

**Megatrend university Belgrade**

**Faculty of Management Zaječar**



## **THEMATIC PROCEEDINGS**

# **THE IMPACT OF THE COVID 19 PANDEMIC ON ECONOMY, RESOURCES AND SUSTAINABLE DEVELOPMENT**

**Edited by:  
dr Bojan Đorđević**

**Zaječar, 2022**

## **The Impact of the Covid 19 Pandemic on Economy, Resources and Sustainable Development**

**Publisher:** Faculty of Management Zaječar, Megatrend university Belgrade

**For publisher:** Nebojša Simeonović

**Editor:** Bojan Đorđević

**Technical editor:** Dragan Jelenković

**Printed by:** Tercija, Bor

**Copies:** 30

**ISBN 978-86-7747-644-1**

**CIP** - Cataloging in publication  
National Library of Serbia

616.98:578.834]:33(082)

### **INTERNATIONAL Symposium on Natural Resources Management (11 ; 2021 ; Zaječar)**

The impact of the covid 19 pandemic on economy, resources and sustainable development : thematic proceedings / 11th International Symposium on Natural Resources Management ; [organizer] Megatrend University, Faculty of Management Zajecar ; edited by Bojan Đorđević. - Belgrade : Megatrend university, Faculty of Management Zaječar, 2022 (Bor : Tercija). - 258 str. : graf. prikazi, tabele ; 29 cm.

Tiraž 30. - Str. 7: Foreword / editor. - Bibliografija uz svaki rad.

ISBN 978-86-7747-644-1

a) Корона вирус -- Економски аспект – Зборници.

COBISS.SR-ID 57195273

**Copyright:** ©2021 Faculty of Management Zaječar. **The publisher reserves all rights. Reproduction of any part or all of this publication is not permitted!**



**11<sup>th</sup> INTERNATIONAL SYMPOSIUM ON NATURAL  
RESOURCES MANAGEMENT IS FINANCIALLY  
SUPPORTED BY THE MINISTRY OF EDUCATION,  
SCIENCE AND TECHNOLOGICAL DEVELOPMENT OF THE  
REPUBLIC OF SERBIA**

## INTERNATIONAL SCIENTIFIC COMMITTEE

- Sung Jo Park, Free University, Berlin, Germany  
Jean Jacques Chanaron, Grenoble Ecole de Management, France  
Radomir A. Mihajlović, New York Institute of Technology, USA  
Shekhovtsova Lada, Faculty of Economics, University of Novosibirsk, Russia  
Yuriy Skolubovich, Faculty of Economics, University of Novosibirsk, Russia  
Lisa Fröhlich, CBS Cologne Business School GmbH, European University of Applied Sciences, Köln, Germany  
Julia Maintz, CBS Cologne Business School GmbH, European University of Applied Sciences, Köln, Germany  
Dominique Jolly, CERAM, Sophia Antipolis, Nice, France  
Antonello Garzoni, Università LUM "Jean Monnet", Bari, Italy  
Antonio Salvi, Università LUM "Jean Monnet", Bari, Italy  
Angeloantonio Russo, Università LUM "Jean Monnet", Bari, Italy  
Candida Bussoli, Università LUM "Jean Monnet", Bari, Italy  
Ljuben Ivanov Totev, "St. Ivan Rilski" University of Mining and Geology, Sofia, Bulgaria  
Vencislav Ivanov, "St. Ivan Rilski" University of Mining and Geology, Sofia, Bulgaria  
Georgi Nikolov, University of World Economy, Sofia, Bulgaria  
Srećko Devjak, MLC Management and Law College Ljubljana, Slovenia  
Žarko Lazarević, Institute for Contemporary History, Ljubljana, Slovenia  
Nikolae Georgesku, Alma Mater University of Sibiu, Romania  
Mihai Botu, University of Craiova, Department of Horticulture & Food Science, Craiova, Romania  
Violeta Nour, University of Craiova, Department of Horticulture & Food Science, Craiova, Romania  
Maria Popa, Faculty of Economic Sciences, "1 December 1918" University in Alba Iulia, Romania  
Gavrila - Paven Ionela, Faculty of Economic Sciences, "1 December 1918" University in Alba Iulia, Romania  
Pastiu Carmen, Faculty of Economic Sciences, "1 December 1918" University in Alba Iulia, Romania  
Jan Polcyn, Economics Institute of Stanislaw Staszic University of Applied Sciences in Pila, Poland  
Bazyli Czyzewski, Economics Institute of Stanislaw Staszic University of Applied Sciences in Pila, Poland  
Sebastian Stepień, Economics Institute of Stanislaw Staszic University of Applied Sciences in Pila, Poland  
Sotirios Theofanis, City College, University of New York, Europe Campus, Thessaloniki, Greece  
Stavros Lalas, Department of Food Technology Technological Educational Institute of Thessaly, Karditsa, Greece  
Nadežda Čalić, Faculty of Mining Prijedor, Banja Luka University, Bosnia and Herzegovina  
Milinko Ranilović, International University of Travnik, Bosnia and Herzegovina  
Marija Janković, Faculty of Business Studies, Mediterranean University, Podgorica, Montenegro  
Mića Jovanović, Megatrend University Belgrade

Milivoje Pavlović, Megatrend University Belgrade  
Dragan Nikodijević, Megatrend University Belgrade  
Tatjana Cvetkovski, Faculty of Business Studies, Megatrend University Belgrade  
Vladimir Živanović, Faculty of Business Studies, Megatrend University Belgrade  
Jelena Vitomir, Faculty of Business Studies, Megatrend University Belgrade  
Dragan Ž. Đurđević, Megatrend University Belgrade  
Milan Milanović, Faculty of Law, Megatrend University Belgrade  
Vesna Baltezarević, Faculty of Law, Megatrend University Belgrade  
Radan Ilić, Faculty of Law, Megatrend University Belgrade  
Gorica Cvijanović, Faculty of Biofarming, Bačka Topola, Megatrend University  
Belgrade  
Gordana Dozet, Faculty of Biofarming, Bačka Topola, Megatrend University Belgrade  
Jelena Bošković, Faculty of Economics and Engineering Management Novi Sad,  
University Business Academy in Novi Sad  
Radmilo Pešić, Faculty of Agriculture, University of Belgrade  
Petar Veselinović, Faculty of Economics, University of Kragujevac  
Svetislav Milenković, Faculty of Economics, University of Kragujevac  
Drago Cvijanović, Faculty of Hotel Management and Tourism in Vrnjačka Banja,  
University of Kragujevac  
Dejan Sekulić, Faculty of Hotel Management and Tourism in Vrnjačka Banja,  
University of Kragujevac  
Miljan Leković, Faculty of Hotel Management and Tourism in Vrnjačka Banja,  
University of Kragujevac  
Marija Lakićević, Faculty of Hotel Management and Tourism in Vrnjačka Banja,  
University of Kragujevac  
Vojin Đukić, Institute of Field and Vegetable Crops, Novi Sad  
Ljubiša Papić, DQM, Research center Prijedor, Čačak  
Slavica Miletić, Mining and Metallurgy Institute, Bor  
Dragan Kostić, Contracting Chamber of Economy Pirot District  
Vladan Jeremić, RARIS - Regional Development Agency Eastern Serbia, Zaječar  
Zoran Milovanović, RARIS - Regional Development Agency Eastern Serbia, Zaječar  
Bojan Đorđević, Faculty of Management Zaječar, Megatrend University Belgrade  
Silvana Ilić, Faculty of Management Zaječar, Megatrend University Belgrade  
Maja Andrijašević, Faculty of Management Zaječar, Megatrend University Belgrade  
Momčilo Manić, Faculty of Management Zaječar, Megatrend University Belgrade  
Miroslava Marić, Faculty of Management Zaječar, Megatrend University Belgrade  
Violeta Jovanović, Faculty of Management Zaječar, Megatrend University Belgrade  
Biljana Ilić, Faculty of Management Zaječar, Megatrend University Belgrade  
Dragica Stojanović, Faculty of Management Zaječar, Megatrend University Belgrade  
Milica Paunović, Faculty of Management Zaječar, Megatrend University Belgrade  
Anđelija Radonjić, Faculty of Management Zaječar, Megatrend University Belgrade  
Leposava Jovanović, Faculty of Management Zaječar, Megatrend University Belgrade  
Ivan Pajović, Faculty of Management Zaječar, Megatrend University Belgrade



## ORGANIZING COMMITTEE

*Bojan Đorđević*

*Dragica Stojanović*

*Milica Paunović*

*Mira Đorđević*

*Andrijana Petrović*

*Nebojša Simeonović*

*Sanja Jevtić*

*Miloš Stević*

*Dragan Jelenković*

*Aleksandar Simonović*

*Jovan Vetović*

## FOREWORD

March 2020, when the COVID-19 pandemic was officially declared, will be remembered as a turning point in the history of modern humanity. While the world was facing this health crisis, with far-reaching consequences to our lives and work, global uncertainty and challenges unprecedented in any of the crises before emerged.

History teaches us that the crisis brings the possibility of change for the better. It is an opportunity, not only for recovery but also for further progress. In this situation, while the whole country is working to strengthen its health system and health capacities, it is necessary to progress towards economic and sustainable development. In addition to the numerous misfortunes in various areas, brought to us by the pandemic, there are some fine examples from a socio-economic point of view. Solutions of social distance and lockdown have led to an enormous increase in the use of all e-commerce services and new digital products and services (e.g. in finance and banking). Work from home and the organization of telework have contributed to introducing new standards in the organization of work in all sectors, with the assistance of the latest Internet technologies and software applications. These solutions existed even before the outbreak of the COVID-19 crisis but were moderately used. Today, they are the standard, and some new ones appear every day. Thus, the pandemic has contributed to unmatched growth and acceptance of digital innovations.

To provide the correct answer and identify the need for new solutions, we need to understand the impact of this pandemic on people's lives, the work of institutions, businesses, and the environment. Of course, the effect of the pandemic on the economy and resources is immense. An analysis is needed on all new ones - globally, regionally, and locally. In addition to the macroeconomic point of view, it is necessary to analyze the effects of the crisis on the microeconomic level, i.e., at the company level. Also, reconciling the impact of the pandemic on some sectors and industries that have been most affected (for example, tourism, auto-industry) is indispensable.

In front of you is a thematic proceeding of scientific papers entitled "The Impact of the COVID-19 Pandemic on Economy, Resources and Sustainable Development". Some works published in this collection were presented at the 11<sup>th</sup> International Symposium on Natural Resources Management, held on October 23, 2021, at the Faculty of Management in Zaječar. This content represents our attempt to partially present the impact of COVID-19 on global, regional, and local economic and sustainable development. The authors of papers, each in their own domain and field, analyzed various problems in a comprehensive and scientifically-based manner and presented the results of their research along with short-term and long-term solutions for recovery. The authors emphasize the need to accelerate the achievements of sustainable development goals, which are now relevant more than ever: health security, equality and prosperity for all, green recovery, and strengthening the resilience of society and economy to potential risks and shocks.

In this way, the authors have provided valuable information that we all have to fully comprehend and act accordingly. Perhaps the decisions that will be made and the steps that will be taken will determine the course of this pandemic that is still ongoing without losing its intensity.





# CONTENT

1. Drago Cvijanović, Vuk Mirčetić, Svetlana Vukotić  
**THE INFLUENCE OF LEADERSHIP STYLE ON ORGANISATIONAL PERFORMANCES AND CHALLENGES IN COVID-19 PANDEMIC AND SIMILAR CIRCUMSTANCES**..... 11-22
2. Andrea Andrejević Panić, Aleksandar Kostić, Slobodan Cvetanović  
**ECONOMIC MODERNIZATION OF COUNTRIES, SUSTAINABLE DEVELOPMENT PARADIGM AND PANDEMIC COVID 19**..... 23-34
3. Milan Tucaković, Dragoljub Bajić, Dušan Polomčić  
**THE IMPACT OF THE COVID-19 PANDEMIC ON THE ECONOMY, WATER RESOURCES AND SUSTAINABLE DEVELOPMENT** ..... 35-44
4. Slavica Miletić, Dejan Bogdanović  
**SELECTION OF SUSTAINABLE BUSINESS MODEL DURING THE COVID-19 PANDEMIC IN SERBIA**..... 45-59
5. Ratko Ljubojević  
**ENERGY SECURITY OF THE REPUBLIC OF SERBIA IN THE CONDITIONS OF THE COVID 19 PANDEMIC**..... 60-68
6. Vladimir Živanović, Jelena Vitomir  
**CHALLENGES OF ECONOMIC POLICY AND INVESTMENT PORTFOLIO RESTRUCTURING DUE TO THE COVID-19 PANDEMIC** ..... 69-95
7. Igor Vukonjanski, Borivoje Baltezarević  
**INNOVATIVE APPROACHES TO PROFESSIONAL TRAINING OF PUBLIC ADMINISTRATION EMPLOYEES IN THE CONDITIONS OF THE PANDEMIC COVID**..... 96-107
8. Dragica Stojanovic, Ivan Jovanovic  
**INFLUENCE AND IMPLICATIONS OF CORONAVIRUS SPREAD ON METAL MARKET IN CONDITIONS OF ECONOMIC UNCERTAINTIES**..... 108-126
9. Ivana Marinović Matović, Andjela Lazarević, Leposava Jovanović  
**SUSTAINABLE BUSINESS MODELS OF SMALL AND MEDIUM ENTERPRISES (SMEs) IN POST-COVID-19 CONDITIONS** ..... 127-140
10. Ivana Baltezarević, Radoslav Baltezarević  
**THE IMPACT OF VISUAL BRAND COMMUNICATION ON SOCIAL NETWORKS ON CONSUMER BEHAVIOR DURING THE CRISIS** ..... 141-150
11. Danijela Despotović, Lela Ristić, Mirjana Knežević  
**MANAGEMENT OF AGRARIAN RESOURCES IN THE REPUBLIC OF SERBIA UNDER COVID-19 PANDEMIC** ..... 151-161

12. Ivana B. Ljutić  
**REGULATORY ASPECTS OF SUSTAINABILITY GOVERNANCE..... 162-180**
13. Radoslav Baltezarević, Ivana Baltezarević  
**THE ROLE OF PERSONAL BRANDING IN THE DIGITAL ENVIRONMENT ON CAREER DEVELOPMENT DURING THE COVID-19 PANDEMIC ..... 181-191**
14. Jane Paunković, Violeta Jovanović, Srđan Žikić, Mihailo Jovanović  
**TELEMEDICINE IN COVID 19 IMPORTANCE OF OPTIMAL AND SUSTAINABLE ORGANIZATIONAL DESIGN..... 192-208**
15. Emina Požega, Slavica Miletić  
**APPLICATION OF AN EFFICIENT ALGORITHM FOR OPTIMIZATION MIXTURE COMPOSITION OF BORONIZING PROCESS DURING THE COVID-19 PANDEMIC ..... 209-227**
16. Jelena Bošković, Vladica Ristić, Tanja Kvesić  
**INFLUENCE OF GRAPEVINE GENETIC DIVERSITY ON THE PRODUCTION OF HIGH QUALITY WINES ..... 228-238**
17. Jelena Bošković, Vladica Ristić  
**ADVANTAGES AND RISKS OF THE IMPACT OF AGRICULTURAL BIOTECHNOLOGY IN INTERACTION WITH THE ENVIRONMENT..... 239-258**

## THE INFLUENCE OF LEADERSHIP STYLE ON ORGANISATIONAL PERFORMANCES AND CHALLENGES IN COVID-19 PANDEMIC AND SIMILAR CIRCUMSTANCES

Drago Cvijanović<sup>1</sup>

Vuk Mirčetić<sup>2</sup>

Svetlana Vukotić<sup>3</sup>

<sup>1</sup>Full professor, Faculty of Hotel Management and Tourism, Vojvođanska bb, Vrnjačka Banja, University of Kragujevac, drago.cvijanovic@kg.ac.rs and dvcmmv@gmail.com

<sup>2</sup>Teaching Assistant, Faculty of Applied Management, Economics and Finance, Jevrejska 24, Belgrade, University Business Academy in Novi Sad, vuk.mircetic@mef.edu.rs

<sup>3</sup>Full professor Faculty of Applied Management, Economics and Finance, Jevrejska 24, Belgrade, University Business Academy in Novi Sad, svetlana.vukotic@mef.edu.rs

### ABSTRACT

*Leadership continuously occupies the attention both of researchers and practitioners. At the same time, when global challenges occur, such as the COVID-19 pandemic, the interest in leadership is intensified as one of the modalities for overcoming complex and demanding business conditions. The paper analysed two leadership approaches: task-oriented behaviour and follower-oriented behaviour. The research findings for both parameters are high, which may imply that the sample of 239 respondents consisted of leaders of effective and efficient organisations, but further findings indicate the predominance of relationships with followers. Additionally, the research results are presented on an adapted leadership grid, which is one of the contributions of this study and can be valuable to top management to have more precise insight into leaders' capabilities and commitment to followers and tasks. Research results open up further possibilities for developing the leadership style in the current changed circumstances.*

### KEYWORDS

*Leadership style, task-oriented behaviour, follower-oriented behaviour, COVID-19, uncertainty.*

*JEL: M12*

## 1. INTRODUCTION

Different theories and approaches to leadership can be found in the literature, which the authors define differently. Sometimes leadership is seen as the core of group processes where the leader is placed at the centre. A different group of authors observes leadership from the aspect of personality and diverse personality traits and characteristics. Some authors define leadership as something innate, and others see the leader as the initiator and implementer of change or the leading performer at the core of the change process.

Changes are inevitable, and consequently, in crisis such as COVID-19 pandemic, knowledge of different theoretical approaches to leadership is needed, which enables the leader to recognise a particular situation, anticipate potential dangers, be prepared for challenges, prevent events that are harmful or damaging to the organisation and apply the appropriate leadership approach in achieving a given goal. In addition, the leader has to resist the changes that are happening or may occur and enable the organisation to move successfully towards its goal through the leadership process.

According to Bass and Stogdill (1990), one of the first leadership studies observed leadership as a set of characteristics. In the years of research that followed, researchers looked at other approaches to leadership, and Bryman (1992) should be mentioned as one of the authors credited with restoring access to leadership as a set of traits in the focus of interest.

Northouse (2008) compares two different leadership approaches: a set of skills with the approach as a set of traits, and concludes that both approaches put the leader in the central role. The focus shifts from the personality traits that are considered innate, to the skills and abilities, as something that can be acquired or learned over time.

The approach to leadership as a set of skills is quite descriptive and provides more basis for understanding the nature of effective leadership than it provides guidance that would help the leader reach a higher level of leadership and be more effective and efficient.

For this paper, it is essential to analyse the approach to leadership style in more detail and elaborate its impact on the performance of organisations in the COVID-19 pandemic and similar circumstances. Proponents of this approach put leader and leader behaviour in the focus of research.

The paper is composed so that the introduction, which provides a brief retrospective overview of the approach to leadership, is followed by the next segment of the paper that focuses on the impact of leadership style on the performance of organisations. Within this part, the so-called managerial grid model includes two factors: care for production/results and care for people. The following segment of the article is related to leadership style and performance in crisis conditions. In the next segment, the research is presented. For this paper, research on leadership behaviour was conducted. The questionnaire used for this research and the interpretation of the obtained results is according to Northouse (2018, p. 158), and it is called Leadership Behaviour Questionnaire. Finally, the sublimation of both theoretical work and the work representing the research is given to the conclusion.

The paper is intended for the interested professional and scientific public whose subject of interest is leadership, especially the influence of leadership style on the performance of organisations and its application in practice.

## **2. THE IMPACT OF LEADERSHIP STYLE ON THE ORGANISATIONAL PERFORMANCE**

Researchers who have studied the behavioural approach to leadership style have found that leadership consists of two basic types of behaviour:

1. Task-oriented behaviour;
2. Relationship-oriented behaviour.

Northouse (2019) pointed out that researchers studying the behavioural approach determined that this approach to leadership is composed of task-oriented or result-oriented behaviours and relationship-oriented behaviours. The essence is whether the leaders in their

actions are predominantly focused on the execution of tasks or are primarily guided by the care of employees (Simović et al., 2018, 14).

Hersey et al. (1979) explain behaviour focused on tasks as guidelines for telling subordinated what, when, where, and how to achieve a particular goal. The leader sets tasks and defines roles. The same authors consider behaviour oriented to relationships as two-way communication and includes listening to and supporting.

Task-oriented behaviour focuses on goal realisation and helps followers achieve goals, while relationship-oriented behaviour concentrates on relationships with followers to make them feel more comfortable with other group members and in various situations. The purpose of this approach to leadership is to combine two basic types of behaviour in order for the leader to guide the followers to accomplish the tasks and accomplish the desired goal. To completely understand the approach to leadership style, three different studies that have contributed to the development and popularisation of this approach should be mentioned. The first one is leadership research at Ohio State University in the late 1940s, and it is based on the results of a study that stated how many times leaders showed a particular type of behaviour. Another study relevant to leadership style is conducted by a group of researchers at the University of Michigan and analysed leadership functioning in small groups. The third analysis that is relevant to this approach to leadership is related to the managerial grid.

A model that joins concern for results and concern for people with two intersecting axes in a quadrature shape is called the managerial grid.

Concern for results relates to how a leader is concerned with accomplishing organisational tasks. Blake & Mouton (1964) point out that concern for results can include whatever the organisation seeks to achieve. Thus, a leader can conduct various activities to achieve organisational goals, including attention to policy decisions, new product improvement, process concerns, workload, and sales capacity (Northouse, 2019, p. 140).

Concern for people relates to a leader's behaviour and attitude towards followers. This concern involves making organisational dedication and trust, promoting the individual value of every follower, providing good working conditions, maintaining a proper salary structure, and promoting good social relations (Blake & Mouton, 1964).

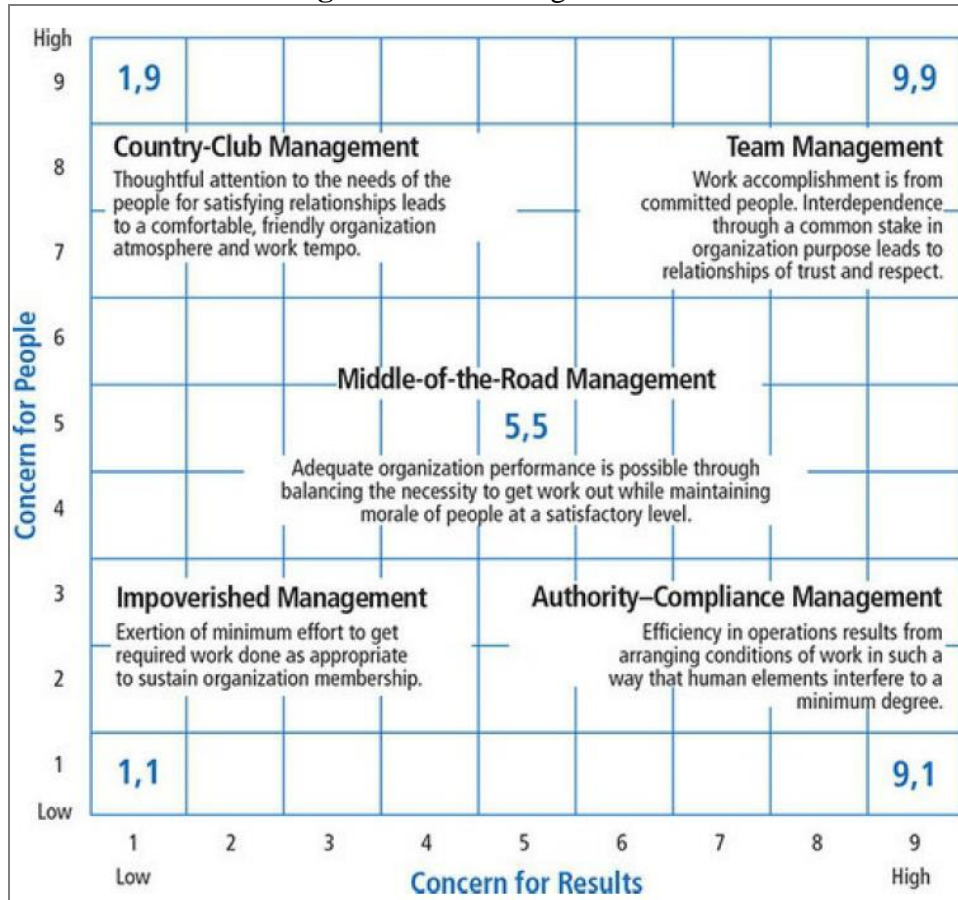
Figure 1 shows the mentioned managerial grid, which appeared for the first time in the 1960s and has been refined and revised several times since then (Blake, Mouton & Bidwell, 1962; Blake & Mouton, 1964, 1978, 1980, 1985; Blake & McCauley, 1991; Mirčetić, 2019).

The managerial grid was created to illustrate leadership style through two factors: concern for results and concern for people.

The horizontal axis symbolises the leader's concern for results, while the vertical axis represents the leader's concern for the people. Each axis is expressed through a 9-point scale. On this scale, 1 represents a minimum concern for people or results, and 9 represents the foremost concern. Several leadership styles can be shown by scheming scores in the grid. The managerial grid portrays five major leadership styles: authority-compliance (9,1), country-club management (1,9), impoverished management (1,1), middle-of-the-road management (5,5), and team management (9,9). Each of the five major leadership styles is described in the Figure above.

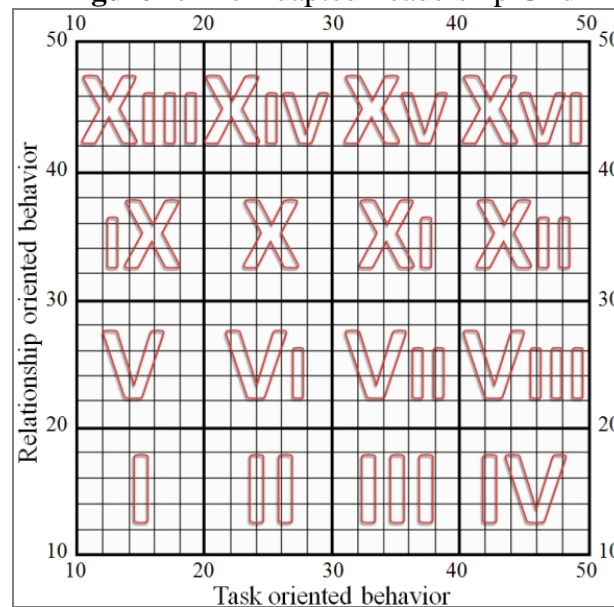
For this paper, The Adapted Leadership Grid (Mirčetić, 2019) is used instead of the managerial grid because it is more detailed and is suitable for more specific analysis. Furthermore, the Grid (Figure 2) is subdivided into 16 quadrants that facilitate simplification of comprehensive behavioural examination.

**Figure 1. The Managerial Grid**



Source: Blake & McCauley, 1991.

**Figure 2. The Adapted Leadership Grid**



Source: Mirčetić, 2019.

The Adapted Leadership Grid consists of two intersecting axes. The horizontal axis signifies behaviour oriented to tasks, and the vertical axis symbolises behaviour oriented to

relationships with followers. The minimum on both axes on the scale is 10 points, and the maximum score is 50 points because respondents can score between 10 and 50 in the Leadership Behaviour Questionnaire, which is used for obtaining leadership behaviour results.

### **3. LEADERSHIP STYLE AND ORGANISATIONAL PERFORMANCE IN THE CRISIS**

The contemporary business environment is rapidly changing. The complexity and unpredictability of the past decades, along with innovations, developments and crises, have affected organisations' business paradigms. Leadership is an essential factor for every organisation that wants to be successful (Vujić et al., 2018). Vukotić and Mirčetić (2020, p. 481) emphasise that "effective leadership is one of the preconditions to effective organisations". Jaško et al. (2013) consider leadership's nature to encourage, guide and motivate followers to accomplish goals and tasks. Mirčetić & Vukotić (2020, p. 94) highlight that "business organisations strive for the most efficient and effective accomplishment of goals, which causes the need for successful leaders".

Hurn (2012) emphasises that the contemporary business environment causes various changes in organisations in all industries. Cvijanović and Stefanović (2018, p. 65) consider that "economic development, being regular progress and increasing prosperity, became the preoccupation of already classic economists". Every organisation faces different challenges in their business. Scholars find interdependency between changes and an organisation's effectiveness very interesting. Cvijanović, et al. (2018) underline the significance of the risk management process in particular branches. Gajić & Cvijanović (2021) emphasise the negative impacts of COVID-19 on tourism. Changes occur in diverse shapes, forms and intensities (Jarrett, 2008). Change dynamics are usually produced due to digital and innovation disruption (Čudanov et al., 2019).

Some scholars (By, 2005; Čudanov et al., 2012; Al-Haddad & Kotnour, 2015; Jeraj et al., 2015; Cameron & Green, 2015) emphasise that successful change management is a pattern for organisational durability and long-term sustainability. Adjusting to changes is recognised as a crucial determinant of an organisation's effectiveness (Brisson-Banks, 2010). Čudanov et al. (2019) conclude that managing complexities and uncertainties of the change process require a growing demand for improvement and selection of suitable quantitative approaches and tools in change management procedures to produce successful change outcome. Tornjanski et al. (2020) consider uncertainty and complexity as causes for constant improvement of organisations, additionally developed by disruptive innovations, the need to accelerate different types of projects and changes. Additional and higher requirement for leaders and top management is managing global organisations (Cvijanović et al., 2016).

Concurrent conditions have imposed new trends of observing leadership in business organisations. For example, within one organisation, the leader can not treat all followers and communicate equally. Instead, the leader can diagnose follower's development level and adjust his leadership style. In that way, the followers will be motivated and efficient, and they will develop over time by performing the tasks entrusted to them by the leader, which will enable better business results for the organisation itself. (Cvijanović et al., 2018).

In crises, for example, transparency about the current situation and achieving participation are essential. Employees need to know the situation about the current situation the organisation is facing and the potential impact on them. By participating in change planning,

they will better understand the need to introduce change, less resist and become part of the solution (Daft, 1998; Cascio, 2009). The success of a leader depends on the ability to understand and adapt to changes in the work setting and the environment. Good leaders can see trends of change and use the opportunity that occurs at a specific time (Lojić et al., 2015, 332). Cvijanović, Sekulić & Mandarić (2021) investigated the changes that have occurred in tourism with the emergence of the COVID-19 pandemic and underlined its devastating consequences.

Taleb (2007) named an unexpected event that can be historical economic, technological or personal, and has a remarkably rare probability of occurrence "The Black Swan". Some scholars (Dunbar, 2019; Ross, 2019) estimate that this event is often considerably improbable to predict because it is an event with a rather profound possibility of occurring. Some scholars (Wood & Bandura, 1989; Tornjanski et al., 2014) emphasise the growing necessity for synthesising appropriate tools and software packages that include external and internal factors and possible alternatives concerning managing the change process.

Mirčetić and Čudanov (2021, p. 225) argued what factors had created a new, uncertain business environment and concluded that those factors are globalisation, economic crisis, recession and the global coronavirus pandemic. Cvijanović, Pantović & Đorđević (2021, p. 123) stated that *the COVID-19 pandemic led to the implementation of many restrictive measures to prevent it*. Ahern and Loh (2020) indicate that the COVID-19 pandemic is the most notable global pandemic after Spanish influenza. Mirčetić, Janošik and Malešević (2019) observe that organisations working in uncertain environments are endeavouring to improve their performance and achieve a competitive advantage in various ways. Berber et al. (2019) emphasise leadership as one of the fundamental concepts in scientific research and business practice, which is essential in crises.

However, changes in work, such as eliminating tasks or reducing the number of people doing the same work, require fewer changes than changes in technology, such as automating work. Notwithstanding, changes in technology usually require less change than changes in structure, such as, for example, eliminating hierarchical levels or merging departments (Vukotić et al., 2012).

#### **4. RESEARCH: THE EXAMINATION OF THE LEADERSHIP BEHAVIOUR**

The target group of this research was exclusively people in certain leadership positions in organisations to determine the extent to which their leadership is task-oriented and how much it is directed towards the relationship with followers. The respondents' organisations have shown that they are both effective and efficient in their work, while some organisations are rewarded for their performance.

The following hypotheses are set:

General Hypothesis H0: Leaders contribute to the efficient and effective operation of organisations, which is manifested through the behaviour of leaders towards tasks and the behaviour towards followers.

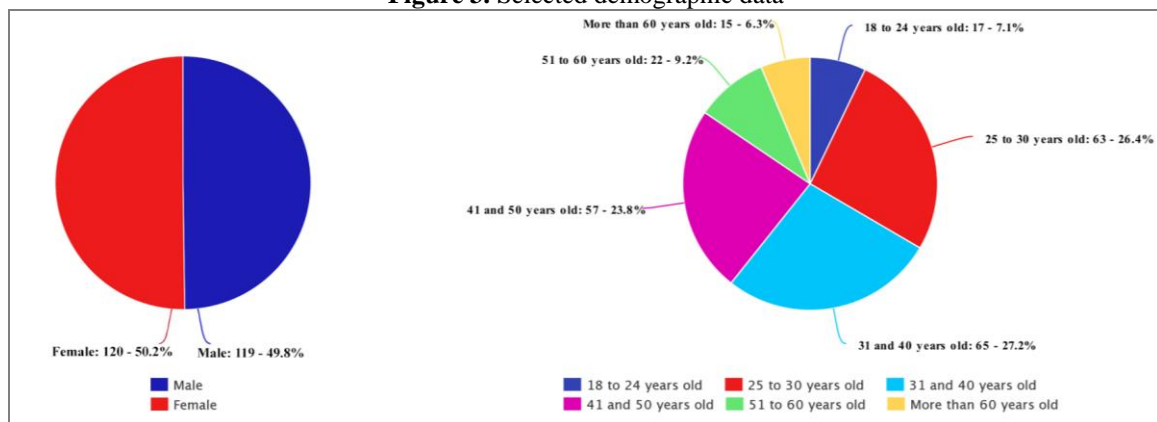
A specific hypothesis H1 states: If organisations are proven to be effective and efficient, leadership style in task-oriented behaviour will be more articulated.

Another specific hypothesis H2 declares: If organisations are proven effective and efficient, the leadership style in terms of behaviour directed towards relationships with followers will be more enunciated.



Respondents were issued the Leadership Behaviour Questionnaire by Norhouse (2019, p. 158). The sample consists of 239 validly completed questionnaires, which is a relevant sample for conducting research. Selected demographic data is presented in Figure 3. Of the total number of validly completed surveys, women completed 120 surveys or 50.2%, while men completed 119 surveys or 49.8%. The age structure of the respondents is diverse. Of the total number of respondents, 17 were between 18 and 24 years old or 7.1%. From 25 to 30 years old, there were 63 respondents or 26.4%, while slightly more respondents, a total of 65, were between 31 and 40 years old, or 27.2%. A slightly lower percentage of respondents, 23.8% or 57, were between 41 and 50 years old. From 51 to 60 years, there were 22 respondents or 9.2%, while the least number of respondents were over 60 years, 15 of them, or 6.3%.

**Figure 3.** Selected demographic data



Source: Authors.

#### **4.1 Research results: Relationship-oriented behaviour**

Results of approach to leadership style as a task-oriented behaviour show that out of 239 respondents, 11, or 4.6%, had a maximum of 50 out of 50 points, while 76 leaders, or 31.8%, scored 45 points or more.

The overall average score for the approach to leadership style as a task-oriented behaviour was 42.27 points. However, a significant number of leaders obtained an extremely high score of 45 points or more, which is 31.8% of the total number of respondents. Therefore, it is considered that the specific hypothesis H1, which stated "If organisations are proven to be effective and efficient, leadership style in task-oriented behaviour will be more articulated", is successfully validated.

#### **4.2 Research results: Task-oriented behaviour**

The results obtained by researching leadership style as a relationship-oriented behaviour are higher than those obtained by researching leadership style as behaviour strived towards tasks. The average result for relationship-oriented behaviour is 44.04 points.

Considering that the maximum result that could be achieved during the survey was 50 points and that for this paper, any result above 45 points was considered extremely high, it can be concluded that the leaders had a high score on average. This data was expected, considering that the initial premise was to research the leaders of those organisations with above-average performance.

Individual results of leaders are higher when viewing leadership as behaviour directed towards relationships with followers than a behaviour directed towards tasks. Interestingly, the highest number of points had the same number of respondents; eleven of them or 4.6% had a maximum of 50 points. More than half of respondents, 50.63% or 121 respondents, had a score of 45 or more points. Only seven respondents, or 2.93%, had a low score, considering that a score of 35 points or less was considered a low score for this paper.

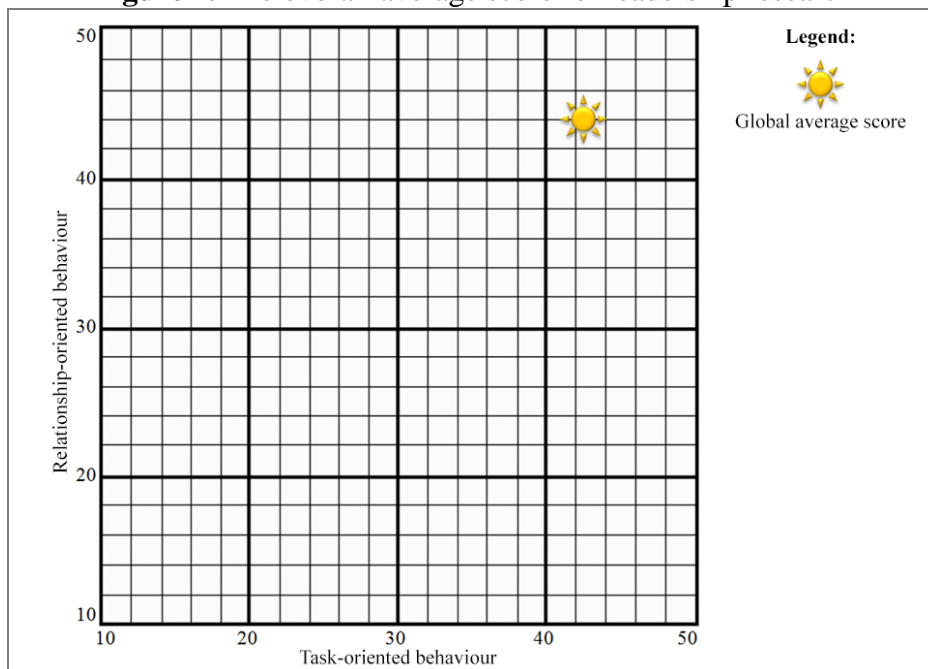
Considering the high results achieved when it comes to observing leadership as relationship-oriented behaviour, as well as the fact that more than half of all respondents had a score of 45 points or more, it is considered that if organisations are proven effective and efficient, leaders' style in terms of behaviour that is directed towards relationships with followers will be more pronounced. Thus the specific hypothesis H2 is proven.

### 4.3 Research results: The overall average score

For this paper, an adapted leadership grid (Mirčetić, 2019) was used, which was formed based on the management grid. Bearing in mind that the respondent could achieve a maximum of 50 points and a minimum of 10 points during the survey, the adapted leadership grid consists of one quadrant divided into 40 segments into one and 40 segments on the other axis. Such differentiation enables very precise registration of research results and gives the possibility to notice similarities and differences in the results graphically.

Figure 2 provides a graphical representation of the overall average for leadership research where the amounts are the result of 42.27 points for leadership in terms of task-oriented behaviour and 44.04 points for leadership in terms of behaviour directed toward followers in the adapted leadership grid.

**Figure 2.** The overall average score for leadership research



**Source:** Authors.

The graphical representation clearly shows the position of the overall average, which is the evidence of successfully confirmed specific hypotheses H1 and H2, that stated "If organisations are proven to be effective and efficient, leadership style in task-oriented behaviour will be more articulated" and "If organisations are proven effective and efficient,

the leadership style in terms of behaviour directed towards relationships with followers will be more enunciated".

Therefore, General Hypothesis H0 stated, "Leaders contribute to the efficient and effective operation of organisations, which is manifested through the behaviour of leaders towards tasks and the behaviour towards followers," is confirmed.

## **5. CONCLUSION**

Leadership is a permanent, organised activity aiming at achieving organisational goals. Thus, leadership implies the existence of two accompanying sides: the leader and followers. A modern leader should direct his behaviour towards followers in an adapted style that motivates and develops followers and accepts all possibilities for change. Therefore, all concepts of leadership consideration for this article are based on the behaviour of the leader. The behaviour of the leader can be oriented towards tasks and relationships with followers.

Leadership is an essential factor in any successful organisation. On the other hand, business organisations strive to achieve their goals as efficiently and effectively as possible, which causes the necessity for successful leaders, implying that efficient leadership is one of the preconditions for efficient organisations. In theory, the nature of leadership is to encourage, guide, and motivate subordinates to accomplish previously set tasks and goals.

This article analyses in more detail two approaches to leadership style: results-oriented behaviour and relationship-oriented behaviour. The subject of the research was the influence of leadership style on the performance of organisations. The contemporary business environment has imposed new trends of observing and incorporating leadership within business organisations. In the research conducted for this paper, the respondents were leaders in organisations with proven efficiency and effectiveness. The outstanding performance of organisations implies proven effectiveness and efficiency, which requires an effective and efficient leader. Therefore, the research results for both leadership styles, task-oriented behaviour and relationship-oriented behaviour, are high and prove all starting hypotheses, two specific and general hypotheses. Results that nevertheless reflect a slight predominance of follower-oriented behaviour are presented on the adapted leadership grid.

The general conclusion is that there is an influence of leadership style on the performance of organisations. However, research in the paper also notes certain limitations, primarily in the number of respondents. Although the sample was of a size that could be considered representative, the results would be determined even more precisely, and conclusions could be made that a more significant number of leaders were surveyed in the research. This limitation is both a recommendation for further research and a good starting point, perhaps for other researchers who can, after some time and especially after the COVID-19 pandemic, compare what the results were and what they will be and to show what the trend is in all analysed aspects.

## REFERENCES

- Ahern, S., & Loh, E. (2020). Leadership during the COVID-19 pandemic: building and sustaining trust in times of uncertainty. *BMJ Leader*, 1-4. <https://doi.org/10.1136/leader-2020-000271>
- Al-Haddad, S., & Kotnour, T. (2015). Integrating the organizational change literature: a model for successful change. *Journal of Organizational Change Management*, 28(2), 234-262. <https://dx.doi.org/10.1108/JOCM-11-2013-0215>.
- Bass, B., & Stogdill, I. (1990). *Handbook of Leadership*. New York: The Free Press.
- Berber, N., Slavić, A., Miletić, S., Simonović, Z., & Aleksić, M. (2019). A Survey on Relationship between Leadership Styles and Leadership Outcomes in the Banking Sector in Serbia. *Acta Polytechnica Hungarica*, 16(7), 167-184.
- Blake, R. R., & Mouton, J. S. (1964). *The Managerial Grid*. Houston: Gulf Publishing Company.
- Blake, R. R., & Mouton, J. S. (1978). *The New Managerial Grid*. Houston: Gulf Publishing Company.
- Blake, R. R., & Mouton, J. S. (1980). *The Grid for sales excellence* (2nd edition). New York: McGraw-Hill.
- Blake, R. R., & Mouton, J. S. (1985). *The Managerial Grid III*. Houston: Gulf Publishing Company.
- Blake, R. R., Mouton, J. S., & Bidwell, A. C. (1962). Managerial grid. *Advanced Management - Office Executive*, 1(9), 12-15.
- Blake, R., & McCause, A. A. (1991). *Leadership Dilemmas—Grid Solutions*. Houston: Gulf Publishing Company.
- Brisson-Banks, C. V. (2010). Managing change and transitions: a comparison of different models and their commonalities. *Library Management*, 31(4/5), 241-252. <https://dx.doi.org/10.1108/01435121011046317>
- Bryman, A. (1992). *Charisma and leadership in organizations*. London: SAGE Publications.
- By, R. T. (2005). Organisational change management: A critical review. *Journal of change management*, 5(4), 369-380. <https://dx.doi.org/10.1080/14697010500359250>.
- Cameron, E., & Green, M. (2015). *Making sense of change management: a complete guide to the models, tools and techniques of organizational change*. London: Kogan Page Publishers.
- Cascio, W., F., (2009). *Employment downsizing and its alternatives*. SHRM Foundation
- Čudanov, M., Jaško, O., & Săvoiu, G. (2012). Public and public utility enterprises restructuring: Statistical and quantitative aid for ensuring human resource sustainability. *Amfiteatru Economic*, 14(32), 307-322.
- Čudanov, M., Tornjanski, V., & Jaško, O. (2019). Change equation effectiveness: Empirical evidence from south-east Europe. *Business Administration and Management*, 22(1), 99-114.
- Cvijanović, D., & Stefanović, V. (2018). Theoretical aspects of medium-term conditions of economic and tourism development. 3rd International Scientific Conference Tourism in Function of Development of the Republic of Serbia – Tourism in the Era of Digital Transformation, Thematic Proceedings – II; University of Kragujevac, Faculty of hotel management and tourism in Vrnjačka Banja, 31 May - 2 June, 2018. Vrnjačka Banja, Serbia, ISBN 978-86-89949-29-2; CIP 338.48(082); 338.48(100)(082); COBISS.SR-ID 264200460; pp. 63-80.
- Cvijanović, D., Mihailović, B., & Vukotić, S. (2016). *Marketing i konsalting u funkciji razvoja turizma Srbije* (monografija). Institut za ekonomiku poljoprivrede, Beograd.

- Cvijanović, D., Mirčetić, V., & Vukotić, S. (2018). Situaciono liderstvo: primena odgovarajućeg stila u zavisnosti od razvojnog nivoa sledbenika. *Zbornik radova 8. međunarodnog simpozijuma o upravljanju prirodnim resursima ISNRM 2018*, Fakultet za menadžment Zaječar, Megatrend Univerzitet Beograd, Zaječar, maj, 2018. ISBN 978-86-7747-591-8. 59-65.
- Cvijanović, D., Pantović, D., & Đorđević, N. (2021). Transformation from urban to rural tourism during the COVID-19 pandemic: The case of Serbia. *Thematic proceedings of The International scientific conference Sustainable agriculture and rural development*, 123-132.
- Cvijanović, D., Sekulić, D., & Mandarić, M. (2021). "Stay at home" and its impact on tourism. In *Collection of professional papers of International round table "Crisis management in the time of COVID 19: Improvise, Adapt and Overcome"*. AREMA, Academy of regional management, Rogaška Slatina, Slovenia, pp. 32-47.
- Cvijanović, D., Vojinović, Ž., Sedlak, O., & Sekulić, D. (2018). The risk management and the insurance of agricultural production. *The CAP and national priorities within the EU budget after 2020, Monographs of multi-annual programme, 75.1*; Warsaw, 2018. ISBN 978-83-7658-751-6; DOI: 10.30858/pw/9788376587516; pp. 125-143.
- Daft, R., (1998). *Organization theory and design* (sixth edition). International Thomson Publishing Company, Cincinnati
- Dunbar, S. R., (2019). *Mathematical modeling in economics and finance with probability and stochastic processes*. American Mathematical Society.
- Gajić, T., & Cvijanović, D. (2021). Immediate and long-term negative impacts of COVID-19 on tourism. *Knowledge - International Journal*, 45(1), 25-31.
- Hersey, P., Blanchard, K. H., & Nagemeyer, W. E. (1979). Situational Leadership, Perception, and the Impact of Power. *Group & Organization Studies*, 4(4), 418-428.
- Hurn, B. J. (2012). Management of change in a multinational company. *Industrial and commercial training*, 44(1), 41-46. <https://dx.doi.org/10.1108/00197851211193417>.
- Jarrett, M. (2008). The new change equation. *Business Strategy Review*, 19(4), 76-81. <https://dx.doi.org/10.1111/j.1467-8616.2008.00567.x>.
- Jaško, O, Čudanov, M., Jevtić, M., & Krivokapić, J, (2013). *Osnovi organizacije i menadžmenta*. Beograd, Srbija: Fakultet organizacionih nauka.
- Jeraj, M., Marić, M., Todorović, I., Čudanov, M., & Komazec, S. (2015). The Role of Openness and Entrepreneurial Curiosity in Company's Growth. *Amfiteatru Economic*, 17(38), 371-389.
- Lojić, R., Ristić, V., Karović, S. (2015). Razvoj liderske karijere, *Vojno delo*, 4, 317-333.
- Mirčetić, V. (2019). Determination of the Adapted Leadership Grid. In Proceedings of the 1st Virtual International Conference Patch to Knowledge Society – Managing Risk and Innovation, *Proceedings PaKSom 2019*. 205-210.
- Mirčetić, V., & Čudanov, M. (2021). Revalidating Blanchard's Situational Leadership Model: Induction of the Unproductive Follower. *Proceedings of the XXVI International Scientific Conference Strategic Management and Decision Support Systems in Strategic Management – SM2021*. May 21, 2021, Subotica, Serbia, pp. 225-234.
- Mirčetić, V., & Vukotić, S. (2020). Development and analysis of situational leadership models. *Thematic Proceedings of MEFkon 2020*. 93-113.
- Mirčetić, V., Janošik, M., & Malešević, A. (2019). Determinisanje liderstva i komparacija teorijskih pristupa. *Zbornik radova sa međunarodno naučno-stručne konferencije MEFkon*, Fakultet za primenjeni menadžment, ekonomiju i finansije, Beograd, Srbija, 146-155. ISBN: 978-86-84531-37-9.

- Northouse, P. (2008). *Liderstvo: teorija i praksa*. Beograd: Data Status.
- Northouse, P. (2019). *Leadership – Theory and Practice*. California: Sage Publications.
- Ross, M. S. (2019). *Introduction to Probability Models* (12th edition). London: Academic Press.
- Simović, O., Raičević, M., & Kovačević, M. (2018). Uticaj stila liderstva na organizacionu kulturu turističkih preduzeća u Crnoj Gori. *Ekonomski izazovi*, 7(14), 14-27.
- Taleb, N.N. (2007). *The Black Swan: The impact of the highly improbable*. New York City: Random House & Penguin.
- Tornjanski, V., Čudanov, M., & Săvoiu, G. (2020). Integration of project and organizational change management: towards sustainable value creation. *Econophysics, Sociophysics & Other Multidisciplinary Sciences Journal (ESMSJ)*, 9(1), 29-34.
- Tornjanski, V., Marinković, S., & Lalić, N. (2014). Application of ANP method based on a BOCR model for decision-making in banking. In *Proceedings of the XIV International Symposium SymOrg: New business models and sustainable competitiveness SYMORG 2014* (107-116). Zlatibor, Serbia.
- Vujić, D., Novaković, S., Maksimović, M., & Karabašević, D. (2018). Examination of leadership styles in organizations in Serbia which in its operations apply the concept of preserving the natural resources. *Mining and Metallurgy Engineering Bor*, 3-4, 41-48.
- Vukotić, S., & Mirčetić, V. (2020). Clustering in agriculture and tourism as a potential for development of rural tourism. *Thematic Proceedings of The 5th International Scientific Conference II "Tourism in Function of Development of the Republic Serbia– Tourism and Rural Development" TISC 2020*, Vrnjačka Banja, Serbia, 470-487. ISBN: 978-86-89449-48-3.
- Vukotić, S., Zakić, N., & Aničić, J. (2012). Uticaj krize na upravljanje ljudskim resursima i daunsajzing, EDASOL 2012, II Međunarodni skup o ekonomskom razvoju i životnom standardu, 12-13. oktobar 2012, Banja Luka, Zbornik radova, 482-490, ISBN 978-99955-49-93-0, COBBIS, BH-ID 3275032.
- Wood, R., & Bandura, A. (1989). Impact of conceptions of ability on self-regulatory mechanisms and complex decision making. *Journal of personality and social psychology*, 56(3), 407-415. <https://dx.doi.org/10.1037/0022-3514.56.3.407>.

## ECONOMIC MODERNIZATION OF COUNTRIES, SUSTAINABLE DEVELOPMENT PARADIGM AND PANDEMIC COVID 19

Andrea Andrejević Panić<sup>1</sup>  
Aleksandar Kostić<sup>2</sup>  
Slobodan Cvetanović<sup>3</sup>

<sup>1</sup> University of Educons, Sremska Kamenica, Republic of Serbia Vojvode Putnika 87, 21208 Sremska Kamenica, andrea.andrejevic@educons.edu.rs

<sup>2</sup> University of Pistina – Kosovska Mitrovica, Faculty of Economics, Republic of Kolašinska 156, 38220 Kosovska Mitrovica, aleksandar.kostic@pr.ac.rs

<sup>3</sup> University of Nis, Faculty of Economics, Republic of Serbia Trg Kralja Aleksandra 15, 18.000 Niš, prof.cvet@gmail.com

### ABSTRACT

*One of the conditions for the long-term economic sustainability of countries is the preservation of total capital stocks observed as drivers of economic growth. This fact makes very relevant the issue of use and especially the substitutability of produced and natural capital in the production process. The answer to it is most closely related to understanding the essence of the concept of weak and strong sustainability. Starting from such explicit observations, the paper attempts to consider the elementary consequences of the crisis caused by the Covid-19 virus pandemic on the phenomenon of substitutability of produced and natural capital in the process of creating material values. It was pointed out that from the point of view of the key postulates of the development economy and the real possibilities for the outbreak of health crises, only the option of strong sustainability is acceptable in the long run.*

### KEY WORDS

*sustainable development, produced capital, natural capital, poor sustainability, strong sustainability*

### 1. INTRODUCTION

We are witnessing radical changes in all aspects of production and life in this century, regardless of the fact that some of them are the key drivers of numerous economic and social transformations. In addition, at the beginning of 2019, the world faced the Covid-19 pandemic, and the crisis caused by it, which is similar to the depression from the beginning of the 1930s. The pandemic has caused great damage to the world economy, at the same time shedding new light on the phenomenon of globalization as the main economic, social, political and cultural phenomenon of the last thirty years. It can be stated with certainty that the Covid-19 pandemic additionally contributed to its slowdown, although it is still not possible to talk about deglobalization. In the time of growing globalization, the world has converged with common values, standards and procedures, which were given impetus by continuous progress of technology, especially in the field of information and communication

technologies, leading economic markets, most important regional economic integration, as global trade and financial institutions. (Cvetanović, Novaković, 2019).

An in-depth analysis of the consequences of this crisis is indisputably necessary for shaping an effective policy of adaptation of national economies to changed circumstances. In general, this statement is applied to all policies, including economic development policy. It depends on the success of economic development management in the conditions of changed circumstances whether specific economies will develop more or less successfully, i.e. sustainably.

It can be argued with certainty that the consequences of the pandemic already imply substantial changes in the policy of economic development. This is for the main reason that the area of finance cannot be a key operational tool in correcting increasing and deeper economic imbalances. Also, it is becoming more and more obvious that, with classical protectionist measures, the excessive use of natural resources and uncontrolled pollution and destruction of the environment on a global level cannot be stopped by far (Jurčić, 2021).

According to the previously expressed reflections on the crisis caused by the Covid- 19 virus and the need to design an effective policy of adaptation of national economies in changed circumstances, the analysis of the imperatives of sustainable economic development in the new conditions of the world economy is imposed. This problem is realized in the paper by looking at the paradigm of sustainable development, primarily through the prism of the need to preserve the total amount of capital treated as a driver of long-term economic growth, on the one hand, and the explication of the elementary consequences of the Covid-19 pandemic on the substitutability, on the other. The composition of the paper was adapted to the subject and the goal of the research, which, in addition to the introduction, conclusion and list of used literature, consists of four sections. In the first section of the paper, a brief overview of the theory of the development phase of Walt Rostov, as the dominant teaching on the economic modernization of countries during the 1960s, is given. In addition, it briefly reviewed the basic postulates of the concept of sustainable development. The second section of the paper gives a brief overview of the basic type of capital as a driver of economic growth and development, while the third section emphasizes the basic differences between the concepts of weak and strong sustainability. Finally, in the fourth section, an attempt is made to consider the consequences of the Covid -19 virus pandemic on the substitutability of produced and natural capital in the process of creating material values.

## **2. FROM THE WALT ROSTOW MODERNIZATION THEORY TO THE PARADIGM OF SUSTAINABLE DEVELOPMENT**

The dominant theory of economic development during the seventh decade of the last century was undoubtedly the so-called theory of the growth stage of American economist Walt Rostow. In his capital work *The Stages of Economic Growth* from 1960, he identified the following five phases in the development of society: Traditional Society, Transition Society, Phase of ascent, Stability or Maturity Phase, and Mass Consumption Phase (Dragutinović, Filipović, Cvetanović, 2015).

In the first phase, which characterized the world economy to early capitalism, the dominant labor force was employed in agriculture (up to 75% of total employment), with very low factor mobility, great unevenness in the distribution of wealth and decentralized political power. It was characteristic for a period of transition, from feudal regulation to early capitalism. During this period, the wealth is redistributed, financial centers are created, and on the basis of that and on the basis of political power, there was the centralization of political decision-making in the form of the organization of political parties.



The next phase is marked with the name of the transition. As its main characteristic, Rostow states that it is necessary to achieve a share of investment in the distribution of the Gross Domestic Product of at least 10% in order to enable self-generating and sustainable development. Rostow, as the primary purpose of the growing investments, mentions investments in public infrastructure, including road, telecommunication, energy and other communications. In this way, there is easier communication between the partners in the market, the transaction costs are reduced, and the integration of the national market is coming to an end (Cvetanović, D., 2017).

The ascent phase is, according to many characteristics, like the transit phase of development. Namely, preconditions for ascent are created just during the transition. Investments in the take-off phase account for far more than 10% of GDP in order to reach such a level of income per capita in the future, which provides significant savings and new investments. Also, during the ascent phase, the propulsive sectors of growth generate the highest growth rates of production and income and represent the engine of the whole economy (Todaro, Smith, 2015).

At the stage of maturity, there is gradual replacement of the pull sectors, so instead of strengthening the production of steel, modernizing the transport infrastructure, and so on, it switches to the production of final industrial products with a much higher added value contained therein. Parallel to the change in the structure of the domestic industry, there are also significant social changes: the urbanization process intensifies; there is depopulation of rural areas, and the structure of labor force is changed by sectors.

The last, mass consumption phase has been achieved only in a limited number of highly developed market economies, and any less developed country will certainly not come to it in the near future. Earlier or later, highly developed countries are reaching this stage as a result of significantly increased production opportunities created by new technologies, intensive application of knowledge and technical progress on it. This phase leads to a radically altered structure of creation of production, employment and concentration of power (Cvetanović, D., 2017).

Although Rostow's theory of developmental phenomena can be subjected to serious researches in various ways, the facts that have been confirmed on the basis of experience show a very high level of correlation between the achieved standard of living and the share of industrial production in GDP creation. In very poor countries, there is almost no industrial production, while in highly developed countries, 20-40% of available resources are engaged in industry. During the economic history it has been shown that the rapid growth of living standards has been created as a consequence of the abandonment of traditional agricultural production and the reallocation of available resources in industrial production. Also, experience shows that there is a high positive correlation between GDP growth rate and growth rate of industrial production, according to the principle: the rate of growth of industrial production is higher than the average growth rate of GDP, that is, the higher the growth rate of industry production than the average growth rate of GDP, the faster the growth rate of GDB, i.e. the faster the industry's share in GDP, the greater the opportunities for faster GDP growth (Jovanović-Gavrilović, 2013).

During the seventies of the previous century, partly because of dissatisfaction with the theoretical phase of Rostow's development, different versions of the theory of dependence appeared. In short, dependency theorists claim that developing countries are confronted with the institutional, economic and political environment. They depend in a certain way on economically developed countries. The theory of dependence also argues that the structural disadvantages of peripheral countries, such as isolation from the capitalist core, the

international division of labor and global trading conditions, are the main obstacles to their development, and not the lack of capital or skills. However, the theory of dependence is criticized for underestimating the internal problems of local economies of developing countries.

Parallel to the growing dissatisfaction with Rostov's economic growth stage at the end of the 1960s, the idea of sustainable development appeared, which was initially inspired by the limitations imposed by the economic activity on the physical environment and the attitude of researchers of economic development that plant and animal species and ecosystems should be used in a way that does not jeopardize their unlimited reproduction.

At the beginning of the 1980s, the prevailing opinion in the scientific and professional public was that the prevailing theories and policies of economic development were necessary in terms of taking into account the fact that unlimited economic growth manifests numerous negative consequences related to the depletion of natural resources and excessive environmental pollution. In part, and in response to the changed attitudes of the professional public in terms of economic growth and development, there was a formation of the World Commission on Environment and Development in 1983 by the United Nations Assembly. In 1987, this Commission submitted a report on important issues of global economic growth and development that threatened the global ecological system and inflicted serious damage under the name *Our Common Future*. In the report, sustainable development is defined as a development that meets the needs of the present without compromising the ability of future generations to undermine their own needs (Saks, 2014; Elliott, 2012; Pokrajac, 2009). This document is known in the broadest public as the Brauntland Report.

The determinants of the sustainable development paradigm are numerous. The following determinants are emphasized by their significance: anthropocentricity, long-term, spatial comprehensiveness, transparency of goals. It turns out that the paradigm of sustainable development encompasses the optimization of numerous interactions of nature, society and economy, not only according to the criteria of economy, but also ecology. Thus, the sustainability development paradigm implies economic growth that starts from the interaction of economics, technology and ecology in a way. By the nineties, the idea that development must be achieved in an environmentally friendly manner has become a standard within the framework of studies on economic development and environmental studies. The concept of sustainable development is based on the principle of intergenerational equity. It is incomparably the broader notion of economic growth and economic development, as it includes many aspects of environmental improvement, sustainable economy, sustainable use of energy, sustainable industrial activity, etc. In short terms, the category of sustainable development is an integral economic, technological, social and cultural development, in line with the need for environmental protection and the needs of future generations, as well as with the principles of the overall economic development policy.

There are three basic dimensions of sustainable development: ecological, economic and social. Ecological sustainability speaks of the elasticity or ecosystem sustainability. It denotes the requirement that the most significant environmental disruption factors, i.e., environmental change factors are kept under control. Key factors of ecological change are: destruction of the biosphere, i.e. pollution of air, water and land; resource constraints; demographic expansion; overcrowding, i.e. formation of megalopolis and metropolitan regions; nutrition problem. The economic aspect of sustainable development represents a new development paradigm, qualitatively different from all previous models of economic development. This development paradigm does not neglect the importance of the intensity of economic growth but it also emphasizes the importance of its quality. In essence, this concept marks an attempt to find the answer to the issue of underdevelopment by simultaneously addressing the problems of

growing devastation of natural resources and especially environmental degradation. Social sustainability refers to the avoidance of serious social conflicts resulting in a decline in economic activity, employment and income.

The basic problem of applying this concept stems from the fact that the proclaimed principles and key categories of sustainability paradigm are not far from the required operational level (Salas-Zapata, Rios-Osorio, Troughon-Osorio, 2013). In other words, it was necessary to make them real in a way that expresses the demands and contents of a concrete historical-geographical area. This is partly due to multilayers, i.e. multidimensionality of the phenomenon of sustainability, or the fact that it has more meanings that are, as a rule, in a conflicting situation. It is practically impossible to approach the simultaneous realization of all aspects of sustainability, which led to the need for a kind of settlement.

### **3. FOUR FORMS OF CAPITAL AS DRIVERS OF ECONOMIC DEVELOPMENT**

The ability to meet the needs of present and future generations depends, first of all, on the availability of capital. The requirement for sustainability is the preservation of total capital stock, assuming no technological progress or population growth. The key question is to what extent different components of total capital stock are interchangeable (Harris, Roach, 2018).

Four forms of capital that are most discussed in theory and in the policy of economic development are physical, human, natural and social capital. Physical and human capital is the result of man's work and is often referred to as anthropogenic capital. In the light of the defined goal of research in this paper, it is of particular importance that theoreticians of economic development view the possibility of their replacement in the process of accelerating the rate of economic growth. It should be noticed that this issue was specifically discussed at the World Summit on Sustainable Development in Johannesburg in 2002.

Physical capital is most commonly referred to as capital goods in macroeconomic literature. The key characteristic of capital goods is that they are the output in the previous production process, and input in the next one. The three most important categories of capital goods are: production equipment (machines, tools, etc.), construction facilities (factory and residential buildings, roads, railways) and stocks. Capital goods are a factor of production that is the result of the creativity of human labor. Their value determines the possibility of producing consumer goods.

Human capital includes knowledge and skills. Similar to physical capital and human capital, it represents the produced factor of production. Education is the process of "production" of human capital, while training, or the acquiring of skills, increases its value.

The concept of natural capital implies the extension of the classical notion of natural resources, that is, the country in terms of the production factor for the area of agriculture and the environmental content. In addition, the environment represents natural and created values whose complex interrelationships form an environment. Activities that affect the environment mean any permanent or temporary operation, which changes the states and conditions in the environment, and refers to: the use of resources; processes of production and traffic; distribution and use of materials; discharge (emission) of pollutants into water, air or land; waste and wastewater management, chemicals and harmful substances; noise and vibration; ionizing and non-ionizing radiation; accidents.

Physical capital is most commonly referred to as capital goods in macroeconomic literature. The key characteristic of capital goods is that they are the output in the previous

production process, and input in the next one. The three most important categories of capital goods are: production equipment (machines, tools, etc.), construction facilities (factory and residential buildings, roads, railways) and stocks. Capital goods are a factor of production that is the result of the creativity of human labor. Their value determines the possibility of producing consumer goods.

Human capital includes knowledge and skills. Similar to physical capital and of "production" of human capital, while training, or the acquiring of skills, increases its value (Andrejević Panić, 2015; Andrejević Panić, Ješić, 2016.). Human capital is a set of knowledge, skills, competencies and abilities embodied in individuals acquired through human capital, it represents the produced factor of production. Education is the process education, training, health care, migration of young and educated people (Benos, Zotou, 2014, 669). Newer approaches refer to the characteristics of people and society as components of human capital, which affect the effects of work, including factors such as ability, motivation and culture. Some experts extend the content of human capital to individual characteristics of people such as: creativity, innovation, attitudes (about life, business, etc.), diligence, responsibility, persistence, self-initiative, success in communication, problem-solving ability, critical thinking, independent learning, flexibility and adaptability. Thus, while the traditional approach emphasizes the level of education, training and health status of the population as its key attributes, the modern approach recognizes that human capital includes many social, political and economic dimensions of human activity. In the years from the end of the 20th century, the concept of human capital was expanded by incorporating into its content the categories of creativity, enthusiasm, innovation, happiness and well-being, communication skills, critical thinking, independent learning and the like (Cvetanovic, Panić, 2021, 13). The Covid-19 pandemic particularly emphasized the importance of the health status of the population in preserving human capital.

The concept of natural capital implies the extension of the classical notion of natural resources, that is, the country in terms of the production factor for the area of agriculture and the environmental content. In addition, the environment represents natural and created values whose complex interrelationships form an environment. Activities that affect the environment mean any permanent or temporary operation, which changes the states and conditions in the environment, and refers to: the use of resources; processes of production and traffic; distribution and use of materials; discharge (emission) of pollutants into water, air or land; waste and wastewater management, chemicals and harmful substances; noise and vibration; ionizing and non-ionizing radiation; accidents.

Social capital is the capital of cooperation, interaction, mutual trust and mutual assistance, which are formed during the economic relations of individuals, it cannot be privately owned and it has the attributes of the public good. It is not directly noticeable because people carry it in itself. Different environments differently support individual forms of social capital, due to which various economic evaluations are possible. Social capital consists of institutions, relationships, attitudes and values that govern interpersonal interactions and which contribute to economic and wider social development. It is a good part of the legal, political and institutional environment in which economic actors work, that is, they perform their functions and realize their goals. It is a capital of permanent and, to a certain degree, of institutionalized relationships between individuals and organizations, which facilitate activities and contribute to the creation of economic values (Milanović, 2009). The fact is that humans, as social beings accustomed to direct communication, find it difficult to experience isolation, spatial distance, and limited freedom of movement as inevitable consequences of the Covid-19 pandemic.

#### **4.CONCEPTS OF WEEK AND STRONG SUSTAINBILITY**

Awareness of the need to respect environmental criteria at all levels became dominant among leading political factors at the time. In 1983, the United Nations formed the Commission for Development and the Human Environment, headed by Swedish Prime Minister G. M. Brautland. In 1987, this body made an extremely comprehensive study on the most pronounced problems of global economic growth and development, which were accompanied by increasingly pronounced environmental requirements. According to it, the term sustainable development is defined as harmonizing the needs of the current generation without compromising the needs of future generations.

The implicit requirements of the concept of sustainability are:

- sustainable intergenerational economic wealth of people,
- ensuring the survival of the human species for as long as possible,
- striving for elasticity in production and economic system,
- biodiversity maintenance,
- ensuring community sustainability and
- stabilization of the biosphere.

Since sustainability has more meaning and content, what is sustainable for a particular community is what:

- enables sustainable economic growth and development,
- is socially acceptable,
- harmonizes the relationship and measure of economic and social development according to ecological capacities,
- is politically acceptable (may be subject to agreement in official institutions).

The idea of sustainable development is more convincing if it is interpreted as a way that an additional level of development can be socially unnecessary, if the environment is catastrophically degraded, if greater inequality in distribution leads to political unrest, and the like. A useful definition of unsustainable development could be that it is the development after which environmental damage influences economic growth. If development is defined as an increase in well-being, then sustainable development means not decreasing well-being over time. Sustainability implies responsible behavior towards future generations, regardless of the fact that they do not have the right to vote and cannot influence the creation of current policy.

The essence of the concept of sustainable development is the interaction of economic and social development and the environment, as well as the mutual conditionality and complementarity of economic development and environmental protection policies, which respect the laws of ecological systems. In other words, unlike all previous concepts of economic development, in the paradigm of sustainable development, economic goals lose their relative significance.

The imperative of sustainable development does not ignore the importance of economic growth, i.e. it does not neglect the necessity of a real increase in production. However, it rightly raises the question of the price of such growth. Actually, it makes sense to talk about the growth of production only under the condition that the increase in production does not lead to growing imbalances in the natural environment.

## **5. SUSTAINABILITY OF NATURAL CAPITAL**

Looking at the paradigm of sustainable development through the prism of preserving the total amount of capital, we come to the question of the concept of weak and strong sustainability. In short, the concept of weak sustainability allows substitution between natural and anthropological capital, provided that the total amount of capital does not decrease.

The essential difference between these two concepts is whether it is possible and to what extent to substitute between anthropogenic and natural capital.

The concept of strong sustainability implies a special observation of natural and anthropogenic capital. This form of separation of these two types of capital is more important than the concept of poor sustainability, because it practically eliminates the possibility of replacing one form of capital with another and, from a point of view concerning the economy of resources, it is more acceptable.

Proponents of strong sustainability argue that natural systems should remain intact wherever possible. They identify critical natural capital (such as water sources) as resources that need to be preserved in all circumstances. According to this view, for example, maintaining the natural fertility of the soil is essential even if degraded soil can be compensated by additional fertilization. According to a more moderate approach to weak sustainability, certain degradation or loss of natural capital is acceptable if the loss is compensated by the accumulation of produced capital. Each of these concepts of sustainability (and especially a strong version) implies that there are limits to economic growth. Economic activity that relies heavily on natural resources, raw materials and fossil fuels cannot grow infinitely (Cvetanović et al, 2013).

If our approach to strong sustainability would be more acceptable, we would separately take into account natural capital and anthropological capital and we would ensure against the depletion of natural capital funds. It would be acceptable, for example, to exclude forests in one area only if similar forests would spread in other areas, which would result in total forest funds remaining the same. Petroleum supplies can only be developed if simultaneously approximately the same capacity of alternative energy sources is developing. The application of strong sustainability would require extensive government intervention in the market and radical changes in the nature of economic activity.

An important justification for sustainability criteria is related to ecological complexity and irreversibility. Current ecological systems evolved over many centuries to achieve a balance that encompasses the interactions of thousands of animal and plant species, and to achieve delicate balanced physical and chemical relationships in the atmosphere, the oceans and freshwater and terrestrial ecosystems. Extensive exploitation of natural resources permanently alters this ecological balance with effects that are not fully predictable. In some cases, the disturbance of the ecological balance can lead to a disaster: the spread of deserts, the collapse of the ocean food systems, the destruction of the ozone layer, pollution of underground water reservoirs, the formation of pests that are resistant to insecticides and the like. Extinction of living species is a clear example of irreversible damage caused by unknown environmental and economic costs in the future. Environmental economists therefore advocate the principle of taking precautionary measures: we should strive for minimal interference with the functioning of natural systems, especially when we cannot anticipate long-term effects. This principle obviously defies simple definitions of economic value calculation and resource use. Such budgets, therefore, have value only if we place them in a wider context, whose priorities sometimes need to bridge the logic of the market equilibrium.

The increase in capital produced in reality causes additional depletion of natural resources. If unlimited substitution between produced and natural capital is allowed, then natural

resources will ultimately be depleted due to the creation of produced capital. Therefore, representatives of environmental economic theory advocate the concept of strong sustainability. They believe that natural and produced capital are complements in the production process. In their view, proponents of poor sustainability do not attach sufficient importance to the depletion of natural resources and environmental pollution, which can limit social well-being regardless of the overall level of capital. Therefore, the parts of the environment that are necessary for the regulation of ecosystems must not be substituted by the produced capital. The basic rule of strong sustainability dictates that natural capital stocks must be constant over time. This minimizes the accumulation of hazardous waste and ensures the availability of stable inputs for future production processes of future generations.

## **6. COVID-19 PANDEMIC AND CONCEPTS OF WEAK AND STRONG SUSTAINABILITY**

The Covid-19 virus pandemic has not been over yet. Moreover, the assumptions of its escalation in the fall of 2021 are very realistic. It is understandable, therefore, that the consequences of the current pandemic on the economy and society are far from being registered, or quantified. It is indisputable, however, that the negative effects of the crisis caused by the Covid-19 virus are extremely visible in the field of economy. They are primarily reflected in the reduction of production, transport and sales. With the rise in unemployment, consumption decreased, which, in accordance with the Keynesian sequence of economic events, further slowed down aggregate production. Numerous service industries are still facing huge labor surpluses and large losses.

The most pronounced change in the period of global isolation was the decline in CO<sub>2</sub> emissions due to reduced human activity. This has resulted in improved air quality, in the countries most affected by the Covid-19 virus, but also globally.

The positive effects of the pandemic include a temporary reduction in the use of fossil fuels, especially in industry and transportation, including air transport, which has led to a short-term decline in carbon dioxide emissions. Due to the restriction of industrial production, a decrease in nitrogen dioxide is also noticeable.

The positive effect of the slowdown in industrial production was also reflected in natural watercourses, which, by self-purification, could mitigate the harmful effects of wastewater flowing into them. The beneficial effect of the current crisis on the state of the environment can be seen through the reduction of noise levels due to quarantine and the interruption of many economic and social activities of people. The reduction of noise levels was also affected by the fact that numerous economic activities took place outside the employer's headquarters, that social distance was maintained, as well as the fact that direct communication was replaced by electronic.

A noticeable negative impact is present in the waste management sector. The fight to reduce the use of disposable plastic was further aggravated by a new source of pollution - disposable protective equipment (masks, gloves, spacesuits, bedding from Covid hospitals) which ends up in rivers and oceans due to improper disposal. Also, because of the difficulty in transportation, there was an increase in food waste due to the expired shelf life of the product. This is the reason why some countries should, in the period of recovery until 2030, harmonize their public policies with the needs of environmental protection and the fight against climate change. In short, they should motivate the representatives of the economy through regulatory and economic instruments to turn to sustainable investments, waste reduction, i.e. to use raw

materials through maximum models in circular economy models and to reduce CO<sub>2</sub> production and use of non-renewable natural resources through energy efficiency. Access to resources is important for any economy, so recycling is imposed as a necessary measure (and activity) that will reduce the need for resources and their shortage. The application of renewable energy sources and other low-carbon technologies can increase the resilience of energy supply (Radić et al, 2020, str. 145).

The Covid-19 pandemic can certainly be considered a negative exogenous shock whose effects are spreading through the economic system. It can be said with certainty that the shock of the pandemic hit the economy both from the side of aggregate demand and from the side of the total supply, which makes the issue of purposeful anti-crisis measures design especially sensitive (Prašćević, 2020). Demand is affected by a significant reduction in all its components. Now, households spend only on basic needs - food, medicine, possibly protective equipment. Entrepreneurs' investments have been reduced, as well as temporary capital expenditures of the state. Most states are increasing their spending on the health care system and on increasing hospital capacity.

An even more drastic example is the impact of the pandemic on aggregate supply. Namely, the recession caused by Covid - 19 was primarily caused by the shock of aggregate supply, in contrast to the Great Global Recession (2007-09) and the Great Depression (1929-30), which were caused by the fall in aggregate demand. This is due to the fact that many economic entities have reduced or completely stopped production since entire parts of the world have been quarantined. This has caused problems in a globalized world characterized by global supply and production chains. All this will have consequences for productivity and aggregate supply.

## 7. CONCLUSION

In the early 1960s, in the scientific and professional public, the prevailing view was that it was necessary to reconsider the previous economic development theories in the sense of the necessity to appreciate the fact that unlimited economic growth exhibits unacceptable negative changes on a global scale. The determinants of the paradigm of sustainable development are numerous. Its significance emphasizes the following: anthropocentricity, long-term, spatial comprehensiveness, transparency of goals. It turns out that the paradigm of sustainable development encompasses the optimization of numerous interactions of nature, society and economy, not only according to the criteria of economy, but also ecology. Thus, the sustainable development paradigm implies economic growth that starts from the interaction of economy, technology and ecology in a way that respects the requirements of the environment, as well as requirements of intergenerational and intragenerational justice.

Looking at the paradigm of sustainable development through the prism of preserving the total amount of capital, we come to the question of the concept of weak and strong sustainability. In short, the concept of poor sustainability allows substitution between natural and anthropological capital, provided that the total amount of capital does not decrease. The concept of strong sustainability implies a special observation of natural and anthropogenic capital. The concept of strong sustainability practically eliminates the possibility of replacing one form of capital with others in the production process, and from a standpoint of the development economy in the longer term, it is more acceptable.

In the light of the defined subject of research in this paper, it is important to point out that the crisis caused by the Covid-19 virus further shook the basic postulates of neoliberal economic theory. Neoliberal views on the expediency of unrestrained market action, on the



one hand, and the unlimited substitutability of produced and natural capital of the environment, on the other hand, have been further called into question. The crisis caused by the Covid-19 virus is without a doubt a serious warning that it is necessary to re-examine confidence in the exclusively progressive future of the human species.

The initiated mechanism of insecurity as an inevitable companion of the pandemic has left numerous negative consequences on almost all social and political events in the world. At the time of the Covid-19 virus pandemic, the relevance of sustainable development goals is becoming even more pronounced. Climate change, waste disposal, greenhouse gas emissions, biodiversity conservation and similar phenomena affect all segments of social life. The world is facing a great challenge, the climate crisis in the future, which scientists warn about and which can cause fatal consequences for the economy and security of the population. The negative socio-economic effects of the health crisis are almost marginal in relation to the potential climate crisis and the global loss of biodiversity.

## REFERENCES

- Andrejević Panić, A. 2015. Analiza usklađenosti visokog obrazovanja sa tržištem rada uz primenu strategije Evropa 2020, *Strukturne promene u Srbiji*. Beograd: Institut ekonomskih nauka, str.416-430.
- Andrejević Panić, A., Ješić, J. 2016. Mogućnosti primene principa četverostrukog heliks modela u visokom obrazovanju. *Pravci strukturnih promena u procesu pristupanja Evropskoj uniji*, Beograd: Institut ekonomskih nauka, str. 285-298
- Cvetanović, S., Andrejević Panić, A. 2021. Ljudski kapital u endogenoj teoriji ekonomskog rasta regiona, *Regionalni razvoj i demografski tokovi zemalja Jugoistočne Evrope*, Niš: Niš, Srbija, 11-18.
- Cvetanović, S. Novaković, I. 2019. *Makroekonomija i makroekonomski menadžment*, Niš: Niški kulturni centar.
- Cvetanović, D. 2017. *Pomeranje globalne industrijske moći*. Beograd: Ekonomski institut.
- Cvetanović, L., Leković, V., Mladenović, I. 2013. Potrebe i mogućnosti održivosti privatnog kapitala, *Teme*, . Vol. 37, Vol. 1, strp. 479-496
- Benos, N, Zotou, S. 2014. *Education and Economic Growth: A Meta-Regression Analysis*. World Development, 64, 669-689.
- Dragutinović, D., Filipović, M., Cvetanović, S. 2015. *Teorija privrednog rasta i razvoja*. Beograd: Ekonomski fakultet Univerziteta u Beogradu.
- Elliott, J. 2012. An introduction to sustainable development. Routledge.
- Harris, J., Roach, B. 2018. *Environmental and Natural Resource Economics: a Contemporary Approach*. Florence: Taylor and Francis.
- Jovanović-Gavrilović, B. 2013. *Privredni razvoj sa ljudskim likom*. Beograd: Ekonomski fakultet, Univerzitet u Beogradu.
- Jurčić, Lj. 2021. Izazovi svjetskoga gospodarstva, *Ekonomska politika Hrvatske u 2021.*, Hrvatsko društvo ekonomista, Zagreb, str. 1-20.
- Milanović, M. 2009. *Ekonomija prirodnih resursa*. Beograd: Megatrend univerzitet.
- Pokrajac, S. 2009. Održivi razvoj i ekološka ekonomija kao poslovne paradigme. *Škola biznisa*, 20, 21-30.
- Prašćević, A. 2020. Ekonomski šok pandemije Covid 19 – prekretnica u globalnim ekonomskim kretanjima, *Ekonomske ideje i praksa*, broj 37, 7-22.

- Radić, V, Stevanović, M., Radić, V. 2020. Životna sredina i resursi – globalni trendovi i odrazi na ekonomiju do 2050. godine, *Ecologica*, Vol. 27. No. 97, str. 141-146.
- Saks, Dž. 2014. *Doba održivog razvoja*. Beograd, JP Službeni glasnik, Centar za međunarodnu saradnju i održivi razvoj-CIRSD.
- Salas-Zapata, W., Rios-Osorio, L., Troughon-Osorio, A. 2013. Typology of scientific reflections needed for sustainability science development. *Sustainability science*, 8(4), 607-612.
- Todaro, M., Smith, S. 2015. *Economic Development*. Pearson.

UDK 616.98:578.834]:338.1  
330.15:556  
502.131.1:556  
COBISS.SR-ID 57315081

## THE IMPACT OF THE COVID-19 PANDEMIC ON THE ECONOMY, WATER RESOURCES AND SUSTAINABLE DEVELOPMENT

Milan Tucaković<sup>1</sup>  
Dragoljub Bajić<sup>2</sup>  
Dušan Polomčić<sup>2</sup>

<sup>1</sup>University of Belgrade, Faculty of Mining and Geology  
<sup>2</sup>Correspondence: dragoljub.bajic@rgf.bg.ac.rs

### ABSTRACT

*The entire world is struggling with the COVID-19 pandemic. It is a major challenge because the SARS-CoV-2 virus spreads quickly. The pandemic has led to lockdowns and human activity has been reduced in an attempt to minimize transmission. Compared to other pandemics, COVID-19 is probably the worst in modern history because of the number of deaths, hindrance of human activity and adverse effect on the global economy. The paper discusses the impact of the COVID-19 pandemic on water resources. It presents possible scenarios of groundwater contamination with wastewater that carries the SARS-CoV-2 virus and addresses the effect of lockdowns on the water sector.*

### KEYWORDS

*Lockdown, groundwater contamination, water sector*

## 1. INTRODUCTION

Water plays a major role in human health. However, water often contains pollutants of natural (geologic) or anthropogenic origin. Most countries are experiencing an increasing number of illnesses and fatalities caused by drinking water of inadequate quality. The water demand is increasing due to population growth and intensifying activities in various sectors, such as industry, agriculture and households.

Pollution is a serious challenge facing the entire world and particularly developing countries. Increasing human activity is having several adverse effects on the environment, including aquatic ecosystems. Heavy metals are highly persistent in nature because of their low biodegradability; they can be extremely toxic in high concentrations (Verma, 2020). The presence of organic pollutants and pathogens also creates major issues. When found in aquatic environments, these pollutants can have a negative effect on plants, domestic animals, people and the food chain (Yan et al. 2019).

Efficient water resources management is one of the most important aspects of sustainable development. Groundwater management is an integral part of efficient water resources

management. It is highly complex because groundwater is not a “visible” resource and detailed investigations are required to determine available quantities. Numerical models are often used to quantify groundwater. The hydrodynamic model applied to determine the infiltration parameters, water budget and groundwater reserves of the Vić Bare alluvial aquifer is an example (Polomčić et al. 2013). Hydrodynamic models are also used to design drainage systems that dewater mines (Polomčić et al. 2015) and assess the impact of floods on the groundwater regime (Polomčić et al. 2018). One of the comprehensive and state-of-the-art approaches to groundwater management is multicriteria analysis based on fuzzy logic (Bajić et al. 2017, Polomčić et al. 2017, Bajić et al. 2020, Polomčić et al. 2019).

Adding to pre-existing challenges, the COVID-19 pandemic has become a significant water quality issue. More than 200 countries worldwide have been combatting COVID-19 since January 2020. It has top priority in most countries. As a result, the scientific community has published more than four million articles on COVID-19 (according to a Google Scholar search of COVID-19 on 30 June 2021). They address a broad range of topics related to COVID-19, focusing on the perspectives of various scientific disciplines such as medicine, biology, tourism, socioeconomics, and environmental studies (Casado-Aranda et al., 2020). An important question that has arisen from the COVID-19 pandemic is whether aquatic ecosystems play a direct or indirect role in the spread of this disease and, if so, under what conditions?

The objective of the paper is to discuss the impact of the COVID-19 pandemic on water resources and the water sector. Since no detailed investigations of the impact of the pandemic on water resources have been undertaken in Serbia, the paper refers to the results reported by El-Ramady et al. (2020), who studied possible interactions between the SARS-CoV-2 virus and water, as well as those of Butler et al. (2020), who studied the effect of the COVID-19 pandemic on the water sector under the auspices of the International Finance Corporation, a member of the World Bank Group.

## **2. GROUNDWATER AND COVID-19**

Water scarcity is a global problem, especially in arid and semi-arid regions. Conserving sources of clean and safe drinking water is of critical importance worldwide. Groundwater is the primary drinking and irrigation water source in many countries, with a major role in the preservation of natural terrestrial ecosystems (Huang et al. 2019). As a result of global climate change, involving temperature increase and redistribution of precipitation, groundwater recharge has decreased in many countries and water salinity has increased. Groundwater pollution has attracted global attention over the past decade due to the frequency and potentially adverse effects on aquatic ecosystems and human health (Kuroda & Kobayashi, 2021). Numerous studies focus on groundwater pollution and remediation.

By contrast, only a few studies dealing with COVID-19 and groundwater have been published in the previous period. Patni and Jindal (2020), Núñez-Delgado (2020) and Steffan et al. (2020) discuss a potential indirect impact of COVID-19 on groundwater. Patni and Jindal (2020) speak of certain positive effects. More specifically, they conclude that groundwater volume and quality have improved during the pandemic due to the decline in human activity. Research that focused on the impact of lockdowns on groundwater has been conducted in India. In one example (Punjab, India), Krishan et al. (2021) examine the effect of lockdown on the salinity of shallow and deep groundwater. In another, Aravinthasamy et al. (2021) assess the impact of lockdown on heavy metal concentrations and microbiological parameters of shallow groundwater in Coimbatore, southern India. Both studies conclude that

lockdowns have had a positive impact on groundwater quality. Núñez-Delgado (2020) and Steffan et al. (2020) discuss adverse effects of COVID-19 on the groundwater system, primarily the occurrence of waterborne SARS-CoV-2 in groundwater due to contact with contaminated wastewater. There are a few open questions relating to the connection between groundwater and COVID-19, such as those about its direct and indirect effects on global groundwater resources. Does groundwater play a role in the spread of COVID-19? What are the positive and negative effects of COVID-19 on global groundwater resources? And how much protection do geologic strata that overlie aquifers provide against contamination with SARS-CoV-2?

## **2.1 COVID-19 and contaminated wastewater**

Wastewater has been defined as water originating from households, public institutions, and industries that do not require specific wastewater treatment (Lahrich et al. 2021). Wastewater can be a source of pathogens, such as that discharged by hospitals and households. According to WHO (World Health Organization), roughly 80% of global human diseases are waterborne. Every year, 1.5-12 million fatalities are attributed to waterborne diseases, including cholera, diarrhea, typhoid and viral hepatitis (Bhatt et al. 2020). Lethal viral illnesses include gastroenteritis and respiratory diseases like COVID-19 caused by the SARS-CoV-2 virus (Cao, 2020). Recent studies have demonstrated the presence of SARS-CoV-2 in wastewater (Mallapaty, 2020; Lodder and Husman, 2020; Ahmed et al., 2020; Wu et al. 2020; Bhatt et al. 2020). It has been suggested that surface water and groundwater bodies should be checkpoints for SARS-CoV-2 due to wastewater discharges and contamination coming from health facilities, sewage and drained water (Kumar et al. 2020a). As such, the transmission pathways of SARS-CoV-2 associated with water need to be identified in order to prevent a further rapid spread of the disease (Bhatt et al., 2020). According to WHO, SARS-CoV-2 can reach an aquifer by different routes, such as feces, evacuated wastewater and infiltration from the land surface. Because it is known that SARS-CoV-2 is airborne and has also been registered in water sources, the possibility of transmission through aquatic and non-aquatic environments needs to be examined closely.

Multiple studies have addressed the transmission and fate of SARS-CoV-2 in wastewater. Some of the important topics include:

- Detection and distribution of the SARS-CoV-2 virus in wastewater (Lahrich et al. 2021).
- The roles of water, salinity and hygiene in the spread of COVID -19 via the fecal-oral route, particularly in low-income countries. It is currently assumed that COVID-19 spreads through respiratory and contact transmission; however, the fecal-oral route has also been suggested as a transmission pathway of SARS-CoV-2, from the human stomach to feces and wastewater (Bhatt et al. 2020).
- The occurrence and persistence of SARS-CoV-2 in various environment and the conditions that favor the survival of the virus in water/wastewater/sewage have not yet been determined, because of evidence of transmission of the contagious virus in communities (Ihsanullah et al. 2020; Mohan et al. 2021),
- Potential secondary transmission of SARS-CoV-2 through wastewater and reducing the risk of transmission by limiting COVID-19 resurgence. Future research should focus on the virus in different aquatic environments (Liu et al. 2020).
- The consequences of SARS-CoV-2 in river water and groundwater that are hydraulically connected to surface waters, in countries with poor sanitary conditions, including major

SARS-CoV-2 loading from urban environments, and how the level of wastewater treatment can affect the risk of COVID-19 (Guerrero-Latorre et al. 2020).

- Epidemiological monitoring of wastewater for the SARS-CoV-2 virus might be an efficient detection technique, but it requires an effective method for SARS-CoV-2 RNA recovery from wastewater (Al Huramiel et al. 2020; Bhatt et al. 2020; Kitajima 2020).

- The seasonality of SARS-CoV-2 and its fate in the environment, transport, inactivation and resistance to antiviral drugs; SARS-CoV-2 is transmissible as a fecal virus through wastewater, surface water and groundwater, leading to human potential exposure (Kumar et al 2020b).

- Environmental conditions conducive to SARS-CoV-2 transmission, such as air temperature and humidity, might control the ability of SARS-CoV-2 to survive in droplets; the fecal-oral route might be a pathway for COVID-19 transmission from contaminated water bodies; and chlorination will not remove/inactivate SARS-CoV-2 fully or effectively (Mohapatra et al. 2020).

Based on research undertaken to date, the main two aspects that likely control the fate of SARS-CoV-2 in aquatic environments are its survival and migration. Enveloped viruses, such as SARS-CoV-2, can be quite mobile in subsurface environments (e.g., groundwater). Transport mechanisms and pathways that affect a water source and its interaction with soil properties (e.g., infiltration rate, soil pH, ionic strength and viral adsorption), as well as the characteristics of overlying sediments, protect groundwater systems from contamination (Kumar et al. 2020a).

In addition to the above, two studies focused on the effect of the COVID-19 pandemic on groundwater quality in India.

- For a study conducted in Punjab, 48 groundwater samples were collected in three major industrial districts (Ludhiana, Jalandhar and Moga). Thirteen samples were from shallow aquifers (<50 m) and 35 from deep aquifers (50–200 m). Sampling was undertaken after lockdown, in the pre-monsoon season (June 2020). The total dissolved solids (TDS) of these samples were compared to those recorded during the monsoon season (August 2020) and post-monsoon season (November and December 2019), to assess the effect of lockdown on groundwater salinity.

- The second study found a positive effect of COVID-19 lockdown on heavy metal concentrations and biological parameters of samples of shallow groundwater in the city of Coimbatore, southern India. The samples (n=15) were collected from shallow wells before and after lockdown (24/25 February and 2/3 June 2020). The samples were analyzed for heavy metals (Fe, Mn, Ni, Cr, Pb) and microbiological parameters (E. coli, fecal coliforms, fecal streptococci and total coliform bacteria) (Aravinthasamy et al. 2021) (Krishan et al. 2021).

Some diseases are caused by waterborne viruses. SARS-CoV-2 has already been detected in wastewater, but further investigations are needed to determine the fate and transmission in water systems. Some of the important questions are whether transmission of COVID-19 through water is possible, how to decrease the occurrence of SARS-CoV-2 in wastewater, what are the risks of COVID-19 transmission through drinking water and water supply/distribution systems, and how much groundwater protection is provided by overlying strata? There are several challenges facing the world with regard to aquatic environments and their connection with COVID-19. Will lockdowns implemented due to the COVID-19 pandemic have a positive effect on addressing environmental problems such as air and water pollution? Or will they aggravate these issues in the future? Such questions constitute serious challenges for all countries, but they concern developing countries in particular.

### **3. IMPACT OF THE COVID-19 PANDEMIC ON THE WATER SECTOR**

Butler et al. (2020) discuss several exceptions and how COVID-19 is reflected in reduced water sector investments across the world. The pandemic has also elevated the importance of operational reliability due to the cost of disruption. Operational requirements originate from work shifts, water demand patterns, supply disruptions and various extraordinary measures implemented by governments to combat the pandemic.

The poorest countries in the world are experiencing a COVID-19 shock in addition to pre-existing issues with urban water supply and sanitation, leading to a potentially overwhelming burden. Low levels of access, reliability and quality of water supply, as well as sanitation and hygiene, constitute risks in developing countries. Large cities are also faced with risks associated with population density and illegal development. A recent World Bank facility that identifies pandemic hotspots has pointed out that crowded living conditions and inadequate public services, especially inefficient waste management and sanitation, are major sources of contagion risk in large and growing cities such as Cairo and Mumbai.

Big water consumers have decreased their activity, which has resulted in a reduced industrial water demand. The reduced water demand of large industrial and commercial users due to lockdown and travel restrictions will decrease water utility revenues. According to Global Water Leaders Group's research, industrial water demand will decrease by 27%, on average, due to the COVID-19 pandemic.

A number of countries have instituted crisis management measures that will affect revenues. Globally, partial suspension of collection from low-income users and moratorium on water service cut-offs are the most common crisis responses. Specific measures include (a) delay or exemption from payment of utility bills for vulnerable groups, (b) suspension of water service cut-offs substantiated by the need for hygiene in order to curtail the spread of the virus, and (c) deferral of meter reading and billing.

For example, the Chilean water supply utilities have reached an agreement with the government to postpone water and wastewater billing for nearly half of its lowest income clients, who consume up to 10 cubic meters of water per month, for the duration of the "state of catastrophe". The amounts accrued during this period will be paid in equal interest free-installments over the next 12 months. In Brazil, water supply utilities have instituted three months of exemption/no charge for low-income households, a three-month tariff adjustment delay, and drinking water donations.

These measures have shrunk water utility revenues. The Global Water Leaders Group (<https://www.watermeetsmoney.com/global-water-leaders-group/>) believes that water suppliers and water treatment plants can expect a decline in revenues of 15%, on average, due to the COVID-19 crisis. In the mid-term, well-managed markets will likely compensate their losses through monthly installments, government transfers or tariff adjustments. These measures might have an effect on utility management and users' payment culture, especially if they are in place for a long time.

Capital expenditures (CapEx) will decrease in both short and mid term. New capital projects will probably be deferred because municipalities will prioritize operating expenses (OpEx) and emergency response. Global Water Intelligence (GWI) estimated that water sector CapEx will decrease in 2020 and 2021, and thereafter possibly revert to pre-crisis forecasts. CapEx projections for 2020 expected a 7% decrease. It is currently unclear to what extent water supply and sanitation CapEx will shrink and how much time will be needed to revert to pre-crisis levels.

Operations could be affected by a higher risk of infection among utility personnel, including both routine and construction work. The continuity and flexibility of operations are of key importance for ongoing water supply and sanitation services, while simultaneously moving forward any construction that had already begun. Many governments have designated people working in the water and sanitation industry as essential workers, thus ensuring continuity of service. However, social distancing protocols necessitate that only critical personnel be kept on site. Logistics and supply chain disruptions have been reported.

Evidence from markets in which IFC operates indicates that financially strong utilities are coping. Most of them are experiencing a short-term revenue shortage and unfavorable borrowing conditions. However, these companies are generally able to bridge cash flow gaps and at the same time continue implementing pre-crisis CapEx plans, albeit with some delay or modifications to financial plans.

### **3.1 Crisis response**

According to Butler et al. (2020), countries coping with historic drinking water supply gaps and lack of access to water are resorting to emergency measures, such as water trucks. For example, South Africa has set up water supply points for hand washing across the country. Ghana and Peru have implemented similar measures. In the mid and long term, the clear lesson learned from the crisis is that water supply and sanitation in insufficiently covered areas need to be expanded and improved. COVID-19 has accelerated project approval in several markets because the pandemic is stressing the importance of water supply and sanitation. Such projects are also part of economic incentives for the public, given the planned level of spending in countries like South Africa.

In response to COVID-19, IFC has been proactive in three water sector areas:

- Crisis response for existing clients. IFC is providing liquidity financing for rapid response facilities to assist long-term clients who have demonstrated strong operational and financial performance and are now facing a decrease in revenues and more stringent liquidity criteria of commercial banks.
- Long-term CapEx support to water supply companies, to build resilience. IFC is providing long-term financing to support water companies that are undertaking critical capital projects which ensure continuity of service in the short and mid term.
- Exchange of knowledge and capacity building. IFC hosts webinars for water companies on crisis recovery, along with World Bank's Water Global Practice.

### **3.2 Prospects**

According to Butler et al. (2020), COVID-19 has highlighted the importance of access to safe and reliable water supply. Capital projects can be deferred, but economic incentives might mitigate decreasing revenues for CapEx financing. Stakeholders should attempt to re-assess water sector priorities after decades of inadequate investment and lack of political prioritizing of water.

The permanent lessons learned about crisis preparedness and resilience of personnel, systems and equipment might lead to increased spending on digital solutions. The pandemic might also help boost the implementation of automation and remote control, which are becoming increasingly important at times such as these. Given the effect of COVID-19, GWI estimates that global spending on digital solutions will grow by 8% per annum on average, from 32 billion in 2019 to 47 billion US dollars by the year 2024.



Today's automated user interfaces might change the future culture. Social distancing due to COVID-19 will prompt suppliers and customers to avoid contact with service centers and give priority to other channels of engagement. More user and useful interactions will take place via telephone, web applications or the internet, which is often the case.

IFC intends to implement initiatives to provide water sector support in the following areas: (a) continuity of investment in essential CapEx and progress toward SDG 6, (b) digitizing and energy efficiency improvement in water utilities, to build future resilience, (c) more water recycling as a viable solution for water scarcity and strengthening of upstream activities to create markets, and (d) systematic development of investment in infrastructure by structuring private-investment risk mitigation mechanisms such as hybrid annuity models, World Bank Group guarantees or mixed finance.

With regard to groundwater, efficient use, detailed investigations, resource quantification, feasibility of regulation and, of course, conservation and reduction of pollution of this valuable resource should be the future focus. In addition, awareness needs to be raised about the importance of groundwater, given that an increasing number of countries are facing water scarcity.

#### **4. CONCLUSION**

The COVID-19 pandemic has emphasized the importance of sanitary conditions and adequate drinking water. Given that the SARS-CoV-2 virus reaches wastewater through human excretions and that such wastewater might come in contact with surface water and groundwater, there is a high risk of waterborne transmission. This aspect has not been examined in detail, but in view of the high risk comprehensive investigations should begin as soon as possible.

The water sector, like other sectors, has been affected by the COVID-19 pandemic. The paper presented several responses of this sector (under the auspices of the IFC/World Bank Group) to the current emergency situation, from both technical and customer relations perspectives. Adverse effects of the pandemic on the water sector include shrinkage of water utility revenues, hindrance of ongoing investigations and infrastructure expansion, and the like. On the other hand, there have been some positive effects, such as a decrease in water demand, particularly of the industrial sector, which has in turn reduced industrial wastewater discharges. The pandemic has shown that the water sector must operate efficiently in emergencies. It has also highlighted potential shortfalls and possible aspects of more efficient use of water, as well as innovation in the water sector.

It has become clear that the COVID-19 pandemic is the longest and possibly worst pandemic that has befallen humankind. In addition to its impact on human health, the pandemic has virtually halted human day-to-day activities. Temporary suspension of industrial, agricultural and other essential activities has had a major impact on the economy. However, there are also some positive effects of the COVID-19 pandemic. For example, there has been a substantial decrease in harmful gas emissions and quantities of solid waste and wastewater, resulting in improved environmental conditions. There are reports of groundwater quality improvement in some parts of India. Given that the situation is now beginning to stabilize and as the world slowly returns to normal, strategies need to be developed to avoid similar scenarios in the future or at least minimize their impact.

## REFERENCES

- Ahmed W., Angel N., Edson J., Bibby K., Bivins A., O'Brien JW., Choi PM., Kitajima M., Simpson SL., Li J., Tschärke B., Verhagen R., Smith WJM., Zaugg J., Dierens L., Hugenholtz P., Thomas KV., Mueller JF. (2020) First confirmed detection of SARS-CoV-2 in untreated wastewater in Australia: a proof of concept for the wastewater surveillance of COVID-19 in the community. *Sci. Total Environ.* 138764, <https://doi.org/10.1016/j.scitotenv.2020.138764>.
- Al Huraimel K., Alhosani M., Kunhabdulla S., Stietiya MH. (2020) SARS-CoV-2 in the environment: Modes of transmission, early detection and potential role of pollutions. *Science of the Total Environment* 744, 140946. <https://doi.org/10.1016/j.scitotenv.2020.140946>.
- Aravinthasamy P., Karunanidhi D., Shankar K., Subraman T., Setia R., Bhattacharya P., Das S. (2021) COVID-19 lockdown impacts on heavy metals and microbes in shallow groundwater and expected health risks in an industrial city of South India *Environmental Nanotechnology, Monitoring & Management* <https://doi.org/10.1016/j.enmm.2021.100472>
- Bajić D., Polomčić D. & Ratković J. (2017). Multi-criteria decision analysis for the purposes of groundwater control system design. *Water Resources Management*, 31(15): 4759-4784. DOI: 10.1007/s11269-017-1777-4
- Bajić S., Bajić D., Gluščević B. & Ristić Vakanjac V. (2020). Application of Fuzzy Analytic Hierarchy Process to Underground Mining Method Selection. *Symmetry*, 12(2): 192. DOI: <https://doi.org/10.3390/sym12020192> ISSN: 2073-8994
- Bhatt A., Arora P., Prajapati SK. (2020) Occurrence, fates and potential treatment approaches for removal of viruses from wastewater: A review with emphasis on SARS-CoV-2. *Journal of Environmental Chemical Engineering*, 8, 104429. <https://doi.org/10.1016/j.jece.2020.104429>.
- Butler G., Pilotto R.G., Hong Y., Mutambastere E. (2020) The Impact of COVID-19 on Water and Sanitation Sector. International Finance Corporation, World Bank Group, [www.ifc.org/infrastructure](http://www.ifc.org/infrastructure).
- Cao X. (2020) COVID-19: immunopathology and its implications for therapy, *Nat. Rev. Immunol.* 20,269-270, <https://doi.org/10.1038/s41577-020-0308-3>.
- Casado-Aranda L-A., Sanchez-Fernandez J., Viedmadel-Jesús MI. (2020) Analysis of the scientific production of the effect of COVID-19 on the environment: A bibliometric study. *Environmental Research*, <https://doi.org/10.1016/j.envres.2020.110416>.
- El-Ramady H., Eid Y., Brevik E.C. (2020) New Pollution Challenges in Groundwater and Wastewater Due to COVID-19. *J. Sus. Agric. Sci.* Vol. 46, No. 4. pp 61-73 (2020). DOI: 10.21608/jsas.2020.51353.1257
- Guerrero-Latorre L., Ballesteros I., Villacrés- Granda I., Granda MG., Freire-Paspuel B., Ríos- Touma B. (2020) SARS-CoV-2 in river water: Implications in low sanitation countries. *Science of the Total Environment*, 743, 140832. <https://doi.org/10.1016/j.scitotenv.2020.140832>.
- Huang F., Zhang Y., Zhang D., Chen X. (2019) Environmental Groundwater Depth for Groundwater-Dependent Terrestrial Ecosystems in Arid/Semiarid Regions: A Review. *Int J Environ Res Public Health*. 16 (5), 763. <https://doi.org/10.3390/ijerph16050763>

- Ihsanullah I., Bilal M., Naushad M. (2020). Coronavirus 2 (SARS-CoV-2) in water environments: Current status, challenges and research opportunities. *Journal of Water Proces Engineering*, <https://doi.org/10.1016/j.jwpe.2020.101735>
- Kitajima M., Ahmed W., Bibby K., Carducci A., Gerba CP., Hamilton KA., Haramoto E., Rose JB. (2020) SARS-CoV-2 in wastewater: State of the knowledge and research needs. *Science of the Total Environment* 739, 139076. <https://doi.org/10.1016/j.scitotenv.2020.139076>.
- Krishan G., Sudarsan N., Sidhu B.S., Vashisth R. (2021) Impact of lockdown due to COVID-19 pandemic on groundwater salinity in Punjab, India: some hydrogeoethics issues. *Sustainable Water Resources Management* <https://doi.org/10.1007/s40899-021-00510-2>
- Kumar M., Mazumder P., Mohapatra S., Thakur AK., Dhangar K., Taki K., Mukherjee S., Patel AK., Bhattacharya P., Mohapatra P., Rinklebe J., Kitajima M., Hai FI., Khursheed A., Furumai H., Sonne C., Kuroda K. (2020b) A chronicle of SARS-CoV-2: Seasonality, environmental fate, transport, inactivation, and antiviral drug resistance. *Journal of Hazardous Materials*, <https://doi.org/10.1016/j.jhazmat.2020.124043>.
- Kumar M., Thakur AK., Mazumder P., Kuroda K., Mohapatra S., Rinklebe J., Ramanathan A., Cetecioglu Z., Jain S., Tyagi VK., Gikas P., Chakraborty S., Islam MT., Ahmad A., Shah AV., Patel AK., Watanabe T., Vithanage M., Bibby K., Kitajima M., Bhattacharya P. (2020a) Frontier review on the propensity and repercussion of SARS-CoV-2 migration to aquatic environment. *Journal of Hazardous Materials Letters*. 1: 100001. <https://doi.org/10.1016/j.hazl.2020.100001>.
- Kuroda K., Kobayashi J. (2021) Pharmaceuticals, Personal Care Products, and Artificial Sweeteners in Asian Groundwater: A Review. In: M. Kumar et al. (Eds.), *Contaminants in Drinking and Wastewater Sources*, Springer Transactions in Civil and Environmental Engineering, [https://doi.org/10.1007/978-981-15-4599-3\\_1](https://doi.org/10.1007/978-981-15-4599-3_1), pp: 3-36. Springer Nature Singapore Pte Ltd.
- Lahrich S., Laghrib F., Farahi A., Bakasse M., Saqrane S., El Mhammedi MA. (2021) Review on the contamination of wastewater by COVID-19 virus: Impact and treatment. *Science of the Total Environment*, 751, 142325. <https://doi.org/10.1016/j.scitotenv.2020.142325>.
- Liu D., Thompson JR., Carducci A, Bi X. (2020) Potential secondary transmission of SARS-CoV-2 via wastewater. *Science of the Total Environment*, 749,142358. <https://doi.org/10.1016/j.scitotenv.2020.142358>.
- Lodder W., Husman AMR. (2020) SARS-CoV-2 in wastewater: potential health risk, but also data source. *Lancet Gastroenterol. Hepatol.* 5 (6), 533–534, [https://doi.org/10.1016/S2468-1253\(20\)30087-X](https://doi.org/10.1016/S2468-1253(20)30087-X).
- Mallapaty S. (2020) How sewage could reveal truescale of coronavirus outbreak. *Nature*, <https://doi.org/10.1038/d41586-020-00973-x>.
- Mohan SV., Hemalatha M., Kopperi H., Ranjith I., Kumar AK. (2021) SARS-CoV-2 in environmental perspective: Occurrence, persistence, surveillance, *J. Sus. Agric. Sci.* Vol. 46, No. 4 (2020) inactivation and challenges. *Chemical Engineering Journal*, 405, 126893. <https://doi.org/10.1016/j.cej.2020.126893>.
- Mohapatra S., Menonc NG., Mohapatra G., Pisharody L., Pattnaik A., Menon NG., Bhukya PL., Srivastava M., Singh M., Barman MK., Gin KY-H., Mukherji S. (2020) The novel SARS-CoV-2 pandemic: Possible environmental transmission, detection, persistence and

- fate during wastewater and water treatment. *Science of the Total Environment*, <https://doi.org/10.1016/j.scitotenv.2020.142746>.
- Núñez-Delgado A. (2020) What do we know about the SARS-CoV-2 coronavirus in the environment? *Science of the Total Environment* 727, 138647.
- Patni K., Jindal MK. (2020) A positive perspective during COVID-19 related to groundwater crisis. *Groundwater for Sustainable Development* 11, 100420. <https://doi.org/10.1016/j.gsd.2020.100420>
- Polomčić D. & Bajić D. (2015). Application of Groundwater modeling for designing a dewatering system: Case study of the Buvač Open Cast Mine, Bosnia and Herzegovina. *Geologia Croatica*, 68(2):123-137. doi:10.4154/gc.2015.07 Online ISSN 1333-4875
- Polomčić D., Bajić D. & Ratković J. (2018). Assessment of historical flood risk to the groundwater regime: case study of the Kolubara Coal Basin, Serbia. *Water*, 10 (5): 588. DOI: 10.3390/w10050588
- Polomčić D., Gligorić Z., Bajić D. & Cvijović Č. (2017). A hybrid model for forecasting groundwater levels based on fuzzy C-mean clustering and singular spectrum analysis. *Water*, 9(7): 541. DOI: 10.3390/w9070541
- Polomčić D., Gligorić Z., Bajić D., Gligorić M. & Negovanović M. (2019). Multi-criteria fuzzy-stochastic diffusion model of groundwater control system selection. *Symmetry*, 11(5): 705. DOI: 10.3390/sym11050705
- Polomčić D., Hajdin B., Stevanović Z., Bajić D., Hajdin K. (2013). Groundwater management by riverbank filtration and an infiltration channel: The case of Obrenovac, Serbia. *Hydrogeology Journal*, 21 (7): 1519-1530. DOI: 10.1007/s10040-013-1025-9. Print ISSN: 1431-2174, Online ISSN: 1435-0157
- Steffan JJ., Derby JA., Brevik EC. (2020) Soil pathogens that may potentially cause pandemics, including SARS coronaviruses. *Current Opinion in Environmental Science & Health* 17, 35-40. <https://doi.org/10.1016/j.coesh.2020.08.005>.
- Verma M. (2020) Ecotoxicology of Heavy Metals: Sources, Effects and Toxicity. In: R. A. Bhat et al. (eds.), *Bioremediation and Biotechnology*, Vol 2, Springer Nature Switzerland AG, [https://doi.org/10.1007/978-3-030-40333-1\\_2](https://doi.org/10.1007/978-3-030-40333-1_2), pp: 13-23.
- Wu F., Xiao A., Zhang J., Gu X., Lee WL., Kauffman K., Hanage W., Matus M., Ghaeli N., Endo N., Duvallet C., Moniz K., Erickson T., Chai P., Thompson J., Alm E. (2020) SARS-CoV-2 titers in wastewater are higher than expected from clinically confirmed cases. *MedRxiv*, <https://doi.org/10.1101/2020.04.05.20051540>.
- Yan H., Li Q., Yuan Z., Jin S., Jing M. (2019) Research Progress of Mercury Bioaccumulation in the Aquatic Food Chain, China: A Review. *Bulletin of Environmental Contamination and Toxicology*, 102, 612-620 <https://doi.org/10.1007/s00128-019-02629-7>.

## SELECTION OF SUSTAINABLE BUSINESS MODEL DURING THE COVID-19 PANDEMIC IN SERBIA

Slavica Miletić<sup>1</sup>  
Dejan Bogdanović<sup>2</sup>

<sup>1</sup>*Mining and metallurgy Institute Bor, MMI; e-mail:slavica.miletic@irmbor.co.rs*

<sup>2</sup>*Technical Faculty Bor, University in Belgrade, V. Jugoslavije 12, 19210 Bor; e-mail:  
dbogdanovic@tfbor.bg.ac.rs*

### ABSTRACT

*In order to better understand the business of companies in Serbia during the COVID-19 pandemic, ISO-Standard 45001: 2018 requires a detailed analysis. The paper presents an assessment of the impact of the consequences of COVID-19 on business using the AHP and PROMETHEE methods. Analysis of the condition of employees during COVID-19, provides an opportunity to see the socio-economic consequences of companies. The author's task is to choose a sustainable business model during the COVID-19 pandemic. The results of the research provide a picture of business models that can survive during the emergency measures caused by the COVID - 19 pandemic prescribed by the Government of the Republic of Serbia.*

### KEYWORDS:

*COVID-19, Business, AHP and PROMETEE method*

**JEL: O1, O15, P51**

## 1. INTRODUCTION

The assessment of the impact of the consequences caused by the COVID-19 pandemic on the operations of companies in Serbia is a requirement of the ISO 45001: 2018 standard. ISO 45001 is the new ISO standard for health and safety at work (OH&S). It is aimed at the top management of the company, which aims to provide a safe and healthy business environment for employees and customers. The requirement of the ISO standard is a constant analysis of employees' operations. The company's managers also need an assessment of the state of business during the pandemic caused by COVID-19.

COVID-19 is a virus of world proportions because it has spread to a large number of countries. With his appearance, it was declared a "public health emergency at the global level" (PHEIC). The coronavirus pandemic has a direct impact on public health (Paul & Chowdhury 2020). In addition to the impact on public health, the coronavirus disease 2019 caused a great economic shock everywhere in the world. For example, the COVID-19 pandemic has affected supply chains and their environmental performance, and economically sustainable growth (Chowdhury & Paul, 2020; Khan et al., 2019; Suhi et al. 2019; Paul et al.

2019; Khan et al., 2020; Moktadir et al. 2020). Many authors have conducted research on the impact of the consequences caused by COVID-19 on the business of companies.

For example, authors Bartik and his collaborators investigated the impact of COVID-19 on small and medium-sized enterprises in the United States (Bartika, et al., 2020); Impact of the pandemic caused by COVID-19, an analysis of the behavior of companies and consumers was performed (Donthu & Gustafsson 2020); Impact in the food and beverage industry from the consequences caused by COVID-19 (Chowdhury T. et al., 2020).

The Decree on Measures for the Prevention and Control of Infectious Diseases COVID-19 was published in the "Official Gazette of the RS", No. 151/2020. The regulation shows and determines all appropriate measures for overcoming infectious diseases and the manner of implementation of all measures for the protection of employees.

The spread of the pandemic caused by COVID-19, the business of companies is leading to uncertainty in Serbia. Covid -19 poses a growing threat to the economy and investments around the world. Today's modern business poses a serious global economic threat as a whole with the spread of the Corona virus pandemic. As the current situation requires, we see how company managers implement all measures prescribed by the Government of the Republic of Serbia, to protect employees and mitigate financial danger.

Taking into account the situation with COVID-19, the paper evaluates the impact of the consequences of the pandemic COVIDA - 19 companies in order to choose a sustainable business model. Because it is an estimation problem and appears to be a suitable AHP method (Analytical Hierarch Process) (Saaty, 1980) for evaluating the criterion. The PROMETEE method (Preference Ranking Organization Method for Enrichment Evaluation) was used to assess and select the most favorable alternative (Brans, et al., 1986; Benoit & Rousseaux, 2003). Each impact factor needs to be considered and the most favorable one to do business during a pandemic. The analysis was done using Super Decision (AHP) and Visual PROMETHEE (PROMETHEE) software.

AHP and PROMETEE methods belong to multi-criterion decision-making (MCDM) methods. The literature shows that due to the rapid development of operational research, there are many different MCDM methods such as: PROMETHEE (Brans & Vincke, 1985), ELECTRE (Roy, 1968), AHP (Saaty, 1977; Saaty 1980), TOPSIS (Hwang & Yoon, 1981). ), VIKOR (Opricović, 1998) and others.

Recently, new MCDM methods have appeared, such as: SVARA method Kersulienė, 2010), FARE (Ginevičius, 2011), MULTIMOORA (Brauers & Zavadskas, 2010), MUSA, (Grigoroudis & Siskos, 2002), EDAS method, 2015) and others.

In a number of studies, MCDM methods have been successfully used for the purpose of: Assessing progress towards the goals of the Europe 2020 strategy using the MULTIMOOR method (Fedayev 2020), Assessment and selection of staff (Yalçın & Yapıcı Pehlivan 2019); Bogdanović & Miletić, 2014); selection of the optimal method of remediation of degraded areas (Bogdanović et. al., 2014); assessment of organizational culture (Miletić et.al., 2020) and others.

## 2. MATERIAL AND METHODS

In order for managers to have an approximate business situation during the COVID-19 pandemic in the coming period, an assessment of the impact of the consequences on the choice of a sustainable model was given. The results of the research are possible sustainable models that would serve other companies as a model for overcoming the socio-economic crisis during the pandemic COVID - 19. Sustainable models would meet the requirements of

the ISO 45001: 2008 standard, and provide managers and stakeholders with information and guidelines for further successful business.

Stakeholders can get the following information: managers on profit and sustainable business, employees on earnings and survival at work, suppliers on sustainable cooperation, customers on quality and sustainable price of products, community on sustainable environment, owners on profit and survival of the company (Miletić et al., 2015). The goal of all stakeholders is to mitigate the economic and social consequences of the pandemic caused by COVID - 19. Given the continued spread of the COVID-19 pandemic, it is important that society as a whole take action to prevent further transmission of the disease, as well as to support control measures (Bender, 2020).

The pandemic caused by COVID -19 has caused consequences that cause employees reduced work capacity, weakening of concentration, which leads to a reduction in business volume and job loss, which means a massive socio - economic crisis (Miletić & Stanojević Šimšić, 2020).

Business alternatives caused by the consequences caused by the COVID-19 pandemic are:

Alternative A1- Mass layoffs and company closures. Company closures in the United States were 43% and active employment fell to 39%. A special and sharp decline was in the Mid-Atlantic region, including New York, where 54% of employment fell and 47% of companies closed (Bartika, et a., 2020). This is just one example of many. Everywhere in the world, the pandemic caused by COVID-19 led to the closure and dismissal of workers. Tourist, catering companies, airlines and food processing companies suffered the most. COVID-19 has significantly influenced education, scientific organizations, fashion, clothing and other retail sectors.

Alternative A2- Risk of permanent closure of the company due to long-term crisis - financial collapse. This alternative plays a central role in the company's strategy during the COVID-19 pandemic. Managers' expectations were that companies would open more than they closed. The crisis has been going on for more than a year and there is still great uncertainty as to when it will end. Thus, uncertainty causes the company to close permanently. 50% of respondents in the Middle States thought that the crisis would last until mid-June, but the crisis has lasted and still lasts (Bartika, et al., 2020). Many companies made the wrong forecast about the ongoing crisis and experienced a financial collapse because they had small stocks of cash. In two weeks, the cash of the stock for the necessary expenses was used up. The companies were optimistic that they would remain open until the end of the year. The evolution of the crisis allows managers to believe and expect the call for a pandemic decision.

Alternative A3- The survival of the company.

Due to the consequences of the COVID-19 pandemic, companies are losing markets, reducing the processes of products and services. Managers make fact-based decisions for the company's survival. They take some of the following measures: downsizing, which means reducing the workforce, reducing the volume of work, abolishing certain departments and retraining employees.

Alternative A4- Work of companies with a stimulus package provided by the state (minimum work with state social assistance). Many companies took advantage of stimulus packages prescribed by the Government of the Republic of Serbia during the COVID-19 pandemic. Analysis of medium-sized companies shows that over 70% of respondents expected to use the assistance program offered by the Government that looks like a salary (Bartika, et al., 2020). Most business owners have taken out loans in the form of loans to ensure the company's liquidity. Company liquidity is important for owners. Such financing

also affected other jobs and qualities of managers, such as the survival of the company and the dismissal of employees.

All previous alternatives need to be considered and assessed which is viable for the company's business while the state of uncertainty persists. The evaluation of alternatives is performed using the PROMETHEE method and the criterion by AHP analysis. As a result, a mutual assessment of the criterion and an assessment of each criterion individually with each alternative is necessary. By assessing the criterion and alternatives, we obtain possible sustainable business models during the pandemic caused by COVID-19.

The hierarchy of solutions to this problem has three levels:

1. LEVEL I - the goal is to assess and select the most favorable business alternative during a pandemic caused by COVID-19.
2. LEVEL II evaluation of criterion, and
3. LEVEL III assessment of alternatives.

The criterion that has an impact on the choice of the best alternative for the company's operations are determined on the basis of the analysis of the consequences of the employees caused by COVID 19 (Table 1).

**Table1. The criterion**

The criterion	Operation	Connotation
C <sub>1</sub>	Digital technology	The impact of digital business is very important for companies and many authors call it industrial revolution (Degrise, 2016; Tihinen, Iivari, et al., 2016). Digital technologies bring a new era of business, the digital age. The digital age has been identified as one of the most important trends changing current business (Tihinen, et al., 2016) and especially during the COVID-19 pandemic. The analysis of employees in one scientific organization shows that 49.9% could do housework with the help of digital technology, 34.8% depending on the job and only 16.3% did work in the organization (Miletić and Stanojević, Šimšić, 2020).
C <sub>2</sub>	Increased costs	Operating costs during the COVID-19 pandemic may increase depending on the increase in taxes and contributions for employees, duties and taxes paid by the company.
C <sub>3</sub>	Reduced consumption	During the COVID-19 pandemic, a large number of employees at many companies did their work from home. Thus, the consumption of electricity and water has been reduced.
C <sub>4</sub>	Reduced offer of services and sales	The offer for services and sales to users during the COVID-19 pandemic was reduced due to special measures of the Government of the Republic of Serbia (movement prohibited, etc.).
C <sub>5</sub>	Reduced revenue	Due to the weak purchasing power of consumers of products and services, the price of products and services decreases. Reducing the demand for a product and service reduces the price and thus the profit. Example of services: The International AIR



		Transport Association estimates that the pandemic cost global air transport between \$ 63 billion and \$ 113 billion in 2020 alone, which means that revenue has decreased so much (Segal and Gerstel, 2020). Product example: The price of crude oil has fallen by about 70% since the beginning of the year due to the price war and declining demand. <a href="https://www.mainstream.rs/uticaj-covid-19-na-globalnu-ekonomiju-i-kako-cloud-moze-da-pomogne/">https://www.mainstream.rs/uticaj-covid-19-na-globalnu-ekonomiju-i-kako-cloud-moze-da-pomogne/</a>
C <sub>6</sub>	Disturbed supply chains	The pandemic caused by COVID-19 has brought risks to supply chains because disruption can affect their sustainability (Moktadir et.al., 2018).
C <sub>7</sub>	Changing user (consumer) behavior	The behavior of users (consumers) is changing due to poor communication with users. It becomes difficult to contract jobs and collect receivables from customers. Users use little or no digital technology.

### 3. AHP-PROMETHEE CONTROL METHOD

Analytical hierarchical process, the AHP method has a strong mathematical basis and was chosen for a quality economic assessment of the criterion that affect the business of companies during the COVID-19 pandemic. The process of choosing the most favorable alternative and determining the criterion is important for making the final decisions of the manager. The AHP and PROMETHHE process gives us the opportunity to find possible sustainable business models of companies. Sustainable business models provide guidance to managers on how and how to overcome the current crisis caused by the COVID - 19 pandemic.

AHP is a decision support system (DSS). Thomas Saaty gave the conceptual and mathematical setting of the AHP (Saaty, 1980). The AHP process belongs to the class of methods for soft optimization. This method belongs to the methods of multi-criterion decision-making and is based on the decomposition of a complex problem into a hierarchy where both qualitative and quantitative aspects of the problem are included. It consists of a goal, a criterion, perhaps a sub-criterion and an alternative. The goal is at zero level, the highest level since you start. The criteria are at the first level and the sub-criteria are below them. The alternatives offered are on another level, a lower level. The criteria are compared with each other in pairs in relation to the zero level, the higher level. A further procedure is to compare each criterion with each alternative in relation to the goal, the lower level.

Authors Saaty, 1986; Harker & Vargas, 1987; and Alphonse, 1997; have defined the axioms on which the AHM method is based:

Reciprocity which reads: element A if n times more significant than element B, then element B is 1/n times more significant than element A.

Homogeneity is if the elements are comparable by comparison and significance if not then there is no effect.

Dependence, if the comparison is lower, it depends on the goal, the higher level.

The expectation when changing the structure of the hierarchy is normal that there is a re-prioritization of calculation in the new hierarchy.

The comparison of criteria and alternatives is done with the help of Satie's scale (Table 1).

**Table1.** Satie's scale for evaluating the two elements *j* and *k* in relation to the target

$$S = \left\{ \frac{1}{9}, \frac{1}{8}, \frac{1}{7}, \frac{1}{6}, \frac{1}{5}, \frac{1}{4}, \frac{1}{3}, \frac{1}{2}, 1, 2, 3, 4, 5, 6, 7, 8, 9 \right\} \left\{ \frac{1}{9}, \frac{1}{8}, \frac{1}{7}, \frac{1}{6}, \frac{1}{5}, \frac{1}{4}, \frac{1}{3}, \frac{1}{2}, 1, 2, 3, 4, 5, 6, 7, 8, 9 \right\}$$

Value $a_{jk}$	Interpretation of results
1	The elements <i>j</i> and <i>k</i> are equally important
3	The element <i>j</i> is somewhat more important than <i>k</i>
5	The element <i>j</i> is more important than <i>k</i>
7	The element <i>j</i> is very important than <i>k</i>
9	The element <i>j</i> is absolutely more important than <i>k</i>
2,4,6,8	Intermediate values between two elements

The results of the comparison criteria placed in the matrix have the following form:

$$W = \begin{bmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \dots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \dots & \frac{w_2}{w_n} \\ \dots & \dots & \dots & \dots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \dots & \frac{w_n}{w_n} \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ \dots \\ w_n \end{bmatrix} = \begin{bmatrix} w_1 & w_2 & \dots & w_n \\ \frac{w_1}{w_2} & \frac{w_1}{w_2} & \dots & \frac{w_1}{w_n} \\ \dots & \dots & \dots & \dots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \dots & \frac{w_n}{w_n} \end{bmatrix} \dots \dots \dots (1)$$

Furthermore, the pairs of alternative *A* are compared with respect to each criterion, thus obtaining a comparison matrix *A* in which the element  $a_{ij}$  represents the ratio of the weight coefficient of alternative *A<sub>i</sub>* in relation to alternative *A<sub>j</sub>*.

$$A = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{1n} & a_{2n} & \dots & 1 \end{bmatrix} \begin{bmatrix} a_{1j} \\ a_{2j} \\ \dots \\ a_{nj} \end{bmatrix} = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{1n} & a_{2n} & \dots & 1 \end{bmatrix} \dots \dots \dots (2)$$

The elements  $A_{ij}$  represent the relationship between the weighting coefficients  $w_i / w_j$  where *w* is the weight vector of each alternative.

$$w = \frac{w_i}{w_j} = \frac{w_i}{w_j} \dots \dots \dots (3)$$

Matrix has a reciprocal properties, which are:

$$a_{ji} = \frac{1}{a_{ij}} \frac{1}{a_{ij}} \dots \dots \dots (4)$$

After the comparison, the weight coefficients *w* are calculated, which is calculated on the basis of the Satie scale in two steps..

$$w = [w_1, w_2, \dots, w_n] \dots \dots \dots (5)$$

First, a matrix comparing pairs normalize, and then calculate the weight.

$$A = [a_{ij}]_{n \times n} \dots \dots \dots (6)$$

Normalization is performed as follows:

$$a_{ij}^* = \frac{a_{ij}}{\sum_1^n a_{ij}} \quad a_{ij}^* = \frac{a_{ij}}{\sum_1^n a_{ij}} \dots \dots \dots (7)$$

For everything  $j = 1, 2, \dots, n$ .

The weight coefficient is calculated:

$$w_i = \frac{\sum_1^n a_{ij}^*}{n} = \frac{\sum_1^n a_{ij}^*}{n} \dots \dots \dots (8)$$

For everything  $j = 1, 2, \dots, n$ .

After comparison, the degree of consistency is checked. The degree of consistency has a value less than 0.1. Otherwise, the values entered in the comparison matrix must be reconsidered.

In order to calculate the degree of consistency, the consistency index is first calculated according to the formula:

$$CI = \frac{(\lambda_{max} - n)}{(n - 1)} \quad CI = \frac{(\lambda_{max} - n)}{(n - 1)} \dots \dots \dots (9)$$

$\lambda_{max}$  represents a significant parameter in the AHP method.  $\lambda_{max}$  is used as a reference index to display information in consistency degree (CR) calculations. The rule is that the closer  $\lambda_{max}$  x is to the number n, the lower the consistency will be.

CR is calculated according to the formula:

$$CR = \frac{CI}{RI} \quad CR = \frac{CI}{RI} \dots \dots \dots (10)$$

RI is a random consistency index taken from Table 2. In Table 2, the first row represents the row of the matrix, and the second the random indices.

**Table 2. Random indices (Saaty, 1980)**

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0,	0,	0,5	0,	1,1	1,2	1,3	1,4	1,4	1,4	1,5	1,4	1,5	1,5	1,5
0	0	8	9	2	4	2	1	5	9	1	8	6	7	9

If the degree of consistency (CR) is less than 0.10 the result is correct, in case it is greater than 0.1 then a re-analysis of the inconsistency is required until we get that the degree of consistency is less than 0.1.

PROMETHEE is a ranking method for a finite number of alternatives (Brans et al., 1984). In this method, the appropriate preference function is firstly determined, and then the weight of coefficients for each criterion is determined. The preference function determines the way in which a certain alternative is ranked in relation to another and translates the deviation between two comparative alternatives into a unique parameter that is related to the degree of preference. The degree of preference represents a growing function of deviation. If the deviation is small it refers to a weak preference, while otherwise, if the deviation is large it

represents a strong preference of the alternative. There are six forms of preference functions (Usual, U-shape; V-shape; Level, Linear, Gaussian), each form depending on two thresholds of indifference (Q and P). The indifference threshold (Q) represents the largest deviation that the decision maker considers irrelevant, while the preference threshold (P) represents the smallest deviation that is considered decisive for the decision maker, where P must not be less than Q. The Gaussian threshold (s) represents the mean value of the thresholds P and Q, (Brans, 1982; Brans & Vincke, 1985).

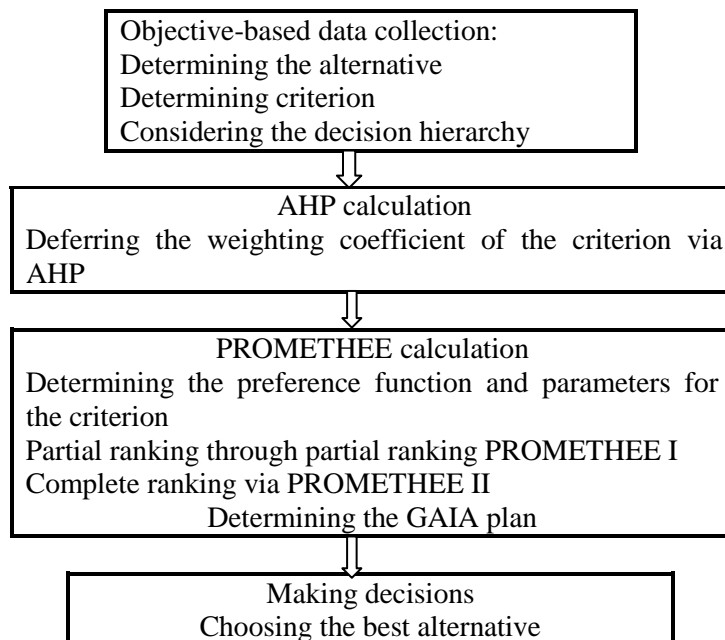
The PROMETHEE method is based on determining the positive flow ( $\Phi +$ ) and negative flow ( $\Phi -$ ) for each alternative according to outranking relations, and in accordance with the obtained weight coefficients for each criterion. The positive flow of preference expresses how much a certain alternative dominates in relation to other alternatives, so if the value is higher ( $\Phi + \rightarrow 1$ ) the alternative is more significant.

The negative flow of preference expresses how much a particular alternative is preferred by other alternatives. The alternative is more significant if the value of the output the flow is smaller ( $\Phi - \rightarrow 0$ ). Complete ranking (PROMETHEE II) is based on the calculation of net flow ( $\Phi$ ), which represents the difference between positive and negative flow of preference. The alternative that has the highest net flow value is the best ranked (Anand & Kodali, 2008).

#### 4. A REAL EXAMPLE OF A HYBRID METHOD

The proposed methodology considers the assessment and selection of the most favorable business alternative in companies during a pandemic caused by COVID-19. Due to the COVID-19 pandemic, company managers are forced to reduce their business.

**Figure2.** Schematic representation of the proposed method



*(Bogdanović & Miletić, 2014)*

### 4.1. Ahp calculation

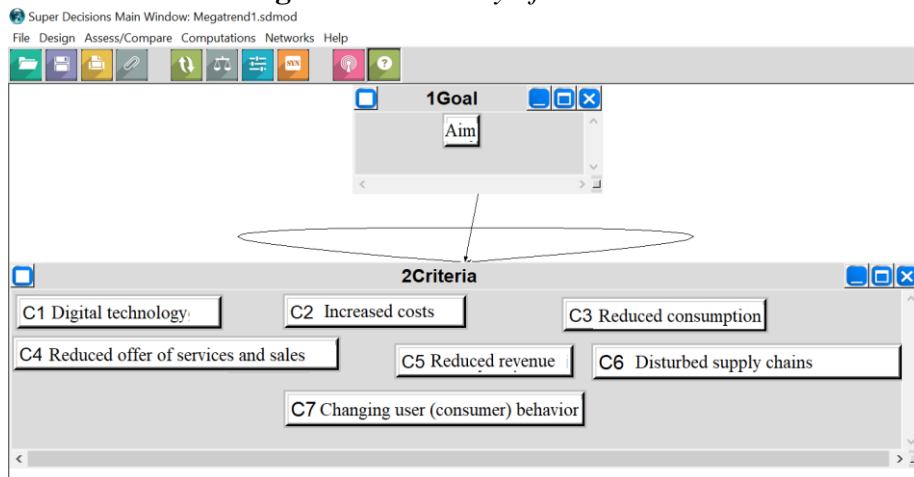
Based on the hierarchy, the weight coefficients of the criterion are firstly calculated using the AHP method - Figure 3.

Let  $A = \{A_1, A_2, A_3, A_4\}$  be a set of given alternatives and  $C = \{C_1, C_2, \dots, C_7\}$  a set of selection criterion. The decision maker forms an individual matrix of pair comparisons using a scale (Table 1).

Table 3. Shows a 7x7 comparison matrix to express the empirical assessment of the decision maker.

The results are given in Figure 4. The figure shows that the most influential criterion is C2 (Increased costs), followed by criterion C3 (Reduced consumption) and criterion C6 (Disturbed supply chains). Other criteria have a significantly smaller impact on the ranking results of alternatives.

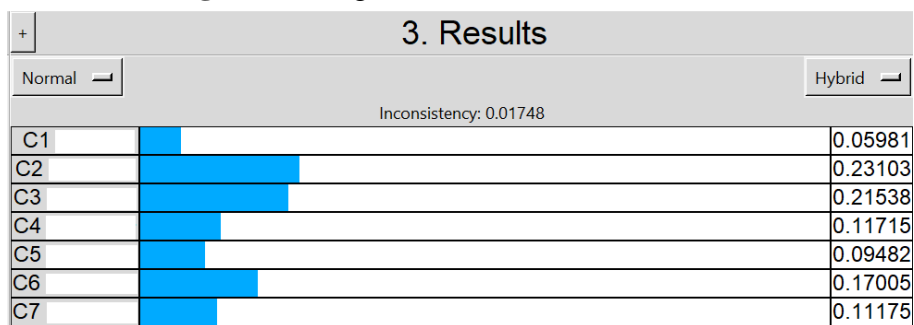
**Figure 3. Hierarchy of AHP methods**



**Table 3. Pair comparison matrix**

Criterion	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>
C <sub>1</sub>	1	1/3	1/3	1/2	1/2	1/3	1/2
C <sub>2</sub>		1	1	2	3	1	3
C <sub>3</sub>			1	2	3	1	2
C <sub>4</sub>				1	1	1	1
C <sub>5</sub>					1	1/2	1
C <sub>6</sub>						1	1
C <sub>7</sub>							1

**Figure 4. Weight coefficients of the criterion**



## 4.2. Promethee calculation

Based on the criterion, the evaluation of alternatives is performed and an evaluation matrix is formed. In this process, the criteria have a qualitative or uncertain structure that cannot be precisely determined and measured. Table 4 gives a qualitative scale that has five levels, as well as the corresponding numerical values for each qualitative assessment.

**Table 4. Qualitative scale**

Qualitative values	Very weak	Low	Medium	High	Very high
Numerical values	1	2	3	4	5

The evaluation of the four alternatives according to the above criterion is shown in Table 5.

**Tabela 5. Evaluation matrix**

Criterion	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>
Unit	-	-	-	-	-	mm/t	%
Max/min	max	min	min	min	min	min	min
Weight coefficient	0.0598	0.2310	0.2154	0.1172	0.0948	0.1700	0.1118
Function preferences	Level	Level	Level	Level	Level	Level	Level
A <sub>1</sub>	3	5	4	4	4	4	3
A <sub>2</sub>	3	5	5	4	5	3	3
A <sub>3</sub>	4	4	3	3	3	3	3
A <sub>4</sub>	4	2	2	3	3	4	3

After forming the evaluation matrix, the evaluation of alternatives is performed using the Visual PROMETHEE software. Table 6 shows the values of positive ( $\Phi^+$ ), negative ( $\Phi^-$ ) and net flows ( $\Phi$ ).

Complete ranking of alternatives was performed using PROMETHEE II (Figure 5). The values of net flows from the last column of Table 6 were used.

**Table 6. PROMETHEE preference flows**

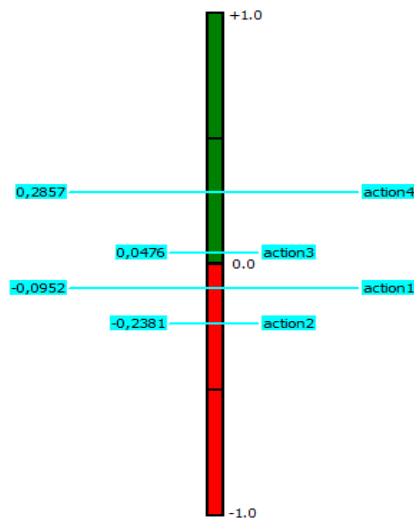
Alternative	$\Phi^+$	$\Phi^-$	$\Phi$
A1	0,0000	0,0952	-0,0952
A2	0,0000	0,2381	-0,2381
A3	0,0952	0,0476	0,0476
A4	0,2857	0,0000	0,2857

The results show that the best alternative is A4 (operation of companies with a stimulus package provided by the state), while the others are ranked in the following order: A3 (survival of the company), A1 (mass relaxation of workers and closure of the company) and A2 (Risk of permanent closure due to a prolonged crisis - financial collapse).

The convenience of this software package is reflected in the implementation of the GAIA plan. Based on the GAIA plan, it is possible to easily determine the discriminatory force of

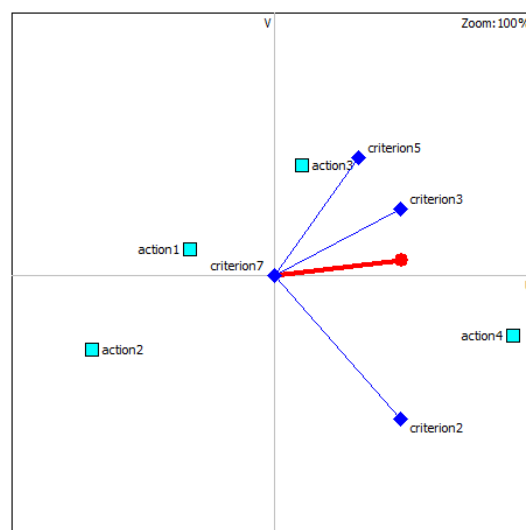
each criterion, aspects of consistency and inconsistency as well as the quality of each alternative by every criterion. The eccentricity of the position of the criterion represents the strength of the influence of that criterion, while the agreement between the individual criteria is defined by approximately the same orientation of the axes of those criteria. In the ranking, the agreement was found between criteria C5, C3 and C2, while the other criteria are evidently not consistent with the other entire criterion. Also, the position of the alternative determines its strength or weakness in relation to the criterion.

**Figure 5.** PROMETHEE II complete ranking of alternatives



If it is closer to the direction of the axis of a certain criterion, the alternative itself is better according to that criterion. Alternative A3 in Figure 6 is the best option, because it is closest to the direction of the axis of those criteria that have the greatest impact (C3 and C2) and is closest to the direction of the decision stick  $\pi$ , which defines the compromise solution according to the given weighted criterion. In contrast, alternative A2 is the worst option because it is located opposite the direction of the decision rod  $\pi$ .

**Figure 6.** GAIA plan



## 5. CONCLUSION

This paper provides an assessment of the impact of the consequences of COVID-19 on the business of companies. Assessing and selecting the optimal sustainable business model is one of the most important decisions during a pandemic. Choosing an appropriate sustainable business model requires consideration of a number of criteria. An integrated AHP and PROMETHEE method was applied in the proposed approach to assess and select a sustainable business model during a COVID-19 pandemic. In this example, AHP is used to determine the weighting coefficients of the criterion. The PROMETHEE method is applied for complete ranking of alternatives where it uses weights obtained by the AHP method that have a low degree of subjectivity. PROMETHEE uses the preference function of each criterion. PROMETHEE I give partial ranking while PROMETHEE II provides full ranking. The GALA plan provides an opportunity to determine the discriminatory force of each criterion, aspects of agreement and disagreement. Based on the Gala Plan, the quality of each alternative is determined according to each criterion.

Based on the obtained results of alternatives A3, the survival of the company is the best option. Alternative A3 is closest to the direction of the axis of those criteria that have the greatest impact C3 (reduced consumption) and C2 (increased costs). A3 is the closest in the direction of the decision stick pi, because it defines a compromise solution in accordance with the given weighted criterion. While alternative A2 (risk of permanent closure of the company due to a long-term crisis - financial collapse) is the worst option because it is located opposite to the direction of the decision stick pi.

The proposed model was applied to the problem of assessing and selecting sustainable business models of companies during the emergency measures caused by the COVID-19 pandemic adopted by the Government of the Republic of Serbia.

## ACKNOWLEDGMENTS

The research presented in this paper was done with the financial support of the Ministry of Education, Science and Technological Development of the Republic of Serbia, within the financing of scientific research work in the Institute of Mining and Metallurgy Bor, according to the Contract No. 451-03-9/2021-14/200052, and at the University of Belgrade, Technical Faculty in Bor, according to the Contract No. 451-03-9/2021-14/200131.

## REFERENCE

- Anand., G., & Kodali., R. (2008). Selection of lean manufacturing systems using the PROMETHEE, *Journal of Modelling in Management* 3 (1) p.40-70.
- Bartika, W.A., Bertrandb, M., Cullenc,Z., Glaeserd, L.E., Lucac. M., and Stanton, C. (2020). The impact of COVID-19 on small business outcomes, *PNAS*, 17656–17666 Vol. 117 no. 30. <https://www.pnas.org/lookup/suppl/doi:10.1073/pnas.2006991117/-/DCSupplemental.y>
- Benoit, V., & Rousseaux, P. (2003). Aid for Aggregating the Impacts in Life Cycle Assessment. *The International Journal of Life Cycle Assessment*, 8(2), pp. 7482
- Bender ,L.(2020). Emergency Education UNICEF New York
- Bogdanović, D., Obradović, Lj., Miletić, S. (2014). Selection the optimum method of rehabilitation the degraded areas around the Bor River downstream from the flotation



- tailing dump Bor. *Journal Mining and Metallurgy Engineering Bor*, Vol. 4, pp. 137-156. ISSN 2334-8836.
- Bogdanović, D., & Miletić, S. (2014). Personnel evaluation and selection by multicriterion decision making method. *Journal of Economic Computation and Economic Cybernetics Studies and Research*, Vol. 48(3), pp. 179-196.
- Brans, J.P. (1982). *L'ingénierie de la décision; Elaboration d'instruments d'aide à la décision. La méthode PROMETHEE*. In R. Nadeau and M. Landry, editors, *L'aide à la décision: Nature, Instruments et Perspectives d'Avenir*, Québec, Canada. Presses de l'Université Laval, pp. 183-213.
- Brans J.P., Mareschal B. & Vincke P.H.(1984). PROMETHEE: A new family of outranking methods in multi-criterion analysis, *Operational Research*, North-Holland, Amsterdam, p.477-490.
- Brans, J.P., Vincke, P.H., Mareschal, B., (1986). How to select and how to rank projects—the PROMETHEE method. *European Journal of Operational Research* 24, pp. 228 -238.
- Brans, J. P. and Vincke, P., (1985). Note—A Preference Ranking Organisation Method: (The PROMETHEE Method for Multiple Criterion Decision-Making). *Management science*, 31(6), pp. 647-656
- Brauers, W.K.M., & Zavadskas, E.K., (2010). Project management by MULTIMOORA as an instrument for transition economies. *Technological and Economic Development of Economy*, 16(1), pp. 5-24
- Chowdhury., P. Paul, S.K. (2020). Applications of MCDM methods in research on corporate sustainability: a systematic literature review. *Manag Env Qual* 31:385–405. <https://doi.org/10.1108/MEQ-12-2019-0284>
- Chowdhury, T., Sarkar, A., Paul, K.S., & Muktadir, A., (2020). A case study on strategies to deal with the impacts of COVID-19 pandemic in the food and beverage industry, *Operations Management Research*, <https://doi.org/10.1007/s12063-020-00166-9>. Springer Science+Business Media, LLC, part of Springer Nature 2020.
- Degryse, C. (2016). *Digitalization of the economy and its impact on labour markets*. Publisher: ETUI aisbl, Brussels.
- Donthu, N., and Gustafsson, A., (2020). Effects of COVID-19 on business and research, *Elsevier Journal of Business Research*, Vol. 117, 284-289.
- Ginevičius, R., (2011) A new determining method for the criterion weights in multicriterion evaluation. *International Journal of Information Technology & Decision Making*, 10(6), pp. 1067-1095
- Grigoroudis, E. and Siskos, Y., (2002) .Preference disaggregation for measuring and analysing customer satisfaction: The MUSA method. *European Journal of Operational Research*, 143(1), pp. 148-170
- Ghorabae, M.K. Zavadskas, E. K. Olfat, L. & Turskis, Z., (2015). Multi-Criterion Inventory Classification Using a New Method of Evaluation Based on Distance from Average Solution (EDAS). *Informatika*, 26(3), 435-451.
- Kersulienė, V. Zavadskas, E. K. and Turskis, Z., (2010). Selection of rational dispute resolution method by applying new step-wise weight assessment ratio analysis (SWARA). *Journal of Business Economics and Management*, 11(2), pp. 243-258.
- Fedajev, A., Stanujkic, D., Karabašević, D., Brauers, WKM., Zavadskas, EK. (2020). Assessment of progress towards “Europe 2020” strategy targets by using the MULTIMOORA method and the Shannon Entropy Index, *Journal of Cleaner Production* 244, 118895

- Hwang, C. L. and Yoon, K., (1981) *Multiple Attribute Decision Making Methods and Applications*. Springer-Verlag, Heidelberg.
- Khan, SAR., Sharif, A., Golpîra, H., Kumar., A. (2019). A green ideology in Asian emerging economies: from environmental policy and sustainable development. *Sustain Dev* 27:1063–1075. <https://doi.org/10.1002/sd.1958>.
- Khan, SAR, Zhang, Y., Kumar, A., Zavadskas, E., Streimikiene, D. (2020). Measuring the impact of renewable energy, public health expenditure, logistics, and environmental performance on sustainable economic growth. *Sustain Dev in press* 28:833–843. <https://doi.org/10.1002/sd.2034>
- Moktadir, M.A., Dwivedi, A., Rahman, A., Jabbour, C., Paul, S.K., Sultana, R., Madaan, J. (2020). An investigation of key performance indicators for operational excellence towards sustainability in the leather products industry. *Bus Strateg Environ in press*. <https://doi.org/10.1002/bse.2575>.
- Miletić, S., Bogdanović, D., Paunković, J. (2015). Selection the optimal model of integrated sustainable management system in the mining companies. *Journal Mining and Metallurgy Engineering Bor*, Vol. 2, crp. 181-204. ISSN 2334-8836.
- Miletić, S., Stanojević, Š.Z., Jovanović, I., Radivojević, M., Conić, V.(2020). AHP analysis of organizational culture in textile companies in Serbia, In: *Industria Textila*, 71, 2, 124–131, <http://doi.org/10.35530/IT.071.02.1588>
- Miletić, S., Stanojević Šimšić, Z. (2020). Analysis of the state of employees due to the covid-19 pandemic: a case study, *Innovation as an initiator of the development “innovations – basis for development”*, 130-148, ISBN 978-86-84531-50-8.
- Moktadir, MA., Rahman, T., Rahman, MH., Ali, SM., Paul, SK. (2018). Drivers to sustainable manufacturing practices and circular economy: a perspective of leather industries in Bangladesh. *J Clean Prod* 174:1366–1380. <https://doi.org/10.1016/j.jclepro.2017.11.063>.
- Opricovic, S. (1998) *Multicriterion optimization of civil engineering systems*. Faculty of Civil Engineering, Belgrade.
- Paul, SK, Chowdhury, P. (2020). A production recovery plan in manufacturing supply chains for a high-demand item during COVID-19. *Int J Phys Distrib Logist Manag* 1-22. <https://doi.org/10.1108/IJPDLM-04-2020-0127>.
- Paul A, Moktadir MA., & Paul SK (2019). An innovative decision-making framework for evaluating transportation service providers based on Chowdhury T. et al. sustainable criterion. *Int J prod res* 1–19. <https://doi.org/10.1080/00207543.2019.1652779>.
- Roy, B., (1968). Classement et choix en présence de points de vue multiples. *Revue française d'automatique, d'informatique et de recherche opérationnelle. Recherche opérationnelle*, 2(1), pp. 57-75.
- Saaty, T. L., (1977). A scaling method for priorities in hierarchical structures. *Journal of mathematical psychology*, 15(3), pp. 234-281
- Saaty, T. L. (1980). *The Analytic Hierarchy Process*. McGraw Hill Company, New York.
- Segal, S., Gerstel, D. (2020). The Global Economic Impacts of COVID-19. <https://www.csis.org/analysis/global-economicimpacts-covid-19>.
- Suhi, SA., Enayet, R., Haque, T., Ali, SM., Moktadir, MA., Paul, SK. (2019). Environmental sustainability assessment in supply chain: an emerging economy context. *Environ Impact Assess Rev* 79:106306. <https://doi.org/10.1016/j.eiar.2019.106306>.
- Tihinen, M., Iivari, M., Ailisto, H., Komi, M., Kääriäinen, J., & Peltomaa, I. (2016). An Exploratory Method to Clarify Business Potential in the Context of Industrial Internet – A Case Study. In: Afsarmanesh H., Camarinha-Matos L., Lucas Soares A. (eds) *Collaboration in a Hyperconnected World*. PRO-VE 2016. IFIP Advances in Information

- and Communication Technology, vol 480. Springer, Cham, 469-478. [https://doi-org-443.webvpn.jnu.edu.cn/10.1007/978-3-319-45390-3\\_40](https://doi-org-443.webvpn.jnu.edu.cn/10.1007/978-3-319-45390-3_40)
- Yalçın, N., & Yapıcı Pehlivan N., (2019). The WS PLP Approach Application of the Fuzzy CODAS Method Based on Fuzzy Envelopes for Hesitant Fuzzy Linguistic Term Sets: A Case Study on a Personnel. Selection Problem. *Journal Symmetry*, 11, 493; doi:10.3390/sym11040493. [www.mdpi.com/journal/symmetry](http://www.mdpi.com/journal/symmetry)

UDK 616.98:578.834]:338.1  
330.524:620.92(497.11)  
COBISS.SR-ID 57316873

## ENERGY SECURITY OF THE REPUBLIC OF SERBIA IN THE CONDITIONS OF THE COVID 19 PANDEMIC

Ratko Ljubojević<sup>1</sup>

<sup>1</sup>*Meagtrend University, Faculty of Law, Maršala Tolbuhina 8, 11070 Novi Beograd*

### ABSTRACT

*The Republic of Serbia does not have enough resources to satisfy its needs for energy. Thus, its energy security must be ensured by the energy imports. The starting hypothesis is that the disruptions in the functioning of the world energy market provoked by the COVID 19 pandemic, revealed the necessity for diversification of energy production. In a crisis situation, excessive reliance on imports is a big threat to macroeconomic stability. The aim of this paper is to show that in the long run the stability of the national energy system calls for the policy of energy imports substitution with domestic renewable energy sources.*

### KEYWORDS

*energy security, COVID 19 pandemic, energy imports, Republic of Serbia*

### 1. INTRODUCTION

With the outbreak and spread of the COVID 19 pandemic, a modern security system that puts collective security at the forefront has been threatened. The plague of international proportions caused by the pandemic has shown that in crisis situations, even the most developed countries are primarily guided by their own interests, due to which they put collective security in the background. In such a situation, international economic cooperation has been jeopardized.

One of the foundations of collective security in the world is energy security. The pandemic has brought into focus the risks posed by energy supply interruptions and the cascading impact on other systems. Economic survival and especially development in the world are conditioned by the necessary amount of limited natural resources. In other words, economic development is not possible without a stable energy supply (Đorđević, 2017). In the conditions of the COVID 19 pandemic, the countries importing energy products are even more vitally interested in long-term stability in supply. As pointed out by the Economic and Social Council of the United Nations (ESCAP, 2021), “the coronavirus disease, COVID-19 pandemic, has raised awareness about the critical role the energy system, and particularly the electricity supply, plays in sustaining health care, information and communications technology, the water supply, logistics, education and other sectors that are critical to the overall functioning of societies and economies.”

## **2. EMERGING CONCERNS AND EXTERNAL THREATS TO ENERGY SYSTEM OF THE REPUBLIC OF SERBIA**

In the context of a new reality posed by the COVID 19 pandemic, emerging concerns and external threats to the energy system of the Republic of Serbia must be considered. Reliance on the imports of oil and natural gas remains the biggest threat, because of the potential for the exporting countries to make unilateral policy decisions to restrict supplies and to influence the changes in energy prices. Moreover, the growth of the clean energy sector based on renewable energy sources is also dependent upon the supply of critical raw materials. In a situation burdened with uncertainties and unreliability in planning, new geoeconomic dependencies could be expected to emerge.

### **2.1. Geoeconomic dependencies in energy sector**

Fossil fuels are non-renewable energy sources. Due to their centuries-long exploitation, the world's reserves of these energy sources are not only limited but to a large extent already depleted. Technological discoveries have conditioned the necessity of fast exploitation of fossil fuels on which the survival of individuals, states and the entire world community depends. Intensive growth of the world population records a constant increase in energy consumption per capita. In the twentieth century alone, the population increased by 3.7 times while the final energy consumption worldwide increased by 30 times (Strategija razvoja energetike Republike Srbije, 2014).

Possession of energy, as well as its consumption, directly affect the geoeconomic and geopolitical positioning of countries. Those who own and distribute energy products are in a position to form their price on the world market, gaining economic and political supremacy. Thus, energy plays an unavoidable role in modern international relations, shaping global and national geoeconomic strategies (Babić, 2009). Considering the unclear demarcation between geopolitics and geoeconomics, especially in the creation of political and economic goals, energy remains an unavoidable factor of geopolitical interests (Deđanski, Ljubojević, 2019).

Energy guarantees the sustainability of economic development. From renewable energy sources such as solar, wind, water to non-renewable energy sources such as fossil fuels, whose resources are limited, energy has been and remains the economic flywheel of every society. The costs of production of all industrial products with no exception include the consumed energy. Thus, the price of energy is an important factor in modern economic relations, since not only the costs of production but also the profits of companies in the energy sector and their investments depend on its height.

Fossil fuels dominate energy consumption in the world. According to the data for 2018, the share of fossil fuels in the total world energy consumption is 85%, with the share of oil being 34%, the share of coal 27% and natural gas 24%. Among other energy sources, the share of hydropower is 7%, the share of nuclear energy is 4%, while the share of all other types of energy from renewable sources is only 4% (Proroković, 2020). Excessive use of coal and oil has led to the depletion of their reserves, producing negative environmental consequences. That is why national economies are increasingly oriented towards the use of natural gas. Although it is a fossil fuel, this non-renewable resource belongs to the so-called. clean energy. In addition to environmentally friendly characteristics, this energy source is relatively economical due to relatively low transport costs, because its transport is performed exclusively by gas pipelines. "Due to that, the gas pipeline routes have an extremely important geoeconomic and geopolitical significance both for the exporting countries and for

the countries importing natural gas. In addition to natural gas, the long-term environmental and thus energy policy of the states requires that their national economies increasingly reorient to the so-called green energy from renewable sources, primarily solar energy, wind energy and geothermal energy. However, despite efforts to accelerate the implementation of new environmental standards, the share of coal and oil use is still very high. For reasons of cost-effectiveness and economy, the transition to more environmentally friendly energy sources is a long-term process, and fossil fuels remain the most important energy source in every respect, with the largest share in consumption” (Proroković, 2020).

The fact is that the world market price of oil and natural gas - fossil fuels participating in energy imports of the Republic of Serbia - is formed in relation to its demand but also to its supply. During 2020, in the conditions of the COVID 19 pandemic, the world supply of those two fossil fuels experienced unprecedented volatility.

The level of oil production reached an all-time high in 2019, at around 95 million barrels per day. However, the coronavirus pandemic and its impact on transportation fuel demand led to a notable decline in oil production. Namely, global oil production dropped to 88.4 million barrels per day in 2020 (Statista, 2021). Lower demand affected the world oil market prices. This could be shown by the example of OPEC crude oil prices. The Organization of the Petroleum Exporting Countries (OPEC) participates with 25% in global crude oil production. OPEC was established in Baghdad, Iraq in 1960, whose primary task has been to form the price of oil and preserve its market stability. OPEC is a permanent, intergovernmental organization, today consisting of fourteen member states: Algeria, Angola, Ecuador, Equatorial Guinea, Gabon, Iraq, Iran, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates and Venezuela. According to its Statute, its main goal is “to coordinate and harmonize the oil policy of member countries and ensure the stability of the oil market to ensure efficient, economical and regular delivery to consumers, stable income to producers and adequate profits for those investing in the oil industry” (OPEC, 2021). However, in the situation of the COVID 19 pandemic, these goals were threatened because lower demand for oil affected crude oil prices. While the price of a barrel of OPEC crude oil was 68.89 US dollars on December 30<sup>th</sup>, 2019, it dropped to 12.41 US dollars on April 28, 2020, and started to grow again afterward, reaching only 51.35 US dollars on January 4<sup>th</sup>, 2021 (Statista, 2021). Since the world is still coping with the pandemic, it is not possible to predict with certainty that the stability of oil prices will be reached on the world market in the near future.

COVID 19 pandemic affected also the production and market prices of natural gas. In 2019, global natural gas production reached a peak of four trillion cubic meters while in 2020, it dropped to some 3.85 trillion cubic meters (Statista, 2021). While in December 2019, the world market price of a cubic meter of natural gas was 2.22 US dollars, in march 2021, it dropped to 1.74 US dollars. Then, the price of natural gas started to grow, reaching 2.47 US dollars in December 2020 (MacroTrends, 2021). Since the world supply of natural gas is less price elastic than the world supply of oil, the share of natural gas in world fossil fuel supply is expected to increase in the future.

According to the data of the International Energy Agency released in 2017 (IEA, 2017), primary energy consumption was supposed to increase by 40% worldwide by 2025, compared to 2005. These estimates have influenced the strategic planning of long-term energy investments in the world, basically in the direction of the transformation of national energy systems from the use of non-renewable sources to renewable ones. However, as explained by International Energy Agency in 2021 (IEA, 2021), one of the consequences of the COVID 19 pandemic was a sharp drop in energy consumption in 2020. Namely, due to national lockdown measures, global fossil fuel demand was 57% lower in 2020 than in 2019. Thus the energy investments had fallen by one-fifth in 2020 compared to 2019, mostly because of the

decline in revenues due to lower energy demand and prices, as well as more uncertain expectations for these factors in the years ahead. That is the reason why, despite the need for transforming national energy systems in the direction of larger use of renewable sources, modern technological solutions still have to rely on fossil fuels. This is true for most countries in the world, among which is the Republic of Serbia, too.

## **2.2. Primary energy needs of the Republic of Serbia**

The production of the energy sector of the Republic of Serbia is classified into several groups of energy sources. The most common are fossil fuels, primarily conventional fuels: oil, natural gas and coal. Oil shales are unconventional fuels and their presence is still negligible, as is the presence of renewable energy sources. Satisfactory energy supply, as well as reliable distribution, are the basic precondition for social and economic development. The total energy dependence of the Republic of Serbia on primary energy imports in 2010 amounted to 33.5% and in 2019 it reached 35.9%, which is still less than in most European Union countries (Deđanski, Ljubojević. 2019). What is expected in the future is an increase in primary energy consumption in the industrial sector, leading to the new relative growth of energy imports.

The availability of economically viable mineral deposits plays an extremely important role in the economy of the Republic of Serbia. Their exploitation provides energy sources and raw materials for the production of material goods. Geological research and discovery of new deposits of coal and deposits of liquid and gaseous fossil fuels expand the possibilities of mining and oil and gas production, which directly affects the expansion of the material basis for economic growth and development of the national economy (Gnjatović, Leković, 2019).

Observed from the point of view of the economics of exploitation, the division of the explored reserves of mineral resources into proven reserves and probable reserves has been established. Proven reserves are determined as explored masses of mineral resources in the deposit that can be exploited and processed in an efficient way with existing techniques and technologies. Probable reserves are explored reserves of mineral raw materials in the deposit whose exploitation by existing techniques and technologies would not be economical. The following is a brief overview of the availability of the most significant explored geological reserves of fossil fuels in the Republic of Serbia, as presented in the Energy Development Strategy of the Republic of Serbia until 2025 (Strategija razvoja energetike Republike Srbije do 2025.godine, 2014).

Fossil fuels: coal, oil and natural gas as energy sources have a strategically important role in the economy of the Republic of Serbia. If we look at the total geological reserves of fossil fuels, oil and gas reserves make up 1% of geological proven and probable reserves of a high degree of exploration, while the remaining 99% of energy reserves are various types of coal. In proven reserves of coal, 95% refers to lignite. The total geological reserves of coal amount to 4.6 billion tons and represent a realistic basis for long-term energy development in general, and especially for electricity production in the Republic of Serbia (Gnjatović, Leković, 2019).

It has to be mentioned that about 76% of the total proven reserves of coal are located in the deposits of the Kosovo-Metohija basin, and about 24% in the narrower area of Serbia, mostly in the deposits of the Kolubara and Kostolac basins. Coal from the Kolubara and Kostolac basins provides about 70% of the country's electricity production. Of that, coal from the mining basin Kolubara enables the production of about 53% of electricity, and coal from the Kostolac mine provides about 17% of electricity production (Elektroprivreda Srbije, 2018).

Oil and natural gas reserves that are exploited in the Republic of Serbia are located on the territory of AP Vojvodina, in Banat and Bačka. The main problem of their exploitation is that

the reserves that have been explored and determined have been significantly depleted. The remaining proven oil reserves amount to about 10.5 million tons. The Strategy of Mineral Resources Management of the Republic of Serbia (Strategija upravljanja mineralnim resursima Republike Srbije, 2012) states that in 2010 the level of utilization of oil deposits was reached at about 80%. When it comes to natural gas, the remaining proven reserves amount to about 4.35 billion m<sup>3</sup>. The mentioned Strategy states that these reserves are "relatively small in volume and of low exploitable quality".

Since the reserves of crude oil and natural gas, as quality energy sources, amount to less than 1% of fossil fuel reserves of the Republic of Serbia, the energy system of the Republic of Serbia must primarily rely on the production of coal. Taking into consideration all lignite reserves, both in narrower Serbia and in the Autonomous Province of Kosovo and Metohija, and according to available geological estimates, it has been determined that there are 8.88 billion tons of lignite reserves in the Republic of Serbia. Based on the projected consumption of coal, the reserves of the Republic of Serbia can meet the needs of the next 80 years (Mitrović, Milosavljević, 2011).

In addition to the above, unconventional fuels should also be mentioned. Geological research has shown that the Republic of Serbia also has natural reserves of oil shale, whose reserves are estimated at 4.8 billion tons. However, oil shale reserves are treated as probable ones, considering that the processing technology is not specified in the technical conditions of exploitation because obstacles in the field of environmental protection are defined. Nuclear reserves are estimated at about 9.2 million tons of uranium ore and as such are classified as probable reserves. The uranium reserves are not negligible. However, it is necessary to define future exploitation technology due to possible limitations in the field of human protection (Parezanović, 2014).

The Republic of Serbia meets its needs for primary energy basically with fossil fuels. Fossil fuels participate with 85% in total primary energy consumption, where the share of coal amounts to 45%, the share of oil amounts to 27.4% and the share of natural gas amounts to the remaining 12.6%. The Republic of Serbia produces 64.1% of the required primary energy, while 35.9% has been provided by imports. Domestic primary energy production includes the exploitation of domestic resources of coal, crude oil, natural gas and renewable energy sources (hydro potential, geothermal energy, wind energy, solar energy, biogas, biomass). In the structure of primary energy production, coal participates with 68.5%, oil with 8.0%, natural gas with 3.1%, hydro potential with 7.2%, biomass with 11.8%, while geothermal energy, solar energy, wind energy and biogas account for 1.4%. Crude oil and oil derivatives have the largest share in imports of 60%, followed by natural gas 25%, coal 8%, electricity 6.6% and biomass less than 1%. (Energetski bilans Republike Srbije za 2021. godinu, 2020). It can be concluded that the main primary energy source produced and consumed in the Republic of Serbia is coal while main imported sources are oil and gas. Thus, the energy sector of the Republic of Serbia depends primarily on the production and imports of non-renewable fossil fuels.

### **2.3. Energy security of the Republic of Serbia**

When we consider the energy security of the Republic of Serbia, we have to bear in mind that energy consumption is not only based on domestic production but depends heavily on imported primary energy sources. Thus we can say with certainty that primary energy imports are extremely important for the survival of the economy and the development of society as a whole. That is why planning sufficient quantities of the production and imports of energy products is of strategic importance. Otherwise, without strategic planning, by neglecting the



energy sector, the population and the economy as a whole would be faced with harsh consequences (Parezamović, 2014).

In 2015, the National Assembly of the Republic of Serbia adopted the Energy Development Strategy until 2025, with projections until 2030 (*Strategija razvoja energetike Republike Srbije do 2025. godine*, 2014). According to that Strategy, the development of the economy of the Republic of Serbia should be based on more efficient use of relatively clean energy, which is in line with the recommendations of the European Commission (European Commission, 2021). In addition, the implementation of the Strategy envisages regular availability of various energy sources, having in mind the strategic importance of the diversification of producers and distributors of energy products. It is important to note that the Strategy assumes that, in the long run, the economy of the Republic of Serbia will be based on the highest standards of modern technology, which will reduce energy intensity per unit of gross domestic product. Primary energy sources will continue to be the basis for planning the economic development of the Republic of Serbia. It is necessary to observe the time factor in terms of the development of the energy sector, taking into account the available energy potential and modern technological solutions.

A special request, which the whole world and thus the Republic of Serbia is facing, too, is the reduction of negative consequences of energy consumption that directly affect the environment. Therefore, the mentioned Strategy envisages the introduction of modern technological processes with a high degree of energy efficiency. Today, energy is considered a commodity that is affected by supply and demand, thus forming a price on the world market. Supply and demand are conditioned by various factors, especially the terms of delivery that depend on international developments and relations. The price of energy also includes external costs, such as, for example, transition fees and technological adjustments. Since the Republic of Serbia depends to a large extent on the imports of primary energy, it is of vital importance to have foreign producers and distributors of imported energy well diversified.

The sustainability of the energy sector is, in fact, impossible to realize without adequate institutional solutions, for which the crisis management of the political elite is responsible, whose task is to detect possible upcoming crises in time (Milašinović et al., 2012). The increase in energy efficiency levels is observed especially from the point of view of environmental safety. Of great importance are the legal regulations that would encourage producers, distributors and users to apply modern technologies, which affect the sustainability of the optimal level of ecology. In addition to the above, it is necessary to harmonize the development of the energy sector with the social and material standard of citizens. Sudden changes, no matter how advanced, could disrupt the energy market, which would produce social consequences for most citizens of the Republic of Serbia (Očić, 2014).

The need to reduce dependence on fossil fuels in total energy consumption, urging the allocation of substantial investments in scientific research and specific projects regarding renewable energy, will bring results only in the long run. In the short run, the only realistic approach to the question regarding the diversification of energy sources for consumption in the Republic of Serbia is to enlarge, in relative proportions, the use of oil and natural gas at the expense of the use of coal. In light of the growing needs of industry for primary energy, with excessive reliance on coal which pollutes the human environment to the worst, it is realistic to expect that the logical reorientation would be in the direction of larger use of oil and particularly natural gas. In that respect, significant dependence on energy imports requires safe and regular pipeline transport.

The transport of oil to the Republic of Serbia is performed by an oil pipeline that stretches along the route from the Danube River on the border with the Republic of Croatia to Pančevo, in a total length of 154.4 km. The associated infrastructure of the oil pipeline consists of a terminal in Novi Sad with four crude oil tanks of 10,000 m<sup>3</sup> each, a dispatch center and a pumping station, then a measuring station in Pančevo and eight block stations along the pipeline route (Transnafta, 2021). In addition to transport, the storage of oil and its derivatives plays a significant role. The storage of required reserves of oil and oil derivatives is regulated by the European Union Directive from 2009 (European Commission, 2017). Member states and candidate countries for EU membership have been obliged to harmonize their national legislation with the mentioned EU directive in order to ensure a secure supply of oil and its derivatives (Ljubojević, 2014). The largest reservoirs of oil and oil derivatives in the Republic of Serbia are owned by the companies *NIS* and *Transnafta*.

Until 2021, the Republic of Serbia could receive imported gas only from the direction of Hungary. Due to that, there was a constant threat of endangering energy security due to potential supply problems that would occur in the event of disruptions in that direction. The construction of a gas connection to the so-called Turkish stream that runs through the Republic of Serbia from the Bulgarian border near Zaječar in the east, to Horgoš near Hungary in the north, and the commissioning of this new gas pipeline in 2021, provided gas supply from two directions. The section of the Turkish Stream gas pipeline that passes through Serbia was built by the joint efforts of the Russian Federation and the Republic of Serbia, through the mixed company *Gastrans*. In this company, 51% is owned by the Russian state-owned company *Gazprom*, and 49% by the domestic public company *Srbijagas*. The length of the pipeline is 402 km (Gastrans, 2021). Thanks to the gas connection to the Turkish Stream, the possibility has been created for the Republic of Serbia to become a transit country for gas delivery to Montenegro and Bosnia and Herzegovina, as well as the possibility for the southern and eastern parts of the country to be connected to gas (Deđanski, Ljubojević, 2019).

In the condition of the COVID 19 pandemic, new strategic directions in energy security planning and investments should be taken into consideration. Namely, it would be of great importance if the economy of the Republic of Serbia could become less dependent on primary energy imports. The volatility of production and prices of imported fossil fuels as a result of interruptions in the functioning of the global energy market in 2020 has pointed out the difficulties in the realization of national energy supply plans. Those difficulties might also emerge in the coming years since it is not clear how long the coronavirus disease would endure in the future and how severe it would be.

Two directions in the investments for enlarging primary energy production in the Republic of Serbia should be taken into consideration. First, if we take into account that domestic production will continue to be primarily based on the exploitation of coal, the investments in new technologies for coal exploitation in line with the demands for cleaner energy should be made. Second, the investments in renewable sources should be structured in such a manner that priorities should depend on relative costs of the implementation of ecological standards in building their infrastructure. Such strategic directions in energy security planning and investments are in line with research in the field of theoretical possibilities and reality in the rational use of energy sources. This research is going in two directions. "Firstly, in the direction of prolonging the life of possible use of non-renewable energy sources and, secondly, in the direction of reorientation to renewable energy sources and technological procedures that minimally affect air pollution and the human environment as a whole. Therefore, it is necessary to ensure continuous growth of energy production in accordance with the growth of industrial production and social standards, while finding suitable technological procedures for the rational use of renewable energy sources and improving the

use of non-renewable energy sources in plants with so-called. low-waste technologies, with the least harmful impact on the environment” (Milovanović et al., 2018).

### 3. CONCLUSION

The Republic of Serbia meets the needs for energy with 64.1% from domestic production and 35.9% from imports. The main energy sources used are conventional fossil fuels: coal, oil and gas. The needs for coal are met almost entirely by domestic production, while at the same time there is a high dependence on imports of oil and natural gas. As much as 80% of the needs for oil and 84% of the needs for natural gas are met from imports. Bearing in mind that natural gas is considered to belong to “clean” energy, although it is a fossil fuel, in the coming period it would be environmentally acceptable for Serbia to increasingly rely on natural gas imports at the expense of oil imports. This primary energy import policy is favored by the fact that by building a connection to the so-called Turkish stream the supply of natural gas is available from more than one direction.

In the short run, it is vital for the energy security of the Republic of Serbia to diversify and enlarge its domestic energy production. Especially in the condition of crisis, relying heavily on energy imports is risky. Any disturbance on the world energy market that affects foreign energy producers and distributors automatically spills over to the Republic of Serbia. Such a disturbance, manifested by strong energy price volatility, has occurred during 2020 under the influence of the crisis caused by the COVID 19 pandemic. Fluctuations in energy prices affect negatively the macroeconomic stability of the national economy because energy is part of the cost of production of all products and services.

In the long run, maintaining the energy security of the Republic of Serbia will depend on success in greater reliance on its own energy sources, i.e. on reducing the import dependence of the energy sector. In addition to coal, which is a non-renewable energy source, the energy system should increasingly rely on renewable energy sources: solar energy, wind energy and geothermal energy. The speed and flow of substitution of oil and gas imports by domestic renewable energy sources will depend primarily on the estimated costs and benefits of this substitution. Namely, the reorientation to renewable energy sources is possible only with high investments in the necessary infrastructure: solar panels, wind generators, wells and geothermal water pools.

### REFERENCES

- Babić, B. 2009. Geoeconomija, stvarnost i nauka. *Megatrend revija*, Vol. 6, No. 1, pp. 29-58
- Dedanski S., Ljubijević, R. 2019. Turski tok kao alternativa Severnom toku, *Energetska diplomatija Republike Srbije u savremenim međunarodnim odnosima*, Institut za međunarodnu politiku i privredu, Beograd, pp. 169-182
- Đorđević, B. 2017. Analiza energetske bezbednosti Republike Srbije: Geoekonomski pristup, *Megabiznis*, Vol. 1, No. 1, pp. 45-64
- Elektroprivreda Srbije. 2018. *Ugalj*. <http://eps.rs/lat/poslovanje-ugalj>
- Energetski bilan Republike Srbije za 2021. godinu. 2020. *Službeni glasnik Republike Srbije*, No. 156/20
- European Commission. 2017. *EU Oil Stocks. EU's Oil Stocks Directive (2009/119/EC)* [https://ec.europa.eu/energy/topics/energy-security/eu-oil-stocks\\_en](https://ec.europa.eu/energy/topics/energy-security/eu-oil-stocks_en)

- European Commission. 2021. *Energy Communities in the Clean Energy Package: Best Practices and Recommendations for Implementation*. Bruxelles, Belgium
- Gastrans. 2021. *Trasa gasovoda*. <https://gastrans.rs/about-the-project/?lang=en>
- Gnjatović, D., Leković, M. 2019. *Nacionalna ekonomija*. Univerzitet u Kragujevcu, Fakultet za hotelijerstvo i turizam, Vrnjačka Banja
- International Energy Agency. 2017. *World Energy Outlook 2017*, Paris
- International Energy Agency. 2021. *World Energy Outlook 2021*, Paris
- Ljubojević, R. 2014. Energetska bezbednost Republike Srbije između Rusije i Evropske Unije. *Srbija, region i Evropska unija*. Institut za međunarodnu politiku i privredu, Beograd, pp. 64-71
- Milašinovi, R., Milašinović, S., Putnik, N. 2012. *Teorija konflikata*. Fakultet bezbednosti, Beograd
- Mitrović, S., Milosavljević, J. 2011. Perspektiva pozicije uglja kao energenta u budućnosti. *Termotehnika*, Vol. 37, No.1, pp. 131-141
- MacroTrends. 2021. *Natural Gas Prices - Historical Chart*.  
<https://www.macrotrends.net/2478/natural-gas-prices-historical-chart>
- Milovanović, Z., Milašinović, A., Papić, Lj., Knežević, D. 2018. Nekonvencionalne, poboljšane i nove tehnologije za proizvodnju korisnih oblika energije. *Održivo planiranje energije, tehnologije i energetska efikasnost*, Istraživački centar DQM, Prijedor, Čačak, pp. 151-180
- Ministarstvo rudarstva i energetike Republike Srbije. 2012. *Strategija upravljanja mineralnim resursima Republike Srbije do 2030. godine*.  
<http://www.ekoregistar.sepa.gov.rs/strategija-upravljanja-mineralnim-resursima-republike-srbije-do-2030-godine>
- Očić, Č. 2014. *Moguće strategije razvoja Srbije*. SANU, Beograd
- Organization of the Oil Exporting Countries. 2021. *OPEC Statute*, Vienna.  
[https://www.opec.org/opec\\_web/static\\_files\\_project/media/downloads/publications/OPEC%20Statute.pdf](https://www.opec.org/opec_web/static_files_project/media/downloads/publications/OPEC%20Statute.pdf)
- Proroković, D. 2020. Geopolitički kontekst energetske bezbednosti. *Međunarodni problemi*, Vol. LXXII, No. 1, pp. 254-273
- Parezanović, M. 2014. *Energetska bezbednost*. Nova srpska politička misao, Beograd
- Statista. 2021. *Oil Production Worldwide from 1998 to 2020*.  
<https://www.statista.com/statistics/265203/global-oil-production-since-in-barrels-per-day/>
- Strategija razvoja energetike Republike Srbije do 2025. godine sa projekcijama do 2035. godine. 2014. *Službeni glasnik Republike Srbije*, No. 145/14
- Transnafta, 2021, *O nama*, <https://transnafta.rs/cp/o-nama-cp/>
- United Nations Economic and Social Council. 2021. *Enhancing energy security in the context of the coronavirus disease pandemic for a greener, more resilient and inclusive energy future in the region*, ESCAP77/17

UDK 616.98:578.834]:338.12  
338.23:336.74  
330.45:519.865  
COBISS.SR-ID 57318153

## CHALLENGES OF ECONOMIC POLICY AND INVESTMENT PORTFOLIO RESTRUCTURING DUE TO THE COVID-19 PANDEMIC

Vladimir Živanović<sup>1\*</sup>  
Jelena Vitomir<sup>1\*\*</sup>

<sup>1</sup>*The Faculty of Business Studies, Belgrade, Serbia*

### ABSTRACT

*The scientific paper investigates the impact of the implementation of an expansionary monetary and fiscal policy due to the COVID-19 pandemic. These economic policies are implemented in the global financial market to mitigate the negative economic and financial consequences of the pandemic and suppress contractionary economic trends. As well, the final goal of the creator of economic policy is to initiate investment activities at the level of national economies. The utilisation of expansive measures causes an increase in the amount of money supply, mainly in the amount of primary money on the financial market, which consequently leads to an inflationary spiral and an increase in the prices of all products on the market. In that respect, has analysed the impact of these measures on the activities of restarting economic flows and whether the revival of economic activity can be cancelled by the growth of inflationary tendencies. The analysis refers to the Republic of Serbia and the countries of the region, six countries belonging to the European Union and Germany as one of the most developed industrialized countries and countries with the most developed financial market in the single European market. To analyze the effects of economic policy implemented by regulators, data were used for the period preceding the announcement of the pandemic due to the COVID-19, 2000 as the year in which all the negative effects of the crisis were manifested, as well as projections of macroeconomic indicators for 2021.*

*In the newly created economic conditions, which are characterized by economic uncertainty related to new investment activities, the structure of the investment portfolio is also changing. The investment portfolio in the situation characterized by the global economic and financial crisis has changed and might be said that there is a kind of portfolio restructuring. Restructuring of the investment portfolio refers to the change of its structure which is conditioned by the change of "appetite" of individual and institutional investors who in the pandemic conditions want to make a portfolio diversification in which the share of real financial assets is higher. In the structurally restructured portfolio, the share of real assets in the form of goods such as gold and silver is increasing. The value of these financial assets is growing due to increased aggregate demand on the international precious metals market. The analysis will prove the basic hypothesis of whether gold and silver as safe haven financial assets can be used to better diversify an investment portfolio.*

### KEYWORDS

*COVID-19, financial crisis, monetary and fiscal policy, inflationary tendencies, cyclical economic trends, investment portfolio*

**JEL CLASSIFICATION: E31, E42, G01, G11, H30**

---

\* Vladimir Živanović – e-mail: vzivanovic@megatrend.edu.rs, Assistant Professor, ORCID: orcid.org/0000-0002-8233-763X

\*\* Jelena Vitomir – e-mail: jvitomir@megatrend.edu.rs, Assistant Professor, ORCID: orcid.org/0000-0001-6995-3297

## **INTRODUCTION**

The paper conducted research related to the analysis of basic macroeconomic indicators for the time under the pandemic COVID-19, which were significantly changed compared to the pre-COVID-19 period. Trends of these basic macroeconomic indicators in many analyzes during the pandemic were neglected due to the need to implement various governmental interventionist measures to prevent the negative economic outlooks due to the COVID-19 pandemic. The pandemic has affected changes in the international commodity and financial markets. These changes are visible in the movements of the most important indices of major financial markets, which are also conditioned by the change in the "appetite" of individual and corporate investors in the structuring of their investment portfolios. Following the developments in international markets, investors are adjusting the structure of their portfolios, in which the share of some hitherto alternative forms of financial assets is increasing, such as trading in precious metals, primarily gold and silver. Analyzing the structure of current investment portfolios and investing in real assets, it has proven to be an investment in a safe financial asset or the so-called "escape to safety", ie. investing in gold as a safe haven asset. Gold as a safe haven asset has always been considered the safest form of investment in real assets, but its value from the beginning of the pandemic to the present day has reached historical values, with an uncertain outcome to further increase the value of this type of financial asset.

Pressure from emerging economies, geopolitical turbulences caused primarily by the trade war between the US and the Chinese economy, the implementation of BREXIT, heightened tensions in the Middle East and fears of a slowdown in the global economy have led to growing investor interest in trading with commodities which led to an increase in the price of precious metals. Gold reached its highest historical value in early August 2020 of 2.067,15 USD/troy oz. The average value of around 2.000,00 USD/troy oz in the middle of 2020 is conditioned to a significant extent by the changed economic tendencies due to the COVID-19 pandemic and the appearance of general economic uncertainty and global contraction economic cycles. During the first eight months of 2020, gold had a growth of over 500 USD/troy oz which is a growth of 32%. If the contractionary cyclical economic trends continue globally during 2021 and next year, it is realistic to expect that gold as a safe haven asset will "break through" its historical value limit. Due to the significant growth in the value of these financial assets, the interest of investors around the world has triggered further growth in aggregate demand, which has led to further growth in the price of this precious metal.

Insufficient amount of gold with the increased aggregate demand on the international market of precious metals (London Bullion Metal Association - LBMA), directs the attention of investors to other precious metals, such as silver, which has long been undervalued. Due to increased demand, its value during 2020/21 had significant growth. The price of silver, as an investment alternative to gold, also depends on the amount of this metal mined on an annual level. Increased demand by the industry for silver as a metal lead to the growth of aggregate demand for this precious metal. Its production is limited with the available reserves and annual capacities of the mine in production, as well as the capacities of the smelters in its final production as a metal. The growth of investment demand, on the other hand, is exerted by market pressure, which forces the growth of the price of this metal on international commodity exchanges. Silver reached a value of over \$ 20.00/troy oz during 2020. With a current value of over \$ 23.00/troy oz, silver tends to grow. This is compared to gold, which during 2020 had the highest historical value and is still below the historically highest value for silver, which had the highest value in April 2011 when it was traded for 48,70 USD/troy

oz. Estimates from international markets are that the value of silver during 2021 will be at a level that is between 20,00 and 21,00 USD/troy oz.

Taking into account these facts that condition the change of "investment appetite" of different investors in the financial market, the paper will analyze the impact of the governmental interventionism measures in the implementation of expansionary monetary and fiscal policy to mitigate contractionary economic trends, but which due to increased supply of primary money at the level of national economies could lead to inflationary pressures. The paper will be analysed the impact of the implementation of expansionary monetary policy, which leads to a stoppage in the further fall of GDP, but which, on the other hand, due to inflationary pressures, may lead to a fall in the value of national currencies. The decline in the value of national currencies leads to a decline in the level of investors' investment portfolio, which should also be taken into account when investors choose a portfolio structure and do a portfolio structuring, which is based on goods that belong to a safe haven financial assets.

## **1. IMPLEMENTATION OF ECONOMIC POLICY – THEORETICAL APPROACH**

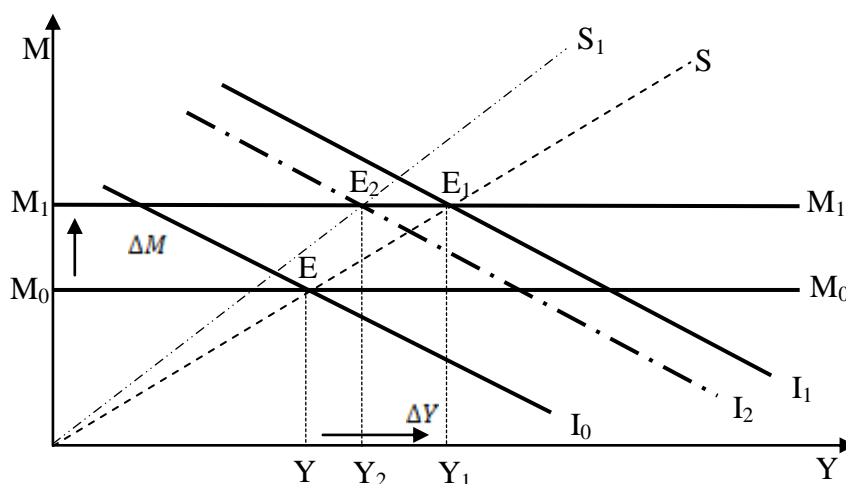
International commodity and financial markets are in an emergency economic situation due to the COVID-19 pandemic. Economic uncertainty, declining production and productivity, the emergence of inflationary trends, rising unemployment rates, rising indebtedness relative to gross domestic product (GDP) are the main negative macroeconomic trends that are present in these international markets. All these negative tendencies appeared as a consequence of the initial lockdown measures at all national economies, which consequently led to the impossibility of regular production processes and international trade. Export activities were almost stopped, which particularly affected certain sectors of the economy such as transport, the sector of tourism, the automotive industry and other sectors in the field of primary production. Consequently, due to the impossibility of imports and production in import-dependent economies, there was another negative macroeconomic phenomenon of stagflation. It is estimated that the strongest negative effect of the pandemic was in the transport and sector of tourism. Negative economic trends have brought tourism at the level of the European Union under an unprecedented level of pressure (Volkman et al. 2021). The United Nations World Tourism Organization (UNWTO) predicts that the global negative financial loss in the tourism sector will be around 40 billion USD (UNWTO 2020). Related to these negative projections, the number of foreign tourists was lower by about 80% during 2020 (UNCTAD 2020), while during 2021 a slightly smaller decline in the number of tourist trips is expected, but for the summer of 2021. This extrapolation for 2021 is based on figures at the end of August 2021, which shows a significant increase in the number of cases infected with COVID-19, which will lead to a further decline in the total value produced in this sector and the sector of transportation by the end of the year. All these facts have conditioned the implementation of expansive economic policy, which is primarily related to the additional „pumping“ of the money supply to solve the problems on the demand side.

It could be mentioned that the global economic crisis due to the COVID-19 pandemic is a crisis unknown to the global economy and that its depth is greater than that caused by the last global financial crisis in 2008 (Rohde 2011). The IMF lists three basic elements that make this crisis different from others. The first element refers to the size of the problem and the need for large allocations at the level of national economies related to health expenditures and the health system, as well as the necessary measures related to liquidity, which can ultimately

trigger a new global financial crisis. As the second element, there is uncertainty about the length and intensity of this crisis. The third element relates to a very different role in the implementation of economic policy (IMF 2020). Looking at economic outlooks during 2000, economists have the opinion that the global economy is facing a worse recession than the one caused by the Great Depression, and that the decline in the value of GDP of national economies is greater than that followed by the financial crisis before just over ten years ago (Wheelock 2020). Partial recovery of national economies is forecast for 2021, but the degree and depth of recovery largely depend on the implementation of economic policy at the level of national regulators, as well as the further pandemic flows particularly at the Q3 2021. This negative economic scenario could lead to the reintroduction of partial or complete lockdown and thus the cessation of production in certain sectors of the economy, which will consequently affect the extrapolated growth rates of GDP.

The COVID-19 pandemic, like any other global economic crisis, is leading to a contractionary economic cycle. In economic theory, a recession represents a negative macroeconomic trend and a decline in economic activity. The causes that lead to contractionary economic trends can be different, but it is most often cases as a consequence of falling consumption caused by shocks on the demand side and falling of aggregate demand. The first sign of the recession was the fall of the stock market in 2020 when the main market indices had a drop in value between 20 and 30% during February and March. The recovery followed during April 2020, and by the end of the year, the recovery would have been stopped for most market indices, or record estimates of falling values were being set again (Zumbrun 2020). Creators of economic policy still have the opportunity to implement expansionary monetary and fiscal policy to resolve or mitigate contractionary economic trends. With the implementation of these policies, national regulators want to reduce taxes and lower interest rates, with the main goal of accelerating the growth of economic activity. By lowering the base interest rate, creators of economic policy want to encourage the lending of funds in the financial market to restart economic activity that should affect increasing quantities of goods, thus establishing the new equilibrium between prices and quantities of goods which should control inflation trends (Živanović 2021). In these extraordinary economic circumstances due to the COVID-19 pandemic, it is necessary to realize a trade-off between measures of expansive economic policy, so that increasing the amount of primary money on the market would not jeopardize the recovery process due to inflationary or deflationary economic tendencies. The problem with the implementation of expansionary economic policy in a crisis similar to the Great Depression of the early 1930s is very problematic because the contractionary stage is not due to negative economic cyclical economic trends, but due to extraordinary circumstances caused by a pandemic that has a degree of uncertainty, refers to the duration of the crisis, the number of days of lockdown of national economies or certain sectors of the economy, the spillover of negative economic tendencies from different commodity and financial markets. In such circumstances, there is a fear that measures related to further increase in the money supply M1 may lead to inflationary tendencies, depreciation of national currencies and the regulators should implement a mix of different economic policies. Increasing the amount of primary money is a necessity given the increased level of costs arising from investments in the health system and health care, as well as the need to help the vulnerable population who are left with reduced monthly income due to inability to perform their regular economic activity.





**Graph 1.** Implementation of expansionary monetary policy

**Source:** Authors research

Graph 1 shows the effect of expansionary monetary policy, which refers to the growth of money supply and loan placement in a state of contractionary economic activity (Sovtić 2008). Expansive monetary policy leads to an increase in the money supply from  $M_0$  to  $M_1$ , which should, under conditions of normal economic trend, lead to an increase in investment activity, which is shown as a movement of the investment curve to the right from curve  $I_0$  to curve  $I_1$ . Due to the given savings at the level of the household and retail sector which is shown by the curve  $S_0$  under the rules of the free market, we have the establishing of the first equilibrium point  $E_0$  as an intersection of the investment curve  $I_0$  and the level of original money supply  $M_0$ . Expansive monetary policy leads to an increase in the money supply from position  $M_0$  to position  $M_1$ . At the intersection of the new increased amount of primary money shown by the  $M_1$  curve and the new investment curve  $I_1$  resulting from increased investment activity. We have established a new equilibrium point  $E_1$ , which is also characterized by an increase in level GDP and movement from initial amount  $Y_0$  to value expressed as  $Y_1$ . Income growth is higher than investment growth so that the growth of money supply and credit leads to multiplied growth of national income (Miletić 2013). In this way, the economic trends could be shown by applying an expansive monetary policy in regular cyclical economic trends. Does the application of classical expansionary monetary policy in extraordinary circumstances lead to the same effects? This is given in the same graph 1 in the form of a modified savings curve  $S_1$  which has a steeper shape compared to the initial savings curve given by curve  $S_0$ . The steeper savings curve was caused by the changing habits of consumers in the conditions of a pandemic to the classic contractionary economic trends. The consumers' habits in the extraordinary circumstances of a pandemic can be equated with economic behaviour in war conditions. These changing consumers' habits are more reliant on „hoarding money“ due to the uncertainty of future economic circumstances. Based on the new savings curve due to the increased amount of money given by the  $M_1$  curve, we have a slightly different scenario compared to the expectations of creators of economic policy, which refers to slightly lower investment growth compared to the situation of the regular contractionary economic cycle. Investment growth is lower than expected and it is shown by curve  $I_2$ . In the intersection of the new investment curve  $I_2$  and the curve of increased money supply  $M_1$ , we have a new equilibrium point  $E_2$ , which also reflects a

slightly smaller volume of growth of GDP. Depending on the depth of the crisis due to the COVID-19 pandemic at the level of one national economy, an increased amount of money can lead to an inflationary spiral and an increase in the prices of all goods. In some other markets, due to reduced production volume and lower demand, another negative macroeconomic situation may occur, which is characterized as stagflation.

Stagflation or negative inflation occurs when there is a general decline in economic activities at the level of the national economy. In situations that are characterized by stagflation, there is a greater supply of products to the existing demand. The standard form of stagflation leads to an increase in the purchasing power of consumers because money is worth more due to a decrease in the amount of money and a decrease in the amount of credit in the financial market, which harms consumers consumption. Milton Friedman argues that due to optimal economic policy, central banks should find a rate of deflation equal to the rate of real interest rates on government bonds (Friedman 1970). Friedman stated out that the nominal rate should be zero and that the price level should fall gradually according to real interest rates. In the case of a pandemic, this economic rule can also be viewed from different angles, all depending on how much the implementation of expansionary economic policy by central banks as regulatory bodies and states leads to stabilization of economic trends, and how much the implementation of different economic policies are weakening due to different consumers behaviour due to the change in "consumer appetites" and the desire of individuals and investors to „hoard money“ or turn it into a real financial asset.

Regarding the implementation of monetary policy, due to the effects of the previous global financial crisis and the effects caused by the pandemic, central banks lowered nominal interest rates in many cases to zero or very close to zero. Economists have an opinion that it is desirable to go with a negative interest rate because the implementation of a negative interest rate should encourage the economy and the consumers to spend or invest more as opposed to keeping money in the accounts of commercial banks and the so-called "hoarding money", whereby their value would be reduced due to the appearance of inflationary trends. On the other hand, there are concerns in the part related to the implementation of negative interest rates, such as the impact of these interest rates on bank profitability, while the other concern is related to depositors who may be motivated to no longer keep their deposits in accounts with commercial banks than to keep money in cash or turn into some other kind of real financial assets. In any case, the application of neutral interest rates that are close to zero in the short term is a reality and implemented by central banks in the international financial market. Neutral interest rates have the main goal of reestablishing economic activity during the contractionary economic cycle (Haksar and Koop 2020). On the other hand, within the framework of expansionary economic policy, regulators implement in parallel an expansionary fiscal policy. Expansive fiscal policy leads to lower taxes and thus to a larger amount of money left to the corporate sector or consumers, which can be used for new investment activities or to increase consumption (Zivanovic 2021).

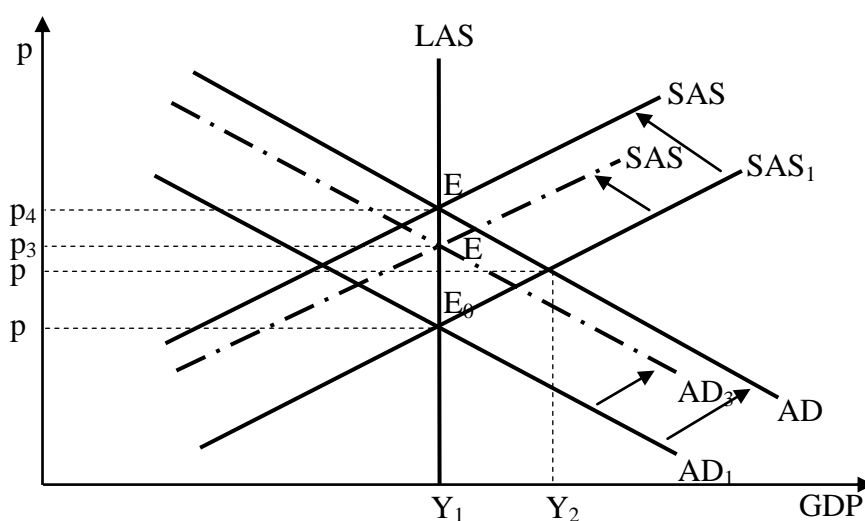
As expansionary fiscal policy leads to an increase in public expenditures, these activities directly lead to a budget deficit. The budget deficit must be financed either by external government borrowing on the international financial market or by the central bank's open market activities related to the sale of short-term securities.

The classical monetarist model of expansionary fiscal policy can be explained by the AS/AD model shown in Graph 2. Monetarists believe that the increase in aggregate demand for AD leads only temporarily to an increase in real gross domestic product, by increasing it to  $Y_1$ . At this volume of production, the first equilibrium is established at point  $E_0$ , which represents the intersection of the curve of long-term aggregate supply of LAS and short-term aggregate supply at the price level  $p_1$ . An increase in the amount of primary money leads to

inflationary expectations, which leads to a shift to the left of the short-run aggregate supply curve SAS1 to the SAS2 curve. This shift in the short-run aggregate supply curve leads to a new equilibrium point E1, which is characterized by higher prices  $p_4$  and a higher inflation rate with unchanged production volume  $Y_1$ . At the same time, we have only a short-term improvement in the macroeconomic position, which is characterized by a reduction in unemployment. Regarding this, monetarists stated that there can only be a short-term trade-off between unemployment and inflation (Friedman 1976). The same graph 2 shows the situation based on the classical monetarist school in the implementation of expansionary fiscal policy, but which is adjusted to the current macroeconomic circumstances due to the COVID-19 pandemic. In these circumstances, we can assume that the consumers will not react in the same way as shown in the basic model, ie. they will not be too interested in new investment activities or for new increased spending, and therefore we have a situation in which there is a short-term shift of aggregate demand from the initial position AD1 to AD3. In parallel, there is a short-term shift of the short-run aggregate supply curve from position SAS1 to SAS3.

At the point of intersection of the short-run aggregate supply curve and the long-run aggregate supply curve, we have a new equilibrium point E2, which is reflected in a slightly higher price  $p_3$  compared to the initial price  $p_1$  with unchanged gross domestic product  $Y_1$ .

As opposed to the monetarist economic school, Kenzians and neo-Kenzians view increased money supply as an endogenous variable, whose movement is influenced by changes in other variables in the economic model. They stated that due to the increase in aggregate demand to the production potential, the needs of consumers will be met as soon as the price at which they can be met is found, and in this way, the model will return to equilibrium (Keynes 1935). In the part of fiscal policy, Keynesians have an opinion that the issue of money increase can be neutralized by increased taxation. This statement given by John Maynard Keynes in the crisis caused by the pandemic is not applicable, because any additional taxation or imposition of a burden on the economy and the consumers is counterproductive. The Kenzians thoughts regarding the contractionary economic trends are that in these circumstances there is a rise in unemployment and a fall in inflation. They believe that the paradox occurs in situations of renewed economic growth when due to cost inflation there is stagnation which is characterized by higher unemployment rates and higher inflation rates.



**Graph 2.** The monetarist approach of expansive fiscal policy  
 Source: Authors research

Within the current situation, there is a somewhat favourable approach by international financial institutions towards countries in the area of conducting fiscal policy, which refers to the increase of public expenditures. In the short term, various creators of economic policy neglect the level of the budget deficit or the level of indebtedness to the GDP, leaving the solution of these problems at the time when economic activity has grown again at the global level, ie until the expansionary economic cycle. This opinion is acceptable, because most of the world's economies do not have the opportunity to finance from their sources an extraordinary increase in public expenditures, primarily related to increased expenditures for the health system and health care, but these activities lead to serious distortions of macroeconomic indicators at the levels of government debt to GDP. The problem of increased levels of government debt to GDP is a problem that cannot be solved in a short period and this is a problem that can lead to serious financial imbalances that most often lead to inflationary or deflationary tendencies and devaluation of national currencies. With the onset of the pandemic, several institutions responded to the new challenges that emerged in the global financial market. The main central banks have extended bilateral swap lines to each other and more other countries than during the previous global financial crisis. The US Federal Reserve (FED) has offered dollar liquidity repo programs for several different countries. However, the main central banks and the FED cannot offer these financial programs for all countries, so in that case, the International Monetary Fund (IMF) appears as an important factor that should enable the financing of the liquidity gap.

To these needs, the IMF has offered several forms of short-term liquidity financing for all member countries. These programs are called Short-term Liquidity Line (SLL), Rapid Financing Instrument (RFI) and Rapid Credit Facility (RCF).

As part of the IMF's broader response to the new economic turbulence due to the COVID-19 pandemic, is presented a new form of short-term SLL<sup>1</sup> financing, providing reliable and innovative credit lines for member countries with a very strong economic policy framework. This form of financing is especially focused on the needs of financing at the level of the balance of payments, and as well as the needs that are expressed in the short term at the level of the capital balance, which is conditioned by the pressures created based on external shocks. The importance of SLL credit lines lies in the fact that the IMF Executive Board can approve a credit line within a few days, regardless of whether the needs of member states are large or small, as part of a program related to the economic downturn due to the pandemic COVID-19 (Okamoto 2021).

Another form of quick financial support provided by the IMF is the Rapid Financing Instrument (RFI)<sup>2</sup>. This program provides short-term financing for all member states that face an urgent need for financing at the level of the balance of payments. Rapid Financing Instrument modifies an earlier IMF funding program related to emergency assistance policy and as such can be used in a variety of circumstances.

The third form of short-term financing by the IMF to overcome short-term insolvency, especially for developing countries and low-income countries (LIC), is called Rapid credit facility (RCF)<sup>3</sup>. RCF provides fast concession financial support with limited conditionality to low-income countries that need urgent financing at the level of balance of payments. This form of short-term financing presented by the IMF was formed within the Poverty Reduction and Growth Trust (PRGT) and represents a broader form of reform in the provision of

---

<sup>1</sup> IMF - <https://www.imf.org/en/About/Factsheets/Sheets/2020/04/17/short-term-liquidity-line>

<sup>2</sup> IMF - <https://www.imf.org/en/About/Factsheets/Sheets/2016/08/02/19/55/Rapid-Financing-Instrument>

<sup>3</sup> IMF - <https://www.imf.org/en/About/Factsheets/Sheets/2016/08/02/21/08/Rapid-Credit-Facility>

financial support that should be more flexible and tailor-made following the needs of LIC, and which are particularly pronounced in periods of the financial crisis.

**SDR allocations: COVID-19 vaccine purchase example**

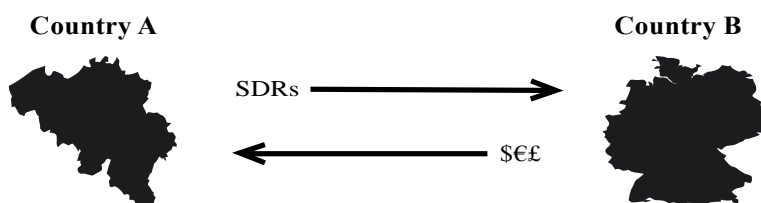
**Step 1: Allocations of SDRs**

If IMF allocates SDRs Country A receives an amount in proportion to its share in the IMF.



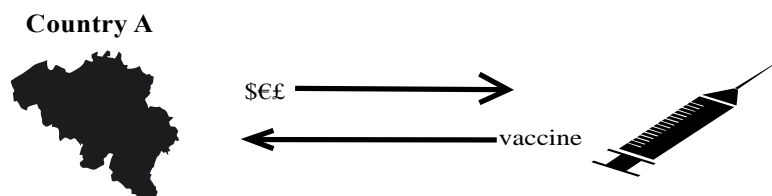
**Step 2: Trade SDRs for currency**

Country A can exchange its SDRs with Country B for foreign currency reserves.



**Step 3: Acquire vaccines**

Country A can then use these foreign currency reserves to purchase vaccines.



**Figure 1.** Allocation of SDR on the example of the purchase of vaccines against COVID-19  
**Source:** IMF - SDR Finance Facility

Finally, as a well-known form of IMF financing for all member countries, depending on their position determined by their quota shares and fiscal stability offered borrowing through Special Drawing Rights (SDR)<sup>4</sup>. At the end of August 2021, the IMF enabled the member countries to distribute the largest financial support in the history of the fund in the amount of 650 billion SDR, as part of the funds that are primarily determined to combat the consequences of the crisis caused by the pandemic, which is characterized as an unprecedented global economic crisis (Kristalina 2021). During the last financial crisis in 2008, the IMF issued aid of 250 billion SDR, so the current financing support is two and a half times higher than the number of approved funds during the last global financial crisis. The specificity of the program related to SDR refers to its speed of approval. These funds are distributed according to the IMF quota shares, closely related to the size of national economies. Of the total amount of SDR funds, 275 billion SDR is committed to emerging and

<sup>4</sup> IMF - [https://www.imf.org/en/News/Articles/2021/08/23/how-the-world-can-make-the-most-of-new-special-drawing-rights?utm\\_medium=email&utm\\_source=govdelivery](https://www.imf.org/en/News/Articles/2021/08/23/how-the-world-can-make-the-most-of-new-special-drawing-rights?utm_medium=email&utm_source=govdelivery)

developing countries. For the LIC is approved 21 billion SDR, which in some cases represents over 6% of GDP of specific countries. SDRs help member states with weak reserves at the level of their balance of payments to reduce their dependence on expensive domestic sources of financing or financing in the external international financial market.

Figure 1 shows how SDR-based funding should work to increase the fight against the COVID-19 pandemic. A national economy that has a deficit of liquidity reserves on its current balance of payments may exchange its share in the SDR with another country that has a surplus of liquid assets at the level of its balance of payments. With these liquid assets, a member state can purchase the vaccines it needs to fight against a pandemic. IMF estimates that national economies have so far spent about \$ 8 trillion to combat the negative economic results due to pandemics (Gaspar, Lam, and Raissi 2020). At the moment, the growth of public debt is visible in most of the world's leading economies, which in certain national economies exceeds twice the value of government debt to GDP. Following the IMF recommendations, we can conclude that the domicile financial market was the first in the region to respond to the challenges of the pandemic and which, to revive the national economy, implemented adequate fiscal and monetary policy whose results were visible in 2020, and whose effect will have a positive impact on economic trends in 2021. Following the applied measures in the field of economic policy, the Republic of Serbia had the lowest decline in production measured by the GDP growth rate in the region during 2020 (IMF 2020).

As an economic phenomenon during the COVID-19 pandemic, which is especially happening in the international financial markets, it is important for a different structuring of an investor's investment portfolio. Individual or institutional investors need to restructure the existing financial instruments on their investment portfolios due to the uncertainty of the economic and financial crisis. This is especially visible in the case when with the new investment portfolio investors would like to diversify it to reduce all forms of financial and market risks. As the value of the main indexes from the international stock exchange fell due to the pandemic and the fall in the value of international trade and production, investors tried to replace the existing financial instruments with some other real financial assets. Precious metals such as gold and silver are playing a significant role, and the share of these real assets is growing at the level of investor's investment portfolios. Due to the growth of aggregate demand from investors and consumers, the value of these assets increased during 2000, with a tendency for further growth during 2021/22. The further analysis will be related to the possibility of adequate diversification of the investment portfolio through gold and silver as real assets with the investors' goal to structure an optimal investment portfolio. Related to analyse of portfolio restructuring will be set up the basic hypothesis regarding the possibility of using precious metals as real assets in the diversification of the investment portfolio.

## **2. MACROECONOMIC ANALYSIS OF ECONOMIC POLICY**

Within the macroeconomic analysis, data on the value of trading are presented, which refer to the main market indices on the international financial markets. The analyzed data include the time series from 2019-2021. This time series covers the pre-COVID-19 period as well as the two years in which the COVID-19 pandemic has a negative economic and financial impact on global markets. The paper analysed trading values for main market indices such as S&P500, NIKKEI225 and STOXX600. To be able to compare the data related to the movement of these market indices is analysed the values and trends of the trading prices for main market indices with alternative forms of financial assets such as gold and silver.

**Table 1.** Main market indices trends and safe haven financial assets

M/Y	Gold	Silver	S&P500	NIKKEI225	STOXX600
01/2019	1.291,688	15,590	2.704,10	20.773,49	358,67
02/2019	1.319,910	15,806	2.784,49	21.385,16	372,80
03/2019	1.301,592	15,321	2.834,40	21.205,81	379,09
04/2019	1.287,048	15,042	2.945,83	22.258,73	391,35
05/2019	<b>1.283,527</b>	<b>14,625</b>	2.752,06	20.601,19	369,06
06/2019	1.358,765	14,996	2.941,76	21.275,92	384,87
07/2019	1.413,795	15,745	2.980,38	21.521,53	385,77
08/2019	1.497,950	17,138	2.926,46	20.704,37	379,48
09/2019	1.510,825	18,170	2.979,74	21.755,84	393,15
10/2019	1.494,783	17,625	3.037,56	22.927,04	396,75
11/2019	1.470,969	17,180	3.140,98	23.293,91	407,43
12/2019	1.478,035	17,114	3.230,78	23.656,62	415,84
01/2020	1.560,671	17,965	3.225,52	23.205,18	410,71
02/2020	1.597,960	17,922	2.954,22	21.142,96	375,65
03/2020	1.592,846	14,918	<b>2.584,59</b>	<b>18.917,01</b>	<b>320,06</b>
04/2020	1.681,480	15,034	2.912,43	20.193,69	340,03
05/2020	1.716,040	16,232	3.044,31	21.877,89	350,36
06/2020	1.733,125	17,720	3.100,29	22.288,14	360,34
07/2020	1.842,060	20,405	3.271,12	21.710,00	356,33
08/2020	<b>1.969,868</b>	26,893	3.500,31	23.139,76	366,51
09/2020	1.922,846	25,886	3.363,00	23.185,12	361,09
10/2020	1.901,400	24,246	3.269,96	22.977,13	342,36
11/2020	1.866,498	24,043	3.621,63	26.433,62	389,36
12/2020	1.854,877	24,887	3.756,07	27.444,17	399,03
01/2021	1.868,330	25,897	3.714,24	27.663,39	395,85
02/2021	1.811,090	27,351	3.811,15	28.966,01	404,99
03/2021	1.719,893	25,613	3.972,89	<b>29.178,80</b>	429,60
04/2021	1.760,239	25,640	4.181,17	28.812,63	437,40
05/2021	1.850,393	<b>27,463</b>	4.173,85	28.084,47	443,76
06/2021	1.835,332	26,982	4.297,50	28.791,53	452,84
07/2021	1.806,483	25,753	4.395,26	27.283,59	461,74
08/2021	1.784,028	24,016	<b>4.522,68</b>	28.089,54	<b>470,88</b>

**Source:** Yahoo Finance – Trading Data<sup>5</sup>

Based on the data from Table 1, it can be seen that for the observed time series, gold had the lowest trading value in May 2019 of 1.283,527 USD/troy oz, and the highest value in August 2020 of 1.969,878 USD/troy oz. Gold values of over 1.800,00 USD/troy oz remained during 2021. The high value for gold during 2020/21 represents growth due to increased aggregate demand for this financial asset. During the 2020 pandemic, investors and consumers wanted to exchange cash and other financial instruments for a real financial asset, which, like gold and silver, is seen as a safe haven asset. The increase in value for the observed time series, which includes the period before the declaration of the pandemic and during the COVID-19 pandemic, if we compare the lowest and highest value, shows an increase in the price of gold of 53,47%. On the other hand, we have data related to the value

<sup>5</sup> Yahoo Finance - <https://finance.yahoo.com>

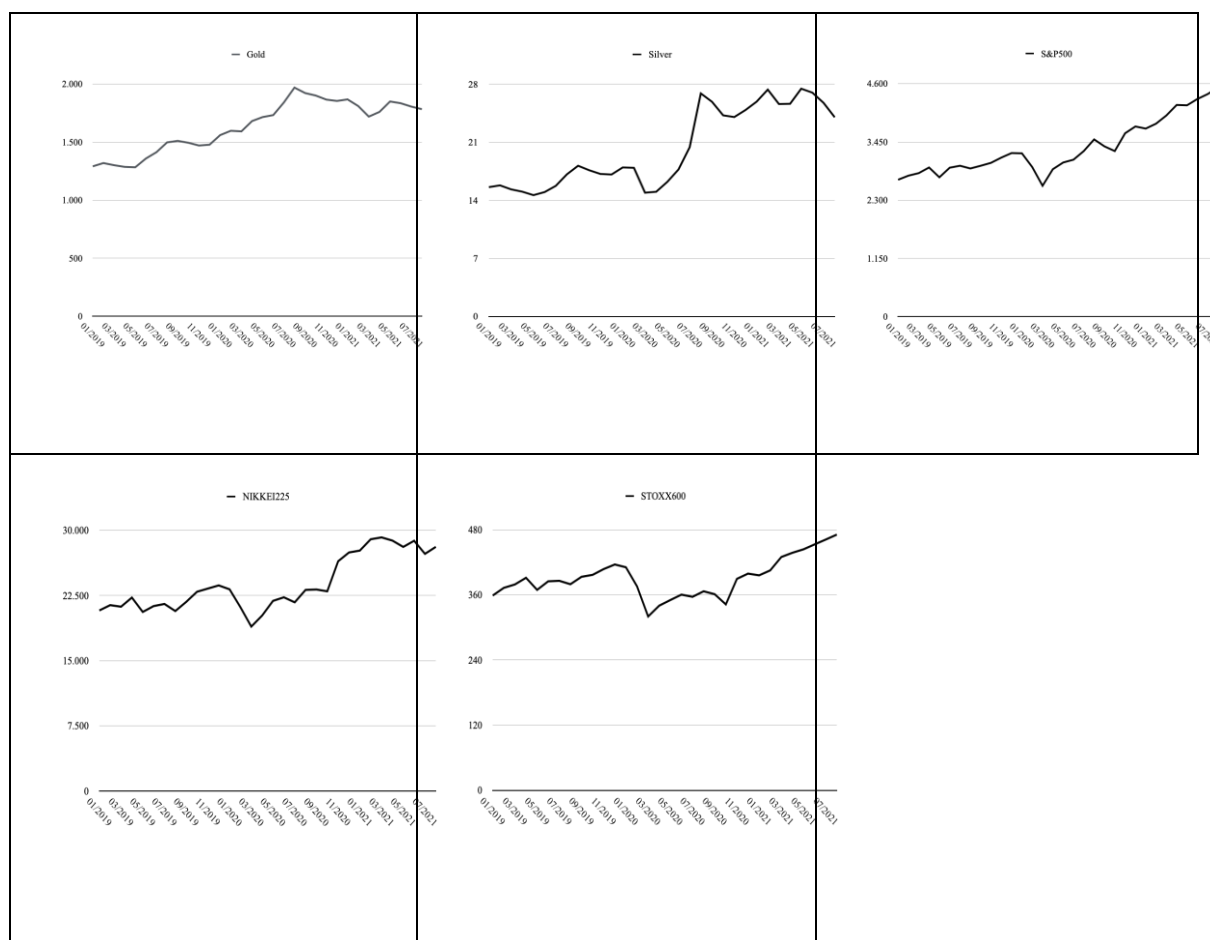
of trading with other real financial assets, which is viewed as trading in precious metals. Due to insufficient supply of gold with increased aggregate demand and other precious metals such as silver, which price has been underestimated for years, it appears as an investment alternative and its value also begins to grow due to increased aggregate demand for this metal. The lowest value of silver in the observed time series was also recorded in May 2019, as for gold. In May 2019, silver was traded at 14,625 USD/troy oz. With the declaration of a pandemic, the demand for this metal is growing and its value is growing during 2020/21. The highest value of silver in the observed time series was recorded in May 2021, when silver was traded at 27,463 USD/troy oz. If we compare the lowest value of silver for the time series before and during the pandemic, we can conclude that silver also had a growth of 87,78%. Silver had higher growth in value compared to gold as a safe haven financial asset. This is the case because silver has been undervalued by investors for many years and was a supplementary financial asset to gold, which had a dominant value and was traded the most to protect the value of real financial assets. Silver maintained high values during 2021, and according to projections from international commodity markets, silver is expected to maintain high trading values in 2022 too.

As well, it was observed the trends for leading trading indices such as S&P500, NIKKEI225 and STOXX600 as a financial instrument that is in the investment portfolio of investors in the same time series. Analyzing the data related to the value of these indices, we can conclude that the leading trade indices had the lowest value in March 2020. This can also be seen as a reaction of main trade indices to the declaration of a pandemic, the emergence of greater risk for all investors and the emergence of contractionary economic trends that affected the volume of international production and trade expressed through the growth rate of GDP at national economies. At the end of 2020, there was a partial recovery and increase in the value of these trade indices, so that the highest values would be achieved during 2021. For the S&P500, the lowest value was achieved in March 2020 with a value of 2.584,59 USD. The highest value of this index was realized in August 2021 at 4.522,68 USD. This represents a growth of 74,99%. The second major market index NIKKEI225 also had the lowest value in March 2020 of 18.917,01 USD. As for the S&P500, this market index has a stabilization value at the end of 2020/21, so that the highest value of this index was achieved in March 2021 with a value of 29.178,80 USD. Observing this value with the lowest value within the analyzed time series, we conclude that this market index had a growth of 54.25%. And the third observed market index STOXX600 had the lowest value in March 2020 of 320,06 USD. The highest value of this market index was recorded in August 2021 with a trading price of 470,88 USD. The STOXX600 had stabilization of the trading value and achieved growth compared to the lowest value during the pandemic of 47,12%. From the three main analyzed market indices, we conclude that the S&P500 had the highest growth in value, followed by NIKKEI225 and finally STOXX600. These trends show the degree of recovery of national economies during the pandemic and the resumption of investment cycles, primarily due to the implementation of economic policy by national regulators. In Table 1, the minimum and maximum values of the variables are shown as bold values.

The values analyzed in Table 1 are given in the form of graphs in Figure 2 on which is presented the trading trends for safe haven assets and the main trading indices. Graphs are given in the form of line charts on which we can see positive growth trends for all observed variables, especially from Q3 2020, as well as positive trends that continued in 2021. Based on these positive trends that are visible from Q3 2020 onwards, we can get the wrong conclusion about the complete recovery of national economies. It is necessary to analyze in detail the data related to basic macroeconomic indicators for individual countries.



*THEMATIC PROCEEDINGS*  
*THE IMPACT OF THE COVID 19 PANDEMIC ON ECONOMY, RESOURCES AND SUSTAINABLE DEVELOPMENT*



**Figure 2.** Graph of trading trends for safe haven assets and main trading indexes  
**Source:** Autor's research

Within this research which is related to the macroeconomic analyses, the macroeconomic indicators were analysed for twelve countries for the same time series from 2019-2021. It analysed the indicators for the domicile economy of the Republic of Serbia and all neighbouring countries. Macroeconomic indicators for Macedonia, Bosnia and Herzegovina, Albania were taken as data for comparable economies belonging to CEFTA countries. Like other neighbouring countries, the analysis includes countries that belong to the European Union, but which are neighbouring countries with the Republic of Serbia, such as Bulgaria, Romania, Hungary and Croatia.

**Table 2.** Macroeconomic data related to GDP growth rate and inflation rates

		GDP % <sup>6</sup>			Inflation rate <sup>6</sup>		
		2019	2020	2021 E <sup>7</sup>	2019	2020	2021 E <sup>7</sup>
1	Serbia	4,25	-0,98	4,97	1,85	1,58	2,19
2	North Macedonia	3,17	-4,53	3,80	0,77	1,20	1,96
3	Albania	2,17	-3,31	5,00	1,41	1,62	1,96
4	Bosnia and Herzegovina	2,83	-4,33	3,50	0,56	<b>-1,05</b>	1,23
5	Hungary	4,64	-4,96	4,30	3,34	3,33	3,63
6	Croatia	2,86	<b>-8,37</b>	4,70	0,77	0,26	0,72
7	Slovenia	3,18	-5,53	3,71	1,63	<b>-0,05</b>	0,81
8	Romania	4,13	-3,86	<b>6,00</b>	3,83	2,63	2,75
9	Bulgaria	3,69	-4,15	4,40	3,10	1,67	0,99
10	Greece	1,86	<b>-8,25</b>	3,76	0,25	<b>-1,25</b>	0,16
11	Italy	0,29	<b>-8,87</b>	4,20	0,61	<b>-0,14</b>	0,76
12	Germany	0,56	-4,90	3,40	1,45	0,51	2,25

The third analyzed group of countries also includes countries belonging to the European Union, such as Greece as a country in Southeast Europe and Slovenia as one of the last countries admitted to the European Union. Slovenia is smaller than the Republic of Serbia in terms of market and number of companies which belong to the real sector, but have strongest economic results than domicile economy. The last analyzed country is Germany as the country of the European Union which is the leading industrialized country and the country with the most developed financial market of all the countries taken in this macroeconomic analysis. Depending on the implementation of economic policy in the monetary and fiscal sphere by this country, all other countries try to harmonize their activities towards the implementation of measures depending on the possibilities and capabilities related to the balance of payments of each national economy.

Table 2 analyzes the first group of macroeconomic indicators for the observed time series. Data for 2021 are given as projected values. Most analysts, including international financial institutions, have made assumptions regarding 2021 as the year in which economic trends are expected to stabilize. Whether these projections will be realized depends largely on the further number of infected due to the COVID-19 pandemic and, accordingly, the normalization of economic activities, which ultimately depends on the speed and degree of vaccination of the world's population and costs related to vaccination, as and availability of vaccines in all parts of the world.

The first indicator in Table 2 refers to the values that show the growth rate of GDP by countries. Based on this indicator, it can be concluded whether a certain economy is in a contractionary or expansive phase of the economic cycle. For the first observed year, a year related to pre-pandemic business conditions, we have positive GDP growth rates for all countries. In 2020, as the year in which the pandemic was declared, all analyzed countries had negative growth rates, which is a direct consequence of negative economic activities. During 2020 all observed countries primarily implemented a monetary and fiscal policy aimed to combat the pandemic and negative effects on the economy due to pandemic. The three observed countries had the largest decline in the value of GDP, such as Croatia, Greece and

<sup>6</sup> World Bank Data – <https://data.worldbank.org>

<sup>7</sup> Statista - <https://www.statista.com/statistics>

Italy. It can be concluded that all three countries that had the highest drop in the rates of GDP have a significant impact on income from the sector of tourism. The sector of tourism was most affected by the negative effects of the crisis due to the pandemic. Italy is a highly developed industrialized country of the European Union, but it is also a country that was one of the most affected countries in Europe due to the pandemic, and the country that has had lockdown measures for the longest period, with serious losses on the level of the national economy. All other analysed countries had a decline of the growth rate of GDP in the range of 3,3-5,5%. Compared to the other analyzed countries, the Republic of Serbia had the best results thanks to the timely implementation of measures in the field of economic policy. These measures referred to the quick reaction in the field of fiscal policy as well as previously implemented fiscal stabilization, implementation of expansionary monetary policy, which is mainly focused on stimulating consumption and stimulating the part of aid to the sectors of the economy that were most affected by the negative economic trends due to the pandemic. The decline of the growth rate of GDP in the Republic of Serbia was 0,98%, so related to this rate the Republic of Serbia was the leader in Europe. Good results allowed the Republic of Serbia to start a business from a good starting position in 2021, and to extrapolate the growth rate of GDP of almost 5%. If there are no unforeseen economic flows by the end of 2021, due to the pandemic which is still present, this extrapolated growth rate may be higher, and it is estimated that the Republic of Serbia can achieve growth rates of about 7% annually. For other observed countries, economic analysts estimate stabilization of economic activities during 2021, and after a year of the falling growth rate of GDP, positive growth rates are expected for 2021 between 3,5-6,0%.

The second macroeconomic indicator in Table 2 refers to information related to inflation rates. For all analyzed countries, the inflation rates during 2019 and 2020 had stable values, ie values that ranged within the target inflation rate proposed by national regulatory authorities. Of the observed group of countries, four countries, such as Bosnia and Herzegovina, Slovenia, Greece and Italy, had negative inflation rates in 2020, which means that the national economies of these countries had stagflation, another negative macroeconomic phenomenon, which in many elements has greater negative effects than inflationary trends. Inflation rate extrapolation for 2021 indicates a stabilization of inflation rates for all observed countries. If we compare the data related to growth rates of GDP and inflation rates, we can conclude that creators of economic policy were focused on the trade-off between activities to maintain the inflation rate on a targeted level with a controlled decline in the growth rate of GDP. How successful they depend on the second and third groups of macroeconomic indicators, which will be given in the following tables.

To further analyze macroeconomic indicators, Table 3 shows the second group of indicators related to data on net debt to GDP and unemployment rates.

These indicators present a continuing analysis that should show the level of growth of net debt to GDP to protect national economies from contractionary economic trends due to the pandemic and how creators of economic policy have struggled to maintain the unemployment rate at pre-existing levels before declaring a pandemic.

**Table 3.** Macroeconomic data related to the level of government debt and unemployment rates

		Net debt/GDP <sup>8</sup>			Unemployment rate <sup>9</sup>		
		2019	2020	2021 E <sup>10</sup>	2019	2020	2021 E <sup>11</sup>
1	Serbia	48,86	54,57	60,00	10,39	9,01	12,99
2	North Macedonia	40,02	50,49	53,70	<b>17,26</b>	<b>17,20</b>	<b>16,34</b>
3	Albania	60,93	69,88	67,00	11,47	11,70	14,00
4	Bosnia and Herzegovina	20,78	28,59	31,00	15,69	15,87	17,50
5	Hungary	58,37	74,24	78,00	3,42	4,25	3,80
6	Croatia	72,80	88,70	86,1	6,62	7,51	9,41
7	Slovenia	42,73	50,50	81,00	4,45	4,97	5,36
8	Romania	28,53	40,44	50,30	3,91	5,03	4,90
9	Bulgaria	8,04	13,27	25,50	4,23	5,12	4,80
10	Greece	<b>180,50</b>	<b>205,60</b>	<b>209,00</b>	<b>17,31</b>	<b>16,30</b>	<b>16,58</b>
11	Italy	<b>122,08</b>	<b>142,03</b>	<b>160,00</b>	9,95	9,16	10,30
12	Germany	41,37	50,01	73,00	3,14	3,81	4,45

In line with the activities of creators of economic policy in combating the negative effects of the pandemic, and especially with increased public expenditures, which related to a large costs to invest in existing and new health systems and health care, all analysed countries have a significant increase of net debt to GDP in 2020, which was in the range of 5-25%. The largest increase in indebtedness was recorded in Greece, which increased its level of government debt by 25%, Italy by 20% and Croatia by 16%. The Republic of Serbia had a moderate growth rate of 5,71% and a level of government debt that is at the level of 54,57% of GDP, which is below 60% of government debt relative to GDP which represents the basis of economic and fiscal stability according to the recommendations given by Maastricht Treaty from 1992 and later the 2007 Lisbon Treaty.

The Maastricht Treaty was concluded in 1992 between 12 member states of the European Union and is the founding document of the European Union. This Treaty sets out the basic criteria relating to the monetary and fiscal stability of member states. The first criterion refers to the inflation rate, which is limited to an amount not exceeding 1,5% annually. At the time of signing the Treaty that was the average inflation rate at the level of the three best signatory countries. The second criterion refers to the avoidance of exceeding the government deficit to GDP which is not higher than 3% annually, as well as the level of government debt which is not higher than 60%. The third criterion refers to the exchange rate at which national currencies could exchange in the margins of normal fluctuation under the exchange mechanism given by the foreign exchange market controlled by the European Monetary System. The last, fourth criterion refers to the nominal long-term interest rate which is not higher than 2% of the lowest inflation rate in the three-member states.

High unemployment rates were recorded in the two observed countries, Northern Macedonia and Greece, while the other observed countries tended to maintain, and in some

<sup>8</sup> Knoema - <https://knoema.com>

<sup>9</sup> World Bank Data - <https://data.worldbank.org>

<sup>10</sup> Trading Economics - <https://tradingeconomics.com/forecast/government-debt-to-gdp>

<sup>11</sup> Statista - <https://www.statista.com/statistics>

cases improve employment, to save the current labour force to the period of restarting production and recovering national economies from the contractionary cycle.

At the end of the analysis of macroeconomic indicators related to the implementation of economic policy during the contractionary economic trends due to the pandemic, Table 4 shows the last pair of macroeconomic indicators. The values related to the money supply are expressed as a quantity of primary money M1 and the quantity of gold used as gold reserves at the level of the central bank of national economies and serve as a defense against unforeseen macroeconomic shocks. The money supply M1 is given in the quantity of the money reserves and deposits as values nominated in national currencies and is not converted into a USD. Data related to the M1 money supply were used to present the growth of primary money in relative numbers compared to the year before the pandemic. On the other hand, data of gold reserves and the percentage of gold to total reserves were used to prove the importance of gold as a safe haven asset in increasing macroeconomic stability in conditions caused by economic and financial crises with uncertain courses and duration.

**Table 4.** Macroeconomic data to the money supply M<sub>1</sub> and gold reserves

		<b>Money Supply M<sub>1</sub><sup>12</sup></b>			
		<b>2019</b>	<b>2020</b>	<b>Q3 2021</b>	<b>Currency</b>
<b>1</b>	Serbia	753.882	1.064.108	1.240.232	RSD million
<b>2</b>	North Macedonia	161.898	190.733	206.404	MKD million
<b>3</b>	Albania	487.750	565.911	655.037	ALL million
<b>4</b>	Bosnia and Herzegovina	12.221	13.638	15.924	BAM million
<b>5</b>	Hungary	22.472	25.774	30.066	HUF billion
<b>6</b>	Croatia	123.688	146.188	172.478	HRK million
<b>7</b>	Slovenia	20.935	23.791	28.100	EUR million
<b>8</b>	Romania	239.383	297.237	350.871	RON million
<b>9</b>	Bulgaria	55.314	75.597	88.465	BGN million
<b>10</b>	Greece	121.572	138.559	169.558	EUR million
<b>11</b>	Italy	1.196.010	1.323.340	1.473.616	EUR million
<b>12</b>	Germany	2.230	2.505	2.764	EUR billion

		<b>Gold reserves<sup>13</sup></b>					
		<b>2019</b>	<b>Holdings %</b>	<b>2020</b>	<b>Holdings %</b>	<b>Q2 2021</b>	<b>Holdings %</b>
<b>1</b>	Serbia	30,60	9,94	35,65	13,05	36,43	12,31
<b>2</b>	North Macedonia	6,90	9,21	6,89	10,14	6,89	8,15
<b>3</b>	Albania	2,80	3,62	2,80	3,53	2,80	3,40
<b>4</b>	Bosnia and Herz.	2,99	2,02	2,99	2,08	2,99	1,96

<sup>12</sup> Take-profit.org - <https://tradingeconomics.com/forecast/government-debt-to-gdp>

<sup>13</sup> GoldHub - <https://www.gold.org/goldhub/data/monthly-central-bank-statistics>

5	Hungary	31,51	4,82	31,51	4,62	94,49	14,62
6	Croatia	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
7	Slovenia	3,17	15,23	3,17	14,69	3,17	13,50
8	Romania	103,65	12,02	103,65	12,05	103,65	11,83
9	Bulgaria	40,48	7,07	40,83	6,55	40,83	6,55
10	Greece	113,50	65,20	113,90	58,00	113,96	59,49
11	Italy	2.451,84	68,33	2.451,84	70,72	2.451,84	68,77
12	Germany	3.366,49	73,48	3.362,45	76,13	3.359,12	74,93

In Table 4, the first analysed macroeconomic indicator refers to the quantity of primary money M1. based on the given data, we can conclude that in all observed countries during 2020 there was an increase in money supply, which is a feature of the implementation of expansionary monetary policy by the national regulatory authorities. All countries have increased the money supply to create space within the expansive monetary policy at the level of national economies for the resumption of consumption by consumers, as well as an increase in investment activities by the real sector. The increased quantity of money supply puts additional pressure on inflationary tendencies in the short and medium-term, so the growth of the inflation rate in the future depends primarily on the duration of the crisis, the start of investment activities and economic activity in general and as well as the end of the financial and economic crisis. Central banks should "sterilize" the money supply with their activities on the open market. The activity of central banks in the open market also depends on the ability of investors and the financial sector to participate in securities purchase activities issued by governments, as well as the implementation of other measures related to monetary and fiscal policy that should establish a new equilibrium market position. The scope for these activities will depend largely on the level of government debt to GDP that will grow in all national economies during the pandemic period. In line with the strengthening of the national economy and the defense of the national currency from future potential revaluation, national regulators have intensified activities in the international market related to the purchase of gold as real financial assets.

In the second part of Table 4, it is presented that during 2020, the share of gold in the total reserves of central banks is growing. This activity related to the increase in demand for gold by central banks affects the increase in the price of this precious metal, but on the other hand, gives a clear signal to individual and institutional investors how to the structure of their further investment. In 2021, it expects central banks to continue with the same trend of gold-related activities as in 2020. According to the data for Q2 2021, the largest increase in gold reserves for the observed countries was in Hungary, which increased the level of gold reserves by 63 mt, from 31,51 mt in 2020 to 94,49 mt in Q2 2021, which represents an increase in the share of gold in total reserves by 10%, from 4,62% to 14,62%. The Republic of Serbia also had an increase in gold reserves during 2020 compared to 2019 by 5 mt, as well as an increase of about 1 mt in Q2 2021. With this growth in the amount of gold, the Republic of Serbia increased the share of gold in total reserves by over 3% at a current level of around 13%. All implemented measures so far in the field of fiscal stabilization and expansionary monetary policy, relatively stable government debt, falling unemployment rate and controlled inflation, the increase in the share of gold in total reserves are a good signal to external investors regarding stable growth projections of the Republic of Serbia in the upcoming period.

### **3. PORTFOLIO RESTRUCTURING AND DIVERSIFICATION**

The last part of the paper is analysed the basic hypothesis H0. The basic hypothesis H0 proves the statement that refers to the question: Can gold and silver be used as safe-haven assets for optimal allocation at the level of the investment portfolio? This hypothesis was set up to prove that due to the effects of extraordinary economic circumstances due to the COVID-19 pandemic, the investment behaviour of individual and institutional investors is changing. In the changed circumstances, individual and institutional investors want to restructure their investment portfolios by managing financial instruments as best as possible to perform optimal diversification at the portfolio level with the main goal to minimize all types of financial and market risks.

The analysis related to proving the basic hypothesis and restructure of the investment portfolio used data for trading values for gold and silver and trading values of three main market indices such as S&P500, NIKKEI225 and STOXX600, for the time series from January 2019 to August 2021. These data are given in Table 1, related to macroeconomic analysis. Gold and silver have been used to prove or disprove the basic hypothesis regarding the use of these precious metals as investment alternatives in the process of restructuring and diversifying the investment portfolio in times of crisis. The remaining three main market indices were used in the analysis because the existing structure of the investment portfolio is mainly composed of a certain percentage of these financial instruments and because with doing analyses of these main market indices we could express the depth of the global contractionary economic cycle and extrapolate future financial and economic trends.

To conduct further statistical analysis of these data, Table 5 provides data related to the percentages of monthly returns on investment for five observed variables. Calculating the monthly rates of return on investment were used the data on the value of trading for all five variables is given in Table 1. Analyzing the obtained data for a given time series, which refer to the monthly return rates for the observed variables, it can be seen that the largest decline in the value for gold was in March 2021. The decline in the trading value for gold was 5,03% and can be characterized as a normal decline due to the exceptional fluctuation of these real financial assets during the previous period when a historically high value of trading with these real assets was recorded. The highest growth for gold as a safe haven was in August 2020, which coincides with a period of extremely negative financial and economic results on international markets due to the pandemic and increased investor demand for this type of financial asset. Silver as an investment alternative to gold had the largest decline in the value of trading in March 2020. The decline in the value of silver was 16,76%. On the other hand, silver as the second precious metal that can be viewed as a safe haven had the highest growth in the same period when the highest growth was recorded for gold in August 2020. The growth in the value of trading for silver was 31,80%. Analyzing the data on the monthly rate of return for the main market indices, we can see that all three observed trade indices had the largest decline in value in March 2020, when silver also had the largest decline in value. These trends reflect a global contractionary economic cycle that has hit all international financial and commodity markets. The decrease in trading values for S&P500, NIKKEI225 and STOXX600 was 12,51%, 10,53% and 14,79%, respectively. The market index S&P500 already in the following month of April 2020 had a correction in the form of growth of its trading value by 12,68%. At the end of 2020, all three market indices had the highest growth in value, which indicates positive market trends that were primarily related to the emergence of the vaccine against the COVID-19 virus and, consequently, the improvement of investment prospects by international investors. The growth of all three basic market indices was 10,75%, 15,04% and 13,72%, respectively.

**Table 5.** Monthly returns for safe haven assets and main trading indices

Monthly returns					
M/Y	Gold	Silver	S&P500 <sup>14</sup>	NIKKEI225 <sup>15</sup>	STOXX600 <sup>16</sup>
01/2019	-	-	-	-	-
02/2019	2,18489	1,38550	2,97289	2,94447	3,93955
03/2019	-1,38782	-3,06846	1,79243	-0,83867	1,68723
04/2019	-1,11740	-1,82103	3,93134	4,96524	3,23406
05/2019	-0,27357	-2,77224	-6,57777	-7,44670	-5,69567
06/2019	5,86182	2,53675	6,89302	3,27520	4,28386
07/2019	4,05000	4,99467	1,31282	1,15440	0,23385
08/2019	5,95242	8,84725	-1,80917	-3,79694	-1,63051
09/2019	0,85951	6,02171	1,82063	5,07849	3,60230
10/2019	-1,06180	-2,99945	1,94044	5,38338	0,91568
11/2019	-1,59314	-2,52482	3,40471	1,60016	2,69187
12/2019	0,48036	-0,38417	2,85898	1,55710	2,06416
01/2020	5,59094	4,97254	-0,16281	-1,90830	-1,23365
02/2020	2,38929	-0,23935	-8,41105	-8,88690	-8,53644
03/2020	-0,32003	<b>-16,76152</b>	<b>-12,51193</b>	<b>-10,52809</b>	<b>-14,79835</b>
04/2020	5,56451	0,77758	<b>12,68441</b>	6,74885	6,23946
05/2020	2,05533	7,96860	4,52818	8,34023	3,03797
06/2020	0,99561	9,16708	1,83884	1,87518	2,84850
07/2020	6,28547	15,15237	5,51013	-2,59394	-1,11284
08/2020	<b>6,93832</b>	<b>31,79613</b>	7,00647	6,58572	2,85690
09/2020	-2,38706	-3,74447	-3,92280	0,19603	-1,47881
10/2020	-1,11533	-6,33547	-2,76658	-0,89708	-5,18707
11/2020	-1,83559	-0,83725	<b>10,75457</b>	<b>15,04318</b>	<b>13,72824</b>
12/2020	-0,62261	3,51038	3,71214	3,82297	2,48356
01/2021	0,72528	4,05834	-1,11366	0,79879	-0,79693
02/2021	-3,06370	5,61455	2,60915	4,70882	2,30896
03/2021	<b>-5,03548</b>	-6,35443	4,24386	0,73462	6,07669
04/2021	2,34584	0,10542	5,24253	-1,25492	1,81564
05/2021	5,12169	7,10998	-0,17507	-2,52723	1,45405
06/2021	-0,81394	-1,75145	2,96249	2,51762	2,04615
07/2021	-1,57187	-4,55489	2,27481	-5,23744	1,96537
08/2021	-1,24302	-6,74485	2,89903	2,95397	1,97947

**Source:** Authors research

<sup>14</sup> The S&P500 index (SPX) tracks the performance of 500 of the largest companies listed on US exchanges, such as the New York Stock Exchange (NYSE) and Nasdaq. The S&P500, also known as the US 500, and can be used as a live indicator for the strength of US equities.

<sup>15</sup> The NIKKEI225 is a price-weighted equity index, which consists of 225 stocks in the 1st section of the Tokyo Stock Exchange.

<sup>16</sup> The STOXX Europe 600, also called STOXX600, SXXP, is a stock index of European stocks. This index has a fixed number of 600 components representing large, mid and small capitalization companies among 17 European countries, covering approximately 90% of the free-float market capitalization of the European stock market (not limited to the Eurozone).



Monthly returns can be expressed by the following formula:

$$R_t = \frac{P_t}{P_{t-1}} - 1 \quad (1)$$

where  $R_t$  represent monthly returns,  $P_t$  and  $P_{t-1}$  the prices of the assets at moments t and t-1, respectively.

**Table 6.** Main statistics for optimally/weighted portfolio and excess return

	Statistics				
	Gold	Silver	S&P500	NIKKEI225	STOXX600
<b>Average monthly return</b>	1,09545	1,71371	1,79816	1,10865	1,00075
<b>Monthly variance</b>	10,16432	68,75385	25,66196	27,17854	23,98871
<b>Annual return</b>	13,14538	20,56452	21,57795	13,30383	12,00900
<b>Annual variance</b>	121,97183	825,04623	307,94351	326,14249	287,86446

**Source:** Authors research

Based on the results from Table 5 in the further analysis is calculated the basic statistical indicators are required for the analysis of the optimal investment portfolio. Table 6 calculates the values of monthly return, monthly variance, annual return and annual variance. The variance calculation is used to calculate the difference between a forecast and the actual result and is expressed in relative numbers. After calculating these basic statistical indicators for the variables of the potential investment portfolio in Table 7 is calculated the excess returns value for all proposed variables of the investment portfolio.

Excess returns are an important metric that helps an investor to gauge performance in comparison to other investment alternatives. Thus, the excess return is identified by subtracting the return of one investment from the total return percentage achieved in another investment. Investors would like to see excess return as the difference in their investment over a risk-free rate.

On other hand, this value can be calculated in comparison to a closely comparable benchmark with similar risk and return characteristics. The positive excess return shows that an investment outperformed its comparison, while a negative difference in returns occurs when an investment underperforms. So, in general, an investor or institutional investors looking for an opportunity to achieve excess returns beyond a comparable proxy. The excess return value depends on an investor's willingness to take a risk.

More risk-taking make opportunities for higher returns. With the risk of an investment, investors should calculate the beta coefficient which is an important metric when we would like to generate an Efficient Frontier graph (Markowitz 1952) or to develop Capital Allocation Line.

Asset returns on an Efficient Frontier can be calculated using the following Capital Asset Pricing Model (Whitehurst 2003):

$$R_\alpha = R_{rf} + \beta \times (R_m - R_{rf}) \quad (2)$$

where  $R_\alpha$  represent expected return on a security,  $R_{rf}$  the risk-free rate,  $R_m$  expected return of the market,  $\beta$  of the security,  $(R_m - R_{rf})$  equity market premium.

The calculation of excess returns value made it possible to obtain the values represented in Table 8. Table 8 presents the values of the variance-covariance matrix. The values obtained from this matrix are an integral part of the final calculation of the optimal investment portfolio and prove the basic hypothesis.

**Table 7.** Excess returns values for all variables of an investment portfolio

Excess returns					
M/Y	Gold	Silver	S&P500	NIKKEI225	STOXX600
01/2019	-	-	-	-	-
02/2019	1,08944	-0,32821	1,17473	1,83582	2,93880
03/2019	-2,48327	-4,78217	-0,00573	-1,94732	0,68648
04/2019	-2,21285	-3,53474	2,13318	3,85659	2,23331
05/2019	-1,36902	-4,48595	-8,37594	-8,55535	-6,69642
06/2019	4,76637	0,82304	5,09486	2,16655	3,28311
07/2019	2,95455	3,28096	-0,48534	0,04575	-0,76690
08/2019	4,85697	7,13354	-3,60733	-4,90559	-2,63126
09/2019	-0,23594	4,30800	0,02247	3,96984	2,60155
10/2019	-2,15725	-4,71316	0,14228	4,27473	-0,08507
11/2019	-2,68859	-4,23853	1,60654	0,49151	1,69112
12/2019	-0,61508	-2,09788	1,06082	0,44845	1,06341
01/2020	4,49549	3,25883	-1,96097	-3,01696	-2,23440
02/2020	1,29384	-1,95306	-10,20921	-9,99555	-9,53719
03/2020	-1,41548	-18,47523	-14,31009	-11,63674	-15,79910
04/2020	4,46906	-0,93613	10,88625	5,64019	5,23871
05/2020	0,95988	6,25489	2,73002	7,23158	2,03722
06/2020	-0,09984	7,45337	0,04068	0,76653	1,84775
07/2020	5,19002	13,43866	3,71197	-3,70259	-2,11359
08/2020	5,84287	30,08242	5,20831	5,47707	1,85615
09/2020	-3,48251	-5,45818	-5,72096	-0,91263	-2,47956
10/2020	-2,21077	-8,04918	-4,56474	-2,00574	-6,18782
11/2020	-2,93104	-2,55096	8,95640	13,93452	12,72749
12/2020	-1,71806	1,79667	1,91398	2,71432	1,48281
01/2021	-0,37017	2,34463	-2,91183	-0,30987	-1,79768
02/2021	-4,15915	3,90084	0,81099	3,60017	1,30821
03/2021	-6,13092	-8,06814	2,44570	-0,37403	5,07594
04/2021	1,25040	-1,60829	3,44437	-2,36357	0,81489
05/2021	4,02624	5,39627	-1,97323	-3,63588	0,45330
06/2021	-1,90938	-3,46516	1,16433	1,40897	1,04540
07/2021	-2,66732	-6,26860	0,47665	-6,34610	0,96462
08/2021	-2,33847	-8,45856	1,10087	1,84532	0,97872

Source: Authors research

**Table 8.** Variance-covariance matrix

Variance-covariance matrix					
	Gold	Silver	S&P500	NIKKEI225	STOXX600
Gold	<b>121,97183</b>	206,73849	32,30389	-15,36215	-12,68602
Silver	206,73949	<b>825,04623</b>	192,50338	155,97673	131,18604
S&P500	32,30390	192,50338	<b>307,94351</b>	252,05337	267,89824
NIKKEI225	-15,36215	155,97673	252,05337	<b>326,14249</b>	257,53191
STOXX600	-12,68602	132,18604	267,89824	257,53191	<b>287,86446</b>

Source: Authors research

To calculate the optimal portfolio diversification, a risk-free rate was used in the model, which is calculated as a rate on 10Y US Treasury Bills<sup>17</sup>. The risk-free rate has a value of 1,34% on September 16, 2021. Based on this rate in Table 9 is calculated the expected returns, risk and Sharpe ratio.

The expected return presented the amount of profit or loss an investor can anticipate receiving on an investment. The formula for the expected return can present as follows:

$$E|R| = \sum_{i=1}^n R_i P_i \quad (3)$$

where  $E|R|$  is expected return,  $R_i$  return in scenario  $i$ ,  $P_i$  probability for the return  $R_i$  in the scenario  $i$ , and  $n$  represent a number of scenarios.

The risk represents the market risk of all assets in the proposed investment portfolio. And the Sharpe ratio is used as a value to show the return of an investment compared to its risk. The Sharpe ratio is the average return earned over the risk-free rate per unit of volatility or total risk. Volatility indicates the price fluctuation of an asset in a portfolio. The formula for the Sharpe ratio can be expressed as:

$$\text{Sharpe ratio} = \frac{R_p - R_f}{\sigma_p} \quad (4)$$

where  $R_p$  is the return of the portfolio,  $R_f$  risk-free rate, and  $\sigma_p$  represent standard deviation of the portfolio's excess return.

**Table 9.** Equally and optimally weighted portfolio

Equally/Weighted Portfolio		Optimally/Weighted Portfolio	
<b>Gold</b>	0,20	<b>Gold</b>	0,59
<b>Silver</b>	0,20	<b>Silver</b>	0,00
<b>S&amp;P500</b>	0,20	<b>S&amp;P500</b>	0,41
<b>NIKKEI225</b>	0,20	<b>NIKKEI225</b>	0,00
<b>STOXX 600</b>	0,20	<b>STOXX600</b>	0,00
<b>SUM</b>	1,00	<b>SUM</b>	1,00
<b>Expected returns</b>	16,12	<b>Expected returns</b>	16,62
<b>Risk</b>	13,87	<b>Risk</b>	10,49
<b>Sharpe ratio</b>	1,07	<b>Sharpe ratio</b>	1,46

**Source:** Authors research

Table 9 presented two investment portfolios. The first investment portfolio has the same structure of financial instruments, ie. in this investment portfolio, each financial instrument participates with 20%. The second investment portfolio represents an optimally structured investment portfolio in times of financial crisis as a crisis due to the COVID-19 pandemic. To compare the two investment portfolios calculate the values of expected returns, risk and Sharpe ratio. The first investment portfolio obtained lower values of expected returns and Sharpe ratios, as well as higher values of market risk. The base interest rate on risk-free bonds, which was 1,34% at the time of analysis used to calculate all values in both investment

<sup>17</sup> Ycharts - [https://ycharts.com/indicators/10\\_year\\_treasury\\_rate](https://ycharts.com/indicators/10_year_treasury_rate)

portfolios. After the application of portfolio diversification based on modern portfolio theory obtained an optimal portfolio, which includes only two financial assets out of a total of five observed. In the optimal investment portfolio, the share of gold is at the level of 59%, while the share of investments in financial instruments of the market index S&P500 is 41%. With this structure of the investment portfolio, investors can achieve the highest value of Sharpe ratio of 1,46 and the lowest value of the market risk of 10,49. Based on these data, we can conclude that the basic hypothesis is partially proven and confirmed the high share of gold as a real financial asset and as safe have assets, while silver as an investment alternative to gold is not a part of the optimal portfolio structure.

An optimally weighted portfolio is calculated using the Generalised Reduced Gradient (GRG), based on an applied algorithm for the nonlinear programming method. Generalised Gradient methodology looks at the gradient or slope of the objective function as the input of variables measuring the changes of different investment assets in an investment portfolio. GRG methodology determines an optimally weighted portfolio when the partial derivatives are equal to zero.

## **CONCLUSIONS**

Based on the conducted research related to the impact of economic policy measures by national regulatory bodies to combat the financial and economic crisis due to the COVID-19 pandemic, as well as on the analysis of the need to restructure the investment portfolio depending on the changed circumstances in the international financial market due to the consequences of the crisis, we can conclude that observing macroeconomic indicators shows the existence of global contractionary economic trends, and proved the basic hypothesis related to the restructuring of the investment portfolio. Analyzing the data for a given time series that coincides with the pre-COVID-19 period, as well as the years in which the pandemic is present, we can conclude that all international financial markets are struggling to find the optimal solution in the implementation of expansionary monetary and fiscal policy. The international economy due to the pandemic is in a contractionary economic cycle, which requires coordinated activities by national regulators and central banks in the open market to provide national economies with a sufficient level of government budget funds to finance increased public expenditures incurred primarily by large expenditures to finance newly incurred costs at the level of the existing health system, construction of new capacities within the health system and increased costs in the part of health care. To these costs related to the national health system and health care should be added the costs at the level of public expenditures related to the procurement of a sufficient number of vaccines to combat the COVID-19 pandemic.

The availability of funds at the level of the balance of payments of national economies is different, and therefore national economies perform a kind of capital structuring that refers to deciding which part of these increased public expenditures will be financed from own sources, and which part will be financed by borrowing on the international financial market. Related to that, international financial institutions have also offered various forms of new financial arrangements that are primarily based on financing increased public expenditures and deficits at the level of the government budget. The IMF is one of the most important international financial institutions that was the first to react to the needs of national economies and member countries.

On the other hand, looking at the macroeconomic indicators for the analyzed group of countries and for a given time series, we can conclude that all countries had a decline in GDP

growth rate for the years related to the COVID-19 pandemic. In addition, certain countries had negative inflation rates during the pandemic years, especially during 2020, which indicates an even more negative macroeconomic situation and the emergence of stagflation. Other observed countries had controlled inflation rates that were within the targeted inflation rates. The same can be concluded for the unemployment rate, which has remained relatively stable. For all countries, it can also be concluded that in the years of the pandemic, there was an increase in the amount of supply of primary money, especially expressed as an increase in the money supply M1. The increase in the value of the monetary aggregate M1, primarily due to the expansionary monetary and fiscal policy, indicates potential future problems related to inflationary trends. Due to increased public expenditures, certain analyzed countries also had an increase in net debt to GDP, which in later years may lead to tendencies related to the need to revalue the national currencies. As the countries that had the highest growth of net debt to GDP are the member states of the European Union, it may happen that after the pandemic, the European Central Bank will be forced to additionally help these national economies or to revalue the euro in the entire European single market. As one of the measures related to additional strengthening of the stability of the national currencies, it was noticed that in certain national economies grows the share of gold in total reserves in the central banks, which for these national economies represents an additional degree of monetary security due to extraordinary economic activities due to the COVID-19 pandemic.

The domicile economy has managed to fight against the negative effects of the COVID-19 pandemic as one of the leading countries in Europe through activities in the area of previous fiscal stabilization, and timely implementation of expansive monetary and fiscal policy. This has been confirmed by the IMF and other independent rating companies. Consequently, the Republic of Serbia had the smallest decline in the value of GDP compared to most national economies in Europe. In the part related to increased public expenditures regarding the health system and health care, the Republic of Serbia managed to finance the increase of health capacities primarily used for patients infected with the COVID-19 virus, and in the part of health care, it is one of the few countries in Europe, which offers its health insurers free health care as well as free vaccines against the COVID-19 virus. In addition to the positive effects related to the GDP growth rate, the Republic of Serbia also has positive trends in the inflation rate, the unemployment rate and the increase in the level of gold in the total reserves of the central bank. Based on all these indicators, it is concluded that the Republic of Serbia can expect a good starting position to restart economic activity after the COVID-19 pandemic. These are also the assumptions made by independent rating companies that announce an improvement in the investment rating for the Republic of Serbia.

The paper presents a basic hypothesis, the proof of which refers to the claim that gold and silver can be used as safe-haven assets in changed conditions due to the pandemic and financial crisis, as well as the need for a different structuring of the investment portfolio. Individual and institutional investors need to restructure the investment portfolio and, accordingly, the need to increase the share of real assets in the investment portfolio. Investing in gold is mostly used as a real asset, but also silver as an investment alternative. Due to the increase in aggregate demand for these real financial assets in the global commodity markets, there was a sharp rise in the value of gold and silver. The research based on the application of the Modern Portfolio Theory and Capital Assets Pricing Model formed the Optimally Weighted Portfolio, which proved the basic hypothesis that gold should be included in the new restructured investment portfolio with a high 59% share. Silver as an investment alternative has not shown significant value. The Optimally Weighted Portfolio calculation was obtained using the Generalized Reduced Gradient.

Based on all the results obtained by this research, we can conclude that the international economy is in a deep contractionary economic cycle and that it will take time and a lot of coordinated activities on a global level to get out of this negative economic phase to find the international economy in the expansionary phase of the economic cycle. The pandemic has changed the way international trade and financial markets work. There are more and more financial assets in the financial markets that can be used as hedging financial instruments. In connection with all these activities, investors and institutional investors are trying to find the optimal structure of their investment portfolio in extraordinary and unpredictable economic and financial conditions and to diversify in the best way at the level of their investment portfolios. With diversified investment portfolios, gold can be used as a safe-haven financial asset.

## **REFERENCES**

- Friedman, Milton. 1970. "The Optimum Quantity of Money." *The Economic Journal* 80 (319): 669–72.
- Friedman, Milton. 1976. "Inflation and Unemployment: The New Dimension of Politics." *The 1976 Alfred Nobel Memorial Lecture Occasional*: 1–44.
- Gaspar, Vitor, Raphael Lam, and Mehdi Raissi. 2020. "Fiscal Policies to Contain the Damage from COVID19." *IMF Blog*, 1–7. <https://blogs.imf.org/2020/04/15/fiscal-policies-to-contain-the-damage-from-covid-19/>.
- Haksar, Vikram, and Emanuel Koop. 2020. "How Can Interest Rates Be Negative?" *Finance and Development* 57 (1).
- IMF. 2020. "World Economic Outlook." *World Economic Outlook* 1 (April): 1–37. <https://blogs.imf.org/2019/07/23/sluggish-global-growth-calls-for-supportive-policies/>.
- Keynes, John Maynard. 1935. *The General Theory of Employment Interest and Money*. Palgrave Macmillan, United Kingdom. <https://doi.org/10.1007/978-3-319-70344-2>.
- Kristalina, Georgieva. 2021. "How the World Can Make Most of New Special Drawing Rights." *Financial Times Opinion: International Monetary Fund*.
- Miletić, Vesna. 2013. *Monetarne i Javne i Finansije*. Prometej, Novi Sad.
- Okamoto, Geoffrey. 2021. "The Short-Term Liquidity Line: A New IMF Tool to Help in the Crisis." *IMF Blog*, 2021.
- Markowitz, Henry. 1952. "Portfolio Selection." *The Journal of Finance* 7 (1): 77–91. <https://doi.org/10.2307/2975974>.
- Rohde, Lars. 2011. "Lessons From the Last Financial Crisis and the Future Role of Institutional Investors." *OECD Journal: Financial Market Trends*, no. 1: 1–6.
- Sovtić, K. 2008. *Monetarne Finansije*. Megatrend univerzitet Beograd.
- UNCTAD. 2020. "COVID 19 and Tourism - Assessing the Economic Consequences." [https://unctad.org/en/PublicationsLibrary/ditcinf2020d3\\_en.pdf/](https://unctad.org/en/PublicationsLibrary/ditcinf2020d3_en.pdf/).
- UNWTO. 2020. "COVID-19: Putting People First." <https://www.unwto.org/tourism-covid-19/>.
- Volkman, Christine, Kim Oliver Tokarski, Dinca Violeta Mihaela, and Anca Bogdan. 2021. "The Impact of Covid-19 on Romanian Tourism - An Explorative Case Study on Prahova Country, Romania." *Amfiteatru Economic* 23 (56): 196–205. <https://doi.org/10.24818/EA/2021/56/196>.
- Wheelock, David. 2020. "Comparing the COVID-19 Recession with the Great Depression." *Economic Synopses* 39. <https://doi.org/https://doi.org/10.20955/es.2020.39>.
- Whitehurst, David. 2003. *Corporate Finance*. MacGraw-Hill.

Živanović, Vladimir. 2021. Fundamentals of Finance. Megatrend univerzitet Beograd.  
Zumbrun, Josh. 2020. "Coronavirus Slump Is Worst Since Great Depression. Will It Be as Painful?" Wall Street Journal.

UDK 616.98:578.834]:331.108.45  
005.963.1  
COBISS.SR-ID 57319433

## **INNOVATIVE APPROACHES TO PROFESSIONAL TRAINING OF PUBLIC ADMINISTRATION EMPLOYEES IN THE CONDITIONS OF THE PANDEMIC COVID 19**

Igor Vukonjanski  
Borivoje Baltezarević<sup>1</sup>

<sup>1</sup>Assistant Professor, Faculty of Management, Sremski Karlovci, University - Union - Nikola Tesla; baltezb@yahoo.co.uk

### **ABSTRACT**

*Modern trends of professional training in public administration imply an organized process of continuous improvement of existing and acquisition of new knowledge, skills and abilities of employees in public administration which ensures competence, legality, regularity and expediency in performing specific functions, activities and tasks from public administration.*

*However, as the training of public administration employees was programmed, conceived and performed exclusively in the form of lectures in the cabinets and amphitheatres of the National Academy of Public Administration, the new Covid 19 pandemic brought into question all activities in this area.*

*In order to continue with the continuous training of public administration employees in the conditions of the "new normality", a new concept was applied in the already existing model of so-called distance learning, by organizing webinars. As a precondition for such an approach to the organization and implementation of on-the-job training, a series of activities ranged from animating and training lecturers, designing a new distance learning platform (LSM platform), creating new databases and work-educational material, to analyzing student satisfaction with new methods. work. As this process entered the second year of operation, there was a need to analyze the efficiency and expediency of such a method of knowledge transfer, which is the subject of this research paper.*

### **KEY WORDS**

*public administration, knowledge transfer, distance learning, Covid 19*

### **INTRODUCTION**

The process of professional development of public administration employees, in addition to planning, selection (recruitment and selection) of staff, their monitoring and evaluation, rewarding and promotion, is certainly one of the essential elements in integrated management and development of human resources in public administration. On the other hand, the implementation of this process contributes to the overall achievement of reform goals and principles of public administration development, which is why it requires systemic solutions and planned direction and development in all issues that are common or characteristic of most public administration entities, including issues related to organizational forms that can



support and achieve integrity and uniformity in the programming and implementation of professional development programs for employees in public administration.

The importance of this process is especially reflected in the general goal of public administration reform, which implies further improvement of public administration in accordance with the principles of the so-called "European administrative space", ie providing high quality services to citizens and businesses, as well as creating such public administration contribute to economic stability and increase the living standard of citizens.

Given that the professional development function aims to bridge the differences between the existing and desired state of professional competence of public sector employees (Donald, Kettl, 2000), professional development is an ongoing process aimed at continuously raising the level of public sector competence. In addition, in addition to establishing a new organizational culture, a new so-called "learning culture" is being created (Armstrong, 2006). This idea – the imperative is also directly related to the global requirements of the economy based on knowledge and the improvement of abilities and skills, which is defined as such by numerous international documents.<sup>1</sup>

In order for the function of permanent professional training, ie lifelong learning of employees in public administration, to achieve maximum efficiency and effectiveness, it is necessary to use all existing capacities that the public sector currently has or could use. On the other hand, in the process of realization of plans and programs of professional development of employees in public administration, they implement the basics of the doctrine of knowledge management.<sup>2</sup> Also, knowledge management contributes to the correspondence of explicit and tacit knowledge at the level of the individual, group, organization and between organizations (Ketelaar, 2007). This means that the primary task is to locate employees who possess tacit knowledge relevant to the job and to keep such employees in the public administration system with the appropriate benefits of the civil service.

For the purpose of proving the importance of continuity in the professional development of public administration employees, regardless of external determinants and conditions imposed by the external environment, it is necessary to point out the importance of the following components such as: 1) identification of knowledge; knowledge and competencies available to employees in the public sector); 2) acquisition of knowledge (from existing resources available to the public sector or "purchase" of knowledge from external sources - outsourcing); 3) developing knowledge (supporting individual skills and stimulating the articulation of so-called "silent knowledge" in order to create new knowledge); 4) sharing and distribution of knowledge (implies an interactive process of administrative organization and employees who need improved knowledge and skills); 5) use of knowledge (a key motivating factor for employees in the public sector, who must have a clear and unambiguous idea of all

---

<sup>1</sup> Let us mention here only a few international documents: 1) "Adult Learning: A Key for the Twenty-First Century" (Fifth International Conference on Adult Education UNESCO Conference in Cooperation with International Partner, Hamburg 1997); 2) "Memorandum on lifelong learning, Commission of the European Communities" (Brussels, 2000); 3) "Education for All: Meeting our Collective Commitments" (Dakar Framework for Action, 2000); 4) "Making a European area of lifelong learning a Reality" (Communication from the Commission, 21.11.2001, EC DG for Education and Culture and DG for Employment and Social Affairs 2001); 5) "The Declaration of the European Ministers of Vocational Education and Training" in Copenhagen 2002); 6) "UN Decade of Education for Sustainable Development" (Resolution of the 65th General Meeting of the German Commission for UNESCO (DUK), Bonn 2005).

<sup>2</sup> Knowledge management involves the use of available resources in order to create an environment in which information is available to individuals, who adopt, share and use it to develop their own knowledge. In such an environment, individuals are encouraged to apply their knowledge for the benefit of the organization in which they work. To achieve this, we must first provide adequate human resources as a source of knowledge through planning, recruiting, selecting and retaining existing quality staff. Next, we need to create a value system within the public sector that will promote knowledge as a key criterion for hiring, promoting, valuing and rewarding the work of public sector employees.

the benefits that newly acquired knowledge brings on a personal and professional or career level) and 6) storage of knowledge (structuring and continuous updating of knowledge within the public sector, in the form of documents and expert systems in which the procedure for using all data is defined (Stewart, Tensley, 2002)). Finally, modern theory and practice of knowledge management pay great attention to the concept of permanent professional development of employees in public administration.<sup>3</sup>

## **MODALITIES FOR PROFESSIONAL TRAINING OF PUBLIC ADMINISTRATION EMPLOYEES**

The current regulations governing the topic of professional training in public administration in the Republic of Serbia (primarily referring to the Law on the National Academy of Public Administration, the Law on Civil Servants and the Law on Employees in Autonomous Provinces and Local Self-Government Units) Professional training conducted by the National Academy of Public Administration is carried out by lecturers, coaches and mentors accredited in accordance with applicable regulations.

While lecturers conduct their training through oral presentations (usually in the form of lectures) and interactive contact with students through exercises, creating practical tasks and answering students' questions, mentors implement a professional development program when, through group or individual work with participants and in the process performing the work of their workplace, it is necessary to provide direct support and transfer of complete knowledge, experience, abilities and skills that the mentor has to work in the field that is the subject of the program, and which should be acquired by a public servant. Finally, coaches ensure the implementation of the program by providing support to participants, which is aimed at jointly or mutually encouraging the exchange of experiences of coaches and students to develop skills to more effectively solve problems and achieve professional interests and improve performance in the workplace. self-government.

It follows that the two most common modalities of knowledge transfer are live lectures and distance learning through the information and instructions provided, using different technologies and other forms of distance learning "is the definition of distance learning given by the American Distance Learning Association (The United States Distance Learning Association).

In addition to the classic distance learning instruments (recorded oral presentations, PowerPoint presentation and accompanying written materials), there are more and more so-called webinars that enable: slide show (Microsoft PowerPoint or Apple KeyNote), video display (whether it is saved in your computer or plays online from YouTube), talk to trainees (during the webinar, an online telephone service is used - Voice over Internet Protocol that allows real-time audio communications), recording lectures (with the possibility of delayed playback of the entire presentation including all audio videos), Chat with participants (written chat with participants, which is of particular importance for audience members who want to ask questions) and finally the option of a poll or voting (the ability to create a poll or voting option, which participants fill out for statistical purposes, and they especially refer to the expression of satisfaction with the attended training, ie the evaluation of the training itself and lecturers).

---

<sup>3</sup> Activities in the field of professional development of public administration employees include: 1) analysis of training needs, 2) planning of general professional training, 3) creation of special professional training programs according to the needs of individual public administration departments, 4) evaluation of implemented activities, 5) reporting and 6) providing continuous and stable sources of financing for these activities..

For the needs of public administration employees, the National Academy of Public Administration designed a special Webeck platform for further learning through webinars, which could influence: automation of webinars (scheduled reproduction to inform participants that the webinar will start soon, encouraging them to apply immediately; recording of lectures, interaction between lecturers and exhibitors (live chat, surveys or virtual presentation board), security (webinar rooms are password protected) and final analytical processing of all data (report and analytics on the rate of webinar specificity and other quality metrics the publications themselves).

### **COMPARATIVE ANALYSIS OF THE PROFESSIONAL TRAINING SYSTEM IN THE COUNTRIES OF THE EUROPEAN UNION AND THE REPRESENTATION OF THE DISTANCE E-LEARNING METHOD**

Comparative analysis of the system of professional development of public administration employees, for the purposes of this paper, was performed on a sample of those countries that meet one of three criteria: the first criterion is the similarity of public administration and the position of public administration employees the closest to ours and the existence of a central institution of professional development of employees in public administration, as is the case in the Republic of Serbia.

Comparative analysis is based only on the processing of available documentation (desk study). Relevant data were collected through the websites of the ministries in the selected countries responsible for civil service training issues, as well as through the websites of their main civil service training institutions. Data were also collected from scientific reports, annual reports of training institutions and other relevant sources that were available to the authors of this paper.

#### **Professional training of employees in the public administration of Germany**

Similar to the Republic of Serbia, the professional development of public servants is organized through the activities of the central institution of professional development, ie the Federal Academy of Public Administration (BAköV). BAKöV is the most important institution for the training of civil servants at the federal level in Germany. The academy was established in 1969 by a decree of the Federal Ministry of the Interior. The decree is based on a decision of the Federal Cabinet. In terms of organization, the Federal Academy is an independent part of the Federal Ministry of the Interior. The seat of the Federal Academy has been located in the premises of the Federal College of Public Administration, located in Brill, near Bonn, since 1988.

The most important tasks of the Federal Academy are: supporting the policy of the Federal Government; maintaining and constantly improving the performance of the federal state administration; improving the quality of narrowly professional and interpersonal skills of employees in the federal state administration, strengthening their motivation and encouraging the exchange of ideas and experiences.

The Academy of Public Administration is a partner of federal bodies in charge of professional development of staff and providing advice; specifically designs its programs in accordance with the specific needs of clients, current policy goals and the latest achievements in research and society; supports federal bodies in modernizing and managing change and

helps federal bodies become “learning” organizations and helps employees more effectively combine work activities and learning.

Planning and implementation of professional training of employees in public administration are organized through the work of seven departments, as follows:

Department 1 is in charge of determining new requirements for professional development, for the development of strategies that will be able to meet such requirements, as well as for the development of annual programs of professional development and new instruments and methods of professional development. Department 1 is also in charge of quality management and evaluation.

Department 2 is in charge of organizing training for the preparation of candidates for promotion from the position in the higher-middle service to the position in the higher service. Within this Department, testing of candidates for professional development programs for the mentioned jobs is also performed.

Department 3 is in charge of professional development of staff in areas related to EU competencies and international skills.

Department 4 is in charge of professional development of executors and staff development.

Department 5 is in charge of professional development in the field of IT and new educational methods (e-learning and "blended" learning). This Department has its own monthly newsletter which contains information on current events and achievements in the field of information technology and e-learning.

Department 6 is in charge of coordination with the Academy's office in Berlin.

Section 7 is in charge of an advanced training program aimed at promoting international skills. The department is in charge of policy issues, planning, organization, implementation and evaluation of professional development aimed at promoting international skills. This department is also in charge of training foreign civil servants, exchanging staff at the international level, cooperating with international organizations, as well as applying for candidates for the French-German academic training program "Master of European Administration" which enables the acquisition of an accredited academic degree.

In the scope of the BAKöV training department described above, it was learned that only one department, namely Section 5, provides training in the field of IT and new learning methods (e-learning and “blended” learning). The content of training is constantly adapted to the needs of clients. Training is organized mainly by standard distance learning methods.

### **Professional training of employees in the public administration of Greece**

The National Center for Public Administration and Local Government (E.K. D.D.A.) is a strategic institution for the professional development and education of civil servants and employees in local government. The center was established in 1983 as a legal entity and is under the supervision of the Ministry of the Interior.

The National School of Public Administration (ESSD) has six departments: the Department of Executive Communication; Department of General Administration; Department of Social and Health Management; Department of Regional Administration and Development; Department of Information System Management and Department of Tourism, Economy and Development.

The scientific staff of the Center, in cooperation with central and local government units, considers the need for professional development, prepares and conducts training in accordance with these needs, and within the set goals of the institution.

The training system is implemented through 3 phases. Within teaching phase 1, an introductory training program lasting 4 months is implemented, and it contains an

introduction to the basic principles of public administration. Within this module, the following are studied: public policy and public administration; ethics in public administration; European political system; electronic administration; research methodology; office business automation skills; writing, standardization and management of public documents, elements of administrative law, organization and management of the public sector, public economy and finally the IT technology system.

Within teaching phase 2, which lasts 9 months, different courses of each department are realized individually. Only within this phase are distance training realized by standard working methods.

Teaching phase 3 lasts 4 months. Within this phase, students are assigned to units selected by the School after their studies on a current topic in the field of public administration.

### **Professional development of employees in the public administration of the Czech Republic**

The Czech Republic does not currently have an institution in charge of centralized management in relation to issues - training policy in the civil service. Based on the Government resolution from 2001, the Institute for Public Administration was established. The main role of the institute is to provide training for public administration employees. In the beginning, the institute was under the auspices of the Cabinet of the Government, but later it was moved under the auspices of the Ministry of the Interior and placed under the authority of the Deputy Minister in charge of European Union Affairs.

The Prague Institute of Administration prepares all training that it is obliged to prepare in accordance with Law no. 312/2002 on employees in local self-government units. This includes: 1) preparation for certification of special professional competencies through an exam (These competencies are defined by public notification of the Ministry of Interior); 2) continuous training, with a focus on topics in the field of certification of special professional competencies and others; 3) training for more experienced employees and managers of organizational units, in order to master the knowledge and skills needed for management in everyday situations and 4) training related to e-government.

According to the information from the website of the Ministry of the Interior, which includes the presentation of the Institute, the Institute of Public Administration presents its courses in the catalog twice a year and continuously. This consists of regular one-day courses, e-learning and blended courses and access to the center with independent learning of English, German and French.

### **Professional development of employees in the public administration of Austria**

The Austrian Federal Academy of Public Administration, *Verwaltungsakademie des Bundes (VAB)*, was established in 1976 as a government training institution. The Austrian Federal Academy of Public Administration provides leadership and management training for senior civil servants, human resource management and human resource management programs, general and special programs and training for European integration and public administration consulting. The academy also provides consulting services and training courses for civil servants and trainers in Central and Eastern Europe.

The Academy provides external lecturers on the basis of: contact with line ministries, government bodies and social partners, in order to find civil servants or other experts with

specific competencies needed for various topics and on the basis of cooperation with European institutions in various fields.

The Austrian Federal Academy of Public Administration offers a wide range of seminars and modules - training programs related to the following areas: Basic Competences and Vocational Training (Grundausbildung), Europe and Language, Human Resources and e-Government, Management and Leadership Training.

The content can be summarized as follows: The seminars are open to civil servants from the Member States and officials from European institutions. The Academy also offers a series of seminars held by partners from other European schools of public administration through E-learning.

### **Professional training of employees in the public administration of Lithuania**

The Lithuanian Institute of Public Administration (LIPA) is the leading institution for the training of civil servants, research and consulting in public administration in Lithuania. The Institute actively cooperates with over twenty foreign institutions and universities and has an active role in international projects.

The beneficiaries of the Institute are employees of the Seimas Office (Parliament), the Office of the President and the Office of the Government, ministries, other state bodies and institutions, districts and municipalities. About 85% of training is provided to civil servants in ministries and institutions within ministries, the Office and government institutions.

The Institute of Public Administration operates in the following directions: 1) Preparation and updating of training programs for civil servants; 2) Training of civil servants; 3) Training and improvement of lecturers' skills; 4) Participation in international programs and projects related to the development of skills in public administration and the mission of the Institute; 5) Methodological, consultative and organizational support for state and municipal institutions; 6) Research on training issues in the civil service; 7) Spreading the culture of state administration; 8) Development of information database and 9) Preparation and publication of methodological literature.

The Lithuanian Institute of Public Administration provides a wide range of training programs and modules. In 2008, 20,000 participants attended the training. Due to the financial crisis, the number of participants decreased dramatically in 2009. The most attended was the training on the topic of the European Union and in the field of legislation. Senior civil servants can participate in about twenty courses in total and all this training is offered by the Institute. Most training programs are short-term training.

In addition to key training in the field of financial resources management; transparency and anti-corruption; globalization; change management; administrative capacity building programs; leadership and development of human resource management skills and development of individual management skills; European Union regional policy and management of EU funds are represented (as a separate entity) and E-learning programs

### **Professional development of employees in the public administration of Norway**

Although Norway is not a member of the European Union, the system of professional development of employees in the public administration of that country is at a very high level. In addition, in the past 20 years, the Government of Norway has made a great contribution to the modernization of public administration in the Republic of Serbia through the action of the Agency for Public Administration and Electronic Administration - Difi.

Norway Agency for Public Administration and Electronic Administration - Difi is the main institution in charge of central training in the civil service in Norway. Difi aims to strengthen the work of the Government in implementing public administration reforms. The Ministry of Public Administration, Reform and Church Affairs oversees the work of the Norwegian Agency for Public Administration and Electronic Administration - Difi.

The Norwegian Agency for Public Administration and e-Government - Difi aims to continuously improve organizational structures and public administration management, through coordination of public authorities and services, providing support to human resource management and leadership training. It should also be noted that Norway is the Agency for Public Administration and Electronic Administration - Difi Government instrument that provides state bodies with generic training with an emphasis on the values of public administration, principles, rules and regulations, internationalization, governance, e-government, work processes and culture.

Norway The Agency for Public Administration and Electronic Administration - Difi implements its training through its employees or other civil servants, university professors, consultants, relevant specialists and international experts. When the Norwegian Agency for Public Administration and Electronic Administration - Difi contracts training with trainers from the private sector, there is an obligation to conduct a public procurement procedure in accordance with the Public Procurement Act.

The main topics of the training are the following: 1) public administration (rules and regulations, principles, values and ethics, governance, governance systems, change management and reform processes); 2) leadership and human resource management (leadership training, change management, mentoring, career planning, empowerment, diversity, introductory programs / "onboarding", coach training.); 3) international skills (Norway in Europe, the EU and the Agreement on the European Economic Area (EEA), comitology, lobbying, language courses, multilateral and bilateral international negotiations (simulation), multicultural understanding, study trips.); 4) communication (clear communication with citizens, public sector communication policies, Norwegian for foreigners in the public sector.) 5) information and communication technologies (ICT) (common information and communication architecture, development of electronic services, management of ICT projects in the public sector.) ; 6) public procurement (courses, seminars and conferences for different target groups in public procurement); 7) economic management (organized by the Norwegian Government Agency for Financial Management (rules and regulations for economic management in the public sector, risk management, productivity measurement, budgeting, accounting, evaluation, management by objectives.) And 8) On-line courses - E-learning (introductory programs for different target groups, progress planning program, value-play for management teams.

∴

This concise analysis shows that there are large differences in the content of training in the civil service, with certain "basic contents" that occur in all countries: laws on public administration and systems, training on leadership skills, human resource management, economic system / budget, international skills, knowledge and skills related to the EU, communication and media. Most countries also have training programs designed to "develop" careers. Individual topics can be more or less the same as in separate training, where they are combined in a way that includes the necessary knowledge and skills intended for further career development and are often elaborated in a more detailed way.

Also, there are large differences in the duration of the training, with most training lasting only a few days. All institutions in charge of organizing the training considered in the analysis have a wide range of short-term training, but they also organize longer training programs based on the form of modules, this especially refers to training programs in the field of leadership skills development.

## **ON-LINE TRAININGS OF PUBLIC ADMINISTRATION EMPLOYEES IN THE CONDITIONS OF THE COVID 19 PANDEMIC IN THE REPUBLIC OF SERBIA**

For the purposes of conducting online training through webinars, public administration employees had at their disposal an LMS platform for distance learning through webinars. The LMS platform has several modules key to the quality of training, such as: 1) module for creating administrators (allows creating accounts with full and limited privileges. This function allows administrators to restrict access to the platform to only certain functionalities of the platform.); 2) module for general adjustment with the following options such as: insertion of logos, favicons and titles of the platform, insertion of links to social networks or editing of the title page, ie selection of the color scheme for the appearance of the platform; 3) module for sending notifications / emails that enables: creation of predefined templates, manual and automatic sending of emails. Review of sent emails, mark of success of sent emails and export overview of sent emails; 4) a module for displaying changes to the system and 5) a module for language settings that enables: creating new languages, editing existing languages; delete existing languages; language selection while working on the platform; 6) user creation module that enables user creation and user search, which enables: user editing, creating user groups, importing and exporting users, summarizing user data (user email, username, password, name, surname, contact phone) and others data that more closely identify the user; 7) a module for creating courses that enables: creating new courses, editing and deleting existing courses, creating tests to check the acquired knowledge of students and an instant view of the course layout; 8) content entry module that allows: adding text (.doc and .pdf), HTML, Powerpoint (.ppt) and video (.mp4) content, defining the name and description of the content, as well as defining the corresponding image / icon and allows or prohibits or permission to download files and finally 9) module for creating tests that allows defining the name and description of the test, questions with one correct answer, questions with multiple correct answers, open questions with entering answers, setting a passing threshold or minimum success in taking the test, allowed time for solving the test and quoting questions - choosing questions by random selection from the library of questions.

For the authors of this paper, a special reporting model was of special importance. Namely, this module enables the following general reports related to: the total number of users who completed the training, the total number of users who successfully passed the test, the total number of correct answers to the question and / or the total number of incorrect answers to the question. In addition, this module provides the following individual reports, which helped the authors of this paper to summarize the indicators of their research, which relate to leading the administration of the participants and their results and monitoring the available resources used for online training.

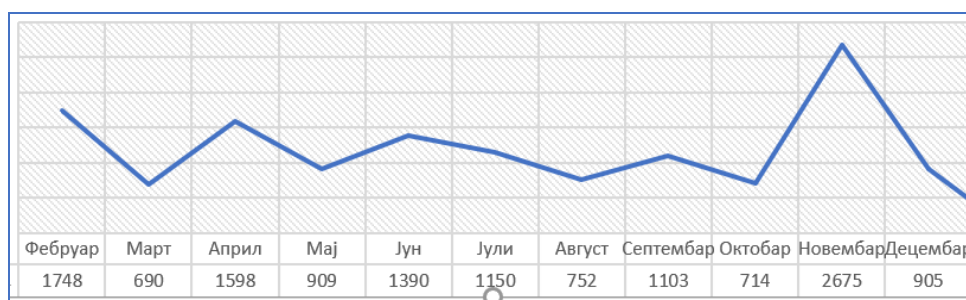
During the first wave of the Covid 19 pandemic, ie during 2020, public administration employees attended training in the classic classroom 58 trainings, in the virtual classroom 183 trainings, online courses 10 and online trainings 18. So, a total of 269 trainings were attended



by 12,559 participants with the engagement of a total of 149 lecturers. On-line trainings were realized through a specially designed LMS platform.

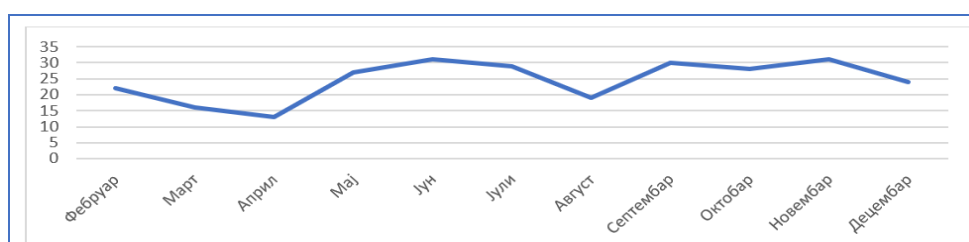
Regardless of the general environment, which was accompanied by a justified fear of infection with the Covid 19 virus, changes in the regime of daily work engagement and the like, observed by months, during 2020 the number of webinar participants was mostly equal.

**Figure 1.** Number of webinar participants during 2020



*Source: NAPA January 2021*

**Figure 2.** Number of organized webinars during 2020



*Source: NAPA January 2021*

A comparative analysis of the data from the presented graphs shows that an average of 37 participants attended each webinar. At 59 webinars, the number of participants was up to 15, at 32 trainings there were 16 to 25 participants and over 26 participants were present at 178 trainings.

Given the presented data, for the purposes of this paper, an analysis of the satisfaction of participants and the success of the webinars was performed. The general criterion for the evaluation of the program is the achieved effect of professional training on raising the level of competencies (personal progress) and on performing tasks in public administration (professional performance). Specific criteria for evaluating the program were: satisfaction with the implemented program (reaction); acquired new knowledge and skills (learning); influence on behavior change (behavior); application of acquired knowledge and skills in work (results).

These criteria were taken from the methodology of research into the effects of the Government Human Resources Management Service professional development program, which were related to: the acquisition and application of knowledge and skills; by changing attitudes and behaviors; career development; motivation for further professional development; professional contact between the lecturer and the trainee and the organization of the training.

According to the presented criteria, the following indicators were obtained:

1) In relation to the expectations of the participants, the grade "fully" was given by 81.14% of participants;

2) self-assessment of knowledge before and after the training was assessed by the participants as +1.12 difference

3) the length of the training was assessed by the participants as “long enough” by 85.08% of the participants;

4) the applicability of the newly acquired knowledge was assessed by the participants with a grade of 3.60

5) the efficiency of the training organization was assessed by the participants with a grade of 3.79.

From the above, there was a general assessment of the trainings, which the participants rated with a score of 3.70.

If we keep in mind that the webinars were a novelty in the implementation of trainings, both for lecturers (98 of them) and for participants, 12 lecturers were graded 4.00; 82 lecturers were graded over 3.50, while 4 lecturers were graded between 3.00 - 3.50. No lecturer was given a lower grade below 3.

## **CONCLUSION**

The process of permanent professional training of employees in public administration is a multi-required process that is accompanied by certain risks. On the one hand, the challenges are on the trainees themselves (motivation, commitment and finding adequate motivation), and on the other hand, the challenges and risks are on the side of the training organizers. When extraordinary circumstances such as a pandemic are added to this, which shifts from one common method of work to the field of virtual training, it is clear that the process of professional development requires constant innovation. As practice has shown, online trainings (standard and / or webinars) are not sufficiently represented in the system of professional development of public administration employees. Namely, compared to previous years, it is noticeable that webinars were an unknown form of education, while n-line trainings were quite sporadic. In addition, it was noticed that the training of public administration employees is mostly reduced to a living word, while materials (records, written documents, tests for knowledge testing and other aids) are not available to public administration employees.

In order for this situation to change, it is necessary to first improve the technical conditions. This refers to the improvement of the online training platform that would fully support the posting of materials in various formats: Word document, pdf document, short descriptive HTML, video file in mp4 format with subtitles in Vtt format. The latter would be extremely important in cases of hiring foreign experts.

In addition, in addition to these types of materials, the possibility of adding SCORM packages, tests, surveys and webinars as part of online training should be improved. According to the experience with online training provided by the private sector, an online training platform enriched with the SCORM package would enable the creation of interactive online training. To create them, an independent authoring tool is needed, which would enable the following settings: to which group of participants the training is available in which time period, options for unlocking - locking the material (reviewing which material unlocks the ability to view the next material, setting / adding notifications) are sent en masse to users, adding sections within the training, the appearance of the certificate - confirmation of completed training and the like.

Furthermore, it is recommended to further improve the Live conferencing - Webinars module, as a module that enables live lectures. The lecturer is recorded with a camera and / or

microphone, and the participants can watch / listen to his lectures on their screens. In addition to this, the main functionality, modules of this type can also contain the following options: 1) the lecturer can use a virtual board for drawing and writing, 2) the lecturer can easily display a picture of his computer screen, 3) the lecturer can receive and accommodate students from the virtual room, 4) the lecturer can "give the floor" to a student who will address the group through a microphone, 5) participants can type different types of questions and comments, 6) the lecturer can make a survey for a particular topic within the lecture and / or 6) that the entire lecture can be recorded for further archiving and broadcasting as needed by the participants.

Finally, two more modules are recommended: the Gamification module and the Coach & sharing module (Forum). The gamification module (an example of the popular application for learning foreign languages Duolingo is an excellent example of gamification in learning, with a developed system of awards, badges and levels in learning), which would increase student motivation and result in faster and better knowledge acquisition. With the help of different types of games, points, badges, nicknames and prizes that are implemented in the learning process on the platform, participants are placed in a competitive environment that awakens their competitive spirit. With the help of gamification, users have an additional motive in learning, but also in contributing knowledge to the entire community. The Coach & sharing module would enable communication between all participants in the education chain in a creative and interactive way. This would allow each participant of online training, during the training, in an intuitive way, to ask a question, comment or contribute their knowledge and experience in a given topic that will be available to all current and future participants. Thus, for example, a participant in some part of the theoretical training could, through his commentary, offer an excellent solution from practice, and at the same time attach a document made for the solution of the mentioned situation.

The authors of this paper are of the opinion that the proposed ideas would improve the process of professional development in public administration and that permanent professional training available to all employees in public administration with the proclaimed idea would come to life in practice at full capacity.

## **REFERENCES**

- A. Ketelaar, "Improving Public Sector Performance Management in Reforming Democratizers", DAIdeas Newsletter, 2007.
- Donald F. Kettl, *The Global Public Management Revolution*, Donald F. Kettl, Brookings Institution Press, Washington, DC. 2000
- Ginsberg, M. B., *Understanding Educational Reforms in Global Context: Economy, Ideology and the State*, 1997.
- M. Armstrong, *A Handbook of Human Resource Management Practice*, 10th edition, Kogan Page, 2006.
- Stewart J., Tensley C., *Training in Knowledge Economy*, CIPD Publishing, London, 2002.
- Steven J. Kelman, *The Tools of Government, A Guide to the New Governance* ", Ed. by Lester M. Salamon, Oxford University press, 2002.

UDK 616.98:578.834]:339.13  
338.45:669.2/.8  
COBISS.SR-ID 57321737

## INFLUENCE AND IMPLICATIONS OF CORONAVIRUS SPREAD ON METAL MARKET IN CONDITIONS OF ECONOMIC UNCERTAINTIES

Dragica Stojanovic<sup>1</sup>,  
Ivan Jovanovic<sup>2</sup>

<sup>1</sup>Megatrend University, Faculty of Management Zajecar, 19000 Zajecar, email:  
dragica.stojanovic@fmz.edu.rs

<sup>2</sup>University of Belgrade, Technical Faculty in Bor, Engineering Management Department, 19210 Bor,  
email: ijovanovic@tfbor.bg.ac.rs

### ABSTRACT

*The paper provides insight into the behavior of non-ferrous and precious metal prices on the London Stock Exchange during the health crisis caused by the spread of coronavirus in the period from February 10 to December 31, 2020. As COVID-19 has overshadowed all other media events and caused instability and unpredictability in the stock markets, the aim of the paper is to determine, using multiple linear regression, to what extent the 8 defined factors, total confirmed cases of COVID-19 infection (Confirmed), total deaths (Deaths), coronavirus panic index (CPI), DailyCases, DailyDeaths, global fear index (GFI), stringency index (SI), and economic support index (ESI), influenced the price movement of non-ferrous metals Copper, Aluminium, Zinc, Nickel, Lead, and Tin, as well as the precious metals Gold, Silver, and Platinum, on the London Stock Exchange. The results of multiple linear regression indicated a statistically significant positive predictive relationship between six defined factors and non-ferrous and precious metal prices. Specifically, factors of Confirmed, CPI, DailyDeaths, GFI, SI, and SCI, contribute to the oscillation of non-ferrous and precious metal prices and lead to market instability. As the economic impact of the pandemic is still uncertain, through an indicative review of current impacts, the conducted research also provides an opportunity to predict the price of non-ferrous and precious metals in the future.*

### KEYWORDS

*Stock market dynamics; COVID-19 pandemic; Multiple linear regression; Non-ferrous metals price; Precious metals price*

*JEL: F14, G14, I18, P22*

### 1. INTRODUCTION

The coronavirus that causes respiratory infection was first discovered in the city of Wuhan in China at the end of 2019, and it spread rapidly in many countries. On March 11, 2020, the World Health Organization (WHO) has declared a global coronavirus pandemic COVID-19 (WHO, 2020a). Namely, at the time of writing the study, more than 80 million confirmed

cases of COVID-19 infection have been reported worldwide in more than 200 countries, resulting in more than 1.82 million deaths worldwide (WHO, 2020b).

In order to stop the spread of the disease and panic and minimize the negative economic impact, governments around the world have taken actions of lockdown, travel restrictions, testing, quarantine, and economic packages. The goal of the actions was to ensure the social distance between people. The direct effect of such a policy is the closure of jobs, schools, offices, and factories, which has created additional uncertainty regarding their efficiency and impact. In this context, researchers have used stringency index (SI)<sup>1</sup> in their papers (Baig et al., 2020; Greenstone and Nigam, 2020; Thunström et al., 2020; Hussain, 2020). Their results show that despite a direct negative effect on economic activity, social distancing can reduce the mortality risk. On the other hand, studies such as Heiden and Heiden (2020), Shanaev et al. (2020), and Zaremba et al. (2020) show that government measures of social distancing are counterproductive.

According to Ji et al. (2020), one of the most visible effects of the COVID-19 pandemic and the decline in economic activity, was the drastic drop in the prices of many commodities on the stock market, as was the case with the price of a barrel of crude oil which fell from over \$65 in early 2020 to less than \$20 in mid-April, much lower than during the 2007-2009 economic crisis.

Salisu et al. (2020b), in their study using a panel VAR model, prove that oil and stock markets can have greater initial and prolonged effects of intrinsic and cross-shocks during a pandemic compared to the period before. The fall in oil prices was also confirmed in the research of Albulescu (2020), Torun et al. (2020) i Wu et al. (2020). This is in line with the studies by Zaremba et al. (2020), Yarovaya et al. (2020), Yin et al. (2020), Corbet et al. (2020b), which state that COVID-19 caused more dramatic and more frequent daily stock market changes than any other disease before.

Also, the World Bank (2020) announced a significant drop in the price of other commodities, such as agricultural products (cereals, edible oils, beverages, fertilizers), metals (copper, aluminum, and even precious metals other than gold), during the spread of COVID-19 disease. In addition to the reaction of commodity markets, studies by Goodell (2020), Al-Awadi et al. (2020), Mazur et al. (2020), Bai et al. (2020), due to the spread of coronavirus, suggest significant reactions in financial markets as well.

Namely, since the COVID-19 pandemic began, fear and uncertainty have taken control of financial markets (Lyocsa and Molnar, 2020a). Under such conditions, investors have changed their economic behavior (Baker et al. 2020) and started trading in panic (Ortmann et al., 2020).

In times of crisis, the response of government policy, in terms of supporting citizens' incomes, can also be shown through the economic support index (ESI)<sup>2</sup> as in the studies of Ashraf (2020), Hale et al., 2020b, Lou et al. (2020) and Wright et al. (2020). Their results indicate that compliance with lockdown orders varies significantly depending on income.

Motivating lower-income people to stay at home can lead to a reduction in the infection rate. Authors Zaremba et al. (2020) provide evidence that government control measures

---

<sup>1</sup> *Stringency index* (SI) records information on social distancing measures and is coded from 8 indicators including school closing, workplace closing, cancel public events, restrictions on gathering size, close public transport, stay at home requirements, restrictions on internal movement, and restrictions on international travel (Haroon and Rizvi, 2020).

<sup>2</sup> *The Economic support index* (ESI) is constructed from 2 indicators including the government income support and debt/contract relief for households programs. This index represents government policies regarding income support to citizens amid crisis (Haroon and Rizvi, 2020)..

(austerity policy) lead to increased market volatility. Their results indicate that movement restriction initiates economic losses that will later participate in economic intervention and relief.

Information on the number of confirmed COVID-19 cases, as well as information on the number of deaths from coronavirus, expressed in total or on a daily basis, is strongly aimed at highlighting high-impact events. Similarly, information on infectious disease and the public health crisis leads to public panic as evidenced in studies (Tetlock, 2007; Su et al., 2017).

Due to this fact, many authors have investigated the impact of various indicators of coronavirus cases around the world and the stringency of government measures taken on price movements in the financial and commodity markets, such as coronavirus panic index (CPI) (Rogone et al. 2020; Haroon and Rizvi, 2020) global fear index (GFI) (Salisu et al., 2020a; Salisu and Akanni, 2020), stringency index (SI) (Greenstone and Nigam, 2020; Thunström et al., 2020; Hussain, 2020) economic support index (ESI) (Lou et al., 2020; Wright et al., 2020).

Since COVID-19 has brought extreme uncertainty that could bring the world to the brink of a terrible crisis, this study investigates how much and to what extent these relevant factors affect the price movement of non-ferrous metals Copper, Aluminum, Zinc, Nickel, Lead, and Tin, as well as the precious metals Gold, Silver, and Platinum, on the London Metal Exchange. On the one hand, the significance of the research goal is reflected in the fact that stock markets have become extremely unstable and unpredictable. On the other hand, the COVID-19 pandemic has destroyed many lives and economies of a large number of countries worldwide.

Our motivation for conducting this research is related to the following facts. First, the spread of coronavirus in many countries in a short time was very astonishing. Due to the lack of the right answers concerning health care and general awareness, what started in Wuhan quickly experienced exponential growth of confirmed COVID-19 cases. The growth of confirmed cases has caused the epicenter of the pandemic to move from China to the rest of the world. In an attempt to stop the spread of coronavirus, country governments are asking people to stay at home and maintain social distance on a daily basis (Wilder-Smith and Freedman, 2020). Comprehensive and rigorous government actions have created more uncertainty, worsened confidence, increased risk aversion and deepened turmoil in global stock markets.

In fact, COVID-19 has introduced great uncertainty into supply chains and especially into the global metal industry market. The security of the metal supply chain is undermined by the very fact that China produces about 20 percent of intermediate products that are a critical element of the global metal and metal products sector (UNCTAD, 2020).

Bearing in mind the results of studies by Conlon and McGee (2020), Corbet et al. (2020a), Yarovaya et al. (2020), Salisu et al. (2020b) on the influence of COVID-19 on oscillations in the precious metal market, it is interesting to study how the mentioned factors affect the prices of non-ferrous and precious metals on the London Stock Exchange.

Another motivation for this study was the fact that life during a pandemic is a new experience for most of the population around the world. COVID-19 is one of the pandemics that paralyze not only economies worldwide but also affect people's psychological consciousness.

Media coverage tends to highlight events with high impact such as outbreaks of infectious diseases that lead to public panic (Donadelli et al., 2017; Rogone et al., 2020). As the COVID-19 disease overshadowed all other events in the media and caused instability and unpredictability in the stock markets, it provides a case for researching oscillations in the non-ferrous and precious metals market.

Our study contributes to the literature in the following dimensions. First, the paper adds to the current literature on the stock market response to the COVID-19 pandemic (Albulescu, 2020; Akhtaruzzaman et al. 2020; Al-Awadhi et al. 2020; Ashraf, 2020; Gkillas et al. 2020; Haroon and Rizvi, 2020a; Ramelli and Wagner, 2020; Zhang et al. 2020). Second, it expands very scarce literature in the area of association of panic-related information with market fluctuations, as evidenced in studies Uhl et al., (2015). Finally, building on financial market research (Blau et al., 2014; Blau, 2017; Baig et al., 2020), we expand our understanding of the impact of restrictive government policies on the stability and efficiency of the metal market.

The rest of the paper is organized as follows. After the introductory part, Section 2 explains the data and methodology applied. Sections 3 and 4 present a review and discussion of empirical results, while section 5 concludes the research.

## **2. RESEARCH METHODOLOGY**

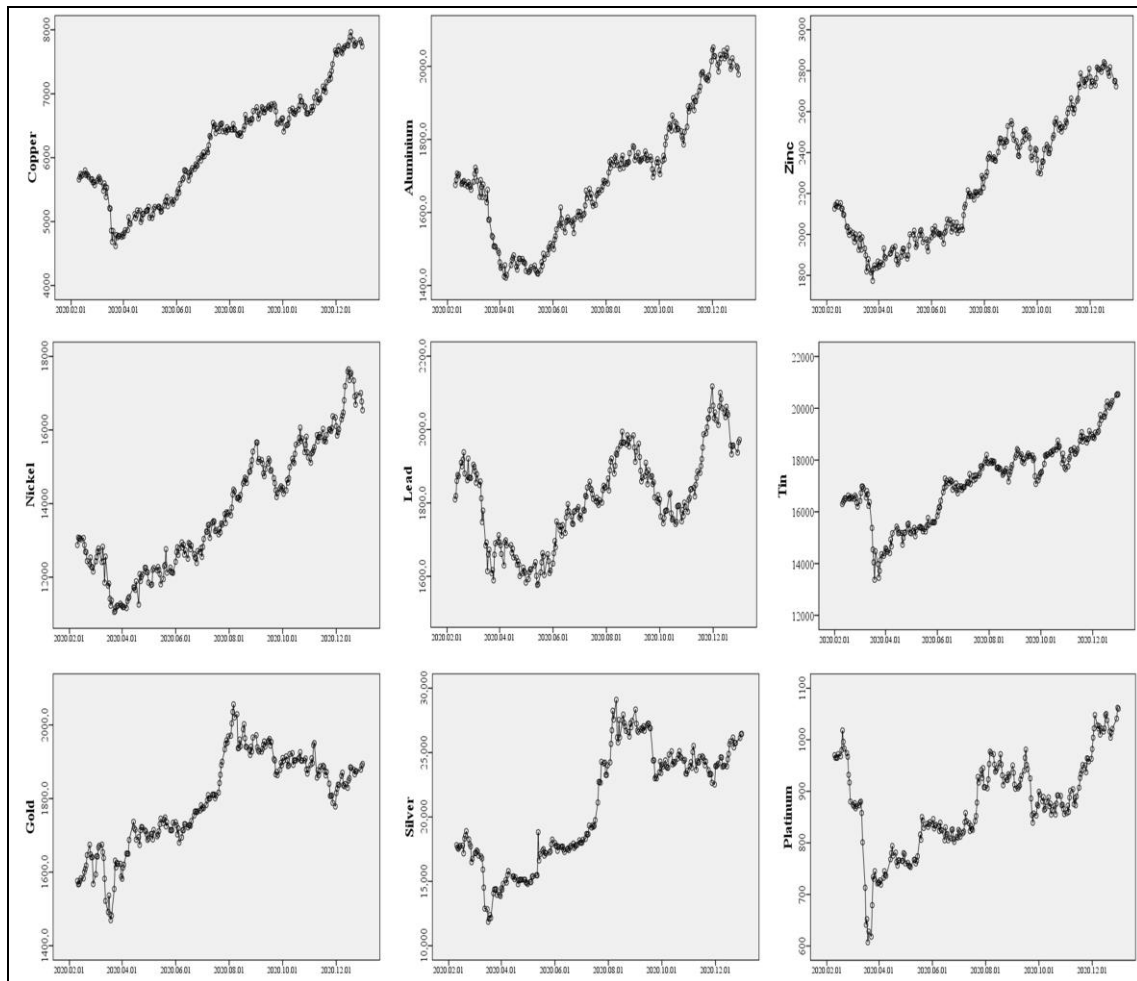
### **2.1 Sample construction**

We started our sample construction by collecting the data on the number of COVID-19 confirmed cases were collected from COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU) for the period from February 10 to December 31, 2020. The cases expressed in daily relative changes were taken from the Worldometer database.

The data on the total number of deaths were also downloaded from the same site. To measure panic, following the papers by Blau et al. (2014), Baig et al. (2020), Rogone et al. (2020), we used Coronavirus panic index (CPI). A Raven pack media monitor places news from hundreds of different sources and creates a daily index of news levels that cause hysteria-panic.

We calculated GFI indices using the method presented in the paper by Salisu and Akanni (2020). The Oxford COVID-19 Government Response Tracker (OXCGR) database was used to quantify government responses to the COVID-19 pandemic. Stringency index (SI) was downloaded from the OXCGR database.

From the same database the Economic support index (ESI) was taken. Also, official prices for non-ferrous metals Copper, Aluminum, Zinc, Nickel, Lead, and Tin, expressed in US\$/tonne, as well as the precious metals Gold, Silver, and Platinum, expressed in US\$/fine troy ounce, were taken daily from the London Metal Exchange (LME) site. Figure 1. shows the instability of non-ferrous and precious metals prices in the considered period from February 10 to December 31, 2020



**Figure 1.** Prices instability of non-ferrous and precious metals, February 10 - December 31, 20

From the data collected in the observed period, data for weekends and public holidays were omitted, because these data were not published on the LME. For this reason, the data for other factors available for each day were adjusted to follow the available data on the metals price on the stock exchange. After data correcting, a sample of 227 cases was compiled for the observed period.

## 2.2 Research model

The relationship between independent and dependent variables is examined by regression analysis, as one of the most used statistical methods, which has great application both in economics and in other social sciences. In statistical modeling, regression analysis is a set of statistical methods that reveal whether there are relationships between the observed phenomena and what they are like by shape (linear, nonlinear, spatial) and direction (positive or negative).

The applied statistical method enables the prediction and evaluation of one phenomenon based on the value of another phenomenon (or group of phenomena). In accordance with the assumption that there is a linear relationship between the independent and dependent variables, i.e., the relationship can be most accurately represented by a straight line, multiple linear regression (MLR) is applied in the paper.



The MLR is a statistical technique that uses several explanatory (independent) variables to predict the outcome of a response (dependent) variable. The goal of MLR is to model the linear relationship between the independent variables and the dependent variable.

The MLR model is described by regression equation (1), as:

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \dots + \beta_p x_{ip} + \varepsilon_i \quad (1)$$

where, for  $i=n$  observations:

$y_i$  – dependent (response) variable

$x_i$  – independent (predictor or explanatory) variables

$\beta_0$  – regression coefficient of the model (y-intercept)

$\beta_p$  – slope coefficients for each independent variable

$\varepsilon_i$  – the model's error term (also known as the residuals)

$p$  – number of independent variables

$n$  – number of observations

The regression model consists of eight independent and nine dependent variables.

The independent variables are:

total confirmed cases of COVID-19 infection (denoted in the model as Confirmed),

total deaths from COVID-19 infection (Deaths),

coronavirus panic index<sup>3</sup> (CPI),

number of confirmed cases of COVID-19 infection per day (DailyCases),

number of deaths from CORONA-19 infection per day (DailyDeaths),

global fear index<sup>4</sup> (GFI),

stringency index (SI), and

economic support index (ESI).

Dependent variables refer to non-ferrous metals prices for:

Copper (Cu),

Aluminium (Al),

Zinc (Zn),

Nickel (Ni),

Lead (Pb),

Tin (Sn),

Gold (Au),

Silver (Ag), and

Platinum (Pt).

---

<sup>3</sup> *The Coronavirus Panic Index* (CPI) measures the level of news chatter that makes reference to panic or hysteria and coronavirus. Values range between 0 and 100 (percentage of all global news about panic and COVID-19). The higher the index value, the more references to panic found in the media (Haroon and Rizvi, 2020).

<sup>4</sup> *The global fear index* (GFI) seeks to measure daily concerns and emotions on the spread and severity of COVID-19 since the pandemic declaration. The GFI is a composite index of two factors; Reported Cases and Reported Deaths, on a scale of zero to 100, respectively, indicating the absence and presence of extreme fear/panic (Haroon and Rizvi, 2020).

Based on equation (1), the research model is described by the MLR equation (2), as:

$$\begin{aligned} \text{Price}_i = & \beta_0 + \beta_1 \cdot \text{Confirmed}_i + \beta_2 \cdot \text{Deaths}_i + \beta_3 \cdot \text{CPI}_i + \beta_4 \cdot \text{DailyCases}_i \\ & + \beta_5 \cdot \text{DailyDeaths}_i + \beta_6 \cdot \text{GFI}_i + \beta_7 \cdot \text{SI}_i + \beta_8 \cdot \text{ESI}_i + \varepsilon_i, \quad i = 1, \dots, n \end{aligned} \quad (2)$$

In the research model described by equation (2), the dependent variables  $\text{Price}_i$  represents non-ferrous metals prices for Cu, Al, Zn, Ni, Pb, and Sn, as well as the precious metals prices for Au, Ag, and Pt. The explanation for independent variables is as follows. Confirmed represents the total number of COVID-19 confirmed cases; Deaths represents total deaths from COVID-19 infection; CPI represents the coronavirus panic index; DailyCases represents the number of daily confirmed CORONA-19 cases; DailyDeaths represents the number of daily deaths CORONA-19 cases; GFI represents global fear index, SI represents stringency index, and ESI represents economic support index.

The regression coefficient  $\beta_0$  determines the y-intercept at time zero. The partial regression coefficients  $\beta_1$  denote the average change of the dependent variable Price when the independent variable Confirmed increases by 1, and all other independent variables are held constant.

Analogous to the previous, all other partial regression coefficients from  $\beta_2$  to  $\beta_8$  can be described. The model's error terms  $\varepsilon_i$  represents a stochastic term, and  $n$  is the number of observations—dependent variables (in the model,  $n=9$ ).

### 3. RESULTS

The SPSS software package was used for statistical data processing. Prior to conducting the regression analysis, it's essential to check the necessary requirements and assumptions (linearity, normality, homoscedasticity, multicollinearity). Sample size has a direct effect on the statistical power of prediction in multiple regression.

To ensure the validity of statistical conclusions, there need to be 20 times more cases than independent variables. In this model, there are 8 independent variables and 227 cases, and therefore the predicted requirement is met.

The MLR model is based on the assumptions that there is a linear relationship between the dependent variables and the independent variables (linearity); that the independent variables are not too highly correlated with each other (multicollinearity); that  $y_i$  observations are selected independently and randomly from the population; that the residues should be normally distributed (normality) with a mean of 0 and variance  $\sigma$ , and homoscedasticity must be assumed, i.e. that the variance is constant across all levels of the predicted variable.

Analysis of the results obtained on the scatter plot showed that the relationship between the variables more or less looks linear, which satisfies the precondition of linearity because the points on the diagrams are grouped around straight lines.

The assessment of the requirements for normality and homoscedasticity was done by visual inspection of a normal P-P plot and standardized residuals plot (scatterplot). As the data points along the hypothetical perfect normality line are displayed on the normality plot, the assumption of normality was met (the residuals are normally distributed). Also, the spread of data with no apparent patterning within the residual scatterplot suggests that homoscedasticity is at an enviable level.

In order to identify the presence of multicollinearity between the independent variables, the VIF test (Variance Inflation Factor test) and its equivalent - Tolerance test were used. The

VIF test shows whether one independent variable is strongly linearly related to other independent variables. If the VIF value is greater than 10, there is a strong presence of multicollinearity (Bowerman and O'Connell, 1990; Myers, 1990).

Also, tolerance below .10 is a serious problem that indicates the presence of multicollinearity. The assumption of the absence of multicollinearity for independent variables Deaths and DailyCases is violated because the values of "Tolerance" are less than .10 and "VIF" values greater than 10. This means that the independent variables of Deaths and DailyCases are omitted from further analysis.

The assumption of the absence of multicollinearity for the remaining six independent variables Confirmed, CPI, DailyDeaths, GFI, SI, and ESI is not violated because the values of Tolerance are greater than .10 and VIF values less than 10.

Also, the results of the analysis confirmed that the independent variables show a significant correlation with the dependent variables Cu, Al, Zn, Ni, Pb, Sn, Au, Ag, and PT because the correlation values are higher than the recommended minimum value of 0.3 (Ho, 2006). Also, it was found that there is a correlation between the independent variables.

After correcting the independent variables, it is concluded that the initial requirements and assumptions of linear regression are not violated, ie that the data are suitable for regression analysis. After testing the regression models, the relevant data are shown in Table 1.

Based on the obtained values, it is concluded that the results of the total regression are significant in all models. The regression coefficient (R) is a measure of association between the observed value and the predicted value of the criterion variable.

The relative measure of the representativeness of the regression line is determined by the coefficient of determination (R-square or R<sup>2</sup>).

**Table 2.** Results of tested models

Models	df (Reg.,Resid.)	F	Sig.	R	R Square	Type of Relationships
Cu	(4,222)	578.348	<.0005	.955	.911	+ very strongly
Al	(6,220)	634.712	<.0005	.972	.945	+ very strongly
Zn	(3,223)	950.975	<.0005	.963	.927	+ very strongly
Ni	(4,222)	795.220	<.0005	.967	.935	+ very strongly
Pb	(5,221)	95,350	<.0005	.827	.683	+ strongly
Sn	(4,222)	339.621	<.0005	.927	.860	+ very strongly
Au	(5,221)	84,375	<.0005	.810	.656	+ strongly
Ag	(5,221)	100,425	<.0005	.833	.694	+ strongly
Pt	(5,221)	163.034	<.0005	.887	.787	+ strongly

The R-square is the square of the measure of association which indicates the percentage of overlap between the predictor variables and the criterion variable, and its value can be between 0 and 1. The value 0 indicates that the outcome cannot be predicted by any of the independent variables and 1 indicates that the outcome can be predicted without error from the independent variables.

As independent variables statistically predict the dependent variable(s) well, the conclusion is that the results of the overall regression are significant and that the regression models are good.

This means that a linear combination of six independent variables: Confirmed, CPI, DailyDeaths, GFI, SI, and ESI, is useful for predicting the prices of non-ferrous metals Cu, Al, Zn, Ni, Pb, and Sn, as well as the precious metals prices Au, Ag, and Pt.

For example, the value R-square of .911 means that the independent variables Confirmed, CPI, DailyDeaths, GFI, SI, and ESI explain 91.1% of the variability of the dependent variable Copper, etc.

**Table 2.** Multiple linear regressions predicting prices for non-ferrous and precious metals

Models	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics		
	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF	
Copper	(Constant)	5506,399	196,619		28,005	,000					
	Confirmed	3,579E-5	,000	,989	28,084	,000	,918	,883	,558	,318	3,146
	CPI	-146,125	13,658	-,226	-10,698	,000	-,439	-,583	-,212	,886	1,129
	DailyCases	-,047	,010	-,182	-4,765	,000	,668	-,305	-,095	,271	3,694
	ESI	10,702	3,503	,073	3,055	,003	,367	,201	,061	,682	1,467
Aluminium	(Constant)	1599,798	51,109		31,301	,000					
	Confirmed	7,018E-6	,000	,951	25,996	,000	,905	,869	,410	,185	5,394
	CPI	-11,068	2,979	-,084	-3,716	,000	-,345	-,243	-,059	,488	2,051
	DailyCases	-,006	,002	-,112	-2,935	,004	,567	-,194	-,046	,171	5,858
	GFI	1,386	,363	,095	3,820	,000	-,191	,249	,060	,403	2,484
	SI	-3,047	,295	-,305	-10,331	,000	-,418	-,572	-,163	,285	3,514
Zinc	(Constant)	2159,730	18,115		119,223	,000					
	Confirmed	1,304E-5	,000	1,004	31,941	,000	,942	,906	,576	,329	3,038
	CPI	-41,782	4,360	-,180	-9,584	,000	-,387	-,540	-,173	,924	1,082
	DailyCases	-,012	,003	-,126	-4,086	,000	,694	-,264	-,074	,343	2,912
Nickel	(Constant)	13205,564	124,167		106,353	,000					
	Confirmed	7,967E-5	,000	1,093	28,493	,000	,938	,886	,488	,200	5,005
	CPI	-273,311	24,637	-,210	-11,093	,000	-,404	-,597	-,190	,824	1,214
	DailyCases	-,125	,021	-,241	-5,864	,000	,675	-,366	-,101	,173	5,769
Lead	(Constant)	1805,119	61,510		29,347	,000					
	Confirmed	1,878E-6	,000	,343	3,903	,000	,667	,254	,148	,186	5,389
	CPI	-14,862	4,541	-,152	-3,272	,001	-,474	-,215	-,124	,667	1,499
	DailyCases	,009	,004	,233	2,556	,011	,406	,169	,097	,173	5,788
	SI	-4,171	,525	-,563	-7,949	,000	-,473	-,472	-,301	,286	3,497
	ESI	3,648	1,252	,166	2,913	,004	,131	,192	,110	,444	2,253
Tin	(Constant)	16312,937	443,784		36,759	,000					
	Confirmed	6,013E-5	,000	,933	20,904	,000	,863	,814	,526	,318	3,146
	CPI	-347,726	30,828	-,301	-11,279	,000	-,501	-,604	-,284	,886	1,129
	DailyCases	-,093	,022	-,202	-4,174	,000	,610	-,270	-,105	,271	3,694
	ESI	19,842	7,907	,076	2,509	,013	,353	,166	,063	,682	1,467
Gold	(Constant)	1413,335	64,116		22,043	,000					
	Confirmed	4,785E-6	,000	,873	9,539	,000	,608	,540	,376	,186	5,389
	CPI	-35,503	4,734	-,362	-7,500	,000	-,384	-,450	-,296	,667	1,499
	DailyCases	-,019	,004	-,480	-5,053	,000	,536	-,322	-,199	,173	5,788
SI	3,517	,547	,474	6,431	,000	,225	,397	,254	,286	3,497	

*THEMATIC PROCEEDINGS*  
*THE IMPACT OF THE COVID 19 PANDEMIC ON ECONOMY, RESOURCES AND SUSTAINABLE DEVELOPMENT*

	ESI	4,999	1,305	,227	3,829	,000	,603	,249	,151	,444	2,253
	(Constant)	13,760	2,131		6,459	,000					
Silver	Confirmed	1,925E-7	,000	,997	11,547	,000	,724	,613	,429	,186	5,389
	CPI	-1,194	,157	-,346	-7,588	,000	-,472	-,455	-,282	,667	1,499
	DailyCases	,000	,000	-,477	-5,334	,000	,509	-,338	-,198	,173	5,788
	SI	,058	,018	,224	3,215	,001	-,068	,211	,120	,286	3,497
	ESI	,120	,043	,154	2,766	,006	,437	,183	,103	,444	2,253
	(Constant)	1074,378	19,353		55,514	,000					
Platinum	Confirmed	1,243E-6	,000	,322	4,556	,000	,656	,293	,142	,194	5,159
	CPI	-20,941	3,075	-,303	-6,810	,000	-,642	-,416	-,212	,488	2,048
	DailyCases	,007	,002	,245	3,260	,001	,400	,214	,101	,171	5,857
	GFI	-1,213	,318	-,158	-3,817	,000	-,459	-,249	-,119	,560	1,786
	SI	-2,281	,257	-,436	-8,866	,000	-,483	-,512	-,275	,399	2,505

*Note: Only those independent variables that have statistical significance  $p < .05$  are shown*

The data on how much each independent variable in the model contributed to the prediction of the dependent variable are shown by standardized coefficients in the Beta column in Table 2.

For example, for the dependent variable Copper, the standardized Beta coefficient for the independent variable Confirmed is +.989, for CPI is -.226, for DailyCases is -.182, and for ESI is +.073.

This means that the independent variable Confirmed contributes the most to explaining the dependent variable Copper (Cu). This is followed by the independent variables CPI, DailyCases, and ESI. An analogous conclusion can be made for other models, too.

Based on the data presented in the Sig column, it can be determined whether the independent variable makes a statistically significant unique contribution to the equation.

This tests whether the unstandardized (or standardized) coefficients are equal to 0 (zero) in the population. If  $p < .05$ , it can be concluded that the coefficients are statistically significantly different from 0 (zero).

Table 2 shows only those independent variables that give a unique and statistically significant contribution to the prediction of the results of the dependent variables.

The t-value (t-statistic/test) and corresponding p-value are located in the “t” and “Sig.” columns in Table 2, respectively. For the sake of clarity, Table 3 shows the impact of nine independent variables on eight dependent variables. The pluses indicate a statistically significant contribution to the prediction of the results.

The actual relationship between the dependent and independent variable can be approximated by a regression model, ie a linear regression equation. To create a linear regression equation, the unstandardized coefficients shown in column B in Table 2 are used.

Unstandardized coefficients indicate how much the dependent variable varies with an independent variable when all other independent variables are held constant.

**Table 3.** Influence of independent variables on the prediction of dependent variables

		Independent variables							
	Models	Total Confirmed	Total Deaths	CPI	Daily Cases	Daily Deaths	GFI	SI	ESI
Dependent variables	Cu	+		+		+			+
	Al	+		+		+	+	+	+
	Zn	+		+		+			
	Ni	+		+		+		+	
	Pb	+		+		+		+	+
	Sn	+		+		+			+
	Au	+		+		+		+	+
	Ag	+		+		+		+	+
	Pt	+		+		+	+	+	

For example, the form of the equation to predict Price for the dependent variable Copper is shown by relation (3).

$$\text{Price}_i = 5506.399 + 3.579 \cdot 10^{-5} \cdot \text{Confirmed}_i - 146.125 \cdot \text{CPI}_i - 0.047 \cdot \text{DailyCases}_i + 10.702 \cdot \text{ESI}_i \quad (3)$$

Results interpretation of the MLR equation is as follows. The parameter  $\beta_0=5506.399$  represents the predicted price for Copper at the beginning of the research (at time zero).

The unstandardized coefficient  $\beta_1=3.579 \cdot 10^{-5}$  represents the expected increase in Copper price with an increase in the number of infected per unit value, or US\$ 35.79 per tonne per 1,000,000 of COVID-19 Confirmed cases.

It can be noticed that the coefficient for the independent variable CPI is negative, which means that the regression is reversed, ie with increasing value for CPI, the price for Copper decreases.

Due to this fact, the model predicts that the Copper price will drop by US\$ 146.125 per ton after the increase in CPI per unit value.

Also, a similar conclusion can be reported for the independent variable DailyCases. The model predicts that the Copper price will drop by US\$ 0.047 per ton after the increase in DailyCases per unit value.

Finally, the model predicts that the Copper price will increase by US\$ 10.702 per ton after the increase in ESI per unit value. Inferences can be drawn analogously for all other models.

#### 4. DISCUSSION, IMPLICATIONS AND LIMITATIONS

The growing number of reported COVID-19 cases and deaths increases fear for health, which at the same time has an impact on global economic activities. The idea of using panic and fear for the health and existence of people, to explain stock market fluctuations is certainly not new, but it is supported by several facts. Large events, such as a pandemic, often overshadow all other events in the media (Mairal, 2011). Using evidence from the psychology literature, Barberis et al. (1998); Ederington et al. (1996) show that financial markets overreact to a consistent news pattern, although the statistical weight of such news should be low. For example, a study by Mitchell and Mulherin (1994), found a weak or moderate relationship between the amount of news and activity (volume, variability, prices). However, as the world became more connected and information flows became almost instantaneous, the interpretation and decision-making based on information became a sustainable trading

strategy in many markets (Groß-Klußmann and Hautsch, 2011). Given the impact of other past events that are in a way similar to COVID-19, the academic community continues to seek risk management strategies (Ji, et al., 2020; Conlon and McGee, 2020; Corbet et al., 2020b), or resources that have a relatively better performance than others during the crisis period (Broadstock et al. 2020).

Each crisis has its specific drivers. Unlike the COVID-19 pandemic, earlier health crises did not lead to social distancing, which could be one of the main reasons for panic and fear, and therefore, stock market negative reactions, as evidenced in the studies of Goodell, (2020) and Rogone et al. (2020). The results of their studies suggest significant reactions of the stock market in the new flare-up of COVID-19.

Similarly, the results of a study by Haroon and Rizvi (2020b) that used the Coronavirus Panic Index (CPI) in their study indicate that the panic generated by news related to coronavirus leads to instability in the stock market. The growing number of reported COVID-19 cases and deaths increases fear for health, which at the same time has an impact on global economic activities. Therefore, for research into market variations resulting from the COVID-19 pandemic, the global fear index (GFI) is extremely helpful (Salisu et al., 2020a; Salisu and Akanni, 2020).

Namely, the study of panic and fear on the stock market during the COVID-19 pandemic provides a unique opportunity because it has affected almost all countries in the world, but at different times and to different degrees. An additional reason is that there is a big difference in the time of the outbreak and the severity of the events that cause panic in various locations. Finally, governments have established various policies and taken different measures at different times and with different severity. In order to stop the spread of the disease and panic and minimize the negative economic impact, governments around the world have taken actions of lockdown, travel restrictions, testing, quarantine, and economic packages.

News of the number of confirmed cases burdened with panic shows a negative reaction of stock exchanges, which has been confirmed in numerous studies (Baiga et al., 2020; Baig and Sabah, 2020; Nicomedesa et al., 2020; Umar and Gubareva, 2020; Lyocsa et al., 2020b; Iyke, 2020a, 2020b).

Also, an increasing number of reported cases and deaths COVID-19 that cause fear is linked to growing instability in stock markets (Haroon and Rizvi, 2020b, Salisu et al., 2020a). Finally, governments have established various policies and taken different measures at different times and with different severity.

Government reactions such as job closures or restrictions on movement to stop the spread of infections are seriously affecting the metal industry market, and thus the global economy. In addition to instability in the stock market, our results also confirm that various indicators of coronavirus cases around the world and the seriousness of the state measures lead to instability in the metal market as well.

By monitoring the behavior of non-ferrous metals prices in the London Stock Exchange and the reactions to the events related to the spread of COVID-19 disease from February 10 to December 31, 2020, it can be noticed that some significant changes took place.

The results of the conducted research confirm that there is a linear relationship between the independent variables Confirmed, CPI, DailyCases, GFI, SI, and ESI and the dependent variables Cu, Al, Zn, Ni, Pb, Sn, Au, Ag, and Pt.

Based on the values of the regression coefficients (R), shown in Table 1, it can be noticed that there is a very strong positive linear relationship between certain independent variables and prices for Cu, Al, Zn, Ni, and Sn, because the Pearson correlation coefficient values of the models are .955, .972, .963, .967, and .927, respectively.

Also, there is a strong positive linear relationship between certain independent variables and prices for Pb, Au, Ag, and Pt, because the values are .827, .810, .833, and .887, respectively.

The values of the explained variability of the dependent variables Cu, Al, Zn, Ni, Pb, Sn, Au, Ag, and Pt the corresponding independent variables are 91.1%, 94.5%, 92.7%, 93.5%, 68.3%, 86.0%, 65.6%, 69.4%, and 78.7%, respectively.

Based on equation (2), the predicted market price of Cu, Al, Zn, Ni, Pb, and Sn, with an increase in the number of infections to 90,000,000, an increase in CPI to 4, an increase in DailyDeaths to 20,000, an increase in GFI to 55, an increase in SI to 60, and an increase in ESI to 60 would be US\$ 7,807; US\$ 2,065; US\$ 2,914; US\$ 16,998; US\$ 2,062; and the US\$ 19,623 per tonne, respectively, i.e. US\$ 1,838; US\$ 23.83; and the US\$ 23.87 per fine troy ounce of Au, Ag, and Pt.

The spread of the COVID-19 pandemic has caused unprecedented instability in stock markets and economic policy uncertainty, which overcome the crises recorded in December 2008, October 1987, and in 1929. Sharif et al. (2020) noted in their study that the effect of COVID-19 is often compared to the 2008 Global Financial Crisis (GFC), which was investigated in the literature of Bekiros (2014), Luchtenberg and Vu (2015).

Mass quarantines around the world and other protection measures that the governments of the countries implemented in order to prevent the spread of the virus and protect the health of their citizens, have made it impossible for people to move. As a consequence, there has been a decline in economic activity that affected all branches of the economy, some to a greater, and some to a lesser extent (Baldvin and Veder di Mauro, 2020; Ramelli and Vagner, 2020). The results obtained indicate that the spread of the COVID-19 pandemic has caused unprecedented instability in stock markets and economic policy uncertainty, which overcomes the crises recorded in December 2008, October 1987, and 1929. Sharif et al. (2020) noted in their study that the effect of COVID-19 is often compared to the 2008 Global Financial Crisis (GFC), which was investigated in the literature of Bekiros (2014), Luchtenberg and Vu (2015).

#### **4.1 Implications**

The COVID-19 pandemic presented a unique challenge for authors and inspired a new stream of literature focused on the impact of the pandemic on commodity markets. The main challenge for authors is the fact that COVID-19 disease differs from other pandemics in terms of scope and nature. In this way, our research contributes to the initial and insufficient literature, ie we document how the non-ferrous and precious metals market has reacted to the panic and fear caused by the spread of information about the coronavirus.

In addition, analyzing the impact of government measures of social distancing on price variations of non-ferrous and precious metals can help design a better government response in the future. The scientific literature has been expanded through the contribution to economic theory.

The fact that the long-term effect of government action has yet to be seen while discussing the dynamics of the COVID-19 pandemic, this study had the ambition to provide knowledge and information relevant to metal market participants as a contribution to the community. Assuming that our study is the first to discuss the predictive power of Google searches regarding the volatility of non-ferrous and precious metal prices in the stock market during the COVID-19 pandemic due to the spread of panic-causing information, it makes a special contribution to the scientific literature in this area.



Our findings also provide information of great importance for predicting the behavior of non-ferrous and precious metal prices during a period of global economic and financial distress. Therefore, considering key attributes and planning measures would reduce the uncertainty and panic that leads to price volatility in the stock market. Thus, considering the characteristics of the pandemic and the assumption that price stability in the metal market depends on the degree of COVID-19 control in the future, it may be the basis for some future research.

## **4.2 Limitations**

The purpose of the study was to investigate the relationship between eight defined factors and the prices of non-ferrous and precious metals on the London Stock Exchange. As no research is free from its own limitations, this research also has its own that may have influenced the results. The first limitation of the study is the inclusion of eight independent variables in the model. In addition to the independent variables considered, future studies could include the Coronavirus Fake News Index, as well as, other indices. Another limitation of the study is the applied methodology. Namely, the adopted statistical approach in the paper was multiple linear regression. Therefore, in order to examine the impact of COVID-19 on the movement of metal prices in the market, future studies could apply other approaches, such as VAR methodology and Panel data analysis. The third limitation of the study is the research of only non-ferrous and precious metals on the London Stock Exchange. Finally, the fact that this pandemic has imposed so many security protocols, the limited literature on the subject of analyzing information that generates panic in commodity markets, is another limitation of the study. Assuming that the general public seeks more information about the virus on the Internet which causes additional panic, the authors want to expand the scope of the research and give new light on how information about the public health crisis is relevant to serious market fluctuations.

Given the limitations, this research is an attempt by the authors to expand the insufficient scientific literature and indicate that there is room for future studies. Further research in the area stems from the authors' expectations that these limitations will not adversely affect the applicability or usefulness of the study result.

## **5. CONCLUSION AND RECOMMENDATIONS**

This paper is an attempt to present in a comprehensive way the implications of the COVID-19 outbreak on the metal market. In this context, the aim of the paper was to determine the impact of COVID-19, ie eight defined factors on non-ferrous and precious metal prices on the London Stock Exchange. By monitoring the behavior of non-ferrous and precious metal prices, it is clear that they change significantly in response to the events related to the spread of coronavirus and government announcements action. The results of multiple linear regressions show that from February 10 to December 31, 2020 factors Confirmed, CPI, Daili Deaths, GFI, SI, and SCI lead to market instability.

The instability of the metal market within this research is reflected in the oscillation of prices of non-ferrous and precious metals. The analysis of the impact of information on the public health crisis and restrictive government measures on market stability and efficiency enables the MLR model prediction of market prices for non-ferrous and precious metals. As

the stock markets have become extremely volatile and unpredictable, the authors suggest the need to establish a strong coordinated global response to future similar health crises.

## ACKNOWLEDGMENTS

The research presented in this paper was done with the financial support of the Ministry of Education, Science and Technological Development of the Republic of Serbia, within the funding of the scientific research work at the University of Belgrade, Technical Faculty in Bor, according to the contract with registration number 451-03-9/2021-14/ 200131.

## REFERENCES

- Al-Awadhi, A.M., Alsaifi, K., Al-Awadhi, A., Alhamadi, S., 2020. Death and contagious infectious diseases: Impact of the COVID-19 virus on stock market returns. *Journal of Behavioral and Experimental Finance* 27:100326. doi:10.1016/j.jbef.2020.100326.
- Albulescu, C.T., 2020. Coronavirus and Oil Price Crash. SSRN Electronic Journal, doi: 10.2139/ssrn.3553452. [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=3553452](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3553452)
- Akhtaruzzaman, M., Boubaker, S., Sensoy, A., 2020. Financial contagion during COVID-19 crisis. *Finance Research Letters* 101604. <https://doi.org/10.1016/j.frl.2020.101604>
- Ashraf, B.N., 2020. Economic impact of government interventions during the COVID-19 pandemic: International evidence from financial markets. *Journal of Behavioral and Experimental Finance* 27:100371, 1-9. <https://doi.org/10.1016/j.jbef.2020.100371>
- Badshah, I., Bekiros, S., Lucey, B., G. Salah Uddin, G., 2018. Asymmetric linkages among the fear index and emerging market volatility indices. *Emerging Markets Review* 37:17–31. doi:10.1016/j.ememar.2018.03.002
- Baig, A.S., Blau, B.M., Sabah, N., 2020. Free trade and the efficiency of financial markets. *Global Finance Journal* 100545. <https://doi.org/10.1016/j.gfj.2020.100545>
- Baiga, S.A., Butt, A.H., Haroona, O., Rizvia, R.A.S., 2020. Deaths, panic, lockdowns and US equity markets: The case of COVID-19 pandemic. *Finance Research Letters* 101701, 1-9, doi: 10.1016/j.frl.2020.101701
- Bai, L., Wei, Y., Wei, G., Li, X., Zhang, S., 2020. Infectious disease pandemic and permanent volatility of international stock markets: A long-term perspective. *Finance Research Letters* 101709. <https://doi.org/10.1016/j.frl.2020.101709>
- Baldwin, R., Weder di Mauro, B., 2020. Economics in the Time of COVID-19. (CEPR Press VoxEU.org). <https://cepr.org/sites/default/files/news/COVID-19.pdf>
- Barberis, N., Shleifer, A. Vishny, R., 1998. A model of investor sentiment. *Journal of Financial Economics* 49(3), 307-343. [https://doi.org/10.1016/S0304-405X\(98\)00027-0](https://doi.org/10.1016/S0304-405X(98)00027-0)
- Bekiros, S.D., 2014. Contagion, decoupling and the spillover effects of the US financial crisis: Evidence from the BRIC markets. *International Review of Financial Analysis* 33, 58–69. <https://doi.org/10.1016/j.irfa.2013.07.007>
- Bento, A.I., Nguyen, T., Wing, C., Lozano-Rojas, F., Ahn, Y.Y., Simon, K., 2020. Evidence from internet 210 search data shows information-seeking responses to news of local COVID-19 cases. *Proceedings of the National Academy of Sciences* 117(21), 11220–11222. doi: 10.1073/pnas.2005335117
- Blau, B.M., Brough, T.J., Thomas, D.W., 2014. Economic freedom and the stability of stock prices: a cross-country analysis. *Journal of International Money Finance* 41, 182–196. <https://doi.org/10.1016/j.jimonfin.2013.12.001>

- Blau, B.M., 2017. Social trust and the liquidity of cross-listed securities. *Journal of Business Research* 78, 155–171. <https://doi.org/10.1016/j.jbusres.2017.05.009>
- Bowerman, B.L., O'Connell, R.T., 1990. Linear statistical models: An applied approach. Boston: 2nd ed. Boston: PWS-Kent.
- Conlon, T., McGee, R., 2020. Safe haven or risky hazard? Bitcoin during the Covid-19 bear market. *Finance Research Letters* 35, 1016072, 1-5. <https://doi.org/10.1016/j.frl.2020.101607>
- Corbet, S., Larkin, C., Lucey, B., 2020a. The contagion effects of the COVID-19 pandemic: Evidence from gold and cryptocurrencies. *Finance Research Letters* 35, 1015542, 1-7. <https://doi.org/10.1016/j.frl.2020.101554>
- Corbet, S., Hou, Y., Hu, Y., Lucey, B., Oxley, L., 2020b. Aye Corona! The contagion effects of being named Corona during the COVID-19 pandemic. *Finance Research Letters* 101591, 1-9. <https://doi.org/10.1016/j.frl.2020.101591>
- Donadelli, M., Kizys, R., Riedel, M., 2017. Dangerous infectious diseases: bad news for main street, good news for wall street? *Journal of Financial Marketing* 35, 84–103. <https://doi.org/10.1016/j.finmar.2016.12.003>
- Ederington, L.H., Lee, J.H., 1996. The creation and resolution of market uncertainty: the impact of information releases on implied volatility. *Journal of Financial and Quantitative Analysis* 31(4), 513–539. doi: <https://doi.org/10.2307/2331358>
- Gkillas, K., Gupta, R., Pierdzioch, C., 2020. Forecasting realized oil-price volatility: The role of financial stress and asymmetric loss. *Journal of International Money and Finance* <https://doi.org/10.1016/j.jimonfin.2020.102137>.
- Goodell, W.J., 2020. COVID-19 and finance: Agendas for future research. *Finance Research Letters* 35:101512, 1-5. <https://doi.org/10.1016/j.frl.2020.101512>.
- Goodell, W.J., Goutte, S., 2020. Co-movement of Covid-19 and Bitcoin: Evidence from wavelet coherence analysis. *Finance Research Letters* 101625. <https://doi.org/10.1016/j.frl.2020.101625>
- Government Response Tracker (OXCGRT) <https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker> (accessed 01. January, 2021)
- Greenstone, M., Nigam, V., 2020. Does Social Distancing Matter? University of Chicago, Becker Friedman Institute for Economics Working Paper No. 2020-26.
- Groß-Klußmann, A., Hautsch, N., 2011. Predicting Bid-Ask Spreads Using Long Memory Autoregressive Conditional Poisson Models. Retrieved September 05, 2020, from SSRN: <https://ssrn.com/abstract=1884237> or <http://dx.doi.org/10.2139/ssrn.1884237>
- Hale, T., Angrist, N., Cameron-Blake, E., Hallas, L., Kira, B., Majumdar, S., et al. (2020b). Oxford COVID-19 government response tracker [Online]. Blavatnik School of Government, Available at: <https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker> (accessed 01. January 2021).
- Haron, O., Rizvi, S.A.R., 2020a. Flatten the curve and stock market liquidity – an inquiry into emerging economies. *Emerging Markets Finance and Trade* 56(10):2151-2161. doi: 10.1080/1540496X.2020.1784716
- Haron, O., Rizvi, S.A.R., 2020b. COVID-19: media coverage and financial markets behavior-A sectoral inquiry. *Journal of Behavioral and Experimental Finance* 27:100343. <https://doi.org/10.1016/j.jbef.2020.100343>
- Heyden, K.J., Heyden, T., 2020. Market reactions to the arrival and containment of COVID-19: an event study. *Finance Research Letters*, 101745 <https://doi.org/10.1016/j.frl.2020.101745>

- Ho, R., 2006. Handbook of univariate and multivariate data analysis and interpretation with SPSS, Taylor & Francis Group, LLC.
- Hussain, A H M Belayeth, Stringency in Policy Responses to Covid-19 Pandemic and Social Distancing Behavior in Selected Countries, SSRN: <https://ssrn.com/abstract=3586319> or <http://dx.doi.org/10.2139/ssrn.3586319> (accessed 02.january 2021)
- Iyke, B.N., 2020a. The disease outbreak channel of exchange rate return predictability:Evidence from COVID-19. *Emerging Markets Finance and Trade* 56(10), 2277–2297. doi:10.1080/1540496X.2020.1784718
- Iyke, B.N., 2020b. COVID-19: The reaction of US oil and gas producers to the pandemic. *Energy Research Letters* 1(2). <https://doi.org/10.46557/001c.13912>
- Ji, Q., Zhang, D., Zhao, Y., 2020. Searching for safe-haven assets during the COVID-19 pandemic. *International Review of Financial Analysis* 71:1015262, 1-10. <https://doi.org/10.1016/j.irfa.2020.101526>
- London metal exchange, <https://www.lme.com/en-GB/Metals/Non-ferrous#tabIndex=0> (accessed 03 December 2020).
- Lou, J., Shen, X., Niemeier, D., Are Stay-At-Home Orders More Difficult to Follow for Low-Income Groups? *Journal of Transport Geography* 89, 102894 <https://doi.org/10.1016/j.jtrangeo.2020.102894>
- Luchtenberg, K.F., Vu, Q.V. 2015. The 2008 financial crisis: Stock market contagion and its determinants. *Research in International Business and Finance* 33, 178–203. <https://doi.org/10.1016/j.ribaf.2014.09.007>
- Lyocsa, Š., Baumohl, E., Vyrost, T., Molna, P., 2020a. Fear of the coronavirus and the stock markets. *Finance Research Letters* 36:101735. <https://doi.org/10.1016/j.frl.2020.101735>
- Lyocsa, Š., Molnar, P., 2020b. Stock market oscillations during the corona crash: The role of fear and uncertainty *Finance Research Letters* 36:101707. <https://doi.org/10.1016/j.frl.2020.101707>
- Mairal, G., 2011. The history and the narrative of risk in the media. *Health, Risk & Society* 13(1), 65-79. doi: 10.1080/13698575.2010.540313
- Mazur, M., Dang, M., Vega, V., 2020. COVID-19 and the march 2020 stock market crash: Evidence from S&P1500. *Finance Research Letters* 101690 <https://doi.org/10.1016/j.frl.2020.101690>
- Mitchell, M., Harold Mulherin, H.J., 1994. The Impact of Public Information on the Stock Market. *Journal of Finance* 49(3), 923-50. <https://doi.org/10.1111/j.15406261.1994.tb00083.x>
- Myers, R.H. 1990. Classical and modern regression application. 2nd edition. Duxbury press. CA
- Nicomedesa, C.J.C., Avilab, A.M.R., 2020. An analysis on the panic during COVID-19 pandemic through an online form. *Journal of Affective Disorders* 276, 14–22. <https://doi.org/10.1016/j.jad.2020.06.046>
- Ortmann, R., Pelster, M., Wengerek, T.S., 2020. COVID-19 and investor behavior. *Finance Research Letters* 101717. <https://doi.org/10.1016/j.frl.2020.101717> 1-19
- Ramelli, S., Wagner, A. F., 2020. Feverish stock price reactions to covid-19. Swiss Finance Institute, Research Paper No. 20-12. [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=3550274](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3550274) (accessed 15 October 2020).
- Raven pack media monitor, <https://coronavirus.ravenpack.com/> ((accessed 01 January 2020).
- Rogone, L., Hyde, S., Zhang, S.S., 2020. News sentiment in the cryptocurrency market: An empirical comparison with Forex. *International Review of Financial Analysis* 69, 101462. <https://doi.org/10.1016/j.irfa.2020.101462>

- Salisu, A.A., Akanni, L.O., 2020. Constructing a global fear index for the COVID-19 pandemic. *Emerg. Markets Finance Trade*  
<http://dx.doi.org/10.1080/1540496X.2020.1785424>
- Salisu, A.A., Akanni, L., Ibrahim Raheem, I., 2020a. The COVID-19 global fear index and the predictability of commodity price returns. *Journal of Behavioral and Experimental Finance* 27:100383, 1-7. <https://doi.org/10.1016/j.jbef.2020.100383>
- Salisu, A.A., Ebuh, G.U., Usman, N. 2020b. Revisiting oil-stock nexus during COVID-19 pandemic: Some preliminary results. *International Review of Economics & Finance* 69, 280-294. <https://doi.org/10.1016/j.iref.2020.06.023>
- Shanaev, S., Shuraeva, A., Ghimire, B., 2020. The financial pandemic: COVID-19 and policy interventions on rational and irrational markets. SSRN: <https://ssrn.com/abstract=3589557> or <http://dx.doi.org/10.2139/ssrn.3589557>
- Sharif, A., Aloui, C., Yarovaya, L., 2020. COVID-19 pandemic, oil prices, stock market, geopolitical risk and policy uncertainty nexus in the US economy: Fresh evidence from the wavelet -based approach. *International Review of Financial Analysis* 70:101496, 1-9. <https://doi.org/10.1016/j.irfa.2020.101496>
- Su, Z., Fang, T., Yin, L., 2017. The role of news-based implied volatility among US financial markets. *Economic Letters* 157, 24–27. <https://doi.org/10.1016/j.econlet.2017.05.028>
- Tetlock, P.C., 2007. Giving content to investor sentiment: the role of media in the stock market. *The Journal Finance* 62(3), 1139–1168. <https://doi.org/10.1111/j.1540-6261.2007.01232.x>
- Thunström, L., Newbold, S.C., Finnoff, D., Ashworth, M., Shogren, J.F., 2020. The benefits and costs of using social distancing to flatten the curve for COVID-19. *Journal of Benefit-Cost Analysis* 11 ( 2 ), 179 - 195 doi: <https://doi.org/10.1017/bca.2020.12>
- Torun, E., Chang, T.P., Chou, R.Y., 2020. Causal relationship between spot and future prices with multiple time horizons: A nonparametric wavelet Granger causality test. *Research in International Business and Research* 52, 101–115. doi: 10.1016/j.ribaf.2019.101115
- UNCTAD, 2020. Global trade impact of coronavirus(COVID-19) epidemic. Trade and Development Report Update, retrieved from: <https://unctad.org/system/files/official-document/ditcinf2020d1.pdf> 1–7.
- Umar, Z., Gubareva, M., 2020. A time–frequency analysis of the impact of the Covid-19 induced panic on the volatility of currency and cryptocurrency markets, *Journal of Behavioral and Experimental Finance* 28:100404, 1-10.  
<https://doi.org/10.1016/j.jbef.2020.100404>
- Uhl, M.W., Pedersen, M., Malitius, O., 2015. What's in the news? Using news sentiment momentum for tactical asset allocation. *The Journal of Portfolio Management Winter* 41(2), 100-112. doi: <https://doi.org/10.3905/jpm.2015.41.2.100>
- Wilder-Smith, A., Freedman, D.O., 2020. Isolation, quarantine, social distancing and community containment: Pivotal role for old-style public health measures in the novel coronavirus (2019-nCoV) outbreak. *Journal of travel medicine* 27 (2).  
10.1093/jtm/taaa020
- World Bank. 2020. A World Bank Report. April 2020. Commodity Markets Outlook.Implications of COVID-19 for Commodities. <https://openknowledge.worldbank.org/bitstream/handle/10986/33624/CMO-April-020.pdf>.
- World Health Organization, 2020a, Director-General’s opening remarks at the media briefing on COVID19 -March 2020.

- World Health Organization, 2020b. WHO Coronavirus Disease (COVID-19) Dashboard. Retrieved from <https://covid19.who.int/>
- Worldometer ,Coronavirus Worldwide Graphs.  
<https://www.worldometers.info/coronavirus/worldwide-graphs/>
- Wright, A.L., Sonin, K., Driscoll, J., Wilson, J., 2020. Poverty and economic dislocation reduce compliance with covid-19 shelter-in-place protocols. *Journal of Economic Behavior & Organization* 180, 544-554 <https://doi.org/10.1016/j.jebo.2020.10.008>
- Wu, K.J.Z., Xu, M., Yang, L., 2020. Can crude oil drive the co-movement in the international stock market? Evidence from the partial wavelet coherence analysis. *The North American Journal of Economics and Finance* 53, 101–119. <https://doi.org/10.1016/j.najef.2020.101194>
- Yarovaya, L., Matkovskyy, R., Jalan, A., 2020. The effects of a ‘black swan’ event (COVID-19) on herding behavior in cryptocurrency markets: Evidence from cryptocurrency USD, EUR, JPY and KRW markets. SSRN: <https://ssrn.com/abstract=3586511>.
- Yin, Z.C., Lu, Z.H., Pan, X.B., 2020. The impact of the Sino-US trade war on China’s stock market: An event-based analysis. *Journal of Management* 33(1), 18–28. doi:10.19808/j.cnki.41-1408/F.2020.01.003.
- Zaremba, A., Kizys, R., Aharon, D.Y., Demir, E., 2020. Infected Markets: novel Coronavirus, government interventions, and stock return volatility around the globe. *Finance Research Letters* 101597. <https://doi.org/10.1016/j.frl.2020.101597>
- Zhang, D., Hu, M., Ji, Q., 2020. Financial markets under the global pandemic of COVID-19. *Finance Research Letters* 36:101528, <https://doi.org/10.1016/j.frl.2020.101528>

UDK 616.98:578.834]:334.713  
005.334:334.7(497.11)  
COBISS.SR-ID 57381129

## SUSTAINABLE BUSINESS MODELS OF SMALL AND MEDIUM ENTERPRISES (SMES) IN POST-COVID-19 CONDITIONS

Ivana Marinović Matović<sup>1</sup>,  
Andjela Lazarević<sup>2</sup>  
Leposava Jovanović<sup>3</sup>

<sup>1</sup>*PUC Parking Service – Nis, Svetozara Markovića 27, Nis, Serbia, ivana.m.matovic@gmail.com*

<sup>2</sup>*Faculty of Mechanical Engineering, University of Nis, Aleksandra Medvedeva 14, Nis, Serbia,  
andjela.lazarevic@gmail.com*

<sup>3</sup>*Faculty of Management in Zajecar, Megatrend University, Park suma Kraljevica bb, Zajecar, Serbia,  
leposava.jovanovic@fmz.edu.rs*

### ABSTRACT

*One year of the crisis under COVID-19, resulted in a rational response of small and medium enterprises (SMEs), in terms of activities aimed at preserving liquidity, and strengthening profitability. This paper investigates the adaptation and response of Serbian SMEs to the COVID-19 pandemic. The developmental orientation of SMEs, in which innovations, improvement and adaptation of business models play a significant role, provides growth in post-COVID-19 conditions. The paper contributes to decision-makers, who need to consider the drivers of profitable SME business in post-COVID-19 conditions, in order to improve the macroeconomic environment, and support them in providing financial and other necessary resources.*

### KEYWORDS

*SMEs, Serbia, COVID-19, Crisis management, Sustainability, Business model.*

**JEL: L26, M21, H12**

## 1. INTRODUCTION

The unexpectedly large pandemic spread around the world during the first half of 2020. It was identified as a new coronavirus (severe acute respiratory syndrome Coronavirus 2, or SARS-CoV-2), and was later named Coronavirus Disease-19 or COVID-19 (Qiu et al. 2020). The coronavirus originated in Asia but spread rapidly in Europe and other parts of the world, resulting in a global economic downturn greater than the great recession that followed the global financial crisis during 2008-2009 (UNCTAD, 2020). COVID-19 first appeared in the city of Wuhan in the Chinese province of Hubei, and then quickly took over the world, resulting in human casualties and enormous economic damage. In early April 2021, there were over 130 million confirmed cases of COVID-19 infection worldwide, with over 2.8 million deaths (World Health Organization, 2021).

The crisis caused by the COVID-19 pandemic has a strong impact on companies, employees and the way they operate, which requires radical government measures to reduce business losses and survival (Shafi et al. 2020). Remote work, almost completely canceling business trips, holding online meetings using various applications, greater work engagement on digital platforms, have become part of everyday business (Atilgan, 2020). COVID-19 crisis is characterized by a high degree of unpredictability, difficult planning of preventive activities in organization, which endangers the survival and sustainable business of companies, jeopardizes their goals, and requires rapid responses (Gostin, Wiley, 2020). SMEs in particular are very vulnerable to the crisis, as they generally do not have a crisis plan that would allow them to survive during a pandemic caused by COVID-19 (Alves et al. 2020). COVID-19 crisis has a strong impact on SMEs' business revenue, especially of manufacturing companies, due to endangered employee health and their frequent absence, and difficult access to financial capital (Marinovic Matovic & Lazarevic, 2021).

Managing crisis in SMEs is a process that results in a relative success and failure, where no organization achieves a fully effective or completely ineffective response to the crisis (Pearson, Clair, 1998). Managing crisis in SMEs requires the adaptation of standardized procedures, and the creation of new business models for their implementation (Dynes, Aguirre, 1979).

The paper analyzes the SMEs' attitudes on the government support measures they expect, with the aim of surviving the COVID-19 crisis; as well as their opinion on other most important activities to help this sector. The research also covers the interests of SMEs in the field of government support, to help the most vulnerable organizations, those who are most intensively affected by difficult business conditions. Based on the review of applied and expected measures, proposals and recommendations are given for SME management and decision makers, in order to improve the macroeconomic environment, and to preserve business continuity and development of the SME sector in crisis conditions.

## **2. LITERATURE REVIEW**

COVID-19 pandemic has serious socio-economic effects (Atilgan, 2020). COVID-19 has caused negative effects in business and social life, especially in industries such as tourism, aviation and stock exchange transactions. The pandemic, which has spread around the world, has caused a global economic shock in the form of a decline in international trade, a reduction of foreign direct investments, a downfall in the volume of production and employment at the global level (Lazarevic, 2017). Developed national economies responded with different packages of measures to preserve and stimulate the business, while underdeveloped and transition countries had limited opportunities to act, due to already burdened budgets (UNCTAD, 2020).

Under the influence of the crisis caused by the COVID-19 pandemic, a large number of SMEs suspended their operations and reduced the number of employees, which leads national economies to new crises with serious socio-economic consequences (Nicola et al. 2020). To manage the crisis, many organizations have digitized their business processes, which at the same time provided a safe work environment for their employees (Atilgan, 2020). In addition to the development of alternative work procedures, in order to maintain business continuity, the danger of the spread of the COVID-19 pandemic required the fulfillment of health and safety protocols (Cora, 2020). Internal communication in crisis conditions should have been conducted in a timely and correct manner, with employee support programs. During the COVID-19 crisis, the importance of proper communication with consumers, employees,



suppliers, investors, regulatory institutions and other stakeholders was emphasized. Proper communication included, among other things, the introduction of timely notification of the effects of the crisis on the continuity of delivery of services and products, which may be jeopardized due to possible interruptions in supply and production (Atilgan, 2020). Proactive communication and taking quick action helps mitigate the negative effects of the COVID-19 crisis, and protect the organizational reputation (Wang et al. 2020).

SMEs are much more exposed to pandemic risks than large organizations (Levashenko, Koval, 2020). The impact of the COVID-19 crisis on SMEs is particularly strong due to their presence in sectors most affected by the crisis (International Trade Center, 2020). Limited resources and insufficient liquid assets available to SMEs make them particularly vulnerable to crisis conditions, reflecting the risk of their possible permanent closure due to the negative impact of the COVID-19 pandemic. Rathore and Khanna (2020) found in their research that up to 70% of small businesses believe that restricted movement measures will lead to the cessation of their business within three months.

Organizations that react quickly and adapt to unpredictable circumstances, are characterized by flexible and direct guidelines in operational activities, and properly distributed workforce, which allows them to survive in times of crisis (Ganatra et al. 2020; Lazarevic 2019). Morales et al. (2020) pointed to the importance of optimal administrative procedures in SMEs during the COVID-19 crisis. Prohorovs (2020) emphasizes the need for a clear understanding of the specifics of the COVID-19 crisis, so that organizations can adapt more quickly to the new situation, and reduce the harmful effects.

If SMEs adequately manage crises, and perform timely planning, they will maintain profitable operations in crisis conditions (Irvine, Anderson, 2006; Munoz et al. 2019). The role of managers in crisis business conditions is crucial for organization (James et al. 2011). Professional management and the quality of human capital are crucial for SMEs in crisis business conditions (Tannenbaum, Schmidt, 1957; Perkins, Murphy, 2013). Dent et al. (2018) also confirmed in their studies that effective crisis management is of great importance for the appropriate organizational response and overcoming the crisis challenges. This achieves a timely organizational response, and the application of adequate crisis management (Ansell et al. 2010), which leads to sustainable business, new opportunities and directions of development (Kuckertz et al. 2020).

### **3. COVID-19 ECONOMIC MEASURES IN THE REPUBLIC OF SERBIA**

The package of measures implemented by the Republic of Serbia, in response to the COVID-19 pandemic, was extensive and directly focused on the economy and business relaxation (Official Gazette of the RS, 2020a). Through the package of measures, the most important suggestions of Serbian businessmen were accepted. The measures primarily affected liquidity, which was the most important due to the conditions of uncertainty, and unpredictable cashflow and sales (Marinovic Matovic & Vemic Djurkovic, 2021). Prolongation of payments, such as contributions, led to more relaxed business operations (Djakovic, 2020). Defining and adopting support measures by the Republic of Serbia, relied on the positive experiences of developed economies and surrounding countries. Requirements and proposals of businessmen associations were also accepted (Marinovic Matovic & Vemic Djurkovic, 2021).

The Government of the Republic of Serbia has implemented fiscal measures aimed at reducing the negative effects caused by the COVID-19 pandemic, which was the priority of

three sets of measures (Ministry of Economy, 2020). The first group of measures included the prolongation of tax liabilities, and installments repayment, till the beginning of 2021. The second set referred to the direct support for SMEs and entrepreneurs, as well as to subsidies for large companies, for maintaining the current employment level. The third set was aimed at maintaining liquidity through loan and guarantee programs of commercial banks (Milanovic & Kolar, 2020). The main goals of proposed measures were: economic load reduction in the short term, stabilizing the decline of macroeconomic indicators, such as the unemployment rate, and encouraging the medium-term demand, after the abolition of restrictions caused by the pandemic.

Measures of the Government of the Republic of Serbia were aimed at small and medium enterprises and entrepreneurs, as well as large companies, and included three benefits: fiscal benefits, direct subventions, and measures to preserve liquidity (Djokic & Rilakovic, 2020). These measures were prescribed by the Decree on fiscal benefits and direct benefits to business entities (Official Gazette of the RS, 2020a), and were intended for privately owned companies, which have not reduced the number of employees by more than 10% since the beginning of the pandemic.

The government measures prescribed by the Decree, among other things, included (Marinovic Matovic & Vemic Djurkovic, 2021)

- Postponement of maturity of taxes and contributions on salaries until the beginning of 2021,
- Postponement of the monthly advance payments of income tax, until the final calculation of income tax for 2020,
- Payment of non-refundable funds in the amount of the minimum monthly net salary per employee,
- Subsidized loans disbursed through the Development Fund of the Republic of Serbia, with an interest rate of 1% per annum,
- State guarantees for loans approved by commercial banks,
- Issuance of debt securities under a simplified procedure.

At the macroeconomic level, in the hospitality, tourism and transport sectors, SMEs have felt a significant negative impact of the crisis, as a result of demand constraints. Given the importance of these sectors in the economic structure of the Republic of Serbia, and the further development of crisis conditions, special government support measures have been implemented, in the field of liquidity, fiscal and other facilities. State support implied special conditions for these three sectors, additional benefits in relation to the already implemented set of measures to support the whole economy.

SMEs in the hospitality, tourism and transport sectors, unlike others, could count on support, although they have reduced the number of employees by more than 10%, which, given the decline in revenues and share of labour costs, was very significant. Liquidity loan repayment terms have been extended from three to five years, with a grace period of two years. The amounts have also been changed, which means that small enterprises could get 80 million dinars, and medium-sized enterprises up to 180 million dinars. The conditions for collateral were also changed, so for a loan of up to 80 million dinars, it was necessary to provide a guarantee from an unrelated company.

Vojvodina Development Fund has financed the support program intended to preserve liquidity through long-term loans. It was specifically intended for companies from the Vojvodina territory, and for small and micro enterprises. Vojvodina Finance Secretariat refunded 2% of the total 3% interest rate on loans, and the remaining 1% was paid by the

borrower. The loan amount for small enterprises was 10 million dinars. The loan term was up to 36 months, with a grace period of up to 12 months. Condition for loan approval was that the borrower has not reduced the employee number more than 10% since the pandemic outbreak.

Ministry of Tourism granted loans to SMEs for improving the tourist offer and intensifying the current capacities use. The purpose of the support was to improve the qualitative and quantitative component of tourist offer. The main purpose of these investments in fixed assets was a long-term increase in capacity, as a basis for revenue growth. At the same time, the goal was to improve customer service, which would enable higher competitiveness and larger prices of offered services per unit. In addition to these two components, the loan funding would enable the offer diversification, the season extension, and revenue generation over a longer period. In addition to investing in fixed assets, the loans were also aimed at covering marketing costs, souvenir production, and the development of tourist infrastructure, with the aim of increasing future demand. The loans granted by the Ministry of Tourism were approved in the minimum amount of 2 million dinars, up to 6 years, with a 12 or 24 months grace period.

In addition to the support program for tourism development at the national level, the Autonomous Province of Vojvodina also allocated significant funds for tourism, through the Development Fund of AP Vojvodina. An additional goal was the development of rural tourism in Vojvodina, which included hunting and fishing tourism, enogastronomic, religious and cultural, as well as health tourism. Support was provided in the form of loans, granted in the amount of up to 20 million dinars, with the interest rate between 1% and 2%, with the 7-year maximum term, and monthly, quarterly or semi-annual repayment. The loan purpose included creating or improving the tourist offer, the construction, adaptation and equipping of tourist facilities. Loans were available to micro, small and medium enterprises, which operate in the tourism and hospitality sector in the territory of Vojvodina.

The Government of the Republic of Serbia also adopted an additional measure, formulated in the Decree on the conditions and criteria for compliance of State aid through the recapitalization of market participants (Official Gazette of the RS, 2020b). The basic criterion was that the applicant could prove serious business difficulties, caused by the COVID-19 pandemic, which would lead to company closure without state aid. Additional criteria were: the state interest to intervene, the impossibility of obtaining financial resources on the market, and the difficult company survival with the existing state aid measures. Recapitalization could include two types of instruments. The individual approach was achieved with an equity instrument and direct acquisition through capital share. The combined approach was performed with hybrid instruments, and through indirect acquiring of a capital share. All instruments implied a gradual increase in state fees, according to predefined scales related to reference interest rate. This was an incentive for companies to repay the state share as soon as possible, and at the same time not to violate competition in the financial market. The companies could repay the state share at any time, and the state could sell its share to third parties.

The state aid model through the recapitalization of SMEs is a new financial model that implies a different risk distribution, compared to conventional lending, and represents a significant step towards diversified access to finance. The precondition of this model is the developed financial management, and significant resources engaged throughout the process from application to reporting, which SMEs do not have. In the coming period, it is necessary to simplify this model of state support, make it more accessible to SMEs, at minimum costs and required resources.

Profitability and sustainability of business, in addition to the applied support measures, depend on the specifics of each SME, its business model, current financial situation, market position and business activities. In addition to relying on economic support measures, it is necessary for SMEs to react in a timely manner and make necessary strategic and operational decisions, in accordance with market circumstances in the conditions of the COVID-19 pandemic.

#### 4. RESEARCH METHODOLOGY

To analyze the sustainable business models, primary empirical data were collected in different SMEs of the Republic of Serbia. The empirical research was realized in 2021, where the entrepreneurs, i.e. SME founders, business owners and managers, were surveyed.

By random sampling, questionnaires were submitted to the addresses of 600 respondents, and the completed survey forms were submitted by 392 SMEs. Participation in the research implied anonymity. The choice of participants in the research was not executed, i.e. respondents were in the same manner invited to participate in the research, and their response could not be affected. The survey questionnaire contained questions methodically distributed in three groups of research variables: 1. Demographic characteristics of SMEs and entrepreneurs; 2. The problems which SMEs faced during the crisis caused by COVID-19 pandemic; 3. Measures applied. All questions were clear and concise; listed gradually in the appropriate order. Respondents were offered several choices for closed questions.

#### 5. RESEARCH RESULTS

Basic demographic characteristics of sampled SMEs, based on the analyzed collected empirical data, are presented in Table 1:

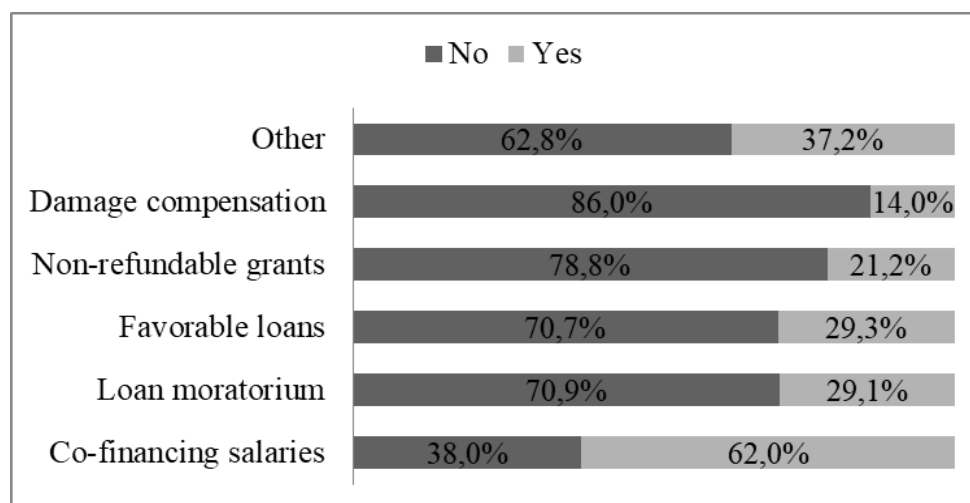
**Table 1.** Demographic characteristics of sampled SMEs

<b>SME size (employee number)</b>	<b>Total</b>	<b>Total (%)</b>	<b>Cumulative (%)</b>
Small	326	83.2	83.2
Medium	66	16.8	100.0
<b>SME size (operational revenue)</b>			
Small	318	81.1	81.1
Medium	74	18.9	100.0
<b>Industry sector</b>			
Sector A	8	2.0	2.0
Sector B	2	0.5	2.6
Sector C	37	9.4	12.0
Sector D	5	1.3	13.3
Sector E	2	0.5	13.8
Sector F	39	9.9	23.7
Sector G	67	17.1	40.8
Sector H	14	3.6	44.4
Sector I	30	7.7	52.0
Sector J	13	3.3	55.4
Sector K	5	1.3	56.6
Sector M	31	7.9	64.5
Sector N	15	3.8	68.4

*THEMATIC PROCEEDINGS*  
*THE IMPACT OF THE COVID 19 PANDEMIC ON ECONOMY, RESOURCES AND SUSTAINABLE DEVELOPMENT*

Sector P	12	3.1	71.4
Sector Q	3	0.8	72.2
Sector R	19	4.8	77.0
Sector S	90	23.0	100.0
<b>Length of business</b>			
< 1 Y	8	2.0	2.0
1-2 Y	30	7.7	9.7
3-5 Y	47	12.0	21.7
6-10 Y	72	18.4	40.1
>10 Y	235	59.9	100.0
<b>Entrepreneur gender</b>			
Male	245	62.5	62.5
Female	147	37.5	100.0
<b>Entrepreneur age</b>			
<30 Y	17	4.3	4.3
31 - 40 Y	94	24.0	28.3
41 – 50 Y	160	40.8	69.1
51 – 60 Y	68	17.3	86.4
>61 Y	53	13.6	100.0
Total	392	100.0	

The research included an analysis of the type of government support, expected by SMEs, to survive, maintain their business and profitability in COVID-19 crisis conditions. The results are shown in Figure 1.

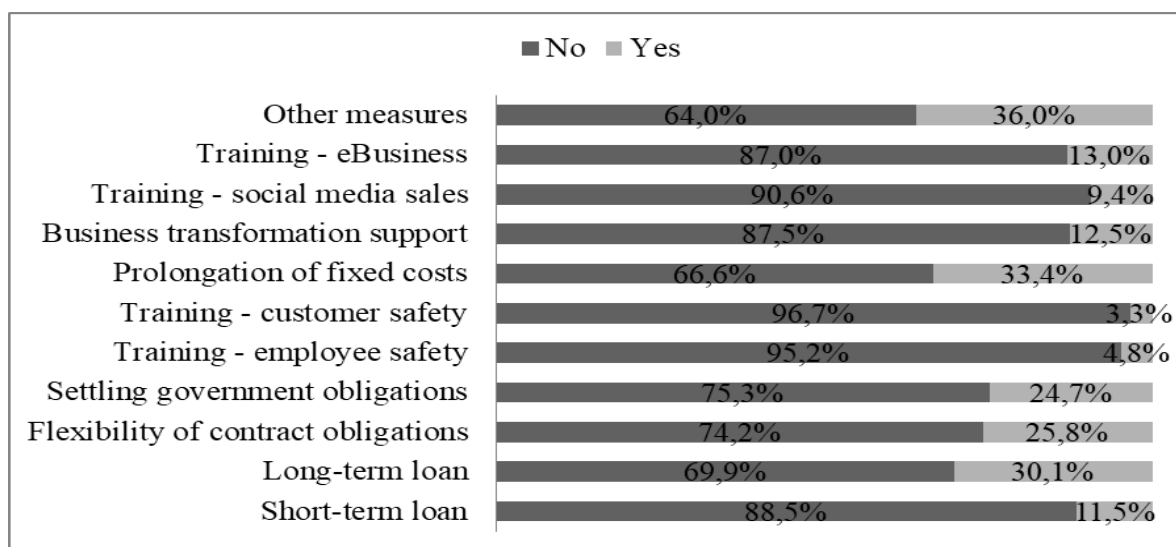


**Figure 1.** Government support measures expected by SMEs in the Republic of Serbia

According to the research results, SMEs expect from the government to co-finance salaries for employees. This measure, already applied after the outbreak of the COVID-19 pandemic, should be continued in the future period, as 62% of respondents confirmed. The state should not participate in damage compensation, caused by business problems that SMEs have experienced, due to the termination of certain activities, cancellations of agreed contracts and similar events that led to losses, as it is considered by the largest number of respondents

(86%). The presented results show that SMEs don't expect the settlement of credit obligations in the future, in the form of a contracted moratorium, a measure generally used in the past, as confirmed by 70.9% of the observed organizations. Similarly applies to the introduction of new favorable credit lines, because 70.7% of respondents do not consider this measure needed. Surprise is the fact that as many as 78.8% of SMEs do not want non-refundable grants from the government, to survive and maintain their business in COVID-19 crisis conditions. In addition to co-financing salaries, some other, not mentioned measures are expected, as confirmed by 37.2% of the observed organizations.

In addition to government measures analysis, the research also included identifying SMEs attitudes on other significant activities to help and support this sector, in order to survive, maintain business and profitability in COVID-19 crisis conditions. The results are shown in Figure 2.

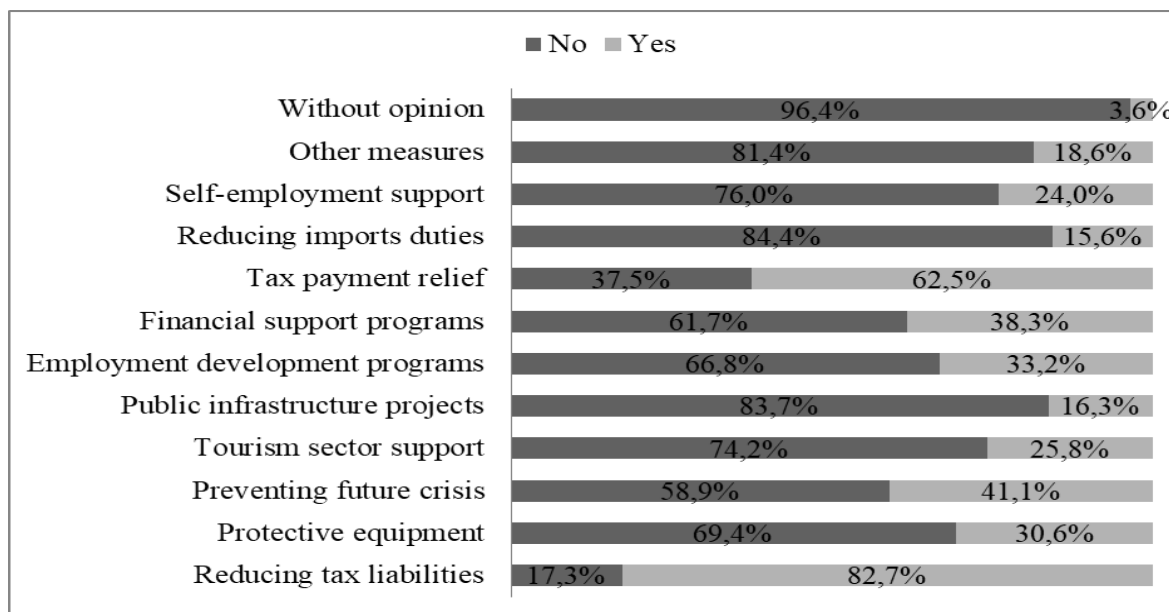


**Figure 2.** Other support measures expected by SMEs in the Republic of Serbia

The results of the research confirm that SMEs identified the following measures as the most significant in the COVID-19 pandemic conditions: Prolonging fixed costs payment without default interest (33.4% respondents), the possibility of credit approval in the form of long-term loans (30.1%), enabling flexibility when performing contractual obligations (25.8%), as well as settling the government obligations to its creditors (24.7%). As less important measures, SMEs stated: additional training regarding employee protection (4.8%) and protection of customers from COVID-19 virus (3.3%).

To maintain SMEs business activities in crisis conditions, it would be significant to organize educational training programs for digital business and online sales (as confirmed by 13% of respondents), provide them with support in the process of transforming business and adaptation to new macroeconomic circumstances (12.5%), and provide support in the form of training for marketing and sales through social networks (9.4%). Short-term credit lines would be important for 11.5% of observed organizations, as well as other measures not covered by this research, according to 36.0% of SMEs, participants in the research.

Research data analysis summarized the views of SMEs regarding the support measures that government should introduce, to help the most vulnerable organizations, those who are most intensely affected by restrictions, introduced for combating the COVID-19 virus. The results are given in Figure 3.



**Figure 3.** Expected government support measures for vulnerable organizations

Respondents believe that the most significant government measures, that would be effective in helping the most vulnerable SMEs, are: reducing tax liabilities (82.7% of respondents), tax payment relief or temporary tax release (62.5%), as well as taking timely measures for future crisis situations (41.1%). SMEs believe that reduced duties on imports, and investing in public infrastructure projects, are not significant measures to encourage the recovery of organizations most affected by the pandemic. In contrast, employment development programs, and governmental support for self-employment, would significantly help the most vulnerable SMEs, as confirmed by 33.2%, and 24% of respondents.

## 6. DISCUSSION AND RECOMMENDATIONS

During the period of uncertainty, it is important that SMEs consider the potential influences of the crisis on employees, customers and suppliers. Organizations that ignore possible risks, and do not take the necessary measures or create adequate business solutions, will be deeply affected by the negative effects of the crisis. Especially managers should anticipate all potential influences of the pandemic, and take a series of measures, in order to make their organization overcome the crisis process as soon as possible. The results of the research confirmed that as many as 41.1% of SMEs in the Republic of Serbia believe that it is crucial to take timely measures for better preparation for future crisis situations.

Improving the sustainability and profitability of business in crisis conditions involves different solutions, very specific to each organization, which SMEs should apply. In addition to technical and technological improvements, this includes a deep process of introducing and strengthening the crisis management, based on strategic and operational planning, human resource management, business process management and decision-making, all the way to the early crisis identification, and developing an adequate concept for maintaining business continuity. The measures available to SMEs for survival and further development, should include the transition from traditional sales channels to online models. This measure also

includes numerous other processes, of which the first step is to introduce an adequate concept of Customer Relationship Management (CRM).

Success in maintaining business continuity in the COVID-19 crisis implies that SMEs generate adequate financial planning in the newly-established crisis scenario that involves uncertainty. Crisis business conditions include taking appropriate measures to maintain flexibility, and reshaping existing plans. Measures for survival and business continuity should include capital increase, debt restructuring, additional credit support from banks, investors or government. In addition, to introduce strategic changes in business, SMEs should take measures to consolidate finance management, investment lending, or some other form of support for business operations. Research results confirmed these SMEs statements. SMEs in the Republic of Serbia have identified the most significant measures in the COVID-19 conditions: prolonging the settlement of fixed costs without default interest (33.4% of respondents); possibility of long-term credit lines (30.1%); flexibility in the contract obligations' execution (25.8%); and settling the government obligations to its creditors (24.7%). All the mentioned measures lead SMEs to consolidation of finance management and adequate financial planning in the crisis business conditions.

According to the results of the conducted research, SMEs in the Republic of Serbia do not prefer favorable credit lines in order to obtain the necessary financial resources (as 70.7% of observed organizations confirmed). Instead of standard forms of financing, it is necessary to provide alternative ways of SME financing, i.e. crowdfinancing. Crowdfinancing model is used for providing the necessary financial resources from a larger group of private individuals or legal entities, which invest relatively small individual amounts. Crowdfinancing is organized in the Republic of Serbia in accordance with the legal regulations, and enabled via Ventu.rs platform.

One of the SMEs' characteristics, insufficient knowledge and skills of the founders/owners/managers, further endangered their survival and sustainable development in COVID-19 crisis conditions. One of the measures to preserve business continuity is additional training of entrepreneurs. The significance of this measure was confirmed by the results of the conducted research. In order to survive and maintain business in crisis conditions, the importance of education is confirmed, especially the training for business digitization and online sales (as 13% of respondents confirmed); education for transformation of business and adaptation to the newly established external environment (12.5%); and support in the form of training for online marketing and sales through social networks (according to 9.4% SMEs). Entrepreneurial training and education in changed business conditions, under the influence of the COVID-19 pandemic, should include precise knowledge and skills, in accordance with the new needs of SMEs, and in order to adapt to different market requirements.

One of the pronounced problems, with which SMEs faced after the COVID-19 crisis, is the problem of maintaining regular supply and preservation of cooperation with suppliers. Lack of anyway limited liquid resources, led to delays in settling obligations to suppliers, and delivery delays in some cases. The preservation of regular supply chains is especially important if SMEs are depending on one or a small number of suppliers, which is most often the case. One of the measures that SMEs should apply to protect the continuity of their business in crisis conditions is the introduction of supplier development programs. SMEs need to develop a business strategy that implies a flexible network of suppliers, ie cooperation with different organizations, to improve the results and encourage continuous business growth.

The flexibility of organizational structure, in terms of adjustment to changes in the macroenvironment, is very significant in crisis conditions. After the outbreak of the COVID-19 pandemic, SMEs with a customizable organizational structure had more success in



adapting and maintaining their business. One of the survival measures in crisis conditions should imply the development of a flexible organizational structure with open corporate culture, where expertise is more important than formal authority. In crisis conditions, an informal organizational structure should be established, within a formal, which involves temporary crisis working groups, independent working groups, and virtual organizational parts.

Digitization is one of the key measures that allowed SMEs to adapt to crisis conditions, and provided a healthy working environment for their employees. Digitization of business is a necessary measure for survival and business maintenance in the crisis conditions caused by the global pandemic, such as the COVID-19 crisis. Digitization processes contribute to increasing sales, reducing costs, and improving relationships with customers and suppliers, through available digital technology. These processes require adequate entrepreneurial training, financial support, as well as changes to certain regulatory frameworks. By accelerating the process of digitization, the SMEs will apply new technologies, new business practices (e.g. completely digitized retail, contactless delivery, etc.), and new business models (e.g. online shopping, online medical care, online education, virtual office, virtual services, digital party, etc.).

## **7. CONCLUSION**

Many SMEs were affected by the COVID-19 crisis, leading to reviewing their approach to crisis management and available resources, in the unpredictable crisis environment. The crisis caused by the pandemic has led to deep market changes in the region and globally. Research results, as a whole, recognized the SMEs' need to preserve liquidity during the first stroke of the COVID-19 crisis. For all SMEs, who managed to maintain their business after the outbreak of the pandemic, to protect liquidity, maintain profitability, and adjust the business model to current market circumstances, new opportunities for growth and development are rising.

In order to improve the business sustainability and profitability in the COVID-19 crisis, SMEs should apply the management concept and process, universally applicable, with specific solutions that are individually adapted. Individual business model adjustment in some organizations involves the reduction of fixed costs, due to reduced revenues, to ensure the continuity of business till reorientation to new market needs. For other SMEs, specific solutions will be needed for additional resources, in order to substitute the missing import components, or the business will continue through custom procurement and sales channels. Under the influence of the COVID-19 crisis, some SMEs will create an essential business turn, such as leaving the domestic market and entering the chain suppliers of multinational companies.

Based on analysis of SME business characteristics in crisis conditions caused by COVID-19 pandemic, applied and expected future measures, the following proposals and recommendations for SME management can be provided:

- Application of the universal crisis management concept, with specific solutions, individually adapted
- Transition from traditional sales channels to online model, with the introduction of Customer Relationship Management, CRM concept
- Application of crisis financial planning that implies an increase in capital base, debt restructuring, additional credit support from banks, investors or government

- Transition to alternative sources of funding, in the form of crowdfunding
- Intensive training and education in accordance with the new needs of SMEs, in order to adapt to different market requirements
- Application of a business strategy that implies the development of a flexible network supplier, in order to improve business and encourage continuous growth
- Development of a flexible organizational structure with open corporate culture
- Digitization of business as a key measure for SME adaptation to crisis conditions, and securing a safe work environment for their employees
- Application of the benefits of ISO standard SRPS ISO 22301:2020 related to the Business continuity management systems, since serious situations such as pandemic outbreaks, provide the real opportunity to check the readiness of the companies for crisis situations, as well as their possibilities and certainty to continue with providing services and supplying products in situations that seriously jeopardize various business processes.

The spectrum of possible solutions for SMEs is wide, and the application of real measures is performed on the basis of analyzes, using the best tools and processes, with adequate professional support. Analysis, planning and realization of crisis business models and SME crisis management, represent the most significant topic of many support programs, at the level of national economies and regions, through international programs, as well as through national initiatives, as a part of government economic policy.

## REFERENCES

- Alves J.C., Lok T.Ch., Luo Y.B., Hao W. 2020. Crisis Management for Small Business during the COVID-19 Outbreak: Survival, Resilience and Renewal Strategies of Firms in Macau. *In Research Square*, pp. 1-29.
- Ansell C., Boin A., Keller A. 2010. Managing trans boundary crises: Identifying the building blocks of an effective response system. *In Journal of contingencies and crisis management*, Vol. 18, No. 4, pp. 195-207.
- Atilgan O., 2020. Chapter 8: COVID-19 and crisis management. *In COVID-19 and New Business Ecosystem*. Ankara, Gazi Kitabevi, pp. 141-152.
- Cora H., 2020. Contemporary Conflict Management and Intervention Strategies for Businesses under COVID-19 Crises. *In TURAN-SAM*, Vol. 12, No. 46, pp. 363-370.
- Dent P., Woo R., Cudworth P. 2018. *Crisis Management for the Resilient Enterprise*. Deloitte Insights.
- Djakovic P. 2020. *Economic measures to mitigate the consequences of Pandemia* [Економске мере за ублажавање последица пандемије]. Friedrich Ebert Foundation, Belgrade.
- Djokic M., Rilakovic I. 2020. Tax offenses from the Regulation on fiscal amenities and direct subsidies in order to mitigate the economic consequences of the COVID-19 pandemic [Порески прекршаји из Уредбе о фискалним погодностима и директним давањима у циљу ублажавања економских последица пандемије COVID-19]. *In Annals of the Faculty of Law in Belgrade*, Vol. 68, No. 3, pp. 129-158.
- Dynes R., Aguirre B. 1979. Organizational Adaptation to Crises: Mechanisms of Coordination and Structural Change. *In Disasters*, Vol. 3, No. 1, pp. 71–74.
- Ganatra S., Hammond S.P., Nohria A. 2020. The Novel Coronavirus Disease (COVID-19) Threat for Patients with Cardiovascular Disease and Cancer. *In JACC CardioOncology*, Vol. 2, No. 2, pp. 350–355.

- Gostin L.O., Wiley L.F. 2020. Governmental public health powers during the COVID-19 pandemic: stay-at-home orders, business closures, and travel restrictions. *In Jama*, Vol. 323, No. 21, pp. 2137-2138.
- International Trade Centre. 2020. *Quantifying the effect of COVID-19 on small business around the world*, <https://www.intracen.org/COVID19/Blog/Quantifying-the-effect-of-COVID-19-on-small-business-around-the-world-the-world/>
- Irvine W., Anderson A.R. 2006. The impacts of foot and mouth disease on a peripheral tourism area: The role and effect of crisis management. *In Journal of Travel & Tourism Marketing*, Vol. 19, No. 2-3, pp. 47-60.
- James E.H., Wooten L.P., Dushek K. 2011. Crisis management: Informing a new leadership research agenda. *In Academy of Management Annals*, Vol. 5, No. 1, pp. 455-493.
- Kuckertz A., Brändle L., Gaudig A., Hinderer S., Reyes C.A.M., Prochotta A., Berger E.S. 2020. Startups in times of crisis—A rapid response to the COVID-19 pandemic. *In Journal of Business Venturing Insights*, Vol. 13, No. June, e00169, pp. 1-13.
- Lazarevic A. 2019. Knowledge Management in the Insurance Companies. *In Insurance Trends: Journal of Insurance Theory and Practice*, Year XXXV, No. 3, pp. 35-53.
- Lazarevic A. 2017. The process of developing decentralised energy policies in the City of London. *In Energy & Environment*, SAGE Publishing, Vol. 28, No. 5-6, pp. 639- 647. DOI: 10.1177/0958305X17719935
- Levashenko A., Koval A. 2020. *Measures of Financial and Non-Financial Support to Small and Medium-sized Enterprises (SMEs) in the Wake of COVID-19*. Monitoring of Russia's Economic Outlook. Trends and Challenges of Socio-economic Development. Moscow. IEP, 9, pp. 7-10.
- Marinovic Matovic I., Lazarevic A. 2021. Business revenue and job retention during COVID-19 crisis in manufacturing sector in Serbia. *In Business Excellence and Management*, Vol. 11, Special Issue 2, pp. 113-128.
- Marinovic Matovic I., Vemic Djurkovic J. 2021. COVID-19 impact on trade and production organizations: The effects of governmental measures in the state of emergency. *In Thematic Collection of Papers of International Significance - Psychology of disaster, state of emergency and their effects on health*, Faculty of Philosophy, Kosovska Mitrovica, pp. 135-151.
- Milanovic F., Kolar M. 2020. *Supplementary measures of economic consequences of COVID-19 pandemic* [Мере сузбијања економских последица пандемије COVID-19]. Center for International Public Policy, Belgrade.
- Ministry of Economy. 2020. *Program of economic measures for reducing negative effects caused by the pandemic of COVID-19 virus and the support of Serbia's economy* [Програм економских мера за смањивање негативних ефеката проузрокованих пандемијом вируса COVID-19 и подршку привреди Србије]. <https://privreda.gov.rs/program-ekonomskih-mera-za-smanjivanje-negativnih-efekata-prouzrokovanih-pandemijom-virusa-kovid-19-i-podrsku-privredi-srbije/>
- Morales A.R., Bonilla-Aldana K., Tiwari R., Sah R., Rabaan A.A., Dhama K. 2020. COVID-19, an Emerging Coronavirus Infection: Current Scenario and Recent Developments – An Overview. *In Journal of Pure and Applied Microbiology*, Vol. 14, No. 1, pp. 1-8.
- Muñoz P., Kimmitt J., Kibler E., Farny S. 2019. Living on the slopes: entrepreneurial preparedness in a context under continuous threat. *In Entrepreneurship & Regional Development*, Vol. 31, No. 5-6, pp. 413-434.

- Nicola M., Alsafi Z., Sohrabi C., Kerwan A., Al-Jabir A., Iosifidis C., Agha M., Agha R. 2020. The socio-economic implications of the coronavirus pandemic (COVID-19): A review. *In International Journal of Surgery*, Vol. 78, No. June, pp. 185-193.
- Official Gazette of the RS. 2020a. *Regulation on fiscal benefits and direct subsidies to economic entities in the private sector and financial assistance to citizens in order to mitigate the economic consequences due to the disease COVID-19* [Уредба о фискалним погодностима и директним давањима привредним субјектима у приватном сектору и новчаној помоћи грађанима у циљу ублажавања економских последица насталих услед болести COVID-19]. The Official Gazette of the RS, No. 54/2020, 60/2020.
- Official Gazette of the RS. 2020b. *Regulation on conditions and criteria of state aid compliance through the recapitalization of market participants in order to eliminate economic diseases caused by COVID-19 pandemic* [Уредба о условима и критеријумима усклађености државне помоћи кроз докапитализацију учесника на тржишту ради отклањања поремећаја у привреди проузрокованих епидемијом заразне болести COVID-19]. The Official Gazette of the RS, No. 126/2020, 17/2021.
- Pearson C.M., Clair J.A. 1998. Reframing crisis management. *In Academy of Management Review*, Vol. 23, No. 1, pp. 59-76.
- Perkins D.N.T., Murphy J.B. 2013. *Into the storm: lessons in teamwork from the treacherous Sydney to Hobart ocean race*. American Management Association.
- Prohorovs A. 2020. *Getting Ready for Recession: How SMEs Prepared for COVID-19 Pandemic and Economic Recession*, Forbes (Latvian edition), 11(May 2020), pp. 46-49.
- Qiu Y., Chen X., Shi W. 2020. Impacts of Social and Economic Factors on the Transmission of Coronavirus Disease 2019 (COVID-19) in China (Working Paper 494). *In GLO Discussion Paper*. <https://www.econstor.eu/handle/10419/215739>.
- Rathore, U., Khanna, S. 2020. *From Slowdown to Lockdown: Effects of the COVID-19 Crisis on Small Firms in India*. Available at SSRN: <https://ssrn.com/abstract=3615339>
- Shafi M., Liu J., Ren W. 2020. Impact of COVID-19 pandemic on micro, small, and medium-sized enterprises operating in Pakistan. *In Research in Globalization*, Vol. 2, No. December, 100018, pp. 1-14.
- Tannenbaum R., Schmidt W.H. 1957. How to Choose a Leadership Pattern. *In Harvard Business Review*, No. March – April 1957, pp. 95-101.
- UNCTAD. 2020. *Impact of the COVID-19 Pandemic on Trade and Development*. United Nations Publications, New York.
- World Health Organization. 2021. *WHO Coronavirus (COVID-19) Dashboard*, <https://COVID19.who.int/>
- Wang C.J., Ng C.Y., Brook R.H. 2020. Response to COVID-19 in Taiwan: big data analytics, new technology, and proactive testing. *In Jama*, Vol. 323, No. 14, pp. 1341-1342.

UDK 616.98:578.834]:659  
339:159.953.35  
658.89:004  
COBISS.SR-ID 57384201

## THE IMPACT OF VISUAL BRAND COMMUNICATION ON SOCIAL NETWORKS ON CONSUMER BEHAVIOR DURING THE CRISIS

Ivana Baltezarević<sup>1</sup>  
Radoslav Baltezarević<sup>2</sup>

<sup>1</sup>Pravni fakultet, Megatrend univerzitet, Bulevar Maršala Tolbuhina 9a, Beograd,  
ivana.baltezarevic@gmail.com

<sup>2</sup>Fakultet za poslovne studije, Megatrend univerzitet, Bulevar Maršala Tolbuhina 9a, Beograd,  
r.baltezarevic@gmail.com

### ABSTRACT

*Today, companies are increasingly using social networks as a very effective way to communicate with the target market. Although the content and form of messages delivered to consumers are diverse, our sense of sight is the most dominant, and therefore, the most attention is paid to visual brand communication. Social networks proved to be an indispensable part of the lives of people, who were locked in their homes during the Covid-19 crisis, due to the recommended health measures. This was an opportunity recognized by many world-renowned companies. In addition to adapting their business to the online environment, they supported people in these difficult times by adapting their promotional campaigns to socially responsible ones, alerting the public, and informing about the importance of recommended measures during a pandemic. Some companies have gone a step further, by temporarily redesigning their visual brand elements, primarily logos, and establishing visual communication with consumers by giving them support. As a consequence of such activities, a positive reaction of consumers and strengthening of emotional connection and loyalty is achieved.*

### KEYWORDS

*Visual Brand Communication, Social Networks, Consumer Behavior, Crisis, Logo Redesign.*

### INTRODUCTION

Brands are something that simplifies the selection process by affirming functional or emotional associations. Emotional or experiential associations promise a successful brand that has the power to create consumer value (Doyle, 2001). A brand can be considered a product with many additional dimensions that distinguish it from other products on the market, which are designed to meet the same needs and desires of consumers. Many brand definitions focus on the methods used to achieve differentiation and highlight the benefits that consumers can have after purchasing a brand (Keller, 2003). These definitions emphasize brands as an image in the consumer's brain, brands as systemic values (Sheth, Newman, Gross, 1991), brand personality (Goodyear, 1993), and brands as added value (Doyle, 1994). A brand is a collection of all the mental connections that people have around them (Brown, 1992). The use of attributes, packaging, names, strategy distribution and advertising can create associations

with brands that are unique and placed in the minds of consumers (Alavinasab, Soltani, Alimohammadi, 2017).

A special form of communication, mass communication, is realized by technical means (mass media) (Kristović, 2010). Mass communication can be defined as a process in which media organizations produce and transmit different messages to the general public and a process by which those same messages are seen, understood and used (Littlejohn, Karen, 2011). The advantages of marketing communication are numerous and vary depending on the situation in which this concept is applied. Companies will differ at the market in their ability to realize these benefits depending on their own marketing capabilities, resources, market circumstances and the context in which they operate. Some organizations may face strong competitive challenges that can reduce the likelihood and nature of these branding benefits (Keller, 2009). Communications are not only a means of presentation within the company, but also a necessity in interaction with external participants such as consumers, business partners, suppliers, etc. Marketing communication is a tool by which a company can influence consumer behavior and create a competitive advantage. The main goal is to inform, persuade and remind the audience about the company and its brands in a direct or indirect way. It can be said that marketing communication includes commercial and non-commercial communication in support of corporate marketing strategy (Kotler, Keller, 2012). Brand communication is one of the most important tools used in brand management. With it, organizations inform, persuade, teach, remind, but also enrich the public's knowledge about the brand, its strengths and values, as well as about its offer of products and services (Bhasin, 2021). New technology is improving the way companies can present their own brand or products. For new media, there are four factors that affect the results of communication (Winer, 2009): The existence of new technologies in the workplace; Focusing on the behavior of a personalized message based on people's online activities; Creating experiences for their customers by marketing experts to differentiate corporate products and services from competitors; Huge differences between individual groups according to demographics. These changes prepare the background for unconventional media, and also increase the relevance of market competition. The internet provides marketers with new marketing interactive tools that can encourage all aspects of marketing (Mallin, Finkle, 2007).

No crisis can be solved by routine actions (Tsang, 2000). Nowadays, many organizations are constantly using mobile phones, Twitter, blogs and other tools to spread information about the crisis (Pang, Hassan, Chong, 2014). Social networks can be one of the main communication strategies in crisis situations (Cho, Park, 2013). Even during the Covid-19 pandemic, many companies realized the importance of crisis communication on social networks, so their activities provided support to the general public, but at the same time emotionally strengthened the connection between the brand and consumers. One of perhaps the best examples is the temporary redesign of their logos, as basic elements of visual identity, in order to draw attention to the importance of measures of social distance.

## **VISUAL BRAND COMMUNICATION**

Visual communication is the communication of ideas through the visual presentation of information. This type of communication is primarily associated with two-dimensional images, which include art, signs, photographs, typography, drawing, colors, and electronic resources. Recent research in this area has focused on web and graphic design. The visual appearance of the product is a key determinant that affects the reaction of consumers, and thus the success of the product (Coates, 2003). Consumer assessments relate to elegance,

functionality, social relevance and are based mainly on visual information. The visual attributes of products are often the center of satisfying consumer desires and with them they actually satisfy their needs (Bloch, 1995). Without a clear understanding of consumer behavior, it would be difficult to devise effective marketing and sales strategies as well as business models (Nejati, Salamzadeh, Salamzadeh, 2011).

Brand communication is defined as any communication that brands have not only with consumers but with all stakeholders, ie with those who have any connection with the brand, such as investors, customers and employees. This type of communication can be in the form of any type of company communication, such as: newsletters, logos, video content, promotional messages, social media posts, company documents, etc. These forms of communication are quite different, however, it is important that effective communication with the brand should be recognizable and consistent regardless of the way the message is delivered (Pettis, 2020). Visual communication may provide consumers with a new and richer experience (Baltezarevic, Baltezarevic, 2015).

Visual messages can be convincing and have a deeper meaning, which attracts more attention, and as a result, it is possible to cause major changes in consumer attitudes. In advertising, there is an interesting connection between visual and text messages, because when these two elements are used together, verbal messages tend to limit the meaning of visual messages, and visual messages tend to expand the meaning of verbal messages (Rogers, 2007). Images in advertising can evoke emotions by simulating the appearance of a real person or object. Photos can serve as proof that something has happened and can eventually create an implicit connection between the product offered and some other photos (Messaris, 1997). Visual communication in advertising aims to attract, arouse interest and make consumers remember what they saw. It should also provoke positive experiences and feelings about the product and thus trigger a reaction from consumers. Several factors, such as attracting attention, slogan, sexuality, novelty are especially important in visual communication and they should be paid special attention (Scott, 1994). Maybe the most popular method for increasing consumer attention is to increase the prominence of an item by increasing its relative size or removing other items from view (Mishra, Mishra, 2015). Sight is the dominant sense that allows people to explore and understand the world. It often transcends other senses and has the power to convince people beyond any logic (Lindstorm, 2004).

## **VISUAL BRAND IDENTITY AT THE TIME OF THE PANDEMIC**

The visual elements of the brand play a key role in building value. Brand elements can be chosen to increase brand awareness, but also to create favorable, strong and unique associations with brands and trigger positive evaluations and feelings about them (Keller, 2003). However, there are occasional changes in the brand's virtual identity, and the main reasons are usually changes in corporate strategy, changes in ownership such as privatization, mergers or acquisitions, changes in competitive positioning in terms of market segmentation, when the image is outdated, and finally in response to sudden events in the external environment, such as crisis or sudden disasters (Muzellec, Doogan, Lambkin, 2003).

Brand identity can be seen as everything that the brand owner wants consumers to associate with the brand, and it consists of benefits, traits, values, differentiation and personality (Roy, Banerjee, 2007). Brand identity is what gives it meaning, what the brand stands for and what makes it unique, in a way it represents the fingerprint of the brand (Melin, 1997). Visual communication is the communication of ideas and creativity through the visual

presentation of information (Baltezarevic, Baltezarevic, 2015). For some authors, brand identity can be equated with visual identity. The visual identity of a brand is just one component that makes up a brand identity, among all the other elements. Visual identity plays a significant role in the way one organization presents itself to external and internal stakeholders (van Riel, Balmer, 1997).

According to research on reactions and perceptions to crisis communication via social networks, by examining study participants, different age groups, employment levels and education (mostly regular internet users), the results showed that different channels through which an organization chooses to communicate with its customers have different effects on how they react to the same information about crisis information (Schultz, Utz, Goritz, 2011). Studies have found that with the same type of communication message and crisis, the way actors respond to crisis messages on social media is different from responding to the same message on traditional media (Liu, Fraustino, 2014). It can be concluded that the choice of media affects the reputation of the organization, the reaction of stakeholders and the potential occurrence of a secondary crisis (Schultz, Utz, Goritz, 2011). Moreover, an organization that communicates its crisis on social media channels may seem honest and caring to stakeholders, because such communication shows that the organization wants to inform stakeholders more quickly and directly and is willing to engage in dialogue with them (Schultz, Utz, Glocka, 2012). It was also concluded that crisis communication on social networks can lead to a higher reputation of the organization than crisis communication through traditional media (Utz, Schultz, Glocka, 2013). By communicating on social networks, the organization shows that it cares about stakeholders and wants to share critical information faster (Schultz, Utz, Glocka, 2012).

The Covid-19 pandemic has endangered many lives, and the recommendation of many medical professionals and governments, almost all over the world, was that people should stay at their homes and reduce their social contacts to the necessary minimum. Many organizations had to temporarily suspend their operations, but they also realized that in such a crisis they could help the society in which they operate, and indirectly strengthen relations with their consumers. Some organizations have reoriented their businesses in order to provide support to the society, others have shared free content via digital media, provided home delivery of products or adapted their advertising messages into educational and entertainment ones that motivated consumers to adhere to the proposed measures. Several world-renowned companies have temporarily redesigned their existing logos and, by separating or adapting graphic elements, conveyed a message that supported the general public emphasizing the importance of social distancing. Such activities were positively accepted by the audience, which further strengthened and deepened the relationship between organizations and their consumers, and thus had a certain effect on the brand's capital (Baltezarevic, Kwiatek, 2020).

The main elements of any visual identification system are lines, textures, typography, shapes, colors, logos, symbols, images, composition, slogans and key messages used in various applications to communicate corporate essence, philosophy, culture, values, and personalities (van den Bosch, de Jong, Elving, 2005). These elements help organizations add value to the products and services they sell, but also improve their brands when used in a coherent and consistent way (Dacin, Brown, 2002). For any organization, the visual identity of the brand is very important for establishing and maintaining a market presence. Visual interpretation of the brand enables the development of easily recognizable visual signs that encourage consumers to build associations between the brand itself and its chosen position. Logos are visual icons that provide two basic but necessary functions for brands: identification and distinction. Over time, the logos directly match the brands they represent (Savard, Gallagher, 2011).



## **LOGO AND TEMPORARY REDESIGN OF LOGOS ON SOCIAL NETWORKS IN TIMES OF CRISIS**

Logos play an important role in corporate identity and should therefore have a serious look. The management of many companies spends huge amounts of money on them, because a quality company logo can add value to the organization's image (van Riel, van den Ban., 2001). There are many different types of logos, such as trademarks (corporate names) and completely abstract logos, which can usually be completely unrelated to corporate activities or a corporate name (Murphy, 1990). Visual elements of the brand often play a crucial role in building value, especially in terms of brand awareness, which initially involves associating the brand - logos, brand names, symbols and so on, with certain associations in memory. If the logo is well designed, it can provide significant benefits to brands and increase capital (Stamatogiannakis, Luffarelli, Yang, 2015). There are four different types of logos: typographic logos (includes the name of the company in particular typography), figurative logos (use images that convey the image of the organization), combination signs (combine graphics with text) and abstract logos (not explicitly visually represent the company name) (Airey, 2009). Adequate communication of the company with consumers achieves an emotional connection between the company and the consumer, which is the main prerequisite for creating emotional connections. The result of such relationships creates an honest relationship, building trust and ultimately long-term consumer loyalty (Baltezarevic, Baltezarevic, 2021).

In one study, the results showed that 55% of logos had a positive or negative effect on image perception, but at the same time, 45% of logos had an effect that could be considered negligible. In terms of recognition, letter symbols and signs scored better than pictorial ones and significantly better than abstracts (Schechter, Alvin, 1993). Research has shown that fonts (Henderson, Cote, Leong, Schmitt, 2003), designs (Henrik, Patrick, 2008), shapes (Ulrich, Malkewitz, 2008) and colors (Gerald, Chattopadhyay, Sengupta, Tripathi, 2004) as logo elements can affect brand value by evoking specific brand impressions. Well-designed logos can facilitate brand recognition and improve brand attitude (Henderson, Cote, 1998). A strong symbol can be a key ingredient in brand development, and in cases of its absence, it can be an essential handicap. Symbols that include visual images can be powerful and memorable (Aaker, 2002).

As we stated in the previous text, there are many reasons why companies decide to redesign their logos. According to Airey (2014), logo design and redesign are important marketing decisions. Redesigning a brand logo can be an effective way to increase attention, because new stimuli are generally considered more exciting than known ones, and consumers are trying to learn more actively when stimuli are new or unknown (Campbell, Keller, 2003). Although little is known about the conditions that lead to the failure or success of a logo redesign in branding campaigns, one of the elements that can contribute to this failure or success is the extent to which the brand logo is redesigned. Organizations apply an evolutionary redesign when brands have a strong market position and want to update their image or convey a change in brand strategy (Airey, 2009). Consumers who are very brand aware attach more importance to certain brand attributes, such as a logo or name. For this type, redesign of the logo may affect the mental processing of the consumer (Jamal, Goode, 2001).

When redesigning the logo, it was discovered that consumers will tolerate changes as long as they are small enough that the new logo design falls within the range of consumer acceptance (Pimentel, Heckler, 2000). One study found that cognitive responses from

consumers to logo changes showed more negative thoughts about the brand in the case of consumers who are highly committed to the brand, and more positive thoughts for less dedicated consumers, which increased to a greater degree of logo change (Walsh, Page, Mittal, 2006).

At the time of the Covid-19 pandemic, there were few examples in the business sphere that could be said to have adequately managed their companies in this crisis situation. Some well-known brands have redesigned their logo (temporarily) and placed it in digital media, to promote social distancing, but they have also launched advertising campaigns to encourage people to stay at home during a pandemic.

Launched content of this kind creates a good feeling, which alleviates anxiety, promotes positive messages and ultimately has a positive impact on brand advancement. However, organizations must show that their contribution is not just a commercial benefit, because consumers are very well aware of their authenticity and real purpose (Bails, 2020).

Many brands such as Audi, McDonald's and Coca-Cola have redesigned their logos to emphasize the importance of social distancing during a pandemic. It is important to note that most of the brands that have redesigned their logos are already well-established and reliable brands that have the power of great influence on society. The redesign of their logos is very simple at first glance, and comes down to separating the elements in order to get the impression of distance. Audi separated their "rings", McDonald's separated their "golden arches", and Coca-Cola separated the letters on their logo. Although this change seems insignificant, there is a much deeper meaning behind this idea, which gives good support to these brands in order to properly continue their advertising in times of crisis. Brands have shown a high level of creativity, relevance and interest, and above all, they have created awareness of something that is generally important and of great social benefit, such as health prevention (Sagona, 2020). Another good example of a company that redesigned its logo during this global crisis is the South American e-commerce brand Mercado Libre. This change in design is reflected in the fact that the handshake, as their familiar symbol, was changed to "elbow salute" to promote social alienation, as elbow salutation was one of the recommended greetings during a virus pandemic (Tan, 2020). Brands that redesign their logo can potentially reduce the severity and anxiety caused by a pandemic. The idea, creativity and passion are driven by the desire to help and educate the general population. Therefore, McDonald's published a redesigned logo on their page on the social network (Facebook) in Brazil. McDonald's has also adapted to the new situation by bringing food to its customers by home delivery. Coca-Cola posted its ad in downtown New York, displaying each letter of its logo separately, reinforced by the slogan 'Staying Separated is the best way to stay connected.' Audi and Volkswagen have shared their redesigned logos (at least temporarily) on their social media accounts. An inspirational video about the importance of social distancing was shot by Volkswagen, which also redesigned its logo by splitting the letter W into two V. Nike launched a major social campaign with global sports stars. The idea of this campaign was to encourage people to play inside and play for the whole world (Valinsky, 2020). Time Out magazine redesigned its logo in Time In, drawing attention to how people can maintain social distance but still be connected to their city (Gilliland, 2020). Singapore-based software and hardware maker Razer has also redesigned its logo, temporarily splitting its symbolic three connected snakes into three individual snakes. During the pandemic, Razer encouraged social media users to play video games from home (CGTN, 2020).

## CONCLUSION

Today, many consumers identify with their brands, and in most cases, a much deeper emotional connection has been achieved in this relationship. Such brands have great credibility to convey the message, which is of general social benefit. Visual brand communication is a powerful marketing tool. It has been proven that people first notice the shapes, fonts and colors of a company (visual brand elements, such as logos). For that reason, the organizations primarily decide to communicate with consumers in that way. In the crisis communication caused by the pandemic, when people were focused exclusively on the digital environment, companies adapted their advertising messages, but also temporarily redesigned their visual brand elements into those that symbolize social distance and placed them mainly through social networks. This strategy has proven to be very effective. It showed, above all, that large global corporations are socially responsible, and able, through their activities, to reduce the feeling of anxiety among consumers and to provide much needed support in difficult times. All this has the potential to directly strengthen the image of the organization and its brands and, further, to contribute to the perception of consumers towards brands and, finally to influence loyalty. Finally, one of the desired results that an organization can expect is a positive impact on consumer behavior when making purchasing decisions. It can be concluded that the last thing recommended to companies in unstable market conditions caused by a crisis, such as a pandemic, is to remain unresponsive to current events.

## REFERENCES

- Aaker, D. A. 2002. *Building strong brands*. London: The Free Press.
- Airey, D. 2009. *Logo design love: A guide to creating iconic brand identities*. Berkeley: Pearson Education.
- Airey, D. 2014. *Logo Design Love: A Guide to Creating Iconic Brand Identities*. Berkeley: New Riders.
- Alavinasab, S. M., Soltani, M., & Alimohammadi, J. 2017. The Effect of Brand Extension Strategy on Brand Image to Customers. *British Journal of Economics, Management & Trade*, 17(4), 1–8. <https://doi.org/10.9734/BJEMT/2017/32736>
- Bails, J. 2020. Brand Marketing Through the Coronavirus Crisis. <https://hbr.org/2020/04/brand-marketing-through-the-coronavirus-crisis> (Accessed: 27.08.2021)
- Baltezarevic, R, Baltezarevic, V. 2015. *Impact of visual communication on consumer behavior*. In Z. Nikitović, & Dj. Minkov (Eds.), *Marketing, business law and transformational governance* (pp. 66-79). Faculty of Business Economics and Entrepreneurship, Belgrade, JEL classification: M31, J24. UDC: 316.77:366.1; ISBN 978-86-6069-115-8 (FBEE); ISBN 978-1-4951-7659-3 (BCG); COBISS.SR-ID 218123020.
- Baltezarevic, R, Kwiatek, P. 2020. *Contemporary challenges in marketing communication* (p.176) Reviewers: Boban Tomic, Abdel-Badeeh M Salem, Milivoje Pavlovic. Saarbrücken, Germany: Lap Lambert Academic Publishing member of Omniscryptum Publishing Group. ISBN-13: 978-620-3-02893-5 ISBN-10: 6203028932
- Baltezarevic, R., Baltezarevic, I. 2021. Uticaj boja u emocionalnom dizajnu logotipa. *Megatrend revija*. Vol.18, № 1,2021: 145-158 10.5937/MegRev2101145B

- Bhasin, H. 2021. What is Brand Communication? Retrieved from:  
<https://www.marketing91.com/brand-communication/> (Accessed: 29.08.2021)
- Bloch, P.H. 1995. Seeking the Ideal Form: Product Design and Consumer Response *Journal of Marketing* Vol. 59. 16 – 29
- Brasel, S. A., Henrik Hagtvedt. 2016. Living Brands: Consumer Responses to Animated Brand Logos. *Journal of the Academy of Marketing Science*, 44 (September), 639-53.
- Brown, G. 1992. *People, Brands and Advertising*. Millward Brown International, New York, NY.
- Campbell, M.C., Keller, K.L. 2003. Brand familiarity and advertising repetition effects. *Journal of Consumer Research*, 30(2), 292-304.
- CGTN. 2020. Brand designs encourage social distancing amid COVID-19 pandemic, [https://www.chinadaily.com.cn/a/202003/25/WS5e7abb20a310128217281ccd\\_2.html](https://www.chinadaily.com.cn/a/202003/25/WS5e7abb20a310128217281ccd_2.html) (Accesses: 27.08.2021)
- Cho, S. E., Park, H. W. 2013. Social Media Use during Japan's 2011 Earthquake: How Twitter Transforms the Locus of Crisis Communication. *Media International Australia Incorporating Culture & Policy*, (149), P. 28.
- Coates, D. 2003. *Watches Tell More than Time: Product Design, Information and the Quest for Elegance*. London: McGraw-Hill.
- Dacin, P. A., Brown, T. J. 2002. Corporate identity and corporate associations: A framework for future research. *Corporate Reputation Review*, 5(2/3), pp. 254–263.
- Doyle, P. 1994. *Marketing Management and Strategy*. Prentice-Hall, Englewood Cliffs, NJ, pp. 159-65.
- Doyle, P. 2001. Building value-based branding strategies. *Journal of Strategic Marketing*. September. pp. 255-268
- Gilliland, N. 2020. How brands are encouraging social distancing, <https://econsultancy.com/coronavirus-how-brands-are-encouraging-social-distancing/> (Accessed: 27.08.2021)
- Goodyear, M. 1993. Reviewing the concept of brands and branding. *Marketing Research Today*, Vol. 21 No. 2, pp. 75-9.
- Gorn, Gerald J., Amitava Chattopadhyay, Jaideep Sengupta, and Shashank Tripathi. 2004. Waiting for the Web: How Screen Color Affects Time Perceptions. *Journal of Marketing Research*, 41 (May), 215-25.
- Hagtvedt, Henrik, Vanessa M. Patrick. 2008. Art infusion: The influence of visual art on the perception and evaluation of consumer products. *Journal of Marketing Research*, 45 (June), 379-89.
- Henderson, Pamela W., Joseph A. Cote. 1998. Guidelines for Selecting or Modifying Logos. *Journal of Marketing*, 62 (April), 14-30.
- Henderson, P. W., Cote, J. A., Leong, S. M., Schmitt, B. 2003. Building strong brands in Asia: selecting the visual components of image to maximize brand strength. *International Journal of Research in Marketing*, 20, pp. 297–313.
- Jamal, A., Goode, M. 2001. Consumers' product evaluation: A study of the primary evaluative criteria in the precious jewellery market in the UK. *Journal of Consumer Behaviour*, 1(2), 140-155. doi: 10.1002/cb.61
- Keller, K. L. 2003. *Strategic brand management: Building, measuring, and managing brand equity* (2nd ed.). Upper Saddle River, NJ: Prentice Hall.
- Keller, K. L. 2009. Building strong brands in a modern marketing communications environment. *Journal of marketing communications*, 15 (2-3), p. 139-155. (p.140).
- Kotler, P., Keller, K. L. 2012. *Marketing Management*. 14.ed. New Jersey: Pearson Education, 2012. ISBN 978-0 -13-210292-6

- Kristović, M. 2010. *Sociologija masovnog komuniciranja*, Novi Sad: Futura publikacije, str. 17.
- Lindstorm, M. 2004. *Brand sense: Build through Touch, Taste, Smell, Sight and Sound*. New York: Free Press.
- Littlejohn, S.W., Karen A.F. 2011. *Theories of Human Communication*. 10th ed. Long Grove, Ill.: Waveland Press.
- Liu, B. F., Fraustino, J. D. 2014. Beyond image repair: Suggestions for crisis communication theory development. *Public Relations Review*, 40(3), 543–546.
- Mallin, M. L., Finkle, A. 2007. Social entrepreneurship and direct marketing. *Direct Marketing: An International Journal*, 1(2), 68-77. doi: 10.1108/17505930710756833
- Melin, F. 1997. *Varumärket som strategiskt konkurrensmedel: Om konsten att bygga starka varumärken*. Lund University Press. Malmö.
- Messaris, P. 1997. *Visual Persuasion: The Role of Images in Advertising*. Thousand Oaks: Sage Publications.
- Mishra, A.K., Mishra, P. P. 2015. Lift the veil to sell. Concept to Visual Merchandising: Case of a Supermarket. *Journal of Entrepreneurship, Business and Economics*, Vol. 3, No. 1, pp. 50–80.
- Murphy, J. 1990. *Brand Strategy*. Upper Saddle River, NJ: Prentice Hall.
- Muzellec, L., Doogan, M., Lambkin, M. 2003. Corporate rebranding: An exploratory review. *Irish Marketing Review*, 16 (2), 31.
- Nejati, M., Salamzadeh, Y., Salamzadeh, A. 2011. Ecological purchase behaviour: insights from a Middle Eastern country. *International Journal of Environment and Sustainable Development*, 10(4), 417-432.
- Orth, Ulrich R., Keven Malkewitz. 2008. Holistic Package Design and Consumer Brand Impressions. *Journal of Marketing*, 72 (May), 64-81.
- Pang, A., Hassan, N. B. B. A., Chong, A. C. Y. 2014. Negotiating Crisis in the Social Media Environment: Evolution of Crises Online, Gaining Credibility Offline. *Corporate Communications: An International Journal*, 19(1), 7-7.
- Pettis, T. 2020. Brand Communication: What it is and How to Do it Right. Retrieved from: <https://www.mhcautomation.com/legacy/ecrion/blog/brand-communication-what-it-is-and-how-to-do-it-right/> (Accessed: 29.08.2021)
- Pimentel, R., Heckler, S. 2000. Changes in Logo Designs: Chasing the Elusive Butterfly Curve,” Working Paper, 1-24. URL: <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.505.4223&rep=rep1&type=pdf> (Accessed: 29.08.2021)
- Rogers, W. 2007. *Persuasion: Messages, Receivers, and Contexts*, Lanham: Rowman & Littlefield Publishers.
- Roy, D. Banerjee, S. 2007. CARE-ing strategy for integrating of brand equity with brand image. *International Journal of Commerce and Management*, vol. 17 no. 1/2, p. 140-148.
- Sagona, C. 2020. Major Brands Create Social Distancing Logos, <https://1063radiolafayette.com/major-brands-create-social-distancing-logos/> (Accessed: 27.08.2021)
- Savard, L., Gallagher, M. 2011. What do people see when they look to your brand? Retrieved from: <http://www.blackcoffee.com/branding-services/brand-identity/visual-identity> (Accessed: 29.08.2021)
- Schechter, Alvin H. 1993. Measuring the Value of Corporate and Brand Logos. *Design Management Journal*, (Winter), 33-39.

- Schultz, F., Utz, S., Goritz, A. 2011. Is the medium the message? Perceptions of and reactions to crisis communication via twitter, blogs, and traditional media. *Public Relations Review*, 37, 20-27.
- Schultz, F., Utz, S., Glocka, S. 2012. Towards a networked crisis communication theory: Analyzing the effects of (social) media, media credibility, crisis type, and emotions. In *Proceedings of the International Communication Association*. Phoenix: All Academics.
- Scott, L., M. 1994. Images in Advertising: The Need for a Theory of Visual Rhetoric. *The Journal of Consumer Research*, Vol. 21, Nr.2, 252-273
- Sheth, J., Newman, B., Gross, B. 1991. Why we buy, what we buy: a theory of consumption values. *Journal of Business Research*, Vol. 22, pp. 159-70.
- Stamatogiannakis, Antonios, Jonathan Luffarelli, and Haiyang Yang. 2015. How to Use Visual Design to Boost Brand Equity? In *The Psychology of Design: Creating Consumer Appeal*, ed. Rajeev Batra, Colleen Seifert, and Diann Brei: Routledge.
- Tan, J. 2020. 12 iconic logos redesigned through a COVID-19 lens. <https://www.marketing-interactive.com/12-iconic-logos-redesigned-through-a-covid-19-lens> (Accessed: 27.08.2021)
- Tsang, A. 2000. Military doctrine in crisis management: three beverage contamination cases. *Business Horizons*, 43(5), 65-73. [http://dx.doi.org/10.1016/S0007-6813\(00\)80011-7](http://dx.doi.org/10.1016/S0007-6813(00)80011-7).
- Utz, S., Schultz, F., Glocka, S. 2013. Crisis communication online: How medium, crisis type and emotions affected public reactions in the Fukushima Daiichi nuclear disaster. *Public Relations Review*, 39(1), 40-46.
- Valinsky, J. 2020. McDonald's and other brands are making 'social distancing' logos. <https://edition.cnn.com/2020/03/26/business/social-distancing-brand-logos-coronavirus/index.html> (Accessed: 26.08.2021)
- van Riel, C. B. M., J. Balmer. 1997. Corporate Identity: The Concept, Its Measurement and Management. *European Journal of Marketing* 31 (5–6): 340–55.
- van Riel, C.B.M., van den Ban., A. 2001. The Added Value of Corporate Logos - An Empirical Study. *European Journal of Marketing*, 35 (3/4), 428-440.
- van den Bosch, A. L. M., de Jong, M. D. T., Elving, W. J. L. 2005. How corporate visual identity supports reputation. *Corporate Communications: An International Journal of Advertising*, 10(2), pp. 108-116.
- Walsh, Michael F., Karen L. Page, Vikas Mittal. 2006. Logo Redesign and Brand Attitude: The Effect of Brand Commitment. *ACR 2006 Conference, September Orlando, Florida*.
- Winer, R. S. 2009. New communications approaches in marketing: Issues and research directions. *Journal of Interactive Marketing*, 23(2), 108-117. doi: 10.1016/j.intmar.2009.02.004

UDK 616.98:578.834]:338.43  
338.43.02(497.11)  
COBISS.SR-ID 57385481

## MANAGEMENT OF AGRARIAN RESOURCES IN THE REPUBLIC OF SERBIA UNDER COVID-19 PANDEMIC

Danijela Despotović<sup>1</sup>  
Lela Ristić<sup>2</sup>  
Mirjana Knežević<sup>3</sup>

<sup>1</sup>University of Kragujevac - Faculty of Economics, Liceja Knezevine Srbije 3, Kragujevac 34000, Republic of Serbia, ddespotovic@kg.ac.rs

<sup>2</sup>University of Kragujevac - Faculty of Economics, Liceja Knezevine Srbije 3, Kragujevac 34000, Republic of Serbia, lristic@kg.ac.rs

<sup>3</sup>University of Kragujevac - Faculty of Economics, Liceja Knezevine Srbije 3, Kragujevac 34000, Republic of Serbia, mknezevic@kg.ac.rs

### ABSTRACT

*Agrarian sector in the Republic of Serbia is characterised by many-decade-long insufficiently effective use of available natural resources, as well as a deficiency of financial, technical-technological resources and infrastructure. Bearing this in mind, in addition to numerous exterior limitations, the aim of this research is to find better solutions, i. e. adequate models of agrarian resources management at macro and micro levels, which would result in visible progress in this domain. The paper concludes that in contemporary conditions, especially due to the COVID-19 pandemic, agrarian resources of the Republic of Serbia should be more creatively used with unavoidable support of the state and greater efforts of other participants, relevant for the development of domestic agro-food sector and rural economy.*

### KEYWORDS

*agrarian resources, agrarian policy, management, regulations, Republic of Serbia, COVID-19.*

**JEL: Q18, Q19, K29.**

### 1. INTRODUCTION

Management of agricultural resources is of exceptional importance for countries that have abundant natural resources for agriculture and where the tradition of practicing agriculture is burdened by a number of problems of internal and external nature, especially those relating to the economic and financial, political and legal or environmental and health aspects. Among such countries is the Republic of Serbia, where finding the best approach to the management of agricultural resources is of crucial importance, especially in the circumstances surrounding the present COVID-19 pandemic, the country's European integration process, global challenges, regional problems, etc.

Previous work of numerous domestic and foreign authors who have been dealing for decades with the issue of agricultural resources management in their countries and beyond (Andrieu et al. 2021; Li et al. 2020; Pawlak, Poczta, 2020; Kucher et al. 2018; Darbyshire et al. 2020; Đurić, Njegovan, 2016; Vujičić, 1997; Grimble, Wellard, 1997; Pimentel et al. 1997; Shah et al. 1986; etc.) confirms the importance of this topic for theory and practice, both from a historical aspect and in terms of future directions of sustainable development. Today, the management of agrarian resources, agricultural policy, development of agriculture, food production, distribution and its quantity and quality, under the COVID-19 pandemic, are between the most important topics in the world, especially because of the importance of agricultural resources and agri-food products for human health and survival.

According to the WHO (2021), coronavirus disease (COVID-19) is an infectious disease caused by the SARS-CoV-2 virus. The COVID-19 has globally led to a number of human health problems, dying from this disease and vulnerability of health systems in many countries. At the same time, except in terms of health, the COVID-19 negatively affects all aspects of life and work, that is, it causes negative effects on all economic activities, and therefore on the ways of using resources. In this context, the use of agricultural resources is very important, because these resources are the basic inputs for agricultural production, that is, for the production of food as a condition of human existence. FAO (2020) notes that the COVID-19 recovery plans offer immense opportunities for enhanced investments in sustainable natural resource management. These investments can create a more productive, greener and inclusive economic recovery, and transition towards healthier and more resilient areas.

The purpose of this paper is to find more adequate models of agricultural resources management, at the macro and micro level, that is, better solutions that would result in more visible progress in this area, under the COVID-19 pandemic with a special emphasis on the Republic of Serbia.

The contribution of this paper is contained in the conclusion reached based on the conducted research, which finds that the agricultural resources of the Republic of Serbia in current circumstances, especially those surrounding the COVID-19 pandemic, should be used much more creatively, including the necessary government support and a greater commitment of all other actors relevant to the country's agricultural and food sector, as well as rural economy.

The paper uses secondary data sources, mostly official data published by the Statistical Office of the Republic of Serbia concerning agricultural resources. Furthermore, the paper relies significantly on the research conducted by numerous domestic and foreign authors working in this field. The paper uses historical, descriptive and comparative research methods, with a tabular and schematic presentation of relevant data and research results.

## **2. MAIN AGRARIAN RESOURCES OF THE REPUBLIC OF SERBIA AND FARM STRUCTURE SURVEY**

Table 1 shows the most important agricultural resources of the Republic of Serbia, i. e. their wealth or limitations, depending on which resource is in question. The richness of natural resources is observed and insufficient resource potential when it comes to agricultural mechanization and the application of appropriate agro-technical measures, as well as the demographic structure of Serbian agriculture.



**Table 1.** Main structural indicators of agricultural resources in the Republic of Serbia

<b>Name and description of agricultural resource</b>
<p><b>Utilized agricultural area (UAA)</b> - according to the Census of Agriculture 2012 (SORS, 2013), in the Republic of Serbia - 3437423 ha; according to the SORS (2020): in 2017 – 3438130 ha; 2018 – 3486908 ha; 2019 – 3481567 ha (about 4% refers to the Beogradski region, 45% to the Region Vojvodine, 30% to the Region Šumadije i Zapadne Srbije and 21% to the Region Južne i Istočne Srbije). In the Republic of Serbia arable fields and gardens make 74.5% of UAA, fruit plantations 5.3% (most plums od total productive area under fruit trees), vineyards 0.6%, permanent grassland 19.5%, other agricultural land 0.1% of UAA (similar structure like according to the Census of Agriculture 2012). In the Republic of Serbia, sown areas by species of crops are: cereals 65.9% (mostly maize and wheat), industrial crops 19%, vegetable crops 1.9%, fodder crops 9.4%, sugar beet 1.6%, potatoes 1.3%, other 0.9%. The structure of family holdings according to the utilized area is: without land 0.9%; under 2.00 ha 39%; 2.01-5.00 ha 32%; 5.01-10.00 ha 16.9%; 10.01-20.00 ha 7.2%; 20.01-50.00 ha 3%; 50.01-100.00 ha 0.7%; over 100.00 ha 0.3%. The utilized arable land – average per holding is 6.5 ha for the Republic of Serbia, and it is largest for the Region Vojvodine, i. e. 12.39 ha (SORS, 2020). According to the Census of Agriculture 2012, in the Republic of Serbia: the average UAA per holding extends over 5.4 ha; the average number of separate lots of the UAA per holding is 6, and the average separate lot covers 0.98 ha.</p>
<p><b>Livestock fund and bees</b> - according to the Census of Agriculture 2012 (SORS, 2013), in the Republic of Serbia: agricultural holdings raise 908102 heads of cattle, 3407318 pigs, 1736440 sheep and 26711220 hens. Of the total number of agricultural holdings in the Republic of Serbia, 77% are engaged in livestock raising. Livestock is predominantly raised in the Region Šumadije i Zapadne Srbije. The most represented size of herd for cattle numbers 1-2 heads, pigs 3 - 9 heads and sheep 3-9 heads. Of the total number of households raising poultry, about 88% raise less than 50 heads of poultry. The largest number of beehives is noted for the Region Šumadije i Zapadne Srbije - in Zlatiborska oblast.</p>
<p><b>Agricultural buildings</b> - the number of buildings for cattle housing is 340337, with the capacity of 2557926 places or 7.5 places per building on average; there are 507031 buildings for pigs housing, with the capacity of 7035648 places or 13.9 places per building. The entire capacities for livestock housing were used in the following way: 36% capacities for cattle housing, 46% capacities for pigs housing, 64% capacities for laying hens housing and 81% capacities for other livestock housing. Thereby, 1804 holdings own cooler facilities, 9510 holdings own drying facilities, 542 holdings own glasshouses and 40066 holdings own poly-tunnels (SORS, 2013 - Census of Agriculture 2012).</p>
<p><b>Agricultural machinery</b> - according to the Census of Agriculture 2012 (SORS, 2013), the number of tractors (with one axle and two axles) is 597816 (410894 two-axle tractors), of which the major part, i. e. 583723 were used in the year of Census. About 50% holdings own a tractor, but 95% of the total number of tractors is older than 10 years. On average, one tractor is used for tilling of 8.5 ha. 26135 agricultural holdings own 31241 harvesters of which 29702 are older than 10 years.</p>
<p><b>Mineral fertilizers</b> - applied on 67% of the UAA (2298574 ha), by 491257 agricultural holdings (SORS, 2013 - Census of Agriculture 2012).</p>
<p><b>Solid dung</b> - applied by 49% agricultural holdings (306297), on 11% of the entire UAA, i. e. 373871 ha (SORS, 2013 - Census of Agriculture 2012).</p>

<b>Name and description of agricultural resource</b>
<b>Liquid manure &amp; slurry</b> - applied on area of 26405 ha, by 8002 agricultural holdings (Census of Agriculture 2012).
<b>Pesticides</b> - applied on area of 2107311 ha, by 455103 agricultural holdings (SORS, 2013 - Census of Agriculture 2012).
<b>Labour force</b> - according to the Census of Agriculture 2012 (SORS, 2013): the dominant number of agricultural holdings (69%) has 1-2 employed persons; the share of females is 43% of the total number of members and employed at agricultural holdings; most of holders of agricultural holdings (94%) also are managers at holdings; the share of female holders of family holdings is 17%. The shares of certain categories of labour force in the total number of annual work units invested in agriculture are: 44% - holders of agricultural holdings, 47% - family members and relatives to holder, 4% - regularly employed at agricultural holdings, and 5% - seasonal and contractual workers.

**Source:** Authors, based on SORS data, 2013 & 2020.

The Statistical Office of the Republic of Serbia conducted the Farm Structure Survey 2018. Thereby, the funds for this Survey are provided from the EU IPA funds and from the Budget of the Republic of Serbia. A total number of 121070 agricultural holdings were surveyed, about agricultural land, livestock breeding, mechanization, labour force in agricultural holdings and applied agro-technological measures. The results of this Survey showed (SORS, 2019):

- the total number of agricultural holdings in 2018 (626865) decreased relative to the Census of Agriculture 2012 (631552), especially the number of holdings with less than 10 ha, while the number of holdings with more than 10 ha has increased;
- the average age of holder is 61 years (2018) - compared to Census of Agriculture 2012 (59), so that it increased by 2 years;
- every 14<sup>th</sup> holder is above the age of 40;
- most of the young holders are in the Regions of Šumadija and Western Serbia;
- 8 of 10 holdings use their own tractors;
- 83% of tractors are over 20 years old;
- when it comes to the level of training of people who make decisions about agricultural production in family farms, most of them have only agricultural experience gained through the practice (274094) or high school (254538), while higher education have 32896 people, and courses in agriculture 1367 persons;
- within the farms with the status of a legal entity, most of the persons are highly educated (881 people), with a high school 310 people, but only 174 people have agricultural experience, and only 10 people attended the courses.

According to the results of the Census of Agriculture 2012, in the Republic of Serbia, of the total number of agricultural holdings, only 0.5% are holdings of legal entities and unincorporated enterprises. Other gainful activities are practised by 78301 holdings, i. e. 12% of all agricultural holdings, of which the largest share (57%) is engaged in milk processing (SORS, 2013). Farm Structure Survey 2018 (SORS, 2019) confirms the largest number of agricultural holdings engaged in milk processing (37368) and in fruit and vegetable processing (31816).

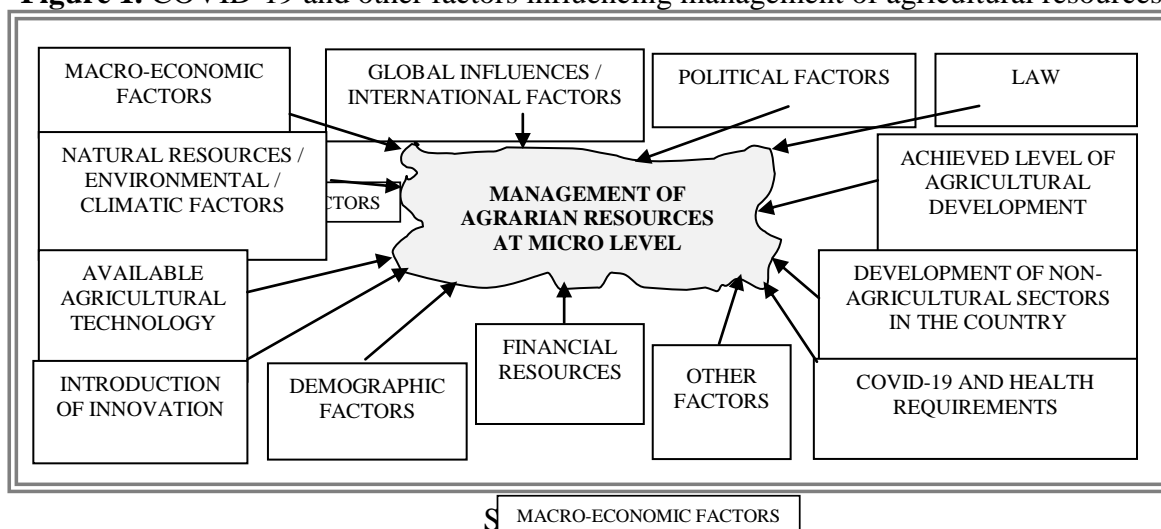
In the Republic of Serbia, the first case of COVID-19 was reported on 6 March 2020, and the outbreak is still ongoing (Ministry of Health, 2021), which significantly affects the use of agrarian resources and agricultural production, as well as food processing and distribution, including export of agri-food products and rural economy. Consequently, in 2020, when

compared to 2019, the net index of physical volume of agricultural production increased by 2,0%. In relation to the previous year (2019), crop production in 2020 increased by 4,6%. Within the crop production, the value of crop farming increased by 4,4%, and the fruit growing by 6,0%, while the value of viticulture decreased by 2,0%. The value of livestock production decreased by 0,3%. Within the livestock production, pig breeding increased by 0,8%, while the value of sheep breeding decreased by 5,9%, cattle breeding decreased by 1,1% and poultry raising increased by 0,1%. In 2020, arable land participated with 74.3% in the utilized agricultural area, fruit plantations (orchards) with 5.3%, vineyards with 0.6%, permanent grassland with 9,7% and pastures with 9,5%. In the structure of sown arable land areas, cereals participated with 66,8%, industrial crops with 18,9%, vegetables with 1,8%, and fodder crops with 9,0%. When compared to 2019, in 2020 the total production increased for wheat by 13,4%, and maize by 7,2%, while sunflower decreased by 12,7% and sugarbeet decreased by 12,4%. Also, in 2020, when compared to the previous year (2019), the number of livestock units decreased by 1.6%, and cow's milk production decreased by 0.9%, but meat production increased by 0.9%. The total agricultural output (goods and services) at producers' prices of the current year, in 2020, when compared to 2019, increased, as well as utilized agricultural area. According to the data of the value of exports by the classification of activities, the value of agricultural exports increased in 2020, when compared to 2019 and 2018 (SORS, 2021).

### 3. COVID-19 AND OTHER KEY FACTORS OF AGRARIAN RESOURCES MANAGEMENT IN THE REPUBLIC OF SERBIA

Numerous factors affect the management of agrarian resources and the development of agriculture worldwide. Among these factors there are a large number of economic and financial factors, and recently, in many countries, within the implementation of the concept of sustainable development, in addition to the economic dimension, the importance of environmental and social components for long-term successful development is growing. In addition to the above, in modern conditions, especially since 2019, due to the outbreak of the COVID-19 pandemic, the issue of health is becoming increasingly important, globally and locally, at the macro and micro levels.

**Figure 1.** COVID-19 and other factors influencing management of agricultural resources



The management of agricultural resources at the micro level is determined by the macroeconomic framework and a number of other factors of internal and external nature (Figure 1). In the Republic of Serbia, this effect is very pronounced, especially when it comes to managing agricultural resources of family farms, since these farms make the largest group of economic entities in domestic agriculture; therefore, numerous economic and non-economic factors in the country and at the global level significantly determine the choice of agricultural resources management models, especially concerning the small farms. The agricultural policy of the Republic of Serbia, as a part of the development policy and macroeconomic framework of the government, is also strongly influenced by a number of domestic and international circumstances.

In the Republic of Serbia, agricultural policy and management of agricultural resources at the macro level are defined by a number of strategic documents, among which the most important are: Strategy for Agriculture and Rural Development of the Republic of Serbia for the period from 2014 to 2024 (2014); National Programme for Agriculture 2018-2020 and National Rural Development Programme 2018 – 2020. The National Programme for the Revival of Serbian Villages (2020) is a recent, professional and interdisciplinary programme, which is essentially a model for the modernization of agriculture and sustainable rural development in Serbia. The process of drafting the National Rural Development Programme 2021-2024 has also begun and this document will be harmonized with previous national strategic documents, as well as the principles of the EU's Common Agricultural Policy (CAP). In accordance with the legislation and in connection with the Sectoral Agreement between the Government of the Republic of Serbia and the European Commission Setting out Provisions for the Management and Implementation of Union Financial Assistance to the Republic of Serbia under the Instrument for Pre-Accession Assistance in the Policy Area "Agriculture and Rural Development" (IPARD), the Conclusion on the Adoption of the IPARD Programme of the Republic of Serbia was adopted. ("Official Gazette of RS", No. 30/2016-3, 84/2017-30, 20/2019-22, 55/2019-55, 38/2021-21).

#### **4. REGULATIONS IMPORTANT FOR MANAGEMENT OF AGRARIAN RESOURCES UNDER COVID-19 PANDEMIC**

Regarding the regulations related to agriculture and management of agricultural resources, the following are of great importance in the Republic of Serbia: Law on Agriculture and Rural Development ("Official Gazette of RS", No. 41/2009, 10/2013 - other law and 101/2016), Law on Incentives in Agriculture and Rural Development ("Official Gazette of RS", No. 10/2013, 142/2014, 103/2015 and 101/2016), Law on Agricultural Land ("Official Gazette of RS", No. 62/2006, 65/2008 - other law, 41/2009, 112/2015, 80/2017 and 95/2018 - other law), Law on Plant Protection Products ("Official Gazette of RS", No. 41/2009 and 17/2019), Law on Waters ("Official Gazette of RS", No. 30/2010, 93/2012, 101/2016, 95/2018 and 95/2018 - other law), Law on Livestock Breeding ("Official Gazette of RS", No. 41/2009, 93/2012 and 14/2016), the yearly regulations pertaining to the distribution of incentives in agriculture and rural development – the Regulation on Determining the Programme of Works on Protection, Arrangement and Use of Agricultural Land for 2021 ("Official Gazette of RS", No. 32/21), the Programme for Winemaking and Viticulture Development of the Republic of Serbia 2021 – 2031 ("Official Gazette of RS", No. 154/20) and etc. In addition to the abovementioned, the management of agricultural resources relies on the National Strategy for Sustainable Use of Natural Resources and Goods ("Official Gazette of RS", No. 33/12), as well as other similar strategic documents of the Republic of Serbia. The COVID-19 was discovered in December 2019 and quickly spread around the world,

including Serbia, so many law regulations have been changed or added due to this coronavirus disease, that is, adapted to new circumstances. Thereby, many of them are related to the development of agriculture and management of agrarian resources under COVID-19 pandemic conditions.

In the Republic of Serbia since the proclamation of the COVID-19 pandemic special attention has been focused on providing a sufficient amount of food to all parts of the country. Stable food supply in the conditions of the COVID-19 pandemic requires that, in accordance with the new situation, all necessary conditions be provided for the implementation of adapted procedures and requirements regarding food production and sales (Ristić, 2020), however, at the same time, agricultural production must be free from obstructions and agricultural resources should be managed rationally.

The regulations of the Republic of Serbia pertaining to the prevention of the spread of COVID-19, which have been implemented from the beginning of the pandemic to the present day, and which concern agricultural production, and therefore the management of agricultural resources, are as follows:

- Decree on Measures for Prevention and Containment of Infectious Disease COVID-19 (“Official Gazette of RS”, No. 151/2020, 152/2020, 153/2020, 156/2020, 158/2020, 1/2021, 17/2021, 19/2021, 22/2021, 29/2021, 34/2021, 48/2021, 54/2021, 59/2021, 60/2021 and 64/2021);
- Decree on Establishment of the Programme of Financial Support to Agricultural Producers by Purchasing Market Surpluses of Fattening Livestock in Difficult Economic Conditions Due to the SARS-CoV-2 COVID-19 Pandemic (“Official Gazette of RS”, No. 113/2020, 115/2020, 118/2020 and 126/2020);
- Decree on Financial Support to Registered Agricultural Households Through Facilitated Access to the Use of Credit in Difficult Economic Conditions Due to the Disease COVID-19 Caused by the SARS-CoV-2 Virus (“Official Gazette of RS”, No. 57/2020);
- Decree on Financial Assistance to Registered Agricultural Households in Order to Mitigate the Effects of the COVID-19 Disease Caused by the SARS-COV-2 Virus (“Official Gazette of RS”, No. 57/2020).
- Decree on Shifting the Deadlines for Holding the Regular Session of the General Meeting of Shareholders and Submitting Annual and Consolidated Financial Statements of Companies, Cooperatives, Other Legal Entities and Entrepreneurs, As Well As Deadlines for Filing Corporate Income and Self-Employment Income Taxes, the Validity of Licensed Auditors' Licenses and Licenses for Assessing the Value of Real Estate That Expire During the State of Emergency Due to COVID-19 Disease Triggered by SARS-CoV-2 (“Official Gazette of RS”, No. 57/2020);
- Rulebook on Conditions, Manner and Application Form for Exercising the Right to Milk Premium ("Official Gazette of RS", No. 28/2013-15, 36/2014-16, 44/2018-27 (other law), 56/2020-7, 159/2020-53).

The COVID-19 pandemic affected the business of all economic entities, including in the field of agriculture. However, fewer problems have been identified in the agricultural sector, as it is more resilient and less dependent on other sectors of the economy. The outbreak of the pandemic was the most difficult period for farmers in Serbia, because they could not bring their products to market. Yet, in the conditions of COVID-19, farmers, in addition to other types of support, were allowed to move freely during the curfew hours in order to cultivate and reap their crops in time and apply all necessary agro-technical measures. The e-market of

Serbia has also started operating with a diverse offer of quality food, which is presented on an interactive map.

Having in mind the extraordinary circumstances surrounding the outbreak of the pandemic, the longstanding problems that have affected agriculture in the Republic of Serbia for several decades - even before the pandemic, as well as a number of limitations characteristic of the modern environment, management of agricultural resources in the Republic of Serbia, both at the macro- and micro-level, during COVID-19 pandemic can be considered satisfactory, although, of course, there is always some room for better solutions, which should be realized in the coming period; however, one must keep in mind the uncertainty brought about by the course of events concerning COVID-19 pandemic and other factors. With this in mind, it is important to develop a more solid base and a more appropriate model for managing agricultural resources at all relevant levels, in the coming years, according to the specific characteristics of domestic agricultural resources and in accordance with other factors that determine the manner of their use. Namely, in the coming period, the management of agricultural resources will be faced with a number of health, economic and financial, environmental, political, law and other important issues.

## **5. CONCLUSION**

Adequate management of agricultural resources, at the macro- and micro-level, is a necessity in modern circumstances. The agricultural resources of the Republic of Serbia, especially concerning the situation that brought about the COVID-19 pandemic, should be used much more creatively and rationally, including a major role and support of the state in that process, as well as a greater commitment of all other actors relevant to the development of domestic agri-food sector and rural economy, especially greater commitment of local self-governments, farmers and other rural population, as well as economic sectors that use agricultural resources in their line of business.

Advantages of this research relate to the availability of relevant data, strategic documents, regulations and previous research on the topic analysed in this paper, bearing in mind that the authors have been researching this important and contemporary domestic topic, as well as other similar and related topics, for years.

Limitations of this research refer to the limited scope of the analysis, due to the limited size of this paper, which at the same time limited the number of researchers involved in this research. A project on this topic would include the analysis of many more elements and many more researchers from different fields of economics, law, management, agronomy, etc.

Possible applications of this research primarily refer to the introduction of new models of agricultural resource management, in view of the fact that the paper points to the need for better management of agricultural resources of the Republic of Serbia both at the macro- and micro- level. Accordingly, the paper emphasizes certain directions that are considered promising and important in terms of management of agricultural resources at the macro level, i.e., institutionally, within the framework of agricultural policy and legal regulations in this area, as well as at the micro level, i.e., at the level of individual agricultural holdings that are a major category in the agriculture of the Republic of Serbia and which are characterized by a number of resource potentials, but also many limitations that need to be overcome through a modern approach to managing available agricultural resources.

## REFERENCES

- Andrieu, N., Hossard, L., Graveline, N., Dugue, P., Guerra, P., Chirinda, N. 2021. Covid-19 management by farmers and policymakers in Burkina Faso, Colombia and France: Lessons for climate action. *In Agricultural Systems*, Vol. 190, Maz 2021, 103092, <https://doi.org/10.1016/j.agsy.2021.103092>.
- Conclusion on the Adoption of the IPARD Programme of the Republic of Serbia for the period 2014-2020 ("Official Gazette of RS", No. 30/2016-3, 84/2017-30, 20/2019-22, 55/2019-55, 38/2021-21).
- Darbyshire, R., Crean, J., Cashen, M., Anwar, M. R., Broadfoot, K. M., Simpson, M., Cobon, D. H., Pudmenzky, C., Kouadio, L., Kodur, S. 2020. Insights into the value of seasonal climate forecasts to agriculture. *In Australian Journal of Agricultural and Resource Economics*, Vol. 64, No. 4, pp. 1034-1058.
- Đurić, K., Njegovan, Z. 2016. *Ekonomika poljoprivrede*. Univerzitet u Novom Sadu - Poljoprivredni fakultet, Novi Sad.
- FAO. 2020. *COVID-19: Investing in sustainable natural resource management for green and inclusive recovery in Asia and the Pacific*. Food and Agriculture Organization of the United Nations (UN), Bangkok. <https://doi.org/10.4060/cb0435en>
- Grimble, R., Wellard, K. 1997. Stakeholder methodologies in natural resource management: a review of principles, contexts, experiences and opportunities. *In Agricultural Systems*, Vol. 55, No. 2, pp. 173-193. [https://doi.org/10.1016/S0308-521X\(97\)00006-1](https://doi.org/10.1016/S0308-521X(97)00006-1).
- Kucher, L., Heldak, M., Orlenko, A. 2018. Project management in organic agricultural production. *In Agricultural and Resource Economics: International Scientific E-Journal*, Vol. 4, No. 3, pp. 104-128.
- Li, M., Fu, Q., Singh, V. P., Liu, D., Li, T., Zhou, Y. 2020. Managing agricultural water and land resources with tradeoff between economic, environmental, and social considerations: A multi-objective non-linear optimization model under uncertainty. *In Agricultural Systems*, Vol. 178, February 2020, 102685, <https://doi.org/10.1016/j.agsy.2019.102685>.
- Ministry of Health. 2021. *COVID-19*. Ministry of Health - Institute for Public Health "Dr. Milan Jovanovic Batut", Belgrade, Republic of Serbia.
- Nacionalna strategija održivog korišćenja prirodnih resursa i dobara ("Službeni glasnik RS", br. 33/12).
- National Programme for Agriculture 2018-2020 ("Official Gazette of the RS", No. 120/17).
- National Rural Development Programme 2018-2020 ("Official Gazette of the RS", No. 60/18).
- National Team for the Revival of Serbian Villages. 2020. *National Programme for the Revival of Serbian Villages*. Institute of Agricultural Economics, Belgrade.
- Pawlak, K., Poczta, W. 2020. Agricultural Resources and their Productivity: A Transatlantic Perspective. *In European Research Studies Journal*, Vol. XXIII, Special Issue 1, pp. 18-49.
- Pimentel, D., Houser, J., Preiss, E., White, O., Fang, H., Mesnick, L., Barsky, T., Tariche, S., Schreck, J., Alpert, S. 1997. Water Resources: Agriculture, the Environment, and Society Assessment of the status of water resources. *BioScience*, Vol. 47, No. 2, pp. 97-106.
- Program razvoja vinarstva i vinogradarstva Republike Srbije za period 2021–2031. godine ("Sl. glasnik RS", br. 154/20).

- Ristić, G. 2020. *Informator za subjekte u poslovanju sa hranom tokom epidemije „COVID-19: Najčešća pitanja i odgovori*. Ministarstvo poljoprivrede, šumarstva i vodoprivrede - Sektor poljoprivredne inspekcije, Beograd.
- Rulebook on conditions, manner and application form for exercising the right to milk premium ("Official Gazette of RS", No. 28/2013-15, 36/2014-16, 44/2018-27 (other law), 56/2020-7, 159/2020-53).
- SORS. 2013. *Census of Agriculture 2012 - Agriculture in the Republic of Serbia*. Statistical Office of the Republic of Serbia, Belgrade.
- SORS. 2019. *Farm Structure Survey 2018*. Statistical Office of the Republic of Serbia, Belgrade.
- SORS. 2020. *Statistical Yearbook of the Republic of Serbia 2020*. Statistical Office of the Republic of Serbia, Belgrade.
- SORS. 2021. *Statistical Yearbook of the Republic of Serbia 2021*. Statistical Office of the Republic of Serbia, Belgrade.
- Shah, S., Kutz, L., Bender, D. 1986. Optimal energy and resource management in bio-production systems. In *Agricultural Systems*, Vol. 20, No. 3, pp. 161-174. [https://doi.org/10.1016/0308-521X\(86\)90072-7](https://doi.org/10.1016/0308-521X(86)90072-7).
- Strategy for Agriculture and Rural Development of the Republic of Serbia for the period from 2014 to 2024 ("Official Gazette of RS", No. 85/2014).
- Uredba o finansijskoj podršci poljoprivrednim gazdinstvima kroz olakšan pristup korišćenju kredita u otežanim ekonomskim uslovima usel bolesti COVID-19 izazvane virusom SARS-CoV-2 ("Sl. glasnik RS", br. 57/2020).
- Uredba o merama za sprečavanje i suzbijanje zarazne bolesti COVID-19 ("Sl. glasnik RS", br. 151/2020, 152/2020, 153/2020, 156/2020, 158/2020, 1/2021, 17/2021, 19/2021, 22/2021, 29/2021, 34/2021, 48/2021, 54/2021, 59/2021, 60/2021 i 64/2021).
- Uredba o novčanoj pomoći poljoprivrednim gazdinstvima u cilju ublažavanja posledica nastalih usled bolesti COVID-19 izazvane virusom SARS-COV-2 ("Sl. glasnik RS", br. 57/2020).
- Uredba o pomeranju rokova za održavanje redovne sednice skupštine privrednog društva i dostavljanje godišnjih i konsolidovanih finansijskih izveštaja privrednih društava, zadruga, drugih pravnih lica i preduzetnika, kao i rokova za podnošenje prijava za porez na dobit i poreza na prihod od samostalne delatnosti, važenja licenci ovlašćenih revizora i licenci za vršenje procene vrednosti nepokretnosti koje ističu za vreme vanrednog stanja nastalog usled bolesti COVID-19 izazvane virusom SARS-CoV-2 ("Službeni glasnik RS", broj 57/2020).
- Uredba o utvrđivanju Programa finansijske podrške poljoprivrednim proizvođačima kroz otkup tržišnih viškova tovnih junadi u otežanim ekonomskim uslovima usled pandemije COVID-19 izazvane virusom SARS-CoV-2 ("Sl. glasnik RS", br. 113/2020, 115/2020, 118/2020 i 126/2020).
- Uredba o utvrđivanju Programa izvođenja radova na zaštiti, uređenju i korišćenju poljoprivrednog zemljišta za 2021. godinu („Službeni glasnik RS”, br. 32/21).
- Vujičić, M. 1997. Ruralni i agrarni razvoj: šta i kako dalje? In *Ekonomika*, Vol. 43, No. 4-6, pp. 166-172.
- WHO. 2021. *Coronavirus disease (COVID-19)*. World Health Organization, Geneva, Switzerland.



Zaključak o usvajanju IPARD programa za Republiku Srbiju za period 2014–2020. godine ("Sl. glasnik RS", br. 30/2016-3, 84/2017-30, 20/2019-22, 55/2019-55 i 38/2021-21).

Zakon o podsticajima u poljoprivredi i ruralnom razvoju ("Sl. glasnik RS", br. 10/2013, 142/2014, 103/2015 i 101/2016).

Zakon o poljoprivredi i ruralnom razvoju ("Sl. glasnik RS", br. 41/2009, 10/2013 - dr. zakon i 101/2016).

Zakon o poljoprivrednom zemljištu ("Sl. glasnik RS", br. 62/2006, 65/2008 - dr. zakon, 41/2009, 112/2015, 80/2017 i 95/2018 - dr. zakon).

Zakon o sredstvima za zaštitu bilja ("Sl. glasnik RS", br. 41/2009 i 17/2019).

Zakon o stočarstvu ("Sl. glasnik RS", br. 41/2009, 93/2012 i 14/2016).

Zakon o vodama ("Sl. glasnik RS", br. 30/2010, 93/2012, 101/2016, 95/2018 i 95/2018 - dr. zakon).

## REGULATORY ASPECTS OF SUSTAINABILITY GOVERNANCE

Ivana B. Ljusic<sup>1</sup>,

<sup>1</sup>Associate Professor of Corporate Law, PhD, MA, LLB, Belgrade Banking Academy, Union University, Belgrade, 11000 Belgrade, Serbia, Zmaj Jovina 11, E-mail: ivana.ljusic@bba.edu.rs

### ABSTRACT

*Corporate governance has been making inroads and expanding to sustainability governance embracing the natural resources use and management. Strong legal background of principles, policies, procedures, defined responsibilities, and accountability used by stakeholders to minimize and dissolve the inherent conflicts of interest in sustainability management, finance and policies at the corporate and regulatory levels. Legal and regulatory framework is enabling interaction between various participants in sustainability, while shaping corporation's participants in environment, corporate responsibility and governance (ESG). Sustainability governance as a rather modern concept is ensuring transparency and strong and balanced economic development for the firm, protecting the interest of shareholders.*

### KEYWORDS

*Law, Sustainability, Governance, Natural Resources, ESG*

*JEL: O13, K22, K23, P28, P48, Q01, Q13, Q56,*

### 1. INTRODUCTION

As natural resources are becoming more and scarcer, the management of those resources is becoming evidently increasingly important. Natural resources, many of them are finite and drastically are running out. The logical approach is to establish and implement in practice the mandatory sustainable management. Since the total World population is increasing exponentially there is a rising need to feed them, while we are aware that the arable land remains constant or even shrinking due to the effects of various factors. Natural resources like fish stocks, forests, and harvest arable land could be preserved for the future generation as a crucial strategic crossroad for mankind. The previous reasoning and elementary logic is increasingly relevant and becoming a part of the political and regulatory agenda of many countries. The growth factor is not any more primary public concern, since it is evident that the economic benefits from the use and exploitation of natural resources is dramatically shrinking.

We should improve our understanding of the success patterns for management of natural resources and sustainability and the role of governance and legal regulation in this process. We are concentrating our research on the legal and regulatory framework for the sustainability governance with a goal to present synthesis for the broader regulatory framework for sustainability governance and reporting, based primarily on a new theoretical and methodological approach.

## **2. CORPORATE SOCIAL RESPONSIBILITY, SUSTAINABILITY, ETHICS, GOVERNANCE AND LAW**

New phenomena and initiatives are taking place especially in European Union (EU) to establish and continually develop and implement new regulatory frameworks based on the company law and concepts of modern corporate governance. Within the concepts of justice and fundamental rights, EU is working on the proposal of a new directive, which in turn shall enable companies to focus on long term sustainable value creation rather than short-term benefits.

Corporate social responsibility (CSR) is a rather modern concept started after the World War II, as social consciousness arm in arm with civil rights, consumerism, and environmental protection has become and shall stay endlessly a top global topic in public discussions and practice. Contemporary SCR has transformed to a modern corporate language, in the focus of the protecting interests of stakeholders. Business of the future shall generate more than profits, they shall be and must be responsible and obey the law and pertinent regulation. At the same level are aspects of ethics, social responsibility and consciousness. The expectation of the public, voters, and non-governmental organizations (NGO) is increasing pressure on modern businesses to do more, make more, be more responsible and responsive while striving to maximize profits, but in a balanced and sustainable way on the future competitive, dynamic global marketplace. CSR has become a cornerstone for benchmarking modern corporate sustainability based on the corporate governance principles applied in practice, but all within a wider and much deeper legal regulatory framework (European Commission, 2020). The goal of the Commission is to improve the alignment of the interests of companies, as well as their shareholder, managers, stakeholders and society. Based on the new directive and national regulation companies shall be in a better position to manage effectively sustainability matters in their own operations, and also in value chains while preserving and protecting social and human rights, climate change, environmental management, and related fields.

The general regulatory e.g. legal framework for sustainability governance is the very new concept and model which is taking place and developing nowadays. There is rather ample previous work and contribution to this topic, so we shall try to draw the starting points and lines which shall draw the boundaries and area for the sustainability governance with a focus on external and internal corporate reporting.

### **2.2 Corporate Governance Concept Rediscovered**

In the first iteration it should be made a clear distinction between corporate governance as a broader embodied term and corporate management which is in charge of dealing and controlling the people and operational processes within the firm. Management as a process embracing planning, decision making, organizing and leading, motivating and controlling the human resources, financial, physical, and information resources of the business entity in order to reach its goals efficiently and effectively (Iedunote, 2021).

Corporate governance is embracing the set of complex relationships between the corporate's top management team, the entity's stakeholders. It embodies the corporate structure through which business objectives and goals are defined, with the adequate means and resources of achieving those goals, also with the specification of monitoring mechanisms for the performance management and reporting mechanisms. Thus corporate governance is also a strong preventive mechanism from business failures, collapses but also an excellent vehicle and tool to achieve and maintain high ESG goals as results.

### 2.2.1. Good Corporate Governance as a Solid Foundation of Sustainability Governance

Corporate governance is embracing the set of rules and corporate practices of the board of directors. This framework is aiming to achieve accountability, fairness, and transparency in a company's relationship with all its stakeholders including creditors. Regulators, board of directors, investors, customers, management, employees, government and the community. Corporate governance regulatory framework, displayed on Graphic 1 is logically stressing the legal and regulatory wide embracing view

Corporate governance practical functional cycle starts and ends with the corporate board and accompanying committees, with a more than strong focus on legal and regulatory framework and supporting systems. Functional cycle based on strong and precise hierarchical structure and system of internal controls. Practical implementation is with a strong focus on corporate policies, procedures and transparency in operations, performance and disclosure of results, with an increasing focus on sustainability governance. The corporate future should be viewed based on its impact to society and environment, while at the same time protecting and prioritizing the interest of employees, shareholders, stakeholders and social responsibility, as it could be observed on the 4(Smart Vision Logistics, 2021).



**Graphic 3.** Corporate governance regulatory framework

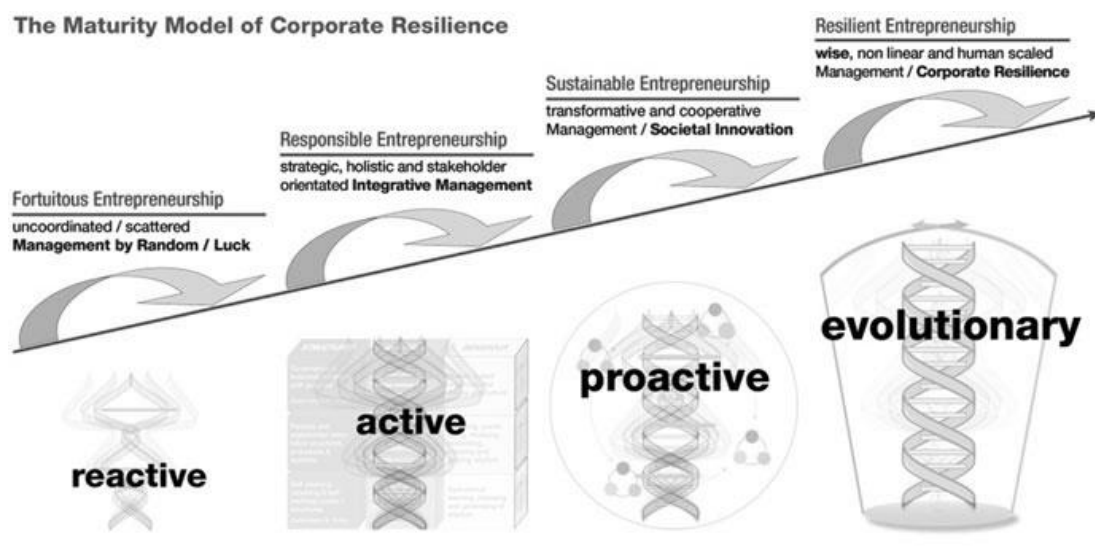
Sustainability governance is increasing accountability to shareholders, stakeholders, employees, while with a strong base in ethical standards and values. Corporate culture is developing based on the strong legal and statutory requirements and standards, while high quality corporate financial reporting is a Sine Qua Non. Recently the model of corporate risk management has been incorporated with the ESG into the body of sustainability governance (Idowu, ed., Okpara, 2015).

John O. Okpara further delineates corporate governance to a host of legal and non-legal principles and practices affecting control of the accountable publicly held business corporations, but also not public interest entities (PIE) could and should freely apply those

principles. As such the principles are balancing the risks and returns of sustainability operations. The gates and framework of standard and classical responsibility of corporations from shareholders with the environmental problems and with the concept of sustainability has been broadened up introducing responsibility of managers not for daily operation but also for the environmental effects and consequences. Now we are at the eve of the phase in which walking shall be more important than talks, nice words and promises. Full accountability and transparency reporting regarding sustainability, to balance corporate, environment and public interests. The focus of corporate governance from the mid of the 2<sup>nd</sup> decade of the XXI century has refocused from the mitigation of internal conflicts and protecting the interest of shareholders to protecting the environment and the Planet Earth, its natural resources. Consequently, means and tools of preventing environmental disasters and good sustainability governance are embracing preventing the conflicts of interests in the processes, customs, policies, laws, and institutions which have an impact on the way a company is controlled and directed, as it has been pointed previously (Idowu, ed., Okpara, 2015).

### 3. CORPORATE RESILIENCE AS A FOUNDATION OF SUSTAINABILITY GOVERNANCE

Corporate resilience is a strength and capability of a firm to survive under the harsh economic, environmental and social conditions in the future and it is the only solid foundation of effective sustainability governance. The maturity model of corporate resilience **Graphic 2** ((Idowu, ed., Walker, Beranek, 2015) is depicting the evolutionary/revolutionary development from the traditional corporate management towards resilient sustainability of the future.



**Graphic 2.** The maturity model of corporate resilience

Corporations from the environmental scandals and ever increasing and more than strong pressure to engage in sustainability governance from the reactive and passive stance of uncoordinated activities and actions should make a drastic turnover towards active responsible environmental operations and natural resources management. The imminent and near future is in proactive attitude of sustainable transformation of the firm with ECS adaptive and flexible management, leading towards evolutionary resilient firms, national and international

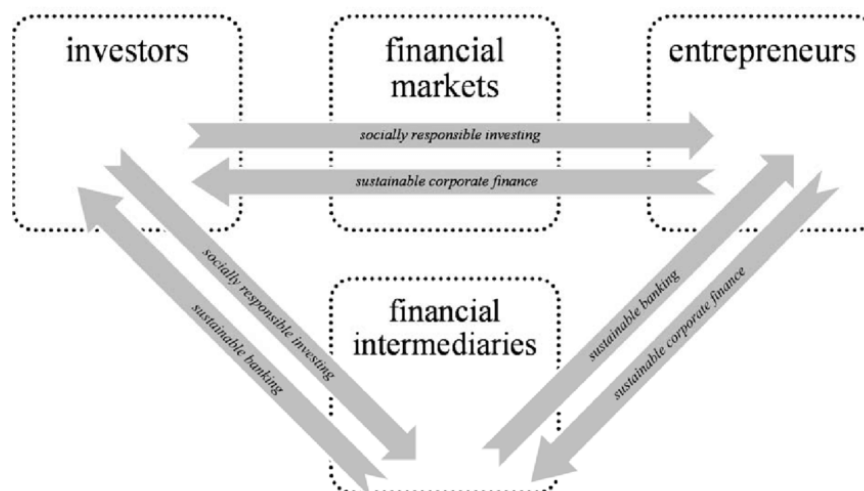
economy. The corporation of the future shall be environmentally liable and responsible, based on strong corporate and professional ethics, while protecting and preserving biodiversity, innovation and sustainability. Corporate products, services, and the whole organization should be based on ESG responsibly and adequate action.

#### 4. EU INTEGRATION OF SUSTAINABILITY IN CORPORATE GOVERNANCE CODES

Global as well as regional institutions like the EU are strongly committed to achieve the goals of sustainability set by the Paris Agreement and the UN 2030 Agenda (Siri, Zhu, 2021). New initiatives to foster sustainable corporate governance. Companies and businesses should be dynamically evaluated on how they are achieving truly integrated long-term strategic sustainable goals of managing natural resources. The next step in creating adequate legal regulation is innovation of corporate governance codes with an aim to support the process as a useful tool of sustainability governance, which is a rather complex and demanding task itself. Based on the research (Siri, Zhu, 2021):

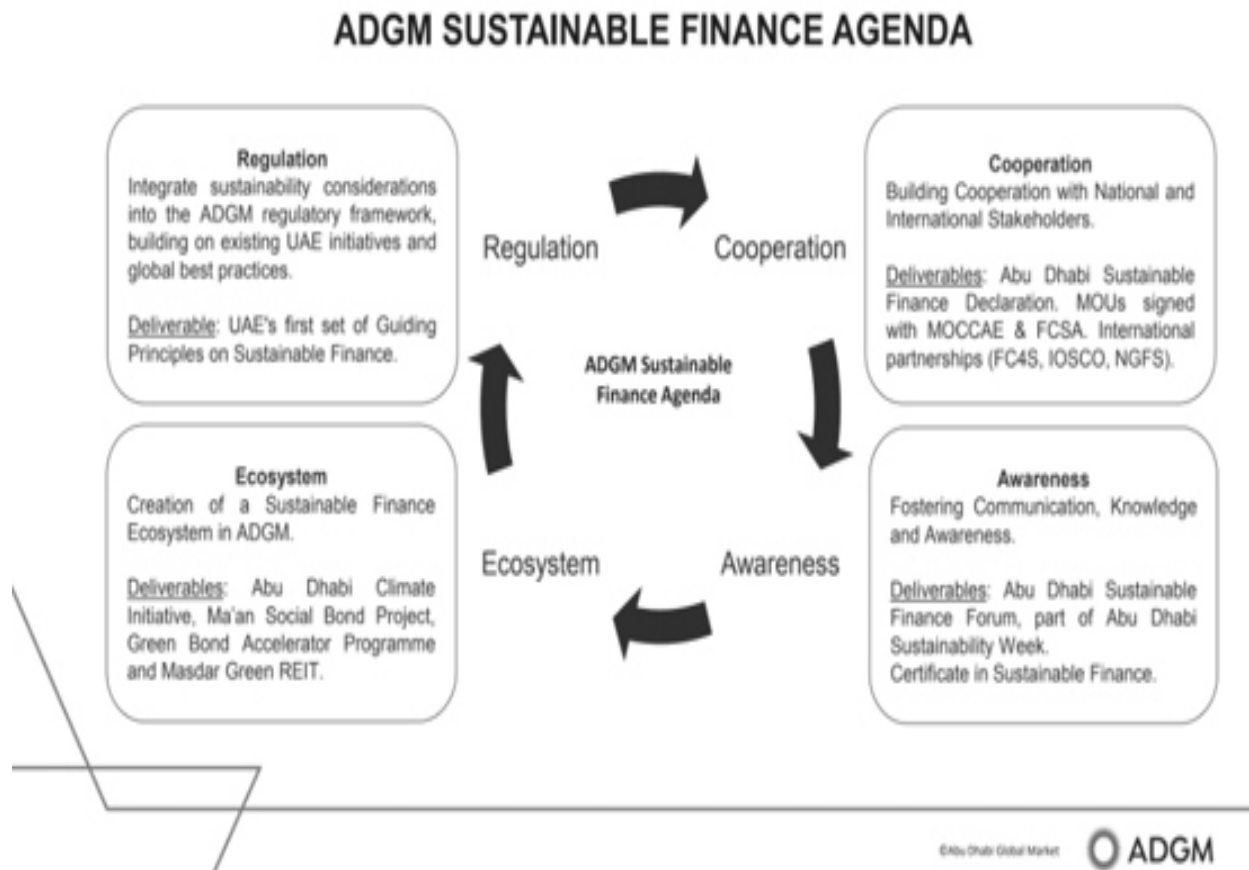
*“Many authors investigated the effective implementation of corporate governance codes, but a few considered the role of the codes in promoting environmental and social responsibility.”*

The aim of this paper is to comparatively evaluate the most recent steps and actions on how to integrate sustainability considerations in corporate governance codes of listed and non-listed companies within the EU Member States, which also could be used in the candidate member states like Serbia and the other Western Balkans countries. In the period to come adapted, remodeled and updated codes with a strong emphasis on sustainability governance should be implemented in the practice of environmental and natural resources management and policy at the corporate and regulatory level. Framework for the sustainable finance portrayed on the **Graphic 3**, is explaining interlocks between the investors, financial markets, entrepreneurs and the role of financial intermediaries. With a focus on socially responsible investing and sustainable corporate finance and banking (Salzman, 2021).



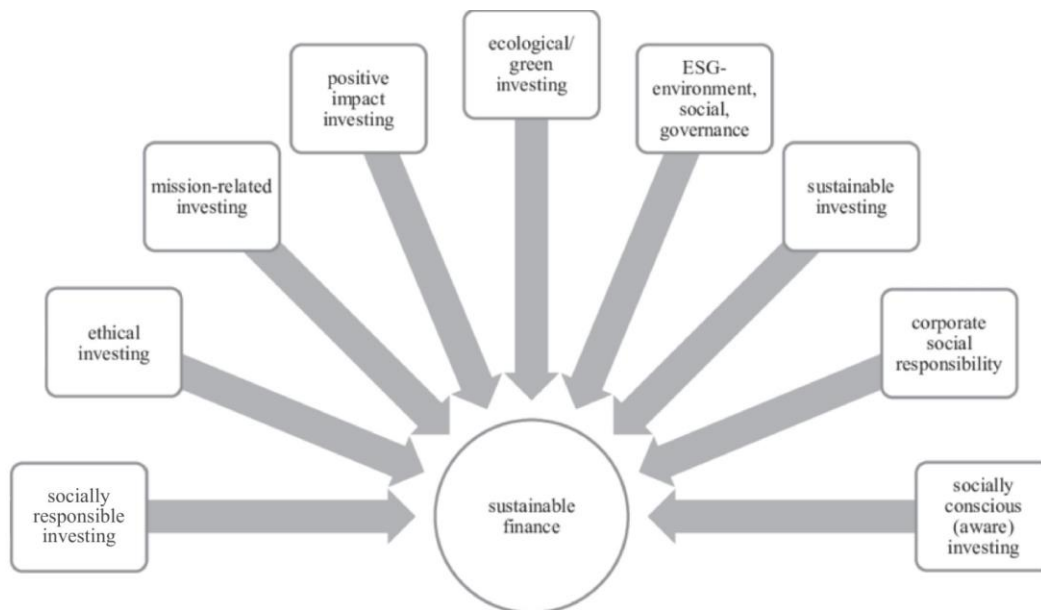
**Graphic 3.** A framework for sustainable finance

Sustainable finance agenda is embracing the factors of legal regulation, cooperation, increasing awareness, the care for ecosystem and regulatory framework which all are enabling the sustainable finance agenda, as a way to enable continuous successful operation of sustainable governance, see on the **Graphic 4**. (ADGM, 2019). Sustainable development is the best and only way to preserve the national economy and environment for the future generations. Effective regulation at the national, regional and global level is the way to integrate diverse interests within the new and emerging regulatory framework, which should be based on the best national and global practices. Regulation is the foundation of the cooperative and collaborative efforts leading towards sustainable finance and banking harmonized with the EU directives and guidelines, also with the UN 2030 Green Agenda. Increasing awareness, information, and knowledge is a way to improve the results of the sustainable finance agenda.



**Graphic 4.** Sustainable finance framework and perspectives

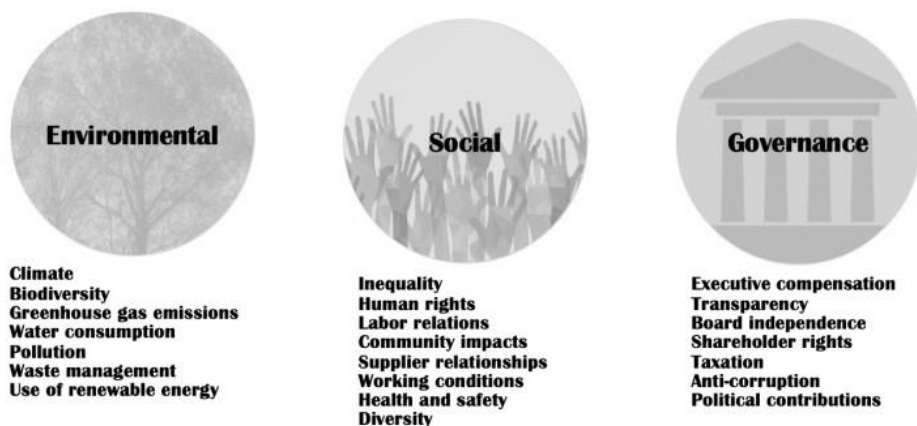
Landscape in which sustainable finance are operating is founded on the ESG, sustainable investing and governance, with an aim to increase the impact and participation of socially aware and responsible investing, **Graphic 5**, ResearchGate Net, 2021.



**Graphic 5.** Sustainable Finance Lendscape

Interaction between environment, society and sustainable governance within the integrated finance is a way to integrate the aspects of climate change, protecting and preserving biodiversity, stopping the greenhouse gas emission, managing the water consumption and limiting the pollution, and managing the use of mineral resources. At the same level is equally important the fight against social inequality, protection of human rights, balanced community impact of growth, working conditions and preserving the diversity of society. Integration and balancing of the environmental and social aspects and interests is a prerequisite for responsible sustainability governance, with a focus on ESG field of action, **Graphic 6**, Global Landscape Forum Org, 2021.

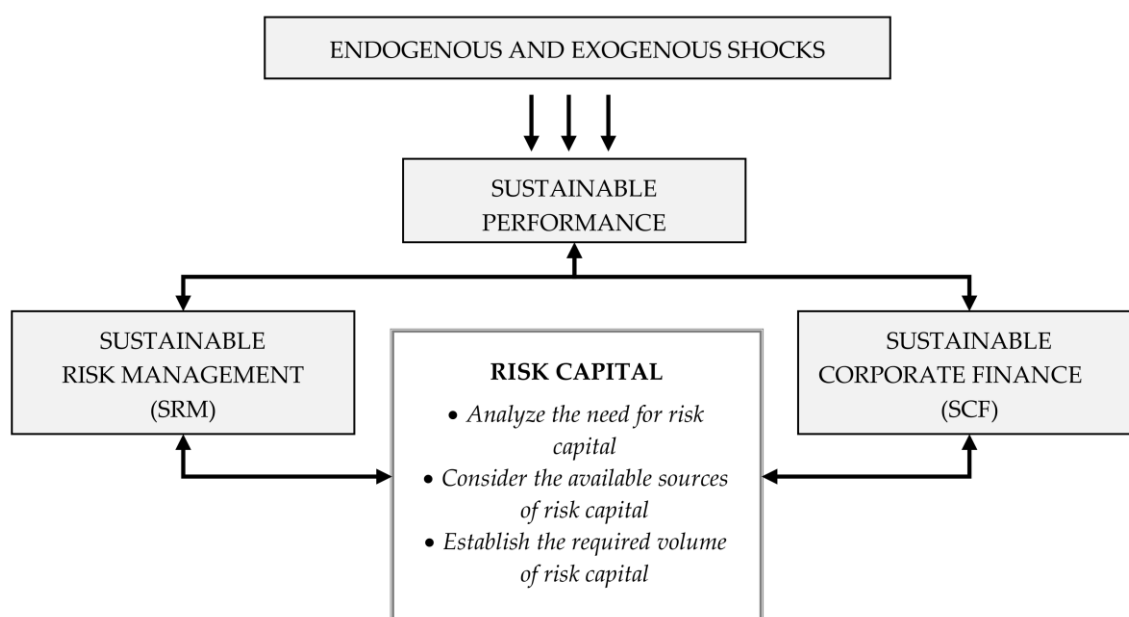
**Environmental, social and governance (ESG) aspects of sustainable finance**



**Graphic 6.** Environmental, social and governance (ESG) aspects of sustainable finance



Sustainable dimensions of risk capital are connecting the external and internal sustainability shocks on the sustainable performance, integrating sustainable risk management, sustainable corporate finance and risk capital to be invested in sustainability, **Graphic 7**, Wieczorek-Kosmala, 2019. The concept of the dynamic role of the risk capital for the implementation and management of the sustainable corporate operations is a vital one. This is presently a dominantly theoretical concept of investing risk capital into sustainable projects and operations, with a focus on the risk aspects of sustainable investments. Approach of corporate finance is stressing the role of sustainability governance, since the traditional sources of capital prefer traditional investment projects, and sustainability investments are a young, new and not well established model nowadays. Risk capital is in some form of tension of investing in sustainable businesses, that is the reason why new decision making processes need further development and research of what is really going on in practice.



**Graphic 7** Effects of internal and external shocks on sustainable performance

## 5. ANALYSIS OF THE CORPORATE GOVERNANCE QUALITY OF COMPANIES LISTED AT BELGRADE STOCK EXCHANGE

Ex-post metadata statistical analysis of the corporate governance quality evaluation and assessment of the listed companies at Belgrade Stock Exchange, period 2013-2020, comprised of the statistical sample of 50 reports, classified as public information at the official website of the BELEX exchange. Methodology was based on IFC guidance and application of the G20/OECD corporate governance principles, Ljubic, 2021. The overview has been a solid foundation for the further improvement of the quality of corporate governance in Serbia.

The new and emerging need for sustainability governance has not been incorporated in the standardized filed corporate governance reports. This shall have negative effects on the future investments in sustainability. There is an urgent need to improve the quality of corporate governance with a new segment or module of sustainability governance. Also, there is evident

need to make real qualitative improvements in business practice, not only in codes. Sustainability transparency, full financial disclosure are prerequisites as non-financial disclosure is the key for sustainability management, as increased performance of the ESG shall become a turning point to attract investors to finance environmental performance and stability. The quality of corporate governance reports of the listed companies at Belgrade Stock Exchange is rather low, and those reports have not been the subject of external auditing or any form of assurance, Ljusic, Diligenski, 2021. With the companies which are not public interest entities (PIE) the situation could not be analyzed in a statistical review in a reliable way, but some haphazard selection has pointed out that even the leading small and medium enterprises in Serbia do not produce the corporate governance reports.

## **6. ROLE OF THE BOARD IN SUSTAINABILITY GOVERNANCE**

Role of the Board of directors is increasingly focused and we could forecast that it shall be from now on dominantly on the sustainability issues and good governance in this field. One of the primary roles of the Board is to determine, monitor and effectively manage ESG factors as identified as material to the business performance, concept of dual materiality.

Sustainability management and boards shall from now on walk hand in hand, Eccles, Johnstone-Lous, Mayer, Strohle, 2020. The authors are strongly pointing out to the fact that investors are increasingly monitoring corporation results of operation through the ESG optics. There is increasingly evident the direct positive link between the long-term strategic profitability and sustainability. There is a need to integrate sustainability into corporate strategy and business model. Boards of directors should change drastically and profoundly their attitude from the conservative reactive to proactive to adopt and accept wholeheartedly the sustainability factors. The obstacle to long term environmental based growth is the short termism and focus on the corporate value maximization strategies and tactics.

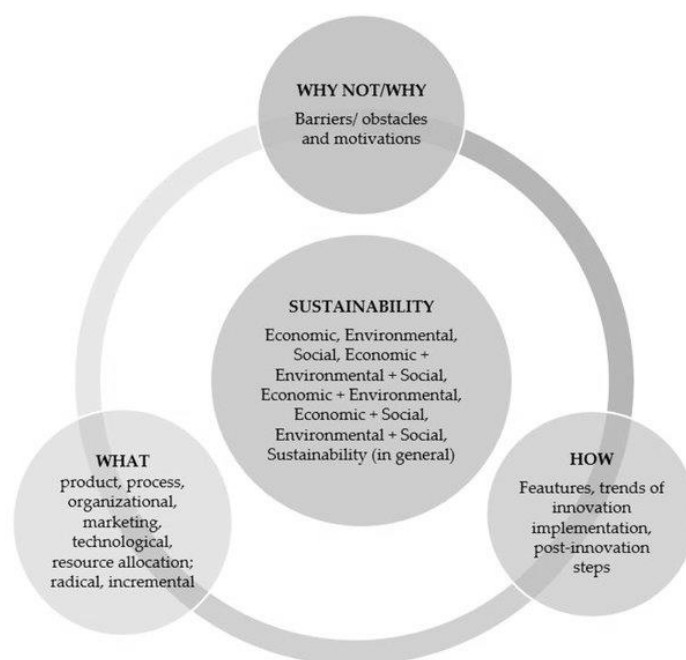
Boards in the USA and EU are talking more and more about sustainability but unfortunately doing much less or in the worst case just nothing. The Boards should make the right steps into the right direction to go to implement sustainability governance, **Graphic 8**, Tebaldi, Bigliardi, Bottani, 2018. Generally top directors are rather reluctant and inert to new trends and changes, more deeply with inherited historic memories and minds. On the other side of the coin, the boards are more than heavily under the influence of corporate secretaries, shareholders, and information from the inside and outside council.

New reality of the 2020 and 2021 with global pandemics COVID-19 is increasing pressure on the top corporations to reconsider their “purpose“ and goals since the ESG problems are knocking at the doors. How to define a strategic long-term corporate mission to survive and sustain operations, how to improve and increase the positive impacts on the environment and society. Only sustainable corporate strategy could create sustainable results for the shareholders and positive impact on the stakeholders. Firms should redefine their purpose in managing natural resources, since the corporate purpose, strategy and performance are closely interlinked angles of the same phenomena. The future lies in necessary simplification, clear language in defining sustainability objectives, understandable by all involved and interested.

Firms should be oriented towards their sustainable successful future, based on clear financial but even more than that ESG objective. Next step is interconnecting the corporate purpose, goals, values with strategy and capital investment decisions, based on the model of sustainable finance.

Board of directors is developing and governing the internal control systems, processes and corporate goals, all based on the strong ethical principles of sustainability governance, while

at the same time improving direct communication not only with external participants but also with employees within the firm. Managers' rewards, perks and bonuses should be directly related to the results of sustainability governance. Although managers are narrowly focusing on superior financial performance and indicators, more and more sustainable performance is contributing to the profit maximization. Risks of environmental hazards are visible and palpable, consequently the responsibility of top managers' board members is to address those risks, and manage them properly, with a focus on value creation of the economy based on the ESG performance.



**Graphic 8** Role of the Board in Sustainability Governance

## 7. ROLE OF BANKS IN SUSTAINABILITY

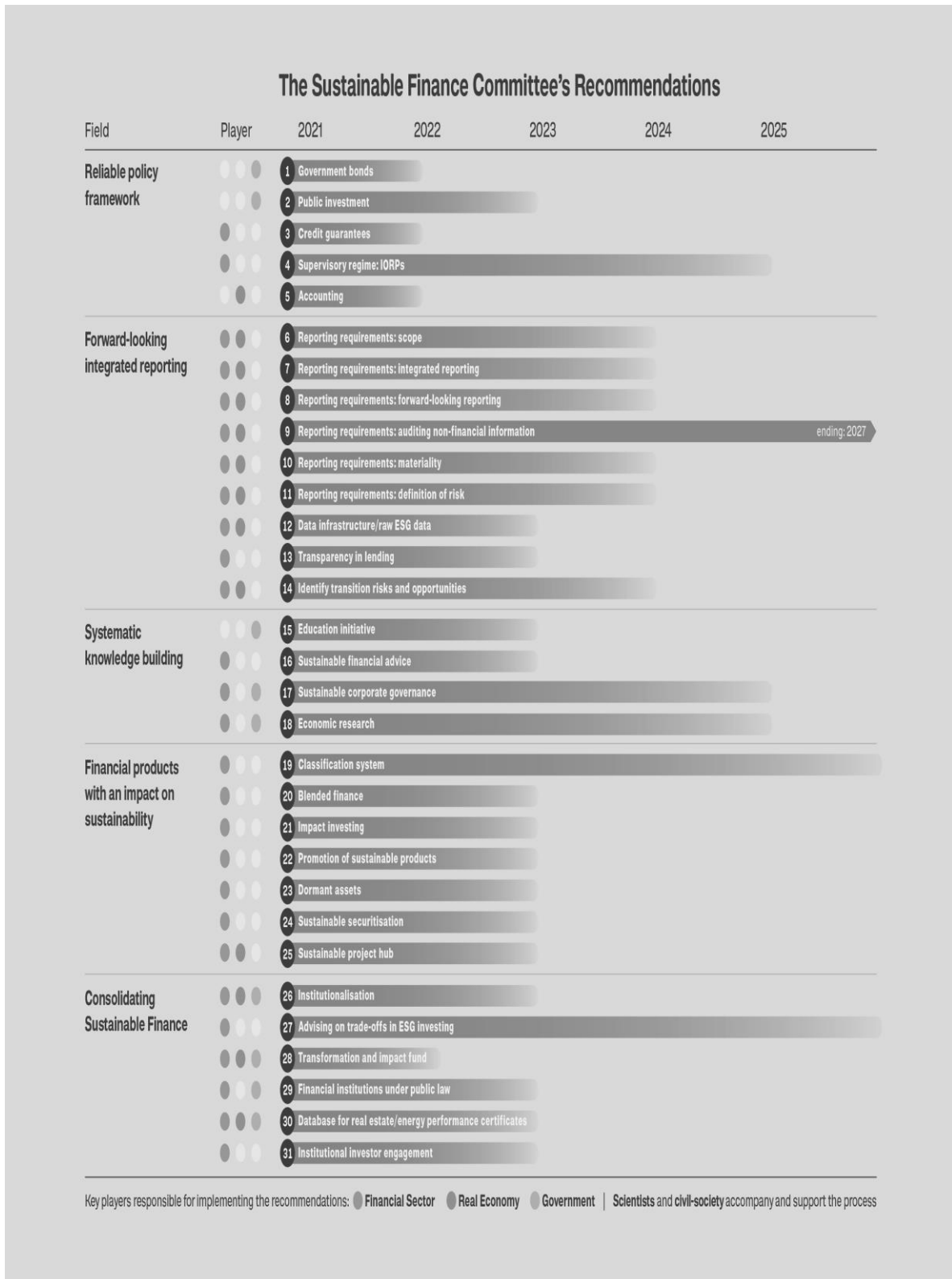
Banking globally and in the EU is facing the rising competition of non-banking services. The European Banking Authority (EBA) is oriented to sustainable finance. The aim is to integrate environmental, social and governance (ESG) interests and embody them into a set of new unified criteria for banking financial services. Thus EU banks and consequently in Serbia and in the region of Western Balkans countries shall finance and support sustainable economic growth based on the sustainability governance performance of their clients. Banks are increasingly aware and focusing on increasing the transparency of reporting about the need to mitigate the risks of ESG operations. Steps into the right direction is to support adequate ESG management of the clients, long-term overview of the natural risks, new problems of valuation and pricing, down-turn of economic activity. The European Commission in March 2018 published its **Action plan on Financing Sustainable Growth**, European Commission, 2018. This plan is mapping the strategy on sustainable finance. It is at the same time a roadmap for future work and development across the financial system with identified key priorities, and with the ESG criteria and role to be incorporated into the monitoring of market practices of sustainability, **Graphic 9**, European Banking Authority, 2021.

New EU banking regulation shall strongly emphasize and stress the key importance of the monitoring system and supervision. Sustainability disclosure regulation shall be all inclusive, and with full transparency in all phases of reporting (pre-contractual, progress periodic and final reports. Risks of ESG shall be incorporated into the risk management corporate model (physical and transition risks) following with the full assessment of prudential treatment. It should include taxative all the individual exposures associated with the environmental and/or social responsibility and objectives.



**Graphic 9** Role of European Banking Authority (EBA) in Promotion of Sustainable Finance

National governments should create and continuously improve the quality and transparency of the reliable policy framework, while designing the forward-looking integrated reporting, see: **Graphic 10**, German Watch Org, 2021. This process is leaning on the systematic build and growth of the knowledge base, with a view on the present but also future financial products with an impact on ESG factors and indicators.



**Graphic 10** The Sustainable Finance Committee's Recommendations: 2021-2025

New research is showing a positive relationship between ESG and financial performance for 58% of “corporate” studies. The researches from the Stern Business School focused on operational metrics (performance indicators like ROE; ROA) or stock price with 13%

showing neutral impact, 21% mixed results (the same study finding a positive, neutral or negative results) and only 8% showing negative, Whelan, Van Holt, Clark, 2020. There is still unclear correlation between different types of investment strategies and asset classes in the financial analysis of ESG performance. The big complexity is between the financial material issues and non-material, that is an obstacle to more certain conclusive results. Only corporations with strong sustainable strategies, driven by innovation, employment relations, supplier loyalty, customer demand, ESG risks mitigation and strong operational ESG efficiency have a bright future, as the previously quoted group of authors rightly concluded. The following **Graphic 11** is showing the feed-back mechanism between the ESG and financial performance, Wiso Univ. of Hamburg, 2021.



**Graphic 11** Links and Interactions between the ESG and Financial Performance

Accounting and auditing profession, especially small and medium practices (SMP) having small and medium enterprises (SME) as clients are playing a crucial role in promoting sustainability governance, **Graphic 12** Accountancy Europe, 2021. Accountants are in the unique professional position as trusted advisers to their clients. SMEs have a crucial and significant role to enhance sustainability by increasing accountability, transparency, developing policies to address ESG segment, while effectively managing ESG risks, communicating with shareholders, maintaining knowledge about sustainability.

Survival of the planet is at stake. Accountants can help firms transition towards a long term sustainable strategy reflecting ESG criteria and performance measures. The UN are pushing and leading the initiatives towards a long-term sustainable strategy, which nowadays strongly supports and promotes the EU. New sustainable corporate strategy is embracing both dimensions, financial and non-financial as depicted in the new concept of sustainable finance. Firms should and must discover how they create and destroy the value of natural resources, and adapt strategies to achieve the goals of ESG from measuring, over disclosing ESG performance towards gaining in add credibility. Sustainability governance shall provide better corporate information, provide independent assurance, encourage ESG goals, help firms implement ESG regulation, better evidence negative costs impacts on the ESG criteria, improve corporate monitoring and benchmark measuring.

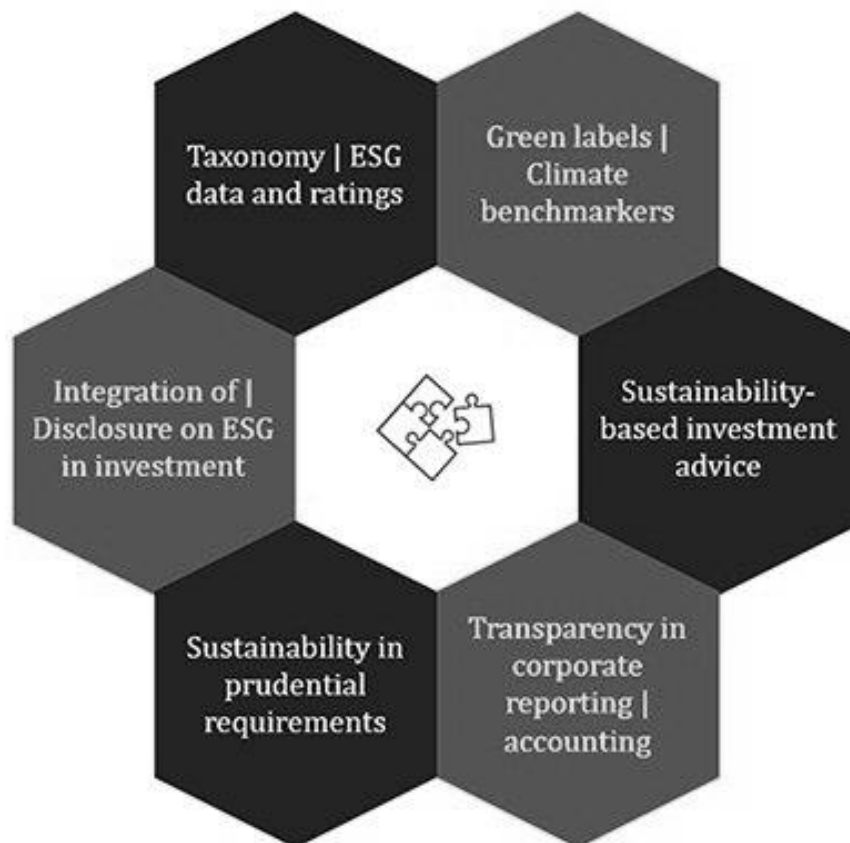


**Graphic 12** Role of Accounting and Auditing Profession in promoting sustainability governance European Commission and EU are fighting climate change through ambitious policies at home and in close cooperation with international partners, **Graphic 13**, Interdependence Coalition EU, 2021. Key EU legislation and policies shall cover: EU Emissions Trading System, National targets, ensuring forests and land, reducing the greenhouse gas emissions from transport, boosting energy efficiency, promoting innovative low-carbon technologies, phasing down climate-warming, protecting the ozone layer, adapting and funding the European Green Deal.



**Graphic 13** Paris Agreement and European Green Deal

Sustainable finance is a new concept and model which consists of the process of taking ESG considerations into account when making investment decisions in the financial sector, **Graphic 14**, DLA Piper, 2021. Long-term investments in ESG operations, in sustainable economic activities and projects. Sustainability governance of private and public institutions includes management structures, social inclusion, labor relations, human capital investments as well as investments in local communities, as well as human rights issues. The sustainability governance plays a fundamental role in balancing ESG considerations in the decision making process.



**Graphic 14** New EU Sustainable Finance Framework

ESG investments should be based on innovation support for businesses, but also consultancy firms which are implementing consulting projects, consultancy and research. Effects of sustainable investments should be viewed through the lens of ESG effects on firms, sector, size of business and geographic location. Close cooperation of all involved at all stages of the project cycle is a vital ingredient of success, **Graphic 15**, Sustentia innovacion social, 2021. Sustainability governance as a new form of responsibility must be embodied by the companies and all involved operating entities, with integrated ESG strategies into business operations, but also the protection of human rights and consumers. Sustainable governance responsible and credible business entities should take into account all stakeholders through the process of ESG management.





**Graphic 15** Strategy Advises how to Reorient Capital Flows into Sustainable Investments

## 8. CONCLUSION

Sustainability governance framework is encompassing aims like:

1. The contractual aspects (explicit and implicit contracts) between the business entity and the stakeholders, for the proper distribution of responsibilities, rights and rewards in operation and business involving natural resources.
2. The prescribed written procedures for detecting, reporting and reconciling the occasional conflicts of interests of stakeholders, with a wider view with their duties, privileges and roles vis-à-vis ESG.
3. Corporate procedures for proper supervision, control, monitoring and information-flows, which all are to serve as a system of checks-and-balances (system of internal control).

When a company has a strong sustainability governance it is emitting signals to the market, general public and all interested that the entity is well managed regarding sustainability, with balanced interest of management and external stakeholders. As a result, the company with a strong sustainability governance is having a strong competitive advantage.

Sustainability governance is encompassing all laws, regulations, codes and practices that define how a company is navigating through the tumultuous waters of sustainability, by strong control of ESG risks, streamlined and consistent organization's procedure. With good sustainability governance the firm is achieving efficient business processes, minimizing errors, reducing costs and waste, smoother running operation, and regulatory compliance.

## ACKNOWLEDGEMENT

I am expressing my sincere acknowledgement and thanks to the Dean of the Faculty of Management, Zajecar, Megatrend University, Belgrade, Serbia Professor Bojan Djordjevic for his kind invitation and support through this complex and demanding process. I am also very grateful to the Dean of the Belgrade Banking Academy, Union University, Belgrade Professor Dejan Eric, and Emeritus Professor Hasan Hanic, President of the Board of Trustees, of the Belgrade Banking Academy for supporting my new interests in the legal and regulatory aspects of corporate and sustainable governance.

## REFERENCES

- Accountancy Europe, 2021. <https://www.accountancyeurope.eu/wp-content/uploads/smart-art-1024x669.png>
- ADGM, 2019: *ADGM Sustainable Finance Agenda*.  
<https://www.adgm.com/documents/fsra/sustainable-finance/adgm-abu-dhabi-sustainable-finance-agenda-16-jan-2019-all.pdf>, January 2019. Accessed: September 9, 2021.
- DLA Piper, 2021.  
[https://www.dlapiper.com/~/\\_media/images/insights/publications/series/diagram-new-eu-sustainable-finance-series.jpg?h=396&w=418&la=nl&hash=4C03639ABD156395AC18BF2A93CE9EAD656D54FB](https://www.dlapiper.com/~/_media/images/insights/publications/series/diagram-new-eu-sustainable-finance-series.jpg?h=396&w=418&la=nl&hash=4C03639ABD156395AC18BF2A93CE9EAD656D54FB)
- Eclles, Robert, G., Johnstone-Louis, Mary., Stroehle C. Judith, 2020. *The Board's Role in Sustainability*. Harvard Business Review. September-October 2020.  
<https://hbr.org/2020/09/the-boards-role-in-sustainability> Accessed: December 4, 2021.
- European Banking Authority, 2021. *Mandates on Sustainable Finance*.  
[https://www.eba.europa.eu/sites/default/documents/files/document\\_library/EBA%20%20Mandates%20on%20sustainable%20finance.png](https://www.eba.europa.eu/sites/default/documents/files/document_library/EBA%20%20Mandates%20on%20sustainable%20finance.png) Accessed: December 5, 2021
- European Commission, 2018. *Action plan on Financing Sustainable Growth*.  
[https://ec.europa.eu/info/publications/180308-action-plan-sustainable-growth\\_en](https://ec.europa.eu/info/publications/180308-action-plan-sustainable-growth_en)
- European Commission, December 3, 2021. *Sustainable corporate governance*.  
[https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12548-Sustainable-corporate-governance\\_en](https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12548-Sustainable-corporate-governance_en)
- German Watch Org, 2021. *Sustainable Finance Recommendations Timeline*.  
[https://germanwatch.org/sites/default/files/sustainable\\_finance\\_recommendations\\_timeline.jpg](https://germanwatch.org/sites/default/files/sustainable_finance_recommendations_timeline.jpg)
- Global Landscape Forum Org, 2021. <https://i0.wp.com/news.globallandscapesforum.org/wp-content/uploads/2021/06/Screenshot-2021-06-14-at-1.39.22-PM.jpg?resize=900%2C533&ssl=1> Accessed September 9, 2021.

- Idowu, Samuel, O., Editor in Chief, 2015. *Dictionary of Corporate Social Responsibility. CRS, Sustainability, Ethics and Governance*. Springer, Cham. Germany. ISBN 978-3-319-10536-9, pp. 113, 119-121).
- Iedunote, December 3, 2021. <https://www.iedunote.com/management> Accessed: December 3rd, 2021.
- Interdependence Coalition EU, 2021. *Business can no longer ignore people and planet*. <https://interdependencecoalition.eu/wp-content/uploads/2021/06/Paris-Agreement-6-768x576.png> Accessed: December 5, 2021
- Ljutić, Ivana, 2021. *Corporate governance of the companies listed on the Belgrade stock exchange: metadata analysis based on the results of the methodology G20/OECD questionnaires*, *Economic analysis : EA*. - Belgrade, ISSN 2560-3949, ZDB-ID 2764079-6. - Vol. 54.2021, 1, p. 71-91. <https://www.econbiz.de/Record/corporate-governance-companies-listed-belgrade-stock-exchange-metadata-analysis-based-results-methodology-g20-oecd-questionnaires-ljuti%C4%87-ivana/10012591851> Accessed: December 4, 2021
- Ljutić, Ivana; Diligenski-Perić, Tijana, 2021. *The Role of Corporate Governance of Unlisted Issuer in COVID-19. First Writing or Rewriting the Rules of Corporate Governance in Serbia*. Beogradska bankarska akademija, Međunarodna naučna konferencija: *Global economic trends – challenges and opportunities*? <https://bba.edu.rs/2021/11/23/odrzana-medjunarodna-naucna-konferencija-global-economic-trends-challenges-and-opportunities-2/> Accessed: December 4, 2021.
- ResearchGate Net, 2021. *Main Ideas Included in the Sustainable Finance Concept: Source Own Analysis*. <https://www.researchgate.net/publication/343141499/figure/fig1/AS:916288692051969@1595471656514/Main-ideas-included-in-the-sustainable-finance-concept-Source-own-analysis.png>
- Salzmann, Astrid, Juliane, 2021. <https://www.researchgate.net/profile/Astrid-Salzmann/publication/257695798/figure/fig2/AS:669088380624902@1536534509139/A-Framework-for-Sustainable-Finance.png> Accessed: September 9, 2021
- Siri M., Zhu S, 2021. Integrating Sustainability in EU Corporate Governance Codes. In: Busch D., Ferrarini G., Grünewald S. (eds) *Sustainable Finance in Europe*. EBI Studies in Banking and Capital Markets Law. Palgrave Macmillan, Cham. [https://doi.org/10.1007/978-3-030-71834-3\\_6](https://doi.org/10.1007/978-3-030-71834-3_6) Accessed: December 3, 2021.
- Smart Vision Logistics, 2021. *Corporate Governance*. <https://smartvisionlogistics.com/services/corporate-governance/> Accessed December 3, 2021.
- Smart Vision Logistics, *Corporate Governance*, December 3, 2021. <https://smartvisionlogistics.com/services/corporate-governance/>  
<https://www.adgm.com/documents/fsra/sustainable-finance/adgm-abu-dhabi-sustainable-finance-agenda-16-jan-2019-all.pdf>
- Sustentia innovacion social, 2021. <https://www.sustentia.com/wp-content/uploads/2021/04/Finanzas-sostenibles-UE.png> Accessed: December 5, 2021
- Tebaldi, Letizia; Bigliardi, Barbara; Bottani, Eleonora, 2018. *Sustainable Supply Chain and Innovation: A Review of the Recent Literature*. [https://www.researchgate.net/publication/328633295\\_Sustainable\\_Supply\\_Chain\\_and\\_Innovation\\_A\\_Review\\_of\\_the\\_Recent\\_Literature/figures?lo=1](https://www.researchgate.net/publication/328633295_Sustainable_Supply_Chain_and_Innovation_A_Review_of_the_Recent_Literature/figures?lo=1) Accessed: December 4, 2021.

- Whelan, T.; Atz, Ulrich; Van Holt, Tracy; Clark, Casey, 2020. *ESG and Financial Performance: Uncovering the Relationship by Aggregating Evidence from 1,000 Plus Studies Published Between 2015-2020*.  
[https://www.stern.nyu.edu/sites/default/files/assets/documents/NYU-RAM\\_ESG-Paper\\_2021%20Rev\\_0.pdf](https://www.stern.nyu.edu/sites/default/files/assets/documents/NYU-RAM_ESG-Paper_2021%20Rev_0.pdf)
- Wieczorek-Kosmala, Monika. 2019. "The Concept of Risk Capital and Its Application in Non-Financial Companies: A Sustainable Dimension" *Sustainability* 11, no. 3: 894.  
<https://doi.org/10.3390/su11030894> Accessed: December 4, 2021.
- Wiso Univ. of Hamburg, 2021. <https://www.wiso.uni-hamburg.de/11890081/grafik-810x386-d6994f4281bb2370385feed1ffd769195a6a8d96.jpg> Accessed: December 5, 2021

UDK 616.98:578.834]:331.101.3  
005.322:316.46  
005.966  
COBISS.SR-ID 57388809

## THE ROLE OF PERSONAL BRANDING IN THE DIGITAL ENVIRONMENT ON CAREER DEVELOPMENT DURING THE COVID-19 PANDEMIC

Radoslav Baltezarević<sup>1</sup>  
Ivana Baltezarević<sup>2</sup>

<sup>1</sup>Fakultet za poslovne studije, Megatrend univerzitet, Bulevar Maršala Tolbuhina 9a, Beograd,  
r.baltezarevic@gmail.com

<sup>2</sup>Pravni fakultet, Megatrend univerzitet, Bulevar Maršala Tolbuhina 9a, Beograd,  
ivana.baltezarevic@gmail.com

### ABSTRACT

*A personal brand in a digital environment is a reflection of a person and, above all, gives a personalized note to those who intend to present themselves in the best possible light. It represents the desired image that someone wants to place about himself or herself in public, woven of values, reputation, behavior, manner of communication, negotiation, skills, manner of dressing, as well as the image of that person. Virtually everything a person does can affect his/her personal brand. Personal branding has proven to be very useful in career development in social media, especially in the difficult conditions caused by the Covid-19 pandemic. Therefore, the main goal of this paper is to offer, primarily to professionals who are looking for a job or want to advance their careers, useful knowledge and skills in this field in order to better stand out, and to increase their chances in difficult conditions in the global labor market.*

### KEYWORDS

*Personal Branding, Social Media, Career Development, COVID-19.*

### INTRODUCTION

Although a large number of researchers today deal with personal branding on social media (a fairly young phenomenon), these studies are still limited mainly to the United States (Molyneux, Holton, 2015). It is increasingly emphasized that owning a personal brand is important not only in the media and politics, but also has an increasing role in professional life (Trzeciak, 2015). A personal brand is an understanding of what is truly unique about a person, and is a useful tool that can allow us to differentiate ourselves in the job market, but also influence our career decisions. By presenting the true self, it is possible to attract what a person really needs to achieve, the desired goals (Aruda 2009). Personal brand development is a continuous process that involves interaction with other people in face-to-face communication and in an online environment (Hearn, 2008). Personal branding is not only about managing impressions, but also narration has an important role in the success of personal branding, ie the introduction of narrative elements in building your own brand

(Cunningham, 2013). Due to its specificity, the personal brand captures the attention of theorists and practitioners, but in the marketing literature it is still more focused on the brand of products, services or corporate brand (Milovanović, Lukinović, Baltezarević, 2018).

An individual's personal brand is a reflection in the mirror of all his or her abilities, skills and way of life (Gehl, 2011). A personal brand relies on a strong presence in a digital environment that conveys elements of the brand and authentically reflects the beliefs and aspirations of the individual. In the age of digital media, self-branding tactics include creating and maintaining personal websites and blogs of social and network profiles, as well as using search engine optimization techniques to facilitate but encourage access to information that someone wants to share with their target audience (Labrecque, Markos, Milne, 2011).

In order to be effective, a personal brand must challenge the basic perceptions of the audience, ie to show that person is different, new and original, that is better (to encourage the belief that you are among the best, in some way, in everything you do) and of course that person is authentic (Montoya, Vandehey, 2003).

There are several major social media platforms used by higher education professionals - LinkedIn, Twitter and blogs that offer many more opportunities to create professional connections, which can be created face to face and certainly provide help to share and promote someone's work to a wider audience. They are especially practical if the users are working in different countries (Gander, Moyes, Sabzaleiva, 2014).

At the beginning of the pandemic, job vacancies decreased, and by the end of April 2020, they had dropped by more than 40%. This collapse had a broad basis and affected all American states (Kahn et al., 2020). However, all other countries in the world have experienced a similar fate. All over the world, the fight against the epidemic involved the use of a "physical distancing" strategy, which meant limiting physical contact between people. This has led to greater use of social media platforms, which helped people to connect in business, education, but also in social interactions. Platforms such as Zoom and Microsoft Teams have seen exponential user growth during pandemics (Bary, 2020). When the world faced a pandemic, the digital environment became the only place for communication, entertainment, but also for doing business or looking for new business opportunities. Of course, all this has conditioned people to quickly adapt to the new conditions, to enrich their skills and do everything in their power to attract attention, to stand out from the competition, and thus increase their chances for career success.

## **PERSONAL BRANDING**

The brand presents signals to the customer about the source of the product, and at the same time, protects the producer and consumer from different competitors who would try to produce identical or similar products (Aaker, 1996). A brand is a name, design, symbol or sign that increases the value of a product above its functional purpose (Farquhar, 1989). A strong brand ensures intense consumer loyalty, representing something that simplifies the selection process by confirming functional or emotional associations. Experiential or emotional associations promise a successful brand that creates consumer value (Doyle, 2001). At the heart of a successful brand is a great product or service, supported by creatively designed and executed marketing, careful planning and long-term commitment (Kotler, Keller, Koshy, Mithileshwar, 2009). The brand can also be understood as a product with many added dimensions that distinguish it from other products, designed to meet the same desires and needs of consumers (Keller, 2003).

In recent years, the personal brand has become a frequent and effective way of communication between a person and his or her public. It allows individuals to differentiate themselves from the competition on the basis of uniqueness and different values (Morton, 2011). With personal branding, one can introduce him or herself much more broadly outside the resume, and further identify who they are as individuals, offering additional important information to corporations on how they can benefit if they choose to hire them. Self-branding can be understood as a form of thinking about oneself as a brand, or as a product that can be creatively and strategically viewed in a highly competitive labor market to bring maximum value to both the individual and their current or potential company (Barnett, 2010). What many people do not understand is that with today's progress of new media, although they are not aware of it, they may already have some form of personal brand. If someone just types their name in an Internet search engine, they will most likely find a list of at least a few results that contain this person's name, which contributes to their personal brand (Bitti, 2007). Personal branding goes beyond the online environment and involves personal self-presentation. Creating a strong personal brand means projecting a strong consistent image of oneself in the way a person speaks, how he/she behaves, what can be concluded from their body language etc. The next step is to take control of their visibility in order to manage their own PR (Everett, 2008).

In the age of digital tools, which are necessary in the process of building a personal brand and enable efficient communication, traditional tools such as letters, telephone or fax have didn't lose their importance and it is believed that such personal communication, verbal and nonverbal will not be so easily overcome. In order to self-promote in cyberspace, a professional can use various information and communication tools such as: professional networking portals, such as LinkedIn - which allow people to present their professional profile online and share their career achievements. Professional networking portals provide an opportunity to build a business network, but also to show the careers of other users whose successes can be an inspiration for their followers; Blogs, such as Twitter, or BlogSpot - allows posts in the form of text or images that are dedicated to specific topics. Blogs enable the exchange of ideas between authors and readers and thus encourage the development of a certain area. Discussion forums - are one of the most popular methods of communication that bring together people who are interested in a particular topic, allowing them to establish contacts, exchange information, but also to oppose their views and opinions; Social networks, such as Facebook, connects users who also share the same opinions and interests. Social networks are considered a very effective marketing tool for transmitting specific information; Services that include interactive content, such as YouTube, or Slideshare, offer the opportunity for people to promote themselves in an online environment by posting interactive content such as videos, or presentations; Photo upload sites, such as e.g. Instagram and Pinterest are sites that give people the opportunity to present themselves or their interests by uploading photos or stories that can be accompanied by a music theme; Video CV - is a relatively new and useful way to make one person stand out in the crowd. In a short video, not only professional skills can be shown, but a person can also be presented as an individual with its specific character traits, which can add a more personalized dimension to a resume; Personal website is another useful way to share reliable information about a person and his/her goals, achievements, activities, passions, etc. An email is an online tool that is often used and allows people to exchange text messages (or multimedia content) with other people (Figurska, 2016).

The concept of personal branding is derived from the same basic concept of product development and promotional strategies that are transformed into self-promotion and personal

development of the individual. The personal brand represents a relatively new concept, applied by different professionals in different fields such as athletes, businessmen, politicians and musicians (Shepherd, 2005). Fortunately, the technology of the modern age has enabled everyone in the world to build the reputation of their own brand through content, engagement and hard work (Schawbel, 2015). A personal brand should represent a virtual version of a person. It is considered that the relationship is crucial in defining a business or personal brand. In both cases, brand recognition is an iterative process with an enriched emotional component that describes the overall relationship experience (McNally, Speak, 2004). In the process of developing a personal brand, in order to be attractive to the audience, requires understanding the current professional identity, forming targeted communication and understanding effective communication channels (Ward, Yates, 2013), this is followed by a phase in which it is subsequently assessed whether the created image adequately meets one's desired goals (Khedher, 2014).

A personal brand consists of the values, reputation, behavior, skills and image of a person, basically, everything we do affects our personal brand. From the way we communicate, how we dress, how we negotiate, how we treat our obligations, to how and whether we keep our promises, it all individually and together affects the building of our personal brand (Montoya, Vandehey, 2003). Branding people requires more than charts and research. It is a living person, who breathes and who can change his/her mind in the middle of the process (Baltezarević, Milovanović, 2014).

## **DEVELOPING ONLINE PROFESSIONAL IDENTITY**

One of the main reasons for the dizzying success of social media is their ability to automatically segment the market (Wright, Khanfar, Kizer, 2010). The world is in the age of mass communication. In such a world, people turn to the media from which they expect information as facts from the world around them. The connection between technology and society is growing. Widespread use of the Internet has opened the door to the cyber world. People are thrown into a virtual space where they can become members of one of the many virtual communities and satisfy their needs for communication and information that this technology enables (Baltezarević, Baltezarević, Baltezarević, 2016).

In the field of information technology, innovations take place very quickly and are introduced through social networks and online websites. LinkedIn, Twitter, Facebook, etc. provide new patterns of social interaction and communication (Sapountzi, Psannis, 2018). Social networks mediate the creation of communities and networks by encouraging participation and interest. It is a term used for online tools and websites that provide users with the ability to communicate with each other by sharing information, opinions and interests (Scissons, Vo, Sim, 2015).

Social networks can be defined as a set of information technologies that facilitate networking and interaction (Kapoor, Tamilmani, Rana, Patil, Dwivedi, Nerur, 2017). Social networks can be defined as "Internet-based, disintegrated and persistent channels of mass personal communication, which facilitate the perception of interactions among users, creating value that primarily stems from user-generated content" (Carr, Hayes, 2015: p. 49). Social networks refer to computer-mediated technology, enabling the growth and exchange of awareness, interests, ideas, information and other methods of expression (Nielsen, 2017). They can also be defined as "a group of Internet applications based on the ideological and technological foundations of Web 2.0" (Kaplan, Haenlein, 2010: p. 61).



Internet communication and the whole cyber culture show an inseparable connection between society and technology. Social interactions, together with the creation of virtual identities of people, social relations and communities, lead to scenarios in which computer technology and virtual communication actually form a parallel society and a new virtual cultural space (Baltezarevic, Baltezarevic, 2016).

Although personal branding is useful for an individual, it is also an important aspect of their professional environment. Personal branding teaches the individual how to stay relevant to the market and the latest thinking (Kaputa, 2005). Being up to date with current market information makes a company and an individual look better for all followers of a personal brand. Also, a personal brand can be a reflection of everything a person stands for. It can also help grow a personal network, which is a great tool for promoting career success. Networking is a basic part of job seekers today. Most people will not get a job if they do not know someone personally in their desired field of work (Schawbel, 2010). Having a large and strong network will help an individual to stand out among the competition when applying for a job. When an employer knows someone in their personal network, they are more likely to trust an individual, which leads to a higher employment rate. "Business success is based on accessibility. Networking gives you accessibility" (Kaputa, 2005: p.138).

A large number of studies have explored how people construct their identities in both offline and online environments (Kozinets, 2002). It is not uncommon to claim that formed virtual identities differ from each other, depending on digital platforms. Most of these relationships in the online environment are based on real-life relationships, so individuals connect online mostly with people who know offline (Birnie and Horvath, 2002). The online environment offers a wide range of platforms for identity formation in order to establish or maintain social relationships, such as social networks, chat rooms, multiplayer games, dating websites, etc. (Ribeiro, 2009).

Feedback from other users of the Internet affects people's perception of themselves, which is inevitable significantly contributes to the development of people's identities on online platforms (Yurchisin, Watchravesringkan, McCabe, 2005). This is supported by earlier studies describing that individuals examine their actions, and cognitive values from the perspective of other people with whom they interact (Goffman, 1990). Individuals' responses to the perspective of others are twofold. The perspective of others consisting of social groups, family members and peers can be described as "significant others", and have a stronger influence and the greater role in the construction of human identity (Mead, 1934). Individuals often adhere to the norms and expectations of the society. Such conformist behavior may be due to the individual's need to be accepted by the social group, or by a desire to emphasize their social status (or to conceal current status, if not satisfied), or eventually, his behavior is conditioned by the elementary need for survival.

Relying on the theory of social capital (Coleman, 1990), according to which online social connections can provide access to valuable resources, it can be confirmed that the use of embedded resources in the online network can be useful for increasing employment and professional development (Manzoor, Wei, Bányai, Nurunnabi, Subhan, 2019). The tools used for personal branding are diverse and include blogging, Facebook, Instagram, Twitter, Quora, Pinterest, YouTube, Slideshare, wikis, videocasts, as well as podcasts (Chen, 2013). It is important that professional profiles are regularly updated, to be able to convey academic and business history, and provide a concise list of accomplishments, as well as career goals (Clark, 2011). Nowadays, LinkedIn is considered a top professional site for connecting with industry and academia professionals and for demonstrating expertise and skills (Poepelman, Blacksmith, 2014). LinkedIn profiles should include recent, professional photography and an

accurate academic and personal history that highlights personal accomplishments (Morgan, 2011). It is important to maintain a virtual resume in order to demonstrate skills and abilities in the most relevant way (McCorkle, McCorkle, 2012). It is recommended to enter keywords on a LinkedIn profile to help search engines and recruiters to facilitate the process of finding suitable candidates for a specific business position (Schwabel, 2009). LinkedIn is considered a top professional social network with over 133 million users in the United States alone and reaching 200 countries and territories worldwide. According to the Jobvite Recruiter Nation Survey, 87 percent of recruiters use LinkedIn to search for candidates. What is considered the most important in the profile of candidates towards recruiters is above all "authenticity". A profile on this platform should represent a more dynamic approach to presenting your experiences, skills, goals, what you know, what interests you in a professional context. It is also necessary for the information to be as complete and fresh as possible, because in that way more opportunities for successful career development will be provided. So it is necessary for users to regularly update their profile, to be comprehensive about current skills and goals, and to highlight their recent experience (Suder, 2021).

### **PERSONAL BRANDING AND CAREER DEVELOPMENT DURING THE COVID-19 PANDEMIC**

When the world faced a pandemic Covid-19, in addition to human health, it endangered the entire world economy. Many companies have failed to survive in these difficult conditions. Some have reoriented their business and sent their employees to work via computers from their homes. However, a large number of workers lost their jobs. At one point, many people faced existential problems, and the only opportunity for communication and possible new employment opportunities was reduced to the online environment. The situation on the labor market, even before this world crisis, was very demanding in terms of finding a job due to great competition, and it seems that it has reached a critical level with the beginning of the crisis. To most people, at least to those who were actively looking for a new job, it became clear that in the sea of those who offered their skills and knowledge to recruiters on professional networks, details and specific digital account management skills (including knowledge of personal branding) can create a better starting position, and increase the chances of employment.

A social media has made it easier for people to do business, due to the fact that it is opening up a global market, and it is also cheaper to advertise (Susanto, Almunawar, 2015). The Internet and social networks, as a medium of mass communication, are increasingly used in business, but also in representing individuals as potential business associates. Although many professionals and organizations are still reluctant to use social networks during crises, it is undeniable that this medium creates a long range of benefits, conveying potentially valuable information to stakeholders, supporting crisis management, but also facilitating the recruitment of new workers.

Crises can be defined as major events that result in potentially negative effects on an organization, business or industry and affect the public, product, service or reputation of the organization and the normal functioning of the organization, and even threaten its survival (Byrne, 2010). In addition to the basic preservation of human health, during a crisis, it is vital that every organization communicates adequately with the public, as this is one of the main ways for an organization to maintain or repair its reputation. A crisis, as an unexpected and sudden event that creates uncertainty and jeopardizes the organization's priority goals, can damage a company's reputation and result in financial losses (Dean, 2004). When a crisis

occurs, organizations and individuals need to change their behavior, beliefs, and values. In some situations it is necessary to improvise and take on more roles than usual (Pearson, Clair, 1998). Technological advances in crisis situations change and disseminate information to affected communities in the best and easiest way (Veil, Buehner, Palenchar, 2011). These methods include micro-blogging, blogs, video sharing, social networking sites, content-driven communities, and professional networks (Walaski, 2013). Weiner (2006) pointed out the need to meet the requirements of today's information and media dynamics by implementing digital communication channels in times of crisis. Social networks can be an effective communication platform used not only to reduce the impact of the crisis, but also as a means of sharing knowledge and crisis management by the organization (Yates, Paquette, 2011). Coombs (2007) said that during the crisis, the relationship between stakeholders and the organization can be damaged, which as a result can affect the reputation of the organization. Reputation is very important for the organization and it is a resource that has the ability to bring customers, investors, attract highly talented employees, produce better business results and ultimately build a competitive advantage. According to Edmund and Balmer (1998), corporate reputation indicates a value judgment about a company's properties and develops over time as a result of continuous performance, improved by efficient communication, while corporate images in consumer minds can be formed more quickly through well-designed communication programs.

It may never have been harder in terms of career development than during the pandemic. According to the results of the research, since the beginning of the pandemic, 305 million full-time jobs have been lost globally. Young people are particularly badly affected. LinkedIn has analyzed millions of job ads on their platform to pinpoint what employers are most currently looking for. They found that the most sought-after skills in candidates were the so-called "soft skills", including communication and problem solving. This reflects previous research by organizations including the World Economic Forum and Deloitte, which in their Report on the Future of Jobs explored the skills that will be needed in the Fourth Industrial Revolution. Five desired skills have been identified: Communication - perhaps the most important for employers. As Covid-19 increased the adoption of remote work software, the need to achieve the "right tone of voice" increased. It is recommended that you leave the right impression with the tone you adopt in texts and e-mails. Another skill required is problem solving. It is about identifying the task, breaking it down into its components and solving it. A candidate's analytical skills can also improve his/her chances of career success. Focused thinking can help at every level of the organization, as companies face difficult choices and make important decisions on a daily basis, from changing the number of employees to budgeting. The fourth skill required is related to customer service. Regardless of the level of management and the industry you target, you need to create a positive experience for those who hired you. Due to the pandemic, retailers have reoriented themselves to the online network, in order to serve customers stuck at home. Great customer service can make a difference in new conditions. China is a good example, and it is currently considered to have very successfully penetrated the secrets of successful e-commerce during the pandemic, providing users not only with speed, but also with security. In the end, though, no less important skill is leadership. Rarely are there only two choices in a difficult situation, you need to make a clear list of your priorities and avoid thinking in a binary way (Kretchmer, 2020).

## CONCLUSION

The global pandemic has caused a lot of damage to both human health and the world economy. Even in the first months of the crisis, a large number of layoffs were recorded. Many companies have failed to cope with these difficulties and have suspended their operations. On the other hand, all those who had reoriented their business to an online environment, offering its consumers the opportunity to order services and products online and have their needs and desires met by home delivery, managed to survive. Due to the recommended health measures and social distance, many employees were sent to their homes, from where they performed their business duties remotely via their computers. It is considered that this period was one of the most difficult to find a new business engagement, both because there were significantly fewer business ads on professional online platforms and the Internet in general, and because of increased competition, although it can be said that the situation in the labor market even before the pandemic was very complex. Those people who quickly adapted to the new conditions and enriched their digital skills, but also the knowledge offered by personal branding, had a better chance of more adequately positioning themselves on the market. In the age of the pandemic, recruiters are looking for those who are authentic and stand out from the crowd, while satisfying the growing need of possessing refined soft skills. Personal branding methods in the digital environment have gained importance in such conditions. Providing a competitive advantage and differentiation, which strengthened the starting position, in conditions when even the slightest positive activity or change could make a significant difference in terms of career advancement.

## REFERENCES

- Aaker, D.A. 1996. *Building strong brands*, New York: The Free Press.
- Aruda, W. 2009. Personal Branding - 1-2-3 Success! - The Keynote Presentation. Retrieved from [http://incitrio.com/docs/123\\_Success.pdf](http://incitrio.com/docs/123_Success.pdf) (Accessed: 28.08.2021)
- Baltezarević R., & Milovanović, S. 2014. Personal branding, In R. Grozdanic, Z. Nikitovic, & D. Jovancevic (Eds.), *Management, Marketing and Communication: Current and Future Trends* (pp. 245-258). Faculty of Business Economics and Entrepreneurship, Belgrade: Valjevoprint, JEL classification: M31, J24. UDK: 658.8. 003.65. ISBN 978-86-6069-105-9, COBISS.SR-ID 210422028.
- Baltezarevic V., Baltezarevic R., Georgievski B. 2016. Human need for communication in the system of virtual organizations. *Egyptian Computer Science Journal*, Volume 40, Issue No.1. pp. 53-60. ISSN -1110-2586.
- Baltezarevic V., Baltezarevic R. 2016. The internet and virtual “reality”. In *Proceedings International Conference, Technology + Society Future*, 2016, Podgorica, Montenegro. Transition to a new society, Montenegrin Academy of Sciences and Arts, World Academy of Art and Science, ALL European Academies (ALLEA), European Academy of Sciences and Arts, Podgorica, Montenegro: Pro File, pp. 193-200. ISBN 978-86-7215-384-2, COBISS.CG-ID 31080464.
- Barnett, C. 2010. Managing your personal ‘brand’ online. *Quill*, 98(2), 23.
- Bary, E. 2020. Zoom, Microsoft Teams usage are rocketing during coronavirus pandemic, new data show. Retrieved from: <https://www.marketwatch.com/story/zoom-microsoft-cloud-usage-are-rocketing-during-coronavirus-pandemic-new-data-show-2020-03-30> (Accessed: 28.08.2021)

- Birnie, S. A., Horvath, P. 2002. Psychological predictors of Internet social communication. *Journal of Computer-Mediated Communication*, 7 (4)
- Bitti, M. T. 2007. *Online career branding; Clean cyberspace identity*. National Post, p.WK1.
- Byrne, B.B. 2010. *Structural Equation Modeling Using AMOS. Basic concepts, Applications, and Programming*. (2nd ed). New York: Routledge.
- Carr, C. T., Hayes, R. A. 2015. Social media: Defining, developing, and divining. *Atlantic Journal of Communication*, 23, 46–65.
- Chen, C. 2013. Exploring personal branding on YouTube. *Journal of Internet Commerce*, 12(4) 332-347. doi:10.1080/15332861.2013.859041.
- Clark, D. 2011. Reinventing your personal brand. *Harvard Business Review*, 89(3) 78-81.
- Coleman, J. 1990. *Foundations of Social Theory*; Harvard University Press: Boston, MA, USA.
- Coombs, T.W. 2007. Protecting organization reputations during a crisis: the development and application of situational crisis communication theory. *Corporate Reputation Review*, Vol. 10(3), pp. 163-176.
- Cunningham, C. 2013. *Social networking and impression management: Self-presentation in the digital age*. Lanham, MD: Lexington.
- Dean, D. H. 2004. Consumer reaction to negative publicity: effects of corporate reputation, response, and responsibility for a crisis event. *Journal of Business Communication*, 41(2), 192-211. <http://dx.doi.org/10.1177/0021943603261748>.
- Doyle, P. 2001. Building value-based branding strategies. *Journal of Strategic Marketing*. September. pp. 255-268
- Edmund R., Gray J., Balmer, M.T. 1998. Managing Corporate Image and Corporate Reputation. *Long Range Planning*, Volume 31, Issue 5, 12 October 1998, Pages 695-702
- Everett, L. 2008. Corporate marketing taking control of ‘Brand Me’. *Accountancy Ireland*, 40(3), 53-54.
- Farquhar, P.H. 1989. Managing brand equity. *Marketing Research*. September. Vol. 1 Issue 3, pg. 24-33
- Figurska I. 2016. Personal branding as an element of employees' professional development. *Human Resources Management & Ergonomics* Volume X, 33-47
- Gander, M., Moyes, H., Sabzaleiva, E. 2014. *Managing your Career in Higher Education Administration*. Palgrave Macmillan, Basingstoke.
- Gehl, R. W. 2011. Ladders, samurai and blue collars: Personal branding in Web 2.0. *First Monday*, 16(9) 3-24.
- Goffman, E. 1990. *The Presentation of Self in Everyday Life*, London: Penguin
- Hearn, A. 2008. Meat, masks, burden: Probing the contours of the branded self. *Journal of Consumer Culture*, 8(2). 197-217. doi: 10.1177/1469540508090086
- Kahn, L. B., F. Lange, and D. G. Wiczer 2020. Labor Demand in the Time of COVID-19: Evidence from Vacancy Postings and UI Claims. Working Paper 27061, *National Bureau of Economic Research*.
- Kapoor, K. K., Tamilmani, K., Rana, N. P., Patil, P., Dwivedi, Y. K., & Nerur, S. 2017. Advances in Social Media Research: Past, Present and Future. *Information Systems Frontiers*, 1-28.
- Kaplan, A.M. and Haenlein, M. 2010. Users of the World, Unite! The Challenges and Opportunities of Social Media. *Business Horizons*, Volume 53, Number 1, pp. 59–68.
- Kaputa, C. 2005. *U R a brand!: how smart people brand themselves for business success*. Mountain View, CA: Davis-Black Publishing.

- Keller, K. L. 2003. *Strategic brand management: Building, measuring, and managing brand equity* (2nd ed.). Upper Saddle River, NJ: Prentice Hall.
- Khedher, M. 2014. Personal branding phenomenon. *International Journal of Information, Business and Management*, 6(2). Retrieved from [https://ijibm.elitehall.com/IJIBM\\_Vol6No2\\_May2014.pdf](https://ijibm.elitehall.com/IJIBM_Vol6No2_May2014.pdf) (Accessed: 27.08.2021)
- Kotler, P., Keller, K., Koshy, A., Mithileshwar, J. 2009. *Marketing Management – A South Asian Perspective*. Pearson Prentice Hall, Delhi
- Kozinets, R. V. 2002. The Field behind the Screen: Using Netnography for Marketing Research in Online Communities. *Journal of Marketing Research*, 39 (February), 61-72
- Kretchmer, H. 2020. Here are 5 skills researchers say employers are looking for right now. Retrieved from: <https://www.weforum.org/agenda/2020/08/covid-19-jobs-key-skills/> (Accessed: 29.08.2021)
- Labrecque, L. I., Markos, E., Milne, G. R. 2011. Online personal branding: Processes, challenges, and implications. *Journal of Interactive Marketing*, 25(1), 37-50. doi:10.1016/j.intmar.2010.09.002
- Manzoor, F., Wei, L., Bányai, T., Nurunnabi, M., Subhan, Q.A. 2019. An examination of sustainable HRM practices on job performance: An application of training as a moderator. *Sustainability*, 11, 2263.
- McCorkle, D.E., McCorkle, Y. L. 2012. Using LinkedIn in the marketing classroom: Exploratory insights and recommendations for teaching social networking. *Marketing Education Review*, 22(2) 157-166.
- McNally, D., Speak, K. 2004. Be your own brand. A Breakthrough Formula for Standing Out From the Crowd, Retrieved from [https://archive.org/details/Be\\_Your\\_Own\\_Brand\\_2nd\\_9781605098111](https://archive.org/details/Be_Your_Own_Brand_2nd_9781605098111) (Accessed: 27.08.2021)
- Mead, G. H. 1934. *Mind, Self, and Society*. Chicago: The University of Chicago Press
- Milovanović S., Lukinović M., Baltezarević R. 2018. Lični brend i integrisano marketing komuniciranje. *Megatrend revija*, Vol. 15 (1). pp. 177-186. UDK 658.8:005.322. ISSN 1820-3159; COBISS.SR-ID 116780812
- Molyneux, L., Avery H. 2015. Branding (Health) Journalism. *Digital Journalism* 3 (2): 225–242. doi:10.1080/21670811.2014.906927.
- Montoya, P. and Vandehey, T. 2003. *The Brand Called You*. Personal Branding Press, 280 pp.
- Morgan, M. 2011. Personal branding, Create your value proposition. *Strategic Finance*, 93(2) 13-14, 60.
- Morton, R. 2012. Bringing Your Personal Brand to Life. *Healthcare Executive*, 27(1), 70, 72-73.
- Nielsen, M.I.S.W. 2017. Computer-mediated communication and self-awareness—A selective review. *Comput. Hum. Behav.*, 76, 554–560.
- Pearson, C.M., Clair, J.A. 1998. Reframing Crisis Management. *The Academy of Management Review*, Vol. 23 Issue 1.
- Poepelman, T., Blacksmith, N. 2014. Personal branding via social media: Increasing SIOP visibility one member at a time. *The Industrial Organizational Psychologist*, 15(3) 112-119 Retrieved from [http://www.academia.edu/6201411/Personal\\_Branding\\_via\\_Social\\_Media\\_Increasing\\_SIOP\\_Visibility\\_One\\_Member\\_a](http://www.academia.edu/6201411/Personal_Branding_via_Social_Media_Increasing_SIOP_Visibility_One_Member_a)
- Ribeiro, J. C. 2009. The increase of the experiences of the self through the practice of Multiple virtual identities. *Psychology Journal*, Vol. 7 Issue 3, p291-302
- Sapountzi, A., Psannis, K.E. 2018. Social networking data analysis tools & challenges. *Future Gener. Comput. Syst.*, 86, 893–913.

- Schwabel, D. 2009. How to build your personal brand on LinkedIn. *Mashable*. Retrieved from <http://mashable.com/2009/07/27/linkedin-personal-brand/> (Accessed: 27.08.2021)
- Schwabel, D. 2010. *Me 2.0: 4 steps to building your future*. New York: Kaplan Publishing.
- Schwabel, D. 2015. How to Become a Personal Branding Expert. (Online). Available at: <https://danschawbel.com/blog/how-to-become-a-personal-branding-expert/> (Accessed: 27.08.2021)
- Scissons, M., Vo, J., Sim, H. 2015. *Instagram Marketing Strategy e-Book*. Toronto: FlashStock Technology Inc.
- Shepherd, I.D.H. 2005. From cattle and coke to Charlie: Meeting the challenge of self marketing and personal branding. *Journal of Marketing Management*, 21: 589-606
- Suder, R. 2021. How to Use LinkedIn to Get a Job. Retrieved from: <https://www.topresume.com/career-advice/14-ways-to-leverage-your-linkedin-profile-during-your-job-search> (Accessed: 28.08.2021)
- Susanto, H.; Almunawar, M.N. 2015. Managing Compliance with an Information Security Management Standard. In *Encyclopedia of Information Science and Technology*, 3rd ed.; IGI Global: Hershey, PA, USA, pp. 1452–146
- Trzeciak, S. 2015. *Coaching marki osobistej czyli kariera lidera* (Coaching of a Personal Brand, That Is Leader's Career). Gdańsk: Gdańskie Wydawnictwo Psychologiczne.
- Veil, S. R., Buehner, T., Palenchar, M. J. 2011. A work-in-process literature review: Incorporating social media in risk and crisis communication. *Journal of Contingencies and Crisis Management*, 19(2), 110–122.
- Ward, C., & Yates, D. 2013. Personal branding and eprofessionalism. *Journal of Service Science*, 6(1), 101-104. doi:10.19030/jss.v6i1.8240
- Walaski, P. 2013. Social Media. *Professional Safety*, 58(4), 40-49. <http://search.proquest.com/docview/1331594111?accountid=13380>
- Weiner, D. 2006. Crisis communications: Managing corporate reputation in the court of public opinion. *Ivey Business Journal*, 70, 1–6.
- Wright, E., Khanfar, M., Kizer, L.E. 2010. The lasting effects of social media trends on advertising, *Journal of Business & Economics Research*, 8(11), 73-80.
- Yates, D., Paquette, S., 2011. Emergency Knowledge Management and Social Media Technologies: A Case Study of the 2010 Haitian Earthquake. *International Journal of Information Management*, 31(1), 6-13. <http://www.sciencedirect.com.ezp01.library.qut.edu.au/science/article/pii/S026840121001453>
- Yurchisin, J., Watchravesringkan, K., McCabe, D. B. 2005. An exploration of identity recreation in the context of Internet dating. *Social Behavior and Personality*, 33(8), 735–750.

UDK 616.98:578.834]:005.7  
61:[621.39:004.738.5  
COBISS.SR-ID 57391113

## TELEMEDICINE IN COVID 19 IMPORTANCE OF OPTIMAL AND SUSTAINABLE ORGANIZATIONAL DESIGN

Jane Paunković<sup>1</sup>  
Violeta Jovanović<sup>2</sup>  
Srđan Žikić<sup>3</sup>  
Mihailo Jovanović<sup>4</sup>

<sup>1</sup>Università LUM Giuseppe Degennaro, Bari, Italy, paunkovic@lum.it

<sup>2</sup>Faculty of management Zaječar, Park šuma Kraljevica bb, 19000 Zaječar, violeta.jovanovic@fmz.edu.rs

<sup>3</sup>University Business Academy in Novi Sad, Faculty of Social sciences, Boulevard of Art, no. 2a, 11070  
Belgrade, Serbia, Phone: +381691638162, E-mail: [srdjan.zikic@fdn.edu.rs](mailto:srdjan.zikic@fdn.edu.rs)

<sup>4</sup>Institut Català de Paleocologia Humana i Evolució Social (IPHES) in Tarragona, Edificio W3, Campus  
Sescelades URV, Zona Educacional, 4, 43007 Tarragona, Spain, Phone: +38162407619, E-mail:  
[mihailo.jovanovic@estudiants.urv.cat](mailto:mihailo.jovanovic@estudiants.urv.cat)

### ABSTRACT

*COVID-19 pandemic has significantly disrupted Public Health Care on a global scale since Health Care Systems were not well prepared for an outbreak of this magnitude. The use of e- health technologies have surged worldwide during COVID-19 pandemic because they can contribute to reduction and mitigation of the advancement of the epidemic by respecting social distance measures. Telemedicine can provide support to the healthcare systems, especially in the areas of public health, prevention and clinical practices. Nevertheless, evidence suggests difficulties in the implementation of the new technological advances in Health Systems. In order to realize benefits from new technologies additional attention needs to be given to organizational change, workflow redesign and human factor issues. It is important that the structural design and culture of the organization is associated with the predominant national culture. Harmonious alignment of these two factors supports effective organizational learning that promotes effective utilization of the new technology.*

*Authors are presenting a study designed for introduction of appropriate implementation methodology for sustainable e-health projects. Special attention is given to certain dimensions of national culture which drive the optimal selection of organizational culture and structure.*

### KEYWORDS

*e-health, telemedicine, health management, sustainable implementation, organizational culture, cultural dimensions, COVID-19 pandemic*

## 1. INTRODUCTION

Due to the rapid progression of SARS-CoV-2 virus in human population and spread of the COVID 19 disease, the usual capacity for Health Care is globally exceeded and Health Systems and governments are in a state of constant exertion. One of the most important strategies to reduce and mitigate the advance of the epidemic is social distance measures. In that context Telemedicine can provide support to the healthcare systems, especially in the areas of public health, prevention and clinical practices (Adlhoch et al. 2020;



[www.ecdc.europa.eu/en/publications-data/considerationsrelating-social-distancing-measures-response-covid-19-second](http://www.ecdc.europa.eu/en/publications-data/considerationsrelating-social-distancing-measures-response-covid-19-second))

There are many definitions of telemedicine. For example, Hayes and associates defines telemedicine as the use of electronic services for the transfer of medical data from one side to the other through the Internet, phones, computers, satellites or video conferences in order to provide health care services (Hayes et al, 1996). According to Reid, telemedicine represents use of complex technology for the exchange of information of health and health service delivery, where there are geographical, temporal, social or cultural constraints. Telemedicine includes the use of information and communication technologies, and two way interactive audio/video connection and a computer. This allows the provision of health services to distant patients. This facilitates the exchange of information between primary care physicians and specialists who are far from each other (Reid, 1996).

The World Health Organization (WHO) has adopted the following definition of telemedicine: "Providing health care services, where distance is a critical factor, by health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of diseases and injuries, research and evaluation, and continuing education of health care providers, and all in the interest of improving the health of individuals and their communities "(WHO, 1998).

Telemedicine seeks to provide advice and support, and to reduce the chances of illness or injury. Historically, technology has evolved over the centuries to give the population a better future. That is why greater interest is to improve medical and health technology and to provide more efficient and accessible services to as many people as possible (Dobrović, Peličić, 2020).

The application of telemedicine has many benefits, including environmental sustainability.

Research in California, US, shows that in terms of saving carbon, each telemedical consultation on average is about 330 kilometers of preserved travel for a single patient. It also achieved the following ecological benefits:

- 1) Total reduction of about 1.5 billion kilometers of travel and 6 hours of time spent per patient needed to visit this university clinic.
- 2) Savings of about 700,000 liters of gas - equivalent to 1,700 metric tons of reduced carbon emitted into the atmosphere.
- 3) Saved an average of \$43.00 for the cost of fuel (\$3.00 per 4 liters of gas) per teleconsultation, and a total of \$200 per vehicle maintenance costs (Yellowlees et al, 2010).

According to WHO Telemedicine is a key strategy to maintain and complement health service disrupted in the COVID-19 pandemic, but the design and implementation of a sustainable and cost-effective telemedicine system depends on myriad of factors, starting with understanding supply and demand for health service, the digital infrastructure, the transformation to care pathway, and the investment case. Despite the increasing recognition and political and social adoption of telemedicine throughout the pandemic, implementing a telemedicine system requires careful consideration and planning due to their complexities (<https://www.who.int/publications/i/item/WPR-DSE-2020-032>).

In general, implementation of Health Informatics e-health or program, requires careful planning, effective management, enthusiastic healthcare professionals and support staff, along with a commitment to appropriate funding. It represents the fusion of multiple technologies such as medical devices, network computing, video conferencing, software and telecommunications, into a seamless system. Nevertheless, attention needs to be given to organizational change, workflow redesign (new ways of working) and human factor issues in

order to provide systems that support the dissemination and sharing of meaning, rather than just information (Hartswood et al. 2003). For the first time in human history during COVID-19 pandemic, technology and social media are used to keep people safe, productive and connected while being physically apart (<https://www.who.int/news/item/20-04-2020-itu-who-joint-statement-unleashing-information-technology-to-defeat-covid-19>)

There are significant disparities in adoption of telemedicine or teletherapy to overcome disruptions to in-person services, even if many countries have adopted them (70%). For example, more than 80% of high-income countries reported deploying telemedicine and teletherapy to bridge gaps in mental health, compared with less than 50% of low-income countries (<https://www.who.int/news/item/05-10-2020-covid-19-disrupting-mental-health-services-in-most-countries-who-survey>).

At the beginning of COVID 19 pandemic in April 2020, overall telehealth utilization for office visits and outpatient care was 78 times higher than in February 2020 in the US. The reasons for this change were discussed as: 1) increased consumer willingness to use telehealth, 2) increased provider willingness to use telehealth, 3) regulatory changes enabling greater access and reimbursement. Telehealth offered a bridge to care, a chance to reinvent virtual and hybrid virtual/in-person care models, with a goal of improved healthcare access, outcomes, and affordability (<https://www.mckinsey.com/industries/healthcare-systems-and-services/our-insights/telehealth-a-quarter-trillion-dollar-post-covid-19-reality>).

Clinical applications of Information and Communication Technologies (ICTs) are possible in all areas of patient care (Harno, 1999) and include the real-time and/or store-and-forward technologies (Loane et al, 2000) ranging from telephone and fax machines, e-mail, chat rooms, discussion boards, audio- and videoconferencing, to mobile technologies in recent years (Free C, et al., 2013) Administrative applications include recording (Schoenberg and Safran, 2000) and sharing of billing summaries, electronic connections to pharmacies, etc. Remote medical instruments include various types of imaging technologies (Starren et al. 2005; Bashshur et al. 2000), pressure sensors, haptic feedback devices and robotics. Educational applications focus on continuing medical education for professionals and patients including tele-mentoring.

ICTs in Europe have been found to be of great assistance to healthcare professionals in the process of diagnosis, treatment, monitoring, medication prescription, referral, information retrieval and communication, documentation and transactions (Brennan et al. 2015).

“e-Health can benefit citizens, patients, health and care professionals but also health organizations and public authorities. E-Health – when applied effectively - delivers more personalized ‘citizen-centric’ healthcare, which is more targeted, effective and efficient and helps reduce errors, as well as the length of hospitalization. It facilitates socio-economic inclusion and equality, quality of life and patient empowerment through greater transparency, access to services and information and the use of social media for health” (<http://ec.europa.eu/>).

The overall usage of telemedicine is quite different across the globe. There is higher usage in developing countries within Asia and the Middle East (31% in Saudi Arabia, 27% in India, 24% in China, and 15% in Malaysia) (Ramírez-Correa et al, 2020). However, in Europe, telemedicine is less common (2–4% in Belgium, Serbia, Russia, France, Spain, and Hungary) (Ipsos Global Views On Healthcare - 2018). For example, Italy did not include telemedicine at a fundamental level when the pandemic started, while in France the use of telemedicine significantly increased during the pandemic (Ohannessian et al, 2020).

In Serbia, ICTs have the potential to improve healthcare through the use of information technology in the following ways:

- To improve access to high quality specialty care, especially in rural and poor communities;
- To improve service and quality of health care;
- To improve productivity and efficiency in the health sector;
- To use the opportunities of IT to distribute information to the general public and health care professionals and to increase the level of knowledge;
- To improve working conditions and personal planning for health care professionals (<http://documents.worldbank.org/curated/en/2012/09/16828470/serbia-additional-financing-health-project>).

The extensive review of the e health state of affairs in Serbia has been published (Paunkovic J., Paunkovic N. 2014). Research conducted in Serbia during 2015 indicated potential benefits of telemedicine such as: allows consultation with a specialist; saves time; eliminates the need to travel and travel expenses; allows possibility for obtaining second opinion; offers services in hard to reach areas; offers educational opportunities; cheap diagnostic equipment; allows effective use of resources (personnel and equipment); improved the quality of healthcare; allows convenient access to patient information; provides safety to patients in critical conditions (Skarin, 2016). The same research as the biggest barriers to telemedicine development states: lack of technical capacity (necessary equipment); fear/resistance of new technologies; lack of knowledge about the benefits of telemedicine among stakeholders; limited financial resources; not supported by law/ not part of healthcare system; resistance to changes/preference for conservative way of providing services; lack of support from the Ministry of Health.

Necessary factors for development of telemedicine in Serbia are numerous, but the most important are: enthusiasm of people, who want to improve existing system; provide education about telemedicine and its benefits to all stakeholders; support of the law; clear distribution of responsibilities in the system (Skarin, 2016).

The significant role in the practical application of telemedicine in Serbia has "Heliant" company. Heliant company developed a digital platform for telemedicine examination through which a specialist doctor performs a contactless examination of the patient in the Heliant information system in the health institution where he works. The online platform for telemedicine examination enables digital counseling of patients with a specialist doctor via video call (<https://pcpress.rs/heliant-telemedicina-zdravlje-na-daljini/>).

Heliant is the largest Serbian IT company focused on health and well-being software solutions. The Heliant Health Information System is used in 80% of state health care institutions and a large number of private hospitals. This prevalence will enable the use of telemedicine examination on the entire territory of Serbia. Heliant's telemedicine examination platform enables consultations with a specialist doctor, whenever he deems it possible, to be conducted online, via video call, regardless of the geographical location of the doctor and the patient.

The pilot project implemented at the Zvezdara Clinical Hospital at the Department of Gastroenterology and Hepatology, is the first digital patient counseling center in the history of Serbian state health care. Through the Telemedicine platform, a specialist doctor performs a non-contact telemedicine control examination of a patient suffering from inflammatory bowel disease - IBD. The online platform for telemedicine examination is used by gastroenterologists during outpatient examinations for the purpose of control examinations of patients. By using the platform, patients suffering from this disease are less exposed to external influences of health disorders, which are a consequence of transport to the health

institution and stay in the health institution. After the successful implementation of the pilot project, the application of remote treatment by digital means at the national level is planned.

The patient examination through the Heliant Telemedicine platform takes place in four steps:

- 1) Scheduling,
- 2) Filling in a professional health questionnaire before the examination,
- 3) Video review and
- 4) Obtaining a specialist doctor's report (<https://pcpress.rs/heliant-telemedicina-zdravljenja-daljnu/>).

It is important to emphasize that the first examination must be performed in the physical presence of the patient.

## **2. BACKGROUND AND SIGNIFICANCE**

Health Informatics systems, as well as all new technical implementations, impact the social system of which they become a part (Hartwood et al. 2003; Whitten et al. 2002). The technological innovation must strategically engage stakeholders within its project scope, and be sensitive to cultural beliefs and the local values system. Effective change requires that people not only believe that change is necessary but understand how change will come about and what the consequences will be. Change management is about people, not about changing technology or processes. For change to work, it needs participation from all sides. It should involve all stakeholders, but the message, the training and the involvement should be tailored to the needs of each individual group. For change to last, it has to be reinforced. And the more control people feel they have over the change, the less stressed they become (Witchalls, 2007).

When introducing a new technology that changes the core processes of an organization, such as an e-health initiative, it is important that the structural design and culture of the organization is aligned with the predominant national culture in which the organization is embedded (Hofstede, 1983). When a harmonious alignment is achieved, speedy and effective organizational learning can occur. This, in turn, promotes effective utilization of the new technology (Bangert and Doktor, 2005).

## **3. ORGANIZATIONAL CULTURE**

Organizational culture is based on values, expectations, experiences and behaviour of the members, which contribute to the unique social and psychological environment of that organization. It is expressed as an image, interactions with the outside world, future expectations, and is based on shared attitudes, beliefs and customs, written and unwritten rules that have been developed over the time, and are considered valid. It is interrelated with national culture and organizations have been found to operate at the optimal level when there is alignment between national and organizational culture.

Organizational structure depends on the organization's objectives and strategy. It defines how the roles, power and responsibilities are assigned and how hierarchical arrangement of lines of authority, communications, rights and duties are defined in an organization. It regulates control and coordination of information flows among the different levels of management. Organizational culture and organizational structure have a correlated inter-

relationship. Structure determines the behaviours, attitudes, dispositions and ethics that create the work culture.

Organizational culture could be defined as a system of assumptions, values, norms and attitudes manifested through symbols which the members of an organization have established and adopted through shared experience, which helps them define the meaning of the outside world and the way they interact with it (Robbins, 2013). Organizational culture defines the character of interpersonal relations in the organization, improves motivation of employees, defines a leadership style, reduces the number of conflicts and improves the coordination in the organization (Nazarian, Atkinson, 2013; Lok, Crawford, 2004). Zheng and associates investigated the relationship between organizational culture, structure, strategy and organizational effectiveness, as well as the role of knowledge management in linking these elements. The results of their study shows that organizational culture, structure, strategy and organizational effectiveness have noticeable inter- relationships (Zheng et al, 2010).

Organizational culture is recognized as a key component of knowledge management and organizational learning and is found to be considerably influenced by national culture (Hofstede, 2001). Cultures have an important impact on management approaches, so the cultural differences call for differences in management practices (Newman and Nollen, 1996; Trompenaars and Hampden-Turner, 1998). For organizational culture to function effectively as a part of managerial mechanism, the organizational culture and the formal organizational structure must be harmoniously interrelated (Worley et al. 1996). The structure and culture of an organization must be aligned with the demands and predispositions of the national culture in which the organization is embedded.

Organizational structure represents the way in which business leaders are unified for the realization of certain tasks. A good organizational structure must provide coordination at all levels. When managing an organization both internal and external factors that create an adequate organizational structure enabling organizational goals to be achieved, must be considered. The most influential internal factors are organizational culture and strategy.

Even economic theory recognizes the importance of culture in shaping the behaviours of individuals and institutions. It proposes that beside the formal, the informal institutional context (termed as “cultural socialization”) has influence on the governance structures that coordinate individual action within firms (Festing, 2006).

Cross-cultural analyses are important to show that what may work in one culture, may not be appropriate in another (Hofstede, 1980). The culture is perceived as “the collective programming of the mind which distinguishes the members of one human group to another”, and as its building blocks includes “systems of values”. The attempts to transport Western practices to other nations where the culture is incompatible with the practices are likely to fail (Gomez-Mejia et al. 1997). As such, culture is conceptualized and measured through different value dimensions (Hofstede and Bond, 1988; Trompenaars and Hampden-Turner, 2004). Based on surveying attitudes of 116,000 employees within subsidiaries of IBM in 40 countries and 3 regions Hofstede in 1980 proposed four basic cultural dimensions, largely independent of each other:

- (1) Individualism vs. Collectivism,
- (2) Power Distance,
- (3) Uncertainty Avoidance, and
- (4) Masculinity vs. Femininity.

Collectivism is measured by the Individualism Index (IDV) ranging from 0 (low Individualism, high Collectivism) to 100 (high Individualism). Power Distance is measured

by the Power Distance Index (PDI) ranging from 0 (small PD) to 100 (large PD). Uncertainty Avoidance is measured by the Uncertainty Avoidance Index (UAI) ranging from 8 (lowest UA country) to 112(highest UA country). Masculinity vs. Femininity is measured by the Masculinity Index (MAS) ranging from 0 (low Masculinity) to 100 (high Masculinity).

Identified dimensions relate to the basic values and assumptions shared by community members and key issues that each society faces. In every society there are almost the same problems, but not the same way of their resolution. Hofstede says that the first basic question facing every society and organization (company) is to regulate the nature of the relationship between the individual and the group. He has labelled this dimension as Individualism – Collectivism (Hofstede, 2001).

Ensuring responsible behavior that allows the preservation of order in society is another fundamental issue that is generally facing all societies. The possibility of solving this problem is in the use of differences in power, relying on the role attributed hierarchical systems to enable socially responsible behavior. The problem of inequality among people which exists in every society is resolved through Power Distance. According to Hofstede, it is "the degree to which the less powerful members of organizations and institutions in a country accept the fact that power is unevenly distributed"(Hofstede, 2001).

The problem of the avoidance of uncertainty and the way of reacting to unfamiliar and ambiguous situations, the attitude towards changes and the unknown, has been explained by the Hofstede's dimension - Uncertainty Avoidance.

The attitude of society towards the achievements or relationships is explained with the dimensions of Male versus Female values. This dimension is often explained as the quantity versus quality of life.

Hofstede's original research into national cultures included the former Yugoslavia as the only East European country. After the disintegration of Yugoslavia Hofstede adapted the original data into data on the national cultures of Slovenia, Croatia and Serbia (Hofstede, 2001). According to Hofstede the Serbian national culture is characterized by high PDI - 86, high UAI- 92, Collectivism – low Individualism (IDV)- 25, and high to medium Femininity– low to medium Masculinity (MAS )- 43.

With reference to implementation of E- Health programs Hu (Hu et al. 1999) suggested that cultural and professional, organization variables may be more explanatory of ICT use than perceived usefulness or perceived ease of use. Bangert and Doktor (Doktor et al. 2005) found the work of Geert Hofstede insightful when considering the organizational designs for successful e-health implementation. They argued that only through a harmonious match of organizational structure and culture effective and efficient organizational learning can emerge. And it is only through organizational learning that new technologies can be effectively utilized.

Multiple authors have explored telemedicine acceptance using models rooted in technology acceptance theories or behavioural theories (Harst et al, 2019). Ramírez-Correa and associates have shown that the attitude variable, as well as the subjective norms was the most significant predictor of behavioral intention (Ramírez-Correa et al, 2020). This is linked to cultural research. Research has shown that values and attitudes are related to national culture dimensions. National culture is an important factor that determines the values of organizational culture, organizations behaviour and the employee's behaviour.

#### **4. ORGANIZATIONAL LEARNING**

Organizational learning is a process of acquiring organizational knowledge. Organizational knowledge is not possessed by any employee individually, but the organization has it as a collective. Some authors view organizational learning as changes and adaptation to the environment (Ramirez et al, 2011), adaptation to the environment and transformation of the organization (Argyris, Schon, 1996; Molina, 2000), acquisition of new knowledge in the organization (Huber, 1991), adaptation environment and knowledge acquisition, (Garvin, 2000), adaptation to the environment or transformation and acquisition of knowledge by employees, which depends on the level of development of the organization, (Castaneda, Fernandez, 2007), research and exploitation of knowledge, (March, 1991), or process change in the individual and the common opinion and activity that influences and is embedded in the institutions of the organization (Vera, Crossan, 2003).

In organizational learning, organizational change cannot be neglected. Organizational learning and organizational change are two closely related concepts for the reason that every type of learning implies change. Any change that improves the key competencies of the organization and thus becomes able to adapt to its environment is organizational learning. With each change that is a product of learning, the organization develops new skills and expands the repertoire of competencies.

The process of organizational learning is influenced by a large number of factors, such as organizational culture, national culture, leadership, organizational structure. National culture shapes organizational culture and, through its dimensions, influences the organization's commitment to organizational learning (Esterby-Smith, 1998). Organizational culture and its dimensions influence the way employees think. Based on the existing organizational culture, the ability of organizational learning of a company can be predicted (Lundberg, 1991; Mehrabi et al. 2013; Azadi et al. 2013; Sharifan, Nodehi, 2014). Organizational learning is important for the introduction of new technologies, and education is recognized as one of the important factors for development of telemedicine in Serbia (Skarin, 2016).

#### **5. RESEARCH OBJECTIVE**

The goal of this research was to test general hypothesis that certain problems in implementation clinical e-health programs in Serbia are organizational in their origin, and correlate with dominant national culture. To understand these problems we have investigated a number of organizational characteristics, and associated them with certain cultural dimensions. Our intent was to explore the optimal organizational design for e-health projects, aligned with the predominant national culture. Our hypothesis was that for Serbia with high PDI (86), high UAI (92), and Collectivism – low Individualism (IDV- 25), successful organizational design of e-health projects has to be strongly supported by leadership, but with dominant collectivistic character.

## **6. RESEARCH METHODOLOGY**

### **6.1. Study design**

Our primary study was conducted in Health centres in Serbia which have implemented software “HELIANT”. This health information system has been developed at the Faculty for Electro-Techniques in Belgrade by the request of the Republic Fond for Health insurance. HELIANT is characterized with a multilayer architecture with centralized data base. During its development, open source technologies were exclusively used. It is a web application, developed in Java EE program language. As the applicative server JBoss is being used. Business logistic layer has been implemented through EJB 3.0 technology use. Any of the operational systems can be installed on the PCs. The Program popularly known as HELIANT was primarily created for the secondary health care and but has been successfully adapted for primary care use. Organizational culture was investigated by questionnaires and unstructured interviews to assess participants’ views on optimal organizational design in health care in reference to implementation of this e-health program. Investigation primarily included 78 employees, (54 female, 24male) with different educational background (40 with high school education, 38 with higher education), and work experience (as a rule over 5 years). Participants in the survey were asked to grade on a scale from 1 to 5 (1- not important; 5 - very important) particular organizational characteristics. Subsequently they were asked to assign the rank from 1-10 (1- the most important...) to the same set of characteristics found in the literature to correlate with organizational culture and structure (Doktor et al. 2005). Methods were explained in details in previous publications (Paunkovic et al. 2010).

The additional research related to organizational structure, organizational learning and leadership was conducted in production organizations in Serbia in last ten years. The study included 138 examinees employed in production organizations, located in the municipality of Bor. The aim of this study was to investigate the type of organizational structure, type of leadership and respondents’ values indicating their interest in learning and improving, and to explore the possible association with national culture dimensions according to Hohstede’s model of national culture for Serbia. The investigation was anonymous. The questionnaires included 50 questions concerning organizational structure and culture, organizational learning and leadership, divided into four groups. Participants in the study were asked to grade (1- not important; 5 - very important) questions on a scale of 1 to 5 in the questionnaire. For the purpose of this paper, the groups of questions related to organizational learning, organizational structure and leadership were delineated. The questionnaire was developed by the methodology which the authors described in details in their previous research (Jovanović, 2016; Paunković et al, 2018).

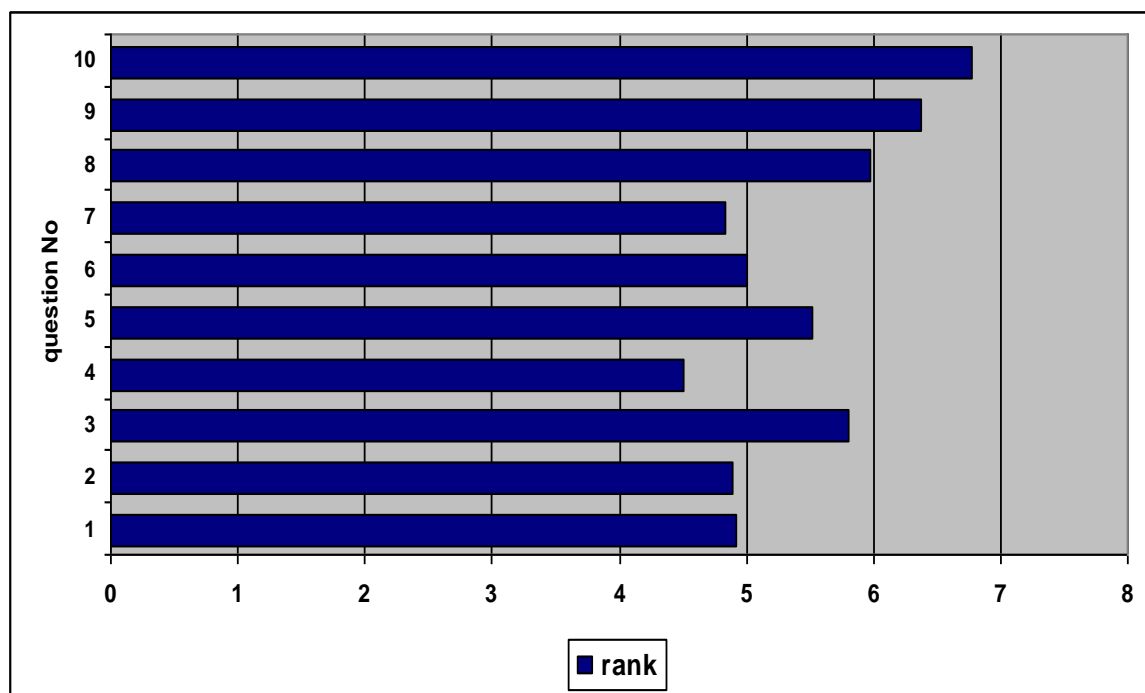
## **7. RESULTS**

The results of investigation of organizational characteristics are presented in the Table 1 and the Figure 1 and Figure 2. Average mark (5 maximum) and average rank (1 as the best) for each investigated characteristic are presented numerically in Table 1.

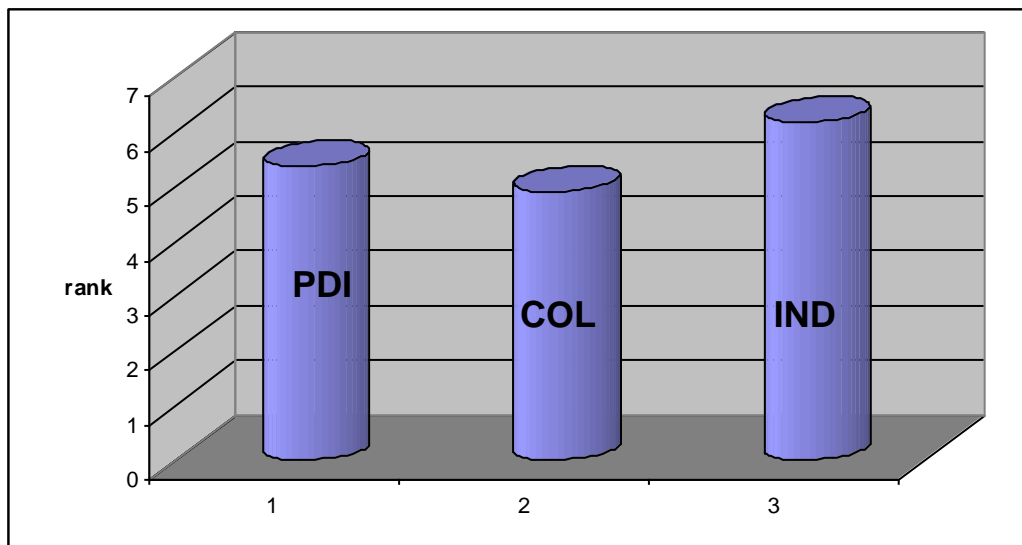


**Table 1.** Average marks and average rank for investigated characteristic

	<b>Organizational characteristic</b>	<b>Average Mark (1-5)</b>	<b>Rank (1-10)</b>
1	Support from superiors	4.52	4.9
2	Involvement of superiors	4.12	4.8
3	Clear instructions from superiors	4.57	5.8
4	Independence in choosing own work style	4.19	4.5
5	Decision making in own line of work	4.23	5.5
6	Good working relations with colleagues	4.60	5
7	Good communication with superiors	4.74	4.8
8	Acknowledge of individual performance through salary	4.12	5.9
9	Career advancement through individual performance	4.35	6.3
10	Support for continuing education	4.4	6.8



**Figure 1.** Average rank for investigated characteristic



**Figure 2.** Pooled values for organizational characteristics associated with PDI (1, 3 ) COL (6,7) IND ( 8, 9)

The research related to organizational structure, organizational learning and leadership was conducted in production organizations in Serbia. The following table represent the average marks for selected questions from the questionnaires.

**Table 2.** Average marks for selected questions

	Questions	Average Mark (1-5)	Standard deviation
1.	Employees in the organization publicly reconsider the decisions of the general manager when they disagree with them – L	2,41	1,001
2.	Managers create and initiate changes in the organization – L	3,83	0,816
3.	There is a clear and precise division of activities and work tasks in the organization - OS	3,88	0,924
4.	Activities and work assignments are grouped - OS	3,89	0,926
5.	There is a well-defined line of authority – who is responsible to whom - OS	4,29	0,898
6.	The main strategic decisions are made by top management without participation of managers from lower levels and employees - OS	3,82	1,108
7.	Decisions are made at all levels of the organization with the participation of all employees - OS	2,30	1,106
8.	The behavior of employees is precisely defined by certain rules and procedures - OS	4,17	0,948
9.	My organization is constantly collecting information about new technologies and innovations - OL	3,63	1,014
10.	In my organization, employees are often trained to acquire the necessary skills - OL	3,64	1,052

11.	In my organization, employees always want to improve - OL	3,83	0,940
12.	In my organization, employees are always rewarded for learning - OL	3,28	1,120
13.	The organization enables employees to get the necessary information quickly and easily - OL	3,34	1,287
14.	Management supports employees in continuous training - OL	3,74	1,076

L – leadership

OS – organizational structure

OL – organizational learning

## 8. DISCUSSION

E-Health programs are actually more predominately change programs, or service improvement programs, with the implementation of technology being only part of the solution (Legris & Collette, 2006). Concentrating mainly on the technological aspects of these programs has been found to lead to less effective results. Cultural norms and the nature of the job have been found by Lucas and Spitler (Lucas and Spitler, 1991) to be far more important in predicting use of technology than the potential user's perception of likely usefulness or ease of use.

In our primary study, as the most important organizational characteristic participants have recognized involvement and support from superiors, communication between superiors and between colleagues, and independence in choosing their way of working, clear instructions from superiors, acknowledgement of individual performance and career advancement through individual performance were found less important. The least important for the participants was support for continuing education. It correlated with our hypothesis that organization of the e-health project has to be strongly supported by leadership (high PDI culture), with dominant collectivistic conduct (very important working relations with colleagues and good communication with superiors), and minor individualistic performance (acknowledge of individual performance through salary, career advancement through individual performance). Nevertheless, some of the characteristics that could be associated with individualism (independence in choosing own work style) was also ranked high. We have already published analogous studies on implementation of information technology projects in Health Care (Paunkovic et al. 2010; Paunkovic et al. 2010). In both studies participants have delineated interdependence and team work along with acknowledgement of individual performance, and highlighted clear instructions from superiors, acknowledge of individual performance and independence in choosing their way of working. The least important for the participants, as a rule, was the involvement from the leadership.

The results of the survey of leadership, organizational structure and organizational learning are correlated with the results of research related to value attitudes that depend on national culture. The average mark of 3.82 for the claim that the main, strategic decisions for the company, as well as other decisions related to the business of the organization, are made by top management, without participation of managers from lower levels and employees, shows that the structure of the company is centralized. This is confirmed by the great disagreement with the claim „Decisions are made at all levels of the organization with the participation of all employees“ (average mark 2.30). These results corroborate Hofstede's research on national culture dimensions (Gomez-Mejia and Palich, 1997; Hofstede and Bond, 1988). According to

Hofstede, national culture of Serbia is characterized by high Power Distance Index (PDI), and consequently, organizations are generally expected to have centralized form of organizational structure.

Bangert and Doktor in 2005 (Doktor et al. 2005) exploring selected organizational categories with US IT professionals, have found involvement and strong leadership, and acknowledgement of individual performance as the most important, while support for continuing education and new things were ranked as the least important. In the same study, IT professionals from South Korea have ranked as the most important to have clear rules to follow and loyal fellowship.

Results of this study confirm our first observation, that successful organizational design in investigated organizations in Serbia, has to be “somewhere in between” (“West –East orientation”).

Critics of Hofstede’s work believe that he takes too simplistic a view of the multifaceted, complex dimensions which comprise the notion of culture. Although his work has been criticized by various authors (Sondergaard, 1994; Gerhart and Fang, 2005), the usefulness of the categories he developed remains very popular and utilized by scholars in a variety of fields including ICT, management and health care.

The coronavirus disease 2019 (COVID-19) pandemic has resulted in major disruption to public health care. Adopting technologies driven by e-health platforms that can significantly help patients in a situation like COVID-19 pandemic appears to be necessary. As stated earlier by Rashid Bashshur (2013), it is important that the considerable promise of telemedicine in addressing issues of quality, efficiency, cost, and access to care should be placed at the forefront of national efforts to reform healthcare (Bashshur et al. 2013).

The recent research (Rahi) performed during COVID 19 pandemic indicate that health-care professional can boost patient behaviour towards the adoption of telemedicine health services by improving service quality, computer self-efficacy and performance expectancy of telemedicine website (Samar et al. 2021). Once again it emphasises the importance of organizational aspects in Health Care and importance of human factor in creating the optimal organizational and sustainable design in health care institutions.

## REFERENCES

- Adlhoch C, Baka A, Ciotti M, Gomes J, Kinsman J, Leitmeyer K, et al. Considerations related to social distance measures in response to the COVID-19 epidemic. <https://www.ecdc.europa.eu/en/publications-data/considerations-relating-social-distancing-measures-response-covid-19-second> (accessed on 11/December/2020).
- Azadi A., Eslami Farsani M., Mirsafaei Rizi R., Aroufsad S., (2013) Relationship between organizational culture and organizational learning among employess in physical education organizations, *European Journal of Sports and Exercise science*, 2 (1), pp. 12-16, Available online at [www.scholarsresearchlibrary.com](http://www.scholarsresearchlibrary.com)
- Bashshur, R. L., Reardon, T. G., & Shannon, G. W. (2000). Telemedicine: a new health care delivery system. *Annual review of public health*, 21(1), 613-637.
- Bashshur, R. L., Shannon, G., Krupinski, E. A., & Grigsby, J. 2013. Sustaining and realizing the promise of telemedicine. *Telemedicine and e-Health*, 19(5), 339-345.
- Brennan, J. E., McElligott, A., & Power, N. (2015). National health models and the adoption of eHealth and ePrescribing in primary care—new evidence from Europe.
- Castañeda, D.I. and Fernández, M. (2007). From individual learning to organizational learning. *The Electronic Journal of Knowledge Management*, 5, 363-372.

- David C. Bangert and Robert Doktor (eds.). Human and Organizational Dynamics in e-Health. Radcliffe: Oxford/Seattle, 2005.
- Dobrović D., Peličić D. (2020) Telemedicine in the covid-19 pandemic, Health Care 49(4)
- Doktor R, Bangert D, Valdez M, Organizational Learning and Culture in the Managerial Implementation of Clinical e-Health Systems An International Perspective Proceedings of the 38th Hawaii International Conference on System Sciences – 2005
- Easterby-Smith, M. (1998) *Organizational learning and National Culture: Do models of organizational learning apply outside the USA?* Boletín de Estudios Económicos 53 (Aug 1, 1998): 281.
- Festing, M. (2006), “International human resource management and economic theories of the firm”, in: Gunter K. Stahl and Ingmar Bjorkman (eds.), Handbook of Research in International Human Resource Management, Cheltenham, UK: Edward Elgar, 449-462.
- Free, C., Phillips, G., Galli, L., Watson, L., Felix, L., Edwards, P., ... & Haines, A. (2013). The effectiveness of mobile-health technology-based health behaviour change or disease management interventions for health care consumers: a systematic review. *PLoS medicine*, 10(1), e1001362.
- Garvin, D. A. (2000). The US Army's after action reviews: Seizing the chance to learn. *Learning in action, a guide to putting the learning organization to work*, 106-116.
- Gerhart, B. and M. Fang (2005), “National Culture and Human Resource Management: Assumptions and Evidence”, *International Journal of Human Resource Management*, June, 971-986
- Gomez-Mejia, L.R. and L.E. Palich (1997), “Cultural Diversity and the Performance of Multinational Firms”. *Journal of International Business Studies*, Vol 28, No 2, 309-335.
- Harno, K. S. R. (1999). Telemedicine in managing demand for secondary-care services. *Journal of Telemedicine and Telecare*, 5(3), 189-192.
- Harst, L.; Lantzsich, H.; Scheibe, M. Theories predicting end-user acceptance of telemedicine use: Systematic review. *J. Med. Internet Res.* 2019, 21, e13117.
- Hartwood, M., Procter, R., Rouncefield, M., & Slack, R. (2003). Making a case in medical work: implications for the electronic medical record. *Computer Supported Cooperative Work (CSCW)*, 12(3), 241-266.
- Hayes, T., Kinsella, A., Brown, N. A., & Perednia, D. A. (1996). The Telemedicine Information Exchange (TIE). *Journal of telemedicine and telecare*, 2(1), 20-27.
- Health-For-All strategy for global health development: report of the WHO group consultation on health telematics, 11-16 December. Geneva, World Health Organization.
- Hofstede, G. (1983), “The cultural relativity of organizational practices and theories”, *Journal of International Business Studies*, Fall, 75-89.
- Hofstede, G. (2001), *Culture's Consequence*, Thousand Oaks, CA: Sage Publications
- Hofstede, G. (1980) “Motivation, Leadership and Organization: do American Theories Apply Abroad?”, *Organizational Dynamics*, Summer, 42-46.
- Hofstede, G. and M.H. Bond (1988), “The Confucius connection: From cultural roots to economic growth”, *Organizational Dynamics*, 16, 4-21.
- Hollander, J. E., and B. G. Carr. 2020. “Virtually Perfect? Telemedicine for COVID-19.” *New England Journal of Medicine* 382 (18): 1679–168
- <http://documents.worldbank.org/curated/en/2012/09/16828470/serbia-additional-financing-health-project> (accessed on 11/December/2020).
- <http://ec.europa.eu/> (accessed on 14/December/2020).
- <https://pcpress.rs/heliant-telemedicina-zdravlje-na-daljini/> (accessed on 28/November/2020).

- <https://www.mckinsey.com/industries/healthcare-systems-and-services/our-insights/telehealth-a-quarter-trillion-dollar-post-covid-19-reality> (accessed on 10/December/2020).
- <https://www.who.int/news/item/05-10-2020-covid-19-disrupting-mental-health-services-in-most-countries-who-survey> (accessed on 30/November/2020).
- <https://www.who.int/news/item/20-04-2020-itu-who-joint-statement-unleashing-information-technology-to-defeat-covid-19> (accessed on 15/December/2020).
- <https://www.who.int/publications/i/item/WPR-DSE-2020-032> (accessed on 17/December/2020).
- Hu P, Chau P, Sheng O, Tam K. (1999) Examining the technology acceptance model using physician acceptance of telemedicine technology. *Journal of Management Information Systems* 1999;16,2:91-112.
- Huber, G. (1991). Organizational learning: The contributing processes and the literatures. *Organization Science*, 2, 88-115.
- Ipsos Global Views On Healthcare—2018. Available online:  
<https://www.ipsos.com/sites/default/files/Global%20Views%20on%20Healthcare%2018%20-%20Personel%20Health%20Perceptions.pdf>
- Jovanović V. (2016) Organizaciono učenje kao faktor održivog upravljanja privrednim društvima, Doktorska disertacija, Fakultet za menadžment Zaječar
- Jovanović V., Paunković J., Stevanović M., (2017). Organizational learning for sustainable development: correlation with the national culture dimensions framework, *Megatrend Review*, vol.14, iss.3, pp.1-19.
- Legris, P., & Colletette, P. (2006). A roadmap for IT project implementation: Integrating stakeholders and change management issues. *Project Management Journal*, 37(5), 64-75.
- Loane, M. A., Bloomer, S. E., Corbett, R., Eedy, D. J., Hicks, N., Lotery, H. E., ... & Wootton, R. (2000). A comparison of real-time and store-and-forward teledermatology: a cost-benefit study. *British Journal of Dermatology*, 143(6), 1241-1247.
- Lok, P., & Crawford, J. (2004). The effect of organisational culture and leadership style on job satisfaction and organisational commitment: A cross-national comparison. *Journal of management development*. 23(4), 321-338.
- Lucas HC, Spitler VK. Technology Use. Performance : A Field Study of Broker Workstations. *Decisions Sciences* 1991;30,2:291-311
- Lundberg, C. C. (1991) "Organizational learning and organizational culture." Eastern Academy of Management Meetings, Hartford, CT
- March, J. (1991). Exploration and exploitation in organizational learning. *Organization Science*, 2, 71-87.
- Mehrabi J., Alemzadeh M., Jadidi M., Mahdevar N, (2013) Explaining the Relation between Organizational Culture and Dimensions of the Learning Organization Case Study: Telecommunications Company in Borujerd County, *Interdisciplinary journal of contemporary research in business*, Vol 5, No 8
- Molina, H. (2000). El desarrollo organizacional como facilitador de cambio. *Estudios Gerenciales*, (77), 13-26.
- Nazarian, A., & Atkinson, P. (2013). How size affects organizational culture in a national context. *Pensee*, 75(12).
- Nazarian, A., & Atkinson, P. (2013). Impact of culture on leadership style: the case of Iranian organisations. *World Applied Sciences Journal*, 28(6), 770-777.
- Newman, K. L. and S.D. Nollen (1996), "Culture and Congruence: The Fit between Management Practices and National Culture", *Journal of International Business Studies*, 27(4), 753-779.

- Ohannessian, R.; Duong, T.A.; Odone, A. Global Telemedicine Implementation and Integration Within Health Systems to Fight the COVID-19 Pandemic: A Call to Action. *JMIR Public Health Surveill.* 2020, 6, e18810.
- Paunković J., Jovanović R, Stojković Z. and Stojković I. 2010. Sustainable implementation of information and communication Technology in health care. Case study of organizational and cultural factors. *Sibiu Alma Mater University Journals. Series A. Economic Sciences*, 3(3), September 2010, 1–8.
- Paunkovic J., Paunkovic N. (2014) eHealth for Sustainable Health Care in Serbia, Editor(s): Woodrow W. Clark, Grant Cooke, *The Green Industrial Revolution*, Butterworth-Heinemann, 2015, Pages 491-513, ISBN 9780128023143, <https://doi.org/10.1016/B978-0-12-802314-3.09984-4>.  
(<https://www.sciencedirect.com/science/article/pii/B9780128023143099844>)
- Paunkovic J., Stojkovic I., Stojkovic Z., Zikic S. Awareness of organizational culture is important for sustainable implementation of e- health International Scientific Conference Management of Technology – Step to Sustainable Production June 2010, Rovinj, Croatia ISBN 978-953-7738-09
- Ramírez, A. M., Morales, V. J. G., & Rojas, R. M. (2011). Knowledge creation, organizational learning and their effects on organizational performance. *Engineering Economics*, 22(3), 309-318.
- Ramírez-Correa, P., Ramírez-Rivas, C., Alfaro-Pérez, J., & Melo-Mariano, A. (2020). Telemedicine acceptance during the COVID-19 pandemic: an empirical example of robust consistent partial least squares path modeling. *Symmetry*, 12(10), 1593.
- Reid, J. (1996). *Telemedicine primer*. Innovative Medical Communications.
- Robbins S. P., Judge T. A. (2013) *Organizational Behavior*, 15 edition, Prentice Hall
- Samar, Mubbsher Munawar Khan & Mahmoud Alghizzawi (2021) Factors influencing the adoption of telemedicine health services during COVID-19 pandemic crisis: an integrative research model, *Enterprise Information Systems*, 15:6, 769-793.
- Schoenberg, R., & Safran, C. (2000). Internet based repository of medical records that retains patient confidentiality. *Bmj*, 321(7270), 1199-1203.
- Schön, D., & Argyris, C. (1996). Organizational learning II: Theory, method and practice. *Reading: Addison Wesley*, 305(2).
- Shrarifan R .A., Nodehi H. (2014) The relationship between organizational learning and organizational culture (Case study in education of neyshabur city), *Reef Resources Assessment and Management Technical Paper* ISSN: 1607-7393 RRAMT 2014- Vol. 40, 2014, 1, Available online at [www.behaviorsciences.com](http://www.behaviorsciences.com)
- Skarin V. (2016) Potential benefits of the application of telemedicine in Serbia, Master Thesis, Faculty of American Public University
- Sondergaard, M. (1994), “Research Note: Hofstede’s Consequences: A Study of Reviews, Citations and Replications”, *Organization Studies*, 15(3), 447-456.
- Starren, J., Tsai, C., Bakken, S., Aidala, A., Morin, P. C., Hilliman, C., ... & Shea, S. (2005). The role of nurses in installing telehealth technology in the home. *CIN: Computers, Informatics, Nursing*, 23(4), 181-189.
- Trompenaars, F. and C. Hampden-Turner (1998), *Riding the waves of culture: Understanding cultural diversity in global business*, 2nd edition, New York: McGraw-Hill.
- Trompenaars, F. and C. Hampden-Turner (2004), *Managing People Across Cultures*. Capstone Publishing.
- Vera, D. and Crossan, M. (2003). Organizational learning and knowledge management: Toward an integrative framework. In: Easterby-Smith, M. and Lyles, M. (eds.),

- The Blackwell Handbook of Organizational Learning and Knowledge Management* (p. 122- 142). Oxford: Blackwell Publishing.
- Whitten P S, Mair F, Haycox A, May C, Williams T, Hellmich S :Systematic review of cost effectiveness studies of telemedicine interventions BMJ, Jun 2002; 324: 1434 – 37
- Witchalls, 2007 Clint. The art of change management. Computing. (June 28, 2007): 33
- World Health Organization - WHO. (1998). A health telematics policy in support of WHO's
- Worley CG, Hitchin DE, Ross WL. Integrated Strategic Change: How OD Builds Competitive Advantage. New York, NY: Addison-Wesley Publishing Company, 1996
- Yellowlees, P.M., Chorba, K., Burke Parish, M., Wynn-Jones, H., & Nafiz, N. (2010). Telemedicine can make healthcare greener. *Telemedicine and e-Health*, 16(2), 229-232.
- Zheng, W., Yang, B., & McLean, G. N. (2010). Linking organizational culture, structure, strategy, and organizational effectiveness: Mediating role of knowledge management. *Journal of Business research*, 63(7), 763-771.



## APPLICATION OF AN EFFICIENT ALGORITHM FOR OPTIMIZATION MIXTURE COMPOSITION OF BORONIZING PROCESS DURING THE COVID-19 PANDEMIC

Emina Požega<sup>1</sup>  
Slavica Miletic<sup>2</sup>

<sup>1,2</sup> Mining and metallurgy Institute Bor, Zeleni bulevar 35, Bor, Serbia,  
<sup>1</sup>emina.pozega@irmbor.co.rs  
<sup>2</sup>slavica.miletic@irmbor.co.rs

### ABSTRACT

Appearance of the covid-19 virus caused a social and economic disorder, a change in the world and people's lives. In order to reduce energy consumption, production costs, obtain high material utilization, reduce the number of experiments in difficult working conditions during the pandemic, a program for boronizing process simulation was applied. The paper presents application of an efficient algorithm for optimization mixture composition of boronizing process during the covid-19 pandemic. The practical application of the tested composition of activators in the boride-based boron mixture on iron powder castings was achieved through obtaining materials with a quality boride layer and with characteristics that meet the conditions of application in modern industrial plants. In order to apply the activator in the boron-based boronizing mixture as the most suitable ratios for obtaining quality boride layers, the obtained samples were characterized. A simplex plan with fifteen experimental points was used for the experiment, and a polynomial of the fourth degree was used for the mathematical model. The impact of the COVID-19 consequences on science and scientists, their works and researches is reduced this way.

### KEYWORDS

COVID-19, analysis, evaluation, boronizing, boride layers

JEL: C3, O1

### 1. INTRODUCTION

Many authors have conducted research on the impact of the consequences caused by COVID-19 on economy, society, science, life and work of people and scientists (Segal & Gerstel, 2020; Paul & Chowdhury, 2020).

In this paper we will present the experience of our research group at the simultaneously sintering and boronizing process using an efficient algorithm for optimization mixture composition during the covid-19 pandemic.

Industrial applications of wear and corrosion resistant materials include: drive shafts, camshafts, pulleys, machine slide-ways, tanks, weapons and parts for agricultural machinery (İpek et al., 2000). Considerable economic loss occurs because of corrosion and wears in mechanical parts of machines and equipment during service. In order to reduce this loss, properties of the surface region of materials should be improved. One of the methods used to improve the surface quality is boriding (Meric et al., 2006; Selçuk et al., 2000; Stojanović & Stanisavljev, 2013; Stojanović et al., 2017; Özge et al., 2016; Makuch, 2020; Makuch et al., 2019). Boriding is a thermochemical surface hardening treatment in which boron atoms are diffused into the metal surface at elevated temperatures, usually between 1223 and 1373 K to form a hard layer of borides consisting of FeB and/or Fe<sub>2</sub>B, needle-like microstructure, of about 150 µm thick (Keddām, 2004; Hunger & Trute, 1994; Xu et al., 1997). The crystal structure is orthorhombic for FeB, while Fe<sub>2</sub>B has a body centered tetragonal structure (Ramirez et al., 2007). The diffusion of boron into the surface of selected samples creates a fully dense reaction zone of metal borides. This effectively generates superior surface properties of materials (Sen et al., 2005). A single-phase structure is desirable and Fe<sub>2</sub>B is preferred to FeB, since FeB is very hard and brittle. Furthermore, since FeB and Fe<sub>2</sub>B phases exhibit substantially different coefficients of thermal expansions, crack formation is often observed at the interface between FeB and Fe<sub>2</sub>B. These cracks often lead to flaking of the coated layer when mechanical load is applied. By controlling the boron activity of the boriding medium and chemical composition of the sample to be treated, it is possible to obtain a microstructure consisting of only Fe<sub>2</sub>B phase without the FeB phase (Sen et al., 2005; Campos et al., 2005). This process is similar in its physical and chemical characteristics to other surface hardening treatments, such as carburization and nitriding. The advantage of boriding over other types of surface hardening methods is that, the surface layer is very hard, friction coefficient is very low, no extra heat treatment is required after boriding and it has considerable resistance against some acid, base, metal solutions and high temperature oxidation. It has been successfully applied to all ferrous materials, nickel alloys, titanium alloys, sintered carbides (Sinha, 1991; Chatterjee, 1989) and sintered materials are significantly different from materials formed by conventional methods (casting, plastic deformation), both in structure and properties. One of the major differences in the structure is presence of porosity in these materials. Porosity, grain distortion, great length of grain boundaries are factors that significantly influence iron sintered material diffusion saturation processes. Boriding of a steel surface allows reducing essentially a velocity of corrosion, wear and shapes of fatigue cracks occurring in an outcome of its operation (Ozdemir, 2006). This process can be performed in solid, liquid or gaseous medium. The boriding in solid medium is technologically simpler and low cost, comparable to other boriding processes (Voroshnin et al., 1977; Požega, 2008; Allaoui et al., 2006; Celebi et al., 2005; Keddām & Chentouf, 2005; Dong et al., 2009). The boriding agent is in powder form. The boriding in solid medium can be carried out under inert atmosphere as well as in tightly closed boxes. Pack boriding method is a process similar to pack carburizing process (Genel et al., 2002; Erdemir & Bindal 1995). The knowledge of the boriding parameters, such as time, temperature, chemical composition and the activators percentage ratio, the composition of the basic mixture, are necessary for control and automation of the pack boriding process. Through the control of boriding process parameters, i.e. boriding powder composition, temperature, time, Fe<sub>2</sub>B phase can be consistently achieved during pack boriding (Jain & Sundararajan 2002).

Modelling and simulation, including computer simulation/calculation software (Berger et al., 2017) or program and mathematical representations of physics and chemistry of complex metallurgical systems, have been increasingly used to assist process development and design, process evaluation and optimization, production scheduling and planning, process control,

and business evaluation. Keddami et al. (Stojanović & Stanisavljević, 2013) developed the diffusion model based on Fick's laws. Their model has allowed simulation the growth kinetics of boride layers on the iron substrate. Kayacan, Şahin and Taştan proposed mathematical model which is based on the nonlinear Fourier law. Diffusion mechanism of the boriding process of AISI 1040 has been studied (Kayacan et al., 2010).

The growth kinetics of Fe<sub>2</sub>B boride layers generated at the surface of a gray cast iron via the powder-pack boriding was estimated by kinetic model (Keddami & Chegroune, 2010). By the use of the mass balance equation at the (Fe<sub>2</sub>B/sample) interface under certain assumptions and considering the effect of the boride incubation time, it was possible to estimate the corresponding parabolic growth constant for three process temperatures and four treatment times.

In this paper is presented an efficient algorithm for a software package of the fourth degree polynomial. The planned experiment represents a new approach to experimental research in which mathematical methods have an active role. Used algorithm for computer program, based on the regression equation, has enabled to obtain the volume change, porosity and depth coordinates and to draw a graph (simplex triangle) (Krasovsky & Filaretov, 1982).

The main interest has been focused on the choice of boriding mixture, activators and their relationship in order to obtain quality boride layers and to monitor certain events at boriding by algorithm for computer program.

## **2. MATERIAL AND METHODS**

Experimental investigation executed in this study included: activators and mixtures composition for boriding choice, pressing pressure, temperature and boriding time. The characterization of iron powder was done as well as powders mixture homogenization, iron compacts formation, pressing samples characterization, boriding of pressed iron samples and their characterization, in order to determine influence of activators on constitution of diffusion layer compacts from iron powder at boriding process. Our own experience was used in selection of the boriding mixture, so the best results of the boride layer depth and quality were achieved using a mixture with boron carbide (B<sub>4</sub>C) and activators. NH<sub>4</sub>HF<sub>2</sub>, NH<sub>4</sub>Cl, and KBF<sub>4</sub> were used as activators in the boriding process. The content of the basic components in the compound prepared for boriding was constant, but the activator's content was variable. The percentage share of the activator was different and it was in the range of 0 to 4 wt %. The regime of boriding was the same for all samples: the temperature was 1223 K and the process time was 4 hours. The samples obtained from iron powder NC 100.24 (Höganäs) by pressing under 400 MPa, had rectangular forms, with the cross-section dimensions of 31 mm × 12 mm.

In order to obtain reliable results the two samples were borided under the same conditions.

The particles are sponge forms, which is characteristic of powders obtained by reduction. Iron powder characterization was carried out by determining the apparent density, outlet flow velocity, specific surface area, chemical and granulometric compositions. Samples were packed in a boriding box made of special steel. The box was then placed into an electrical resistance furnace for boriding. Samples were taken out from the box by removing the used boriding mixture when the box was gradually cooled to room temperature. In boriding treatment, as a result of boron diffusion into the surface, a boride layer in the upper surface of the borided specimen was formed; just under this layer there was a diffusion zone and in the inner part was the base material. The boride layer, having toothed structure, was made up of iron-boride phases.

Samples dimensions before and after boriding are given in Table 1. The linear dimensions of samples, before and after boriding process on the basis of which the volume changes (in Table 2.) was determined, were measured with the precision of  $\pm 0.01$  mm. The porosity of samples was determined with the vacuum method. Samples porosity changes are given in Table 3. The boride layer depth was determined by a device for hardness measurement, with precision of  $\pm 0.5$   $\mu\text{m}$ . For each sample the cross-section was measured eight times and the average values were calculated. The depth of boride formed on the samples surface is strongly dependent of activators. The obtained boride layer depth results are given in Table 4. The presence of borides formed on sample surfaces was identified by X - ray diffraction (XRD) measurements which were performed on the Siemens device “KRISTALLOFLEX 810”. For recording is used Cu anti – cathode with filtered radiation, Ni filter, at voltage of 40 KV and current intensity of 20 mA. To compare changes in microstructure caused by boriding process, metallographic examination of boriding samples cross – section was carried out.

**Table 1. Dimensional changes before and after boriding**

numbe r of sample s	activators	h (mm)		b (mm)		l (mm)		$\Delta h^a$ (%)	$\Delta b^a$ (%)	$\Delta l^a$ (%)
		h before	h after	b before	b after	l before	l after			
I	4%NH <sub>4</sub> FHF	11.7	11.635	12.1	12.11	30.1	30.24	-0.556	0.083	0.465
		11.7	11.625	12.1	12.115	30.1	30.2	-0.641	0.124	0.332
II	4%NH <sub>4</sub> Cl	11.6	11.61	12.1	12.16	30.1	30.22	0.086	0.496	0.399
		11.6	11.69	12.1	12.295	30.1	30.56	0.776	1.611	1.528
III	4%NH <sub>4</sub> Cl	11.82	11.575	12.1	12.18	30.1	30.21	-2.073	0.661	0.365
		11.82	11.51	12.1	12.125	30.1	30.2	-2.623	0.207	0.332
IV	1%NH <sub>4</sub> FHF 3%KBF <sub>4</sub>	11.92	11.88	12.1	12.145	30.1	30.2	-0.336	0.372	0.332
		11.92	11.79	12.1	12.18	30.1	30.2	-1.091	0.661	0.332
V	2%NH <sub>4</sub> FHF 2%KBF <sub>4</sub>	11.22	11.21	12.1	12.13	30.1	30.19	-0.089	0.248	0.299
		11.27	11.27	12.1	12.125	30.1	30.17	0	0.207	0.232
VI	3%NH <sub>4</sub> FHF 1%KBF <sub>4</sub>	11.8	11.54	12.1	12.11	30.1	30.17	-2.204	0.083	0.232
		11.8	11.72	12.1	12.105	30.1	30.27	-0.678	0.041	0.565
VII	3%NH <sub>4</sub> FHF 1%NH <sub>4</sub> Cl	11.4	11.735	12.1	12.13	30.1	30.19	2.938	0.248	0.299
		11.57	11.54	12.1	12.135	30.1	30.21	-0.259	0.289	0.365
VIII	2%NH <sub>4</sub> FHF 2%NH <sub>4</sub> Cl	11.65	11.64	12.1	12.15	30.1	30.49	-0.086	0.413	1.296
		11.65	11.555	12.1	12.17	30.1	30.2	-0.815	0.578	0.332
IX	1%NH <sub>4</sub> FHF 3%NH <sub>4</sub> Cl	11.15	11.165	12.1	12.18	30.1	30.22	0.134	0.661	0.399
		11.22	11.315	12.1	12.2	30.1	30.25	0.847	0.826	0.498
X	3%NH <sub>4</sub> Cl 1%KBF <sub>4</sub>	12.05	12.135	12.1	12.635	30.1	30.37	0.705	4.421	0.897
		12	12.065	12.1	12.31	30.1	30.25	0.542	1.735	0.498
XI	2%NH <sub>4</sub> Cl 2%KBF <sub>4</sub>	11.4	11.34	12.1	12.125	30.1	30.25	-0.526	0.207	0.498
		11.4	11.675	12.1	12.14	30.1	30.25	2.412	0.330	0.498
XII	1%NH <sub>4</sub> Cl 3%KBF <sub>4</sub>	11.52	11.705	12.1	12.155	30.1	30.25	1.606	0.454	0.498
		11.82	11.535	12.1	12.145	30.1	30.2	-2.411	0.372	0.332
XIII	1%NH <sub>4</sub> FHF 2%NH <sub>4</sub> Cl 1%KBF <sub>4</sub>	11.52	11.745	12.1	12.14	30.1	30.3	1.953	0.330	0.664
		11.85	11.59	12.1	12.135	30.1	30.19	-2.194	0.289	0.299
XIV	1%NH <sub>4</sub> FHF 1%NH <sub>4</sub> Cl 2%KBF <sub>4</sub>	11.45	11.695	12.1	12.125	30.1	30.19	2.140	0.207	0.299
		11.4	11.615	12.1	12.11	30.1	30.18	1.886	0.083	0.266
XV	2%NH <sub>4</sub> FHF 1%NH <sub>4</sub> Cl 1%KBF <sub>4</sub>	11.75	11.685	12.1	12.185	30.1	30.24	-0.553	0.702	0.465
		11.77	11.615	12.1	12.15	30.1	30.32	-1.317	0.413	0.731

$${}^a \Delta h, \Delta b, \Delta l = \frac{h, b, l_{\text{afterboriding}} - h, b, l_{\text{beforeboriding}}}{h, b, l_{\text{beforeboriding}}} \cdot 100\%$$

$h, b, l_{\text{after}}$  – samples dimension (measure) after boriding [mm]

$h, b, l_{\text{before}}$  – samples dimension (measure) before boriding (compact samples dimension) [mm]

**Table 2.** Weight and volume changes before and after boriding

number of samples	activators	$m_1$ (g) samples weight before boriding	$m_2$ (g) samples weight after boriding	$\Delta m$ (g) weight of boroning layer	$V_1$ (cm <sup>3</sup> ) samples volume before boriding	$V_2$ (cm <sup>3</sup> ) samples volume after boriding	$\Delta V^b$ (%) volume changes
I	4%NH <sub>4</sub> FHF	24.91	25.53	0.62	4261.257	4260.811	-0.010
		24.98	25.59	0.61	4261.257	4253.274	-0.187
II	4%NH <sub>4</sub> Cl	24.98	25.49	0.51	4224.836	4266.387	0.983
		24.94	25.72	0.78	4224.836	4392.344	3.965
III	4%NH <sub>4</sub> Cl	25.01	25.42	0.41	4304.962	4259.112	-1.065
		24.98	25.36	0.38	4304.962	4214.674	-2.097
IV	1%NH <sub>4</sub> FHF 3%KBF <sub>4</sub>	25.02	25.49	0.47	4341.383	4357.335	0.367
		24.98	25.4	0.42	4341.383	4336.786	-0.106
V	2%NH <sub>4</sub> FHF 2%KBF <sub>4</sub>	25.07	25.48	0.41	4086.436	4105.155	0.458
		24.8	25.25	0.45	4104.647	4122.693	0.440
VI	3%NH <sub>4</sub> FHF 1%KBF <sub>4</sub>	24.99	25.53	0.54	4297.678	4216.239	-1.895
		25.01	25.46	0.45	4297.678	4294.423	-0.076
VII	3%NH <sub>4</sub> FHF 1%NH <sub>4</sub> Cl	24.99	25.74	0.75	4151.994	4297.412	3.502
		25.07	25.72	0.65	4213.91	4230.545	0.395
VIII	2%NH <sub>4</sub> FHF 2%NH <sub>4</sub> Cl	25.01	25.83	0.82	4243.047	4312.079	1.627
		25.01	25.68	0.67	4243.047	4246.855	0.090
IX	1%NH <sub>4</sub> FHF 3%NH <sub>4</sub> Cl	24.97	25.49	0.52	4060.942	4109.609	1.198
		24.84	25.49	0.65	4086.436	4175.801	2.187
X	3%NH <sub>4</sub> Cl 1%KBF <sub>4</sub>	24.92	25.72	0.8	4388.731	4656.502	6.101
		24.99	25.76	0.77	4370.52	4492.735	2.796
XI	2%NH <sub>4</sub> Cl 2%KBF <sub>4</sub>	24.96	25.56	0.6	4151.994	4159.299	0.176
		24.92	25.47	0.55	4151.994	4287.469	3.263
XII	1%NH <sub>4</sub> Cl 3%KBF <sub>4</sub>	24.29	24.96	0.67	4195.699	4303.797	2.576
		24.93	25.61	0.68	4304.962	4230.796	-1.723
XIII	1%NH <sub>4</sub> FHF 2%NH <sub>4</sub> Cl 1%KBF <sub>4</sub>	25.03	25.51	0.48	4195.699	4320.304	2.970
		25.34	26.01	0.67	4315.889	4246.062	-1.618
XIV	1%NH <sub>4</sub> FHF 1%NH <sub>4</sub> Cl 2%KBF <sub>4</sub>	24.81	25.5	0.69	4170.205	4280.999	2.657
		24.98	25.76	0.78	4151.994	4245.048	2.241
XV	2%NH <sub>4</sub> FHF 1%NH <sub>4</sub> Cl 1%KBF <sub>4</sub>	24.91	25.62	0.71	4279.468	4305.623	0.611
		24.99	25.73	0.74	4286.752	4278.827	-0.185

$${}^b \Delta V = ((V_2 - V_1) / V_1) \times 100\%;$$

$V_2$  – samples volume after boriding

$V_1$  – volume of compacts

$\Delta m = ((m_2 - m_1) / m_1) \times 100\%$ ;  
 $m_2$  – samples weight after boriding  
 $m_1$  – weight of compacts

**Table 3. Porosity of samples**

number of samples	activators	$m_1$ (g)	$m_2$ (g)	$m_3$ (g) oil mass	V (cm <sup>3</sup> ) samples volume	V (cm <sup>3</sup> ) pore volumes	Porosity <sup>c</sup> (%)
		samples weight before immersion	samples weight after immersion				
I	4%NH <sub>4</sub> FHF	22.85	23.37	0.52	3.823	0.622	16.259
		22.94	23.47	0.53	3.817	0.633	16.600
II	4%NH <sub>4</sub> Cl	21.82	22.33	0.51	3.638	0.610	16.760
		22.92	23.18	0.26	4.018	0.311	7.735
III	4% KBF <sub>4</sub>	22.72	23.34	0.62	3.850	0.741	19.249
		22.53	23.17	0.64	3.820	0.765	20.029
IV	1%NH <sub>4</sub> FHF 3%KBF <sub>4</sub>	22.69	23.32	0.63	3.707	0.753	20.318
		22.31	22.9	0.59	3.589	0.705	19.652
V	2%NH <sub>4</sub> FHF 2%KBF <sub>4</sub>	22.59	22.81	0.22	3.614	0.263	7.277
		22.43	22.91	0.48	3.630	0.574	15.807
VI	3%NH <sub>4</sub> FHF 1%KBF <sub>4</sub>	22.99	23.6	0.61	4.056	0.729	17.978
		23.91	24.52	0.61	3.999	0.729	18.235
VII	3%NH <sub>4</sub> FHF 1%NH <sub>4</sub> Cl	23.03	23.16	0.13	3.920	0.155	3.964
		23.09	23.37	0.28	3.807	0.335	8.791
VIII	2%NH <sub>4</sub> FHF 2%NH <sub>4</sub> Cl	23.01	23.2	0.19	3.849	0.227	5.900
		22.99	23.08	0.09	3.792	0.107	2.837
IX	1%NH <sub>4</sub> FHF 3%NH <sub>4</sub> Cl	22.78	23	0.22	3.653	0.263	7.199
		22.86	22.98	0.12	3.716	0.143	3.861
X	3%NH <sub>4</sub> Cl 1%KBF <sub>4</sub>	23.22	23.52	0.3	3.987	0.359	8.994
		23.12	23.43	0.31	4.220	0.370	8.782
XI	2%NH <sub>4</sub> Cl 2%KBF <sub>4</sub>	22.92	23.08	0.16	3.707	0.191	5.160
		22.66	22.96	0.3	3.849	0.359	9.317
XII	1%NH <sub>4</sub> Cl 3%KBF <sub>4</sub>	22.35	22.63	0.28	4.057	0.335	8.249
		23.17	23.42	0.25	3.879	0.299	7.705
XIII	1%NH <sub>4</sub> FHF 2%NH <sub>4</sub> Cl 1%KBF <sub>4</sub>	22.93	23.3	0.37	3.816	0.442	11.591
		23.04	23.19	0.15	3.666	0.179	4.891
XIV	1%NH <sub>4</sub> FHF 1%NH <sub>4</sub> Cl 2%KBF <sub>4</sub>	22.97	23.16	0.19	3.935	0.227	5.7
		23.45	23.75	0.3	4.113	0.359	8.720
XV	2%NH <sub>4</sub> FHF 1%NH <sub>4</sub> Cl 1%KBF <sub>4</sub>	23	23.36	0.36	3.999	0.430	10.761
		20.77	21.06	0.29	3.394	0.347	10.215

$m_1$  - samples weight before immersion [g]  
 $m_2$  - samples weight after immersion [g]  
 $m_3$  -oil mass in samples;  $m_3 = m_2 - m_1$  [g]

$$V_{pore} = V_{oil} = \frac{m_3}{\rho_{oil}} [cm^3]$$

$$\rho_{oil} = 0,8365 [g/cm^3]$$

$$V_{samples} = h \cdot b \cdot l [cm^3]$$

$$^c \text{Porosity: } P = \frac{V_{pore}}{V_{samples}} \cdot 100\%$$

**Table 4. Boride layers depth**

number of samples	activators	dept of boride layer [ $\mu m$ ]								average value of boride layers depth <sup>d</sup> [ $\mu m$ ]
		$\delta_1$	$\delta_2$	$\delta_3$	$\delta_4$	$\delta_5$	$\delta_6$	$\delta_7$	$\delta_8$	$\delta$
I	4%NH <sub>4</sub> FHF	68.5	62.5	95	87	83	78.5	74.5	89.5	79.813
		107	82	111	123.5	94.5	84	116	116	104.250
II	4%NH <sub>4</sub> Cl	182.5	168.5	96.5	96.5	122.5	114.5	117.5	110.5	126.125
		119.5	119.5	121	129	138	111	106	139.5	122.938
III	4%NH <sub>4</sub> Cl	129.5	98.5	85.5	99.5	136.5	117	117	148	116.438
		146.5	149.5	137	169.5	141	137.5	169.5	160.5	151.375
IV	1%NH <sub>4</sub> FHF 3%KBF <sub>4</sub>	136	97.5	130.5	127.5	116.5	148.5	134.5	148.5	129.938
		125	126	132	150	141.5	149	144	146.5	139.250
V	2%NH <sub>4</sub> FHF 2%KBF <sub>4</sub>	148	145.5	123	120.5	125.5	147	132	137	134.813
		76.5	147	116.5	110.5	90.5	146.5	149.5	197	129.250
VI	3%NH <sub>4</sub> FHF 1%KBF <sub>4</sub>	194	183	149.5	187	175	185	176.5	206.5	182.063
		149.5	126.5	146.5	171.5	124.5	200	175	198.5	161.500
VII	3%NH <sub>4</sub> FHF 1%NH <sub>4</sub> Cl	161.5	199	148	176	139.5	149.5	177	184.5	166.875
		120	127	117.5	194.5	167	165.5	111	170	146.563
VIII	2%NH <sub>4</sub> FHF 2%NH <sub>4</sub> Cl	120	120	161	177.5	177.5	162	159.5	132	151.188
		165	196.5	149.5	158.5	161.5	141	149.5	167	161.063
IX	1%NH <sub>4</sub> FHF 3%NH <sub>4</sub> Cl	106.5	126	76	112	129.5	123.5	91	99.5	108.000
		99.5	107	111	149.5	111.5	165	74.5	69	110.875
X	3%NH <sub>4</sub> Cl 1%KBF <sub>4</sub>	147	157	175.5	171	90	87.5	148.5	184.5	145.125
		106	82	149	144	134	129	121	123	123.500
XI	2%NH <sub>4</sub> Cl 2%KBF <sub>4</sub>	119	137.5	91	121	122	97.5	143.5	139.5	121.375
		149.5	126	126.5	140	136	149.5	124	157	138.563
XII	1%NH <sub>4</sub> Cl 3%KBF <sub>4</sub>	124	149.5	125	122	103.5	134.5	113.5	107	122.375
		111	129	112	115.5	120.5	115	130.5	129.5	120.375
XIII	1%NH <sub>4</sub> FHF 2%NH <sub>4</sub> Cl	98.5	136	149.5	132	132	139.5	133.5	129	131.250
		129.5	148.5	125	118.5	118.5	174	116.5	116.5	130.875
XIV	1%NH <sub>4</sub> FHF 1%NH <sub>4</sub> Cl	144	138	127	127.5	135	132	106.5	131.5	130.188
		129	107.5	120.5	105.5	121	144	144	144	126.938
XV	2%NH <sub>4</sub> FHF 1%NH <sub>4</sub> Cl	103.5	126	126	134	126.5	130.5	130.5	135	126.500
		129	106	141	126	126	139	136	130.5	129.188

$$^d \delta = \frac{\sum_{i=1}^8 \delta_i}{8} [\mu m]$$





THEMATIC PROCEEDINGS  
THE IMPACT OF THE COVID 19 PANDEMIC ON ECONOMY, RESOURCES AND SUSTAINABLE  
DEVELOPMENT

V	2	0	2	½	0	½	0.449	11.542	128.562	Y <sub>ikkk</sub>
VI	3	0	1	¾	0	¼	-0.985	18.106	129.969	Y <sub>iiik</sub>
VII	3	1	0	¾	¼	0	1.949	6.378	171.781	Y <sub>iiij</sub>
VIII	2	2	0	½	½	0	0.858	4.369	156.719	Y <sub>iiij</sub>
IX	1	3	0	¼	¾	0	1.693	5.530	156.125	Y <sub>iiij</sub>
X	0	3	1	0	¾	¼	4.449	8.888	134.312	Y <sub>jjjk</sub>
XI	0	2	2	0	½	½	1.719	7.239	127.844	Y <sub>jjkk</sub>
XII	0	1	3	0	¼	¾	0.427	7.977	121.375	Y <sub>jjkk</sub>
XIII	1	2	1	¼	½	¼	0.676	8.240	134.594	Y <sub>ijjk</sub>
XIV	1	1	2	¼	¼	½	2.449	7.246	133.875	Y <sub>ijkk</sub>
XV	2	1	1	½	¼	¼	0.213	10.488	109.437	Y <sub>iiik</sub>

Polynomial of fourth degree was used to obtained mathematical model for boriding process simulation. Polynomial is shown by relation (1):

$$\begin{aligned}
 y = & b_i x_1 + b_j x_2 + b_k x_3 + b_{ij} x_1 x_2 + b_{ik} x_1 x_3 + b_{jk} x_2 x_3 + c_{ij} x_1 x_2 (x_1 - x_2) + c_{ik} x_1 x_3 (x_1 - x_3) + \\
 & c_{jk} x_2 x_3 (x_2 - x_3) + d_{ij} x_1 x_2 (x_1 - x_2)^2 + d_{ik} x_1 x_3 (x_1 - x_3)^2 + d_{jk} x_2 x_3 (x_2 - x_3)^2 + \\
 & b_{iijk} x_1^2 x_2 x_3 + b_{ijjk} x_1 x_2^2 x_3 + b_{ijkk} x_1 x_2 x_3^2
 \end{aligned} \quad (1)$$

where are activators used in experiment:

x<sub>1</sub> - NH<sub>4</sub>FHF

x<sub>2</sub> -NH<sub>4</sub>Cl

x<sub>3</sub> -KBF<sub>4</sub>

and regression coefficients are:

$$b_i; b_j; b_k; b_{ij}; b_{ik}; b_{jk}; c_{ij}; c_{ik}; c_{jk}; d_{ij}; d_{ik}; d_{jk}; b_{iijk}; b_{ijjk}; b_{ijkk}; (i= 1, j= 2, k= 3)$$

It can be noted (Table 5.) that first three samples are related to influence of pure activators. From the 4th to 12th sample is presented influence of binary mixtures of activators in all combinations, samples 13, 14 and 15 give influences of ternary mixtures. After finishing of experiments, on the basis of obtained experimental results for volume changes, porosity and boriding layer depth (Table 5.) the unknown coefficients of polynomials are calculated by the following formulas:

$$b_i = y_i \quad (2)$$

$$b_j = y_j \quad (3)$$

$$b_k = y_k \quad (4)$$

$$b_{ij} = 4y_{iiij} - 2y_i - 2y_j \quad (5)$$

$$b_{ik} = 4y_{iikk} - 2y_i - 2y_k \quad (6)$$

$$b_{jk} = 4y_{jjkk} - 2y_j - 2y_k \quad (7)$$

$$c_{ij} = 8/3(y_j - y_i + 2y_{iiij} - 2y_{iiij}) \quad (8)$$

$$c_{ik} = 8/3(y_k - y_i + 2y_{iik} - 2y_{iikk}) \quad (9)$$

$$c_{jk} = 8/3(y_k - y_j + 2y_{jjk} - 2y_{jjkk}) \quad (10)$$

$$d_{ij} = 8/3(4y_{iiij} + 4y_{iiij} - 6y_{iiij} - y_i - y_j) \quad (11)$$

$$d_{ik} = 8/3(4y_{iik} + 4y_{iikk} - 6y_{iik} - y_i - y_k) \quad (12)$$

$$d_{jk} = 8/3(4y_{jjk} + 4y_{jkk} - 6y_{ijk} - y_j - y_k) \quad (13)$$

$$b_{ijk} = 32(3y_{ijk} - y_{iij} - y_{ijk}) + 8/3(6y_i - y_j - y_k) - 16(y_{iij} + y_{iik}) - 16/3(5y_{iij} + 5y_{iik} - 3y_{ikk} - 3y_{ijj} - y_{jjk} - y_{jkk}) \quad (14)$$

$$b_{ijk} = 32(3y_{ijk} - y_{iij} - y_{ijk}) + 8/3(6y_j - y_i - y_k) - 16(y_{jjk} + y_{iij}) - 16/3(5y_{jjk} + 5y_{iij} - 3y_{jkk} - 3y_{iij} - y_{ikk} - y_{iik}) \quad (15)$$

$$16/3(5y_{jjk} + 5y_{iij} - 3y_{jkk} - 3y_{iij} - y_{ikk} - y_{iik}) \quad (16)$$

Where experimental results (Table 1) are:  $y_i, y_j, y_k, y_{iij}, y_{ijj}, y_{iik}, y_{iij}, y_{jjk}, y_{ijk}, y_{jkk}, y_{iik}, y_{ikk}, y_{jjk}, y_{jkk}$  ( $i=1, j=2, k=3$ )

Values of regression coefficients are given in Table 6.

**Table 6.** Regression coefficients for polinomial of four deegree, equation (1).

	Volume changes	Porosity	Depth
$b_i$	-0.099	16.430	131.062
$b_j$	2.474	12.247	132.031
$b_k$	-1.581	19.640	92.031
$b_{ij}$	-1.317	-39.878	100.690
$b_{ik}$	5.155	-25.970	68.062
$b_{jk}$	5.092	-34.819	63.252
$c_{ij}$	8.227	-6.632	86.083
$c_{ik}$	-9.905	-1.461	-75.080
$c_{jk}$	10.637	24.569	-37.669
$d_{ij}$	18.773	-19.358	288.579
$d_{ik}$	-11.815	125.453	62.760
$d_{jk}$	22.115	-20.953	84.325
$b_{iijk}$	-74.916	279.778	-3342.565
$b_{ijjk}$	147.793	186.042	402.456
$b_{ijkk}$	200.285	-216.647	1131.261

### 3.1 The validation of the model

Checking the adequacy of the mathematical model was carried out in two control points – K1 and K2 (Figures 2a, 2b, 2c). The validation of the model was checked by Student t – criteria.

$$t_{ki} = \frac{D_{ki} \sqrt{r}}{\sigma_y \sqrt{1 + A_{ki}}} < t_{kr \alpha/k, f}, \quad (17)$$

Where is:

$D_{ki}$  - maximum difference between calculated and actual properties values in investigated points, determined by equation:

$$D_{ki} = \bar{y} - \hat{y}_i \quad (18)$$

$i=1, 2, 3, \dots, n$ ; and depends of control points number

$\bar{y}$  - value of the regression polynomial for all combinations of factor levels in selected control points

$\hat{y}_i$  - values obtained by experiment

$r$  – number of repeated experiments in the plan points

$\sigma_y$  – average square experiment error (experiment dispersion)

Deviation of standard results at measuring, used to determine experiment error, is calculated by dispersion analysis, equation (19).

$$\sigma^2 y = \frac{1}{n} \sum_i^n \left( y_i - \bar{y} \right)^2 \quad (19)$$

where are:

$\sigma^2 y$  - dispersion of experiment

$y_i$  - values obtained by experiment

$\bar{y}_i$  - is mean values of experiment values sum

$A_k$  – value which depends on the control points positions in the plan of experiment triangle which usually is determined for each plan (first, second, third, fourth degree) separately (Keddad & Chegroune, 2010; Krasovsky & Filaretov, 1982; Zedginidze, 1971).

For the fourth degree plan  $A_k$  is determined by equation:

$$A_{ki} = \left[ \sum a_i^2 + \sum a_{ijj}^2 + \sum a_{iiij}^2 + \sum a_{iilk}^2 \right] \quad (20)$$

$$a_i = 1/3x_i(32x_i^3 - 48x_i^2 + 22x_i - 3); (a_1, a_2, a_3) = a_i \quad (21)$$

$$a_{ijj} = 4x_i x_j (1 + 16x_i x_j - 4x_i - 4x_j); (a_{1122}, a_{1133}, a_{2233}) = a_{ijj} \quad (22)$$

$$a_{iiij} = 16/3x_i x_j (8x_i^2 - 6x_i + 1); (a_{1112}, a_{1222}, a_{2333}, a_{1113}) = a_{iiij} \quad (23)$$

$$a_{iijk} = 32x_i x_j x_k (3x_i - x_j - x_k); (a_{1123}, a_{1223}, a_{1233}) = a_{iijk} \quad (24)$$

$\alpha$  – level of probability ( $\alpha = 0.01$ );

$k_i$  – number of control points in which the validation of the model adequacy is executed ( $i = 1, 2$ )

$f$  – number of freedom degrees for the results dispersion evaluation  $\sigma_y^2$

$$t_i < t_{kr} \quad (25)$$

If  $t_i$  is less than  $t_{kr}$  i.e.  $t_i < t_{kr}$ , hypothesis of inadequacy is accepted. Model is then inadequate and vice versa.

Based on the Student t – criteria, the adequacy of the fourth level mathematical model was confirmed with 99% probability.

### 3.2 Algorithm for a real solution determining

```
0010 REM PROGRAM FOR THE FOURTH DEGREE POLYNOM
0020 READ B1,B2,B3,B4,B5,B6,C1,C2,C3,D1,D2,D3,E1,E2,E3
0030 DATA 70.6,100.5,65.7,2,4,5,9,7,4,8,9,6,5,5,3
0031 DATA 514.53,737.2,51.73,-2209.23,743.29,2470.37
0040 INPUT R1,R2,R3,N,K
0050 INPUT E5

0060 FOR Y=R1 TO R2 STEP R3
0065 FOR X3=0 TO 1 STEP K
0100 H=1/N
0110 FOR I=1 TO N STEP 1
0120 Z1=(H)*(I-1)
0130 Z2=(H)*(I)
0140 GOSUB 200
0150 NEXT I
0155 NEXT X3
0156 NEXT Y
0160 END

0200 Z3=(Z1+Z2)/2
0210 X1=Z1
0220 GOSUB 500
0225 IF X2<0 THEN GO TO 240
0230 Y1=Y5
0240 X1=Z2
0250 GOSUB 500
0255 IF X2<0 THEN GO TO 270
0260 Y2=Y5
0270 X1=Z3
0280 GOSUB 500
0285 IF X2<0 THEN GO TO 440
0290 Y3=Y5
0300 Y4=ABS(Y3-Y)
0310 IF Y4>E5 THEN GO TO 340
0320 PRINT "X1=";X3,"X2=";X2, "X3=";X3, "Y=";Y, "YY=";Y3
0330 GO TO 440

0340 B8=(Y1-Y)*(Y3-Y)
0350 B9=ABS (B8)
0360 IF B8=B9 THEN GO TO 390
0370 Z2=Z3
0380 GO TO 200
0390 B8=(Y2-Y)*(Y3-Y)
0400 B9= ABS (B8)
0410 IF B8=B9 THEN GO TO 440
0420 Z1=Z3
0430 GO TO 200
```

0440 RETURN

0500  $X_2=1-X_1-X_3$

0510  $A_1=(B_1)*(X_1)+(B_2)*(X_2)+(B_3)*(X_3)+(B_4)*(X_1)*(X_2)+(B_5)*(X_1)*(X_3)$

0520  $A_2=(B_6)*(X_2)*(X_3)+(C_2)*(X_1)*(X_2)*(X_1-X_2)+(C_2)*(X_1)*(X_3)*(X_1-X_3)$

0530  $A_3=(C_3)*(X_2)*(X_3)*(X_2-X_3)+(D_1)*(X_1)*(X_2)*(X_1-X_2)*(X_1-X_2)$

0540  $A_4=(D_2)*(X_1)*(X_3)*(X_1-X_3)*(X_1-X_3)+(D_3)*(X_2)*(X_3)*(X_2-X_2)*(X_2-X_3)$

0550  $A_5=(E_1)*(X_1)*(X_1)*(X_2)*(X_3)+(E_2)*(X_1)*(X_2)*(X_2)*(X_3)$

0560  $A_6=(E_3)*(X_1)*(X_2)*(X_3)*(X_3)$

0570  $Y_5=A_1+A_2+A_3+A_4+A_5+A_6$

0580 RETURN

Algorithm application for computer program requires entering following information:

- experiment plan
- experimental results for volume changes, porosity and depth boriding layers,
- regression coefficients
- borders to determine iso - lines
- step that depend on the lines density in the simplex triangle
- control points

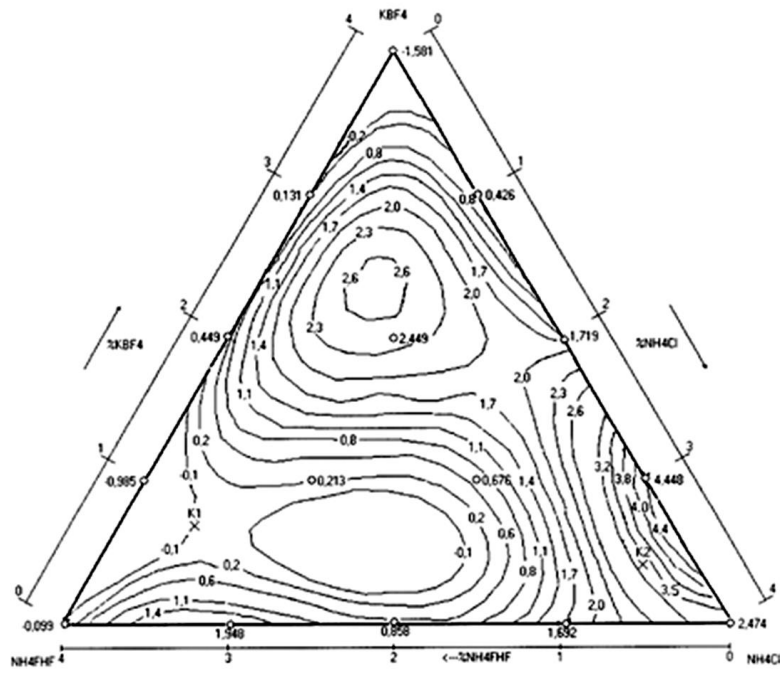
#### 4. RESULTS AND DISCUSSION

After the activation of program a dialog box appears that contains a table which is filled on the basis of the provided plan for the experiment and based on the obtained experimental results (volume changes, porosity and boriding layer depth). The program is designed to enable us to draw simplex triangle, (figures 2a, 2b and 2c), give us the value of regression polynomial (1).

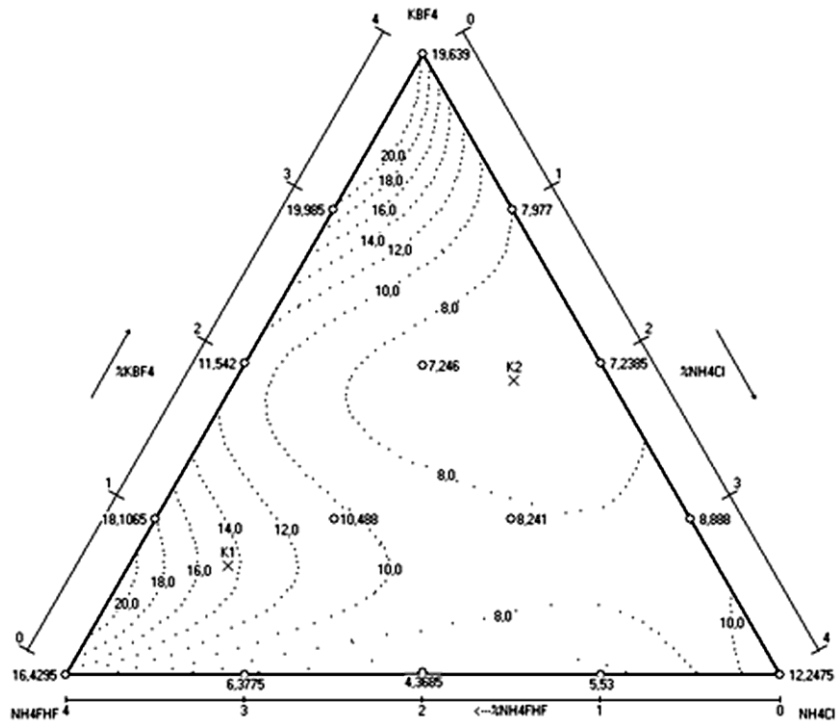
The value of regression polynomial indicates obtained volume changes, porosity or boriding layer depth changes with the selected activator content (coordinates  $x_1$ ,  $x_2$  and  $x_3$ ), so these changes can be predicted in advance or specified. By analysis of iso lines, it can be seen where are obtained extreme values of observed changes. In Figure 2a, is shown pressed and boriding samples volume changes dependence of the mixture composition. Closed iso-line are obtained when a volume changing is 2.6% to -0.1%, which means that in these areas are achieved extreme values of boriding samples dimensional changes.

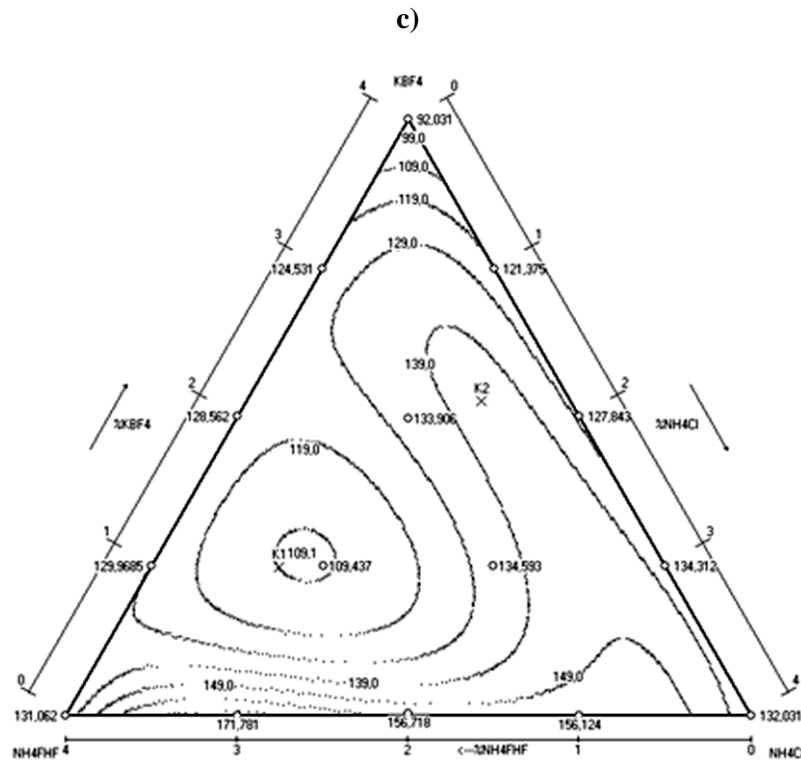
Maximum values, 2.7% and - 0.5%, in these areas were obtained by algorithm for computing. Such volume changes will be possible if boriding process is performed in mixtures which contain: 0.9%  $NH_4FHF$ , 0.7%  $NH_4Cl$ , 2.4%  $KBF_4$  and 1.7%  $NH_4FHF$ , 1.7%  $NH_4Cl$ , 0.6%  $KBF_4$ , respectively. After boriding, due to the influence of boriding mixture and the presence of activated sintering, sample size may remain the same, or there may be shrinkage or increase in sample size.

a)



b)





**Figure 2.** General principles followed by the pressed borided samples observed changes from boriding composition mixture for a) volume changes b) porosity c) depth of boride layers of the pressed borided samples (o - experimental points, • - points obtained by calculations, × - control points) (Celebi et al., 2005; Ivanov & Požega, 2008; Požega et al., 2009; Požega & Ivanov, 2008; Požega et al., 2009)

Influence of the mixtures composition for boriding on the volume changes for pressed and boriding iron powder samples is dual. In some samples was observed contraction, and in others increase in size, ie. expansion. Influence of boron - a saturation element, is dominated when volume is increased. As a result of boron atoms diffusion from boriding mixture to the surface layer of samples, there was an increase in sample size, thus and in volume.

By formation of diffusion layers on the pore surface volume increases, because the surface crossing of the pore channel reduces and a large number of pores disappears. Internal mass transport processes reduce the distance between particles of powder, resulting in the pressed samples shrinking. In samples where there is a shrinking, there is a reduction in porosity. This leads to reduction in pore volume and an increase in pressed samples density.

Application working by described algorithm allows us to pre-determine the volume change without practical experiment and allows optimization of the boriding process. Increased porosity of boriding samples, compared to the normal, is the consequence of insufficiently activated sintering. The quantity of activated sintering depends on diffusion coefficient, powder particle size and pressing pressure. During sintering the pores become orbiculate and at the final stage of sintering, open porosity transforms in closed porosity with isolated pores. By simulation of boriding process we can determine the activators percentage content and the adequate values of samples porosity, (figure 2b). The largest porosity of boriding samples, 19.985% are observed in the mixtures with 1% NH<sub>4</sub>Cl, 3% NH<sub>4</sub>FHF and 0% KBF<sub>4</sub>. On the other hand, the lowest porosity of 4.369% and most visible activated sintering was observed

on boriding samples in mixtures which contain 2% NH<sub>4</sub>Cl, 2% KBF<sub>4</sub> and 0% NH<sub>4</sub>FHF, (table 3). In Figure 2c. is given the dependence of pressed samples and boriding samples depth changes from mixtures composition for boriding. It can be observed varying in depths of boriding layers due to the influence of different mixtures composition and the uneven effects of activator. The depth of diffusion layer depends on the active and adsorbed boron atoms concentration on the surface of the sample. Boron saturation in the gas environment in the presence of a large number of pores, allowed obtaining of boriding layers higher depth. Concentration of diffused element (boron) is increased at a significantly greater depth, since the saturation proceeded from the sample surface, and also from pore surface. At boriding layer depth of 109.1 μm was obtained a closed iso-lines, which means that in this area reached depth of boriding layers are extreme. Experimentally obtained value in this area amounts to 109.437 μm. Such depth would be obtained if the boriding performed in mixtures containing 2% NH<sub>4</sub>FHF, 1% NH<sub>4</sub>Cl, 1% and 1% KBF<sub>4</sub>.

## CONCLUSION

Analysis and evaluation of the basic indicators for the quality boride layers obtain was done by computer program during the emergency measures caused by the COVID-19 pandemic adopted by the Government of the Republic of Serbia and work from home. The presented paper is the achievement of efficient science performance of our research group for the given measures during the covid-19 pandemic.

Algorithm for computer program proposed in this work is a simple and convenient tool for simulation of volume changes, changes in porosity and depth boriding layer as a function of activators.

By adjusting basic mixture which is modified by the addition of activators, it makes it possible to optimize the properties of borides layers. By algorithm it is able to predict the most suitable activator composition. In this way can be reduced number of practical experiments, new product development time and work of researchers during the COVID-19 pandemic. The obtained results are part of broader continued and ongoing investigations of new substances that have a positive impact on the boriding metallic materials produced using powder metallurgy in the frame of our research group (Krasovsky & Filaretov, 1982; Ivanov & Požega, 2008; Požega et al., 2009; Požega & Ivanov, 2008; Požega et al., 2009; Miletić & Stanojević, 2018; Miletić et al., 2016).

## ACKNOWLEDGMENTS

The authors are grateful for the assistance in computer program preparation to his colleague Ćerim Abazi.

The research presented in this paper was done with the financial support of the Ministry of Education, Science and Technological Development of the Republic of Serbia, within the financing of scientific research work in the Institute of Mining and Metallurgy Bor, according to the Contract No. 451-03-9/2021-14/200052, and at the University of Belgrade, Technical Faculty in Bor, according to the Contract No. 451-03-9/2021-14/200131.



## REFERENCES

- Allaoui, O., Bouaoudja, N., & Saindernan, G. (2006). Characterization of boronized layers on a XC38 steel. *Surface and Coatings Technology*, 201(6), 3475-3482.
- Berger, A., Grigoriev, A., & Winokorow, A. (2017). An efficient algorithm for the single facility location problem with polyhedral norms and disk-shaped demand regions. *Computational Optimization and Applications*, 68, 661-669.
- Campos, I., Baustina, O., Ramirez, G., Islas, M., De la Parra, J., Zúñiga, L., (2005). The matrix which is not affected by boron. *Applied Surface Science*, 243, 429-436.
- Celebi, G., Ipek, M., Bindal, C., Ucisik, H. (2005). Some mechanical properties of borides formed on AlSi 8620 steel. *Materials Forum*, 39, 456-460.
- Chatterjee, F. (1989). *Surface Modification Technologies*. T S Sundarshan, USA, Marcel Dekker Inc
- Dong, X., Hu, J., Huang, Z., Wang, H., Gao, R., Guo, Z. (2009). Microstructure and properties of boronizing layer of Fe-based powder metallurgy compacts prepared by boronizing and sintering simultaneously. *Science of Sintering*, 41, 199-207.
- Erdemir, A., & Bindal, C. (1995). Formation and self-lubricating mechanisms of boric acid on borided steel surfaces. *Surface and Coatings Technology*, 76-77, 443-449.
- Genel, K., Ozbek, I., Kurt, A., Bindal, C. (2002). Boriding response of AISI W1 steel and use of artificial neural network for prediction of borided layer properties. *Surface and Coatings Technology*, 160, 38-43.
- Hunger, H., & Trute, G. (1994). Boronizing to produce wear-resistant surface layers. *Heat Treatment of Metals*, 2, 31-39.
- İpek, R., Selçuk, B., Karamiş, M., Kuzucu, V., Yücel A. (2000). An evaluation of the possibilities of using borided GG25 cast iron instead of chilled GG25 cast iron (surface properties). *Journal of Materials Processing Technology*, 105, 73-79.
- Ivanov, S., & Požega, E. (2008). Influence of the composition of the boroning mixture on the dimension change of pressed and boroned samples from iron powder. *Science of Sintering*, 40, 197-205.
- Jain, V., & Sundararajan, G. (2010). Influence of the pack thickness of the boronizing mixture on the boriding of steel. *Surface and Coatings Technology*, 149, 21-26.
- Kayacan, Ö., Şahin, S., Taştan, F. (2010). A study for boronizing process within nonextensive thermostatics. *Mathematical and Coputational Applications*, 15, 14-24.
- Keddam, M., & Chegroune, R. (2010). A model for studying the kinetics of the formation of Fe<sub>2</sub>Be boride layers at the surface of a gray cast iron. *Applied Surface Science*, 256, 5025-5030.
- Keddam, M. (2004). A kinetic model for the borided layers by the paste-boriding process. *Applied Surface Science*, 236, 451-455.
- Keddam, M., & Chentouf, S. (2005). A diffusion model for describing the bilayer growth (FeB/Fe<sub>2</sub>B) during the iron powder-pack boriding. *Applied Surface Science*, 252, 393-399.
- Krasovsky, I., Filaretov, F. (1982). *Plans of Experiment*. Minsk, Publishing house of BSU-Belarusian State University (in Russian)
- Makuch, N. (2020). Nanomechanical properties and fracture toughness of hard ceramic layer produced by gas boriding of inconel 600 alloy. *Transactions of Nonferrous Metals Society of China*, 30(2), 428-448.
- Makuchp, N., Dyiarski, P., Kulka M., Piasecki, A., Tuliński, M., Majchrowski R. (2019). Influence of niobium and molybdenum addition on microstructure and wear behavior of

- laser-borided layers produced on Nimonic 80A-alloy. *Transactions of Nonferrous Metals Society of China*, 29(2), 322-337.
- Meric, C., Sahin, S., Backir, B., Sinan Koksall, N. (2006). Investigation of the boronizing effect on the abrasive wear behavior in cast iron. *Materials and Design*, 27, 751-757.
- Miletć, S., Stanojević Šimšić, Z., (2018). Strategic analysis of organization by AHP method, Innovation as an initiator of the development “innovations – basis for development” International Thematic Monograph – Thematic Proceedings, University Business Academy in Novi Sad, Faculty of Applied Management, Economy and Finance, Belgrade, MEFkon 2018, December 6th Belgrade, 289-307.
- Miletić, S., Bogdanović, D., Milanović, D., (2016). Advantages of implementation the process model for sustainable business operations of mining companies. *Journal Mining and Metallurgy Institute Bor*, 3, 71-82.
- Novik, S. (1971). *Mathematical methods for planning experiments in metal science*. Moscow, Moscow Institute of Steel and Alloys. (in Russian)
- Nyborg, L., Nylund, A., Olefjord, I. (1987). *Thickness determination of oxide layers on spherical shaped metal powders by ESCA*. Proc. of ESCASA 1987. Stuttgart
- Ozdemir, O., Usta, M., Bindal, C., Ucisik, H. (2006). Hard iron boride (Fe<sub>2</sub>B) on 99.97 wt% pure iron. *Vacuum*, 80, 1391-1395.
- Özge, B., Duygu, A., Lütfi, M., Duman, İ. (2016). Synthesis of niobium borides by powder metallurgy methods using Nb<sub>2</sub>O<sub>5</sub>, B<sub>2</sub>O<sub>3</sub> and Mg blends. *Transactions of Nonferrous Metals Society of China*, 26(3), 747-758.
- Paul, SK, Chowdhury, P. (2020). A production recovery plan in manufacturing supply chains for a high-demand item during COVID-19. *Int J Phys Distrib Logist Manag* 1-22. <https://doi.org/10.1108/IJPDLM-04-2020-0127>.
- Požega, D. E. (2008). *Activators influence on the diffusion layer formation at boronizing of pressed iron powder*. [Masters Thesis] Serbia, SRB; University in Belgrade, Technical faculty in Bor.
- Požega, E., Ivanov, S. (2008). Influence of activators on constitutes of diffusion layer at boronizing pressed samples from iron powder. *Hemijska Industrija*, 63,164-169. (in Serbian)
- Požega, E., Ivanov, S., Abazi, Ć. (2008). Computer programme for polynomial of fourth degree. *Inovacije i razvoj*, 2, 51- 62. (in Serbian)
- Požega, E., Ivanov, S., Conić, V., Čađenović, B. (2009). The possibility of the boronizing proces on the pressed samples of iron powder. *Hemijska Industrija*, 63, 253-258. (in Serbian)
- Požega, E., Ivanov, S., Ivanović, A. (2009). Influence different chemical composition and percente rate of added activators on depth of boride layer. *Zaštita Materijala*, 50, 99-104. (in Serbian)
- Ramirez, G., Campos, I., Balankin, A. (2007). Fracture toughness of iron boride layers obtained by paste boriding process. *Materials Science Forum*, 553, 21-26.
- Segal, S., Gerstel, D. (2020). The Global Economic Impacts of COVID-19. <https://www.csis.org/analysis/global-economicimpacts-covid-19>.
- Selçuk, B., İpek, R., Karamış, B., Kuzucu, V. (2000). An investigation on surface properties of treated low carbon and alloyed steels (boriding and carburizing). *Journal of Materials Processing Technology*, 103, 310-317.
- Sen, S., Sen, U., Bindal, C. (2005). An approach to kinetic study of borided steels. *Surface and Coatings Technology*, 191, 274-285.
- Sinha, K. (1991). *Heat treating*. ASM Handbook. Ohio, USA, ASM International, Materials Park

- Stojanović, Ž., Stanisavljev, S. (2013). Protection of parts of mechanical systems by multicomponent boronizing methods. *Zaštita materijala*, 54(4), 381-388. (in Serbian)
- Stojanović, Ž., Stanisavljev, S., Erić, S., Đurđić, M. (2017). Increasing the efficiency of forging tools by thermal diffusion boronizing. *Zaštita materijala*, 58(1), 22-29. (in Serbian)
- Voroshnin, G., Lyakhovich, S., Lovshenko, G., Protasevich, F. (1977). Chemical heat treatment of cerment materials Minsk, Science and Technology. (in Russian)
- Xu, H., Xi, K., Gao, W. (1997). Improving the mechanical properties of boronized lazars by superplastic boronizing. *Journal of Materials Processing Technology*, 65, 94-98.
- Zedginidze, G. (1971). Mathematical design of an experiment for the study and optimization of the mixtures properties. Tbilisi, Metsniereba. (in Russian)

## INFLUENCE OF GRAPEVINE GENETIC DIVERSITY ON THE PRODUCTION OF HIGH QUALITY WINES

Jelena Bošković<sup>1</sup>,  
Vladica Ristić<sup>2</sup>,  
Tanja Kvesić<sup>3</sup>

<sup>1</sup>Jelena Bošković, PhD, Full professor, Academician of IRASA, University Business Academy in Novi Sad, Faculty of Economics and Engineering Management in Novi Sad, Cvećarska 2, 21000 Novi Sad, Republic Serbia Email: jboskovic@fimek.edu.rs

<sup>2</sup>Vladica Ristic, Full Professor, Academician of IRASA, Metropolitan University of Belgrade, Faculty of Applied Ecology "FUTURA" in Belgrade, Republic Serbia Email: vladicar011@gmail.com

<sup>3</sup>Tanja Kvesić, Msci in ecology, University Business Academy in Novi Sad, Faculty of Economics and Engineering Management in Novi Sad, Cvećarska 2, 21000 Novi Sad, Republic Serbia Email: tanjuska88ns@gmail.com

### ABSTRACT

*The grapevine is one of the most important economic fruit crops that are widely grown in almost all continents. The fruits produced worldwide are mainly processed into wine. In addition, significant portions have also been used for fresh consumption, dried as raisins or processed into juice. The objectives of grapevine breeding vary according to its usage and often are region-specific. However, most breeding programs aim at combining high yield and high fruit quality with improved resistance to multiple diseases and pests, and/or increased adaptation to adverse environments. These desirable traits can be exploited from the vast genetic resources of the Vitis genus. Different methods have been used to incorporate useful traits including conventional breeding, mutation and polyploid breeding, and biotechnological approaches. Integration of these tools will allow breeders to meet with the increasing demands for novel grapevine varieties with improved yield and quality in an era of limited resources, increasing health and ecological awareness, as well as increasing environmental pressures.*

### KEYWORDS

*Grapevine; Vitis vinifera; wine quality; genetic resources; genetic variability.*

### 1. INTRODUCTION

The grapevine (*Vitis vinifera* L.) is the most economically important woody perennial fruit crop, cultivated in most of the continents of the world. Viticulture and wine making have been part of human culture for thousands of years (IGGP 2002). Approximately 71% of the world's harvest is processed into wine, 27% is consumed fresh and 2% is dried for raisins (Tantasawat et al., 2010).

Grapevine (*Vitis vinifera* L.) is one of the most widely cultivated and economically significant crops in the world, with 7.5 mha of worldwide cultivated area generating 259 mhl of wine production. Since the early domestication period, expansion of human activity led to

the creation of thousands of grapevine varieties with extensive phenotypic diversity (Freitas et al., 2019) *V. vinifera* L. is the most widely cultivated *Vitis* species due to its adaptability to a wide range of temperate to subtropical or tropical conditions. It probably originated in the Mediterranean Basin and the Middle East, where it was domesticated 5,000 years ago. *V. vinifera* has given rise to over 14,000 cultivars grown in most of the cultivated areas worldwide. It is estimated that more than 90% of the world's grapevines are either *V. vinifera* or *V. vinifera* hybrids. *V. vinifera* cultivars are usually of outstanding quality but they are susceptible to a variety of biotic and abiotic stresses. Therefore, grapevine improvement is necessary to achieve specific goals and local adaptation (Tantasawat et al., 2010).

Increased production efficiency and improved fruit quality have traditionally been based on the modification of management and growing conditions of specific genotypes which have generally been kept constant by vegetative multiplication (IGGP, 2002). Numerous breeding programs have been conducted in different parts of the world using various breeding methods (Tantasawat et al., 2010) Unfortunately, the recent favoring of specific varieties/clones, and the globalization-driven exposure to pathogens, has led to extensive genetic erosion. Breeding for resilience to climate change, yield or other traits, requires a crucial understanding of the genetic basis of phenotypic variation, a field that has seen significant advances due to the use of genome-wide approaches (Freitas et al., 2019) Continued advances in technology at the genomic level will increase the understanding of grapevine genetics and genes which underlie its important traits. Therefore, integration of these new and classical technologies into grapevine breeding programs will further ensure outstanding breeding successes in the future (Tantasawat et al., 2010).

## 2. BERRY AND WINE QUALITY

A first attempt to elucidate berry quality genetically was reported by Hendrick and Anthony (1915). The authors analyzed results of various crosses with different parental combinations. Most noticeable was the very low percentage of seedlings whose quality was good or above good even when parents of the best quality were used. The authors observed a tendency for the proportion of seedlings giving good quality to decrease with the use of parents showing poorer quality. They concluded that for breeding only high quality parents should be used. Thousands of years of selection of grapevine during domestication have raised the quality in *V. vinifera* subsp. *vinifera* to a point that it has become a powerful factor in transmitting high quality (Hendrick and Anthony, 1915).

Berry quality and hence wine quality is by far the most complex trait in grape breeding. It relies on complex sensory perceptions including taste, smell, and mouthfeel. Selection of good quality genotypes depends on the organoleptic perception of the tasting panel thus being rather subjective. Berry quality is difficult to evaluate for table grapes and even more difficult for wine grapes since fermentation by yeasts increases the complexity of the trait through metabolic conversions. The amount of sugars, acids, fermentable nitrogen (amino acids), minerals (e.g. potassium), balanced (positive) aroma compounds and lack of off-flavors in the must are major components to estimate berry quality. In particular the concentration, the balance and the interactions of up to 800 different aroma compounds (Rapp, 1994), not all are relevant for sensory perception and most are formed during fermentation – are crucial for the appraisal of quality. In wine, which is free of sugar after fermentation, any inharmonious taste can easily be recognized and off- flavors quickly emerge. Changes during storage and aging of wine need to be evaluated to uncover sensory deficits which are attributed to the

breeding line. Within a breeding program berry, respectively, must quality can be recorded only 4 to 5 years after a cross and it is strongly influenced by environmental factors. Furthermore, the amount of grapes available for experimental micro-vinification for assessment of wine quality is limited. The number of vines available impairs the scale of fermentation and hence a quality evaluation. Thus the assessment of berry quality is direfully complex, time consuming and the most important trait to be evaluated. Up to now the trait “quality” was treated mostly empirically with the help of trained tasting panels and analytical measurements of major must components (Töpfer et al., 2011).

### 3. MARKERS FOR BERRY AND WINE QUALITY

With respect to wine quality a considerable lack of knowledge and methodology has to be stated. However, insights into the complex trait of wine quality will be gained during the forthcoming years. A method of choice will be the use of SNP markers in canalizing diverse and expensive analytical methods like GC, GC/MS, LC, LC/MS. Concerning positive aroma compounds (e.g. monoterpenes) first QTLs have been described (Eibach et al., 2003 ; Grando et al., 2004; Doligez et al. 2006) and a good candidate gene (1-deoxz-D- xylulose 5-phosphate synthase) for terpenol content was identified on chromosome 5 (Battilana et al., 2009; Duchene et al. 2009) But the data still needs to form a clearer picture to become useful for MAS of berry quality. In contrast it could be much easier to develop markers to monitor off-flavors. They would be very useful to eliminate undesirable flavor compounds (e.g. fureneol or methylantranilate) very rapidly from the gene pool while introducing new resistance genes to *V. vinifera*.

Recently the biosynthesis of tartaric acid contributing to taste, mouthfeel and aging potential received some interest since too low acidity in hot climate viticulture is a major quality issue. De Bolt et al. (2004; 2006) gained major insight in the biosynthetic pathway of tartaric acid synthesis and the underlying enzymes (De Bolt et al. 2004; De Bolt et al., 2006). Hypothesized for a long time the authors gave convincing evidence that tartaric acid in grapevine is a product of vitamin C (ascorbate) catabolism. In a recent report about ascorbate metabolism first regulatory aspects could be elucidated (Melino et al., 2009). The accumulating knowledge will be used to unravel the regulation of the pathway opening the possibility to build up new selection schemes for cultivars showing an appropriate acid balance.

As indicated, an important trait is the color of the grapevine berries which is caused by the synthesis of anthocyanins in the berry skin of red and black genotypes in the second ripening phase after véraison. The key biosynthetic enzyme for anthocyanin formation (UDP-glucose:flavonoid 3-O-glucosyltransferase (UFGT)) has been mapped on chromosome 16 (Fischer et al., 2004) by using a SCAR marker deduced from sequence information provided by Sparvoli et al., (1994). More important for color formation is the transcription factor *mybA* that controls UFGT gene expression. The *mybA* gene is located on chromosome 2. Due to a transposon-based mutation within the promoter of one allele of the *mybA* gene the development of a molecular marker is now possible correlating very tightly with berry skin color (Kobayashi et al., 2004; Walker et al., 2007). This transposon insertion was tightly correlated with white berry color. Color variants could be explained in 95% of the cases by different alleles of the *mybA1* gene showing molecular fingerprints of transposon excision (Lijavetzky et al., 2006; This et al., 2006). Further modulation of color can be explained by different expressions of genes for anthocyanin modifying enzymes (Castellarin et al., 2007).

In terms of genetic understanding another modification which has been introgressed into *V. vinifera* L. subsp. *vinifera* has been much easier to be accomplished. Among the anthocyanins two major types exist: anthocyanin 3-glucosides and anthocyanin 3,5-diglucosides (mainly malvin). Anthocyanin 3-glucosides are found in all colored grapes whereas anthocyanin 3,5-diglucosides occur in most wild *Vitis* species and in derivatives of crosses of *V. vinifera* L. subsp. *vinifera* with wild *Vitis* species. They are absent on a very low level in traditional *V. vinifera* L. subsp. *vinifera* cultivars. Anthocyanin 5-glucosyltransferase (5-GT) is the responsible enzyme catalyzing the glycosylation reaction from anthocyanin 3-glucoside to anthocyanin 3,5-diglucoside. Expression of the 5-gt gene correlates positively with anthocyanin 3,5-diglucoside formation in berry skins of different grape genotypes (Hausmann and Töpfer, 2006) Therefore the gene encoding 5-GT was cloned and sequenced from different *Vitis* genotypes. The 5-gt alleles from traditional *V. vinifera* genotypes showed mutations leading to non-functional gene products in contrast to a functional 5-GT originally descended from a wild *Vitis* species (Hausmann et al., 2009; Jánváry, L. et al., 2009). Based on the sequence differences in the 5-gt alleles a molecular marker was developed. Using this 5-gt sequences characterized amplified region (SCAR) marker the 5-gt gene was mapped on chromosome 9 at the same site where the trait “malvin” has been previously localized (Welter et al., 2007). Since malvin is very intense in color and quite stable it may be used to develop cultivars with dark colored berries.

#### 4. GRAPEVINE GENETIC RESOURCES

There are several species of wild and cultivated grapevines in the world, and each species consists of numerous varieties. In different countries more than 10,000 named varieties of grapevine were found. The list of new varieties is continually being added to every year. Grapevine germplasm collections are crucial for maintaining the genetic resources of *Vitis*. Genetic resources can be divided into 4 types: wild species, old traditional cultivars, new cultivars and breeding lines. The wild species are potential sources for various traits. Both *Euvitis* and *Muscadinia* species are good sources of resistance. Several American species are resistant to phylloxera (*Dactylosphaera vitifoliae*; mainly *Vitis riparia*, *Vitis rupestris* and *Vitis berlandieri*) and are used extensively in breeding programs. Among these three species, only *Vitis berlandieri* is adapted to highly calcareous soils, and it is used to develop root stocks resistant to phylloxera and lime-induced chlorosis. Wild Chinese species including *Vitis bryoniifolia*, *Vitis davidii* and *Vitis piasezkii*, and Asiatic species *Vitis amurensis* are good sources of powdery mildew (*Uncinula necator*), and/or downy mildew (*Plasmopara viticola*) resistance. *Muscadinia* is a useful source of resistance to phylloxera, nematodes, Pierce’s disease (PD; *Xylella fastidiosa*) and fungal diseases including powdery mildew and downy mildew. Several sources of tolerance to abiotic stresses (cold, drought, salinity, lime etc.) are also observed in different *Vitis* spp. for example, cold tolerance is found in the northern species *Vitis riparia*, *Vitis labrusca* and *Vitis amurensis*. While southern species, *Vitis lincecumii*, *Vitis bourquiniana* and *Vitis rotundifolia*, provide tolerance to hot conditions. However, these wild species have small berries with excessive seeds and strong pungent flavors. Therefore, extensive backcrosses are often needed to eliminate some unfavorable characteristics of the wild species. In addition to the wild *Vitis* spp., many traditional or new cultivars are also good sources of desirable traits. Germplasm collections have stored at least 10,000 grapevine varieties. However, because synonyms and homonyms occur in grapevine, a more accurate estimate of the number of varieties might be closer to

5,000. The true number of varieties and the relationships between them remain to be determined possibly by extensive DNA profiling of the grape varieties in different collections and the development of a common database. Germplasms are being maintained in the field as well as in tissue culture or cryopreservation (at -196°C). It was found that selection of the superior accessions and evaluation of the germplasms are probably one of the first steps for grapevine breeding. During the past ten years, there has been increasing interest in grape germplasm resources and genetic diversity analysis. It helps to protect some varieties of grapes, especially wild grapes like *Vitis vinifera* ssp. *sylvestris*, which is an ancestor of cultivated varieties, and facilitates their utilization in grapevine breeding programs. *Sylvestris* grapes can climb forest trees at about 20-30 m of height and produce small bunches of fruits. In addition, they resist/tolerate both biotic and abiotic stress factors including drought, lime, pests and diseases. Nowadays, information on grape database and germplasm collections can be found on different websites (Tantasawat et al. 2010).

## 5. PRESERVATION OF GRAPEVINE GENETIC RESOURCES

The cultivated grapevine *Vitis vinifera* does not breed true from seed (Mullins, 1992). Vegetative propagation provides relative genetic stability, as well as phenotypic consistency of desirable traits (Jackson, 2008). For this reason and to ensure the perpetuation of the elite selected phenotypes, grapevine cultivars have been selected, conserved and maintained via vegetative propagation since domestication thousands of years ago (Thomas et al. 1994; Pelsy, 2010). Vegetative propagules from a single common ancestor are referred to as clones (Forneck, 2005). One drawback associated with clonal propagation is the loss of genetic diversity generated by genome recombination during sexual reproduction (Emanuelli et al., 2013).

Despite the relative genetic stability that vegetative propagation provides, somatic mutations are still possible (Meneghetti et al 2012). Although such mutations have the potential to disrupt quality traits, they can also result in the appearance of superior qualities or distinct characters producing an individual sport or new cultivar (Anhalt et al., 2011). Somatic mutations may be fixed via asexual propagation leading to intra-varietal diversity within cultivars resulting in several clonal lines with differing phenotypes (Franks et al., 2002).

A range of techniques have been utilized to study genetic diversity within cultivars including sequence specific amplification polymorphism (S-SAP) (Stajner et al., 2009), microsatellites or simple sequence repeats (SSRs) (Imazio et al., 2002), inter simple sequence repeats (ISSR) and amplified fragment length polymorphism (AFLP) (Forneck, 2005). The advent of next generation sequencing (NGS) and the use of single nucleotide polymorphism (SNP) markers allow economic and reliable screening of tens or hundreds of thousands of markers per assay (de Lorenzis et al., 2017). SNPs are able to be identified from short reads created by NGS platforms, through aligning to a reference genome or *de novo* genome assembly (Nielsen et al., 2011). The use of reduced representation libraries (RRLs) as a form of complexity reduction combined with barcoded sampling allows for multiplexing of multiple samples in a single sequencing lane, has significantly reduced the cost and complexity of SNP genotyping. Compared to other genotyping techniques SNPs are highly stable and reproducible between laboratories (Elshire et al., 2011).

However, many clonal lines of *Vitis vinifera* can often be indistinguishable using genetic information alone. A recent example of this was presented in two cultivars – Anglianico and Muscat, whereby an 18k SNP array could not discriminate clonal lines. However this study



did discriminate clones based on chemical diversity of secondary metabolites, specifically anthocyanins and phenolic substances (de Lorenzis et al. 2017). This is a method of discrimination via phenotype not unlike the physical practice of ampelography albeit at a finer resolution. The authors speculated that epigenetic regulatory mechanisms could contribute to clonal diversity in grapevine. This was hypothesized much earlier by Imazio et al. (2002) who suggested that morphological differences amongst clones could be the result of differential expression owing to clone specific epigenetic differences. Since then the use of epigenetic approaches has shown to be better suited for the identification of clonal lines (Ocana et al., 2013).

The process of vegetative propagation in plants shortcuts the developmental transition from seedling to adult plant. This vegetative phase change has already occurred in woody perennials sometimes at the expense of juvenile potential (such as rooting). This phase change can be reversed and is known as rejuvenation. Various techniques of propagation from mature tissues have resulted in observations of change due to rejuvenation. Phase change following rejuvenation has been shown to present altered DNA methylation states compared with juvenile and mature tissues in *Sequoia sempervirens*. Propagation based methylation differences have been observed in several species including *Sequoiadendron giganteum*, *Manihot esculenta*, *Pinus radiata* and *Vitis vinifera* (Grigg, 2017).

Another way to preserve the genetic diversity of grape varieties is institutional germplasm conservatories. They are certainly useful, but it is not reasonable to count only on these conservatories for the preservation of the genetic resources of vines. Their surfaces and their numbers are insufficient to take into account the wide genetic diversity of the vine. They depend on public funding and thus are subject to possible budget cuts. By gathering the genetic resources in a small number of sites, one increases the risk of accidents: climatic catastrophes, diseases, budget cuts.... To show how fragile they are, one can quote the case of Vassal estate in France, which gathers the greatest number of vine genotypes in the world (INRA, 25 ha, 7,500 genotypes, 2,600 *Vitis vinifera* varieties, 210 rootstocks and 720 hybrids originating from 47 countries). The INRA is not the owner of the land and the lease is expiring. This situation forces the INRA to move this vast collection. In complement of the conservatories, genetic resources could be preserved in private wine producing estates. Without questioning institutional clonal selection, which has shown its effectiveness, it is desirable to promote private mass selections on a minority but significant proportion of planted surfaces, for example 5% (van Leeuwen and Roby, 2010). Such a proportion would make it possible to preserve a genetic diversity on approximately 40,000 ha in France, that is to say about 1000 times more than is possible today in the institutional conservatories. The private clonal selections can also contribute, in a more limited way, to the preservation of the biodiversity. It is necessary to accompany these private selections (mass or clonal) in particular to limit the risk of propagation of virus diseases and phytoplasma. Mass selection is the easiest way to carry out a private selection of plant material. It is also possible to implement a true private clonal selection programme. This way requires obviously more important technical and financial means than the mass selection and contributes more modestly to the preservation of the biodiversity (Roby et al., 2014).

## 6. CONCLUSION

Over the past millennia, human selection for traits of interest, especially those important to fruit production, have shaped the appearance of grapes. In particular, selection for hermaphroditic flowers increased grape production, as propagating both male and female plants was no longer required. While nearly half of all grapes grown are vinified into wine, 36% are consumed fresh and the rest are dried or used for juice.<sup>2</sup> Desirable berry traits differ depending on the use of the grapes, and, thus, the different breeding targets for table and wine grapes have led to differences in berry and bunch size. There is also evidence of selection for white berry color.

Over the past millennia, human selection for traits of interest, especially those important to fruit production, have shaped the appearance of grapes. In particular, selection for hermaphroditic flowers increased grape production, as propagating both male and female plants was no longer required. While nearly half of all grapes grown are vinified into wine, 36% are consumed fresh and the rest are dried or used for juice.<sup>2</sup> Desirable berry traits differ depending on the use of the grapes, and, thus, the different breeding targets for table and wine grapes have led to differences in berry and bunch size. There is also evidence of selection for white berry color.

The ability to save time and money when breeding makes grapes an attractive candidate for MAS. Using genetic markers, individuals can be tested for a trait at the seed or seedling stage. Thus, MAS offers the greatest potential for traits that are difficult and expensive to phenotype, such as disease resistance, or time-consuming to measure, such as fruit traits only visible after several years. Wild *Vitis* relatives have been previously used for hybrid grape breeding and are a promising source of resistance loci for introgression through MAS (For example, *V. arizonica* was used in the development of Pierce's disease-resistant wine grapes), while *Muscadinia rotundifolia* was used to pyramid resistance from both powdery and downy mildew into *V. vinifera*. Markers have also been identified for many other traits in grape including berry color, flower sex, seedlessness and muscat aroma.

The discovery of markers for agriculturally important traits has facilitated the use of MAS in grapes. However, the technique is only worthwhile when the cost of phenotyping is higher than the cost of discovering new markers and genotyping cultivars. Decreasing DNA sequencing costs will continue to accelerate both marker discovery and the implementation of MAS in grape breeding. While sequencing costs have decreased, phenotyping remains a slow and expensive process. Fortunately, historical phenotype information already available in gene banks can be linked with genomic information for genetic mapping of important traits.

## 7. ACKNOWLEDGEMENT

This paper is part of the project Improving the Competitiveness of the Wine Sector of Serbia - EduNaWi (2020). Project code: 680-00-0071 / 2020-02. Republic of Serbia, Ministry of Agriculture, Forestry and Water Management.

## REFERENCES

- Anhalt, U.C.M., Martinez, S.C., Ruhl, E. & Forneck, A. (2011) Dynamic grapevine clones – an AFLP – marker study of the *Vitis vinifera* cultivar Riesling comprising 86 clones. *Tree Genetics & Genomes* 7, 739-746
- Bacilieri, R., Lacombe, T., Le Cunff, L., et al. (2013) Genetic structure in cultivated grapevines is linked to geography and human selection. *BMC Plant Biol* 13
- Battilana, J., Costantini, L., Emanuelli, F., Sevini, F., Segala, C., Moser, S., Velasco, R., Versini, G. & Grando, M.S. (2009) The 1-deoxy-D-xylulose 5-phosphate synthase gene co-localizes with a major QLT affecting monoterpene content in grapevine. *Theoretical and Applied Genetics* 118, 653-669
- Boss, P.K. & Davies, C. (2009) Molecular biology of anthocyanin accumulation in grape berries. In: Roubelakis-Angelakis KA (Ed) *Grapevine Molecular Physiology and Biotechnology*, Springer, Dordrecht, pp 263-292.
- Castellarin, S.D. & Di Gaspero, G. (2007) Transcriptional control of anthocyanin biosynthetic genes in extreme phenotypes for berry pigmentation of naturally occurring grapevines. *BMC Plant Biology* 7, 1-10.
- De Bolt, S., Hardie, J., Tyerman, S. & Ford, C.M. (2004) Composition and synthesis of raphide crystals and druse crystals in berries of *Vitis vinifera* L. cv. Cabernet Sauvignon: Ascorbic acid as precursor for both oxalic and tartaric acids as revealed by radiolabelling studies. *Australian Journal of Grape and Wine Research* 10, 134-142.
- de Lorenzis, G., Squadrito, M., Rossoni, M., di Lorenzo, G.S., Brancadoro, L. & Scienza, A. (2017) Study of intra-varietal diversity in biotypes of Anglianico and Muscat of Alexandria (*Vitis vinifera* L.) cultivars. *Australian Journal of Grape and Wine Research* 23, 132-142.
- DeBolt, S., Cook, D.R. & Ford, C.M. (2006) L-tartaric acid synthesis from vitamin C in higher plants. *Proceedings of the National Academy of Sciences USA* 103, 5608-5613.
- Doligez, A., Audiot, E., Baumes, R., & This, P. (2006) QTLs for muscat flavor and monoterpene odorant content in grapevine (*Vitis vinifera* L.). *Molecular breeding* 18, 109-125)
- Duchene, E., Butterlin, G., Claudel, P., Dumas, V., Jaegli, N. & Merdinoglu, D. (2009) A grapevine (*Vitis vinifera* L.) deoxy-D-xylulose synthase gene collocates with a major quantitative trait loci for terpenol content. *Theoretical and Applied Genetics* 118, 541-552.
- Edge-Garza, D.A., Luby, J.J. & Peace, C. (2015) Decision support for cost-efficient and logistically feasible marker-assisted seedling selection in fruit breeding. *Mol Breed* 35, 223
- Eibach, R., Hastrich, H., & Töpfer, R. (2003) Inheritance of aroma compounds. *Acta Horticulturae* 607, 337-344
- Eibach, R., Zyprian, E., Welter, L. & Töpfer, R. (2007) The use of molecular markers for pyramiding resistance genes in grapevine breeding. *VITIS* 46, 120–124.
- Elshire, R.J., Glaubitz, J.C., Sun, Q., Poland, J.A., Kawamoto, K., Buckler, E.S. & Mitchell, S.E. (2011) A robust, simple genotyping-by-sequencing (GSB) approach for high diversity species. *Plos One* 6.
- Emanuelli, F., Battilana, J., Costantini, L., et al. (2010) A candidate gene association study on muscat flavor in grapevine (*Vitis vinifera* L.). *BMC Plant Biol* 10, 241.
- Emanuelli, F., Lorenzi, S., Grzeskowiak, L., Catalano, V., Stefanini, M. & Troglio, M. (2013) Genetic diversity and population structure assessed by SSR and SNP markers in a large germplasm collection of grape. *BMC Plant Biology* 13.

- Fischer, B.M., Salakhutdinov, I., Akkurt, M., Eibach, R., Edwards, K.J., Töpfer, R. & Zyprian, E.M. (2004) Quantitative trait locus analysis of fungal disease resistance factors on a molecular map of grapevine. *Theoretical and Applied Genetics* 108, 501-515.
- Forneck, A. (2005) Plant breeding: Clonality – A concept for stability and variability during vegetative propagation. In: *Progress in Botany*, Vol 66: Genetics Physiology Systematics Ecology. Eds. K. Esser, U. Lüttge, W. Beyschlag & J. Murata (Springer: Heidelberg, Berlin), pp. 164-183.
- Fournier-Level, A., Lacombe, T., Le Cunff, L., Boursiquot, JM. & This, P. (2010) Evolution of the VvMybA gene family, the major determinant of berry colour in cultivated grapevine (*Vitis vinifera* L.). *Heredity* 104, 351–362.
- Fournier-Level, A., Le Cunff, L., Gomez, C., et al. (2009) Quantitative genetic bases of anthocyanin variation in grape (*Vitis vinifera* L. ssp. *sativa*) berry: a quantitative trait locus to quantitative trait nucleotide integrated study. *Genetics* 183, 1127–1139.
- Franks, T., Botta, R., Thomas, M.R. & Franks, J. (2002) Chimerism in grapevines: implications for cultivar identity, ancestry and genetic improvement. *Theoretical and Applied Genetics* 104, 192-199.
- Freitas S., Gazda Małgorzata A., Rebelo M., Munõz-Pajares A. J., AzevedoSilva D., Beja-Pereira A., Sottomayor M., Gonçalves E., Martins A., Ferrand N., Carneiro M., Azevedo H. Insights on grapevine (*Vitis vinifera*) biodiversity using NGSenabled approaches. In *Book of Abstracts*. INTEGRAPPE 2019 - Data Integration as a key step for future grapevine research, Conference Center of Mediterranean Agronomic Institute of Chania, Crete, Greece, 25 - 28 March 2019.
- Grando, M.S., Sevini, F., Moser, S., Marino, R., Dalla Serra, A. & Versini, G. (2004) Genetic mapping of aroma compounds in grape. *Bulletin de l'Organisation Internationale de la Vigne et du Vin*. 77, 503-514
- Grigg, D. (2017) An investigation into the effect of grapevine age on vine performance, grape and wine composition, sensory evaluation and epigenetic characterization. School of agriculture, Food and Wine, Faculty of Science, The university of Adelaide, Weite Research Institute, Glen Osmond, SA 5064.
- Hausmann, L. & Töpfer, R. (2006) Analyse von Kandidatengenen für die Biosynthese von Anthocyanidin-3,5-Diglucosiden bei der Rebe. *Vorträge für Pflanzenzüchtung* 70, 180-186.
- Hausmann, L., Neumann, K., Eibach, R., Zyprian, E. & Töpfer, R. (2009) Development of a molecular marker for an anthocyanin 3,5-diglucoside formation in berry skin. *Acta Horticulturae* 827, 457-460.
- Hendrick U.P., Anthony R.D. (1915) Inheritance of certain characters of grapes. *Journal of Agricultural Research* 4, 315-330.
- Houle, D., Govindaraju, D.R. & Omholt, S. (2010) Phenomics: the next challenge. *Nat Rev Genet* 11, 855–866.
- Imazio, S., Labra, M., Grassi, F., Winfield, M., Bardini, M. & Scienza, A. (2002) Molecular tools for clone identification: the case of the grapevine cultivar “Traminer”. *Plant Breeding* 121, 531-535.
- International Grape Genome Program (IGGP) (2002) White paper. [<http://www.vitaceae.org>].
- Jackson, R.S. (2008) Grape species and Varieties. In: *Wine Science* (Third Edition), Ed. R.S. Jackson (Academic Press: San Diego), pp. 15-49.
- Jánváry, L., Hofmann, T., Pfeiffer, J., Hausmann, L., Töpfer, R., Fiscer, TC. & Schwab, W. (2009) A double mutation in the anthocyanin 5-O-glucosyltransferase gene disrupts

- enzymatic activity in *Vitis vinifera* L. *Journal of Agriculture and Food chemistry* 57, 3512-3518.
- Kobayashi, S., Goto-Yamamoto, N. & Hirochika, H. (2004) Retrotransposon-induced mutations in grape skin color. *Science* 304(5673), 982.
- Kobayashi, S., Goto-Yamamoto, N. & Hirochika, H. (2004) Retrotransposon-induced mutations in grape skin color. *Science* 304, 982–982.
- Lijavetzky, D., Ruiy-García, L., Cabezas, J.A. De Andrés, M.T., Bravo, G., Ibañez, A., Carreno, J., Cabello, F., Ibañez, J. & Martínez-Zapater, J.M. (2006) Molecular genetics of berry color variation in table grape. *Molecular Genetics and Genomics* 276, 427-435.
- Luby, J.J. & Shaw, D.V. (2001) Does marker-assisted selection make dollars and sense in a fruit breeding program? *HortScience* 36, 872–879.
- Marguerit, E., Boury, C., Manicki, A., et al. (2009) Genetic dissection of sex determinism, inflorescence morphology and downy mildew resistance in grapevine. *Theor Appl Genet* 118, 1261–1278.
- McClure, K.A., Sawler, J., Gardner, K.M., Money, D. & Myles, S. (2014) Genomics: a potential panacea for the perennial problem. *Am J Bot* 101, 1780–1790.
- Mejía, N., Soto, B., Guerrero, M., et al. (2011) Molecular, genetic and transcriptional evidence for a role of VvAGL11 in stenospermocarpic seedlessness in grapevine. *BMC Plant Biol* 11, 57.
- Melino, V.J., Soole, K.L. & Ford, C.M. (2009) Ascorbate metabolism and the development demand for tartaric and oxalic acids in ripening grape berries. *BMC Plant Biology* 9, 145.
- Meneghetti, S., Calò, A., & Bavaresco, L. (2012) A strategy to investigate the intravarietal genetic variability in *Vitis vinifera* L. for clones and biotypes identification and to correlate molecular profiles with morphological traits or geographic origins. *Mol Biotechnol* 52, 68-81.
- Migicovsky, Z. & Myles, S. (2017) Exploiting wild relatives for genomics-assisted breeding of perennial crops. *Front Plant Sci* 8, 460.
- Migicovsky, Z., Sawler, J., Money, D., et al. (2016) Genomic ancestry estimation quantifies use of wild species in grape breeding. *BMC Genomics* 17, 478.
- Mullins, M.G. (1992) *Biology of the grapevine*. Cambridge University Press: Cambridge, NY, USA.
- Myles S. (2013) Improving fruit and wine: what does genomics have to offer? *Trends Genet* 29, 190–196.
- Nielsen, R., Paul, J.S., Albrechtsen, A. & Song, Y.S. (2011) Genotype and SNP calling from next-generation sequencing data. *Nature Reviews Genetics* 12, 443-451.
- Ocana, J., Walter, B & Schellenbaum, P. (2013) Stable MSAP markers for the distinction of *Vitis vinifera* cv. Pinot noir clones. *Mol Biotechnol* 55, 236-248.
- Pelsy, F. (2010) Molecular and cellular mechanisms of diversity within grapevine varieties. *Heredity* 104,331-340.
- Rapp, A. (1994) Aroma compounds of wine. *Die Winzer-Zeitschrift* 9, 28-32.
- Riaz, S., Tenscher, A.C., Graziani, R., Krivanek, A.F., Ramming, D.W. & Walker, M.A. (2009) Using marker-assisted selection to breed Pierce’s disease-resistant grapes. *Am J Enol Vitic* 60, 199–207.
- Roby, J.-P., van Leeuwen, C., Gonçalves, E., Graça, A., & Martins, A. (2014) The preservation of genetic resources of the vine requires cohabitation between institutional clonal selection, mass selection and private clonal selection. In: *BIO Web of Conferences*, volume 3. 37th World Congress of Vine and Wine and 12th General Assembly of the OIV, Mendoza, Argentina, November 9-14, 2014.

- Sparvoli, F., Martin, C., Scienza, A., Gavazzi, G. & Tonelli, C. (1994) Cloning and molecular analysis of structural genes involved in flavonoid and stilbene biosynthesis in grape, *Vitis vinifera* L. *Plant Molecular Biology* 24, 743-755.
- Stajner, N., Jakse, J., Javornik, B., Masuelli, R.W. & Martinez, L.E. (2009) Highly variable AFLP and S-SAP markers for the identification of “Malbec” and “Syrah” clones. *Vitis* 48, 145-150.
- Tantasawat P., Poolsawat O. & Chaowiset W. (2010) Grapevine breeding and genetics. In *The Role of Food, Agriculture, Forestry, and Fisheries in Human Nutrition*; Squires, V.; Publisher: Eolss Publishers Company Limited, Truemans Solicitors, Eden House, 2 St Aldates, Oxford, Oxfordshire.
- This, P., Lacombe, T. & Thomas, M.R. (2006) Historical origins and genetic diversity of wine grapes. *Trends in Genetics* 22, 511-519.
- Thomas, M.R., Cain, P. & Scott, N.S. (1994) DNA typing of grapevines: A universal methodology and database for describing cultivars and evaluating genetic relatedness. *Plant Molecular Biology* 25, 939-949.
- Töpfer, R., Hausmann, L. & Eibach, R. (2011) Molecular breeding. In: *Genetics, Genomics and Breeding of Grapes*. Adam-Blondon, A.-F., Martínez-Zapater, J.M., Kole, C. (eds). CRC Press: Boca Raton, FL, 2011, pp 160–185.
- Töpfer, R., Hausmann, L., Harst, M., Maul, E., Zyprian, E., Eibach, R. (2011) New Horizons for Grapevine Breeding. *Fruit, Vegetable and Cereal Science and Biotechnology* 5 (Special Issue 1), 79-100.
- van Leeuwen C. & Roby. J.-P. (2010) Diversité génétique de la vigne: promouvoir plusieurs voies de sélection. *Union Girondine*, 1063, 38–44.
- Walker, A.R., Lee, E., Bogs, J., McDavid, D.A.J. Thomas, M.R. & Robinson, S.P. (2007) White grapes arose through the mutation of two similar and adjacent regulatory genes. *The Plant Journal* 49,772-785.
- Welter, L.J., Göktürk-Baydar, N., Akkurt, M., Maul, E., Eibach, R., Töpfer, R. & Zyprian, E.M. (2007) Genetic mapping and localization of quantitative trait loci affecting fungal disease resistance and leaf morphology in grapevine (*Vitis vinifera* L.). *Molecular Breeding* 20, 359-374.

## ADVANTAGES AND RISKS OF THE IMPACT OF AGRICULTURAL BIOTECHNOLOGY IN INTERACTION WITH THE ENVIRONMENT

Jelena Bošković<sup>1</sup>  
Vladica Ristić<sup>2</sup>

<sup>1</sup>Jelena Bošković, PhD, Full professor, Academician of IRASA, University Business Academy in Novi Sad, Faculty of Economics and Engineering Management in Novi Sad, Cvećarska 2, 21000 Novi Sad, Republic Serbia  
Email: jboskovic@fimek.edu.rs

<sup>2</sup>Vladica Ristić, Full Professor, Academician of IRASA, Metropolitan University of Belgrade, Faculty of Applied Ecology "FUTURA" in Belgrade, Republic Serbia Email: vladicar011@gmail.com

### ABSTRACT

Application biotechnologies are considered genetic engineering in agriculture with the introduction of genetically modified (GM) plants are constantly creating new opportunities to increase crop production and to solve problems in agriculture, such as diseases, pests, weeds, abiotic stresses and nutritional limitations. These are formed, and the plants have new properties that enable their use in pharmaceutical manufacturing. As the GM plant introductions to various locations characterized by a variety of ecosystems, types of agriculture, biodiversity and agricultural practices, it is necessary to scientifically understand the effects of growing GM plants on the environment, which will provide security and environmental sustainability. The most important research it focused on was the invasiveness of the GM plant, vertical and horizontal gene transfer, the impact on biological diversity and on other products. These tests are very complex, multi, inter and transdisciplinary. This article discusses some of the most important problems related to the application of the technology of genetic engineering in agriculture and the introduction of GM plants into the environment, such as plant protection, ecological effects of horizontal gene transfer, biodiversity, stress, the effects of land etc. There is a clear need to further investigate the size and scope of the risk spreading of transgenic plants. In assessing the interrelation of GM plants and existing varieties, more detailed knowledge of the development of GM plants will provide a clearer, more reliable and precise directed activity in plant sciences.

### KEY WORDS

Genetic engineering, crop production, GM plants, biotechnology

### 1. INTRODUCTION

Genetic manipulations have been commonly used throughout modern plant selection, including new combinations of genes [1], artificial manipulation of the number of chromosomes [2], the development of addition [3], substitution and breeds containing specific chromosomes, chemical and radioactive treatments aiming to induce mutations and chromosomal rearrangements, cell, tissue and embryo cultures, in vitro fertilization and fusion

of protoplasts for detection of interspecies and genus hybridization. Integration of these technologies have made the greatest contribution to genetic improvement in yield, adaptation to the environment [4], resistance to pests and parasites [5], as well as improving the quality [6], that was permanently required by both food producers and consumers [7; 8; 9; 10; 11].

Developments in molecular biology, genetic engineering enabled the efficient modification of cultivated plants and CRISPR/Cas9 [12; 13; 14; 15]. These technologies may have adverse impact on the environment [16; 17], human health and increase poverty. During the forthcoming period it is necessary to devote more attention to commercially and economically justified use of GM crops in agricultural food production [18; 19; 20; 21; 22; 14; 24]. In this respect, linking science and politics should facilitate an overall assessment of acceptability and spread of GM crops. There are still significant disagreements about the extent to which sustainability, globalization, ethics and socio-economic approach should be parts of the risk assessment of GM crop use in most countries [25; 26; 27; 28].

## **2. PLANT PROTECTION AND GENETICALLY MODIFIED CROPS**

Major plant protection considerations about GM crops (GMCs) are the possibilities of incorporation of resistance genes into insects, fungal and bacterial pathogens, viruses, emphasizing the long-term resistance as the main problem of [29; 30; 31; 32; 33]. Pest plant protection by genetic modification is demonstrated by the use of Bt toxins from *Bacillus thuringiensis*, successfully used as spray for many years, that has been introduced in a number of plant species such as: tomato, tobacco, cotton, etc. It has been proved that pea lecithin protects against insect attacks in transgenic potato and tobacco. Trypsin inhibiting protein of fodder pea has also been used. GM plants provide a great possibility of benefits to the environment by reduced pesticide use by the development of pest resistance. However, these advantages can be quickly denied: there are possible strategies of exposure reduction of pests to transgenic products, thus lowering resistance level and applying restricted transgene action [34; 35; 36].

It has been shown that the application of transgenic resistance to viruses through indirect protection of cap-proteins is possible, and it can be used as a method for a wide range of viruses and hosts, e.g. expression of TMV cap-proteins for tobacco mosaic virus of potato and tomato resistant to PVX and PVY [12; 37].

The use of genetic modification in fungal and bacterial plant pathogens control has also been developed. As with pests, the main problem is transient resistance and complex interactive pathogen-hosts relations. The improvement of such resistance was attempted to achieve by the use of GM plants. In addition, there is a need to develop multiple resistance strategies (i.e. pyramiding resistance genes) towards different virulence levels of plant parasites [12; 35; 38; 20; 21; 30; 39].

## **3. HORIZONTAL GENE TRANSFER (HTG)**

Horizontal gene transfer (HTG) is the transfer of the genetic material between cells or genomes that belong to different species, during processes that differ from the common reproduction. During basic reproduction processes genes are transferred vertically from parents to their offspring. Bacteria are known to participate in gene exchange between different species in nature. It is performed via three mechanisms: during conjugation when genetic material passes between cells, by transduction where the genetic material is



transferred from one cell of infective viruses into another and by transformation in which genetic material is taken directly from the cell or its environment [5; 12; 40]. For the successful horizontal gene transfer, foreign genetic material must become part of the cell genome, or be maintained stable within the recipient cell. In certain cases, foreign genetic material that enters the cell, will be removed before it incorporates into the genome, especially if it originates from the different species [41]. Under specific yet not fully clarified ecological conditions, foreign genetic material avoids the removal and incorporates into the genome [42].

Horizontal gene flow is well known in bacteria, but also in some higher plants and animals. In its base this process comprises the whole biosphere, and bacteria and viruses are intermediary in gene flow, gene pool, replication and recombination [16; 43].

There are many potential pathways for horizontal gene transfer in plants and animals. As there are many viruses that infect plants and animals, transduction is expected to be the most frequent way of transfer. Latest investigations in gene therapy indicate potential high importance of transformation for mammal cells, including humans. Direct transformation is not as significant for plant cells that have protective cell walls. However, soil bacteria that belong to the genus *Agrobacterium* are able to transfer T (tumor) segment of its induced tumor (Ti) plasmid into plant cells in the conjugation process. This Ti-DNK is widely used as a resource of gene transfer in plant genetic engineering. Foreign genetic material from insects and arthropods with strong mutagenic reactions can also be built in into plant and animal cells. Additionally, bacterial pathogens that penetrate into plant and animal cells can take over foreign genetic material and carry it over in cells as vectors, probably to any kind of organisms on the planet. The most significant barriers for horizontal gene flow are employed after penetration of the foreign genetic material into the cell [44].

However, viruses and other genetic parasites, such as plasmids and transposons, have special genetic signals and probably a structure that enables them to avoid annihilation. The genetic material of viruses is protected by the protein coat. They discard their protein coat when penetrating the cell, thus enabling the creation of numerous copies or pass directly into the cell genome. Plasmids are free fractions usually round in shape so that genetic material can finally be maintained in the cell separately from the cell genome [45]. Transposons (jumping genes) are blocks of genetic material that have the ability to incorporate into the genome but can survive out of chromosomes, with or without the replication, and are kept within plasmids for further reproduction. Genes of genetic parasites such as viruses, plasmids and transposons have a significantly higher ability to be successfully transferred into the cell genome. In such manner they function as vectors for horizontal gene transfer regulated by inner characteristics of the organism, linked to the specific ecological conditions [1; 44; 14].

#### **4. EVIDENCE OF HORIZONTAL TRANSGENIC DNA TRANSFER**

It is believed that once incorporated transgenic DNA becomes stable. However, there is a body of evidence against this assumption. There are molecular data that prove structural stability of transgenic DNA, with regard to its location, point of penetration into genome and gene arrangement within the following generations. Transgenes can be either stabilized in successive generations or completely lost. Gene for herbicides tolerance incorporated into *Arabidopsis* with a vector, can show up to 30 times stronger vector avoidance behavior, and it spreads as the identical gene obtained by mutagenesis. The results obtained suggest that

horizontal gene transfer can occur via insects visiting plants for pollen and nectar, and that pollen can transfer transgenic DNA into the bee larvae gut [43; 44].

It has been experimentally confirmed that the secondary horizontal transgene and gene resistance markers to antibiotics transfer in genetically modified plants, soil bacteria and fungi. Transfer to fungi was achieved by simple co-cultivation, while the transfer to bacteria by reisolation of transgene DNA or a whole DNK of a transgenic plant. Successful transfer of kanamycin resistance gene markers to the soil bacteria *Acinetobacter* was achieved by the use of extracted total DNA from homogenized plant leaf of the following transgenic plants: *Solanum tuberosum* (potato), *Nicotiana tabacum* (tobacco), *Beta vulgaris* (sugar beet), *Brasica napus* (canola) and *Lycopersicon esculentum* (tomato). It has been evaluated that about 2500 copies of kanamycin resistance genes are enough for a successful transformation of a bacteria, regardless if there exist 6 million folded strands) of the present plant DNA.

However, natural conditions in the environment are widely unpredictable and some studies on synergetic effects could not be neglected in this case. Free transgenic DNA would be free in the rhizosphere around plant root, which is a significant critical point in the environment. Some other scientists have found a horizontal transfer of the kanamycin resistance gene from transgenic DNK to *Acinobacter*, and positive results have been obtained by the use of homogenized 100 $\mu$  of plant leaf.

Biotechnology industry insists that the existence of horizontal gene flow in laboratory conditions does not mean that it occurs in natural environments. However, there is a body of evidence showing that it can and does occur in nature. Above all, genetic material taken from dead and living cells resists outer conditions, does not dissolve or devastate as it has been previously assumed. This indicates that sand, humus acid parts and plant debris enable infections with more microorganisms in the soil. Bacterial transformation in soil via absorbed DNA into sandy clay has been confirmed by various experiments on microorganisms.

In 1993 researchers in Germany started a series of experiments with the rhyzomania resistant transgenic sugar beet plants [46], which contained a gene marker for kanamycin resistance, studying the stability of transgenic DNA and horizontal gene flow of transgenic DNA into the soil bacteria. Thus, horizontal gene flow represents a leading phenomenon that has occupied a significant place in the evolution of species, and it still does. All this suggests that natural horizontal gene flow presents a regulated process, limited by specific obstacles and mechanisms of rejection and inactivation of foreign genetic material. Genetic engineering created great variability of artificial construction for overcoming barriers between all kinds of organisms and forestalling all genomes [13; 47; 48; 49].

## **5. STRESS TOLERANCE AND PLANT RESISTANCE TO HERBICIDES (HRC)**

Great efforts have been directed also toward the increase of crop tolerance toward herbicides, and it has been tested worldwide [50]. Herbicide tolerance can be achieved through the increase of protective mechanism, by reduction of herbicide uptake, by degradation or reduction of susceptibility [51; 52; 53; 54]. Herbicide tolerance genes are widely used as markers in transgene plants selection. If genes are of different tolerance to herbicides, developed or incorporated into the identical plant species, they could stipulate the creation of weeds with multiple resistance genes [55; 56; 57; 58; 59; 60; 6; 109]

Numerous genes for tolerance to various environmental stress were inserted into plants. Greenhouse experiments showed that metallothioneins inserted in tobacco increased cadmium tolerance. The manipulation of genes that affects compatible solutions, such as betaine-

aldehyde dehydrogenase, improves tolerance to salinity. The spread of crops tolerant to drought and salinity could increase the range of wild relatives, making them more competitive, with consequential negative effects on ecosystems and agroecosystems [5; 61; 23].

Hybridization of plants resistant to herbicides (HRC) with populations of wild relatives makes these plants complicated for control, especially if they possess resistance to widely used herbicides [62; 38; 63]. Transgene plant resistance to herbicides [50; 64] makes chemical control easier, above all because it includes compounds that are active to a very wide spectrum of weed species [65; 66; 67]

## **6. QUALITY CHARACTERISTICS OF GM PLANTS**

Transgene diversity is directed towards the improvement of products derived from cultivated plants [67]. The effects of these changes on the whole plants are reflected in their metabolism and are of immediate interest to their commercial application. Some of these plants, especially commercially produced antisense "tomatoes" in the United States have been tested in field trials. The simplest change is probably the removal of the natural gene, for example, "antisense" tomato polygalacturonase gene.

Other modifications include metabolic pathways changes via the introduction of various metabolic enzymes from other species, turning the natural path to a different end product. This can result in manufacturing plant products in different plant species, animal or bacterial products in plants or completely new products [47; 38]. There are no a priori concerns about these types of GM plants, because the modifications are very different. Metabolism modification in the classical selection sometimes produces unexpected and undesired secondary effects. Unacceptably high levels of tannin were found in brown sorghum seed cultivated for resistance to birds.

Therefore, random change of characteristics, such as the nutrient value of the main product or an increase in toxic secondary metabolites, should be carefully considered. It is necessary to collect as many biochemical and other data on transgenic plants, before they are widely accepted, in order to avoid unintended consequences that may become a problem [68]. Adaptive effects of plants or hybrids with new characteristics, must be studied case by case [69; 16].

## **7. NON-CULTIVATED POPULATIONS OF TRANSGENIC PLANTS**

The possibility of transgenic plant introduction will be highly dependent upon their adaptive capability to the new environment. For many crops it is known that they form temporary non-cultivated populations, and these are species such as canola, lucerne, radish, carrot, rye, clover, sugar beet, chicory, beet, cabbage, of which some are native, whereas the others have probably been introduced for cultivation [70]. In some cultivated crops, i.e. rye, the difference between non-cultivated and natural population is unclear, whereas in case of some other species the colonization is not extensive and there probably has been no harmful influence on non-cultivated plant species [71]. Possibilities of gene flow from the trial field with GM plants through pollen will depend upon sexual compatibility between GM crops and their wild relatives, and possibilities for pollination and obtaining of seed [72; 73].

The occurrence frequency of such gene transfer will be influenced by important spatial isolation between GM crops and suitable recipients that depend upon the method of pollination, wind or insects, isolation in time, i.e. flowering season.

The experiments have been carried out in order to determine rates of cross-pollination between GM and non-GM potato planted at different spatial distances one from another [74]. The results were well harmonized, both showing that transgene movement outside GM trial field has been negligible at distances less than 10 m, and low rates of cross pollination that is usually present in potato have also been in accordance.

In contrast, in canola seed the compatible inbreeding is present, it can produce huge seed quantities, it is pollinated by wind and insects. Pollination at huge distance happen probably due to the insects; air born pollen can be found 30-50 m away from canola plants, but it is reduced with increasing distance [75; 76] have estimated the importance of pollination performed by honeybees in pollen dispersal from transgenic oilseed rape and concluded that although bees can travel up to 1-2 km from their hive, the food is carried from the vicinity of the hive.

Experimental trials on fields that use GM or non-GM plants can provide useful data in regard to necessary isolation distances used to avoid the release of transgene. However, trials on natural populations suggest that the situation could be more complex, and sub-classifications of local populations can strongly influence the transgene incorporation into wild populations [1].

Interpretation of the results has also been complex, and [77] emphasizes the prevailing importance of the calculation of dose changes in relation to distance from the GM experimental field, over the absolute percentage of GM seeds at a given distance from the plot. However, gene flow can depend not only on crops, but also on the variety, location and season [26]. Experiments on gene flow in populations of wild radish suggest that the size of donor and recipient population play a significant role in gene flow [78]. In that way would huge pollen sources, such as the great spectrum of GM gene introduction have a significant influence on the small wild population of compatible plants. They also note that there are noticeable variations in evaluations of gene flow, probably due to local-positional and pollinator effects. The other researchers have found similar effects in Cucurbita [79] and rice [80]. Further work on gene spreading in populations can be necessary during the assessment of the potential transgene dispersal. Such assessments become particularly important in analyzing the possibilities of transgene transfer from cultivated crops to related species [76; 81].

## **8. GENE TRANSFER FROM CROPS TO WEEDS**

The global group for wheat has identified three crops that have sexually compatible weed relatives for which it is probable that will be subject to gene transfer in agricultural systems [82].

Breeding via pollination and production of fertile hybrids varies from case to case. Even when chosen characteristics have positive advantage, introgression of new characteristics into existing weed population is still possible [53]. Risk of environmental damage that depends upon weed habitat. In weed-crops complexes [83; 49] analyzed in these studies, where the habitats of weed relatives are restricted to agricultural systems, it is not possible that new trait endangers natural ecosystems [84; 6].

## 9. ROLE OF AGRICULTURAL WEED ECOLOGY IN ACCIDENTAL HYBRIDIZATION

Weed ecology and evolutionary biology are of high importance in assessment of the perspective of accidental flow of resistant transgene to harmful organisms in the population of agricultural weeds [52; 25].

Model for accidental transgene flow has three phases that lead to creating widely distributed transgene carrying weed populations [85]. The first phase presents hybridization between weed and transgenic crops. The second phase is the occurrence of introgression and adaptation processes with evolutionary mechanisms that improve inadaptable traits in hybrid products of earlier generations. As a consequence, weeds transfer resistance transgene to harmful organisms [86] and due to that have a high adaptation level for certain agro ecosystems. Finally, the process of dispersion and dissemination of these new weeds in nature, together with local adaptation of various conditions is important during the transition of sufficiently wide areas.

Weed ecology and evolutionary biology are important for understanding the interaction between the three previously described phases. The real scientific data on weed ecology are still lacking. During the few last decades, scientists focus on herbicide weed control. Amongst these prevailing studies, ecological research and especially theoretical description have been neglected [62; 53; 16]. Hybridization between transgenic or conventional plant species and sexually compatible relatives occurs in many crops and produces new forms of weeds in obtained populations. In numerous papers this hybridization has detailed description and it can be expected that transgenes will transfer even over great spatial and significant obstacles of genetic incompatibilities [27]. In some systems accidental transfer of transgenes by hybridizations seems unavoidable. However, in other cases it is not clear if hybridization is a proportionally limiting phase in the transfer of transgenes. It is the assumption that hybridization can even be proportionally limiting in some circumstances, i.e. when hybridization occurs over significant obstacles of incompatibility. Aspects of weed ecology that can influence hybridization levels in these situations include weed cropping systems and effects of spatial and timely distribution of weeds in several phases.

The selection system between weeds in field agro-ecosystems of crops is a mixed system of fertilization in which occur inbreeding and cross fertilization (outbreeding), although the other reproductive systems have also been known. Therefore, the widely distributed systems of weed selection enable hybridization, but such fertilizations must happen during a significant level of inbreeding.

For selection systems and other aspects of genetic systems and reproductive ecology, that influence to the hybridization levels it is known to vary within and between weed populations. For instance, *Datura stramonium* populations in Northern Carolina have flowers that open to pollinators and exhibit approximately 10% outbreeding level. Quite the contrary, certain populations are exclusively self-pollinating, with flowers that do not open to the pollinators. In some cases this variation refers to the adaptation of the selection system after great expansion [84], however the attitude of the pollinators can vary in many ways, even geographically. These aspects of reproduction therefore should not be considered as permanent characteristics in the frame of weed species [46; 87].

Spatial weed distribution can strongly influence the hybridization of weed-plant species. First, many weeds have uneven distribution in fields, and in some papers it is described that uneven distribution in some species has a certain level of temporary stability [88]. Uneven distribution can be caused by edaphic factors or by persistent effects of high seed production.

In the frame of a field, uneven weed distribution can reduce hybridization weed-crop. Occurrence of weeds in plant population of adequate density, with a small proportion of single weeds at the ends of these plant populations limits populations proportionally to hybridization. More homogeneous and uneven distribution can significantly favor considerably higher levels of cross fertilization. In locally isolated individuals can be present higher quantities of crop pollen due to changes in the movement of pollinators as a function of local density. Weed density can have a contra-effect to the hybridization levels, when a plant serves as the female parent. In this case, high densities can favor hybridization with the advantage of achievement of great local weed pollen densities, and homogenous weed density can reduce plant hybridization. Weed distribution in a wide area around field crops agro-systems also has potential importance in determining the level of weed-crop hybridization. If conditions allow stabilization of weeds in areas that are not under crops in the region, then many small, isolated populations can exist [89].

Weed-crop hybridization can occur at higher levels in these populations than in populations in the field due to a number of reasons. For example, because of the differences in reproduction in many weed species, the flowering can occur over a long period of time during the growing season of a given species. Seed from the commercial crop fields, pollinated by wind or insects, scatter for more than 1 km outside the field. Therefore the crop pollen can be expected to reach the weed populations outside the agricultural fields within this distance. When considering the population of weeds in a particular environment, the proportion of intense flowering and the presence of pollen of cultivated plants, can significantly extend the range of opportunities for hybridization in many weed-crop systems.

Many weeds are highly variable. During certain years weather factors can lead to failure in controlling weeds in the wider region, resulting in high density of weeds in some areas. Weed density varies on a regional basis because of the interaction between the biology of weeds and regionally dependent different ways of weeds distribution and other factors of the breeding system. Both forms of variation can result in a significant increase in the absolute number of hybridization cases.

The level of hybridization is affected by the density of weeds, dependent variations in the behavior of pollinators or spatial distribution. For example, increased local presence of the species may enable them to settle border habitats in agricultural areas, which are densely populated, probably increasing the likelihood of hybridization. Therefore, levels of hybridization can vary significantly over the years and a number of weed species [81; 91; 92].

## **10. TRANSGENE INTROGRESSION AND WEED ADAPTATION**

The evolutionary process that follows hybridization will certainly be influenced by many ecological weed properties in agro systems of cultivated plants [50]. The nature of these systems seems prevalent only for strongly expressed factors of weed population regulation [110], compared with the majority of annual plant populations, which are short-lived and inhabit other types of ecosystems [93].

This can facilitate transgene introgression even if the hybrids and starting backcrossed generation have a low level of adaptive features in comparison to weeds that do not carry transgenes [61; 65].

Weed populations are frequently small and sometimes temporary, so the effects of selection, migration and random genetic changes will influence the evolution of introgression. Seed ecology is of primary importance for weed survival therefore the effects of transgenes on other genes in plant species and seed ecology will probably induce strong selective effects in these genes. The introgression of genes that improve adaptations of weeds to these

predominant selective factors can significantly increase the average adaptability of weed population [94]. Exchanges between adaptations to different limiting factors that result from introgression of a single gene can also be minimal. The best example is the evolution of herbicide resistance in weeds [50; 64; 89].

The occurrence of herbicide resistance often significantly increases the average survival and population growth of weed. Herbicide resistant mutation can have high absolute adaptability, despite basic functional damages that are caused by pleiotropic effects of resistance mutations. This shows how selection can favor a mutant that exceeds limiting factors. The other line of evidence rises from multiple examples of increased distribution and density of weeds from field trials over hybridization [88]. Finally, many cases of the basic increase in distribution and density of certain weeds follow moderate changes in cropping systems, providing an additional proof that many weed communities are regulated with several strong factors [81].

If correct, this assumption suggests that the adaptation of weeds can rely upon randomly transferred transgenes after hybridization and is made easier by the biological uniformity of the actual field crop ecosystems. Weeds can demand relatively narrow evolutionary movement, as it is a break of linkages toward undesirable characteristics of plant species in accordance with adaptation to a wide area [95; 96]. One criterion for assessment of transgene spread into weed population is that the survival rate of the hybrid weed-crop that carries transgene should be higher than the adaptability of non-hybrid weeds. This criterion can be much easier met in temporary ecosystems of field crops than in the majority of others. Therefore, the transfer of transgenes can be a fast process. Even hybrids with very low adaptability and early back-crossings can survive in agrosystems in adequate densities. There is a possibility for introgression and adaptation that make their survival easier. These assumptions can be applied to accidental transgene transfer that influences tolerance to abiotic factors. However, weed populations in wider areas can be restricted by one biotic factor adaptation to which it would provide basic survival increase [97; 43].

The other characteristics of weed ecology that probably influences the adaptation of the crop-weed hybrid is the frequency of occurrence of low efficient population size and high levels of self-fertilization, especially during the colonization process [55; 56]. Small population sizes cause random changes in genetic composition. These mechanisms can act at genetic base produced by hybridization, producing a number of genetically differentiated small populations from genetically different back-crossed weed populations.

This implies that adaptation in weed populations that contain random transgenes probably will be influenced by selection and random genetic change. Presence of both factors enables occurrence of evolutionary processes that do not occur when selection is dominant evolutionary mechanism. Specifically, adaptive effects of transgene combinations, other crop genes and weed genes can be more adaptable in expression with mutual action of random genetic exchanges in regard to the selection that acts alone [16]. These mechanisms can be especially expressed when weed populations have high levels of weakening and repeated colonization, forming ecological and genetic metapopulations. Although, it is still not clear if weeds in agriculture have metapopulative structure, occurrence of such structures, in combination with small sized population and altering selection pressures create convenient conditions for equilibrium processes. However, the effect of these processes can itself be unpredictable due to geographic variations in population structure in some weed species due to the cropping system, local adaptation after colonization, time span from colonization and hybridization with related taxonomic categories [1; 26].

The final dimension of weed ecology in relation to adaptation after hybridization is the ecology of seeds. The ability to maintain seed stability in the soil, together with effective spreading and the ability of fast and efficient reproduction are the most important features in the spread of weeds in crop field agro-ecosystems [98]. The weed population's dynamics have shown that seed demography (i.e. survival and germination levels) greatly affects growth levels of weed populations. The longevity of weed seeds varies considerably between species. Many agricultural activities affect the demographics of seed amounts in the soil, preventing germination or otherwise increasing the seed extinction levels. These factors include stubble crops, tillage and residue burning, that can affect the seed directly or indirectly, via effects on the animals that feed on seeds and pathogens. Germination and dormancy of weed seeds is important for the survival in any given developmental system [25].

If the transgenes affect the weed ecology, the caused effects are likely to act as factors dominant for the survival [34] hence leading to weed infestation. Similarly, the unadjusted effects on the ecology of seed may be the primary mechanism by which non-transgenic crops reduce the adaptation after hybridization. There are several other aspects of the ecology of weed seed, which affect the adaptation phase. The first is the well-known effect of dormancy, where the genotypes of plant weeds that grow out of environmental conditions, can again be separated for the storage during adverse conditions periods. Therefore, the seed populations are affected by the genetic variability of weed populations. Also, seed population, as a form of temporary expansion of genotypes allows weeds to be tested over a wider range of conditions what would not be possible otherwise. This effect can significantly increase the possibility that a weed carrying accidentally transposed transgene appears in an environment to which it was adapted. Molecular and biochemical data on homology levels between species of crops and their wild relatives worldwide indicate gene introgression from crops into populations of wild relatives [99], in various plant species including maize, melon, carrot, sugar beet and rice. The possibility of transgene introgression into wild populations, during time within some species and in some geographic areas would be very high. Hybrids between crops and their wild relatives most probably occur in crops with low adaptation grown in their region of origin. Minimal divergence and maximum exposure from the other relatives should be provided. Level of transgene introgression from crops into wild species is influenced by factors such as overlapping of flowering period with wild species, and capability of hybrid to back-cross with wild relatives within the population [76]. This suggests that gene transfer possibility is especially significant in tropic areas, because many important crop species evolutionary originate from these areas.

Isolation distance or incompatible flowering time, can be realized through the use of lines - barriers with different species, guard-lines with the same species and application of genetic engineering causing male sterility [95] that might contribute to genetic isolation. Evidence suggests that isolation itself could reduce the degree of introgression due to pollinating insects [34; 35], while the use of barriers or guard plants could be useful for limiting the spread of GM pollen from experimental field. Other proposed methods of genetic isolation include the selection for increased feeding in GM crops or reduced sexual compatibility with wild relatives. The use of suicide genes was also considered, however, such measures involve significant limitations in the application of GM plants.

## **11. SPATIAL SEED DISPERSION AND WEED COLONIZATION**

Efficient spatial dispersion of seed is considered a primary feature of weeds [66] and it is expected that weed ecology influences the fate of the accidentally transferred spread transgenes in a number of ways. On the field scale, simulation modeling indicates that high



levels of weed seed dispersal generally greatly increase the population of weeds [46; 90]. For most weeds in field crops dispersion is determined by the interaction of characteristics of weeds and human activities, such as contaminated seeds of cultivated plants, equipment, water for irrigation and seed transmission. When human activities become the main vectors of the spread of weed seed, those dispersions are difficult to characterize, because of the geographical variations of the processing system. As a result, the maximum spreading distances are not known in most cases.

On a wider scale, many cases of rapid expansion of the sub-continental weed species are known. Weed species were found to become abundant over large areas west USA [81], due to the changes in farming methods that improve their abundance, such as *Aegilops cylindrica*, sexually compatible weed in wheat. Weeds resistant to herbicides spread over hundreds of kilometers of road shoulders in less than a decade. These observations suggest that weed populations of road shoulders of other non-field habitats may be important for the spatial spread of weeds, recognizing the importance of weed ecology in agricultural areas and the accidental spread of the transgenes [62; 25]. Herbicide resistant crops can be agronomically harmful if the resistant species germinates before the sown plants germinate, or if the herbicide resistant plant occurs as a weed on another field [100].

Weeds can have significantly higher adaptability over large spatial areas of the transferred transgene. In theory, the resulting spatial homogeneity of a suitable habitat [27; 16] and the absence of the need for local adaptation accelerate rapid expansion of the colonizing organisms. Therefore, the ecology of weed spread and population regulation in agroecosystems and agricultural areas seems to enable large and rapid expansion of the adapted weeds.

The weed properties that affect their spreading (e.g. seed size, shape, similarity to crop seeds, etc.) should be considered adaptive characteristics that are probably the result of a strong selection. The effects of crop genes and ecological expansion can adversely affect the adaptation of hybrids. The weed spread may have an evolutionary role. In a small basic population it can cause an adaptive process, which does not occur in large populations. In the increasing balancing process, the spread of weeds has an important role in evolution, moving into small populations in other areas and affecting changes in other populations [101].

The weed ecology in cultivation systems can facilitate the random transgene transition, allowing the survival of weed-crop hybrids that are not adjusted, compared to wild-type weeds, in a series of adaptability components. This probably happens when the hybrids and next generation back cross, carrying the appropriate transgene adaptive value. Ecology of seed, the expansion of some basic characteristics responsible for the weed adaptability and the level of population growth are not widely accepted parameters. Effects arising from transgenic and other crop genes will greatly influence the adaptation of weed-crop hybrids and back cross generations. Most of the main weed species show intensive spatial and temporal variations in reproduction, ecology and seed spread on several scales. This variation has both genetic and environmental causes [38; 43]. The populations of agricultural weeds are widespread in agricultural regions, including many populations that appear out of farmland. Specific ecology of these populations may affect all phases of the random transgene transfer [58].

## **12. THE INFLUENCE OF GM PLANTS ON BIODIVERSITY**

One of the limitations for the introduction of GM plants into the environment is the concern about adverse effects of those plants on biodiversity, including the possibility of its devastation. Fear of loss of biodiversity [102] is an important basis for opposition to genetic modification and GM plants by several influential environmental protection research groups from around the world.

The influence of GM plants on biodiversity is a complex and complicated problem. Scientific studies and discussions have been directed towards the understanding of whether GM crops have an impact on biodiversity and defining their qualitative and quantitative differences from commercial crops. Biodiversity and agriculture are strongly interrelated since biodiversity is crucial for agriculture, while agriculture can contribute to sustainable use of biodiversity. Biodiversity is very important for the survival and maintenance of global planetary conditions, providing the aesthetic, scientific, cultural and other values. The general value of the world's biodiversity is estimated to be about 33 trillion \$ per year [103; 20]. Regarding multidimensional complexity of biodiversity concept and taking into account significance of technological development of GM plants, further studies that will clarify this interdependence are needed. In broader sense they will rely upon social, economic and political context of genetic modification application that will determine the risks or potential advantages of GM plants to biodiversity [104].

## **13. TRANSGENES**

The genetic modification itself does not substantially change anything, but the adaptability of GM plants will depend on the transgene effects and the impact of a particular stage in the transgene development. For example, the length of the vitality of seeds and seedlings stabilization can be especially important modification of oil crops seed. Both may be more important for the stabilization of annual plants, in relation to the characteristics that affect the survival of adult plants or fertility. The effects of transgenes within natural populations of ecologically important plants, which may have greater effect on the species that carry the transgene were also examined [80; 6]. If transgenes were giving selective advantage to a wild type, it might become dominant, which would result in a reduction in the natural variation [97].

Certain characteristics of transgenic genetic modification may present an advantage in some environments, e.g., tolerance to salinity, drought, cold and pest resistance. A wide variety of existing genes for transgenes transfer [105; 82] and the changes feasible by molecular techniques, make this technology fundamentally different from traditional methods of selection [106].

## **14. MONITORING**

Complex ecosystems are needed even after commercialization. This complexity varies from year to year and indicates indirect biotic effects. As laboratory and field experiments cannot sufficiently repeat all interactions that occur in one ecosystem, the only way for evaluation of the full level of ecological effects of GM plants is monitoring in natural ecosystems. Some of these effects cannot be predicted in advance, so ecological monitoring will be needed to reveal and differentiate existing ecological influences [62; 1; 107; 108].

Environmental monitoring is very expensive, so the information obtained should be used within the clear system of adaptive management. Such management includes repeated cycles of firmly set rules within specially designed programs, the use, evaluation and estimation of the monitoring as a whole [69; 43; 106].

A more significant problem in GM plants monitoring is the lack of adaptive management systems specifically developed for this application. To control the evolution of resistance to pathogens and pests, the frequency of resistance should be monitored in the field, with additional research in order to set standards for monitoring and determining appropriate management that can clarify the problem [24]. Monitoring of new GM plants will need to be evaluated by a diverse group of scientists and scientific disciplines including agriculture, forestry, ecology of wetlands, entomology, pathology, etc. In the future scientists and technological advances will continue to expand opportunities for artificial design and construction of plant organisms. Genomics and bioinformatics will facilitate identification of commercially important genes that can potentially be transmitted between species. Environmentalists will more significantly contribute to the wider debate on the public contribution for the prevention of risks of those innovations.

## **15. CONCLUSION**

Biotechnology alongside the introduction of genetically modified (GM) crops is constantly providing new opportunities for increasing crop productivity and tackling problems in agriculture, such as diseases, pests and weeds, abiotic stress and nutritional limitations of staple food crops. Crops possessing new traits enabling the use in pharmaceutical production are also being generated. As GM crops are being introduced into various locations with different ecosystems, agriculture, biodiversity and agriculture practice, a scientifically based understanding of the environmental effects of GM crops cultivation would assist decision makers worldwide in ensuring environmental safety and sustainability. The main important environmental assessment of GM crops deals with their putative invasiveness, vertical and/or horizontal gene flow, effects on biodiversity and the impact on other products. These investigations are all highly interdisciplinary and complex. This paper deals with some of the most important problems related to entering GM crops into the environment, such as plant protection, ecological effects of HRCs, gene flow, biodiversity, stress, ecological risks of GM crops, effects on soil ecosystems etc. There is a clear need to further assess the severity, magnitude and scope of risks associated with the massive field deployment of transgenic crops. When assessing GMC inter-relation with the existing cultivars, an increased knowledge base underpinning the development of GMC will provide greater confidence in plant science while assessing the risks and benefits of releasing such crops.

## **16. ACKNOWLEDGMENTS**

The research was financed by the Ministry of Science and Technology of the Republic of Serbia under project TR 31032.

## REFERENCES

- Aliaga-Franco, N., Zhang, C., Presa, S., Srivastava, A. K., Granell, A., Alabadí, D., Sadanandom, A., Blázquez, M. A., Minguet, E. G. (2019): Identification of Transgene-Free CRISPR-Edited Plants of Rice, Tomato, and Arabidopsis by Monitoring DsRED Fluorescence in Dry Seeds. *Front. Plant Sci.* 10:1150. doi: 10.3389/fpls.2019.01150.
- Altieri, M. A. (2000) The ecological impacts of transgenic crops on agroecosystem health. *Ecosystem Health*, 6:13-23.
- Anon (1994) Biodiversity. The UK Action Plan. HMSO, London. 187 pp.
- Aslam, S., Gul, N. (2020) Impact of Genetically Modified Crops on Environment. In: Singh R., Shukla P., Singh P. (eds) Environmental Processes and Management. Water Science and Technology Library, vol 91. Springer, Cham. doi.org/10.1007/978-3-030-38152-3\_13.
- Bartsch, D., Lehnen, M., Clegg, J., Pohl-Orf, M., Schuphan, I., Ellstrand, N. C. (1999) Impact of gene flow from cultivated beet on genetic diversity of wild sea beet populations. *Mol Ecol*, 8, 1733-1741.
- Bauer-Panskus, A., Miyazaki, J., Kawall, K., Christoph, T. (2020) Risk assessment of genetically engineered plants that can persist and propagate in the environment. *Environ Sci Eur* 32, 32. <https://doi.org/10.1186/s12302-020-00301-0>.
- Beres, Z. T. (2020) Ecological and evolutionary implications of glyphosate resistance in *Coryza canadensis* and *Arabidopsis thaliana*.
- Beringer, J. E. (2000) Releasing genetically modified organisms: will any harm outweigh any advantage? *J Appl Ecology*, 37, 207-214.
- Bošković, Z. J., Isajev V. (2007). Genetics. Megatrend University Belgrade. ISBN 978-86-7747-254-2. CIP 575(075.8). COBISS. SR-ID 137961484. p. 551. (Hard cover, A4 format, 1 electronic optical disc (CD ROM).
- Bošković J., Bošković M. (2009) Durable resistance to *Puccinia triticina* by accumulation of resistance genes. *Genetika*. Vol. 41, No. 3. P. 353-378.  
<http://www.doiserbia.nb.rs/img/doi/0534-0012/2009/0534-00120903355B.pdf>
- Bošković, J. (2020) Genetic base of pyramiding strategies for durable resistance to leaf rust of wheat. IRSA International Scientific Conference Science, Education, Technology and Innovation SETI II. Book of Proceedings. Publisher: IRSA- International Research Academy of Science and Art. Belgrade, October 2-3, 2020. CIP 0/9(082)(0.034.2). ISBN 978-86-81512-02-9. COBISS.SR-ID 21757449. P. 13-36.
- Bošković, J., Zečević, V., Prijić, Ž., Vukašinović, D. (2011): Ecological monitoring of genetically modified organisms. 9<sup>th</sup> International Scientific Conference. Serbia Facing The Globalization and Sustainable Development. Proceedings. Belgrade, November 25<sup>th</sup>, 2011. P. 253-262
- Bošković, J., Bojat, Č. N. (2019) Biotechnological advances in plant breeding and molecular markers as useful tool. IRSA (International Research Academy of Science and Art), International Scientific Conference. Science, Education, Technology and Innovation, SETI I, Book of Proceedings - Belegrade, April 12. 2019. ISBN 978-86-81512-01-2. P. 88-102.
- Bošković, J., Bošković, M., Hojka, Z., Simić, J., Mićanović, Ž. (2004a) Genetically modified plants and environment. International Conference on Sustainable Agriculture and European Integration Processes. September 19-24, 2004. Novi Sad, Serbia and Montenegro. Programme & Abstracts, p.56.
- Bošković, J., Prijić, Ž., Bošković, M. (2004b) Primena genetičkog inženjeringa kod otpornosti biljaka prema patogenima. Zbornik Apstrakta III Kongresa genetičara Srbije, Subotica, 30. novembar - 4. decembar 2004. godine. str. 6.

- Bošković, J., Prodanović, R. (2018) Application of Genetic Engineering Technology in Agriculture and Environmental Impact, Conference Proceedings, INOVAEDUCATION 2018 – Innovation, ICT and Education for the Next Generation, p. 86 – 102, Editors: Soleša, D., Šimović, V., Faculty of Economics and Engineering Management in Novi Sad, Serbia. ISBN: 978-86-87619-89-0 UDK: 37:004.738.5(082).
- Bošković, J., Trkulja, N., Prodanović, R. (2016) The impact of insecticides on honey bees production. Proceedings 6<sup>th</sup> International Symposium on natural resources management. 2016, June 25-26, Faculty of management Zaječar, Republic Serbia, Zaječar, 2016. p.17-24.
- Bošković, M., Browder, L. E., Bošković, J., Jerković, Z. (2000) International survey approach for *Puccinia recondita tritici* of wheat using multilocation testing. *Acta Phytopathologica et Entomologica Hungarica*, 35 (1-4), pp. 351-358.
- Bouchard, E., Michaud, D., Cloutier, C. (2003) Molecular interactions between an insect predator and its herbivore prey on transgenic potato expressing a cysteine proteinase inhibitor from rice. *Mol Ecol*, 12, 2429-2437.
- Bradley, P.R., Johnson, W.G., Hart, S.E., Buesinger, M.L., Massey, R. E. (2000) Economics of weed management in glufosinate-resistant corn (*Zea mays L.*). *Weed Technology*, 14, 495-501
- Breeze, V. G., Marshall, E.J.P., Hart, A., Vickery, J. A., Crocker, J., Walters, K., Packer, J., Kendall, D., Fowbert, J., Hodkinson, D. (2019): Assessing pesticide risks to non-target terrestrial plants. Commission PN0923. MAFF Pesticides Safety Directorate.
- Brookes, G., Barfoot, P. (2018) GM crops: Global socio-economic and environmental impacts 1996- 2016. *PG Economics Ltd*, UK. p 1-204
- Buckelew, L.D., Pedigo, L.P., Mero, H.M., Owen, M.D.K., Tylka, G.L. (2000) Effects of weed management systems on canopy insects in herbicide-resistant soybeans. *Journal of Economic Entomology*, 93, 1437-1443.
- Burgarella, C., Barnaud, A., Kane, N. A., Jankowski, F., Scarcelli, N., Billot, C., Vigouroux, Y., Berthouly-Salazar, C. (2019) Adaptive Introgression: An Untapped Evolutionary Mechanism for Crop Adaptation. *Front. Plant Sci.* 10:4. doi: 10.3389/fpls.2019.00004.
- Caseley, J.C., Cussans, G.W., Atkin, R. K. ,eds. (1991) Herbicide resistance in Weeds and Crops. Butterworth-Heinemann, Oxford.
- Colbach, N., Clermont-Dauphin, C., Meynard, J. M. (2001a) GeneSys: a model of the influence of cropping system on gene escape from herbicide tolerant rapeseed crops to rape volunteers I. Temporal evolution of a population of rapeseed volunteers in a field. *Agriculture, Ecosystems & Environment*, 83, 235-253.
- Colbach, N., Clermont-Dauphin, C., Meynard, J. M. (2001b) GeneSys: a model of the influence of cropping system on gene escape from herbicide tolerant rapeseed crops to rape volunteers II. Genetic exchanges among volunteers and cropped populations in a small region. *Agriculture, Ecosystems & Environment*, 83, 255-270.
- Conner, A.J., Glare, T.R., Nap, J. P. (2003) The release of genetically modified crops into the environment. Part II. Overview of ecological risk assessment. *Plant J*, 33, 19-46.
- Costanza, R., D'Arge, R. , Groot, R. de (1997) The value of the world's ecosystem services and natural capital. *Nature*. 387: 253-260.
- Cresswell, J. E., Osborne, J. L., Bell, S. A. (2002) A model of pollinator-mediated gene flow between plant populations with numerical solutions for bumblebees pollinating oilseed rape. *Oikos*, 98, 375-384.
- Dale, P. J. (2002) The environmental impact of genetically modified (GM) crops: a review. *Journal of Agricultural Science*, 138, 245-248.

- Daniell, H. (2002) Molecular strategies for gene containment in transgenic crops. *Nature Biotechnology* 20:581-586.
- Darmency, H., Lefol, E., Fleury, A. (1998) Spontaneous hybridizations between oilseed rape and wild radish. *Mol Ecol*, 7, 1467-1473.
- David, A., Wickell, Fay-Wei, L. (2020) On the evolutionary significance of horizontal gene transfers in plants. *New Phytologist* 225: 113–117. doi: 10.1111/nph.16022.
- Desplanque, B., Hautekeete, N., Van Dijk, H. (2002) Transgenic weed beets: possible, probable, avoidable? *Journal of Applied Ecology*, 39, 561-571.
- Devang, M., Hirsch-Hoffmann, M., Mariam Were, M., Patrignani, A., SyedShan-e-Ali, Z., Were, H., Gruissem, W., Vanderschuren, H. (2019) A new full-length circular DNA sequencing method for viral-sized genomes reveals that RNAi transgenic plants provoke a shift in geminivirus populations in the field. *Nucleic Acids Research*, 2019, Vol. 47, No. 2e9doi: 10.1093/nar/gky914.
- Dewar, A. M., May, M. J., Woiwod, I. P., Haylock, L.A., Champion, G.T., Garner, B. H., Sands, R.J.N., Qi, A., Pidgeon, J.D. (2003) A novel approach to the use of genetically modified herbicide tolerant crops for environmental benefit. *Proceedings of the Royal Society: Biological Sciences*, 270, 335-340
- Dewar, A.M., Haylock, L.A., Bean, K.M., May, M. J. (2000) Delayed control of weeds in glyphosate-tolerant sugar beet and the consequences on aphid infestation and yield. *Pest Management Science*, 56, 345-350.
- Dissertation presented in partial fulfillment of the requirements for the degree Doctor of Philosophy in the graduate school of the Ohio State University.  
[http://rave.ohiolink.edu/etdc/view?acc\\_num=osu1555600547328876](http://rave.ohiolink.edu/etdc/view?acc_num=osu1555600547328876).
- Drobnjaković, T., Marčić, D., Prijović, M., Perić, P., Milenković, S., Bošković, J. (2016) Life history traits and population growth of *Encarsia Formosa* Gahan (Hymenoptera: Aphelinidae) local population from Serbia. *Entomologia Generalis* Vol.35 N<sup>o</sup>4 p. 281–295. <https://www.schweizerbart.de/papers/entomologia/list>
- Dunning, L. T., Olofsson, J. K., Parisod, C., Choudhury, R.R., Moreno-Villena, J.J., Yang, Y., Dionora, J., Quick, W. P., Park, M., Bennetzen, J. L., Besnard, G.<sup>11</sup>, Nosil, P., Osborne, C. P., Pascal-Antoine, C. (2019) Lateral transfers of large DNA fragments spread functional genes among grasses. *Proceedings of the National Academy of Sciences, USA* 116: 4416– 4425
- Dunwell, J. M. (1998) Novel food products from genetically modified crop plants: methods and future prospects. *Int J Food Sci Tech*, 33, 205-213.
- Fagan, J., Schoel, B., Haegert, A., Moore, J., Beeby, J. (2001) Performance assessment under field conditions of a rapid immunological test for transgenic soybeans. *Int J Food Sci Tech*, 36, 357-367.
- FAO (2003) Expert Consultation of Environmental Effects of Genetically Modified Crops, 16-18 June 2003, Rome, Italy
- Farmer, J. A., Webb, E. B., Pierce, R. A., Bradley, K. W. (2017) Evaluating the potential for weed seed dispersal based on waterfowl consumption and seed viability. *Pest Manag Sci* 73 (12):2592-2603. doi: 10.1002/ps.4710.
- Firbank, L.G., Heard, M. S., Woiwod, I. P., Hawes, C., Haughton, A. J., Champion, G.T., Scott, R.J., Hill, M. O., Dewar, A. M., Squire, G. R., May, M. J., Brooks, D. R., Bohan, D. A., Daniels, R. E., Osborne, J. L., Roy, D. B., Black, H. I. J., Rothery, P., Perry, J. N. (2003) An introduction to the Farm-Scale Evaluations of genetically modified herbicide-tolerant crops. *J Appl Ecology*, 40, 2-16.
- Francis, M., Stéphane, H., Ertao, W. (2021): Impact of global change on the plant microbiome. *New Phytologist* Special Issue. In press.

- Glišin, V. (2005) Genetički modifikovani organizmi. *Arhiv za poljoprivredne nauke*. Vol. 66; No 237. str.7-19.
- Gueritain, G., Bazot, S., Darmency, H. (2003) Emergence and growth of hybrids between *Brassica napus* and *Raphanus raphanistrum*. *New Phytol*, 158, 561-567.
- Hauser, T. P., Jørgensen, R.B., Ostergård, H. (1998) Fitness of backcross and F2 hybrids between weedy *Brassica rapa* and oilseed rape (*B. napus*). *Heredity*, 81, 436-443.
- Huang, J. (2013) Horizontal gene transfer in eukaryotes: the weak-link model. *BioEssays* 35: 868– 875
- Huang, Y., Wang, Y., Qiang, S., Song, X., Dai, W. (2019) Fitness of F1 hybrids between stacked transgenic rice T1c-19 with cry1C\*/bar genes and weedy rice. *J Integr Agric* 18 (12):2793–2805. [https://doi.org/10.1016/S2095-3119\(19\)62662-6](https://doi.org/10.1016/S2095-3119(19)62662-6).
- Hudson, L.C., Chamberlain, D., Stewart, C. N. (2001) GFP-tagged pollen to monitor pollen flow of transgenic plants. *Mol Ecol Notes*, 1, 321-324.
- Kim, K. U. (2001) Trends and expectations for research and technology in the Asia-Pacific region. *Weed Biol Manage*, 1, 20-24.
- Klümper, W., Qaim, M. A. (2014) Meta-Analysis of the impacts of genetically modified crops. *PLoS One*. 9 (11):e111629. doi:10.1371/journal.pone.0111629.
- Konstantinović, B., Bošković, J. (2001): Biotehnologija u zaštiti bilja. Izdavač: Poljoprivredni fakultet & Stylos. Str. 362.
- Kudsk, P., Streibig, J. C. (2003) Herbicides - a two-edged sword. *Weed Res*, 43, 90-102.
- Kuiper, H.A., Kleter, G.A., Noteborn, H. P. J. M., Kok, E. J. (2001) Assessment of the food safety issues related to genetically modified foods. *Plant J*, 27, 503-528.
- Kumar, S., Barone, P., Smith, M. (2016) Gene targeting and transgene stacking using intra genomic homologous recombination in plants. *Plant Methods* 12, 11. <https://doi.org/10.1186/s13007-016-0111-0>
- Kwon, Y.W., Kim, D. S. (2001) Herbicide-resistant genetically-modified crop: its risks with an emphasis on gene flow. *Weed Biol Manage*, 1, 42-52.
- Liang, Z., Chen, K., Li, T., Zhang, Y., Wang, Y., Zhao, Q., Liu, J., Zhang, H., Liu, C., Ran, Y.<sup>1</sup>, Gao, C. (2017) Efficient DNA-free genome editing of bread wheat using CRISPR/Cas9 ribonucleoprotein complexes. *Nat Commun*. 8:14261. doi:10.1038/ncomms14261.
- Lutman, P. J. W., Berry, K. (2003) Herbicide-tolerant crops - good or bad for Europe? *Outlook on Agriculture*, 32, 91-95.
- Marlander, B., Hoffmann, C., Koch, H.J., Ladewig, E., Merkes, R., Petersen, J., Stockfisch, N. (2003) Environmental Situation and Yield Performance of the Sugar Beet Crop in Germany: Heading for Sustainable Development. *J Agron Crop Sci*, 189, 201-226.
- Marshall, E. J. P. (2002) Introducing field margin ecology in Europe. *Agriculture Ecosystems and Environment*, 89, 1-4.
- Marshall, E. J. P., Moonen, A. C. (2002) Field margins in northern Europe: their functions and interactions with agriculture. *Agriculture Ecosystems & Environment*, 89, 5-21.
- Marshall, E.J.P. (2001) Biodiversity, herbicides and non-target plants. In *Pesticide Behaviour in Soils and Water*. BCPC Monograph No. 78 (ed A. Walker), pp. 419-426. BCPC, Farnham, UK, Brighton, UK.
- Massart, S., Candresse, T., Gil, J., Lacomme, C., Predajna, L., Ravnikar, M., Reynard, J. B., Rumbou, A., Saldarelli, P., Škorić, D., Vainio, E. J., Valkonen, J. P. T., Vanderschuren, H., Varveri, C., Wetzels, T. (2016) A Framework for the Evaluation of Biosecurity, Commercial, Regulatory, and Scientific Impacts of Plant Viruses and Viroids Identified by NGS Technologies: <https://doi.org/10.3389/fmicb.2017.00045>

- May, M.J. (2003) Economic consequences for UK farmers of growing GM herbicide tolerant sugar beet. *Annals of Applied Biology*, 142, 41-48.
- Moonen, A. C., Marshall, E. J. P. (2000): The influence of sown margin strips, management and boundary structure on herbaceous field margin vegetation in two neighbouring farms in southern England. *Agriculture, Ecosystems & Environment*, 86, 187-202.
- Moyes, C. L., Lilley, J.M., Casais, C. A., Cole, S.G., Haeger, P. D., Dale, P. J. (2002) Barriers to gene flow from oilseed rape (*Brassica napus*) into populations of *Sinapis arvensis*. *Mol Ecol*, 11, 103-112.
- Nakayama, Y., Yamaguchi, H. (2002): Natural hybridization in wild soybean (*Glycine max* ssp. *soja*) by pollen flow from cultivated soybean (*Glycine max* ssp. *max*) in a designed population. *Weed Biol Manage*, 2, 25-30.
- Nandula, V.K., (2019) Herbicide Resistance Traits in Maize and Soybean: Current Status and Future Outlook. *Plants* 2019, 8(9), 337. <https://doi.org/10.3390/plants8090337>
- Nishiura, H., Imai, H., Nakao, H., Tsukino, H., Kuroda, Y., Katoh, T. (2002) Genetically modified crops: consumer attitudes and trends in plant research in Japan. *Food Serv Technol*, 2, 183-189.
- Oliveira, P. H., Touchon, M., Cury, J., Rocha, E. P. C. (2017) The chromosomal organization of horizontal gene transfer in bacteria. *Nat Commun* 8, 841. <https://doi.org/10.1038/s41467-017-00808-w>.
- Pacher, M., Puchta, H. (2017) From classical mutagenesis to nuclease-based breeding – directing natural DNA repair for a natural end-product. *Plant J.* 90 (4):819–833. doi:10.1111/tpj.13469.
- Perry, E. D., Ciliberto, F., Hennessy, D. A., Moschini, G.C. (2016) Genetically engineered crops and pesticide use in U.S. maize and soybeans. *Science Advances* 2 (8): e1600850. <http://advances.sciencemag.org/content/2/8/e1600850.full>
- Perry, J. N. (2002): Sensitive dependencies and separation distances for genetically modified herbicide-tolerant crops. *Proceedings of the Royal Society: Biological Sciences*, 269, 1173-1176.
- Perry, J. N., Rothery, P., Clark, S. J., Heard, M .S., Hawes, C. (2003) Design, analysis and statistical power of the Farm-Scale Evaluations of genetically modified herbicide-tolerant crops. *J Appl Ecology*, 40, 17-31.
- Pidgeon, J. D. (2003): A novel approach to the use of genetically modified herbicide tolerant crops for environmental benefit. *Proceedings of the Royal Society: Biological Sciences*, 270, 335-340
- Pidgeon, J. D., Dewar, A. M., May, M. J. (2001) Weed management for agricultural and environmental benefit in GMHT sugar beet. In Brighton Crop Protection Conference Weeds, pp. 373-382.
- Pierre, J., Marsault, D., Genecque, E., Renard, M., Champolivier, J., Pham-Delegue, M. H. (2003) Effects of herbicide-tolerant transgenic oilseed rape genotypes on honey bees and other pollinating insects under field conditions. *Null*, 108, 159-168.
- Pretty, J. (2001) The rapid emergence of genetic modification in world agriculture: contested risks and benefits. *Environmental Conservation*, 28, 248-262.
- Pretty, J. (2001) The rapid emergence of genetic modification in world agriculture: contested risks and benefits. *Environmental Conservation*, 28, 248-262.
- Richter, O., Zwerger, P., Böttcher, U. (2002b) Modelling spatio-temporal dynamics of herbicide resistance. *Weed Research*, 88, 52-64
- Richter, O., Zwerger, P., Böttcher, U. (2002b) Modelling spatio-temporal dynamics of herbicide resistance. *Weed Research*, 88, 52-64.



- Richter, O., Zwerger, P., Bottcher, U. (2002a) Modelling spatio-temporal dynamics of herbicide resistance. *Weed Res*, 42, 52-64.
- Richter, O., Zwerger, P., Bottcher, U. (2002a) Modelling spatio-temporal dynamics of herbicide resistance. *Weed Res*, 42, 52-64.
- Robinson, S., Scott, N., Gackle, A. (2000) Gene technology and future foods. *Asia Pac J Clin Nutr*, 9, S113-S118.
- Rognli, O.A., Nilsson, N.O., Nurminiemi, M. (2000) Effects of distance and pollen competition on gene flow in the wind-pollinated grass *Festuca pratensis* Huds. *Heredity*, 85, 550-560
- Ruchir, R. (2017) The impact of Genetically Modified (GM) crops in modern agriculture: A review. *GM Crops Food*. 8(4): 195–208. 10.1080/21645698.2017.1413522.
- Saeglitz, C., Pohl, M., Bartsch, D. (2000): Monitoring gene flow from transgenic sugar beet using cytoplasmic male-sterile bait plants. *Mol Ecol*, 9, 2035-2040.
- Sarvikas, P., Tyystjärvi, T., Tyystjärvi, E., (2010) Kinetics of prolonged photoinhibition revisited: photoinhibited Photosystem II centres do not protect the active ones against loss of oxygen evolution, doi: 10.1007/s11120-009-9496-1
- Schütte, G., Eckerstorfer, M., Rastelli, V., Reichenbecher, W., Restrepo-Vassalli, S., Ruohonen-Lehto, M., Wuest Saucy A.G., Martens, M. (2017) Herbicide resistance and biodiversity: agronomic and environmental aspects of genetically modified herbicide-resistant plants. *Environ Sci Eur* 29, 5. <https://doi.org/10.1186/s12302-016-0100-y>.
- Sharma, K. H., Sharma, K.K., Seetharna, N., Ortiz, R. (2000) Prospects for using transgenic resistance to insects in crop improvement. *Molecular Biology and Genetics*, Vol.3 No. Issue of August 15. 2000.
- Simić, J., Bošković, J., Hojka, Z., Komazec, G., Krmpotić T., Sarić, R. (2005) Biotehnologija i procesi globalizacije. *Arhiv za poljoprivredne nauke*, Vol. 66; No 237. str. 215-223.
- Smyth, S. (2017) Genetically modified crops, regulatory delays, and international trade. *Food and Energy Security*. 2017; 6(2):78–86. doi:10.1002/fes3.100.
- Snow, A.A., Andow, D.A., Gepts, P., Hallerman, E. M., Power, A., Tiedje, J. M., Wolfenbarger, L. L. (2004) Genetically engineered organisms and the environment: Current status and recommendations. ESA Public Affairs Office, GEO Position Paper 2004, 1-38.
- Song, Z., Lu, B., Zhu, Y., Chen, J. (2002) Pollen competition between cultivated and wild rice species (*Oryza sativa* and *O. rufipogon*). *New Phytol*, 153, 289-296.
- Steinbrecher, R. A. (1996) From green to gene revolution: the environmental risks of genetically engineered crops. *Ecologist*, 26, 273-281.
- Suarez-Gonzalez, A., Lexer, C., Cronk, Q. C. B. (2018) Adaptive introgression: a plant perspective. *Biol. Lett.* 14:20170688. doi: 10.1098/rsbl.2017.0688.
- Svitashev, S., Schwartz, C., Lenderts, B., Young, J., Mark Cigan, A. (2016) Genome editing in maize directed by CRISPR–Cas9 ribonucleoprotein complexes. *Nat Commun.* 7:13274. doi:10.1038/ncomms13274.
- Tester, M. (2001) Depolarizing the GM debate. *New Phytol*, 149, 9-12.
- Thompson, C.J., Thompson, B.J.P., Ades, P. K., Cousens, R., Garnier-Gere, P., Landman, K., Newbigin, E., Burgman, M. A. (2003) Model-based analysis of the likelihood of gene introgression from genetically modified crops into wild relatives. *Ecological Modelling*, 162, 199-209
- Topisirović, Lj. (2005): Potencijali biotehnologije bazirani na genetičkim modifikovanim organizmima. *Arhiv za poljoprivredne nauke*. Vol.66, No237. str.19-27.
- Trkulja, N., Milosavljevic, A., Stanisavljevic, R., Mitrovic, M., Jovic, J., Tosevski, I., Boskovic, J. (2015) Occurrence of *Cercospora beticola* populations resistant to

- benzimidazoles and demethylation-inhibiting fungicides in Serbia and their impact on disease management. *Crop Protection*. Vol. 75. p.80—87.  
<http://www.sciencedirect.com/science/article/pii/S0261219415300399>
- Vila-Aiub, M., Yu, Q., Powles, S. (2019): Do plants pay a fitness cost to be resistant to glyphosate? *New Phytol* 223 (2):532–547. <https://doi.org/10.1111/nph.15733>.
- Vogel, A., Schwacke, R., Denton, A.K., Usadel, B., Hollmann, J., Fischer, K., Bolger, A., Schmidt, M. H., Bolger, M. E., Gundlach, H. K., Mayer, F. X., Weiss-Schneeweiss, H., Temsch, E. M., Krause, K. (2018) Footprints of parasitism in the genome of the parasitic flowering plant *Cuscuta campestris*. *Nature Communications* 9: 2515.
- Watkinson, A. R., Freckleton, R. P., Robinson, R. A., Sutherland, W. J. (2000) Predictions of biodiversity response to genetically modified herbicide-tolerant crops. *Science*, 289, 1554-1557.
- Wu, Q., Ding, S., Zhang, Y., Zhu, S. (2015) Identification of viruses and viroids by Next-Generation sequencing and homology-dependent and homology-independent algorithms. *Annu. Rev. Phytopathol.*, 53, 425–444.
- Zhong, Z., McDonald, B., A., Palma-Guerrero, J. (2021) Tolerance to oxidative stress is associated with both oxidative stress response and inherent growth in a fungal wheat pathogen. *Genetics*, DOI:10.1093/genetics/iyaa022

