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The Digital Economy and Society Performance of Saudi Arabia

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The Digital Economy and Society Performance of Saudi Arabia*

Abstract

This paper investigated the relationship between digital economic performance and sustainable development and the digital competitiveness of Saudi Arabia's economy from 2015 to 2020. To this end, we proposed the International Digital Economy and Society Index. This index uses a weighting system to rank Saudi Arabia based on its digital performance to benchmark the development of the digital economy and society. Our study's findings show that Saudi Arabia is rated moderate in its performance in terms of digital evolution compared to the European Union countries before COVID-19 spread. However, after the health crisis broke out, Saudi Arabia witnessed a dramatic digital development depicted across the five I-DESI dimensions. Hence, this paper uses Pearson's correlation and the cross-correlation test to explore the correlation between I-DESI results and the Sustainable Development Goals Index. Our results indicate a strong relationship between digital performance and sustainable development.

Keywords: Digital economy, digital society, I-DESI, development sustainability, Saudi Arabia.

JEL Classifications: *A13, C43, O30*

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1. Introduction

The rise of the digital economy and the vast adoption of Information and Communication Technologies (ICT), which were at their first stage in many countries, have become a requirement for all countries to achieve sustainable and inclusive development outcomes, including the Sustainable Development Goals (SDGs) adopted by United Nations in the 2030 Agenda (UNCTAD, 2019; OECD, 2020; UNU, 2020). Moreover, the coronavirus pandemic (COVID-19) has further accelerated the need to fill the gaps, as digitization is increasingly used as a tool to support remote economic and social activities (Lyons and Kass-Hanna, 2020). Indeed, this health crisis has presented two major challenges to governments worldwide: a health crisis and a consequent economic turmoil. The countries' technological infrastructure was the communal area for successfully addressing the dual challenges of the health and economic crises. Countries, companies, and people had to adapt quickly to modern technologies, learn and work online, order their necessities online, and virtually enjoy their family and friends.

For Saudi Arabia, the digital economy can serve as a catalyst to achieve the SDGs and promote the non-oil sectors that will contribute to the economic growth and diversity needed to achieve Vision 2030. By implementing this digital economy policy under the National Program Transformation, Saudi Arabia aims to increase the contribution of the digital economy as a share of total GDP (Gross Domestic Product) to reach 19.4 percent of the GDP by 2025 and be on par with other major global economies (Little, 2021). During the health crisis, Saudi Arabia has been proactive in fostering digital transformation and

pressing to promote a more resilient and sustainable economy and society. However, these paths are not clearly defined. As a result, attempts to measure the progression toward achieving and sustaining these goals in the context of digitization remain challenging.

In this context, this study sought to assess the digital performance of Saudi Arabia (H1), rank the evolution of Saudi Arabian digital competitiveness (H2) and evaluate the relationship between Saudi digital performance and sustainable development (H3).

Thus, we first adopted the International Digital Economy and Society Index (I-DESI). This index is a composite measure introduced by the European Commission (EC) to evaluate the evolution of five key dimensions of the Digital Economy; Connectivity, Human Capital, Use of the Internet (citizens), Integration of Digital Technology (businesses), and Digital Public Services (European Commission, 2021). Indeed, the I-DESI shows how Saudi Arabia performs digitally compared to the 27 Member States of the European Union (EU) and 17 other countries worldwide. In addition, it shows how a digital economy and society in Saudi Arabia are one of the key priorities that would secure and sustain socioeconomic prosperity and ensure development sustainability, as well (A Sustainable Saudi Vision - Vision 2030; National Digital Transformation Unit, 2017). Furthermore, the I-DESI analyzed Saudi's digital performance progress over the 2015-2020 period. In the second part, this paper aims to investigate the relationship between the digital economy and society performance and the economic and social sustainable development of Saudi Arabia. Therefore, Pearson's correlation coefficient and the cross-correlation test are used to explore the relationship between the I-DESI results and the Sustainable Development Goals Index (SDGI). The SDGI

is presented by Sachs et al. (2016), reflecting the 17 SDGs agreed upon at the United Nations in 2015. This index seeks to assess where each country stands regarding achieving sustainability in its economic, social, and environmental dimensions.

Our theoretical and empirical contributions in this paper are twofold. First, most contemporary research has focused on digital transformation - economic growth nexus without admitting the digital society's performance. As far as we are concerned, to our knowledge, there are very few studies that have examined the combination of the two main frameworks of the digital economy and sustainable development in Saudi Arabia (Arab Federation for Digital Economy, 2020; European Center for Digital Competitiveness, 2021). Second, from an empirical side, the adoption of the index system technique and the use of the I-DESI for a new non-European country like Saudi Arabia represents a novelty.

The remainder of this manuscript is organized as follows: The literature on the importance and the measurement of the digital economy and society was reviewed in section two. Section three described the adapted methodology, data sources, and variables used in this study. The fourth section revealed and discussed the empirical results of this research. The last section concluded the study and proposed some recommendations.

2. Literature Review

Existing literature has rarely examined the digital economic performance in Saudi Arabia (Koniagina et al., 2019; Alharbi, 2019a; Woishi, 2019; Mahmud, 2020). This paper, therefore, introduced the most relevant studies related to our variables of interest by classifying the existent reviews into two research strands. The first explores the importance of the digital economy and society and how the new economy and society ensure sustainable development. The second strand proposes the measurement of the digital economy. Besides, each strand is classified by type of conclusion.

2.1 The Importance of Digitalized Economy and Society and Sustainable Development

Rapid digital technology development such as artificial intelligence, the Internet of Things, big data, and 3D printing have affected business, innovation, and society (Cho et al., 2022). However, ensuring a successful deployment of future digital infrastructure remains a substantial challenge. Due to the massive development of the digital economy supported by ICT, new models of such platforms need to be created. Besides, strategies and plans for forming the digital economy have been established and used in many countries (Mamatzhonovich et al., 2022). Indeed, digital technology should not only be merely in terms of economic aspects but also in terms of social efficiency. There is no doubt that digital technologies are renovating essential social services, such as education, health care, and the interaction between people and their governments. In addition, the potential for massive expansion in the use of universal services such as transportation, energy and power distribution is evident. Indeed, technological advances and their applications are creating

new needs to be met and new issues to be resolved in all markets (Lee et al., 2022; Ranerup and Henriksen, 2022). In another research article, Stozhko et al. (2019) explore the contradiction between the traditional values of culture and those of digital society. The authors present the culture of the economy as a value system and reveal that it should be dominant in the transition to a "digital society" and a "digital economy". The main requirements for such a transition are the growing importance of firms' intellectual assets (capital) and the development of the creative potential of the individual (employee). Thus, the transition toward a digital economy and society requires innovative technologies, creativities, and particularly digital innovations. In this context, Yousaf et al. (2021) investigate the importance of digital orientation, the Internet of Things, and digital platforms in achieving sustainable digital innovation in the context of the digital economy and frugal environment. The authors relied on correlational and structural equation modeling approaches and collected their data from 397 chief executive officers and managing directors of small and medium enterprises in Pakistan. Their findings indicate that digital orientation, the Internet of Things, and digital platforms are the major keys to sustainable digital innovation. Likewise, their results confirm that digital platforms are a moderator between the digital orientation-sustainable innovation link and the Internet of Things-sustainable innovation nexus. In the same vein, Yoo and Yi (2022) identify the factors that affect the acceleration of digital economic innovation and explore the findings of existing studies on digital transformation and economic growth using a systematic literature review method from 2000 to 2021. The results of their research reveal that digital economic

innovation involves changes in the industry's structure, improves productivity, and reduces costs in the production sector. Pan et al. (2022) have proved the impact of the digital economy on the total factor productivity in their study of China during the period 2010-2018 using the pooled regression. The study's findings display that the digital economy index has a positive nonlinear relationship with the provincial total factor productivity. Additionally, findings prove that the digital economy performance is an innovation driver for sustainable development of total factor productivity. The effect of the digital economy on the level of high-quality economic development was also the main objective of the study of Ding et al. (2021). To measure this relation empirically, the authors used a mediating effects model and a spatial Durbin model for 30 Chinese provinces during 2011-2019. Their findings show that the digital economy and high-quality development level is not high. However, the digital economy stimulates the high-quality economic development level on the one hand, and a significant spatial spillover effect, on the other. In the same line of thought, Liu et al. (2022) explore how the digital economy stimulates economic growth, industrial promotion, and environmental improvement, taking 286 Chinese cities as an example. The study uses the Direction Distance Function (DDF) and the Global Malmquist-Luenberger (GML) productivity index methods to measure the green total factor productivity (GTFP). It also relies on Tobit, quantile regression, impulse response function and intermediary effect models to study the correlation between digital economy development, industrial structure upgrading and green total factor productivity. The findings indicate that the digital economy can improve China's GTFP eventually. In another

study, Ma et al. (2022) indicate the importance of the digital economy and whether the digital economy is a sustainable source of green economy for China over the 2006-2019 period by using the method of moment's quantile regression. Their results show that the digital economy is used to achieve economic growth and environmental sustainability.

Several research studies tried to explore the role and importance of the digital economy in economic growth and sustainable development with different methods. The rest of this part examines the research studies that used various index systems to review this relationship. For instance, Zhang et al. (2021) use the digital development index of 30 cities in China over the 2015-2019 period to examine the role of the digital economy on the development of a high-quality economy. This index, which contains three dimensions, namely digital infrastructure, digital industry, and digital integration, verifies the importance of technological progress and the relationship between the digital economy and high-quality economic development. This study's findings reveal that the digital economy and the digital infrastructure progress are important while the growth of the digital industry is still slow. In addition, the three dimensions have significant positive but different effects on regional total factor productivity. Li et al. (2022) assess the relationship between the digital economy and green economy efficiency in 277 cities in China from 2011 to 2018 by referring to the digital economy index and the green economy efficiency index. The study results show that the digital economy significantly but differently enhances the green economy efficiency among the cities. In addition, technological innovation represents a crucial tool for a digital economy to advance the green economy efficiency level. In the same context, Wang et al.

(2022) study the importance of the digital economy in developing green innovation and green economy as a new economic form using a comprehensive digital economy index for 274 Chinese cities from 2011 to 2019. The research findings show that the digital economy development significantly improves the green innovation capabilities in China's central and western regions. Similarly, Ma and Zhu (2022) construct an index to evaluate the level of the urban digital economy and high-quality green development in China from 2010 to 2018. They try to reveal the mechanisms and effects of the digital economy in a unified framework. The findings concluded that the the digital economy could be a direct driver of high quality green and sustainable development.

The assorted studies presented in this section analyze the importance of the digital economy in diverse ways and its role in sustainable development. Still, they have not explored how to measure the digital economy and society. The next part of the literature review looks at how to measure the digital economy.

2.2 Measurement of the Digital Economy

In an effort to improve the growth of digital economies, it is necessary that the economic and political requirements be associated with both technological innovations and growth levels. Besides, this immense enhancement requires new strategies based on the government-controlled private sector and evaluated by academia and civil society (Kosimov and Ruziboyeva, 2022). Hence, several approaches and indicators have been established to cover many aspects of the Digital Economy. Consequently, the digital economy was redefined as *"an economic activity in which the main key factor of production is digital data,*

the processing of large volumes and the use of the analysis results of which, in comparison with traditional forms of management, can significantly increase the efficiency of several types of production, technologies, equipment, storage, sale, delivery goods and services. In other words, a characteristic feature of the "Digital Economy" is the maximum satisfaction of the needs of all its participants through the use of information, including personal information" (Kobilov et al., 2022). Because of the digital economy surge and its phenomenal growth in significance, its measurement has become a fundamental aspect (Williams, 2021; Cho et al., 2022). Some studies group the ICT-producing sectors (i.e., those that provide the Internet infrastructure) with those that use infrastructure (e.g., internet services), sometimes including provisions such as e-commerce value of traded goods that are difficult to justify. These measurement problems reflect the conceptual difficulty of clearly separating the digital economic dimension from other dimensions (European Commission, 2020). In another study, Kokh and Kokh (2019) measure the improvement of the digital economy of Russia by relying on a novel methodology that calculates the currently existing indices such as the ICT development index, Huawei Global Networking Index, e-government development index, the digital economy and society index, the international digital economy and society index, the digitalization index of the economy of the Boston Consulting Group, global digital competitiveness index, digital evolution index and Ivanov digital index. However, Chen et al. (2022) claim that the digital economy measurement method must be different from the traditional one. For instance, to estimate the digital economy growth in China for 2017-2020, they first use an appropriate proxy for

socioeconomic activities which is the nighttime light (NTL) remote sensing data. Then, they use Zipf's law to assess the evolution of the digital economy at the city level. The research outcome shows that the total NTL strength has a logarithmic relationship with the digital economy index. They also highlight an instable distribution and a decentralized polycentric structure of the digital economy among all cities in China. Zhao and Zhou (2022) investigate the method of mesearing the scale of digital economy through deep learning and its application based on the big data cloud platform. The study's outcome proves that the big data cloud platforms application can ameliorate the share of digital media and digital transactions in the digital economy and optimize the structure of China's digital economy.

The United Nations Conference on Trade and Development (UNCTAD) proposes a portal of Information economy indicators for ICT trade and ICT use in businesses. It works on introducing indicators and methodologies concerning the evolving Digital Economy (UNCTAD, 2019). As for the Organization for Economic Co-operation and Development (OECD), it introduced several indicators and policy information to facilitate the implementation of coherent policies for policymakers and to meet the challenges of digital transformation in order to fully exploit its opportunities (OECD, 2020). The OECD provides users with 33 core indicators and a series of complementary indicators and explores the underlying data interactively to obtain new informations. Nevertheless, these indicators only cover the OECD, accession countries, Brazil, Russia, India, China, and South Africa economies. The World Bank, in turn, provides a common set of indicators that can be useful

to the country as a whole, its regions, or to specific sectors of the economy to help them assess their digital adoption readiness.

The International Telecommunication Union (ITU) also unveiled a diversity of indicators describing the state of digital development across its 196 member countries (International Telecommunication Union, 2021). The European Commission (2021) has introduced the Digital Economy and Society Index (DESI), which consists of 5 dimensions that focus on indicators of digital performance across some key aspects of the European information society, among which we can cite the Telecom sector, Broadband, Mobile, Internet usage, e-government, e-commerce, e-business, and ICT skills. This index measures the country's performance in each dimension and summarizes it in a composite index of digital competitiveness of EU Member States. The International-DESI covers geographical coverage. It uses a simplified index to measure the performance of individual EU countries and the EU relative to other advanced economies.

In Saudi Arabia, little research attempts to quantitatively assess the digital economy and society and is limited to qualitative analysis. For instance, Alharbi (2019b) presents in his paper a clear picture of the state of digitization in Saudi Arabia and recognizes areas where the government and organizations should focus to achieve digital transformation goals. He conducted a survey in September 2018 of more than 150 analysts, managers, and business executives from different organizations in Saudi Arabia. The outcomes show that Saudi Arabia is at the early stage of digital transformation and most of the organizations in the country are not equipped for digitalization.

Mahmud (2020) explores the existing digital business ecosystem with special reference to its effect on the success of entrepreneurs in the eastern province of Saudi Arabia. A stratified sample survey was operated online with a sample of 111 entrepreneurs spread across different sectors in the eastern region of Saudi Arabia. The results reveal that the eastern province entrepreneurs agree that digitalization greatly impacts their business revenue generation. However, Al-Ruithe et al. (2018) highlight the role of cloud computing in achieving digital transition in Saudi Arabia and empirically examine the cloud computing concerns in the public sector organizations of Saudi Arabia. To do so, they use an online review pointing the existing cloud computing adoption and its concerns in Saudi Arabia. Results show that security, privacy, and loss of governance are the main difficulties to adopting cloud computing technology.

This review exposes different statistical and research institutes such as the World Bank, European Commission, ITU, and OECD that have demonstrated several indicator systems. These indicator systems are established by different structures, each of which uses several criteria for each indicator type. The main objective of these systems is to find an appropriate quantitative characteristic for the digital economy. In this study, we employed the I-DESI elaborated by the European Commission for many reasons. Firstly, it is the only index that provides a single overview of the digital economy and society. Secondly, it allows for a comparison of the performance and capabilities of EU member states and the non-EU countries, in our case Saudi Arabia. Thirdly, it is useful to help countries to pinpoint areas

requiring investments and action to reach the best-performing global countries levels and assure the digial competitiveness.

3. Methodology

Based on the extensive state-of-the-art, we found that only a few studies deal with the digital economic performance of Saudi Arabia (Alharbi, 2019a; Mahmud, 2020; Arab Federation for Digital Economy, 2020).

The lack of theories that build and evaluate digital performance has stimulated us to assess Saudi Arabia's performance in its endeavor toward a digital economy and society relying on the International Digital Economy and Social Index (I-DESI) (European Commission, 2021). This index extends the Digital Economy and Society Index, which makes it possible to compare Saudi Arabia's digital performances to those of 45 countries representing the EU27 Member States and 17 non-EU countries.

In fact, the I-DESI is a composite index used to evaluate the evolution of five key dimensions of the Digital Economy. Each dimension reflects a relevant policy area: Connectivity, Human Capital, Use of the Internet (citizens), Integration of Digital Technology (businesses), and Digital Public Services. Each dimension is divided into a set of sub-dimensions which, in their turn, consist of 24 individual indicators.

In this context, we followed the same calculation and mathematical method procedures of the 2020 I-DESI index (European Commission, 2021) for Saudi Arabia's economy covering 2015-2020. This analysis can be described as a six-stage approach; data collection; selection

and validation; normalization; estimation of missing values; application of weights; calculation of the final index (OECD, 2008).

The indicators used in this paper are the same as those applied in the 2020 I-DESI. An overview of all the indicators used in the study is provided in Table 5 (Appendix).

This research collected data for Saudi Arabia for the period 2015-2020. Important and rapid economic and global alterations characterize the reference years. Indeed, in 2015, the final SDGs were introduced by the United Nations (2016) as a universal plan to end poverty, protect the planet, and provide a focus for the international community's development efforts until 2030. At the beginning of 2019, the World Health Organization declared the coronavirus disease as a public health emergency worldwide that put at risk the growth of the global economy. Therefore, it has become crucial to examine the country's economic and social progress during the 2015-2020 period and especially explore the economic and social reaction after the spread of the pandemic.

The data used in this study were carefully collected from official reports, websites, and different databases such as the World Bank, the International Telecommunication Union (ITU) and World Bank (Appendix: Table 5). However, missing values in this research represent almost 15 percent, which required us to carry out a few estimations. We followed the same estimation method as the 2020 I-DESI, which includes two steps. The first is to recognize the missing data points that could be found through research without requiring mathematical estimations. The second step consists in using Harvard economist Gary King's

estimation software program Amelia II (Honaker et al., 2011) for the undetermined missing values in the literature review.

The I-DESI uses a three-step weighting system, namely; standardization (to aggregate indicators into the sub-dimensions and main dimensions of the I-DESI, the indicators were normalized), weighting (some dimensions, sub-dimensions and individual indicators are more relevant than others; therefore they were given higher weights in the computation of the final index score for each country) and then aggregation (the aggregation of indicators into sub-dimensions, of sub-dimensions into dimensions, and of dimensions into the overall index was performed from the bottom up using simple weighted arithmetic averages). The I-DESI score is calculated for country X (in our case Saudi Arabia) using the formula released by the 2020 DESI:

$$\text{I-DESI}_{\text{Country X}} = \text{Connectivity}_{\text{Country X}} \times 0.25 + \text{Human Capital}_{\text{Country X}} \times 0.25 + \text{Use of Internet Services by Citizens}_{\text{Country X}} \times 0.15 + \text{Integration of Digital Technology by Businesses}_{\text{Country X}} \times 0.2 + \text{Digital Public Services}_{\text{Country X}} \times 0.15$$

The values of the I-DESI score range from 0 (worst) to 1 (the best) (European Commission, 2021). Subsequently, we analyzed the relationship between the digital economy and society performance and the development sustainability of Saudi Arabia and how digital performance enhances development sustainability. To evaluate this relationship, we measured the correlation between the I-DESI results and the sustainable development index SDGI (Sachs et al., 2016) of Saudi Arabia from 2015 to 2020 using the Pearson correlation test.

The SDGI is introduced by Sachs et al. (2016) as a measure of the SDG starting point for 2015 at the country level. It presents a tool for each country to identify priorities for early action, understand key implementation challenges, and identify gaps that need to be addressed to achieve the SDGs by 2030. Each SDG is constructed with different measures so that they immediately indicate a country's position in the world on a scale of 0 to 100, from "worst" (score 0) to "best" (score 100) (Sachs et al. 2016).

Although the correlation coefficients do not imply a causal relationship, they can show the linkage between the observed variables and the strength of the link (Jovanović et al., 2018). To foster this relationship, we consider an analysis examining the cross-correlation test using the Eviews software. This method detects the causal relationship between I-DESI and SDGI variables, which are defined as:

$$r_{xy}(l) = \frac{c_{xy}(l)}{\sqrt{c_{xx}(0)}*\sqrt{c_{yy}(0)}} \text{ where } l = 0, \pm1, \pm2, \ldots.. \quad (1)$$

$$\text{and } c_{xy}(l) = \begin{cases} \sum_{t=1}^{T-1} \frac{(x_t-\bar{x})(y_{t+1}-\bar{y})}{T} & l = 1, 2, \ldots. \\ \sum_{t=1}^{T+1} \frac{(y_t-\bar{y})(y_{t-1}-\bar{x})}{T} & l = 1, 2, \ldots. \end{cases} \quad (2)$$

Where x_t and y_t represent I-DESI and SDGI, respectively.

4. Results and Discussion

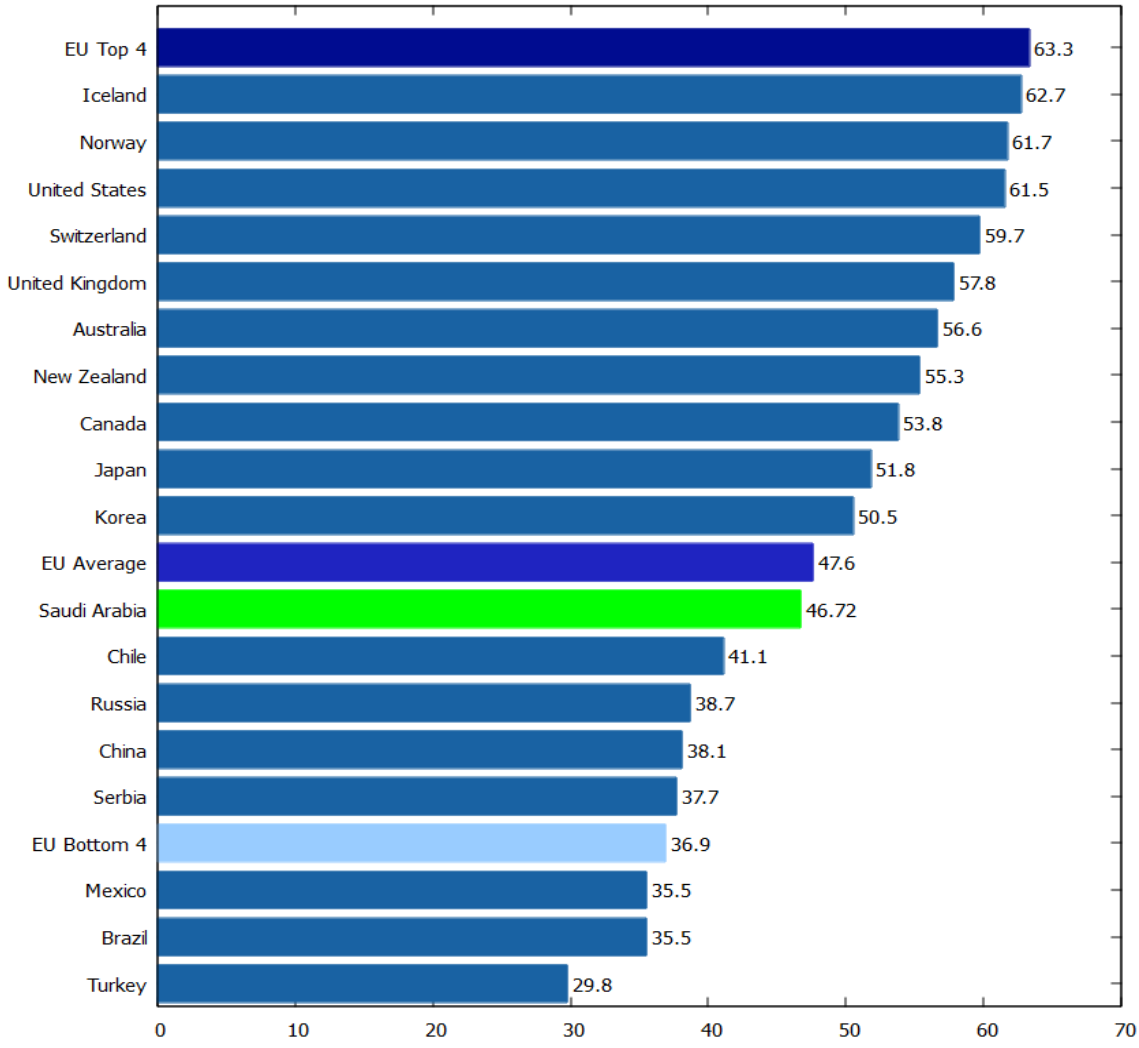
The analysis methods included three parts. The first consists of a comparative analysis - of the I-DESI performance between Saudi Arabia and the group of 17 non-EU countries and 27 EU Member States over four years (2015 - 2018). The second part analyses Saudi Arabia's I-DESI evolution over 2015-2020. The third part deals with the relationship between digital economic performance and sustainable development.

4.1 Comparative Analysis of the I-DESI Performance over Four Years (2015 – 2018)

The first part provided a comparison of the performance of Saudi Arabia with the average performance of EU27 Member States and the performance of the leading four and last ranking four Member States in each group and 17 non-EU countries based on the 2020 I-DESI report (European Commission, 2021). The comparison of the overall I-DESI was carried out using the average scores for the period 2015-2018, while the performance scores of the dimensions were compared for the year 2018 for two reasons. The first reason is that the I-DESI data they used were available up to 2018 in the report introduced by the EU (European Commission, 2021). The second reason is rather technical and deals with analyzing the digital economic performance before the COVID-19 pandemic in 2019.

Figure 1

Non-EU Countries' Performance Scores for I-DESI



Source: Saudi Arabia: 'Authors' calculations according to statistical data, Rest of Country: European Commission (2021).

Figure 1 and Table 1 show the results of the calculation and ranking of the I-DESI for Saudi Arabia and the rest of the compared countries. Figure 1 shows that the EU27 Member States lead the digital economy and society performance with an average score of 63.3.

However, Saudi Arabia seems to perform rather moderately, recording an average score of 46.72, which is lower than the EU average score (47.6) and less than that of Japan (51.8) across the four years (2015-2018). This underperformance is mainly due to the weak score of Saudi Arabia's connectivity dimension (31.24) compared with countries' performance in this dimension, as shown in Table 1. This dimension score is rather poor and less than that of the three least-performing countries, among which we can cite Turkey (43). This deficiency is mainly relative to the size of the population and the continuous increase of the Broadband price index value during the whole period.

However, Saudi Arabia performs best in the human capital dimension, which is even higher than the score of the best-performing countries achieving 70.62 during 2015-2018, according to the results shown in Table 1. This high performance can also be relative to the size of the population besides the serious focus of Saudi Arabia on upskilling citizens.

The provided broadband connectivity and human capital competencies facilitate the use of the internet for citizens and businesspeople and allow them to enjoy online content, communications, shopping and payments. At this level, Saudi Arabia performs well in the use of the internet dimension, with a score of (50.4) higher than that of the EU average (47) and close to the Japanese performance score (51.6). Concerning the integration of the digital technology dimension, Saudi Arabia achieved a score of 55.75, which is higher than the EU average but less than the best-performing countries (75.6) in 2018.

Table 1

Scores across all Dimensions for I-DESI

	Connectivity		Human Capital		Use of Internet		Integration of Digital Technology		Digital Public Services	
Country	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score
EU Top 4	3	70.4	3	58.6	4	66.7	3	75.6	3	80.5
Iceland	2	71.7	6	50.8	**1**	**75.4**	5	71.4	20	38.4
Norway	7	67.1	9	46.5	2	73.3	7	64.4	4	77.2
United States	4	69.8	2	65.7	3	68	4	73.4	2	81.4
Switzerland	5	69.2	5	55.8	5	64.2	**1**	**86.1**	17	50.1
United Kingdom	8	66.8	12	42	8	61.3	6	64.7	8	64.1
Australia	9	65.2	4	57.4	10	52.2	11	49.5	5	77.2
New Zealand	10	62.1	10	46.1	13	49.1	12	48.7	7	66.9
Canada	12	59.9	16	36.5	7	61.6	9	55.7	6	70.2
Japan	**1**	**74.5**	11	42.2	11	51.6	8	57.6	11	60.2
Korea	6	68.7	17	36.5	9	53.5	14	34.8	**1**	**85.3**
EU Average	11	61.5	13	41.8	15	47	13	41.1	15	56
Saudi Arabia	**22**	**31.24**	**1**	**70.62**	**12**	**50.4**	**10**	**55.57**	**13**	**57.46**
Chile	16	52.6	21	29	22	25.2	15	28.6	21	35
Russia	19	45.8	15	37.2	14	47.8	16	27.8	10	60.5
China	13	56.3	7	47	16	46.3	18	21.4	9	62.5
Serbia	17	49.5	14	40.2	19	32.3	20	18	18	45.5
EU Bottom 4	15	54.4	20	33.6	21	31.4	21	15.1	22	34.1
Brazil	18	46.3	18	35.7	17	37.3	22	10.3	14	56.3
Mexico	20	44.6	19	34.3	20	32.1	19	19.1	12	57.5
Turkey	21	43	22	23	18	36.8	17	24.1	19	45.1

Note: Scores across all dimensions for I-DESI are shown for 2018. *Source*: Saudi Arabia: Authors' calculations according to statistical data, Rest of Country: European Commission (2021).

It is crucial to compare the digital public services performance of Saudi Arabia to the major developed economies and global economies and examine the interaction between businesses and citizens and the public sector. In fact, Saudi Arabia performs well in the dimension of digital public services with a score of 57.46, exceeding the EU average (56) and close to Japan (60.2) but still weak compared to the EU's top four performing countries

at this level dimension (80.5). This weakness is mostly attributed to the weak open data service during 2015-2018.

Nevertheless, Saudi Arabia achieved significant progress of 28.09 percent in its I-DESI performance score, climbing from 41.22 in 2015 to 52.80 in 2018, according to Table 2. This progress reflects the effort made by Saudi Arabia to be more digitally competitive and achieve Vision 2030 goals concerning digital transformation.

In sum, Saudi Arabia is said to perform rather moderately in the digital world by achieving an average score of 46.72 across the four years 2015-2018, which is still lower than the score of the EU average (47.6).

4.2 I-DESI Evolution

The second part of the analysis focused on evaluating Saudi Arabia's I-DESI evolution during 2015-2020 and the impact of the COVID-19 health crisis on this index. Table 2 displays the evolution of the performance scores across all the I-DESI dimensions during 2015-2020.

Table 2

The Performance Scores Evolution across all the I-DESI Dimensions for Saudi Arabia.

	2015	2016	2017	2018	2019	2020
Connectivity	32.19	29.34	29.38	31.24	45.89	51.71
Human Capital	51.25	52.34	68.94	70.62	71.09	78.18
Use of Internet	22.31	35.85	43.84	50.40	57.92	66.89
Integration of Digital Technology	42.99	43.13	51.10	55.75	53.56	57.87
Digital Public Services	56.08	58.45	55.38	57.46	61.78	65.92
I-DESI	41.22	43.19	49.68	52.80	57.91	63.97

Source: 'Authors' calculations according to statistical data

It seems that the 2030 Vision goals and the necessary digital transformation strategy, on the one hand, as well as the unpredicted health crisis, on the other, have a considerable impact on the I-DESI performance of Saudi Arabia.

The outcomes were explained by a dimension that allows recognizing the position of Saudi Arabia in each key element of the digital economy. Digital infrastructure and internet connectivity are crucial for developing a digital society and transitioning to a digital economy. The connectivity dimension of the I-DESI is the most important dimension that has progressed swiftly in a brief period. Indeed, Saudi Arabia's score performance has jumped by 65.62 percent from 31.24 in 2018 to 51.71 in 2020. This result reflects the effort made by the Saudi government to develop the ICT infrastructure in the private sector and invest in fixed-broadband networks as part of its national broadband plan (Little, 2021).

The human capital dimension is represented by the digital skills required to take advantage of the opportunities offered by the internet and the digital society. At this level, Saudi Arabia achieved the highest dimension performance during the six years examined in this study, principally in 2020, with a score of 78.18. According to UNESCO (2018), the proportion of youth and adults with ICT skills in Saudi Arabia is close to that of the leading digital economies such as France and South Korea, which attests to the Saudi government’s focus on upskilling its citizens. During the COVID-19 pandemic, Saudi Arabia was among the first countries to implement digital education and digital services. Saudi Arabia also witnessed important progress concerning the use of the Internet dimension. In fact, this dimension consists of three sub-dimensions that describe the use of online activities by citizens and

businesses, such as music, videos, games, online shopping, and banking. Saudi Arabia achieved a significant increase in this dimension by 32.72 percent in two years, going from 50.40 in 2018 to 66.89 in 2020. The same index has increased by almost 200 percent from 22.31 in 2015 to 66.89 in 2020, which is significant progress reflecting the transition of Saudi citizens answering the digital society requirements. This result can be proven by the significant increase of Saudi Arabia in the e-commerce index, presented by the United Nations, in recent years (UNCTAD, 2020). Business performance in the digital world is described in the integration of digital technology dimension. This dimension is made up of two sub-dimensions; business digitization and e-commerce. As mentioned previously, Saudi Arabia performs well in this dimension compared to the 45 studied countries in the I-DESI 2020. For instance, this dimension saw a steady increase of 3.81 percent between 2018 and 2020. The rapid digital transformations require Saudi firms and enterprises to make more efforts to adopt the latest technologies and invest in technological innovation to remain competitive and enhance economic growth. As a proxy of the digital transformation of enterprises, software spending represents 0.4 percent of Saudi Arabia's Gross Domestic Product, reflecting the required challenging work to reach the digital transformation and achieve development sustainability (Little, 2021).

The relationship between the business, citizens and the public sector was analyzed in the last I-DESI dimension of this study. Saudi Arabia performs well at the digital public services dimension level, as indicated in Table 1. Saudi Arabia's performance score recorded a significant increase of 14.72 percent, from 57.46 in 2018 to 65.92 in 2020. In fact, Saudi

Arabia's government introduced *Yesser* as an e-government transformation program which enabled Saudi Arabia to achieve the 43rd position among 193 countries concerning the e-government development index (United Nations, 2020).

Moreover, Saudi Arabia's digital economic performance recorded a significant increase of 21.17 percent, from 52.80 in 2018 to 63.97 in 2020, which reflects the mobilization of all the economic actors like civil society, businesses, and governments to establish digital transformation and achieve the SDGs.

4.3 The Relationship between Digital Performance and Sustainable Development

The third part of the analysis method investigated the relationship between digital performance and sustainable development. To evaluate this relationship, we measured the correlation between the I-DESI and the Sustainable Development Goals Index (SDGI) (Sachs et al., 2016) using Pearson's correlation coefficient in STATA software as a first step. To more explain this correlation, we attempt to analyze the cross-correlation between the digital economy performance and the SDGI.

Table 3 shows Pearson's correlation results and indicates that the SDGI strongly correlates with I-DESI.

Table 3

Pearson's Correlations between SDGI and I-DESI Dimensions

	SDGI	I-DESI	Connectivity	Human Capital	Use of Internet	Integration of Digital Technology	Digital Public Services
SDGI	1						
I-DESI	.868*	1					
Connectivity	0.590	.862*	1				
Human Capital	.920**	.936**	0.657	1			
Use of Internet	.887*	.980**	0.775	.933**	1		
Integration of Digital Technology	.954**	.919**	0.631	.982**	.919**	1	
Digital Public Services	0.533	.839*	.941**	0.600	0.797	0.591	1

Source: 'Authors' calculations in SPSS according to statistical data

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

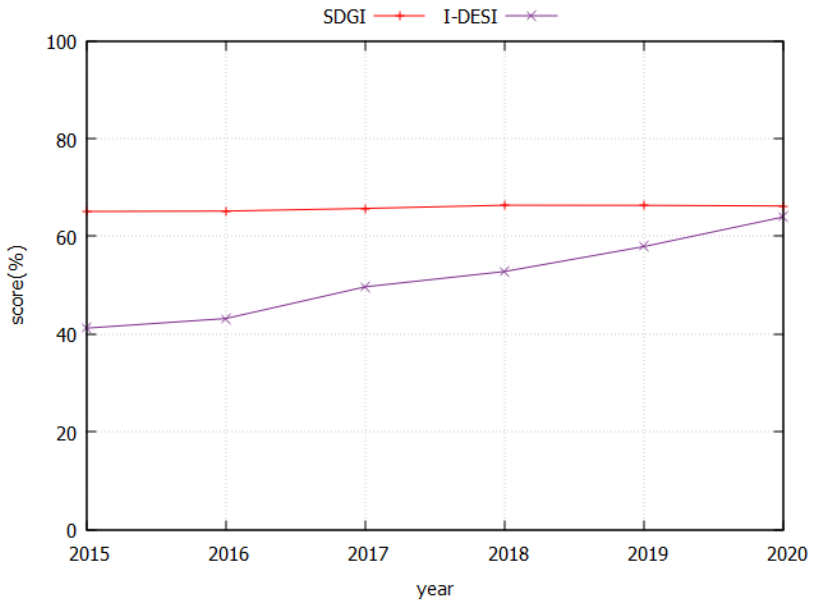
According to this measure, the results imply that the digital economy and the achievement of sustainability goals are much closed. These results align with the outcome of the Arab Digital Economy Index, which confirms that the SDGs intersect with all the dimensions of the Arab Digital Economy Index. This latter was introduced by the Arab Federation for Digital Economy, the Council of Arab Economic Unity and the League of Arab States in 2018, covering 22 Arab countries (Arab Federation for Digital Economy, 2020). In addition, these findings are consistent with the United Nations (2022), as the e-government is one indicator of the digital public services pillar. The e-government index represents a development tool for countries that can identify the extent of their e-government initiatives in agreement with achieving the SDGs. The finding results align with the Network Readiness Index (NRI)

(2021) introduced by the World Economic Forum. The NRI, which is composed of technology, people, governance and impact pillars, measures how well an economy uses information and communication technologies to boost competitiveness and well-being and uses the SDGs as an indicator for the impact pillar.

The analysis of the five I-DESI components and the SDGI shows that all respective components are significantly, strongly, or moderately strongly associated with SDGs.

Figure 2

I-DESI and SDGI Trends in Saudi Arabia from 2015 to 2020



The strongest relationship was found between the SDGs and digital technology integration. This finding reveals that business digitization and the rapid increase of e-commerce in Saudi Arabia as a component of digital economic growth help to attain sustainable development. In fact, digital innovation and technologies enable SMEs to moderate resource usage and waste and improve sustainable economic activities, which

results in the development of a competitive digital environment (Jovanović et al., 2018; Yousaf et al., 2021). Along the same line, the knowledge skills represented in the human capital have a strong relationship with sustainability which is in line with the results of the 2020 digital riser report (European Center for Digital Competitiveness, 2021). This suggests that human development is essential to acheiving sustainable development and that human skills must always be updated updated to meet the demands of the new digital marketplace. Therefore, the collaboration between the labour market and academia is essential to establish the necessary skills for the modern workplace and contribute to sustainable and inclusive economic growth with full and productive employment (Sun et al., 2022; Mohamed et al., 2022). The use of the internet has a committed relationship with the SDGs. This means that Saudi Arabia's citizens use online transactions and payment, especially during the COVID-19 crisis and the social quarantine that contribute to the development of the digital economy and e-finance. However, the relationship between connectivity and the SDGs is positive but moderately strong compared to the other dimensions, while digital public services have the smallest impact on the SDGs. This result suggests that the indicators of the dimensions computed in the I-DESI are not close to a sustainable development measurement.

Table 4

Cross-Correlation Function between SDGI and I-DESI Variables

Relationship	l	0	1	2	3	4
SDGI-I-DESI	lag(-l)	0.87*	0.38	-0.15	-0.41	-0.34
I-DESI-SDGI	lead(-l)	0.87*	0.67	0.27	-0.24	-0.51

Source: 'Authors' calculations in Eviews software according to statistical data

**. Correlation is significant at the 0.05 level (2-tailed).*

Referring to Table 4, we provide evidence that the values of cross-correlation at the moment (l = 0) are statistically significant and positive (0.87). This corroborates the existence of an instantaneous interaction between I-DESI and SDGI. Hence, the significant values of the cross-correlation coefficient at the time (0) are a synonym of a common shock that directly affects the two variables. These results indicate that higher digital performance leads to attaining the SDGs. In this context, Savchenko and Borodina (2020) have approved that digitalization and the green economy can have breakthrough effects in ensuring sustainable development. These results support the findings of Aniqoh (2020) and Kadom and Kader (2021) since it shows that digital economy enhances sustainable development and the goals of sustainable development 2030.

In addition, Table 4 shows that the values of cross-correlation computed based on previous lags (from $l = 1$ to $l = 4$) are non-significant. This indicates that the past information relating to the SDGI variable has no impact on the contemporaneous I-DESI variables. Similarly, empirical results illustrate that the previous values of I-DESI variables cannot forecast the current SDGI variable.

5. Conclusion and Policy Implications

The digital economy is potentially the main and most crucial tool for a dynamic change in sustainable development worldwide. Hence, digital transformation is one of the crucial strategic objectives of Saudi Arabia's Vision 2030. This paper evaluated Saudi Arabia's digital economic performance using the I-DESI index for the period 2015-2020, focusing on the effect of digital economic performance on the sustainable development of Saudi Arabia. In light of our empirical results, we concluded that Saudi Arabia performed moderately in digital economic and social evolution compared to the EU countries in 2015-2018. This result is due to the lack of infrastructure and the high price of broadband in that period, on the one hand, and the provision of existing electronic services by governments and the structural problems related to institutional, cultural, and economic factors, on the other. Yet, the appropriateness and usefulness of the services provided by government websites and their consistency with the needs of individual users which are affected by age and life cycle factors, are also key.

Nevertheless, Saudi Arabia has achieved remarkable progress across all the I-DESI dimensions in the 2018-2020 period, which coincides with the COVID-19 spread period. This reflects the rapid mobilization of Saudi Arabia towards a digital transition and the achievement of sustainable development that goes beyond the health crisis. Furthermore, this study's findings show that digitalization strongly correlates with the SDGs. According to these findings, Saudi Arabia's government needs to undertake some practical actions. The Saudi government should encourage firms to invest in the latest innovative technology and

support firms to adapt them, given that the integration of digital technology in the business strongly influences sustainable development.

Along the same line, to improve the policy and regulatory ecosystem, Saudi Arabia needs to ensure that regulations are flexible to adapt to technological development. Similarly, the dynamism of Saudi business requires the creation of a favorable and stimulating environment for start-ups to innovate and grow, and for potential entrepreneurs to enter the market (Schwab, 2019). Thus, the government should continue its efforts in enhancing the environment for the development of the ICT industry, ensure robust IP protection systems, and promote internet users' awareness. Additionally, Saudi Arabia's government can upskill citizens and promote collaboration between academia and the private sector to respond to the requirements of the new digital workplace.

To conclude, we can state that despite the critical challenges raised by these recommendations, it is important to understand that the coordination of all the economic actors - government, academia, industry, and citizens - is vital to building a sustainable digital economy.

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Appendix

Table 5

Indicators and data sources used for computing the I-DESI for Saudi Arabia

Dimension	Sub-dimension	Indicator	Source
Connectivity	Fixed Broadband	1a1 Fixed Broadband Coverage	ITU
		1a2 Fixed Broadband Take-Up	WB
	Mobile Broadband	1b1 4G Coverage	ITU
		1b2 Mobile Broadband Take-Up	ITU
	Speed	1c1 Fixed (wired)-broadband speed; in Mbit/s	CISCO
	Affordability	1d1 Broadband Price Index	GSMA
Human Capital	Based on Skills and Usage	2a1 At least basic skills (Word processing)	GaStat
		2a2 Above basic (advanced spreadsheet skills)	ITU
		2a3 At least basic software (coding)	ITU
	Advanced Skills and development	2b1 Telecommunication emps FTEs	GaStat
		2b2 ICT Graduates	OECD.Stat
Use of Internet Services	Content	3a1 Internet Users	WB
		3a2 Fixed broadband traffic (GB/mth/person)	ITU
	Communication	3b1 Video Calls	GaStat
		3b2 Social Networks	DataReportal
	Transactions	3c1 Banking	DataReportal
		3c2 shopping	DataReportal
Integration of Digital Technology	Business digitization	4a1 Availability of latest technologies	NRI
		4a2 Firm-level technology absorption	NRI
	e-commerce	4b1 SMEs Selling Online	NRI
		4b2 Secure Internet Servers per million people	WB
Digital Public Services	eGovernment Development index	5a1 eGovernment Users	Knoema
		5a2 Online Service Completion	GII
		5a3 Open Data OKF OECD	ODIN

Note: ITU: International Telecommunications Union World Telecommunication/ICT Indicators database, WB: World Bank, GSMA: GSMA Mobile Connectivity Index, GaStat: General Authority for Statistic (Kingdom of Saudi Arabia), NRI: Network Readiness Index, GII: Global Innovation Index, ODIN: Open Data Inventory