LIMEN 2021 – Selected Papers
https://doi.org/10.31410/LIMEN.S.P.2021.1

Significance of Innovations in the Time of Crisis – The Impact of COVID-19 Pandemic on Innovation Activities

Ivana Janjić[1]
Milica Đokić[2]

Received: January 12, 2022
Accepted: February 15, 2022
Published: May 5, 2022

Keywords:
Innovations;
Economic crisis;
COVID-19 pandemic;
Global Innovation Index;
Research and development

Abstract: *The outbreak of the coronavirus pandemic in 2020 is unquestionably one of the greatest challenges the world has ever faced. Aside from the terrible repercussions for human health, the current situation with COVID-19 pandemic has impacted all economies across the globe. Based on scientific literature, publicly available data and analytical reports, this paper will try to identify the changes in innovations potential of certain countries caused by the current pandemic. Observing the indicators of the Global Innovation Index (GII), comparative analysis will show how much has the pandemic affected the innovation capacity of the chosen countries and indicate the differences among them. Furthermore, the paper aims to research and to perceive the importance of undertaking innovations and R&D activities in crises such as the spread of coronavirus.*

1. INTRODUCTION

Despite the fact that the 21st-century world had been already changing fast and it had become clear that only those who had been continuously adapting and improving can succeed, the COVID-19 pandemic emphasized, even more, the necessity of being able to adjust to new conditions fast enough. It started as a health threat and continued to grow into a serious crisis, economic and social, disturbing every aspect of peoples' lives. The global economy slowed down, international relations were on the test, many sectors of the economy were collapsing and organizations were fighting for their survival. Overcoming difficulties often required the introduction of new methods, implementation of different approaches and creation of some original solutions. To survive, many companies have found ways to transform the ongoing crisis into an opportunity for success. COVID-19 has caused many enterprises to become innovation-oriented, forcing entrepreneurs to innovate and emphasizing innovation as an effective approach for overcoming the negative consequences of the pandemic (Van Auken et al., 2021). Government support regarding financial aid, adequate infrastructure and policy measures that encourage acquiring new knowledge and technology development had an important role in improving organizations' performance and capability to innovate.

2. INNOVATION AS RESPONSE TO THE CRISIS

The evidence from previous economic crisis shows that enterprises which are able to maintain their innovation activities gain an advantage over those that are not, and are capable to recover faster. Firms that did not invest and conduct any innovation process experienced the largest losses (Spescha & Woerter, 2019). Those who continued to be innovative and to support their research and development (R&D) projects, adapted more easily, improving their resilience and sustaining competitiveness (Flammer & Ioannou, 2015). The previous researches also

[1] Innovation center, University of Niš; Serbia
[2] Innovation center, University of Niš; Serbia

implied that enterprises which undertook R&D-based innovations, usually more radical than non-R&D-innovations, were more isolated from the external economic shocks and achieved more stable growth development than non-R&D innovators (Laursen & Salter, 2006). Furthermore, small and medium enterprises (SMEs) which invest in R&D and innovations have increased their chances for survival during a recession (Jung, Hwang & Kim, 2018).

However, the ongoing COVID-19 crisis has differed in many ways from the previous economic crises. Closure of state borders, lockdowns and quarantines have never been seen before in modern times and therefore organizations have had to find different approaches to solve the existing problems. Common product or process innovation usually has not been good enough to face the unprecedented circumstances the whole world has been in. Enterprises have been forced to find new ways of implementing innovations into their business and decide what type of innovation is necessary for survival and fast recovery during the pandemic. Not only that strategic competitive innovation has turned out to be the main source of financial success during the crisis, but the type of innovation has had a significant impact as well (El Chaarani et al., 2021). The research of El Chaarani et al. (2021) showed that marketing and process innovations have had a considerable and positive effect on firms' financial results, while the product or organizational innovations have had no impact on financial performance. Hence, the results suggest that enterprises should adopt new process practices based on cost reduction and quality improvement, and develop new marketing strategies which would enable them to build a loyal relationship with customers and enter new markets. The study of Chinese enterprises' response to the COVID-19 crisis supported these claims showing that in almost all industries firms "have explored possible options of marketing innovation strategies to different degrees and in different forms" (Wang et al., 2020, pp.215). Not only that companies were compelled to create new ways of responding to the crisis, but they had to do it as fast as possible. Innovation processes that would otherwise take years now were forced by the unexpected health crisis to move rapidly, achieving radical shifts in technology in days (Brem, Viardot & Nylund, 2021). Besides that, firms and organizations from completely different industries were ready to unite in order to help society to overcome the crisis, which provided new ideas for innovation. The results of recent studies suggest that the pandemic has served "as an effective catalyst for service innovations" as well, pressuring organizations to go beyond usual strategies and testing their dynamic capabilities (Heinonen & Strandvik, 2021). The main difference between service innovations during the COVID-19 crisis and pre-crisis period is that now the great emphasis has been placed on the relevance, regarding created value for customers, rather than on originality and newness.

3. AN OVERVIEW OF SELECTED GLOBAL INNOVATION INDEX (GII) SUB-INDICATORS BEFORE AND DURING THE PANDEMIC

While the COVID-19 pandemic had an overall negative impact on the global economy, it has a mixed impact on the innovation system, with certain industries experiencing growth or contraction in R&D spending. The Global Innovation Index (GII) assigns a ranking to world economies based on their ability to innovate, which consists of about 80 indicators categorized into innovation inputs and outputs. Sub-indicators of innovations show factors that significantly affect the innovation level of these countries' economies.

Research and development (R&D) – R&D refers to the actions that companies engage in order to innovate and create new products and services. R&D investments foster innovation and creativity, leading to the development of new technologies, knowledge, concepts, ideas, and expertise, which increases the country's innovative capacity. It is vital to have the competence

of R&D for an effective innovation process since R&D precedes innovation as a preliminary phase. Innovations are the outcome of a company's proactive R&D.

Gross expenditure on R&D, % of GDP – The proportion of gross domestic product (GDP) committed to research and development, also known as R&D intensity, is shown by gross domestic spending on R&D. R&D expenditure as a percentage of GDP is an indicator that may be used to assess the relative level of investment in creating new knowledge. One of the key preconditions for further development of scientific-research potential, creation and commercialization of innovations, is increasing allocation for R&D.

Innovation linkages – Effective innovation links allow companies to expand their base of ideas and technology and are crucial to locate complementary knowledge and competencies to overcome hurdles like limited finance and a lack of managerial resources and technological competencies. Nowadays, innovation linkages increasingly rely on the integration of diverse technologies and the combination of various types of knowledge and skills. Furthermore, innovative companies are facing increased rivalry, a faster rate of invention and a shorter life cycle, all of which drive them to seek faster ways to develop.

University-industry R&D collaboration – The ability of a university to assist industry innovations, inventions and consulting has become a major factor of innovation capacity and prosperity in many countries. University-industry R&D collaboration is increasingly seen as a tool for enhancing innovation through knowledge exchange (Ankrah & AL-Tabbaa, 2015). To increase research productivity and encourage the transfer of university research findings, state governments have to implement some administrative policies and initiatives.

Knowledge creation – The constant combination, transfer, and conversion of various types of knowledge is referred to as knowledge creation. As a result of knowledge creation, new knowledge is disseminated, assimilated and integrated into new goods, services, and systems (Phan & Peridis, 2000). Knowledge is widely recognized as a critical component of all types of innovation (Tekic et al. 2013). The unique outputs of knowledge creation are also known as innovations (Škudiene et al. 2021).

Patents by origin – Patents can be obtained by introducing and controlling R&D operations, acquiring a competitive advantage, and establishing a foothold in the marketplace. A patent is an exclusive right awarded for an invention, which is a product or a technique that offers a new technical solution to a problem or provides a new way of doing something in general. In order to obtain a patent, technical details about the invention must be given to the public in the form of a patent application. Patents by origin are determined on the basis of a patent application, which includes the residence of the first-named inventor.

Scientific and technical articles –The number of published scientific and technical articles, as well as their citations, show that quantitative and qualitative scientific outcomes can contribute to the formation and strengthening of scientific research and innovation capacity. The goal of the scientific and technical articles is to disseminate information about new research findings that are based upon relevant, strong and understandable proofs of their validity (Marušić & Marušić, 2009).

The impact of COVID-19 on the countries' innovativeness can be assessed by comparing the score and rank of mentioned sub-indicators. In order to determine how much this global crisis

has affected the innovation systems of some countries, the analysis includes data before the pandemic as well. Table 1 shows ranks and scores of GII and some sub-indices of innovations for the US, China, Japan, and India.

Table 1. Comparative overview of some innovation parameters on the global level, 2017-2020

GII	R&D	Gross expenditure on R&D, % GDP	Innovation linkages	University-industry R&D collaboration	Knowledge creation	Patents by origin	Scientific and technical articles
US (score/rank)							
2017	78.9/4	2.7/10	48.8/16	78.4/1	65.0/6	15.9/6	11.5/43
2018	77.9/3	2.8/9	54.3/9	80.9/1	72.3/3	15.1/6	10.5/44
2019	77.1/2	2.8/9	60.6/8	75.7/4	72.8/3	13.8/1	10.7/48
2020	78.3/2	3.1/8	59.9/5	74.4/3	79.9/3	13.3/1	18.9/46
China (score/rank)							
2017	59.1/17	2.1/14	30.7/58	56.5/27	69.1/4	65.6/1	11.7/42
2018	58.8/17	2.1/15	27.2/58	56.5/27	68.1/4	53.7/1	11.9/42
2019	58.8/16	2.2/13	24.5/48	56.5/29	70.4/4	55.1/1	13.8/39
2020	59/14	2.2/14	31.3/32	70.5/6	70.5/4	53.2/1	21.3/42
Japan (score/rank)							
2017	77.3/5	3.1/5	45.7/20	62.3/22	54.9/11	49.7/1	9.8/52
2018	76.3/5	3.2/5	50.2/12	64.5/18	56.1/11	47.8/1	9.2/53
2019	74.9/5	3.3/5	47.7/17	62.4/20	57.2/11	45.3/1	9.7/53
2020	74.3/4	3.2/4	46.4/18	60.1/22	58.3/11	45.0/1	16.8/50
India (score/rank)							
2017	34.3/32	0.6/52	37.4/41	57.2/25	15.6/55	1.5/55	5.6/73
2018	34.2/35	0.6/50	33.6/41	60.1/23	20.9/42	1.6/52	5.3/77
2019	32.9/35	0.6/57	26.6/41	47.7/45	19.8/51	1.6/51	5.8/76
2020	32.51/35	0.7/52	24.1/50	42.7/65	21.0/51	2.0/36	10.3/84

Source: Authors, based on the Global Innovation Index Report (2018, 2019, 2020, 2021)

In the field of R&D, the best-positioned country within the group throughout this observed time was the US (2nd place in 2020 and 2019) and Japan (4th place in 2020 and 5th place in 2019, 2018 and 2017), whereas India was the worst-ranked country. Analysis of data presented in Table 1, leads to the conclusion that Japan is the biggest spender on R&D and the best ranked according to the gross expenditure on R&D (3.2% of GDP in 2020 and 3.3% of GDP in 2019), followed by US (3.1% of GDP in 2020 and 2.8% of GDP in 2019) and China (2.2% of GDP in 2020 and 2019). The R&D expenses below 1% of GDP were recorded in India. According to the GII, the US is the best-ranked country within the innovation linkages (59.9 and 5th place in 2020, 60.6 and 8th place in 2019 and 54.3 and 9th place in 2018). During these four years, high score and rank in this category has been achieved also by Japan (46.4 and 18th place in 2020, 47.7 and 17th place in 2019, 50.2 and 12th place in 2018), while China and India had an unfavorable ranking and score. An overview of university-industry collaboration points that the US was the best among the other countries in the mentioned group, with a GII of 89.9 and at 1st place in 2018. Based on a comparison of the score and rank within knowledge creation, India was the lowest-ranked country in 2017, 2019, and 2020, followed by Japan. The US (3rd position in 2018, 2019 and 2020) and China (4th place during all observed years) were the highest-ranking countries of the observed group in terms of this indicator, while Japan and India recorded lower rank. In the domain of patents by origin, the US had the leading positions in 2019 and 2020 (13.8 and 13.3 the 1st place) as well as China and Japan in all regarded periods. Towards scientific and technical articles, it could be noted that all the countries had an unfavorable ranking throughout the observed period.

To evaluate the achievements of some European countries, scores and ranks are presented in Table 2. The findings show that the economy of Switzerland, according to the World Intellectual Property Organization (WIPO), was the best ranked in the domain of the R&D during the observed years (2nd place in 2017, 4th place in 2018 and 2019 and 3rd place in 2020), followed by second-ranked Sweden and the third-ranked United Kingdom. Sweden and Switzerland hold first and second place when it comes to the gross expenditure on R&D. Of the above-mentioned top 4 European countries, Sweden has the highest rankings in terms of innovation linkages (4th place in 2017 and 2nd place in the other three years). Concerning university-industry collaboration, Switzerland is the first, and the Netherlands and Sweden are the second and third countries in Europe. During the whole period, Switzerland also dominated in knowledge creation and patents by origin. Furthermore, Switzerland has been top-ranked in Europe considering scientific and technical articles, followed by Sweden.

Table 2. Comparative overview of some innovation performances in Europe, 2017-2020

GII	R&D	Gross expenditure on R&D, % GDP	Innovation linkages	University-industry collaboration	Knowledge creation	Patents by origin	Scientific and technical articles
Switzerland							
2017	80.2/2	3.4/3	57.9/3	79.5/1	89.9/1	17.4/5	38.0/2
2018	77.9/4	3.4/4	63.0/3	79.1/3	84.7/1	16.5/5	34.1/3
2019	76.6/4	3.3/4	66.2/5	77.5/2	87.9/1	16.7/1	35.8/3
2020	75.8/3	3.2/6	63.9/4	77.1/2	86.6/1	15.6/1	56.6/3
Sweden							
2017	77.0/6	3.3/4	56.8/4	70.7/10	75.9/2	11.2/9	32,1/7
2018	75.3/6	3.4/3	66.1/2	71.8/9	73.5/2	11.3/10	30.2/7
2019	74.0/6	3.3/3	76.2/2	71.0/7	76.0/2	10.7/9	31.9/8
2020	74.1/5	3.4/3	70.3/2	67.1/11	78.4/2	10.8/8	54.4/5
United Kingdom							
2017	68.8/11	1.7/20	50.8/10	73.1/6	58.0/9	6.8/17	25.3/16
2018	67.8/9	1.7/22	50.1/13	73.7/7	66.9/5	6.4/16	23.8/16
2019	67.6/9	1.7/21	51.0/14	69.0/11	66.2/6	6.1/15	25.2/15
2020	67.7/9	1.8/21	47.0/17	63.7/16	65.0/8	5.6/16	43.7/13
Netherlands							
2017	65.8/12	2.0/17	54.4/6	76.1/5	64.3/7	10.5/10	22.8/21
2018	64.4/12	2.0/17	59.0/5	75.5/4	65.0/7	10.0/12	20.8/21
2019	65.3/11	2.2/14	62.6/7	74.4/5	65.7/8	9.5/10	22.3/22
2020	64.0/11	2.2/15	54.8/10	72.4/5	67.7/6	8.9/11	41.3/16

Source: Authors, based on the Global Innovation Index Report (2018, 2019, 2020, 2021)

4. R&D INVESTMENT AS DETERMINANT OF SUCCESSFUL SURVIVAL AND RECOVERY FROM THE COVID-19 CRISIS

According to the latest Eurostat data, on average around 2.3% of GDP was spent in the EU on research and development during 2020, which represents a slight increase of 0.1% compared to 2019 (2.2%). However, that increase could lead to a misconception since it is a consequence of the GDP reduction caused by the COVID-19 crisis. Analysis of the amount of money spent on R&D in the EU clearly shows that in 2020 EU member states spent 1 billion less than the year before, 311 billion € compared to 312 billion in 2019. Belgium and Sweden were the countries with the highest R&D intensity (3.5%). Austria, Germany, Denmark, Finland and France followed, all with the R&D expenditure above the EU average. The rest of the member states recorded lower

levels, whereas six of them were below 1%, with Romania being at the very end of the scale (0.5%) and Malta and Latvia at a somewhat better position with 0.7% of R&D intensity (Eurostat, 2021). The largest part of R&D expenditure was spent in the business enterprise sector (66%), even as triple as in the higher education sector (22%). The government sector spent around 11% of total R&D funds and the private non-profit sector about 1%. The data concerning government budget allocations for R&D (GBARD) indicates that the pandemic has urged countries to decrease their funds for R&D activities. The share of GBARD in total general government expenditure in the EU area has declined to 1.42% in 2020 from 1.46% in 2019. However, the total government budget allocations for R&D (GBARD) across the EU in 2020 amounted to 100 786 million €, recording a rise compared to previous years (Eurostat, 2021). Switzerland, Sweden and the Netherlands have emphasized the most a need for university-industry R&D collaboration, in order to battle the COVID-19 pandemic and commercialize research fast.

Although still incomplete, data published by the Organization for Economic Cooperation and Development (OECD) provides estimations that government budgets for R&D in the OECD countries have increased in real terms by 6.2% in 2020 (OECD, 2021). Even though the R&D budgets have grown over the years, this rise was significantly higher than the one recorded in 2019 (3.2%), almost certainly as a result of additional funds distributed for R&D activities in the health sector, particularly for those related to the COVID-19 vaccine development and medical treatments. Based on the preliminary data, the OECD (2021) evaluation of R&D investments made by companies suggests that business R&D expense continued its growth in 2020, but at a noticeably reduced rate and with considerable variation across industries. Namely, the average R&D expense growth in selected companies in 2019 was 9.7%, whereas in 2020 it was around 6.2%. The software, computer services, technology hardware and electronic equipment sector recorded the biggest increase in R&D investment. The pharmaceuticals and biotechnology industry experienced significant growth of R&D funds as well, mainly directed towards projects and research related to COVID-19. On the other hand, industries like automotive, aerospace and defense were the most affected by the pandemic, suffering the biggest R&D investment fall. As stated in the report, the analysis of the selected group of companies also indicated an increase in R&D intensity across all industries, considering that companies' R&D investment grew faster, or fell less, than the revenue in 2020.

In 2020, companies in the US and China increased their overall R&D investments by 9.1% and 18.1%, respectively (Grassano et al., 2021). During the coronavirus crisis, US and Chinese corporations increased their R&D share in specific sectors, such as health (US – 17.9%, China – 30.7%), ICT services (US – 2.4%, China – 21.2%) and ICT manufacturers (US – 12.4%, China – 21.2%) (Grassano et al., 2021). In 2020, patent applications increased and this trend is projected to continue. According to the report of World Intellectual Property Indicators (WIPO, 2021), the companies based in the United States have filled up the most patent applications abroad, followed by applicants from Japan and China.

5. CONCLUSION

The sudden and unexpected crisis caused by the pandemic forced everyone – individuals, societies, organizations and governments across the globe to accept new circumstances and behave according to them. Therefore, changes and innovations have become inevitable and much needed. Despite the crisis, governments across the world have tried to devote as much financial resources as possible to R&D in the last two years. Although the pandemic has caused negative

consequences and severe losses, effects on innovation activities have been mixed, and mostly positive in many areas. The ongoing crisis highlighted the critical importance of the system of cooperative knowledge creation, technology development and creative solutions as a response to COVID-19 challenges. Investments in innovations surged in areas connected with COVID-19 containment, such as medicine and biotechnology, information and communication technology (ICT), ICT hardware and electrical equipment, according to the GII 2021. On the other hand, corporations in the transportation and travel sectors, whose business models were entirely thrown off by the pandemic, tended to reduce their R&D spending. The digital transformation has been expedited during COVID-19 and many companies transferred their activities online, linking users to markets, suppliers and resources. There is no doubt that this "new normality" created the necessity of new approaches, methods or products which pushed innovations forward, more and faster than ever before.

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