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Digitalization as a Factor in Reducing Poverty and Its Implications in the Context of the COVID-19 Pandemic

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Abstract: In the present economic context, one of the most important topics of discussion is that regarding sustainable development. According to the agenda developed by the United Nations, one of the most important objectives for the present decade is represented by the list of the Sustainable Development Goals. The Sustainable Development Goals can be divided into five pillars: people, planet, prosperity, partnership and peace. One of the first stipulated goals of the UN agenda is the eradication of poverty and famine. We consider that a significant influence on the eradication of poverty is represented by the development of technology. In this paper, the authors aim to establish a connection between the rate of technological development and the poverty headcount rate. To measure the digital development of the analyzed countries, we decided to compose an index of digital development by taking into account indicators made available by the International Telecommunication Union and the poverty headcount ratio, as was calculated by the World Bank database. This empirical study is of interest for the implications that it has in shaping governmental policies regarding easing the access to digital technology. The method used to quantify the influence of digital development on poverty was the panel data GMM vector autoregressive model for a dataset composed of 35 countries for the period between 2005 and 2018. The results indicate that an increase in digital development will lead to a reduction in the poverty headcount rate. These results imply that by increasing access to technology, countries could help reduce their level of poverty. In this paper, we will also analyze the way in which adopting digital development leads to better economic performance when faced with the COVID-19 pandemic. The results of the present study are of great interest to the scientific community and the public due to the implications of digital development in the field of economics and the combined effect of this phenomenon and the COVID-19 pandemic. We thus conclude that by encouraging digital development and through adopting new technologies, the government can lead to the eradication of poverty. This seems counterintuitive due to the fact that investment in shelter and primary goods can be seen as one of the primary ways of developing the economy. We conclude that better and more consistent results regarding the reduction of poverty can be obtained by increasing the digital development of a country.

Keywords: poverty; panel data; digitalization index; economic development; COVID-19 pandemic; digital development; Sustainable Development Goals (SDGs)

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1. Introduction

One of the most discussed problems of the present is sustainability. The problem of sustainable development was defined for the first time in its present form in the Brundtland Report [1] published in October 1987, where the concept gained additional focus regarding

the building of a socially inclusive and environmentally sustainable form of economic development (at first, the concept had a bigger and greater focus on the environment, such as in the definition offered by the International Union for the Conservation of Nature [2] in 1980).

Taking into account the importance of the concept, the present paper proposes a model for analyzing the influence of digital development on the poverty headcount ratio as calculated by the World Bank. We considered the poverty headcount ratio to be a determinant factor of sustainable development due to its priority on the agenda of the United Nations in the 2030 Sustainable Development Goals [3]. In the following sections, we will review the articles that we considered to be of the highest importance in the development of the present paper, and we will develop a digitalization index and quantify its influence by using the methodology of the vector autoregressive model for the panel data. The scope of this paper is to answer the following research question:

RQ: How does the increase in technological development influence the rate of poverty at a national level, and how does digital development relate to the response to the COVID-19 pandemic?

The present article was developed as a result of studying the literature, with the scope of assessing the way in which sustainable development and poverty relate to digital development and presenting the main topics of research in the field of the Sustainable Development Goals and their implementation. From this extensive study, the authors discovered a research gap represented by the way in which the relation between digital development, expressed as an indicator measured by precise metrics, has an influence on the poverty headcount rate. We decided to analyze the way in which the real impact of technology adoption can be quantified. In order to measure this, the authors decided to implement a vector autoregressive model with panel data, with this being, in our opinion, an original contribution to this field of study (i.e., the application of quantitative methods with calculable results). Another interesting approach that we developed in the present paper is the building of a digital development index. This allowed us to compare the level of development of the analyzed countries and also gain a better understanding of their evolution in the given time frame. The article also allows for a worldwide view of digital development and technology adoption by ranking 175 countries for the year 2019. In order to present the results of the research, the authors decided to first present a brief discussion regarding the main topics of research in the field of the Sustainable Development Goals and their implementation. In this article, we also investigate the relation between digital development and resilience to external shocks. One of the more significant shocks of the last decades was the COVID-19 pandemic, and in this paper, we will try to show that the more developed countries from a digital standpoint were less impacted by the pandemic.

This literature review is continued by a quantitative research study that consists of using a panel data vector autoregressive model to better understand the relation between the rate of poverty and the digital development of a country. At the end of the paper, we present a set of discussions regarding the relation of the findings to the relevant scientific literature and the research limitations, along with further study directions, and a section of conclusions in which the authors present the theoretical implications of the present study, the possibility of the model to be used by international organizations for promoting the application of technology affordability programs and the perspectives of this field of knowledge in light of the present article. This study takes into consideration only the correlation between the digital development and poverty, with this being due to the fact that the authors wanted to have an isolated view of how digital development and poverty are related. The authors recognize the fact that poverty is a very complex subject with many underlying connections including but not limited to societal institutions, education, democracy, rule of law and other factors. Even if the present study offers a small insight into the way in which poverty is related to digitalization, due to the mentioned limitations, we consider it to be of interest because of its global scale and for generalizing the relation between poverty and digital development. The originality of the current paper

is represented by the fact that we present a worldwide view of the digitalization process and the relation between digital development and the reduction of the poverty headcount as a significant influence on this phenomenon. Additionally, the present paper also aims to make sense of the patterns regarding digital development at a worldwide level by presenting the results of a vector autoregressive model with dynamic panel data for the period between 2005 and 2018. These developments and the overview of the scientific literature lead to the conclusion that an increase in digital development at a country level will lead to a decrease in the poverty headcount ratio, thus making an impact in the context of the Sustainable Development Goals promoted by the United Nations.

2. Literature Review

In the following section, the authors develop, in a brief manner, the three main points of interest of the scientific literature that were considered when developing our paper in order to study the relation between digital development and the poverty headcount rate. This review presents in an organized structure the methodologies used and the main influences that the authors had in developing this paper. In accordance with this, the authors decided to present the main papers in each of the three main identified ideas relating to our research question.

2.1. Sustainable Development Goals and Their Implementation at a Worldwide Scale

One of the most cited papers that analyzed the concept of the Sustainable Development Goals is the one written by Griggs et al. [4] with the title "Policy: Sustainable development goals for people and planet". The conclusions of this paper indicate that global stability depends on integration of the goals, such as combating poverty and securing human well-being in the plans of the United Nations. Another interesting article is the one written by French and Koze [5]. This article analyzes the ways in which statistics regarding poverty are calculated and their accuracy for the indicators that measure the level of poverty. This paper estimates that in 2013, approximately 385 million children were living on less than USD 1.90 per day. These data are, however, stated as being an approximation due to the fact that 63% of countries do not publish data regarding child poverty, with this being in the context of the UN Sustainable Development Goals agenda for 2030, in which the eradication of poverty is the first priority.

An interesting overview of the subject is described in "A Systematic Study of Sustainable Development Goal (SDG) Interactions" by Pradhan [6]. We decided to analyze the Sustainable Development Goals set by the UN Agenda for 2030 for potential synergies between them. It is stated that the first goal of the agenda (the eradication of poverty) has a synergistic relation with most of the other goals, and the twelfth goal (responsible consumption and production) is described by the authors as being the most likely to suffer trade-offs. This is due to the implications of reducing the use of coal and oil use in industry which, if carried out in an unprepared economy, will lead to unemployment and poverty. The article concludes that in order for the goals to become obtainable by the 227 analyzed economies, they must be adopted in a non-obstructive way, and the current strategies of implementation should take into account the level of development of the analyzed countries. Another interesting paper is the one written by Filho et al. [7], which presents a series of three case studies to show how the Sustainable Development Goals are an opportunity to advance equal opportunities and foster the economic development of countries by promoting sustainable development. The topic of sustainable development has been linked in the literature with the resilience of the economy. One such paper is the one written by Folke et al. [8]. In this article, the authors describe two fundamental errors in the design of environmental policies: the implicit assumption that the ecosystem's responses to the influence generated by humans are defined by linearity and predictability and that the environment and human society can be treated separately when designing a policy. The authors used the concept of resilience, defined as the capacity to change, learn

and develop, to analyze the best strategies to increase the economy's capacity and adapt in the present climate.

Another interesting view on the subject is presented in the article written by Hickel [9]. According to the author, there in is an inherent contradiction in the two sides of the sustainable development concept, as stated in the Sustainable Development Goals in of the United Nations between the goal of yearly global economic growth of 3% and the protection of the environment (as stated in goals 6, 12, 13, 14, and 15). The paper states that the by accepting the global economic growth rate at 3%, it is almost impossible to achieve any reductions in the aggregate global resource use. In our opinion, this offers an interesting view, due to the alternative of downscaling resource use in order to reach the target of climate change rate reduction in high-income nations by introducing quantified objectives for resource use.

In the scientific literature, there are views [10–12] that state that the evolution of sustainable development is difficult to quantify, and its influence on macroeconomic indicators is challenging to analyze. In this paper, we aim to present the means of measuring the impact of digital development on an essential part of sustainable development: the reduction of the poverty headcount (this being part of the first two Sustainable Development Goals (reducing poverty and eradicating famine) stated by the United Nations).

In other articles [13,14], we can see that the relevant scientific literature considers using indicators for assessing the evolution of the Sustainable Development Goals agenda. These attempts deal with studying the progress for a short period of time and for various regions. Due to the fact that, in the present paper, we seek to analyze the progress toward the reduction of poverty which has been manifesting in the last two decades, we decided to use the poverty headcount rate as a proxy for sustainable development, and we aimed to determine its correlations and relations with a technology development index.

In addition to the mentioned scientific papers, a major contribution in the advancement of the measurement of poverty is the 2030 Agenda itself [3]. This represents a holistic approach to the problems that the United Nations consider to be fundamental to solve until 2030. In the case of the first goal, which is the eradication of poverty in all its forms, the agenda offers several targets: eradicate extreme poverty, reduce poverty by at least 50%, implement nationally appropriate social protection systems, equal rights to ownership, basic services, technology and economic resources, build resilience to environmental economic and social disasters, the mobilization of resources to end poverty and the establishment of poverty eradication frameworks at all levels. As stated, we are interested in the eradication of extreme poverty. The indicator that the UN considers to be the most important is the proportion of the population living below the international poverty line, aggregated by sex, age, employment status and geographical location. The UN considers the poverty line to be USD 1.90 per day, and in this paper, we used the USD 5.50 poverty line indicator due to its availability for more countries and because we considered that for developed countries, the USD 5.50 per day threshold was closer to the national poverty line (which is linked to an indicator of the second target—reduce poverty by at least 50%—with the indicator of the proportion of the population living below the national poverty line). For example, the USA poverty line was USD 35 per day in 2020 [15], and India's was USD 12 per day in urban areas and USD 7.50 in rural areas in 2005 [16].

By analyzing the literature regarding the Sustainable Development Goals and their relation to the economic development of a country, we can state that they represent more than a list of goals. They represent a development program for bettering the future of the world and a blueprint for sustainable development. With that being said, in the present paper, we attempt to analyze the relation between digital development and the poverty rate. This is due to the attempt to obtain a focused view on the relation between these two variables in order to observe if encouraging digital development (e.g., by subsidizing the acquisition of computers) could lead to advancement in the Sustainable Development Goals. In addition, the adoption of technology could also lead to an increase in equity due to more access to information and opportunities.

2.2. Measuring the Impact of Digital Development on Poverty

In the scientific literature, there has been a number of articles that focus on analyzing the effect of digital development on the poverty level. One such paper is the one written by Kwilinski et al. [17], where the digital economy and society index were used to evaluate the digitalization of the countries of the European Union and were analyzed along with the AROPE indicator (people at risk of poverty and social exclusion). As the main research methods, the paper implements a correlation analysis and uses the Monte Carlo method to take into consideration the probability that a change in the value of the AROPE indicator will happen in 2021. The conclusions state clearly that the countries with a higher digitalization level have a lower percentage of people in poverty and lower social exclusion risk.

Other articles [18,19] argue that in the case of the African continent, mobile phone development has led to a significant increase in informal financial development, even though its effects are less noticeable at the macroeconomic level, and that the use of mobile phones with internet access in 44 African countries in the period between 2000 and 2016 has led to an increase in financial inclusion. Other literature review-based studies [20] claim that there are few papers that can present a causal inference between ICT development and poverty. The interaction between the internet and mobile phone access or other technologies and poverty is a topic of focus for many papers [21–25], which have applied a multitude of methodologies in order to analyze this relation for different countries.

Additionally, in the scientific literature, there has been a trend toward analyzing the impacts of technology as a means of inclusion and access to information on poverty in either South Asia or Sub-Saharan Africa [26] or in Latin America [27]. The studies conclude that in the case of South Asia and Sub-Saharan Africa, the adoption of new technologies is an important factor in sustaining the reduction of poverty in developing countries. In the case of Latin America, the study proposes a heterodox type of growth strategy in order to counter the perceived inequality generated by the acceleration of wealth creation. In studying individual countries, from several studies that we considered to be of interest [28–31], due to their implications for the present article, we found that the majority of the results indicate that the impact of internet adoption was mainly a positive one, as it reduced the rates of poverty. However, a problem still remains regarding the affordability of computers and internet access.

Furthermore, in several articles [32,33], there has been a focus on the relation between the internet and technology and the knowledge economy. This relation is significant because the growth in the percentage of internet users can increase the transition to the knowledge economy, and this favors the reduction of the poverty rate.

2.3. Using an Index to Measure Digital Development

The use of an index to measure digital development has been widely described in the scientific literature, and several articles [34–37] have proposed and used indices for measuring digital development, such as the one written by Archibugi and Coco [34], which had a focus on the developing countries and calculated a proprietary index—ArCo—based on three main components: the creation of technology, the available technological infrastructure, and the level of development of human skills.

In the present paper, we considered that a better focus for our index was the personal adoption of technological development. As such, the authors used indicators that were related to the adoption of technology by ordinary citizens. Approaches regarding the measurement of the impact of the personal adoption of technology have been published [38–41], with the novelty of our approach being the effort to quantify the level of digital personal adoption at the country level by using a digital development index built with data made available by the International Telecommunication Union.

Another important field of study in the scientific literature is the analysis of the differences in digital development between different regions of a country or between countries [42–52]. These studies analyze the concept of the digital divide. The digital divide

can be defined in a simple way as the gap present between the part of the population that has access to technology and the one that does not. In this context, some papers [45,47,49] analyze the digital divide for countries in a region in order to observe the level of development of each country and compare their indicators. A method that was used in the article written by Beynon-Davies and Hill [45] was the use of the digital divide index, which was used in analyzing the Wales region of the United Kingdom at two points in time: 1997 and 2000. In addition, in the scientific literature, there have been studies [43,46,50–52] that maintain the idea that the adoption of technology increases the participation of the population in the economy, promotes the sustainable development of the economy and leads to the eradication of poverty. The relation between the reduction of poverty and digital development appears in the paper written by Dawood [52]. This paper observes a relation between the digital development and the social and economic progress in the case of the rural communities of northern Malaysia, stating that there is a correlation that could be made stronger by correlated action at a central level and pragmatic action at the grass roots level.

2.4. Measuring Influence Using Panel Data Vector Autoregressive Models

In order to quantify the influence of digital development on the poverty headcount rate, we decided to implement a panel data vector autoregressive model. The method of modeling using the vector autoregressive model was developed for the first time in the paper written by Sims [53]. The methodology has been improved since its introduction in 1980, and important landmarks are represented by several articles [54–56]. One of the articles of interest in developing the present article is the one written by Andrews and Lu [57], in which the methodology for GMM estimation on dynamic panel data models was developed.

In order to measure the effect of digital development on the poverty headcount, the authors used the methodology presented in the paper written by Dahlberg and Johansson [58] to develop the present article.

2.5. The Economic Effect of the COVID-19 Pandemic

The connection between digitalization and the economy has been best observed in the last unique period, more precisely during the pandemic. In this sense, works such as the one written by Fernández-Portillo et al. [59] tracked the impact of innovation on the relationship between the digitalization of companies and their economic and financial performance. The conclusion that the authors reached was that to reach a certain level of performance, not only is digitization needed, but a new strategy that will lead to the improvement of the company's performance is needed as well. Khera et al. [60] showed that digital financial services have been a key factor in economic growth. Thus, for the developing countries studied, the notes from the results indicated that digital financial inclusion is positively associated with GDP growth per capita and accelerating economic growth, with their recommendations being related to the digitization of financial services. Dirk Kohnert [61] showed that in Africa, digitalization and mobile telecommunications have made a positive contribution to economic growth during the pandemic, even for less-developed regions. However, the population here is facing, with new forms of the digital divide, the gap between the poor and rich, between advanced and less advanced African countries as well as between Africa and the rest of the world. According to Amankwah-Amoaha et al. [62], this shows how the pandemic has driven or constrained the digitalization of business around the globe, moving to global acceleration in the use of modern, digitized technologies that have changed working patterns and business strategies in a word lifestyle. Guo et al. [63] showed that the pandemic has put small- and medium-sized enterprises under enormous pressure to survive, which has forced them to adopt various digital technologies to cope with the crisis. The empirical results of the analysis show that digitalization has allowed small- and medium-sized enterprises to respond effectively to the public crisis. In their study, Almeida et al. [64] analyzed the impact of

digital transformation processes during the pandemic in three business areas: labor and social relations, marketing and sales and technology. The result was that digitalization would increase in each of these areas and would encourage the emergence of new digital products and services.

Härting et al. [65] showed that the key driver of business development is digital transformation, and with the pandemic, the need for digital solutions became more acute considering the opportunities for digitalization, especially for small and medium enterprises. Singh et al. [66] conducted a survey to distribute and meet food demand during the pandemic, and the results confirmed the positive impact of information on cost-saving performance and supply chain relationships, where the online distribution and application process was used. Abidi et al. [67] showed that the pandemic has led to an unprecedented shock for businesses and the economy in general, while digitalization has acted as a fence or as a popular key used to mitigate economic losses. The results obtained by the authors illustrate that digitally activated companies were able to mitigate the economic losses resulting from the unique situation better than companies with digital restrictions in the Middle East and Central Asia regions.

Döhring et al. [68] showed in their work that in a pandemic, even if a persistent increase in the demand for digital services was expected, the estimated economic impact was unknown. This paper states that competition policy and the labor market have come to support the digital transition, making digitalization grow at the same pace as economic growth.

Ragoussis and Timmis [69] showed the crucial role played by digital technologies in helping companies cope with the shock caused by the pandemic and found that digitalization has transformed the trajectory of the online market, leading to significant growth.

Xiang et al. [70] illustrated in their study that the sectors severely affected by the pandemic did not use the necessary technological and digital strategies to sustain their economies, showing as a conclusion the vital role of information technology and digitalization in supporting economies and helping them sustain themselves during crises. Chauhan et al. [71] showed that global blockages due to the pandemic from different economic branches have accelerated the digitalization of various sectors of the economy from retail to finance, education and healthcare, but at the same time, they have intensified inequalities at the national level and between countries. The COVID-19 (or Coronavirus) pandemic has exacerbated inequalities in nationality, occupation, income, sex and race as well as, in fact, a decrease in global productivity. Claeys et al. [72] showed that the pandemic has led to a global recession, and although both developing and advanced countries have lost about the same proportion of production, the real annual decline in GDP was higher in advanced countries, except for China, which saw an increase in GDP but below the pre-pandemic forecasts. Dannenberg et al. [73] in their study showed the impact of the pandemic in online food retail in Germany and the fact that there has been a strong increase in food and a disproportionate increase in online food trade because of digitalization. Katz et al. [74] showed through empirical evidence the important role of digitalization and technology in mitigating the disruption of economic and social effects created by the pandemic while assessing the vulnerable population groups, unemployment rates and level of readiness of developing countries to meet the challenge. Chakravorti et al. [75] illustrated in their study the growth and development of pandemic digitalization. This has helped people to work, learn, shop and socialize safely during a pandemic, a unique situation, and to maintain a semblance of normalcy. With the expansion of digitalization, e-commerce has grown, video conferencing has become more widely used, and the Zoom platform has reached high levels, competing with IBM.

2.6. Conclusions of the Literature Review

In the preceding section, we presented the main influences on the development of the ideas and the way in which the research question was answered in this paper. By studying the literature, the authors identified a lack of a global and international vision regarding the

way in which the poverty rate headcount is influenced by digital development. The authors considered that only a global vision could highlight the benefits of digital development for emerging countries which, as seen in the previous sections, are a major focus of scientific research. In this way, the present research will extend the findings of the analyzed papers, such as the ones written by Asongu [18] and Evans [19], to a worldwide level. This could offer interesting insights regarding the patterns of digital development and their relation with poverty.

3. Materials and Methods

In this research paper, the authors present a digital development index calculated for 175 countries for the period between 2000 and 2019. The selected 175 countries were the following: Hong Kong (China), United Arab Emirates (UAE), Malta, Japan, Korea (Rep. of), Seychelles, Montenegro, Luxembourg, Germany, Singapore, Switzerland, Cyprus, the United Kingdom, France, the Netherlands, Iceland, Estonia, Lithuania, Taiwan (Province of China), the United States, Israel, Kuwait, the Russian Federation, Belarus, Denmark, Spain, Uruguay, Costa Rica, Sweden, Portugal, Austria, Thailand, Greece, Mauritius, Italy, Slovenia, Iran (Islamic Republic of), Canada, Qatar, Belgium, Brunei Darussalam, Slovakia, Serbia, Ireland, Malaysia, Finland, Norway, Monaco, the Czech Republic, Saudi Arabia, Oman, Hungary, Kazakhstan, Poland, Croatia, Bahrain, Georgia, South Africa, Puerto Rico, Romania, El Salvador, Latvia, Botswana, China, Vietnam, Panama, Gibraltar, Bosnia and Herzegovina, Ukraine, Bulgaria, Colombia, Azerbaijan, Armenia, Tunisia, North Macedonia, Morocco, Andorra, the Philippines, Cambodia, Mongolia, Liechtenstein, Trinidad and Tobago, Turkey, Brazil, Gabon, Mexico, Barbados, Uzbekistan, San Marino, Ghana, Paraguay, Cabo Verde, Côte d'Ivoire, Albania, the Faroe Islands, Algeria, Indonesia, Sri Lanka, the Dominican Republic, Curacao, the British Virgin Islands, Guatemala, Palestine, Suriname, Maldives, Egypt, Australia, Chile, Argentina, Bolivia (Plurinational State of), Gambia, the Bahamas, Namibia, Senegal, Greenland, Mali, Kyrgyzstan, the Syrian Arab Republic, Cuba, Moldova, India, Kenya, Jamaica, Nigeria, Saint Vincent and the Grenadines, Guinea, Lesotho, Cameroon, Bangladesh, Burkina Faso, Zimbabwe, Benin, Zambia, Ecuador, Iraq, Sao Tome and Principe, Guinea-Bissau, Timor-Leste, Djibouti, Mauritania, Tanzania, Sierra Leone, Sudan, Rwanda, Bhutan, Togo, Pakistan, Nicaragua, Haiti, Venezuela, Vanuatu, Honduras, Macao, Jordan, Angola, Lao P.D.R., Lebanon, Belize, Solomon Islands, Tonga, Comoros, Mozambique, Malawi, Burundi, Peru, Afghanistan, Chad, Uganda, the Democratic Republic of the Congo, Kiribati, the Central African Republic, Ethiopia, Grenada, Liberia and South Sudan.

In the last decade, digital technologies have had an impressive spread in the case of most countries in the world. However, the existing literature and specialized practice highlight the existence of certain internationally recognized indices for digital technologies. According to the World Bank (2016) in the Digital Dividends—World Development Report 2016, the Digital Adoption Index (DAI) includes a cluster of 180 countries and represents a worldwide index which measures countries' digital adoption across three main dimensions of the economy: people, government, and business. Moreover, it defines digital technologies as "the internet, mobile phones, and all the other tools to collect, store, analyze, and share information digitally" but considers the fact that "technology can be transformational" [76]. This digital technologies index covers 180 countries in a composite of DAI (Economy) = DAI (Business) + DAI (People) + DAI (Governments). Some researchers used this World Bank index in order to complete certain studies on digital technology [77].

Another important perspective on digital technologies is provided by the Institute for Management Development (IMD) World Digital Competitiveness Ranking, using a cluster of 64 economies which are ranked from the most to the least digitally competitive based on 52 certain ranked criteria. Digital competitiveness constitutes the essential pillar of "new technologies in transforming governments' and businesses' process as well as how society interacts" but also determines value creation on the long-term horizon [78].

Furthermore, the European Commission also provided the Digital Economy and Society Index (DESI), which encapsulates the indicators on Europe's digital performance while following the progress of European Union member states. Digital Economy and Society Index (DESI) annual reports have been published by the European Commission since 2014. For instance, regarding official statistics, the European Commission (2022) argued in the Digital Economy and Society Index (DESI) annual report for 2022 that despite the fact that around 87% of adults between the ages of 16 and 74 years old used the internet regularly in 2021, only 54% had basic qualifications regarding digital skills. The European Commission also argued that 56% of persons in the European Union can handle tasks using at least basic digital skills, but digital technologies still remain an important deficiency in the context of advanced digital skills [79].

According to the European Investment Bank, between digitalization and firm performance, there is a very strong linkage, considering that digital firms tend to exhibit higher productivity compared with non-digital firms, have more sustainable management practices, become more innovative, grow faster and generate higher-paying positions of employment. It seems that digital adoption rates in European Union countries are lower compared with the United States of America. For instance, only 66% of manufacturing firms in the European Union, compared with 78% in the US, reported using at least one digital technology, while in the construction field, the share of digital firms was 40% in the European Union and 61% in the United States of America [80].

However, our approach is original, being essential in research to identify optimal alternative solutions to well-known digitalization indices already established internationally. In the existing literature, there are many research studies that use these previously listed digitalization indices, so this article tried to provide a much more innovative framework. The focus of the index is on the personal adoption of digital technology. In order to measure these factors for the analyzed countries, we took into account the following indicators: the percentage of individuals using the internet, the mobile cellular subscriptions per 100 people and the fixed telephone subscriptions per 100 people, as published by the International Telecommunication Union [81]. The index is computed by adding up the percentages of the indicators to obtain a total score for each year.

An advantage of the index calculated in this article, when compared with the Digital Economy and Society Index [82] or the ICT Development Index [83], is that it focuses mainly on the adoption of digital technology at a personal level. The authors consider this approach to be interesting, due to the fact that it makes possible a comparison between the digital development levels of the analyzed countries. In the analysis, we used the following packages from the R software package: panel var [84] and data table [85]. The model that the authors implemented in order to analyze the connection between the digital development index and the poverty headcount, as calculated by the World Bank database, was the indicator of the poverty headcount ratio at USD 5.50 per day (2011 PPP) (percentage of population) [86]. The model that we implemented was the two-step generalized moments method with two lags, similar to the one implemented by Dahlberg and Johansson [58] to measure the impact of the log returns of the local government expenditures, grants and revenues in Sweden for the time period between 1979 and 1986. The model was tested according to the procedure indicated in the paper written by Andrews and Lu [57] in order to set the proper number of lags and to see if the eigenvalues of the model were inside the unit circle.

The presented methodology is in line with the scientific research and the results of the studies described in the literature review section. In the following section, we aim to present the most relevant results of our research in a clear and concise manner by explaining the results and their implications. These implications lead to the conclusion that by increasing digital development, it is possible to eradicate poverty. This is of great interest to the scientific community and the political decision factors. This relation could be used in order to reshape the political strategies of the ruling governments in developing and emerging world countries.

4. Results

4.1. The Digitalization Index

In order to calculate the index, the authors decided to add up the components of the index in order to calculate a composite score for each country. The index was calculated by adding up all the percentages in nominal values (i.e., 9% was considered 9) in order to obtain a total score of digital development and the adoption of technology by the general population. This method allowed us to calculate the index for a great number of countries (175 in 2019) and understand the patterns of digital development at a worldwide scale. We consider this of great importance to presenting discussions on a worldwide scale for topics such as the problems faced by developing nations.

To generate the results presented in Figures 1 and 2, the authors used the Plotly [87] and Geopandas [88] packages for Jupyter Notebook. In Figure 1, we can observe the distribution of the world's countries by their digital development index scores for the year 2019. In the darkest color are the most-developed countries, and within the lighter colors are the least-developed countries. We can state that the most-developed countries were Europe and North America, and the least-developed ones were in Africa. A full list of the index values and the ranking of the countries is presented in Table A1 in Appendix A.

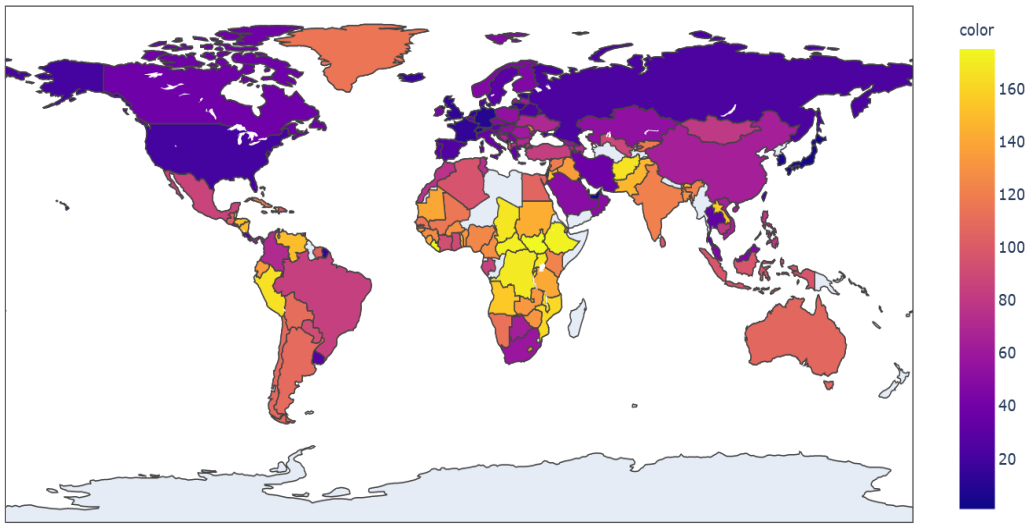

Figure 1. The results of the calculation of the digitalization index.

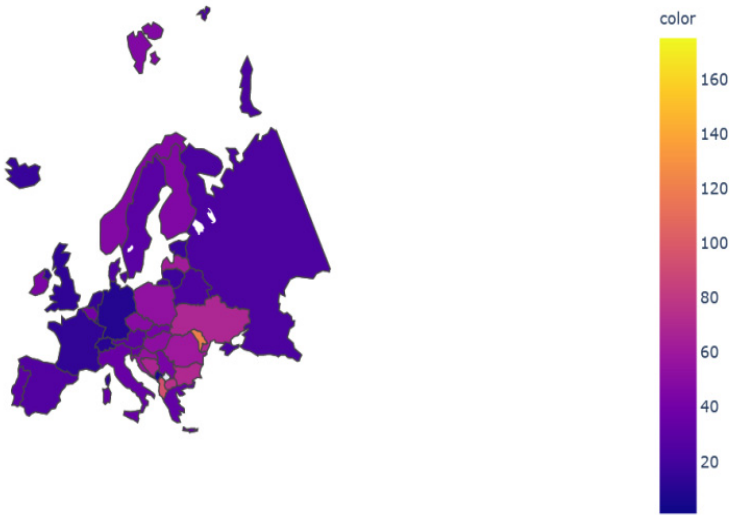

Figure 2. The results of the calculation of the digitalization index for Europe.

By analyzing Figure 1, we can state that the pattern of digital development was biased toward the Northern Hemisphere, with Europe being the most digitalized continent, along with North America and the southeast region of Asia. As we can see, the results for Africa show that this continent had the most developing countries, and access to technology was scarce.

In Figure 2, we present the European countries by the digitalization index score for each country, with the darkest color indicating the most digitalized countries and the lighter colors indicating the ones that were less developed.

From analyzing the results of the index, at a global level, we can see that the country considered the most developed from a digital standpoint was Hong Kong in the year 2019, and the least developed country was South Sudan. In the following part of the paper, we present several descriptive statistics regarding the values registered by the digital development index in 2000 and the values registered in 2019. The results are presented in Table 1.

Table 1. Comparative descriptive statistics for the index.

Statistic	2000	2019
Mean	50.2124	202.4483
Minimum	0.05857	46.5648
Maximum	191.9521	472.1837
Minimum/Maximum Percentage	0.031%	9.86%

In Table 1, we can see the way in which the digital development index depicts the evolution of the level of technological adoption of each country at the beginning and the end of the analyzed period. We can state that the difference between the most advanced country in the sample and the least advanced one was smaller in 2019 than it was in 2000. This is a clear indication that technology creates homogeneity in the development of countries. In this way, technology may accelerate the development of the economy and lead to a faster reduction in poverty. When taking into account the agenda of the Sustainable Development Goals, we can state that the advancement of technology should lead to the eradication of poverty, due to the effect of connecting the supply and demand of foreign markets. Another way in which digital development could lead to the eradication of poverty is by reducing unemployment. There have been several papers [89–92] that indicate a correlation between internet usage and employment (explained by the way in which the internet makes job opportunities more visible to the general public) or economic growth. Other interesting papers [91,92] regarding the development of digital technology and its effect on the business environment as part of the economy have been written, and the present paper acknowledges their contributions but aims to present a global image of digital development. Additionally, useful resources regarding the evolution of education and skills are presented on the OECD website [93], which are useful in gaining an overview of the presented problems regarding the effect of digital development on the reduction of poverty and its greater correlation with education and skill development (which is, in our opinion, essential in keeping up with technological advancement).

Moreover, the descriptive statistics show an increase in the level of the digital development of the analyzed countries, with the mean of the index being 50 in 2000 and reaching 202 in 2019. In addition, the ratio between the minimum value and the maximum value rose from 0.031% in 2000 to 9.86% in 2019.

In Table 2, the first 10 countries and the last 5, rated according to the digitalization development index, are presented. In the table, the authors presented only countries which had at least a population of 1.5 million people. The most developed countries, as calculated by our index, were Hong Kong, the United Arab Emirates, Japan, and South Korea.

Table 2. This table presents the rankings of the countries according to the index.

Rank	Country
1	Hong Kong, China
2	United Arab Emirates
3	Japan
4	Korea (Rep. of)
5	Germany
6	Singapore
7	Switzerland
8	United Kingdom
9	France
10	Netherlands
128	Central African Rep.
129	Ethiopia
130	Liberia
131	South Sudan

In Table 2, we decided to implement a restriction regarding the size of the population for the analyzed countries. This was performed to eliminate the bias of the index toward small countries (e.g., Luxembourg, Seychelles, etc.). The results for the full data sample are presented in Appendix A (Table A1). We decided to present a version of the table without the small countries because we considered that the results were significant for bigger and larger countries, due to the index being composed of indicators that were presented for 100 inhabitants.

In Figure 3, the authors present the evolution of four countries from the database that were considered to be of interest: Hong Kong, the United States of America, Germany, and South Africa. We can see that all the countries have evolved over time, but the digital index saw significant growth in the case of Hong Kong in the last 5 years. On the *y*-axis, we present the value of the digital development index, and on the *x*-axis, we present the years for which the index was calculated.

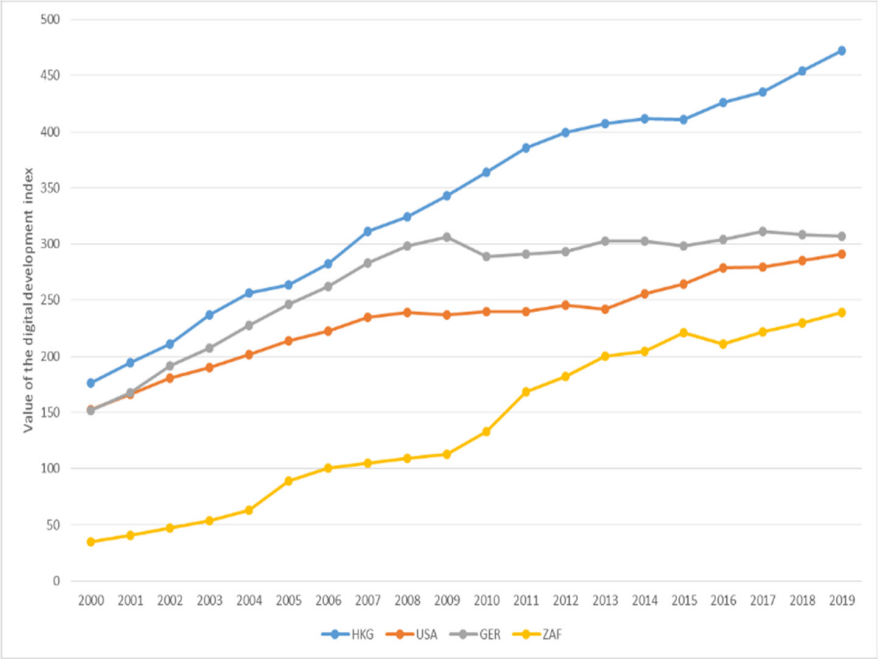

Figure 3. Evolution of the index for the selected countries.

By analyzing Figure 3, we can see that in the case of South Africa, the digital development index saw a significant increase in the analyzed time period. The authors also observed the fact that the analyzed countries experienced growth in digital development, but the difference between Hong Kong and South Africa remained relatively constant for

the analyzed time period. Moreover, the US, Germany, and South Africa were closer in the terms of digital development in 2019 compared with their positions in 2000.

4.2. The Relation between the Poverty Headcount Ratio and Digitalization

We decided to study the relation between the digital development index and the headcount poverty rate (as measured by the poverty headcount ratio at USD 5.50 a day (2011 PPP) (percentage of population) [64]) by applying a two-step dynamic panel vector autoregressive estimation with two lags. In the model, we used the first difference of the indicators by implementing a natural logarithm difference between the current value and the last value registered by the variable. The data used for the model were for the time period between 2005 and 2018 for the following countries: Armenia, Austria, Belgium, Belarus, Costa Rica, the Czech Republic, Denmark, the Dominican Republic, Ecuador, Spain, Estonia, Finland, France, Georgia, Greece, Honduras, Hungary, Indonesia, Kazakhstan, Lithuania, Latvia, Moldovia, the Netherlands, Norway, Panama, Peru, Poland, Portugal, Paraguay, the Russian Federation, Slovenia, Sweden, Turkey, Ukraine, and the United States of America. We selected these 35 countries due to the available data regarding the poverty headcount ratio. In this way, only these countries had all the data available for the analyzed time period. This explains the way in which the model was constructed. One useful indication was that we had countries from almost all of the continents (except Oceania), and this allowed us to still present a global overview for the selected data.

The results of the estimation of the model are presented in Figure 4. We can state that the poverty rate was influenced by the digital development index for both lags. For the first lag of the digital development index, the value of the coefficient was −1.7551 and was significant for a threshold of 95% for the poverty rate headcount. Moreover, the second lag of the digital development index was significant in the equation for the poverty rate, having a value of 1.3426. Consequently, we can state that the values of the poverty rate headcount were influenced by the values of the digital development index, with the value of the index in the previous year exerting a significant influence on reducing the poverty rate headcount, and the coefficient for the second lag indicated a positive influence on the poverty headcount rate. This could be due to the fact that the time interval was short and may have presented contradictory phases of the evolution of society.

```
-----------------------------------------------
Dynamic Panel VAR estimation, two-step GMM
-----------------------------------------------
Transformation: Forward orthogonal deviations
Group variable: ID
Time variable: Year
Number of observations = 385
Number of groups = 35
Obs per group: min = 11
avg = 11
               max = 11
Number of instruments = 308
==================================
               ID__1         Pov_rate
-----------------------------------------------
lag1_ID__1      1.1974 *     -1.7551 *
               (0.4971)      (0.7194)
lag1_Pov_rate   0.0599 (n.s) -0.1240 (n.s)
               (0.1956)      (0.1762)
lag2_ID__1     -0.4222 (n.s) 1.3426 *
               (0.4397)      (0.6733)
lag2_Pov_rate  -0.1414 (n.s) -0.0222 (n.s)
               (0.1352)      (0.1146)
==================================
* p < 0.05, n.s- not significant
```

Figure 4. Vector autoregression model results for the analyzed data.

In Figure 4, ID__1 represents the evolution of the digital development index, and the Pov_rate represents the evolution of the poverty rate calculated as the logarithmic difference of the values of the poverty headcount ratio at USD 5.50 a day (2011 PPP) (percentage of population) [86], as calculated by the World Bank. In Figure 5, we can see the results of the impulse response function for the vector autoregressive model.

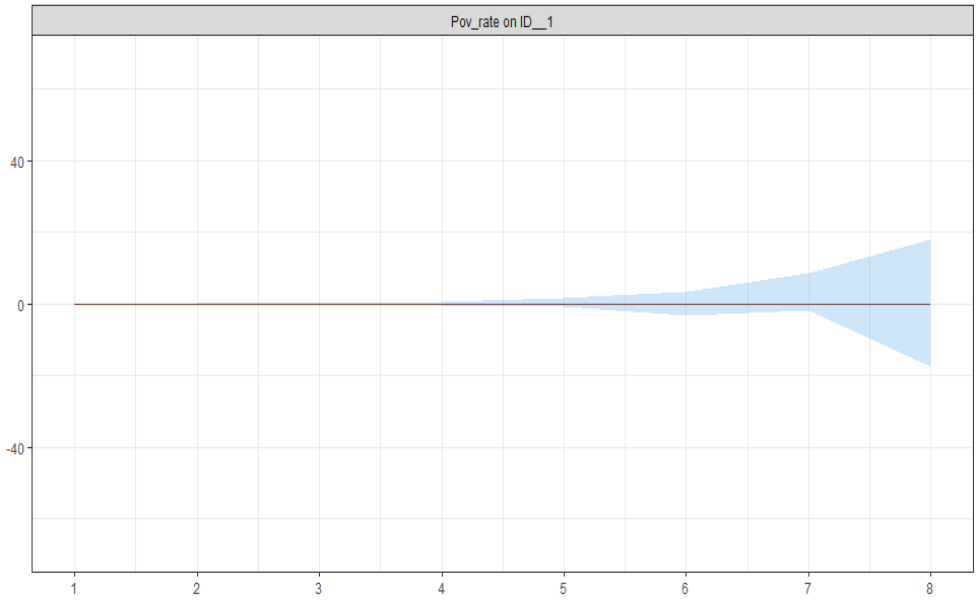

Figure 5. Impulse response function of the poverty headcount rate for the digitalization index.

By analyzing the results in Figure 5, we can see that there was a certain significant impact from the poverty rate headcount on the digital development index. This is important because it implies that the poverty rate can be decreased by the digital development index. Moreover, the shock had an effect on the last periods analyzed. Even though the impulse response function seemed to depict a small but significant effect, the results of the VAR model estimation as stated presented a significant coefficient of −1.7551 for the variable of the first lag of digital development in the equation that approximated the value of the poverty headcount ratio.

4.3. The Performance of the Digital Developed Economies during the COVID-19 Pandemic

In the following section, we present an analysis regarding the way in which the gross domestic products for the most digitally developed countries have evolved in the time of the COVID-19 pandemic. For this, we take the most developed countries according to our digital development index and compare them to the other countries in the sample.

In Figure 6, the authors depict the evolution of the economic growth values for four countries that were considered to be in the category of the most-developed countries from the studied sample (Switzerland, Germany, Japan and South Korea) and compared them to the average of the countries that are members of the OECD, European Union and the euro area.

By analyzing the figure, we can observe that the digitally developed countries had more stable economic growth in the pandemic period when compared with the average of the European Union, eurozone or the OECD. This fact indicates that a higher level of digital development led to a more equilibrated response to the pandemic's shock. The complete data of the figure are depicted in Table 3, with the data being available from the OECD database [93].

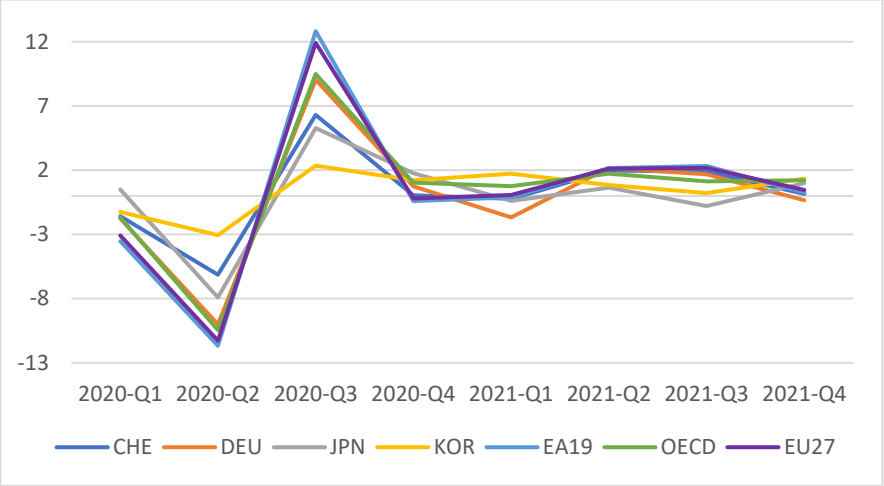

Figure 6. Evolution of the economic growth for the studied countries.

Table 3. Economic growth of the analyzed countries as percentages.

Date	CHE	DEU	JPN	KOR	EA19	OECD	EU27
2020-Q1	−1.59	−1.76	0.49	−1.26	−3.53	−1.70	−3.09
2020-Q2	−6.14	−10.00	−7.90	−3.05	−11.67	−10.45	−11.27
2020-Q3	6.30	9.04	5.28	2.35	12.82	9.49	11.91
2020-Q4	0.04	0.74	1.76	1.21	−0.40	1.02	−0.20
2021-Q1	−0.24	−1.68	−0.40	1.72	−0.12	0.75	0.07
2021-Q2	1.97	2.17	0.64	0.83	2.16	1.72	2.11
2021-Q3	1.87	1.67	−0.80	0.21	2.32	1.12	2.18
2021-Q4	0.16	−0.35	0.98	1.34	0.25	1.21	0.45

In Table 3, the authors present the results of presenting the economic growth from the first quarter of 2020 to the fourth quarter of 2021. The analyzed countries were Switzerland, Germany, Japan and Korea. In the table, we also present the values reported for the euro area, the OECD and the European Union. The countries that were the most digitally developed, such as Japan (ranked third in 2019) and South Korea (ranked fourth in 2019) had a growth rate higher than the eurozone, OECD and the European Union. In the following part, we present the discussions regarding the findings of this article and the conclusions.

By analyzing these results, we can conclude that the countries that had better digital development had a better evolution during the COVID-19 pandemic and also had a less powerful impact than in the case of the average of the OECD, the euro area and the European Union countries. The number of countries in the sample was relatively small compared with the number of countries used in the index (35 vs. 175) due to the lack of data regarding the poverty headcount ratio for the period between 2005 and 2018.

5. Discussion

In the present article, we described how to compute an index for digital development that takes into account the personal adoption of technology. This was achieved by taking into account data made available by the International Telecommunication Union in order to obtain a better understanding of the level of development of each country and offers the possibility of comparing the digital development of the countries.

Some researchers [94] revealed that the transportation and accommodation sectors have been significantly affected by COVID-19-related lockdowns, but on the contrary, other sectors of the sharing economy such as freelance work, streaming services and online deliveries have reached increasing levels of development and profit. At the quantitative level, the most likely effect of the COVID-19 pandemic on the global economy has been

quantified to be between USD 5.8 trillion and 8.8 trillion, equivalent to 6.4–9.7% of the global gross domestic product (GDP) as approximated by the Asian Development Bank (ADB) on May 2020 [95]. According to other researchers [96], the COVID-19 pandemic raised unprecedented challenges while earnestly affecting all businesses worldwide.

The results of the vector autoregressive model led to the conclusion that there is a significant statistical influence from the digital development index that we constructed in this paper and the poverty headcount rate as described by the World Bank indicator (poverty headcount ratio at USD 5.50 a day (2011 PPP) (percentage of population)) [86]. This led to the idea that by increasing the access to technology, governments could contribute to the reduction of poverty. This reduction in poverty could lead to the advancement of the Sustainable Development Goals and progress in implementing the 2030 Agenda of the UN [3]. The presented findings are similar to the ones obtained in other papers [26–31], with the exception that the data sample used in this article contained countries from all over the world, and we provided a comparison of the influence of digital development on the reduction of poverty that is easier to understand at a global level. In this context, we can state that the digital development of a country leads to a reduction in the poverty headcount. These results agree with those of the majority of the papers in the scientific literature. An interesting development contribution is the way in which digital development is measured in the present article. The authors decided to use an index that measured the personal adoption of technology due to the effect that technology at an individual level has on the reduction in poverty. The usefulness of the present research is the fact that it proves that the adoption of technology at the personal level leads to a reduction in poverty. This could be used as the basis for shaping policies regarding the eradication of poverty at the international level. By increasing the access to technology among the population, citizens could access job opportunities that they otherwise would not have seen, or they could have access to information at an unprecedented scale. These results could be seen as a continuation of the work conducted in several papers [43,46,50–52] regarding the way in which technology increases the opportunity to participate in the economy for all the citizens. In this case, the authors recommend an increase in the interest that governments have in the adoption of technology at the personal level by creating programs which encourage the use of and access to technology and also make the acquisition of IT devices easier (e.g., this could be achieved with vouchers or discounts for an individual's first computer).

In addition, we note that the results of this paper seem to generalize certain findings for specific continents [18,19,26,27], such as the beneficial effect of digital development on the reduction of poverty in Africa and for the 35 countries analyzed in the model (which are mostly in Europe and the North and South American continents). In this way, our study demonstrates a clear relation between digital development (concentrated on the personal adoption of technology due to the composition of the index: the percentage of individuals using the internet, the mobile cellular subscriptions for 100 people and the fixed telephone subscriptions for 100 people) and the reduction of poverty. This confirms the findings of several studies [43,46,50–52,67–70], which stated that the adoption of the internet leads to the reduction of poverty. The mechanism of this influence is, as stated by Dawood [52], for the case of the rural communities of northern Malaysia, and it works by encouraging a connection between individuals and action at the grass roots level. This implies that technology changes society by giving power to the people to communicate and create groups in an easier and more interest-based way. For example, a group that promotes the creation of parking lots in a certain area of the city could promote the idea on the internet and, by doing this, make it more visible for the city council. In this way, we consider that the adoption of the internet will lead to the reduction of poverty by increasing the freedom of the population and access to information, which promotes a better understanding of the way government functions.

Additionally, the index presented in this paper could be used on its own for assessing the digital development of the world's countries. In this way, the index is similar to the one developed by Archibugi and Coco [34] in their paper "A New Indicator of Technological

Capabilities for Developed and Developing Countries (Arco)", which ranked Sweden as the most digitally developed country in 2000. In our index, the most digitally developed country in 2019 was Hong Kong, which in [34] was number 21. This growth seems to be confirmed by the results presented in Figure 3. In this way, the index developed in our article, along with the digital divide indices developed in other papers [42–52], can offer a way to compare digital development and the progress of countries in the adoption of technology. Possible future researchers could, by using the methodology described in this paper, compare results and see the way in which countries evolved from a digital development standpoint. The present paper describes an original and interesting research study regarding the influence of the personal adoption of digital technology on the poverty rate. The authors also appreciate that the results of the present study could be of interest to governmental institutions and to international organizations such as the United Nations and the OECD due to its implications for the planning and achievement of the Sustainable Development Goals, as stated in the 2030 Agenda [3]. In this way, the present study could inspire similar approaches and lead to advancement of the rate of the eradication of poverty by making technology available to all citizens.

Regarding the relation between digital development and the COVID-19 pandemic, we can state that the economies of the more digitally developed countries have been more stable in the face of the COVID-19 pandemic. These observations are in line with the relevant scientific literature [59–75], meaning that digital development helps develop a stronger economy (that responds to external shocks, such as the COVID-19 pandemic, better). This observation leads to the idea that by developing the digital capacity of a country, the authors can improve its response in the face of the COVID-19 pandemic.

The presented results are similar to those in the scientific literature, and they present a correlated and significant view of digital development as a key factor in reducing the poverty headcount ratio. Our results are similar to the ones presented in several cited studies [43,46,50–52,67–70], and by generalizing aspects that were observed at continental level by several articles [18,19,26,27], these results should be of interest to the scientific and academic communities as well as researchers in the economic area.

6. Conclusions

Starting from the research hypothesis stated in the introduction, ("How does the increase in technological development influence the rate of poverty at the national level, and how does digital development relate to the response to the COVID-19 pandemic?") we can say that this research study presents a clear and significant influence between the digital development of a country and the poverty headcount ratio, as calculated by the World Bank [64]. The present paper shows a correlation between the adoption of technology at the personal level (due to the way in which the digital development index is calculated: considering the percentage of individuals using the internet, the mobile cellular subscriptions per 100 people and the fixed telephone subscriptions per 100 people) and the reduction in the poverty headcount ratio. In addition, this study's contributions to the general field of knowledge regarding the analysis of digital development, as well as its importance in the reduction of the poverty headcount ratio, are significant and interesting. First, this study establishes a connection between the development of the digital capacity of a country, as measured by using the digital development index, and economic development. The index is calculated as the sum of the following indicators: the percentage of individuals using the internet, the mobile cellular subscriptions per 100 people and the fixed telephone subscriptions per 100 people, as published by the International Telecommunication Union [76]. This connection is similar to the one described in several papers [34–37] that have proposed and used indices for measuring digital development, such as the one written by Archibugi and Coco [34]. These interesting results are doubled by the interesting connection between the digital development of a country and the reduction of the poverty headcount ratio. This result is of great interest due to the interesting effects that digitalization has for increasing the wealth of nations. In this case, such an

observation, though stated in several papers [18,19], only applied for limited datasets that were related to single continents. For example, Asongu [18] and Evans [19] presented a hypothesis that explains, in the case of the African continent, the way in which mobile phone development led to a significant increase in informal financial development, even though its effects were less noticeable at the macroeconomic level, and that the use of mobile phones with internet access in 44 African countries in the period between 2000 and 2016 led to an increase in financial inclusion, although the literature review-based studies [20] make claims that there are few papers that can present a causal inference between ICT development and poverty. The fact is that the interaction between the internet, mobile phone access or other technologies and poverty, which was also the focus of many papers [21–25], was demonstrated in this research paper for the 35 countries that were analyzed in the data sample.

Additionally, in the scientific literature, there has been a trend toward analyzing the impacts of technology as a means of inclusion and access to information on poverty, either in South Asia, Sub-Saharan Africa [26] or in Latin America [27]. This also makes our study of interest regarding the way in which digital development has led to worldwide developments instead of regionally based implications. This concentration of the study on proving and presenting results at the global level is, in our opinion, its biggest strength and sets it apart as an interesting and dynamic approach of a much-studied and debated economic and social phenomenon [97–99].

The results of this study suggest that by making technology more affordable and available for a population, the Sustainable Development Goal of eradicating poverty could be accomplished in a faster and more efficient way. One of the challenges that we met in the development of the present study was the lack of data regarding the poverty rate of the analyzed countries, with this being due to the fact that we determined the application of the model to only be for 35 countries and for the period between 2005 and 2018, as these were the only available data on the subject at the national level.

This paper presents a quantifiable method of analyzing the impact of digital technology adoption at the personal level on the poverty headcount ratio. This approach is an original one due to the way in which we can observe the impact of the possible increase in the adoption of technology. Of additional interest is the composition of the digital development index. The index allowed us to compare the evolution of the countries in the analyzed period of time. The index is easy to build and can offer a benchmark for developing a comparative analysis between different countries and observing the way in which policies have shaped the evolution of digital development in each country. Another contribution of the index could be its use in the better understanding of the problems of developing countries, as we observed that the countries of the African continent were the ones that presented the greatest gap in digital development. This is of interest due to the fact that sustainable development should promote growth at the global level. In this context, the calculation of this index in the future could provide researchers with a perspective of the progress made by developing countries, and it could also serve as an indicator of appropriate regional policy and a sustainable approach at the international level.

On the other hand, a notable research limitation is that the data analyzed in this paper deal with country-based indicators. This approach leads to the exclusion of the idea that within a country, there might be several levels of technological adoption, depending on the regions of the country or whether the population lives in rural or urban environments. Moreover, in the development of the study, the authors noticed a lack of data regarding the poverty headcount ratio for most of the world's countries. This fact led us to use only 35 countries in the final study in order to develop the vector autoregressive model. Another limitation to take into consideration is represented by the bias of the index toward small countries. This is explained by the way in which the index takes into account indicators that are expressed as percentages. Although such an approach could favor small countries, using nominal values of the indicators (e.g., millions of internet users) could lead to confusing results, and the index is more understandable as a total score of all the percentage-based

indicators. Another limitation is represented by the fact that poverty itself is a complex phenomenon, and in this paper, the authors attempted to analyze only the relation between digital development and poverty without taking into consideration other determining factors of poverty, such as government- and society-related factors, in order to analyze the relation at a fundamental and singular level. However, this approach has the advantage and the limitation of offering a clear view of only a small piece of the relations of poverty and its determining factors.

Another interesting effect of digital development on the economy is raising its resilience in front of external shocks. One such shock is the COVID-19 pandemic, with which the world has been confronted in the last two years. By analyzing the evolution of the most digitally developed economies, during the pandemic, we can conclude that the ones that were the most developed according to the digital development index (Japan and South Korea) performed better than the European Union, euro zone and OECD averages. This is of interest because it shows that by increasing the access to technology, the government not only reduces the poverty headcount ratio, but it also makes the economy more resilient to outside shocks. This leads to the idea that digital development has many positive impacts that should be further researched.

The present study also has interesting managerial implications for presenting a global perspective of the digital development of the world's countries. For a company that wants to become active in a digitally developed country, it could use the results of this study as a guideline to analyzing the development of each country. In addition, the relation between the digital development of a country and reduction of the poverty headcount is useful for quantifying the way in which a certain country could evolve in the future from a digital standpoint.

Further research studies should focus on investigation of the relation between technological adoption and other Sustainable Development Goals. This could be useful because it holds significance in demonstrating that technology is an important driving force in the creation of a more sustainable economy. Another interesting research direction could be the impact of the technology price level on the poverty headcount rate, so this could be of interest due to the connections between the affordability of technology and its adoption.

Thus, it can be concluded that the present research paper presents an established and clear correlation between digital development and the poverty headcount ratio. This is not only a new approach to the field of study but also presents significant relevance to the reader. In this way, this article is of great interest to all of the scientific community and the political decision factors due to the implications of the research performed. In this way, by encouraging digital development of the population (by adopting new technologies), the government can lead to reduction of the poverty headcount ratio. Even though investment in shelter and primary goods can be seen as the way to go for a developing nation, we conclude that better and more consistent results regarding the reduction of poverty can be obtained by increasing the digital development of the country.

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Appendix A

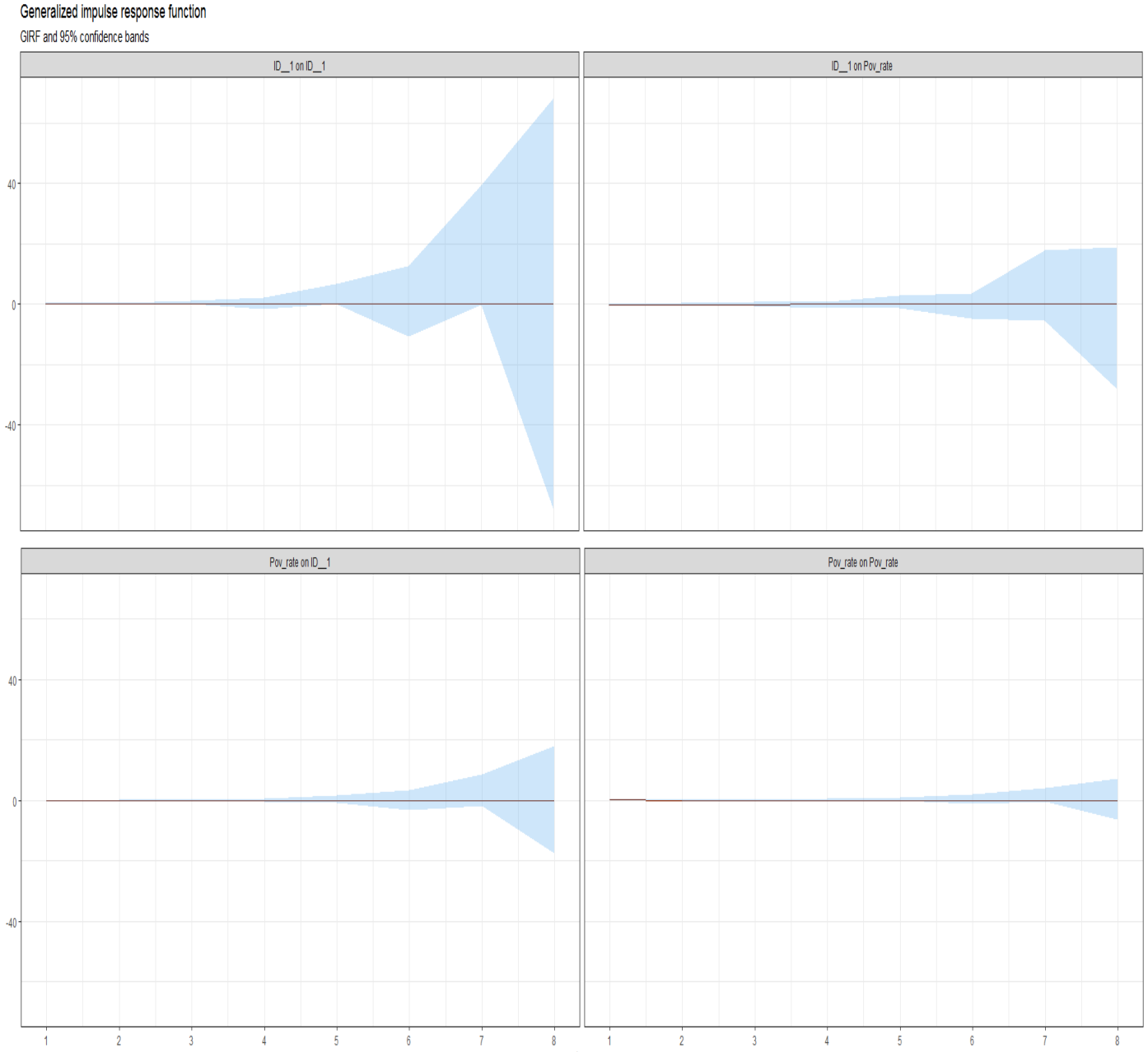

Figure A1. Generalized impulse response function.

Table A1. List of countries based on rank in 2019.

Country	Rank in 2019	Country	Rank in 2019
Hong Kong, China	1	San Marino	89
United Arab Emirates	2	Ghana	90
Malta	3	Paraguay	91
Japan	4	Cabo Verde	92
Korea (Rep. of)	5	Côte d'Ivoire	93
Seychelles	6	Albania	94
Montenegro	7	Faroe Islands	95
Luxembourg	8	Algeria	96
Germany	9	Indonesia	97

Table A1. *Cont.*

Country	Rank in 2019	Country	Rank in 2019
Singapore	10	Sri Lanka	98
Switzerland	11	Dominican Rep.	99
Cyprus	12	Curacao	100
United Kingdom	13	British Virgin Islands	101
France	14	Guatemala	102
Netherlands	15	Palestine	103
Iceland	16	Suriname	104
Estonia	17	Maldives	105
Lithuania	18	Egypt	106
Taiwan, Province of China	19	Australia	107
United States	20	Chile	108
Israel	21	Argentina	109
Kuwait	22	Bolivia (Plurinational State of)	110
Russian Federation	23	Gambia	111
Belarus	24	Bahamas	112
Denmark	25	Namibia	113
Spain	26	Senegal	114
Uruguay	27	Greenland	115
Costa Rica	28	Mali	116
Sweden	29	Kyrgyzstan	117
Portugal	30	Syrian Arab Republic	118
Austria	31	Cuba	119
Thailand	32	Moldova	120
Greece	33	India	121
Mauritius	34	Kenya	122
Italy	35	Jamaica	123
Slovenia	36	Nigeria	124
Iran (Islamic Republic of)	37	Saint Vincent and the Grenadines	125
Canada	38	Guinea	126
Qatar	39	Lesotho	127
Belgium	40	Cameroon	128
Brunei Darussalam	41	Bangladesh	129
Slovakia	42	Burkina Faso	130
Serbia	43	Zimbabwe	131
Ireland	44	Benin	132
Malaysia	45	Zambia	133
Finland	46	Ecuador	134
Norway	47	Iraq	135
Monaco	48	Sao Tome and Principe	136
Czech Republic	49	Guinea-Bissau	137
Saudi Arabia	50	Timor-Leste	138
Oman	51	Djibouti	139
Hungary	52	Mauritania	140
Kazakhstan	53	Tanzania	141
Poland	54	Sierra Leone	142
Croatia	55	Sudan	143
Bahrain	56	Rwanda	144
Georgia	57	Bhutan	145
South Africa	58	Togo	146
Puerto Rico	59	Pakistan	147
Romania	60	Nicaragua	148
El Salvador	61	Haiti	149
Latvia	62	Venezuela	150
Botswana	63	Vanuatu	151
China	64	Honduras	152
Vietnam	65	Macao, China	153
Panama	66	Jordan	154
Gibraltar	67	Angola	155

Table A1. *Cont.*

Country	Rank in 2019	Country	Rank in 2019
Bosnia and Herzegovina	68	Lao P.D.R.	156
Ukraine	69	Lebanon	157
Bulgaria	70	Belize	158
Colombia	71	Solomon Islands	159
Azerbaijan	72	Tonga	160
Armenia	73	Comoros	161
Tunisia	74	Mozambique	162
North Macedonia	75	Malawi	163
Morocco	76	Burundi	164
Andorra	77	Peru	165
Philippines	78	Afghanistan	166
Cambodia	79	Chad	167
Mongolia	80	Uganda	168
Liechtenstein	81	Dem. Rep. of the Congo	169
Trinidad and Tobago	82	Kiribati	170
Turkey	83	Central African Rep.	171
Brazil	84	Ethiopia	172
Gabon	85	Grenada	173
Mexico	86	Liberia	174
Barbados	87	South Sudan	175
Uzbekistan	88		

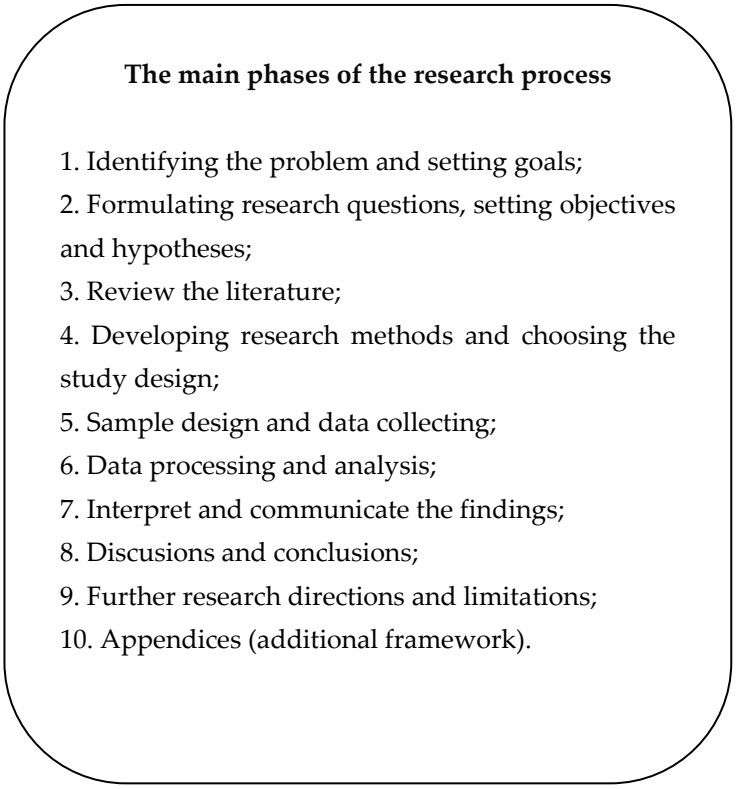

Figure A2. The flow diagram of the main phases of the research.

References

1. United Nations World Commission on Environment and Development (Ed.) *Report of the World Commission on Environment and Development: Our Common Future*; Oxford University Press: Oxford, UK, 1987.
2. International Union for Conservation of Nature and Natural Resources. 1980. World Conservation Strategy: Living Resource Conservation for Sustainable Development. Available online: https://www.a21italy.it/medias/31C2D26FD81B0D40.pdf (accessed on 17 March 2022).

3. United Nations Statistics Division (UNSD). SDG Indicators—Global Indicator Framework for the Sustainable Development Goals and Targets of the 2030 Agenda for Sustainable Development. Available online: https://unstats.un.org/sdgs/indicators/indicators-list (accessed on 17 March 2022).
4. Griggs, D.J.; Stafford-Smith, M.; Gaffney, O.; Rockström, J.; Öhman, M.C.; Shyamsundar, P.; Steffen, W.; Glaser, G.; Kanie, N.; Noble, I.R. Policy: Sustainable development goals for people and planet. *Nature* **2013**, *495*, 305–307. [CrossRef] [PubMed]
5. French, D.; Kotzé, L.J. *Sustainable Development Goals*; Edward Elgar Publishing: Cheltenham, UK, 2018. [CrossRef]
6. Pradhan, P.; Costa, L.; Rybski, D.; Lucht, W.; Kropp, J.P. A Systematic Study of Sustainable Development Goal (SDG) Interactions. *Earth's Future* **2017**, *5*, 1169–1179. [CrossRef]
7. Leal Filho, W.; Tripathi, S.K.; Andrade Guerra, J.B.; Giné-Garriga, R.; OrlovićLovren, V.; Willats, J. Using the sustainable development goals towards a better understanding of sustainability challenges. *Int. J. Sustain. Dev. World Ecol.* **2018**, *26*, 179–190. [CrossRef]
8. Folke, C.; Carpenter, S.; Elmqvist, T.; Gunderson, L.; Holling, C.S.; Walker, B. Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations. *Ambio* **2002**, *31*, 437–440. [CrossRef]
9. Hickel, J. The contradiction of the sustainable development goals: Growth versus ecology on a finite planet. *Sustain. Dev.* **2019**, *27*, 873–884. [CrossRef]
10. Coscieme, L.; Mortensen, L.F.; Anderson, S.J.; Ward, J.D.; Donohue, I.; Sutton, P.C. Going beyond Gross Domestic Product as an indicator to bring coherence to the Sustainable Development Goals. *J. Clean. Prod.* **2020**, *248*, 119232. [CrossRef]
11. Kubiszewski, I.; Mulder, K.; Jarvis, D.; Costanza, R. Toward better measurement of sustainable development and wellbeing: A small number of SDG indicators reliably predict life satisfaction. *Sustain. Dev.* **2022**, *30*, 139–148. [CrossRef]
12. MacFeely, S. Measuring the Sustainable Development Goal Indicators: An Unprecedented Statistical Challenge. *J. Off. Stat.* **2020**, *36*, 361–378. [CrossRef]
13. Schmidt-Traub, G.; Kroll, C.; Teksoz, K.; Durand-Delacre, D.; Sachs, J.D. National baselines for the Sustainable Development Goals assessed in the SDG Index and Dashboards. *Nat. Geosci.* **2017**, *10*, 547–555. [CrossRef]
14. Allen, C.; Nejdawi, R.; El-Baba, J.; Hamati, K.; Metternicht, G.I.; Wiedmann, T.O. Indicator-based assessments of progress towards the sustainable development goals (SDGs): A case study from the Arab region. *Sustain. Sci.* **2017**, *12*, 975–989. [CrossRef]
15. Federal Register: Annual Update of the HHS Poverty Guidelines. Available online: https://www.govinfo.gov/content/pkg/FR-2020-01-17/pdf/2020-00858.pdf (accessed on 24 April 2022).
16. Government of India, Press Information Bureau, Poverty Estimates for 2004-05. Available online: https://web.archive.org/web/20120917001050/http://planningcommision.gov.in/news/prmar07.pdf (accessed on 24 April 2022).
17. Kwilinski, A.; Vyshnevskyi, O.; Dzwigol, H. Digitalization of the EU Economies and People at Risk of Poverty or Social Exclusion. *J. Risk Financ. Manag.* **2020**, *13*, 142. [CrossRef]
18. Asongu, S.A. How has Mobile Phone Penetration Stimulated Financial Development in Africa? *J. Afr. Bus.* **2013**, *14*, 7–18. [CrossRef]
19. Evans, O. Connecting the poor: The internet, mobile phones and financial inclusion in Africa. *Digit. Policy Regul. Gov.* **2018**, *20*, 568–581. [CrossRef]
20. May, J.; Diga, K. Progress Towards Resolving the Measurement Link Between ICT and Poverty Reduction. In *Impact of Information Society Research in the Global South*; May, J., Diga, K., Eds.; Springer: Singapore, 2015; pp. 83–104. [CrossRef]
21. James, J. The Internet and poverty in developing countries: Welfare economics versus a functionings-based approach. *Futures* **2006**, *38*, 337–349. [CrossRef]
22. Adomi, E.E. *Frameworks for ICT Policy: Government, Social and Legal Issues*; IGI Global: Hershey, PA, USA, 2011. [CrossRef]
23. Ramírez, R. Appreciating the Contribution of Broadband ICT with Rural and Remote Communities: Stepping Stones toward an Alternative Paradigm. *Inf. Soc.* **2007**, *23*, 85–94. [CrossRef]
24. Rao, S.S. Role of ICTs in India's rural community information systems. *Info* **2004**, *6*, 261–269. [CrossRef]
25. Cecchini, S.; Scott, C. Can information and communications technology applications contribute to poverty reduction? Lessons from rural India. *Inf. Technol. Dev.* **2003**, *10*, 73–84. [CrossRef]
26. Lyons, A.; Kass-Hanna, J.; Greenlee, A.J. Impacts of Financial and Digital Inclusion on Poverty in South Asia and Sub-Saharan Africa. *Food Sustain. Secur. Ejournal* **2020**. [CrossRef]
27. Arocena, R.; Senker, P. Technology, Inequality, and Underdevelopment: The Case of Latin America. *Sci. Technol. Hum. Values* **2003**, *28*, 15–33. [CrossRef]
28. Dercon, S.; Christiaensen, L. Consumption Risk, Technology Adoption, and Poverty Traps: Evidence from Ethiopia. *J. Dev. Econ.* **2011**, *96*, 159–173. [CrossRef]
29. Lee, J.N.; Morduch, J.; Ravindran, S.K.; Shonchoy, A.S.; Zaman, H. Poverty and Migration in the Digital Age: Experimental Evidence on Mobile Banking in Bangladesh. *Am. Econ. J. Appl. Econ.* **2021**, *13*, 38–71. [CrossRef]
30. Mora-Rivera, J.; García-Mora, F. Internet access and poverty reduction: Evidence from rural and urban Mexico. *Telecommun. Policy* **2021**, *45*, 102076. [CrossRef]
31. Tayo, O.; Thompson, R.J.; Thompson, E.J. Impact of the Digital Divide on Computer Use and Internet Access on the Poor in Nigeria. *J. Educ. Learn.* **2016**, *5*, 1–6. [CrossRef]

32. Pînzaru, F.; Zbuchea, A.; Anghel, L.C. Knowledge Development through the Internet. In Proceedings of the International Conference on Intellectual Capital, Knowledge Management & Organisational Learning, Sydney, Australia, 6–7 November 2014. [CrossRef]
33. Massimo, G.C.; Luca, G. Technology policy for the knowledge economy: Public support to young ICT service firms. *Telecommun. Policy* **2007**, *31*, 573–591. [CrossRef]
34. Archibugi, D.; Coco, A. A New Indicator of Technological Capabilities for Developed and Developing Countries (Arco). *SSRN Electron. J.* **2004**, *32*, 629–654. [CrossRef]
35. Álvarez, I.G.; Magaña, G. ICT and development: A new indicator for international comparisons. *Int. J. Technol. Glob.* **2008**, *4*, 170–185. [CrossRef]
36. Nevado-Peña, D.; López-Ruiz, V.; Alfaro-Navarro, J. An analysis of the key role of human and technological development in the smart specialization of smart European regions. *Inf. Technol. Dev.* **2020**, *26*, 728–741. [CrossRef]
37. Hongxi, C.; Juan, P. A Study on the Dynamic Relationship between Digital Financial Development, Social Consumption and Economic Growth. *J. Econ. Public Financ.* **2021**, *7*, 56–69. [CrossRef]
38. Fornerino, M. Internet adoption in France. *Serv. Ind. J.* **2003**, *23*, 119–135. [CrossRef]
39. Martínez-Domínguez, M.; Mora-Rivera, J. Internet adoption and usage patterns in rural Mexico. *Technol. Soc.* **2020**, *60*, 101226. [CrossRef]
40. Masaki, T.; Rodríguez-Castelán, C.; Ochoa, R.; Lach, S. Mobile Internet Adoption in West Africa. *Technol. Soc.* **2021**, *68*, 101845. [CrossRef]
41. Pénard, T.; Poussing, N.; Mukoko, B.; Piaptie, G. Internet adoption and usage patterns in Africa: Evidence from Cameroon. *Technol. Soc.* **2015**, *42*, 71–80. [CrossRef]
42. Cavalcanti, D.R.; Oliveira, T.; Santini, F.D. Drivers of Digital Transformation Adoption: A Weight and Meta-Analysis. *Heliyon* **2022**, *8*, e08911. [CrossRef] [PubMed]
43. Jovanović, M.; Dlačić, J.; Okanovic, M. Digitalization and society's sustainable development—Measures and implications. *Proc. Rij. Fac. Econ. J. Econ. Bus.* **2018**, *36*, 905–928. [CrossRef]
44. Bagchi, K.K. Factors Contributing to Global Digital Divide: Some Empirical Results. *J. Glob. Inf. Technol. Manag.* **2005**, *8*, 47–65. [CrossRef]
45. Beynon-Davies, P.; Hill, R.A. Evaluating a digital divide index in a regional context. *J. Syst. Inf. Technol.* **2007**, *9*, 46–59. [CrossRef]
46. Taylor, D.; Packham, G.A. Social Inclusion through ICT: Identifying and Overcoming Barriers to ICT Use. *Strateg. Change* **2016**, *25*, 45–60. [CrossRef]
47. Ayanso, A.; Cho, D.I.; Lertwachara, K. The digital divide: Global and regional ICT leaders and followers. *Inf. Technol. Dev.* **2010**, *16*, 304–319. [CrossRef]
48. Ayanso, A.; Cho, D.I.; Lertwachara, K. Information and Communications Technology Development and the Digital Divide: A Global and Regional Assessment. *Inf. Technol. Dev.* **2014**, *20*, 60–77. [CrossRef]
49. Chinn, M.D.; Fairlie, R.W. ICT Use in the Developing World: An Analysis of Differences in Computer and Internet Penetration. *Inf. Syst. Behav. Soc. Methods* **2006**, *18*, 153–167. [CrossRef]
50. Dijk, J.V. *The Deepening Divide: Inequality in the Information Society*; SAGE Publications Inc.: Thousand Oaks, CA, USA, 2005. [CrossRef]
51. Warren, M. The digital vicious cycle: Links between social disadvantage and digital exclusion in rural areas. *Telecommun. Policy* **2007**, *31*, 374–388. [CrossRef]
52. Dawood, S.R. Digital Divide and Poverty Eradication in the Rural Region of Northern Peninsular Malaysia. *Indones. J. Geogr.* **2019**, *51*, 172–182. [CrossRef]
53. Sims, C.A. Macroeconomics and Reality. *Econometrica* **1980**, *48*, 1–48. [CrossRef]
54. Kiviet, J. On Bias, Inconsistency, and Efficiency of Various Estimators in Dynamic Panel Data Models. *J. Econom.* **1995**, *68*, 53–78. [CrossRef]
55. Bond, S.R. Dynamic Panel Data Models: A Guide to Micro Data Methods and Practice. *Port. Econ. J.* **2002**, *1*, 141–162. [CrossRef]
56. Anderson, T.; Hsiao, C. Formulation and Estimation of Dynamic Models Using Panel Data. *J. Econom.* **1982**, *18*, 47–82. [CrossRef]
57. Andrews, D.; Lu, B. Consistent Model and Moment Selection Procedures for GMM Estimation with application to dynamic panel data models. *J. Econom.* **2001**, *101*, 123–164. [CrossRef]
58. Dahlberg, M.; Johansson, E. Behavior of Local Governments Using GMM Bootstrapping Methods. *J. Appl. Econom.* **2000**, *15*, 401–416. [CrossRef]
59. Fernández-Portillo, A.; Almodóvar-González, M.; Sánchez-Escobedo, M.C.; Coca-Pérez, J.L. The role of innovation in the relationship between digitalisation and economic and financial performance. *Eur. Res. Manag. Bus. Econ.* **2022**, *25*, 100190. [CrossRef]
60. Khera, P.; Ng, S.; Ogawa, S.; Sahay, R. Is Digital Financial Inclusion Unlocking Growth? IMF Working Paper. 2021, p. 167. Available online: https://ssrn.com/abstract=4026364 (accessed on 23 July 2022).
61. Kohnert, D. The Impact of Digitalization on Poverty Alleviation in Africa. Munich Personal RePEc Archive (MAPRA). 2021, p. 110296. Available online: https://mpra.ub.uni-muenchen.de/110296/ (accessed on 25 July 2022).
62. Amankwah-Amoaha, J.; Khan, Z.; Wood, G.; Knight, G. COVID-19 and digitalization: The great acceleration. *J. Bus. Res.* **2021**, *136*, 602–611. [CrossRef]

63. Guo, H.; Yang, Z.; Guo, A. The digitalization and public crisis responses of small and medium enterprises: Implications from a COVID-19 survey. *Front. Bus. Res. China* **2020**, *19*, 1–25. [CrossRef]
64. Almeida, F.; Santos, J.D.; Monteiro, J.A. The Challenges and Opportunities in the Digitalization of Companies in a Post-COVID-19 World. *IEEE Eng. Manag. Rev.* **2020**, *48*, 20022139. [CrossRef]
65. Härting, R.-C.; Rösch, A.-L.; Serafino, G.; Häfner, F.; Bueechl, J. Opportunities and Barriers of Digitization in the COVID-19 Crisis for SMEs. In *Smart and Sustainable Technology for Resilient Cities and Communities. Advances in Sustainability Science and Technology*; Springer: Singapore, 2022; pp. 47–60. [CrossRef]
66. Kashav, S.; Singh, R.; Centobelli, P.; Cerchione, R. Digitization of Information Sharing to Minimize the Impact of COVID-19 in the Food Supply Chain. In *Handbook of Research on the Platform Economy and the Evolution of E-Commerce*; IGI Global: Hershey, PA, USA, 2021; pp. 251–272. [CrossRef]
67. Abidi, N.; Herradi, M.E.; Sakha, S. *Digitalization and Resilience: Firm-Level Evidence During the COVID-19 Pandemic*; IMF Working Papers; International Monetary Fund: Washington, DC, USA, 2022; p. 034. [CrossRef]
68. Döhring, B.; Hristov, A.; Maier, C.; Roeger, W.; Thum-Thysen, A. COVID-19 acceleration in digitalisation, aggregate productivity growth and the functional income distribution. *Int. Econ. Econ. Policy* **2021**, *18*, 571–604. [CrossRef]
69. Ragoussis, A.; Timmis, J. Global Transition Online. World Bank Group. Working Paper 2022. Available online: https://openknowledge.worldbank.org/handle/10986/37103 (accessed on 10 June 2022).
70. Xiang, S.; Rasool, S.; Hang, Y.; Javid, K.; Javed, T.; Artene, E.A. The Effect of COVID-19 Pandemic on Service Sector Sustainability and Growth. *Front. Psychol* **2021**, 1178. [CrossRef]
71. Chauhan, N.; Corredera, M.; Lukasik, K.; Reis, F. Post-pandemic future of work—How does digitization impact labour? *Explor. Econ.* **2021**. Available online: https://www.exploring-economics.org/en/discover/post-pandemic-future-of-work-digitization-labour/ (accessed on 10 June 2022).
72. Claeys, G.; Darvas, Z.; Demertzis, M.; Wolff, G.B. The Great COVID-19 Divergence: Managing a Sustainable and Equitable Recovery in the EU. *Intereconomics* **2021**, *56*, 211–219. [CrossRef]
73. Dannenberg, P.; Fuchs, M.; Riedler, T.; Wiedemann, C. Digital Transition by COVID-19 Pandemic? The German Food Online Retail. *J. Econ. Human Geogr.* **2020**, *111*, 543–560. [CrossRef]
74. Katz, R.; Jung, J.; Callorda, F. Can digitization mitigate the economic damage of a pandemic? Evidence from SARS. *Telecommun. Policy* **2020**, *44*, 102044. [CrossRef]
75. Chakravorti, B.; Chaturvedi, R.S.; Filipovic, C.; Brewer, G. *Digital in the Time of COVID*; The Fletcher School at Tufts University: Medford, MA, USA, 2020.
76. World Bank. *Digital Dividends—World Development Report 2016*; International Bank for Reconstruction and Development/The World Bank: Washington, DC, USA, 2016; ISBN1 978-1-4648-0671-1, ISBN2 978-1-4648-0672-8. Available online: https://books.google.com.au/books?hl=zh-CN&lr=&id=dAl-CwAAQBAJ&oi=fnd&pg=PP1&dq=10.1596/978-1-4648-0671-1.&ots=E6aPxif7cu&sig=Ouvz1fjHt79d2DrTs2eX9t6WL94&redir_esc=y#v=onepage&q=10.1596%2F978-1-4648-0671-1.&f=false (accessed on 17 July 2022).
77. Skare, M.; Soriano, D.R. How globalization is changing digital technology adoption: An international perspective. *J. Innov. Knowl.* **2021**, *6*, 222–233. [CrossRef]
78. Institute for Management Development (IMD) World Competitiveness Center. IMD World Digital Competitiveness Ranking 2021, 186p. Available online: https://www.google.com.hk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjlz42KiOT5AhUTU_UHHfB4DFwQFnoECBwQAQ&url=https%3A%2F%2Fwww.imd.org%2Fglobalassets%2Fwcc%2Fdocs%2Frelease-2021%2Fdigital_2021.pdf&usg=AOvVaw3W8RN2Qr4bg8Wkw_X4vZBY (accessed on 10 July 2022).
79. European Commission. Digital Economy and Society Index (DESI) 2022 Thematic Chapters, 2022. 88p. Available online: https://digital-strategy.ec.europa.eu/en/policies/desi (accessed on 15 July 2022).
80. European Investment Bank. Who Is Prepared for the New Digital Age? Evidence from the EIB Investment Survey, 2020. 134p, Report of the EIB Economics Department, ISBN 978-92-861-4582-7. Available online: https://www.eib.org/attachments/efs/eibis_2019_report_on_digitalisation_en.pdf (accessed on 10 August 2022). [CrossRef]
81. International Telecommunication Union. Available online: https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx (accessed on 17 March 2022).
82. Digital Economy and Society Index. Available online: https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2021 (accessed on 17 March 2022).
83. International Telecommunication Union. Available online: https://www.itu.int/en/ITU-D/Statistics/Pages/publications/mis2017/methodology.aspx (accessed on 17 March 2022).
84. The Comprehensive R Archive Network. Available online: https://CRAN.R-project.org/package=panelvar (accessed on 17 March 2022).
85. The Comprehensive R Archive Network. Available online: https://CRAN.R-project.org/package=data.table (accessed on 17 March 2022).
86. World Bankhttps. Available online: https://data.worldbank.org/indicator/SI.POV.UMIC (accessed on 17 March 2022).
87. Plotly Python Open Source Graphing Library. Available online: https://plotly.com/python/ (accessed on 17 March 2022).
88. Geopandas Pyhton Library. Available online: https://geopandas.org/en/stable/ (accessed on 17 March 2022).

89. Akerman, A.; Gaarder, I.; Mogstad, M. The Skill Complementarity of Broadband Internet. *Q. J. Econ.* **2015**, *130*, 1781–1824. [CrossRef]
90. Atasoy, H. The Effects of Broadband Internet Expansion on Labor Market Outcomes. *Macroecon. Employ* **2013**, *66*, 315–345. [CrossRef]
91. Holt, L.; Jamison, M.A. Broadband and Contributions to Economic Growth: Lessons from the U.S. Experience. *Telecommun. Policy* **2009**, *33*, 575–581. [CrossRef]
92. Ford, G.S.; Koutsky, T. Broadband and Economic Development: A Municipal Case Study from Florida. *Rev. Urban Reg. Dev. Stud.* **2005**, *17*, 177–270. [CrossRef]
93. OECD Database. Available online: https://data.oecd.org/ (accessed on 17 June 2022).
94. Batool, M.; Ghulam, H.; Hayat, M.A.; Naeem, M.Z.; Ejaz, A.; Imran, Z.A.; Spulbar, C.; Birau, R.; Gorun, T.H. How COVID-19 has shaken the sharing economy? An analysis using Google trends data. *Econ. Res. EkonomskaIstraživanja* **2020**, *34*, 2374–2386. [CrossRef]
95. Zheng, C.; Zhang, J. The impact of COVID-19 on the efficiency of microfinance institutions. *Int. Rev. Econ. Financ.* **2021**, *71*, 407–423. [CrossRef]
96. Pourmansouri, R.; Mehdiabadi, A.; Shahabi, V.; Spulbar, C.; Birau, R. An Investigation of the Link between Major Shareholders' Behavior and Corporate Governance Performance before and after the COVID-19 Pandemic: A Case Study of the Companies Listed on the Iranian Stock Market. *J. Risk Financ. Manag.* **2022**, *15*, 208. [CrossRef]
97. Ionescu, C.A.; Fülöp, M.T.; Topor, D.I.; Căpușneanu, S.; Breaz, T.O.; Stănescu, S.G.; Coman, M.D. The New Era of Business Digitization through the Implementation of 5G Technology in Romania. *Sustainability* **2021**, *13*, 13401. Available online: https://www.mdpi.com/2071-1050/13/23/13401 (accessed on 15 July 2022). [CrossRef]
98. Gupta, S.; Rhyner, J. Mindful application of digitalization for sustainable development: The Digitainability Assessment Framework. *Sustainability* **2022**, *14*, 3114. Available online: https://www.mdpi.com/2071-1050/14/5/3114 (accessed on 8 July 2022). [CrossRef]
99. Future of Education and Skills. 2030. Available online: https://www.oecd.org/education/2030-project/ (accessed on 7 July 2022).