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QUALITY MANAGEMENT IN INDUSTRY 4.0 IN THE POST-COVID-19 PERIOD FOR ECONOMIC SECURITY AND SUSTAINABLE DEVELOPMENT

Abstract*: Unexpected shock hit the world economy in February 2020 when the spread of the COVID-19 virus began worldwide. In this regard, the technology of Industry 4.0 can be an important tool for economic recovery by allowing for sustainable product change. Therefore, it is necessary to measure the global readiness of Industry 4.0 to guide policies in defining the benefits of promoting Industry 4.0 and to unlock its potential in the event of an pandemic (Javaid et al., 2020).*

In this context, the paper aims to understand the readiness and responsiveness of the various regions in terms of Industry 4.0 before the pandemic and to identify best practices to support companies acquired by Industry 4.0, with a focus on those that promote sustainable practices. The framework for pre-pandemic testing is provided based on two components: the readiness of the firms to invest in Industry 4.0 and the excellent scenario. The study shows a group of regions that are more cautious than the inequality group, especially those related to diversity in the North and South. Considering how "vigilant regions" are likely to successfully manage and overcome the post-COVID-19 problem, it provides an overview of how various regions have sought to promote the adoption of digital technology to improve resilience after a shock. Analysis shows that funding mechanisms are targeted at small and medium enterprises. In addition, tenders promoting the acquisition of Industry 4.0 indicate that collaboration between stakeholders will be critical.

Keywords: *Sustainable development; Economic security; Industry 4.0; Post-COVID-19 period; Quality management.*

1. Introduction

The global expansion of COVID-19 has become an economic and labour crisis, affecting the delivery of goods and services as well as the need for consumption and investment and the challenge of land trade. With the reduction of emergency-related emergency measures and the continued opening of manufacturing operations, the adoption of Industry 4.0 technology will help the survival of many companies. In the case of COVID-19, Industry 4.0 technology is expected to accelerate and move forward to

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sustainable development (Sozinova et al., 2021a). Above all, achieving sustainable development will be a key to economic recovery, which will need to address biodiversity loss, climate change, and the promotion of sustainable economic goals. In addition, increasing attention will be paid to the production and use of sustainable materials. In fact, awareness of environmental and social problems is increasing, as is the awareness of products that pay close attention to the impact of environmental purchases (Ovcharenko et al., 2021). Russia could be a European exhibition, as businesses are hit by the effects of the spread of coronavirus. Before COVID-19, Industry 4.0 technology was only considered to increase productivity and competitiveness, but today it has become a requirement to keep companies open. Policymakers and managers view artificial inteligence requests to reduce staff unavailability as a first response to the closure. Indeed, technology was essential during the global shutdown to ensure the continuity of business through remote operations (Popkova & Giyazov, 2021; (Sozinova et al., 2021b; Misita, 2019). However, the rapid acceleration of Industry 4.0 trends is likely to result in digital fragmentation in Russia, as the pandemic is expected to expand these segments internally and externally. In this context, the paper aims to understand whether COVID-19 will be the key to high levels of technological acceptance and act as a catalyst for sustainable production. To this end, we propose and use a framework to measure Russia's Industry 4.0 readiness before the pandemic, with a focus on a regional level, in line with the Nomenclature of Territorial Units for Statistics (NUTS) level 2 (States Member States, Level Three NUTS established by Eurostat to agreement with each member state; segregation of other levels. With Russian NUTS2, the level corresponds to its regional division). Thus, six flexible options for measuring the readiness of Russian regions to Industry 4.0:

The readiness of firms to invest in Industry 4.0 and the favourable conditions of the Industry 4.0 structure

Identifying these two dimensions allows for the identification of other appropriate styles and differences between regions not exposed to the pandemic. With this initial analysis, the youth of this paper lies in the investigation of the Italian regional response to the adoption of Industry 4.0 technology as a means of promoting sustainable development. The results show that among these variables there is the low focus on new co-operation agreements, which are expected to be very important during the economic recovery after COVID-19. In the second part of the analysis, we show how COVID-19 regenerates at high levels of digital technology acquisition by providing an overview of how Russia seeks to promote the adoption of digital technology to improve resilience and adaptation to panic while promoting sustainable practices. The findings indicate that these measures are mainly targeted at small and medium enterprises (SMEs) and that a growing number of financial measures link Industry 4.0 to sustainable development. In addition, collaboration between stakeholders has become increasingly important in supporting firms to use digital models and sustainability.

This paper is organized as follows. First, after reviewing the Industry 4.0 programs in the post-COVID-19 sections, we introduce the Russian context of Industry 4.0 before the pandemic (Sozinova, 2019; Lysova et al. 2020). Second, after defining the method used, we examine the selected variance, regional readiness in the Industry 4.0 region looks at their potential role in managing post-COVID-19 phases. Thirdly, we present the best practices adopted by regional authorities to promote better implementation of Industry 4.0. The effects of the pandemic on two phases: immediately after the outbreak (Phase 1) and after the end of the initial closure (Phase 2). Lastly, we conclude, focusing on practical implications

and on a future research agenda to exploit the connections between Industry 4.0 and sustainability (Ovcharenko et al., 2021)

Industry 4.0 Applications Promoting Sustainable Manufacturing in the COVID-19 Era

Industry 4.0 emphasizes the importance of data collection and exchange across the value chain by introducing the most efficient, independent and automated production systems. Industry 4.0 Styles can drive the introduction of sustainable models to SMEs that have a positive impact on their performance. Industry 4.0 can be defined as the integration of information and communication technology (ICT) and industry technologies. Many companies use technologies such as Cyber-Physical System (CPS), the Internet of Things (IoT), robots, Big Data, Cloud Production, and Add-ons to improve products and processes, increase efficiency and productivity, reduce costs, and increase customer satisfaction. There are many advantages firms can shoot from Industry 4.0: greater flexibility and speed from prototype to series production; increased productivity due to shorter set times, reduced errors and downtime of equipment; better quality and less waste. In addition, risks to the company can be prevented by integrating Industry 4.0 technology into security management systems. It is possible to use Industry 4.0 technology during the pandemic, according to a recent publication on the relationship between Industry 4.0 and COVID-19. Table 1 shows how Industry 4.0 can contain the effects of COVID-19 data abuse, computer power and connectivity. Rapid conversions require a re-examination of current business models. It is important to develop "digital resilience", as the key to the success of firms. SMEs can consider sharing the necessary costs of investing in technology by relying on collaborative networks, such as new access and large knowledge bases Industry 4.0 trends can drive the introduction of sustainable SME models that have a positive impact on their performance (Rodrigues et al., 2021; Dukić Mijatović, 2020).

Given these resources, we are investigating the readiness of Russian regions in relation to Industry 4.0 concepts, thinking that those who are most qualified will be able to cope better with the COVID-19 period. For these reasons, in the following sections, after introducing the context of Russian Industry 4.0 before COVID-19, we discuss the method used to assess the readiness and responsiveness of Russian regions. The current phase of global social development, including Russia, is accompanied by a shift to the sixth technology system, Industrial Development 4.0, and digital economic development. Clearly, the importance of solving the problem of Russia's transition to a new path of development; many scientific books over the past two decades have contributed to this. However, the real consequences of Russia's new government policy are controversial. Within the framework of this article, the emergence of a country's policy, its current trends and problems in the field of innovation in the Russian Federation are considered. The purpose of this study is to identify the features and prospects of the new policy of the Russian Federation. In this regard, the following tasks are set: to identify the current state of Russia's development and its strengths, to identify the strengths, weaknesses and the limitations of the new policy of the Russian Federation, and to identify potential indicators to overcome shortcomings in the new sector. Based on the findings of the study, indicators of economic development have been suggested. The conclusions reached during the study may be of interest to the research community, as well as to planning and youth issues in countries facing the challenge of meeting the requirements of development leaders, by carefully studying the benefits and opportunities of new technological change, Fourth Industrial Revolution and digital integration.

Table 1. Technologies of the Industry 4.0 and their applications in COVID-19 (Brozzi et al., 2021)

Industry 4.0 enabling Technologies	COVID-19 Applications
Advanced Manufacturing Solutions	Robots can be made and trained for repetitive tasks, ensuring social orientation. The sensor used in personnel can monitor the real-time symptoms of COVID-19. Chatbots can answer a large number of questions from the general public and customers.
Additive Manufacturing	3D printing can produce much-needed products and delicate parts that are temporarily unavailable from suppliers. Technology may contain the spread of the virus from the production of masks. 3D scanning can be used for motion capture, robotic mapping, and industrial construction.
Augmented Reality	Virtual and Augmented Reality devices close the visible distance between people who can work together and give instructions in an almost "real" place.
Industrial Internet and Cloud	Cloud-based software allows companies to store and monitor equipment performance remotely. IoT can be used in conjunction with drones used to monitor or track the origin of rash or zero patient search. After that, the IoT can be used by remote medical personnel for home-based patient care.
Cyber-security	Companies can improve cybersecurity at all levels when asset downtime is high or operations are shut down.
Big Data and Analytics	IoT-based software provides a real-time dashboard of key performance indicators to support low-cost job interviews and increased openness. Inserted details may include details of real-time and historical machine conditions, as well as customer records. Big Data can be useful in predicting the impact of a virus on a business, collecting real-time data and providing this information to management to develop a strategy for addressing the problem.

2. Literature review

In this age of technological advancement and modern industrialization, the ideas presented by the Germans promised great benefits and untapped opportunities for industrial use. The concept of Industry 4.0 is one of the most discussed topics for academic and working researchers. In this age of consumerism, manufacturing industries need to be equipped with quality products and services in order to maintain competitiveness in the consumer market. The concepts of Smart Factory, Cyber-Physical System and Internet of Things and Services offer excellent opportunities and also have quality management challenges in the manufacturing fields. Therefore, this paper presented a discussion of the opportunities and challenges in implementing Industry 4.0 for quality management resulting from a successful understanding of the Austrian manufacturing company. The findings of the latest research challenges were made on three key elements of Industry 4.0 which is a combination of horizontal, dry and final production products. The first to emerge as a key strategic plan for the German government sector in 2011, Industry 4.0 or Forth Industrial Revolution has emerged as a hot topic in the negotiations of companies, researchers and international governments. Industry 4.0 is digital sector innovation with the introduction of the Internet of Things (IoT), data integration and other high-tech products that start with a focus on the manufacturing/production sector and grow in a wide range of industries outside the industry. This industrial revolution does not have a single complete definition of the word as there are many meanings in it. The study explains this next-generation sector change consisting of four basic concepts namely

Smart Factory, CPS, IoT and IoS. The concept of a Smart Factory is where the factory uses Cyber-Physical Systems or CPS (a combination of physical and cyber technology) and integrates with various programs available that make automated technology more complex and straightforward. For Complete Io or Industry 4.0, Industrial Internet of Things (IIoT) is a sector that uses smart electronics in their product production system to enable a global or internal information network and is supported by Internet services (IoS) for example cloud computing. The purpose of the 4th phase transformation is to promote a flexible production model in terms of products and services that are digitally produced and integrated with real-time communication between all resource-related components during the production process. For example, a manufacturing company that receives custom purchases or orders through cloud services and quickly makes changes to the production line in a more expensive way to cater to different customer needs and quality needs. This will be especially true of the traditional product sales model (Quality Control in Industry 4.0, 2019)

Quality Management: Ensuring competitiveness and economic stability, manufactured or corporate products, services and process processes are essential in today's industry. The definition of quality depends on the people who define it and is available from the American Society of Quality, which is defined as "the essence of the features and characteristics of a product or service that carries its potential to meet set standards". For example, the clear concept of quality management as shown in Figure 1 is not limited to other methods such as Total Quality Management (TQM) and Zero Defects Concepts (Miller, 2018).

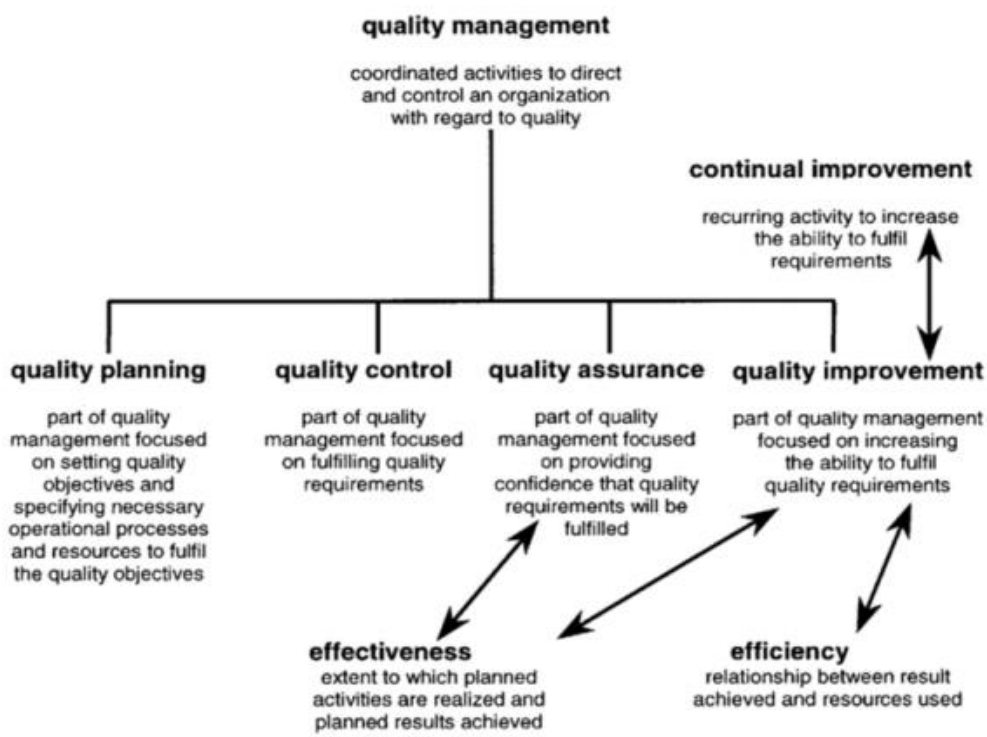

Figure 1. Quality management concepts based on ISO (Zaidin et al., 2018)

With the emergence of the Fourth Industrial Revolution, quality management has improved with the use of smart electronics connected to internal or external data networks (IIoT) that can be automatically controlled without the introduction of human intervention (IoS). This has somehow impacted good or bad quality management.

As Industry 4.0 aims to transform production systems, the impact of new technologies will be enormous. New technologies help the manufacturing industry embrace new types of business. These technologies can be supplemented with traditional quality management systems to bring new approaches to a variety of quality systems. Quality efforts include statistical control, preservation of speculation, supplier quality, and product quality to name a few. Quality improvement will improve significantly product profits and will serve as a major difference in market strategies. Profit development will make the organization more competitive in the global market. Consumers are willing to pay for high-quality products, and they are increasingly aware of quality. It has become a major concern for manufacturers as products become more complex, especially in terms of product features. Currently, 16% of companies have started any Quality 4.0 programs and 63% of companies have reported (Miller, 2018).

How to: evaluate the readiness and responsiveness of Russian regions Industry 4.0 with respect to the COVID-19 problem depends on process and quality. First, to provide a measure of the suitability of Russian regions, the existing documents were considered as the choice of the appropriate size that would reflect the readiness of the firms to adopt Industry 4.0 technology and the availability of structural features that could be unlocked by Industry 4. 0. Descriptive statistics at the national level are given the best and worst indicators. Next, with the inclusion of this Ward, various analyzes were performed to divide the districts into larger groups according to the number to be calculated last year. The integration results are comparable to the results obtained from firms using Industry 4.0 technology (Javaid et al., 2021).

As a second step, to measure the readiness of Russian regions to support the adoption of Industry 4.0 technology, we have reviewed key initiatives presented twice: immediately after the outbreak of COVID-19, identified as Phase 1 (March to May 2020) and immediately after the end of the first closure in Phase 2 (May to September 2020). This process is summarized in the Figure 2.

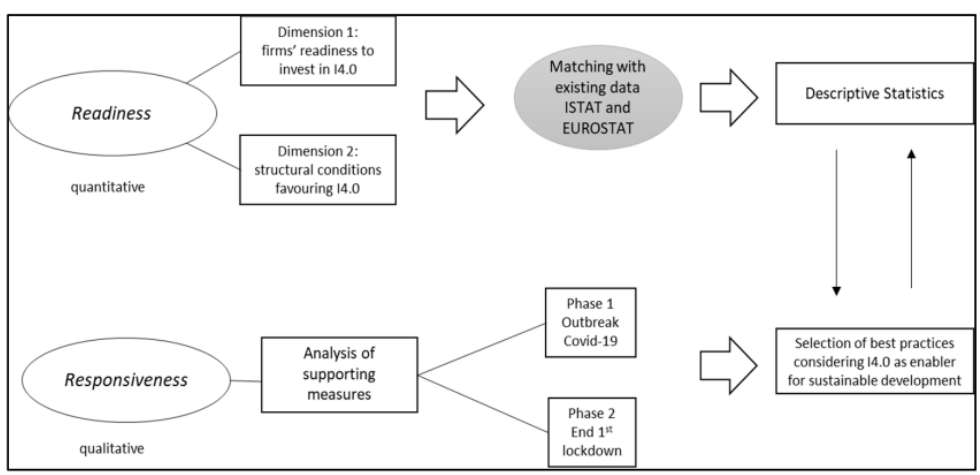

Figure 2. The process to check the responsiveness and readiness (Lepore et al., 2021)

2.1. Step 1—A Framework Assessing Industry 4.0 Readiness for the Economic Recover

Although Industry 4.0 is one of the most popular topics in the industry and education, Industry 4.0 maturity test documents remain scarce. A study by the Russian Ministry of Economic Development can be considered an attempt to assess the maturity level of Russian businesses, but the analysis cannot be considered complete, including a sample of companies. As Industry 4.0 introduces new concepts, it becomes difficult to define and measure their impact (Ngoc Thach et al., 2021). In addition, many organizations cannot monitor their growth in Industry 4.0. Two possible reasons for this gap are the difficulty of finding the exact size that defines Industry 4.0 and the lack of measurement data in those sizes. Many Industry 4.0 maturity models are built on a solid level to take a picture of the company, measuring their level of acceptance of Industry 4.0. There are nine aspects: strategy, leadership, customer, product, performance, culture, people, management, and technology, which determine the maturity of Industry 4.0 by focusing on organizational structures. A six-dimensional model: strategy and organization, smart factory, smart jobs, smart products, data-driven services, and staff found. However, without looking at digital diversity, measuring access to and distribution of ICT is complex. There is no set definition of digital development, and considerations on these topics vary between countries and organizations (Sergi, 2019).

For these reasons, we are trying to test Russia's readiness to watch Industry 4.0, a six-point index (data available at the regional level) that defines two dimensions. Industry 4.0 is expected to upgrade the existing capacity of existing firms (table 2). Firms with a high tendency for new inventions may not be ready to integrate Industry 4.0. At the heart of wisdom is the creative process. Industry 4.0 introduces new production methods where the combination of production and innovation enhances the use of digital technology. In addition, these new types of production are expected to produce a smarter and more stable product (Nabokikh et al., 2020). For firms that have registered a new product or process and the new equipment being considered, it is assumed that firms with a high level of innovation may not be ready to integrate Industry 4.0 concepts. In addition to the latest volume, affiliate networks are expected to promote the acquisition of Industry 4.0. This is especially true for horizontal integration, such as linking chain prices from suppliers to customers. Such integration should be based on a reliable infrastructure that supports collaboration between production organizations and partners who can communicate and share information in real-time. In addition, productive relationships can help meet the needs of sustainability in the sector. The cooperation of universities in the industry with public finances can lead to the introduction of new methods of sustainable production. These collaborative networks can assist SMEs, who face the challenges of accessing financial and information resources to integrate Industry 4.0 technology with ongoing practices. The need to share and integrate information and resources is in line with the priorities of the partnership. COVID-19 has already revitalized a collaborative environment, involving scientists, pharmaceutical companies, and governments to initiate programs to find an effective response to the virus. In addition, therefore, in recognizing the cooperative role of Industry 4.0 in overcoming the challenges of the pandemic, we include as a representative the existence of cooperative agreements for new firms (Popkova & Sergi, 2020).

Table 2. Indicators for Industry Readiness (Brozzi et al., 2021)

Indicator	**Dimension**
Firms with innovative activities (%)	Firms' readiness for Industry 4.0
Expenditure for innovation per worker (1,000 euro per employee)	
Firms cooperation agreements for innovation (%)	
Firms with a broadband connection (%)	Favourable Structural conditions
People with tertiary education (%)	
Employed in Science and Technology (%)	

2.2. The Responsiveness of Russia towards Industry 4.0: The Emerging Best Practices in Post-COVID

With the Budget Act 2020, before the pandemic, the Russian government has already recognized the role of digital technology, the introduction of tax breaks and funding tools as discounts for innovators. Incentives for research and development (R&D) and training are added to the regional incentives found in many areas. COVID-19 has put Italy under pressure with the unexpected growth of demand for digital services. The country has shown various levels of resilience. Areas with rapid broadband and corporate and social management that have invested digitally in the past have found themselves equipped to deal with this situation. On the other hand, areas that do not have adequate coverage by businesses and managers outside of an integrated digital culture are suddenly taken over (Popkova & Sergi, 2020)

At the national level, new measures are included in the Industry 4.0 "Transitioned 4.0" program to support firms in the post-COVID-19 phases. This strategy introduces financial mechanisms that directly address the development and testing of new sustainable solutions. In the following phases, measures introduced by Italian regions to support Industry 4.0 adoption among firms are reported twice: immediately after the outbreak, identified as Phase 1 (March to May 2020) and after the end of Phase 2 (May to September 2020) (Cheglakova et al., 2020)

Initial Steps to Support Post-Outbreak Outbreaks

The initial steps adopted by district managers can be divided into three categories including those that are most closely related to remote operation, those aimed at Industry 4.0, and those that promote the implementation of the Industry 4.0 system. At these stages, the link between Industry 4.0 and sustainable production is found in selected tenders and financial incentives that promote the adoption of Industry 4.0 technology to enable sustainable products and processes. The first phase includes funding mechanisms related to the training and procurement of digital tools that allow firms to switch to remote operations. This is the case with the issuance of a training certificate assisting in public administration management (PA) and remote firms. The package, which was already used by PA as part of a previous regional project, aims to increase productivity and flexibility in PA. Instead, digital discounts have been introduced for employers with at least three employees to purchase technology equipment or request consultation with remote employees. Financial instruments, targeted at SMEs and large enterprises, include investments in tangible and intangible assets. If you look at the second phase which aims to support the broader adoption of Industry 4.0, allocating resources to purchase digital micro and SME digital technologies as non-performing loans. Similarly, to encourage the implementation of Industry 4.0 microtechnology and SMEs, the tender introduces emergency management tools or develops green

systems. The tender includes a change in production plans concerning new measures of social deviation and long-term performance (Chiarini, 2020).

Second Analysis after Lockdown

The second analysis looks at the efforts proposed by the regions after the closure. Financial support especially for small businesses and SMEs, who had been fighting for Industry 4.0 before the pandemic. Efforts are found mostly in the Northern regions identified in the team of the best performers. The technology incorporates solutions for making voluntary production and marketing programs, preferring social segregation. In addition, there are incentives for broadband connection and remote operation. Accordingly, the government has provided free subsidies to small firms, SMEs, firms, and manufacturing industries as well as those in the tourism, commerce, cultural and higher education sectors. The measure looks at investment to ensure safety and job planning away from non-shooting companies. With regard to the tourism sector, the tender emphasizes that the use of digital can be a solution to the major problems that have plagued the industry since the pandemic. Indeed, due to tourism restrictions, the pandemic has had a major impact on tourist planning while highlighting the importance of digital marketing strategies. In addition, the pandemic has undermined the role of tourism, which has been described as a guide to environmental impact. The tender can add a lot of points if the firm has certificates that guarantee product sustainability and good behaviour as well as procedures. They look at construction conditions, focusing on ensuring greater communication with mountain firms with discounts. In addition, the region has received a long list of new tenders and industrial research due to delays in focusing on COVID-19 and focusing on Industry 4.0 skills development (Diesing, 2021).

3. Discussions

3.1. Accelerating Industry 4.0 and Sustainable Trends through Collaborative Networks

In addition to the COVID-19 pandemic, the development of Industry 4.0 will stimulate the development of critical sectors in the Russian economy, thereby ensuring its potential for consumer goods and their health while achieving better working conditions and higher productivity. Analysis of the Russian Industry 4.0 system in the post-COVID-19 stages shows that sustainability has been a measure of the availability of financial resources that address the readiness of “firms to invest in Industry 4.0”. Such methods are most evident in the second phase of the analysis, after closure and in the northern part of the country corresponding to the most efficient group. The new production models found in the introduction of Industry 4.0 technology promote intelligent and sustainable production. In addition, funding mechanisms target small businesses and SMEs, which face many challenges in adopting both digital technologies and sustainable models. The collaborative approach of DIHs and CCs is expected to play a key role in unlocking Industry 4.0's ability to produce sustainable products. The DIH network provided response tools to support firms, especially SMEs, in their digital transformation by organizing dynamic courses (Sergi, 2019).

4. Conclusion

This paper shows that Russia with varying degrees of maturity and readiness of Industry 4.0 to support the adoption of digital technology in companies during the post-COVID-19 phases with a growing interest in sustainable production. The study analyzes and discusses the current and potential role of Industry 4.0 in companies, focusing on their impact on the industrial and social sectors. In this study, we look at the

differences in testing the readiness to go to Industry 4.0 in Russia, where Industry 4.0 will help revitalize the COVID-19 disaster economy. The Industry 4.0 rating is difficult without a closed time definition and does not have measurement data, especially with location accuracy. Although these conditions present significant limitations, there is sufficient evidence to make an initial decision on the readiness of countries to adopt Industry 4.0. Using the 2014 and 2016 data available, we look at variables that should measure the readiness of "firms to invest in Industry 4.0" and the availability of "good structural conditions" in terms of their role in the recovery phase. The sample shows a group of the best performing regions in the North associated with those who record the highest percentage of Industry 4.0 firms. This can be linked to the goals of Southern companies to increase their readiness to Industry 4.0 through major cooperation agreements, which will form the basis for pandemic management in the Industry 4.0 vision. The research relied on comparing the readiness of Russian regions in terms of their response to firms that support digital transformation and sustainability. Analyzing the support mechanisms introduced by the regions after the outbreak (Phase 1) focuses on services that promote the remote operation, especially small businesses and SMEs in the North and South of the country. Usually, after the end of the closure (Phase 2), the Northern regions focused on the adoption of Industry 4.0 technology through collaborative networks. In a collaborative environment, financial benefits are expected to invest in Industry 4.0 technology that supports ongoing practices. A proposed variation on the Industry 4.0 Readiness Test to guide the first phase of using descriptive regional policy tools, to design and develop specific programs at the local level, to address major COVID-19 challenges at the industry level. Targeted investments in digital technology will allow an increase in professionals who will be able to work remotely. Given the low levels of higher education and S&T staff, policies should improve Industry 4.0 training to create a local environment for highly skilled people. Regional programs and programs identified during the pandemic to promote the use of digital technology can increase factory openness and lead to sustainable development (What is the future for Industry 4.0 in the post-COVID-19 paradigm? 2020).

The framework can provide regional policies with guidelines on how to support the new production process and define technical and manufacturing areas with a focus on regional service interventions and services. In terms of tangible impacts, managers should accelerate the digital transformation of their firms using on the one hand the opportunity of financial resources on the other hand the consulting, training and communication function of the emerging Industry 4.0 network. This means that the Industry 4.0 ecosystem needs to map out the needs of these companies in order to provide appropriate support, which must be in line with industry and regional performance standards. Above all, the emerging environmental system of Industry 4.0 can support the positive role of Industry 4.0 in promoting productive processes and sustainable use. The future line of research will be to determine the effectiveness of the measures to promote intelligent and sustainable production and to ensure that the top regions in Russia in the adoption of the Industry 4.0 paradigm have shown significant post-disaster resilience and limited development. In addition, I may be interested in future studies to mark and compare supporting measures submitted by various regions in Europe and compare their level of readiness and response (Sergi, 2019).

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