advanced educational software, online learning platforms, and more efficient communication channels between students and instructors. Additionally, technology improves access to educational materials and creates an engaging learning environment, which overall elevates the quality of the educational experience.

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The second hypothesis centers on the notion that the positive impact of The ICT Usage on promoting gender equality "SDG5" in selected countries between 2010 and 2022. The findings confirmed a statistically significant correlation, demonstrating that ICT usage positively influences gender equality promotion, with an effect size of (0. 793377). This implies that a one unit increase in ICT utilization leads to a (0. 793377) unit rise in the level of gender equality promotion per year. Consequently, the hypothesis asserting that “ The ICT Usage has a positive impact on on promoting gender equality," is validated by the study's outcomes. The reasoning behind this is that technology provides platforms for communication and collaboration that enhance the participation of women and girls in educational and professional activities, which enhances their opportunities for advancement and effective participation in society. In addition, it contributes to improving access to information and educational resources for all individuals regardless of their gender, which contributes to reducing gender gaps in the field of education and other fields.

The third hypothesis centers on the notion that the positive impact of The ICT Usage on developing industry, innovation, and infrastructure "SDG9" in selected countries between 2010 and 2022. The findings confirmed a statistically significant correlation, demonstrating that ICT usage positively influences industry, innovation, and infrastructure development, with an effect size of (0. 4686083). This implies that a one unit increase in ICT utilization leads to a (0. 4686083) unit rise in the level of industry, innovation, and infrastructure development per year. Consequently, the hypothesis asserting that “ The ICT Usage has a positive impact on developing industry, innovation, and infrastructure," is validated by the study's outcomes. The reasoning behind this is that ICT enhances efficiency and innovation in industrial processes by introducing new tools and technologies, such as automation, data analytics, and smart technologies, which help companies improve their productivity and product quality. Technology also contributes to accelerating infrastructure development by providing modern digital solutions for project

management, improving transportation and communications networks, and enhancing the information infrastructure.

The fourth hypothesis centers on the notion that the positive impact of The ICT Usage on strengthening partnerships for the Goals "SDG17" in selected countries between 2010 and 2022. The findings confirmed a statistically significant correlation, demonstrating that ICT usage positively influences improvement in strengthening partnerships for the Goals, with an effect size of (0. 412884). This implies that a one unit increase in ICT utilization leads to a (0. 412884) unit rise in the level of improvement in strengthening partnerships for the Goals per year. Consequently, the hypothesis asserting that “ The ICT Usage has a positive impact on strengthening partnerships for the Goals,” is validated by the study's outcomes. The reasoning behind this is that ICT facilitate and facilitate communication and cooperation between different stakeholders, including governments, businesses, and local communities. This improved cooperation promotes effective coordination and contributes to the achievement of common goals.

Lastly, Table (6) will provide a comprehensive summary of the study's findings, consolidating the results of all four hypotheses.

**Table 6:** Summary of the results of checking the study hypotheses

| N° hypothesis | Formulate the hypothesis                                                                   | Test result |
|---------------|--------------------------------------------------------------------------------------------|-------------|
| <b>H1</b>     | The ICT Usage has a positive impact on ensuring quality education                          | Achieved    |
| <b>H2</b>     | The ICT Usage has a positive impact on promoting gender equality                           | Achieved    |
| <b>H3</b>     | The ICT Usage has a positive impact on developing industry, innovation, and infrastructure | Achieved    |
| <b>H4</b>     | The ICT Usage has a positive impact on strengthening partnerships for the Goals            | Achieved    |

**Source:** Prepared by the researchers

## **6. 2 Recommendations**

Governments and international institutions should promote investment in ICT infrastructure by supporting and financing ICT infrastructure projects, especially in remote and rural areas, to ensure universal access to

and benefit from these technologies in education, gender equality, and global partnerships.

Encouraging public-private partnerships to promote innovation and investment in information and communication technologies. Cooperation between governments, private companies, and non-governmental organizations should be strengthened. This can lead to the development of innovative technical solutions that support sustainable development and contribute to achieving goals related to global partnerships.

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