Journal of Economics and Behavioral Studies (ISSN: 2220-6140)
Vol. 16, No. 1, pp. 64-76, March 2024

The Necessity of the Digital Economy for Sustainable Economic Growth in OECD Countries

Boni David Jonathan Yapi, *Mehdi Seraj, Huseyin Ozdeser
Department of Economics, Near East University, Nicosia, North Cyprus
20202821@std.neu.tr, *mehdi.seraj@neu.edu.tr, huseyin.ozdeser@neu.edu.tr

Abstract: This paper's main intent is to study the relationship between the digital economy and the sustainable economic growth of selected OECD countries from 2016 to 2020. In doing so, we will also endeavor to shed a brighter light on distinct elements of the digital economy and to comprehend their collective inputs on the economic returns of the digital systems. To achieve this, secondary data have been gathered to contribute to the quantitative design research method. We further employed a panel data set and regression techniques such as the unit root test, the cointegration test and the dynamic GMM amongst others. The results of the study revealed that sustainable economic growth is slightly significantly linked to the input of the digital economy in the short and long run. However, it has also been discovered that e-commerce revenues have a significantly positive effect on sustainable economic growth in the short and long run. Lastly, this study recommended the establishment of national and international economic metrics, reflecting more on the presence of digital systems.

Keywords: *Digital economy, economic growth, digital system, sustainable.*

1. Introduction

Our world is moving at a fast rate and technology's role in this global shift is being perceived by the acceleration of the momentum of activities and processes core to the traditional economy. Considering those movements in the economy, we leaned on countries part of the OECD given its potential to fast-track those occurrences and monitor the causes of those shifts. The OECD is the Organization for Economic Co-Operation and Development established on December 14, 1960, with 18 European countries alongside Canada and the United States. By 2020, it has grown to a total number of 38 countries discussing and formulating global social and economic policies.

Having contended with several nation's issues over the years, the OECD contributed to the rise of world trade and the stabilization of economies. Unlike many sectors, technology didn't settle in its sphere, it merged itself with almost every other industry in direct partnership with human expertise. It blossomed beyond being an industry, to now invading at diverse span almost all the economic sectors at different scales. While technology can be seen as the ground for the digital economy, digital itself stands as the building materials of the new methods of production and payments occurring in this age. By digitalizing the core element of the economy, digital is challenging and reshaping bit by bit the economic process itself. The digital economy springs up as an aggregate of those distinct innovations empowering individuals, and helping them achieve their core activities culminating in the sustenance of the economic system. Observing the merger between the traditional economy and the digital economy (DE); the various amount of industries shaped by the innovations occurring in the DE; the increasing and consistent level of attention the convoke and their ability to integrate and run almost entire internal activities of most business, it is only a question of time until the digitalization fully supersedes all economic processes (Choong & Leung, 2021).

The DE is a data-led economy. Its value can also be perceived through the creation, collection, storage and analysis of data to be used and merchandised as intelligence. Basically, individuals and groups able to do properly the above or part of it and hand it over to business in the most simplistic manner stand to gain. The digital economy includes all segments of the economy that employ digital to affect the process and outcome of day-to-day activities, either internally or externally. The way we interact, shop, share, work and receive from each other has been greatly affected but another aspect that has also encountered adjustments is the way value is created and traded.

The DE is continually expanding, a full comprehension of its current situation and elements will enable business to deliver steadily and reflect in a continual monetary gain. The digital economy is progressing at lightning speed, nevertheless, this progress is linked to its capacity to gather, use and interpret a huge number of

information created and stored in a computerized system; regardless of the topic. The spread of the DE has been furthered by COVID-19, with the need for accurate and timely information and rapid adaptability. Between 2019 and 2023, mobile- and fixed-broadband traffic has had an estimated annual average growth of 30 percent, with a peak rate of growth at the start of the COVID-19 pandemic in 2020. Post-pandemic traffic growth slowed between 2021 and 2022: mobile broadband traffic increased by 22 percent, and fixed broadband increased by 10 percent (International Telecommunication Union, 2023). Fixed broadband remains the service of choice for heavy Internet data usage. During the pandemic, a considerable share of mobile traffic was rerouted through fixed networks using home Wi-Fi connections. In 2020, fixed broadband accounted for 96.6 percent of all Internet traffic. In 2022, the mobile broadband share of traffic had increased from 3.4 to 4.2 percent (International Telecommunication Union, 2023). Estimations also showed that the DE's global spread will be accountable for 70% of the new economic value created over the coming decade. However, Doreen Bogdan-Martin, The International Telecommunications Union's Secretary General revealed that one-third of the world's population or an estimated 2.7 billion people still lack access to the Internet (International Telecommunication Union, 2023). Hence, whilst we are sure of the existence of a high potential of the digital economy to further economic value for everyone, there also lies the opportunity for the creation of wider economic disparities and social instability, if the bedrock of those innovations remains partial.

2. Literature Review

Although It's hard to attribute a specific date of birth to the digital economy, the Information and Communication Technologies (ICT) tools and the Internet both building grounds of the DE saw the light of day in the late 1980s. The public launch of the World Wide Web occurred in the early 1990s and the appearance of the first smartphones in the late 90s. Nonetheless, the share of digital access is highly unequally distributed among countries. Internet use remains tightly linked to the level of a country's development. In 2020, nine out of ten people in high-income countries used the Internet. In 2023, the share edged up to 93 percent, getting closer to universality (International Telecomunication Union, 2023). Within the OECD countries, the digital gap is getting closer but for the rest of the world, the experience is different. The business world is also experiencing a shift, and whilst new business models and companies emerge, the old ones failing to adjust themselves to the changes are falling. The inability of the business to satisfy its clientele via its current medium of choice (digital) will result in a loss of profit and ultimately in bankruptcy. For instance, tourism and real estate industries are industries that have been positively disrupted by platforms such as TripAdvisor and Airbnb, among others.

Digital photography offered by smartphones has highly challenged the market share of Kodak. Bookstores, movies and music stores endured similar challenges due to the rise of eBook and streaming platforms (Gannes, 2016). Banks through online banking, FinTech and several other industries, pillars of the global economy are facing the same restructuring. The way human beings fulfill their basic needs and wants has shifted through the use of digital technology, and a whole economic system is taking form under this evolution. The economic benefits are attributed to companies behind those innovations, and for valid reasons, but besides them, there is also a large number of users simultaneously deriving economic benefits from their efficient use of those tools. The commission has also stated that if all the country's members learned from the best-performing European nations or the USA and China, the EU internet economy would witness the arrival of 400,000 to 1.5 million new jobs (Commission, 2016). Since its appearance in the mid-90s, the digital economy has progressed due to the dynamic nature of technology which is a high rate of adoption by both producers and customers (Barefoot & Curtis, 2018). The term internet economy can be traced back to the late 1990s, and from then on, the economic potential it could bring about if fully adopted by society, was apparent (Brynjolfsson & Kahin, 2002).

Economic growth is defined as an increase in the real income or production level of a country during a specific timeframe. At first, the digital economy emerged in developed countries but given its information, goods and services sharing abilities, it spread itself to new regions. This includes developing countries due to the continual ongoing international trade and political bonds which simultaneously further the expansion of digital devices (UNCTAD, 2019). The scale at which the DE penetrates regions varies on the mean of penetration and the current development level in the place. 98 percent of the population living in rural areas of high-income economies is covered with a mobile broadband network. This implies that almost every person without access to a mobile broadband network lives in a rural area of a developing country (International Telecommunication Union, 2023).The bilateral relations between developed and developing countries are fertile ground for the

prosperity of digital tools and processes. Although they are quite costly to acquire and maintain, they are undoubtedly time and cost-saving in the long term. Additionally, the level of professionalism and efficiency they provide is irrefutable in this age. At the Central Economic Work Conference in 2019 in China, it was clearly stated that reviving the development of the digital economy is a sure path to reaching a place of sustainable and high-quality economic growth (Zheng, Jiang & Yang, 2021). Most governmental sectors are being affected by the digital economy, but its impact on the manufacturing industry is one of the highest. It is the physical extension or the tangible expression of the DE given that its outcomes usually empower all the other economic sectors. The economic benefit straightly derived from the usage of the internet in a nation can be identified as the iGDP or e-GDP (Manyika & Castillo, 2013). A high iGDP translates into an important online trade in a country. The share of e-commerce in the European economy was 4.3% in 2020 and accounted for 4.6% in 2021. As a comparison, the spending on defense in Europe amounted to 1.2 % of GDP in 2019 (Lone & Weltevreden, 2021). There are a specific number of online industries that result in the growth of iGDP, notably online media, e-commerce, online advertising and digital financial services.

In these last years, we have witnessed the accentuation of digital services, products and methods which are imposing themselves on society across all the spheres of the economy (Brennen & Kreiss, 2014). This change is often described as digitalization, the advancement of business operations and human activities through digital services and products (Malecki & Moriset, 2007). A recent focus has addressed the several cross-sectoral digitalization trends ongoing in the traditional economic sectors (OECD, 2016). Based on the terminology of the DE, the global value of the DE is also fluctuating. However, it has been esteemed that the DE is responsible for around 4.5% and 22.5% of world GDP, according to the attributed definition of the digital economy employed. In the case whereby the DE constitutes around 4,5% of the GDP, the DE is attributed to the narrowest range of impact, only considering the value-added by the ICT industry alone. When considering this description, its impact on global GDP remained constant at around 4.5% from 2008-2018 (UNCTAD, 2019). Higher figures are obtained when we tend to include the spilling effects of the ICT industry in other sectors of activity constituents of the economy. The World Bank estimates that the digital economy contributes to more than 15% of global domestic Product (GDP), and in the past decade, it has been growing at two and a half times faster than physical world GDP (WEF, 2022). Deemah AlYahya, Secretary-General of the Digital Cooperation Organisation (DCO), expects the digital economy to grow tremendously contribute 30% to the global GDP and create 30 million jobs by 2030. The world's digital economy industry is controlled by two countries, the USA and China. The fact that developing nations have the upper hand in the digital economy and its potential benefits doesn't come as a surprise. It compels us to assess the correlation between the existing development level of a nation and the economic benefit a country can derive from the DE.

Approximately sixty-seven percent of the world's population, or 5.4 billion people, is now online. This represents a growth of 4.7 percent since 2022, an increase from the 3.5 percent recorded from 2021 to 2022 (International Telecommunication Union, 2023). The number of people offline in 2023 decreased to an estimated 2.6 billion people, representing 33 percent of the global population. Internet use remains tightly linked to the level of a country's development. In 2020, nine out of ten people in high-income countries used the Internet. In 2023, the share edged up to 93 percent, getting closer to universality. In low-income countries, 27 percent of the population uses the Internet, up from 24 percent in 2022. This 66-percentage point gap reflects the width of the digital divide between high-income and low-income countries and regions (International Telecommunication Union, 2023).

Is a strong economic level a prerequisite for a nation to derive the most from the digital economy? Seeing those two countries have been in the top ten largest economies by average values of (GDP) during the past 40 years. In 2015, The USA and China represented around 44% of the world's digital economy (Knickrehm, Berthon & Daugherty, 2016). Moreover, they both hold 75% of all patents concerning blockchain and account for 50% of the spending on the Internet of Things. Additionally, they hold 90% of the 70 largest digital platforms (UNCTAD, 2019). As of 2019, they were responsible for approximately 72% of global e-commerce sales (E-Marketer, 2019). Does the digital economy necessitate a preexisting level of development for it to be fully profitable? Those are some of the questions we will try to cover in this topic. But the fact that aside from the USA and China other relatively strong developing countries hold quite a small fraction of the global digital economy, reveals that aside from being a developed nation several additional and major factors have to be considered to derive a consistent economic benefit from the digital economy. The DE has been found to amount to up to 10% of the

GDP of developing nations, while in advanced nations it was responsible for nearly 18.4% of their GDP (Huawei, 2017). In the same year, developing nations accounted for 27% of participation in the global digital economy, (Huawei, 2017). While evaluating the importance of the DE, it has to be observed through the lens of a given set of technologies. As highlighted by (UNCTAD, Information Economy Report: Digitalization, Trade and Development, 2017). the development of the DE can be tracked by a continuous increase of robotic innovations and the adoption rate by society of the infrastructure constituents of the Internet of Things (IoT). However, observing the latest trending innovations will not always result in a proper understanding of the DE, hence its main constituents should be explored.

In recent years, scholars have investigated both the practical and theoretical aspects of the digital economy, it has been noted that the period to assess the bond between economic growth and the digital economy has passed and now researchers should rather shift from the benefiting relationship to now elucidate how digital systems directly and indirectly influence the economic performance (Vu, Hanafizadeh & Bohlin, 2020). Although the development of the DE triggers a rise in regional economies it also fosters a vast digital separation (Lopez & Nanclares, 2003). A study equipped with surveys sourced from the Dutch population observed that considerable inequalities in society will continually spring up as the internet gains in maturity (Van & Duy, 2020). With the use of empirical techniques, Cardona assessed the digital economy and its elements and their role in pushing forward productivity in all the spheres of activities it penetrates (Cardona & Kretschmer, 2013). Scholars also observed that high-quality economic growth can originate from the DE, given its ability to enhance the production factor, time efficiency, quality, and the economic inputs of previously irrelevant elements (Hong, 2019). Among the several traits of the digital economy, the highlight traits of the digital economy are its large diffusion, continuous rise, high sphere of influence, and ability to increase returns and reduce cost in the long term (Song, 2019). Also, given its informational feature, and both the external and internal support it gives business, it has the potential to increment marginal gains. In an aim to assess the relationship between the DE and economic growth, the two variables within 222 prefectural regions in China have been gathered and results that the DE has the potential to significantly promote sustainable economic growth (Zhao & Zhang, 2020).

In the same region, with the use of the Digital Inclusive Finance Index and Household Tracking Survey data, digital finance was observed to be a generator of inclusive growth in China's economy regarding the DE (Zhao & Zhang, 2020). Ren & Yang (2020) believed that quality economic development emanates from innovations in technology. Other economists have had quite divergent conclusions on this view (Wang & Chen, 2018). This is one of the main reasons why this study has been instigated. The impact of the DE on economic prosperity is perceivable tangibly but theoretically, it is hardly perceivable and poorly reflects the true state of reality. Zheng, Jiang & Yang (2021) focusing on how much of the high-quality development of 30 Chinese provinces from 2011 to 2019 relies on the digital economy discovered a low significant correlation between the two elements. We often blame the government for not establishing proper policies and laws to fast-track certain innovations. But when it comes to digital, the groups at the forefront have to be the first to both explain and showcase realistic findings and the economic benefits of digital systems. The economic benefit from the digital economy showcased is often that of turnover made by the sale of digital products and services to the market. These habits in itself conceal the many avenues through which economic gain is made digitally. Groups have to showcase how the internal use of those digital systems translates into economic gains by helping them to save cost, time and resources. Users also have to be surveyed and disclose the gains they made from digitalizing their business. We often highlight unemployment levels due to digital but seldom mention the various new professions human beings are venturing into through the digital economy. The negative aspects of the rise of the digital economy on humans (often linked to their misuse of the digital), as it regards health, security and unemployment are many blatant (Guliyev, 2023). On the other hand, the lack of theoretical reports on how several individuals are endeavoring into online business and entrepreneurship quite easily, with few experiences and qualifications daily is far undermined. The high level of privacy of digital companies affects the availability of accurate literature on the economic gains of implementing digital systems. It is also responsible for the shortage of conclusive studies, established theories and the absence of internationally accepted deep digital measurement tools.

3. Data and Methodology

This segment of the study focuses on the approach used to assess the role of the digital economy in the economic growth of 21 OECD country members, from 2016 to 2020. On this basis, the following section begins with the research design and next will be an elaborate presentation of the variables to be processed. The source of the data as well as the regressors and analysis techniques employed for their assessment, will also be revealed in this segment.

Research Design: This study's theoretical frameworks draw on existing theories and research which revealed that technology has a positive impact on economic growth. On this basis, this study brought forward two key players of both technology and economic growth, which are respectively the digital economy and sustainable growth. These days the topic of sustainability cannot be properly discussed without mentioning the integral usage of digital systems. We observed that the digital economy seems to bring suitable answers to most of society's sustainable issues. Our collection of data will be made with the intent to verify if this observation is equally perceived theoretically.

As briefly stated by Creswell (1994), quantitative research elucidates happenings through the collection of numerical data which are processed mathematically mostly in statistics. Quantitative research enables researchers to perceive the world's happenings, as a reality that can be objectively grasped. The findings of the quantitative analysis are founded on logic, impartiality and statistics. Both the primary and secondary methods can be applied in the collection of variables. The variables for our study are secondary data and the collection method and source will be displayed in the following part. Although several theories have been found on the impact of digital on productivity, its financial outcome is usually acknowledged and effectively reported by companies but rarely by countries and governments if not in speech. Therefore, this research can be classified as correlational and experimental given the assessment of the interconnection between those two parties.

Data Source and Collection: The yearly secondary data used for this study have been sourced from various databases. The main one is from the E-commerce Europe (EE) report 2021. Ecommerce Europe is a European association representing the digital commerce sector in Europe. It is the principal European structure representing the retail sector.

The EE aims to equip nations with tools that will help lawmakers design frameworks more fitted for the evolution of DE and online entrepreneurs and businesses. The EE also intervenes in public affairs and stands for the interest of digital commerce. It is shaped as a working committee whose outcome is transferred understandably for non-IT individuals and legislators to make informed policy recommendations. The second source was the United Nations Conference on Trade and Development (UNTCAD) a permanent structure designed by the General Assembly of the United Nations in 1964. It is an intergovernmental organization, part of the UN Secretariat and the United Nations Development Group. The UNTCAD works with several governments to ensure a proper implementation of Financing for Development.

For our study, we gather from their reports the e-commerce sales of some countries in the chosen time periods. The third source was the OECD Stat which is a segment of the Organization for Economic Co-operation and Development (OECD). It is an international organization devoted to constructing policies that once implemented result in an amelioration of the life of citizens to an extent. To achieve this, they design policies that further equality, prosperity and the availability of development opportunities. It's in this vein that their statistics branch has been developed and also made available to the public. They not only disclose their analysis and projects but also part of the information they use to establish policies and monitor their impact in countries. Unavailable variables on the aforementioned databases, during a certain period have been obtained from the OECD Stats. In total, for our estimation of the econometric model, the variables concerning 21 countries members of the OECD from 2016-2020 have been selected every year for the composition of the balanced panel.

Data Presentation

Independent variables

-E-commerce sales (ECOM) refer to the annual revenue generated online by businesses in each country. It is expressed in euros and varies based on the scale of online activities in a country. Several elements such as

internet penetration, ICT usage and adoption rate and IT literacy affect its value. However, a low e-commerce sale shouldn't directly translate into a low internet penetration or usage rate. A more detailed analysis has to be conducted, and factors like demography have to be included. E-commerce is so dense that in cases where products cannot be digitalized or the services are unable to be provided digitally, businesses still find a way to enlarge by multiples their customer shares and by doing so their economic returns.

-E-Shoppers (ESH) or online customers, are the first portion of the total population which are accessing the internet annually. It highlights the percentage of internet users who bought goods and paid for services online. Knowing that the total online population is not necessarily engaged in buying and selling online, it is important to separate those who do engage in it from those who do not. In our analysis we opted for the growth rate in online shoppers for a more distinct analysis of their ascent or decline over the years in regions. The e-shoppers' growth rate can be either positive or negative since it considers the data of prior years.

-The GERD or Gross Expenditure on Research and Development, refers to the total domestic spending on research and development performed on the national territory over a period of time. It includes all sectors of activity such as governmental, public and private business, higher education and healthcare. The GERD focuses on all R&D activities executed locally or within the limit of the country. Regardless of the source of R&D funding, GERD encompasses both domestic and overseas funds.

-The Gross Domestic Product per Capita (GDPC) is globally acknowledged for indicating the economic growth of a nation. It is derived from the Gross Domestic Product, which is calculated as the sum of investment, consumption, government spending and net export, generated by a country on an annual basis. The GDPC can be obtained by dividing the real GDP of a nation by its population.

Dependent variables

The Sustainable Development Index (SDI) is an index that first of all acknowledges and supports the fact that progress shouldn't be achieved at the expense of the planet's wellness. It states that genuine development should be pursued within the delineations of the environmental limits and progress should only be recognized through the lens of its conformity with the planetary boundaries. The Sustainable Development Index has been designed to efficiently assess the ability of society to further development, whilst abiding by the environmental and societal norms (Jyoti, 2019). Generally, several elements are included in the calculation of the SDI. Amongst them, we can cite demography, employment inclusivity, labor force, unemployment, life expectancy, mortality rate, education and industrialization index among many others. In our context, we used a summarized version obtained by the ratio of the development index over the ecological impact index. We opted for the SDI as a dependent factor given the ability of digital factors to provide sustainable solutions and improvements in society.

Methodology and regression equation

Dynamic Panel Model

The usage of panel data analysis is gaining in popularity given its prowess when several countries are involved in the research application. Panel data refers to a common sample set of elements that nations or organizations have during a certain period. The use of panel data holds several benefits, in fact one of them is that given its ability to support and examine a larger number of variables over a long period, it reduces the amount of multicollinearity among the variables, and enhances the performance of the estimation. Given the aim of this study, 21 countries members of the OECD have been observed over five years beginning in 2016, to examine the impact of the digital economy on economic growth. We first of all considered the dynamic panel data model estimated as follows:

$SDI_{i,t} = \beta 0 + \beta 1 GERD_{i,t} + \beta 2 ECOM_{i,t} + \beta 3 ESH_{i,t} + \beta 4 GDPC_{i,t} + \varepsilon_t$

Where each country in the panel is represented by *i* and *t* reflects the period.

The functional form of the model being used is as follows

$SDI_{i,t} = f(GERD_{i,t}, ECOM_{i,t}, ESH_{i,t}, GDPC_{i,t}, \varepsilon t)$

Which, $SDI_{i,t}$ presents Sustainable Development Growth, $GERD_{i,t}$ shows Gross expenditure on research and development, $ECOM_{i,t}$ is E-commerce sales, $ESH_{i,t}$ presents Online customer, $GDPC_{i,t}$ is Gross Domestic Product Per Capita, and ε_t is the Error Term
The coefficients of the regressors are symbolized by $\beta 1$ to $\beta 4$ in the equation above and the constant is symbolized by $\beta 0$.

4. Empirical Results

In this part of the study, we will showcase the results obtained by the application of previous methodologies and interpret each finding in line with our main topic. The overhaul aim of this paper remains the investigation of a relationship between the digital economy and sustainable economic development.

Descriptive Statistics

The descriptive statistic test is used to depict the fundamental aspect of the variables used in our research. It presents a summarized and classified version of the raw variables, to provide a meaningful viewpoint of the raw data. It gives a quantitative depiction of each variable and presents their specifications such as their maximum, minimum, mean, standard deviation, and level of skewness.

Table 1: Descriptive Statistics

Variables	SDI	GERD	GDPC	ECOM	ESH
Mean	78.90402	2.094190	42430.38	50.641771	5.651048
Median	79.40000	2.070000	43784.29	8.200000	4.240000
Maximum	85.60711	3.500000	87097.04	720.0000	22.62000
Minimum	69.81073	0.300000	12447.44	0.260000	9.580000
Std. Dev	3.780484	0.837726	20808.79	117.9223	5.545152
Skewness	-0.364099	0.018014	0.401690	3.685737	0.620955
Kurtosis	2.639828	1.730539	2.260488	17.30507	3.345161
Jarque-Bera	2.887483	7.056130	5.216310	1133.009	7.268963
Probability	0.236043	0.029362	0.073670	0.000000	0.026398
Sum	8284.922	219.8900	4455201	5317.380	593.3600
Observation	105	105	105	105	105

Source: Estimate by the researcher using EViews.

Table 1 above shows the descriptive results of the SDI, GERD, GDPC, ECOM, and ESH of 21 OECD countries members from 2016 to 2020. We have in total 105 observations. The mean value of the SDI of 78.9 reflects that a relatively high degree of sustainability is included in their economic development procedures. Concerning the GERD, the average of 2.09 lies within the findings of previous researchers. It has been revealed that the GERD as a portion of GDP on the global scale rose from 1.8% in 1981 to 2.2% in 1990 and has since then remained as such (May, 1998). The GERD also has the lowest volatility amongst the variables. The online customer population growth, being a proportion of internet users, has a 5% average growth. The mean for the GDP Per Capita of those combined countries expressed in euro is also relatively high. The e-commerce sales of those countries, which are expressed in billions of euros, also have on average a relatively high value. The ecommerce variable also has one of the highest standard deviations, which means that it fluctuates more than the other variables, unlike the GDPC whose composition depends on a greater number of variables absent in

our set. Overall, the proximity between the mean and the median of the variables, except in the case of ECOM, revealed that this econometric model is experiencing a normal distribution.

Table 2: Unit Root

ADF					
		Intercept		Trend & Intercept	
Variables	Significance	T-Statistic	P-Value	T-Statistic	P-Value
SDI	Level	104.743	0.0000***	99.9964	0.0000***
GDPC	Level	-1.68478	0.0460**	-7.7132	0.0000***
ECOM	Level	22.7709	0.9932	34.75787	0.7784
	1st Difference	62.4733	0.0218**	74.8772	0.0013***
GERD	Level	66.0640	0.0103**	7.6432	0.000***
ESH	Level	87.5486	0.0000***	98.8686	0.0000***
Levin, Lin & Chu T					
		Intercept		Trend & Intercept	
Variables	Significance	T-Statistic	P-Value	T-Statistic	P-Value
SDI	Level	-16.7426	0.0000***	23.9964	0.0000***
GDPC	Level	-7.71320	0.0007***	1.7132	0.0000***
ECOM	Level	6.3643	1.0000	34.75787	0.9784
	1st Difference	-1.99436	0.0231**	-6.8772	0.0000***
GERD	Level	-15.4567	0.0000***	7.74532	0.0000***
ESH	Level	-19.2875	0.0000***	98.8686	0.0000***
Phillip Perron					
		Intercept		Trend & Intercept	
Variables	Significance	T-Statistic	P-Value	T-Statistic	P-Value
SDI	Level	119.7426	0.0000***	98.9964	0.0000***
GDPC	Level	77.71320	0.0007***	1.7132	0.0000***
ECOM	Level	34.3643	0.7784	34.75787	0.9784
ECOM	1st Difference	74.8772	0.0013***	-6.8772	0.0000***
GERD	Level	40.8493	0.5214	79.74532	0.0004***
ESH	Level	98.8686	0.0000***	98.8686	0.0000***

*** Significance at 1%; ** Significance at 5%; * Significance at 10%. Source: Estimate by the researcher using EViews.

Table 2 presents results obtained with the use of the Augmented Dickey-Fuller (ADF) test. This test has been used to check the stationary level present in the set of variables. The null hypothesis of the ADF test states that the data are non-stationary and it symbolizes the presence of a unit root in the data set. In the event of the presence of a unit root, the variables are converted in the first difference for correction of the problem. However, if the variables are found to have unit root after being converted it is sometimes advised to remove the variable. The results of the unit root test with only the trend shows SDI, GDPC, GERD and ESH as significant at level, at a 1% significance level. Regarding GERD, it is significant at the 5% significance level and the ECOM is significant at the first difference. However, when the trend is added to the parameters, the p-values of SDI, GERD, GERD and ESH are all below 0.05, hence significant at the level at a 1% significance level. Concerning the ECOM it is statistically significant at first difference with a 1% significance level. The presence of the unit root in the e-commerce variable is treated on the first difference. The SDI, GDPC, ESH and GERD being all significant at level, respectively 1% and 5% significance and the ECOM being significant at first difference, means that the null hypothesis will be discarded. We then accept the alternative hypothesis which states that there is no unit root. Levin Lu & Chu present similar results except for the significance level of GDPC and GERD. Likewise, the findings of the Phillip Perron tests are similar, besides the GERD which is only significant with trend and intercept at level. In consideration of the results of those three tests, we can safely conclude that the collected set of variables is all stationary.

Table 3: Cointegration Test

Kao's Residual Cointegration Test	Hypothesis	T-statistic	P-Value
Null Hypothesis	No Cointegration	-8.128693	0.0000
Residual Variance	-	5.336785	
HAC Variance	-	4.196876	

Source: Estimate by the researcher using EViews.

Table 3 above presents the results from the panel cointegration test, proposed by Kao in 1999 which employs a first regressors technique. The null hypothesis of the test is that there is no cointegration and therefore no long-run relationship exists amongst the variables. The P-value being inferior to 0.005 leads us therefore to the acceptance of the alternative hypothesis. The null hypothesis of no cointegration is then highly rejected at a 1 percent significance level, which indicates that the analyzed variables in all the panel sets are cointegrated, and share a long-run relationship. The statistical information enables us to ascertain the presence of a sure cointegration among the variables.

Table 4: Dynamic Panel Generalized Methods of Moments

	Coefficient	Std. Error	t-Statistic	P-value
SDI (-1)	0.235348	0.118881	1.979689	0.0617*
GERD	1.130857	0.467810	2.417343	0.0253***
LOG (GDPC)	-3.028035	2.380131	-1.272214	0.2179
ESH	0.039383	0.017594	2.238517	0.0367**
ECOM	0.014607	0.002757	5.298816	0.0000***

*** Significance at 1%; ** Significance at 5%; * Significance at 10%. Source: Estimate by the researcher using EViews

Table 4 presents the results for the dynamic Generalized Method of Moments (GMM). First, the effect of e-commerce on sustainability growth shows that a percentage change in the e-commerce return can lead to a 1.4 percent increase in the level of sustainable development, in the short run at a 1% significance level, on average ceteris paribus. Hence, e-commerce and the SDI exhibit an elastic connection. The value of e-commerce sales depicts the involvement scale of a nation with the digital economy. It is a reliable instrument to measure the development of the DE in a nation. Considering that e-markets are vastly composed of digital elements, and are found to be significant for sustainable development, it is quite safe to say that digital systems are contributing significantly to the advancement of sustainable development. The more people remain at home, whilst maintaining or even increasing their economic involvement in their society has a positive impact on the environment, the healthcare of the population and inevitably on the economy. It also mirrors the vital position that digital improvements have globally in the active and effective establishment of durable economic infrastructures. The research and development findings also indicate that a percentage change in the amount allocated by the officials towards research can lead to up to a 113 percent increase in the index of sustainable development, in the short run at a 1% significance level, on average ceteris paribus. The GERD, hence, has a high input in the evolution of sustainable development. As discussed in this study, technological prowess which led to the recent digital improvement couldn't have happened without several research. That research is costly and does not often immediately result in high profits, hence requiring a constant stream of financial support. The gross expenditure on research and development and the SDI shares an elastic connection.

However, the full return on investment in the research tends to be perceivable in the long term. Only then we can say the fruits of this research are ripe, fully matured and well-received by society. Hence, there is a need for high digital literacy in society. The sooner a proven innovation is received, the sooner the people involved in its creation and usage will benefit economically from it. Several research hasn't brought forth concrete results because they tend to focus on the portion of GERD that failed to deliver. However, the knowledge acquired from that failure is invaluable and is more than often directly linked to successful discoveries. It is based on knowledge derived from those failures that the next successes are born. The total return of a single, fully matured and accepted innovation can offset the R&D investments made by officials over several years.

Regarding the involvement of the online customers population in sustainability growth the results reveal that a percentage change in the e-shoppers can lead to a 3.9 percent rise in the index of sustainable development, in the short run at a 5% significance level, on average ceteris paribus. Several benefits for the environment and health can be traced back to the reduction of physical movements of individuals. During the Covid-19 pandemic, we've witnessed the quarantine which was only possible due to the simultaneously high increase in the number of online customers in several industries. The Census Bureau revealed that not only online shoppers spurged but also e-commerce sales increased by $244.2 billion or 43% in 2020, the first year of the pandemic, rising from $571.2 billion in 2019 to $815.4 billion in 2020 (ARTS, 2022) . Those e-shoppers were not only maintaining the economy but also the health condition of each other. Reducing each one's exposure to the outside environment had an advantage on the global health state. On the topic of sustainability, the most crucial end goal is health. But considering that ESH is a function of internet users, it might be difficult to directly perceive its impact at first glance. Regardless, ESH has an elastic relationship with the sustainable development of a nation. The GDP per capita is the only variable disclosing an insignificant probability value. GDPC is a function of GDP and demography which are themselves impacted by several factors external to those used for our study. The GDP is largely composed of the inputs of capitalistic industries and the share of companies involved in the sustainability aspect of their production systems is quite low. It is hence hard to connect the GDPC with sustainable development since the SDI does not portray the amount earned by the population, rather it rates the methods and processes employed by the demography in the acquisition of those riches. The Gross Domestic Product per capita exhibits then an inelastic relationship with the sustainable development index. Finally, the coefficient obtained for the lagged dependent variable, SDI (-1) is quite small nearly 0.2 positive and significant at a 10 percent significance level. This means that a large portion of the model has a relatively small influence (0.2) on the sustainable index in the short term. As discussed above, although most of the constituents of sustainable development are not directly tied to the DE, they are highly connected with digital systems but the SDI structure doesn't equally attest to it. This shouldn't be so, the impact of the DE has to be acknowledged, given the presence of unique elements, characteristic of the DE in today's sustainable economies. The proper reflection of digital systems in the global economy is experiencing several hindrances.

We could have chosen dependent variables such as the returns from the technology and the manufacturing industry which are very profitable to the global economy and also obvious constituents of the digital economy. But the intent of this study being to give a global wakeup call and provoke changes, we opted for a dependent variable that both touches and relies on the involvement of all spheres of economic activities. The technology and related sectors are already aware of the economic advantage of the DE, but other industries are still lagging due to a lack of knowledge on the subject and the committed use of incomplete profitability measurement tools. Those habits obstruct the full acknowledgment of the impact of the DE. Despite this situation, the DE is still finding a way to spring up as a small significant element. Moreover, the discovery of a 0.2 value has not been previously investigated let alone found by prior studies. To ensure the effectiveness and consistency of the GMM estimation, the investigation for the absence of serial correlation amongst residuals and their validity is necessary.

Table 5: Collinearity Variance Inflation Factor

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
GERD	0.415055	11.12022	1.1410345
GDPC	0.000278	4.914534	1.032945
ESH	0.002994	1.879655	1.153693
ECOM	0.000022	1.302560	1.265972
C	2.835467	15.80948	NA

Source: Estimate by the researcher using EViews.

The term multicollinearity indicates a state by which two or more variables are found to be highly correlated to one another. Table 5 presents the findings from the variance inflation factor (VIF), which is a method used to evaluate the presence of multicollinearity among variables in a regression model. As discussed in the methodology, there is no formal VIF value set for the determination of the presence of multicollinearity, such as the thumb rule with other methods. An ideal variable's VIF value lies around 1. When it reaches this value,

we can then be sure of the absence of multicollinearity among variables. Based on the findings of the model, we can conclude that they testify to the absence of multicollinearity, as all p-values for the centered VIF are close to 1.

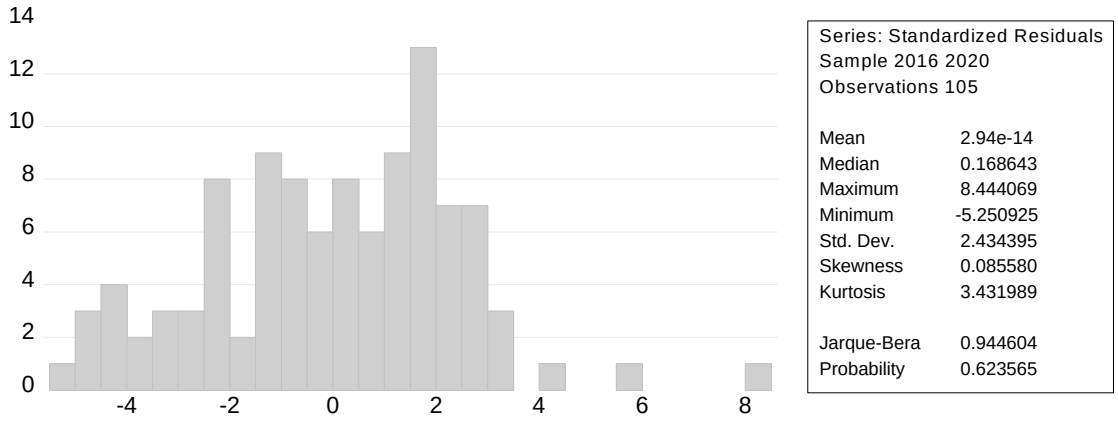
Table 6: Arellano Correlation Bound Test

Test Order	m-Statistic	SE (rho)	P-value
Null Hypothesis:	No first-order serial correlation		
AR (1)	-2.252876	20.319493	0.123
AR (2)	NA	NA	NA

Source: Estimate by the researcher using EViews

The dynamic panel data has been additionally diagnosed with the Arellano-Bond's (1991) test, to investigate the correlation between the variables. According to Arellano and Bond, this diagnostic is of great importance in analyzing the validity of the instruments when a dynamic set of data is involved. Furthermore, it is necessary to examine the reliability of the dynamic outcome using the Arellano–Bond estimator. Table 6 presents the results obtained after investigating serial correlation. The serial correlation of idiosyncratic error term being the aim of the Arellano-Bond test, led to the completion of the test at first difference. The null hypothesis of the test is that there is no first-order serial correlation. The AR (1) p-value of 0.1234 is higher than 0.05, then leads us to the acceptance of the null hypothesis. the error terms are not serially correlated in the first difference.

Figure 1: Normality Test



Source: Estimate by the researcher using Eviews

Figure 1 presents the Jarque-Bera test, which is a multiplier instrument, mostly employed to assess the normality status of the variables to either infirm or confirm the normal distribution of the dataset. The degree of kurtosis and skewness can also be used to assess the normality. The null hypothesis of the Jarque-Bera test is that the data are normally distributed, whilst the alternative hypothesis states that the residuals are not normally distributed. The requirement for Kurtosis is that the value must its value must lie between -3 and 3. Furthermore, regarding the skewness, its boundaries are between -1.96 and +1.96. Finally, to reject the null hypothesis of the test and accept the alternative hypothesis, the P-value should be less than 0.05. Henceforth, as showcased in Table 7, the value of the kurtosis is just above criteria 3, and the value of skewness of 0.08 lies within the -1.96 and +1.96 limits. The investigation also presented a probability value of 0.623565. the P-value being greater than 5%, leads to the acceptance of the null hypothesis. Based on those findings, we then state that the given set of data is normally distributed.

5. Conclusion

In recent years, our personal lives have greatly benefited from digital systems, and they've offered us durable and sustainable solutions for most of our economic and social issues. It is widely considered that our society will enter a phase whereby national and global governance fully backed by the digital economy will be the norm. Proper economic inclusion and globalization are nearly impossible without a global adoption of the digital economy. If economies of the world truly want sustainable economic prosperity, they must be willing to part with the incongruent traditional economics models they simultaneously carrying on. Failure to make drastic decisions for global integration of the DE will equate to the expansion of the economic gap between developing nations and developed ones. Developed countries alike have the ability to quickly forsake certain old methods of operations when they're presented with a new effective and sustainable one. The adoption is complete, when the previous methods are blatantly obsolete when compared to the new ones.

Considering the fast pace of innovations, the problem of waste and emissions can't be ignored. The DE is also at the root problem of various societal issues. The huge gains provided by big data companies often come at the cost of the user's privacy; the free flow of information threatens international and national security. The intelligence agencies behind several IT companies have been accused of mass surveillance and breach of privacy through their software and the personal smart devices they commercialize. Furthermore, the automation processes which largely constitute digital systems, have a great substitution effect on the activities involving mankind, and it ends up affecting the labor industry as we know it. The DE should not be handed the laissez-faire approach, rather governments have a major role in monitoring its evolution by directing its entry and exit points. The economic benefits from the digital economy often seem to increase in nations that have beforehand established a conducive ground for its implementation. Henceforth, the necessity to display information concerning the DE, in an intelligible form by non-IT individuals. Large digital companies must be considered in line with the power they have at their disposal. Besides being some of the largest organizational tax contributors, governments must see them as allies to accurately support innovations and to establish proper legislation on all aspects of the digital economy. The impact of digital on economic growth has been proven both practically and in theories, however, the focus of this study was to highlight the importance of the digital economy on the establishment of sustainability. The results which are less showing than expected are not congruent with reality. The shortage of specific data concerning the digital economy at the national level is one of the barriers. However, the lack of a proper definition of the digital economy further complicates the establishment of the data that can reflect best its sustainability impacts.

References

ARTS. (2022). *Annual Retail Trade Survey Shows Impact of Online Shopping on Retail Sales During COVID-19 Pandemic.* The Census Bureau's.

Barefoot K., Curtis D. (2018, March 15). Defining and measuring the digital economy. (URL: https://www.bea.gov/sites/default/files/papers/defining-and-measuring-the-digital-economy.pdf).

Brennen, S. & Kreiss, D . (2014). Digitalization and digitization. *Culture Digitally, 8*.

Brynjolfsson E & Kahin, B. (2002). Understanding the Digital Economy. *Massachusetts Institute of Technology*.

Choong, K .& Leung, P. W. (2021). A critical review of the precursors of the knowledge economy and their contemporary research: implications for the computerized new economy. *Journal of the Knowledge Economy*, 1-38.

Commission, E. (2016). *The importance of the digital economy.* From European Commission: European Commission (2016a): The importance of the digital economy, https:/ec.europa.eu/growth/sectors/digital -economy/importance_de.

Cardona, M & Kretschmer, T. (2013). ICT and productivity: conclusions from the empirical literature. Information Economics and Policy, 25(3), 109-125. *Information Economics and Policy, (3)*(25), 109-125.

E-Marketer. (2019). *Digital Ad Spending.* E-Marketer.

Gannes, D. (2016). *Kodak invented the digital camera - and then killed it. Why does innovation often fail?* From World Economic Forum: https ://www.weforum.org/agenda/2016/06/ leading -innovation -through-the-chicanes/

Guliyev, H. (2023). Artificial intelligence and unemployment in high-tech developed countries: New insights from dynamic panel data model. *Research in Globalization*, 7, 100-140.

Hong, Y. (2019). Cultivating new momentum: An upgraded version of supply-side structural reform. *Economics Science*, 5–13.

Huawei. (2017). Digital spillover: Measuring the true impact of the digital economy. *Oxford Economics, https://www.oxfordeconomics. com/recent releases/digital spillover.*

International Telecomunication Union. (2023). *Measuring Digital Development Facts and Figures.* Development. Geneva: ITU.

Jyoti, B. (2019). A conceptual review on economic, business, intellectual property rights and science & technological related activities in Asian economies. *JNNCE Journal of Engineering & Management*, 3(2) 1-22.

Knickrehm, M., Berthon, B. & Daugherty, P. (2016). Optimizing digital investments to realize higher productivity and growth Accenture. *Digital Disruption*.

Lone, S & Weltevreden, J. (2021). European e-commerce report.

Lopez, F.L & Nanclares, H. (2003). The Digital Divide as a Challenge to the Knowledge-Based Society. *Rev. Econ. Mund*, 8, 119–142.

Manyika, J & Castillo, M. (2013, May 13). Ten IT-enabled business trends for the decade ahead.

Malecki, E & Moriset, B. (2007). The Digital Economy: Business Organization, Production Processes and Regional Developments.

OECD. (2016, June 21–23). The Meeting on The Digital Economy: Innovation, Growth and Social Prosperity. *Ministerial Declaration on the Digital Economy*, (pp. https://www.oecd. org/internet/Digital-Economy-Mi). Cancun, 21–23 June.

Ren, X.Y. & Yang, S.L. (2020). Technological innovation, industrial structure upgrading and high-quality economic development: Analysis based on the measurement of independent effects and synergistic effects. *East China Economics Manag*, 11, 72–80.

Song, Y. (2019). Digital economy and high-quality development from the perspective of economic development quality theory. *Guizhou Social Science*, 11, 102–108.

UNCTAD. (2017). Information Economy Report: Digitalization, Trade and Development. E.17.II.D.8.

UNCTAD. (2019). Rapid eTrade Readiness Assessments of Least Developed Countries: Policy Impact and Way Forward.

Vu, K, Hanafizadeh, P & Bohlin, E. (2020). ICT as a driver of economic growth: A survey of the literature and directions for future research. *Telecommunications Policy*, 44(2), 101922.

Van, N & Duy, T. (2020, November). Digital economy: Overview of definition and measurement criteria. *In 2020 5th International Conference on Green Technology and Sustainable Development (GTSD)*, pp. 593-596.

Wang, X & Chen, R. (2018). The influence of science and technology innovation on the regional economy—an empirical analysis based on provincial panel data. *Journal of Industrial Technological Economics*, 37(09): 39-44.

WEF. (2022). *Digital trust: How to unleash the trillion-dollar opportunity for our global economy.* World Economic Forum.

Zhao, T. & Zhang, Z. (2020). Digital economy, entrepreneurial activity and high-quality development: Empirical evidence from Chinese cities. *Manage World*, 10,65-76.

Zheng, D., Jiang, Y & Yang, X. (2021). Smoothing the energy transfer pathway in quasi-2D perovskite films using methanesulfonate leads to highly efficient light-emitting devices. *Nature Communications, 12(1)*, 1-8.