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In this issue of *Economics of Enterprise*, we are pleased to present a selection of papers that address some of the most pressing economic, technological, and environmental challenges facing Serbia and the broader global community.

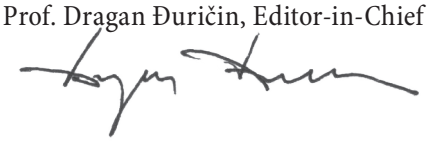
The issue begins with a critical analysis by *M. Labus* in the *International Economics and Business* section, where he examines Serbia's strategic position within a rapidly changing global landscape. As the shift from neoliberal to strategic competition redefines international trade and economic alliances, he explores the complexities of deglobalization and the challenges of protecting small, open economies like Serbia amid such seismic changes. Continuing the theme of sustainability, a duo of authors, *I. Popović Petrović* and *R. Dragutinović Mitrović*, presents the second paper in this section, focusing on the implementation of trade facilitation measures by SMEs in Serbia and the CEFTA 2006 region. They used data from the UN Global Survey on Digital and Sustainable Trade Facilitation, revealing that CEFTA 2006 signatories, including Serbia, did not fully implement many of these measures between 2017-2023. However, Serbia made significant progress, outperforming the CEFTA average and even developed countries by 2023, particularly in areas that support SMEs as key drivers of sustainable and inclusive growth.

The *Finance* section features research by *M. Milašinović*, *J. Ognjanović* and *A. Mitrović* that casts the spotlight on the impact of intellectual capital on bank profitability, particularly during the tumultuous period of the COVID-19 pandemic. Their study shows how various components of intellectual capital have influenced the financial performance of banks, offering key insights for maintaining stability and growth in knowledge-intensive sectors.

In the *Technology Change and Innovation* section, a team of authors, *B. Boorová, V. M. Mijušković*, *S. Aćimović* and *D. Đurđić*, provides an in-depth analysis of how artificial intelligence is revolutionizing logistics within the framework of Logistics 4.0. Through a case study of DHL, they demonstrate the transformative power of AI in optimizing operations and enhancing supply chain resilience. Following this, the second paper in this section, written by *Lj. Radonjić*, *Lj. Bojić*, and *M. Novaković* addresses the challenges and opportunities of integrating blockchain technology into the public sector. Their comprehensive review highlights blockchain's potential to enhance procedural efficiency and data security, despite the legal and economic hurdles associated with its implementation. In the third paper of this section, *M. Strugar Jelača*, *S. Marić*, *V. Vuković*, *L. Raković*, *R. Bjekić* and *M. Aleksić* investigate the intersection of digital entrepreneurship and sustainable development. Their findings illustrate how high-tech and digital entrepreneurship contribute to the structural changes essential for achieving sustainable growth across various economic sectors.

This issue concludes with a paper in the *Economic Growth and Development* section, written by *M. Dimitrijević,* which is dedicated to the agricultural sector. The paper underscores the importance of innovation for sustainable agricultural development, particularly in the transition from purely productivity-based technologies to a more comprehensive approach that encompasses economic, ecological, and social aspects. The author analyzes innovation in the agri-food sectors of both highly innovative countries and Serbia, highlighting the need for Serbia to adopt similar practices to improve input productivity.

Prof. Dragan Đuričin, Editor-in-Chief



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FROM NEOLIBERAL TO STRATEGIC COMPETITION: WHAT WILL HAPPEN TO SERBIA?

Od neoliberalne ka strateškoj konkurenciji – šta će biti sa Srbijom?

Abstract

The disintegration of the world's market and the outbreak of the global crisis show that something went wrong with the process of globalization, which dominated in the previous period. The current crisis of globalization is called deglobalization, and it takes place as strategic competition between the leading economies of the world replaces liberal competition. Consequently, global trade has been falling apart into two trading blocks. The main question is how to protect small open economies from the negative outcomes of such changes. An additional problem for Serbia is that, due to the war in Ukraine, the EU decided to neutralise Russian influence by accelerating the harmonization of the Western Balkans' market with its internal market. That does not guarantee Serbia formal EU membership but imposes a strategic partnership in supplying strategic raw materials. Nevertheless, that is a development opportunity for Serbia, but the price might be (too) high concerning potential damage to the environment and public health.

Keywords: *(de)globalization, Serbia's accession to the EU, critical raw materials, environmental protection*

Sažetak

Dezintegracija svetskog tržišta i izbijanje globalne krize pokazuju da je nešto pošlo po zlu u procesu globalizacije, koji je dominirao u prethodnom periodu. Aktuelna kriza globalizacije naziva se deglobalizacija i odvija se tako što strateška konkurencija između vodećih ekonomija sveta zamenjuje liberalnu konkurenciju. Shodno tome, globalna trgovina se raspada na dva trgovinska bloka. Glavno pitanje je kako zaštititi male otvorene ekonomije od negativnih posledica ovakvih promena. Dodatni problem za Srbiju je to što je EU, zbog rata u Ukrajini, odlučila da neutrališe ruski uticaj ubrzavanjem harmonizacije tržišta Zapadnog Balkana sa svojim unutrašnjim tržištem. To Srbiji ne garantuje formalno članstvo u EU, ali joj nameće strateško partnerstvo u snabdevanju retkim sirovinama. U svakom slučaju, to je razvojna šansa za Srbiju, ali bi cena mogla biti (pre) visoka u pogledu potencijalne štete po životnu sredinu i zdravlje ljudi.

Ključne reči: *(de)globalizacija, pristupanje Srbije EU, kritične sirovine, zaštita životne sredine*

Introduction

The disintegration of the world's market and the outbreak of the global crisis show that something went wrong with the process of globalization, which dominated in the previous period. Right now, strategic competition is slowly replacing liberal competition between the leading economies in the world. The subject of friction is not access to energy resources or financial markets, but strategic raw materials, which are indispensable for decarbonisation of the global economy. In that context, Serbia might be a vital player by extracting lithium, which is crucial for assembling batteries in electric cars, for which there is a strong German demand. Will that mining push Serbia towards the EU membership, assuming a stark German support?

The EU has proposed the "New Growth Plan for the Western Balkans" which envisages seven areas that are priorities for rapid harmonization with EU rules. The plan should eliminate Russia's influence in the Western Balkans and speed up the region's EU accession process. We are sceptical about its achievements. Particularly, there is no correlation between strategic raw materials and formal conditions for the EU membership. Additionally, acceptance of any candidate to the EU depends not only on Germany but on every single member of the EU. Finally, Serbia has good trading relations with Russia and China, which contributes to the country's development. On the opposite side, the EU has imposed sanctions on Russia due to the war in Ukraine while considering China as a main trading challenger [8]. Serbia is a small open economy trying to trade with all competing parties. Is it sustainable such an economic policy? To address such a question, we need to put it into a broader context of (de)globalization, geopolitical frictions, the EU accession of Western Balkan states and the role of strategic raw materials.

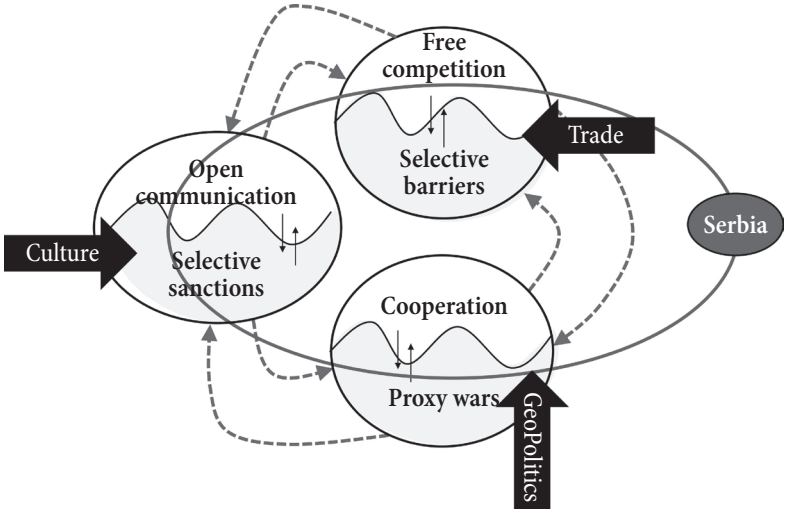
Globalization

Usually, globalization is identified with the expansion of free trade in the world. This can be nicely documented by data on imports and exports of goods and services between countries. However, this process does not happen in isolation. Along with the turnover of goods go capital flows, with somewhat less transparent data. First, they were trading loans, then financial loans, then portfolios and foreign direct investments, all accompanied by current money transactions. Of course, it has always been necessary to protect economic spheres of interest by geopolitical means, including military interventions. Initially, colonies were created under direct foreign rule, and later this was transformed into a series of geopolitical alliances. In any case, trade and geopolitics went hand in hand. At the same time, the workforce was moving. The migration of people brought new cultural habits, which were sometimes easier, sometimes much more difficult, to accept. And then came the age of great advancement in transportation and digital communication. Tourism and the exchange of ideas and information have spread rapidly to the whole world. Globalization has become a complex process of linking trade, geopolitics and culture, with the predominance of cooperation over conflicts. We showed this schematically in Figure 1.

The neoliberal concept of world trade seemed to have prevailed along with the reduction of tensions between nuclear superpowers. Parts of Figure 1 "free competition", "communication" and "cooperation" illustrate this. Then came *the Global Financial Crisis* of 2007-2009, which originated in the United States, but was rapidly transmitted to the whole world. This is the result of financial globalization. Investment banks in the EU, Japan and other countries have invested in U.S. bonds issued based on mortgages of owners with weak credit ratings. The rise in interest rates has led many of them to bankruptcy, and with it to negative consequences for American banks and the entire financial world. Bonds were losing their price dizzyingly, causing panic in the financial markets. Many banks were unable to fend off the sudden withdrawal of deposits and a decrease in the value of their portfolio. In a word, neoliberal banking could not defend itself from a serious crisis. State intervention was needed.

This is the first major blow to globalization. The second blow was a military, not a financial one. The civil war in Syria hailed as the "Arab Spring of Democracy," soon turned into a *proxy war* between several NATO countries, Russia and regional powers. It was an unprecedented

Figure 1: Complex globalization



Source: Author

event. The shattered confidence quickly turned into a set of economic sanctions imposed by the EU, the US and Japan on Russian firms in the military, energy and banking industries over the annexation of Crimea in 2014. These sanctions build on the financial crisis in Russia that erupted in 2014 as a result of a sharp fall in oil prices and a rising government deficit.

The next blow to globalization was the outbreak of the trade war between the US and China in 2018. Soon there was a global pandemic of the COVID-19 virus and the general closure of communications between people, within and between countries. This was followed by the war in Ukraine, which forced access to Russian firms and banks completely blocked in 2022 for international dollar payment channels.

Of course, the process of globalization could not withstand all this without negative consequences. The process of globalization is currently dominated by conflicts in the geopolitical sphere, barriers are being introduced in the trade and financial spheres, and in the cultural sphere, there are still obstacles in communication between people, especially when it comes to migrants. This all says that there is currently not only a global crisis but a globalization crisis. Many talk about its end and the reversal of the trend towards deglobalization (fragmentation and regionalization). On the other hand, a trend of politically motivated reglobalization has also emerged. Both of these interrelated trends are contributing to inflationary pressures and other forms of macroeconomic instability [1, p. 8].

We agree with the assessment that there is a crisis of globalization. What we are interested in is what will happen to Serbia in these contexts. Serbia is a small and very open economy, which does not want to belong to any sphere of interest, although it is part of the European market, with the application to become a permanent member of the European Union. Such a position could be maintained for a shorter period because, regardless of all the old and new initiatives, the EU enlargement process to the countries of the Western Balkans is going slowly. However, regardless of this process, there are some other processes in the complex of global relations that Serbia should consider (see, e.g., [11], [15]). This primarily refers to the formation of secure supply chains – both strategic raw materials and rare earths – in the context of a trade war between the world's two largest economies.

A brief history of globalization in two pictures

As we have already stated, globalization is a long-term process of establishing the free exchange of goods and services across borders that has gained a special momentum with the development of transport and tourism, on the one hand, and the digital revolution, the introduction of the Internet and modern communication technology into everyday practice around the world, on the other. Thus, the exchange of goods and services across borders has expanded to the exchange of ideas, cultural habits, information, people and capital. In this sense, globalization

cannot be reduced to a single dimension – economic globalization as the movement of goods, services and capital and, in connection with this, the transfer of technological knowledge.

The second dimension is formed by social or cultural globalization, which adds to this movement the exchange of ideas, information, people and the transmission of cultural habits. In addition, the third dimension represents geopolitical globalization as a reduction of military tensions between nuclear superpowers and cooperation in the fight against international terrorism. Although recent events do not inspire much optimism, we believe that *proxy wars* and nuclear threats will disappear in the medium term.

Let's take a look at how the globalization process has unfolded in recent history. The most known index of globalization was developed by the Swiss Economic Institute KOF in Zurich (KOF). The institute regularly publishes annual data for a large number of countries, starting from 1970 to 2021. Numerous indicators are grouped into twelve areas. All are expressed as percentage ranks from 0 to 100.

The General Globalization Index is the weighted average of economic, cultural and political globalization. We have shown it in Figure 2. As there are no data for the period 2022-23, we have estimated these indices. Also, we made corrections to the globalization index in Serbia in two sub-periods: 1992-95 and 1998-1999. Until the democratic changes in 2000, Serbia was slower to engage in global world trends compared to the world average. After that time, Serbia has been rapidly integrating.

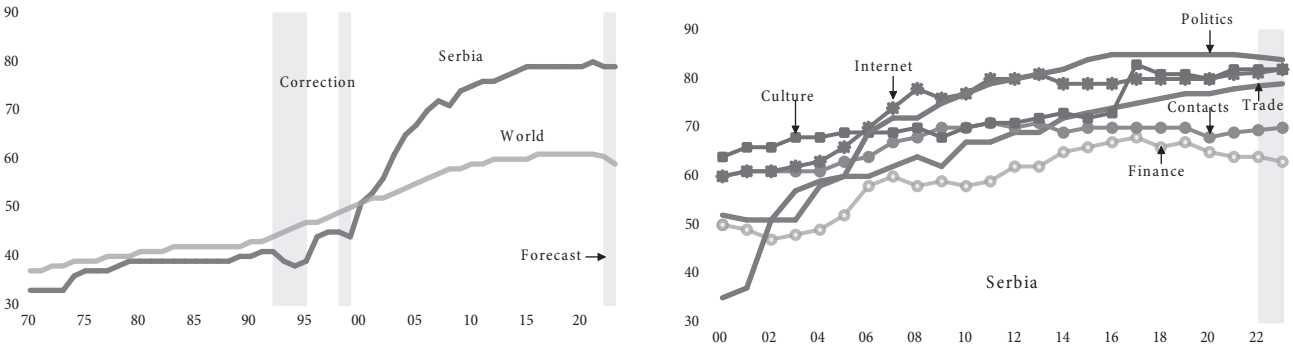
As we have already mentioned, globalization is a complex process. This can be seen in the case of Serbia over the past 20 years. Figure 2 shows the six components of the globalization process. Serbia is primarily politically integrated into global relations. This process began on a very low basis after the democratic changes in 2000 but recorded visible results until 2015-16. Since then, it has stagnated and slowly declined for the past two years due to Serbia's refusal to impose sanctions on Russia after the outbreak of war in Ukraine. However, many diplomatic contacts continue.

Then comes the Internet and the cultural globalization of Serbia. Cultural globalization has returned to pre-COVID-19 levels. Serbia is particularly developing digitalization and with it goes the increased integration into global digital networks. Trade globalization has a stable upward trend despite the narrowing of trade with Russia. Personal contacts have also returned to pre-COVID-19 levels. In terms of finances, there has been a steadily declining trend of globalization for some time. FDIs are at a significant level, but the country's external debt is growing, while maintaining the existing nominal exchange rate level despite high inflation. Therefore, in general, Serbia has maintained the level of globalization in these times of crisis, but structural changes have occurred within it.

Strategic competition

It is commonly thought that protectionism and free competition are two mutually incompatible processes. This was the case in international trade. Today, this is no longer the case. Strategic competition has replaced free competition by introducing the parallel existence of conflict and cooperation.

Figure 2: Globalization indices - World (left) and Serbia (right)



Source: KOF Globalisation Index, Author

The conversion of GATT into the World Trade Organization in 1994, together with the accession of Ukraine in 2008 and Russia in 2012, has enabled the reduction of trade barriers, the opening of financial accounts around the world and high capital mobility. Through foreign direct investment and technology transfer, the economies of developed and less developed countries have integrated into one large common market. The principle of free trade finally seemed to prevail.

However, progress never goes straight, especially in conditions of competition in an integrated world market. The free market creates imbalances and negative external effects. They lead to unexpected consequences. U.S. capital developed China's economy, and then it turned out that the U.S. created an unsustainable trade deficit with China. Complaining that the Chinese side is unauthorizedly taking over modern technology, in 2018 the US imposed additional tariffs in the amount of 25% on imports of certain goods from China. China responded in kind. $34 billion of mutual trade in goods on each side was affected by these restrictions. This corresponds to the level of GDP in Serbia. So, the amount was not large, but it had far-reaching and symbolic consequences. A trade war between the U.S. and China began. In May 2024 additional amount of trade of $17 billion was restricted on both sides.

They say this is the biggest trade war in the economic history of the world. Regardless of the scale, it has strange characteristics. Two processes take place in parallel. On the one hand, barriers to the free movement of goods and capital in certain areas are introduced, and on the other hand, mutual trade and financial operations in other areas are further developed. In one segment of the market, economic interdependence is deepened, and in another segment of the market, restrictions are introduced. In international trade, the WTO formulates free trade rules, but behind the backs of the WTO, major trading partners introduce barriers to each other. The WTO is powerless.

Protectionist measures, including economic sanctions, are not just part of the system of foreign trade. They play a prominent role in the national security system of the great powers. In this sense, the term "strategic competition," introduced by the RAND Corporation, encompasses both trade and geopolitics, with a clear emphasis that it is a combination of conflict and cooperation while avoiding open war, [12][1]. Although it has been years since placing strategic competition at the heart of the new U.S. security strategy, The RAND Corporation argues that there is still no clear theory of what it means.

An example of strategic competition is the erection of the "New Berlin Wall" in trade with Russia. It was not created as a result of the new regulations in the WTO but as a consequence of the war in Ukraine, where the G7 countries (including their allies) expanded economic sanctions on Russia. So, they made formal decisions in their representative bodies on how to limit trade with Russia, not for all goods, but for precisely targeted products. Trade with Russia is not interrupted, it is selectively restricted. A small number of European countries still import oil and gas from Russia. Other countries, such as China and India, do not pay any attention to the imposed economic sanctions on Russia. They even increase trade with Russia, while maintaining trade with the G7 countries.

The countries we look at in this paper represent the top ten most developed world economies and account for half of the international trade: the US, Canada, UK, Germany, France, Italy, Japan, Russia, China and India. The data refer to 2023 (USA, Canada, Germany and Serbia) and 2022 (all other countries except Russia, to which the data refer for 2021)[2]. Data is read by columns. Unfortunately, export and import data are not fully aligned with national statistics. Regardless, they speak convincingly about the relationships between the observed economies.

Figure 3 shows trade flows between seven trading blocs: the US, Canada, Europe (UK, Germany, France and Italy), Japan, Russia, China and India. Table 1 contains

1 This study was commissioned for the U.S. Department of Defence. As the authors say, it is based on numerous economic, military and geopolitical data on the state of competition between major powers. "By releasing a new National Security Strategy in 2022 and removing confidentiality from the national defence strategy summary, the United States has confirmed the existence of a new era in defence planning: replacing the focus from threats from non-state extremist groups to a major emphasis on threats posed by major powers similar forces. This new focus was announced in the 2017 National Security Strategy and the 2018 National Defence Strategy, and it is now clear, especially after the Russian invasion of Ukraine, that this new emphasis will persist."

2 The data is taken from the portal [19]. There is no official data for trade between China and Russia for 2023. We have downloaded them from reliable newspaper articles with the help of Microsoft's artificial intelligence program "Copilot in Windows."

the data on which these charts are made, including the rest of the world RoW (Rest of the World).

What does this figure tell us about?

1. In order of size, the three largest U.S. trading partners on the export side are Canada, Europe and China, and on the import side China, Canada and Europe. In the last place comes Russia, whose trade is so small that it is almost not visible in Figure 3. It is beyond every priority of the United States.
2. In China, the largest export market is the United States, followed by Europe and Japan. The largest markets from which goods are imported are Europe, Japan and the United States. Trade with Russia is not insignificant, but it does not enter the top three markets. Those markets are the U.S., Europe and Japan.
3. Russia's foreign trade is much smaller than that of the U.S. and China. The largest export markets, before the outbreak of war in Ukraine, were China, Europe and India. In 2022, Turkey – and some other countries that are not on the list of our selected economies – have joined this area, significantly pushing Europe back.[3] On the other hand, the largest import markets were China, India and Europe. China, India and Europe were, therefore, Russia's strategic trading partners, but not the US. With the continuation of the war in Ukraine, Europe's position has drastically narrowed and from a strategic partner, it has become a strategic adversary. On the other hand, according to news reports, China's position has strengthened. Exports to China increased by 13% in 2023 and imports by 47%, while the Russian side still has a small positive trade balance.
4. In Europe, the most important internal trade is between the Member States of the European Union. In terms of foreign trade, the US, China

3 This trend continued in 2023. Thus, according to German statistics, its exports to Russia in 2023 fell by -83% compared to exports the previous year, and imports by -69%.

Table 1: Bilateral trade in the World, USD billion

Export 2022/23	USA	Canada	Germany	France	Italy	UK	Japan	China	Russia	India
USA		439.6	165.5	49.1	68.5	64.6	90.7	582.8	15.1	80.2
Canada	352.8		13.9	4.3	6.7		16.6	53.7	0.7	4.3
Germany	76.5	5.1		84.6	81.6	41.4	22.7	116.2	30.3	10.4
France	45.3	3.2	125.9		66.5	30.7	10.1	46.1	16.5	8.1
Italy	28.9	2.0	91.3	56.6		11.3	11.7	50.9	30.7	8.5
UK	74.1	10.5	85.3	35.2	28.7		6.9	81.5	6.8	11.2
Japan	76.2	11.7	22.2	6.7	8.5	7.2		172.9	15.0	5.7
China	147.8	22.6	106.0	25.0	17.3	35.6	188.9		114.2	15.1
Russia	0.6	0.0	9.9	3.3	6.1	1.3	14.9	111.8		2.9
India	40.1	3.8	18.0	6.3	5.1	10.1	6.5	118.5	40.6	
Top 10	842.1	498.5	638.0	271.0	289.0	202.2	368.9	1,334.5	269.9	146.4
Total	1,976.4	571.5	1,660.1	605.7	649.5	513.0	696.5	3,512.6	451.0	447.5

Import 2022/23	USA	Canada	Germany	France	Italy	UK	Japan	China	Russia	India
USA		280.1	101.0	56.3	26.2	97.8	139.8	179.0	17.3	51.8
Canada	429.6		7.2	3.6	2.0	17.1	8.6	42.4	0.9	3.9
Germany	163.0	18.5		119.9	94.5	71.0	19.6	111.4	27.4	13.9
France	58.9	6.4	74.5		50.7	34.8	6.4	35.6	12.2	4.2
Italy	75.2	9.5	76.8	60.3		30.4	5.3	27.0	12.0	5.5
UK	64.8	7.0	39.6	28.5	8.6		11.0	21.8	4.5	9.6
Japan	151.6	15.3	28.0	5.8	5.5	13.3		184.5	9.1	15.8
China	448.0	66.1	173.0	51.8	60.9	110.3	144.5		72.7	102.3
Russia	4.9	0.1	4.3	15.9	28.6	6.9	4.6	129.0		40.6
India	87.3	5.6	15.5	8.0	10.6	14.4	13.9	17.5	29.6	
Top 10	1.483.2	408.5	519.8	350.1	287.7	395.9	353.8	748.1	185.7	247.6
Total	3,080.7	562.4	1,501.3	814.5	695.1	807.0	868.9	2,481.5	379.0	729.1

Source: UN Comtrade

and Japan come in sequence. The situation with imports is somewhat different because this rank is formed by China, the US and Russia. This speaks of Europe's energy dependence on Russia and trade in industrial goods and raw materials with China. Europe's main trading partners are the United States and China.

Figure 3 does not show one important fact, which is visible in Table 1. These trade flows represent only one-half of the total trade of the observed countries. This means that strategic competition also takes place in trade with third countries (RoW). This trade can significantly affect relations between global rivals. For example, in 2023, Russia neutralized the effect of economic sanctions by expanding its trade with third countries in the field of agro-industry. It has positioned itself as the world's fourth-largest food exporter despite economic sanctions.

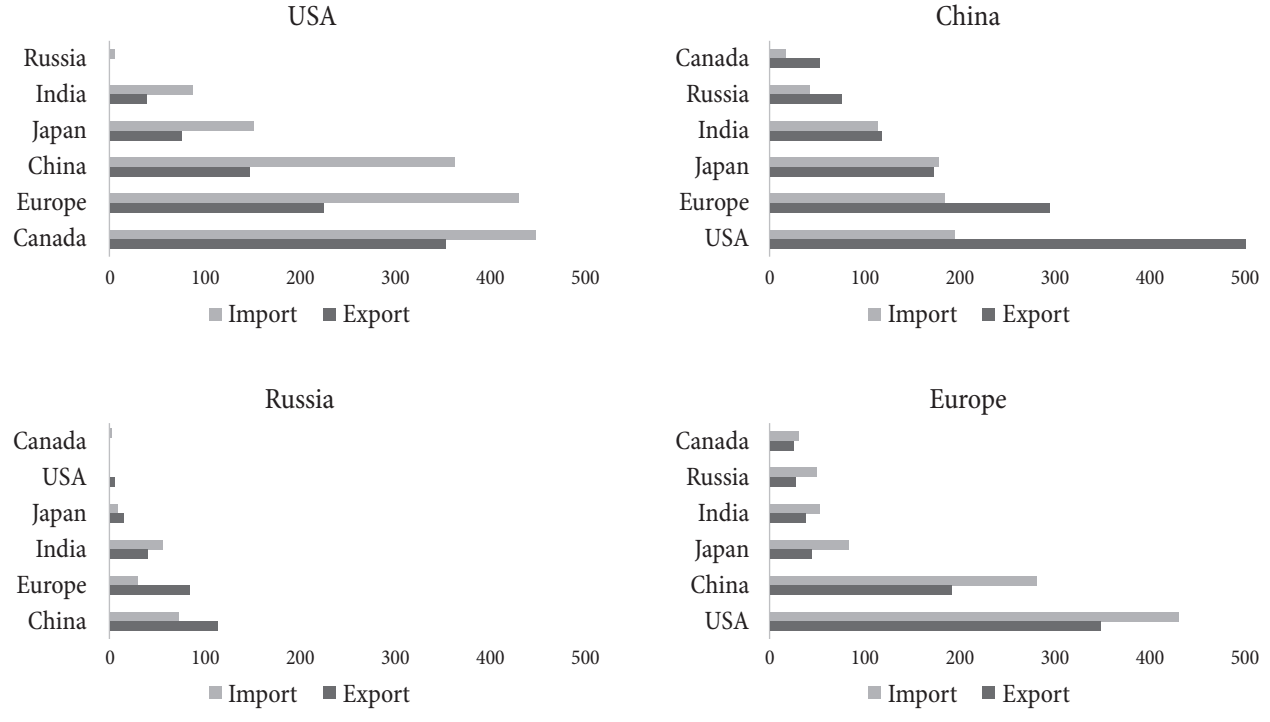
Therefore, the world trade is influenced by geostrategic relations. After the fall of the Berlin Wall in 1989, a unipolar world was formed with the United States as the only superpower. The USSR went bankrupt and collapsed. However, it turned out very quickly that this unipolar world was unsustainable. Today we are witnessing its disintegration. NATO's *proxy war* with Russia, via Ukraine, illustrates this.

Let's ask a rhetorical question (which, however, is increasingly being asked): Will NATO go to war with China tomorrow? The reasons for this exist. Just as NATO's expansion into Ukraine has provoked a (disproportionate) reaction from Russia, so support for Taiwan poses a challenge for China. However, China is not Russia. So, the answer to the above question is found in Figure 3. The US did not have any trade interest in Russia, so the *proxy war* with it did not affect its economy. However, a *new proxy* war with China would be a completely different matter. It would cause immeasurable damage to the U.S. economy. That is why our answer to the above rhetorical question – is negative (although it did not seem so twenty years ago).

We must extend the above sentence with the following statement: supporting Russia in a war with Ukraine would be a great moral failure. However, an even bigger historical failure would be to push Russia into China's orbit.

The geopolitical position of a country depends on several factors. That's the size of the odds, the economic strength of a country, the number of inhabitants as a natural basis for recruiting military personnel, the amount of military expenditures and the standard of living of residents (GDP per capita). Except for Canada and Japan, all of these countries have nuclear weapons.

Figure 3: Strategic trade relations



Source: UN Comtrade

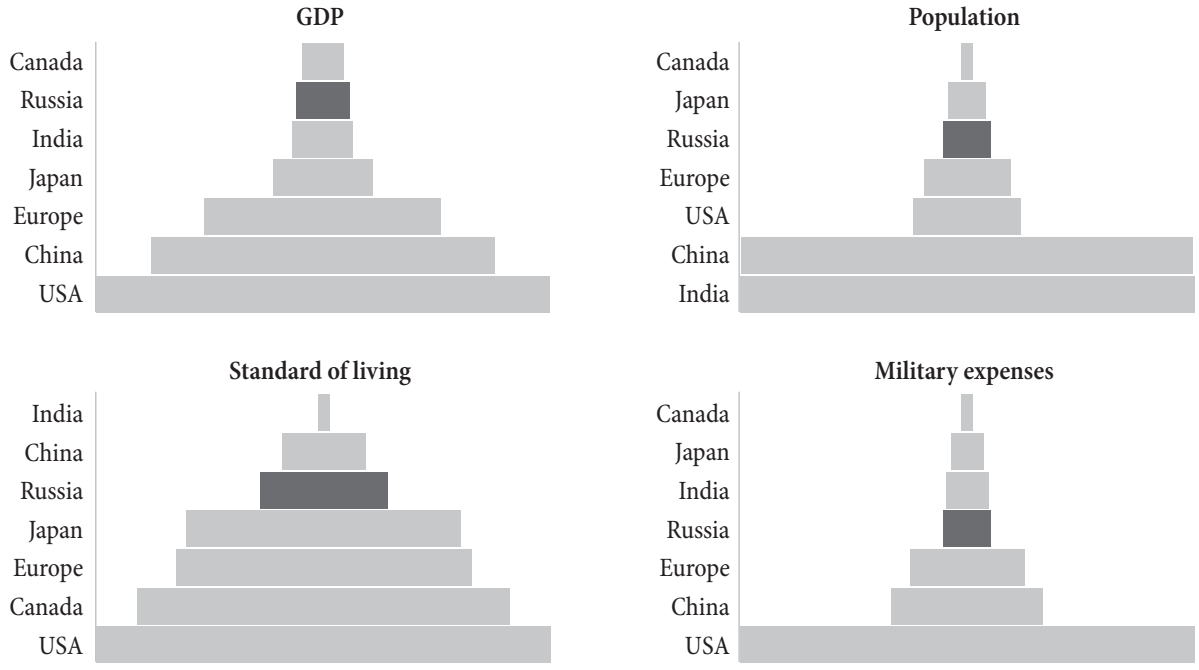
That's why we didn't include it in Figure 4. In Figure 4, we specifically singled out the position of Russia. Surprisingly, it works, but the fact is that Russia's position is inferior to its competitors, according to each of the listed key factors. That is probably why the US and Europe see Russia as a weak enemy to be defeated and contained (as when the USSR went bankrupt and collapsed). In contrast, they have respect for China and treat it as a competitor to be outdone in strategic competition. For its part, China treats Russia as a (necessary) ally. However, the world today is geopolitically divided into two blocs, which has a decisive impact on globalization relations. Also, on the position of Serbia (see Figure 5).

Trade position of Serbia

Let's simplify Figure 3 to answer the second key question that interests us, and that is the question of what Serbia's position is in existing and future, strategic relations. Today's situation in the world is in many ways reminiscent of George Orwell's futuristic novel "1984", [14]. Figure 5 tells how much the "Orwell prophecy" has come true in today's world[4]. Although Orwell had something else in mind, today the "struggle" has been replaced by "strategic competition" and is not openly fought between two parties

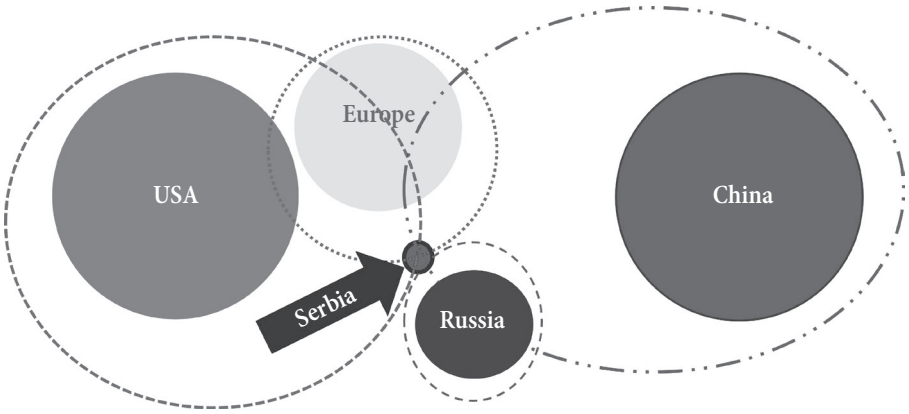
4 At Orwell, Eurasia could be Europe and Russia, Eastasia China and India, and Oceania could be North America and Australia. However, the war in Ukraine spoils this picture and moves Russia to Eastasia and connects Oceania and Western Europe into Euroatlantic.

Figure 4: Factors of geopolitical strength



Source: Author

Figure 5: Orwell's prophecy



Source: Author

against a third party, but between two sides (with their natural, or extorted, satellites) with the help of *proxy wars*.

Where is Serbia here? Serbia, first of all, does not want to be either formally or factually anyone's satellite in strategic relations. It's a noble idea, but practically unachievable. Invoking non-alignment today is completely inappropriate under conditions where there is a formal application for EU membership. After the fall of the Berlin Wall in 1989, non-alignment in the world disappeared (although formally some of its diplomatic forums still exist). Non-alignment is no longer an applicable formula in international relations. The conditions for a non-alignment policy would be:

1. The country's good international standing as a consequence of the recognition of key decisions under UN foreign policy standards (this could have been in 2000 but was lost as early as 2001 due to the lack of cooperation with the International Tribunal in The Hague; later events never regained this opportunity).
2. Alliance with other non-aligned countries to form a critical mass of influence (such countries do not exist after the fall of the Berlin Wall, as we have already stated).
3. Internationally recognized diplomacy in the service of reducing tensions in the world (the opposite is happening in the Balkans – Kosovo, the Incident in Banjska, the constant media quarrel with Croatia, for example – increase tensions in the Western Balkans).

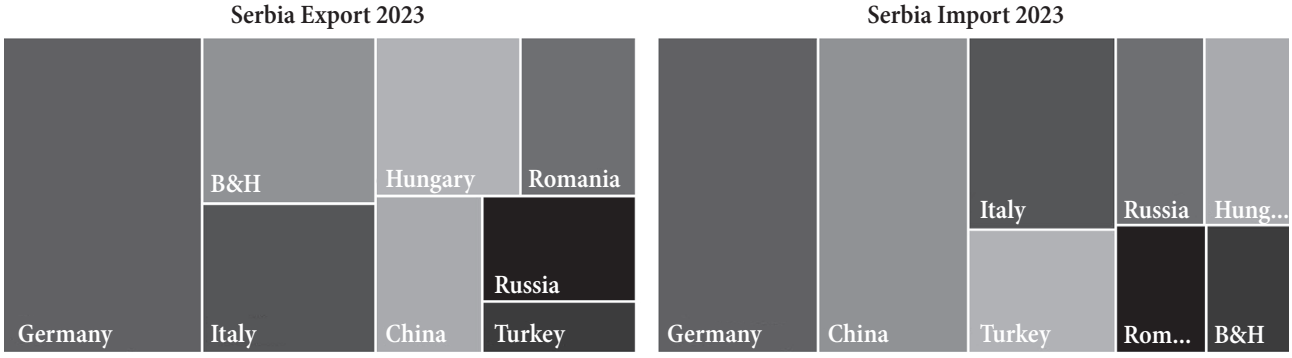
None of the above three conditions are met by Serbia. Therefore, even though it does not want to, Serbia has to spin in one of two strategic orbits: Euro-Atlantic (US and EU) or Eurasian (Russia and China), as Figure 5 implies. Serbia is too small a country to form its independent orbit.

What are the practical consequences? Very simple – Serbia will constantly be under pressure from the Euro-Atlantic orbit (to which it naturally belongs), and trade and political cooperation with the Eurasian orbit will only complicate these relations. An increasing number of individuals and businesses will be placed on different sanctions lists[5]. This is, of course, a problem for Serbia. Economic cooperation with Russia and China is very beneficial for the country, but not acceptable to the other side. EU membership cannot compensate for losses if this cooperation is interrupted. Brussels is probably aware of this fact but ignores it.

Now let's look at the formal foreign trade flows in Serbia (Figure 6 and Table 2), [17]. The scale and structure of Serbia's foreign trade changed in 2023 compared to the previous period (as shown by the arrows in Table 2). Compared to the previous year, exports increased by 6.5%, while imports decreased by – 3.2%. On the export side, the top five destination countries were Germany, Bosnia and Herzegovina, Italy, Hungary, and Romania. Then came China, Russia, and Turkey. Altogether, these countries bought 52.1% of export goods from Serbia. Since four of these countries are EU members, and the fifth is in CEFTA, it is obvious that the EU is Serbia's main trading partner on

5 At the end of May 2024 – when we write this text – there are two persons and four companies on the US list, and on the European list and the UK list one company from Serbia. The reason is the re-export of modern electronic equipment that can be used in military production. By the way, this trade is not prohibited under the regulations of Serbia, but the companies found themselves on increased control of the Tax Administration.

Figure 6: Exports and imports of Serbia in 2023



Source: SORS

Table 2: Serbia's main trading partners in 2023

2023	Export growth %	Compared to 2022	Import growth %	Compared to 2022
Germany	15.1	▲	13.1	▲
B&H	6.9	▼	2.8	▼
Italy	6.2	▼	7.3	▲
Hungary	5.5	▲	4.2	▼
Romania	4.4	▲	3.0	▲
China	4.0	♦	12.2	▲
Russia	3.9	▼	4.3	▼
Turkey	1.9	▲	4.7	▼
World	52.1	▲	48.4	▼

Source: SORS

the export side. The first five countries of import origin were Germany, China, Italy, Turkey and Russia, followed by the remaining three countries. Imports from these countries accounted for 48.4% of total imports. In terms of imports, the dominance of Europe is much smaller than in exports.

The first impression from Table 2 is that the trade in goods with Germany has increased and decreased with Russia. A more detailed reading of the data requires separating exports from imports. From the point of view of exports, Serbia will not be much affected by the strategic relations of trade in the world, including economic sanctions on Russia. Russia and China account for less than 8% of Serbia's total exports. On the import side, however, the situation is different. Imports of energy from Russia and various industrial products from China, make Serbia sensitive to import edible flows of goods from these countries. This import accounts for one-sixth of Serbia's total imports. Further reduction of energy imports from Russia requires some adjustment time, not to consider the increased cost of supply.

Strategic supply chains

Serbia is a small economy that is not included in the production chains of the US, China or Russia. Serbia's participation in the EU market is not a strategic circumstance for this association, although it is for Serbia. However, what is a strategic circumstance for the EU is the possible participation of Serbia in supply chains of strategically critical raw materials.

Before the opening of the trade war with China in 2018, the US realized that there was a problem in ensuring secure supply chains not only for goods and services but also for critical raw materials, including rare earth elements[6]. The initial interest was only for the energy sector, and later it spread to other branches of technology. Critical raw materials are crucial to modern technology. For example, tungsten is key to vibrant technology in mobile phones; lithium, cobalt and nickel for electric cars, boron for wind turbines and for the production of glass and artificial fertilizer, silicon for semiconductors, and magnesium and scandium for aircraft. These are key sectors of the European economy (consumer electronics, environmental technologies, automotive, aviation, defence). The raw materials are strategically important, but their supply is subject to risks due to high import dependence and significant concentration in individual countries. In addition, there is no substitute for them due to their very unique properties. In other words, the functioning of the entire economy in Europe depends on them, and their supply is beyond secure supply chains.

China is a major producer of strategic raw materials, of which it supplies the EU with 45% of the total consumption of barite, 65% bismuth, 71% gallium, 45% germanium, 97% magnesium, 40% natural graphite, 67% scandium, 32% tungsten and 62% vanadium. In addition, it is an exclusive supplier of heavy rare earth elements.

Hence, the Council of the European Union adopted the law on critical raw materials, which came into force in May 2024 (CRMA) [6]. That is one of the flagship legislative initiatives under the EU Green Deal Industrial Plan. It identifies two lists of materials (34 critical and 17 strategic) that are crucial for the EU's green and digital transitions, as well as for the defence and space industries. The CRMA establishes three benchmarks for the EU's annual consumption of raw materials: 10% from local extraction; 40% to be processed in the EU and 25% to come from recycled materials. No more than 65% of the EU's consumption of each strategic raw material should come from a single third country. That condition is the

6 The U.S. Department of Energy started working on this in 2010. In 2011, the EU made the first list of strategic critical raw materials, which is renewed every three years. The last list includes bismuth, boron – metallurgical purity, cobalt, copper, gallium, germanium, lithium – battery purity, elemental magnesium, manganese – battery purity, nickel – battery purity, platinum group metals, rare earth elements for magnets (Nd, Pr, Tb, Dy, Gd, Sm and Ce), elemental silicon, elemental titanium and tungsten.

most challenging. If we look at Figure 7, it is immediately clear that the challenge does not come from Russia, but from China. China is the biggest supplier of critical raw materials and rare earth elements.

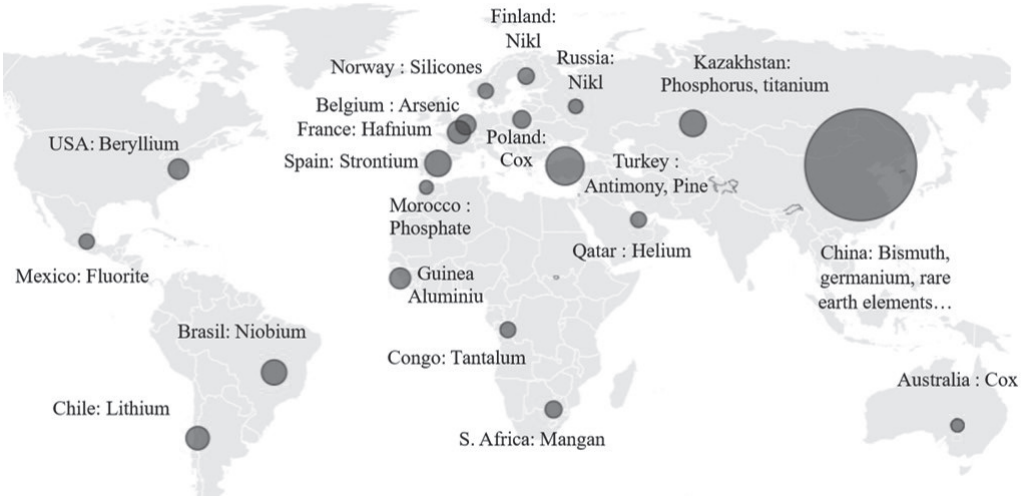
How will all these affect Serbia? First of all, climate change should be added to this. To achieve climate neutrality in 2050, the EU has decided to reduce greenhouse gas emissions by at least 55% by 2030 [4]. Ensuring the secure supply of rare strategic materials is thus complicated because it is associated with the task of simultaneously decarbonizing the energy system.

On the website of the European Commission, in the section related to the Raw Materials Information System (RMIS), is the following text, [3]:

- "EU production and supply diversification. Total battery consumption in the EU will reach almost 400 GWh in 2025 (and 4 times more in 2040), driven by the use of e-mobile devices...
- The EU is expected to expand its production base for raw materials and battery components in 2022-2030 and improve its current position and global market share. However, dependencies and bottlenecks in the supply chain will continue to create vulnerabilities.
- The EU will continue to depend on imports of cobalt and nickel (concentrates and semi-finished products) for processing in its refineries. In contrast, most of the inputs for the production of refined lithium compounds will come from *new lithium mines in the EU.* Refining natural graphite for anodes will rely on both domestic production and imports. In terms of manganese, the EU is likely to be self-sufficient in both primary and processed raw materials. The structure of the global supply in the coming years provides an initial insight into the potential sources of imports into the EU...
- Australia and Canada are the two countries with the highest potential to secure additional and low-risk supplies to the EU. Other manufacturers that could significantly reduce supply risks to the EU are Argentina and Chile for lithium, Mozambique and Tanzania for natural graphite and the US for refined graphite. *Serbia is a probable source of lithium minerals* in Europe for further refining into chemical compounds, and Norway is a reliable source of refined graphite."

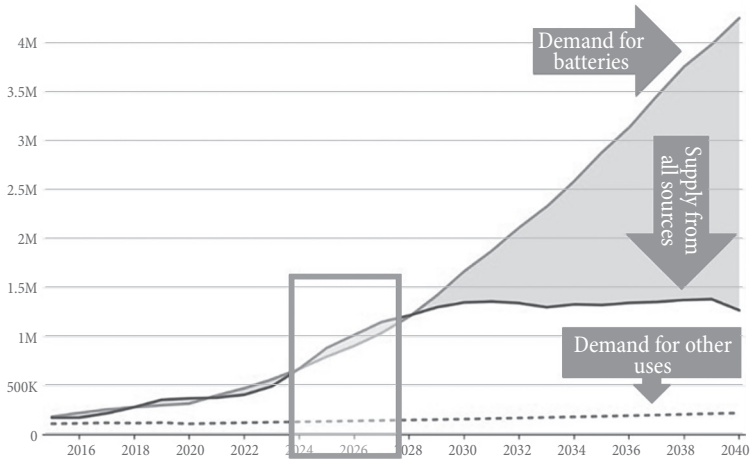
These are European assessments and plans within which we have highlighted what is expected of Serbia. Figure 8 provides additional background information. In 2030, Serbia should deliver 3% out of the 66% of the total EU procurement from other countries in secure supply chains, not China, which is estimated to cover the remaining part of 34%. RMIS cites the estimate of the Joint Research Centre that in 2030 the total demand for lithium in the EU will be about 1.3 million tons, so 3% of the supply from Serbia would be about 40,000 t. Rio Tinto plans to produce 58,000 tonnes of lithium annually.

Figure 7: The map of critical raw materials



Source: Consilium Europe.EU

Figure 8: Estimating the global supply and demand balance for lithium



Source: RMIS

The European Commission's estimate dramatizes the lack of lithium in the post-2028 period. As can be seen from Figure 8, it is estimated that the demand for lithium will grow exponentially, while supply will stagnate after 2028. According to the data from the above image, supply and demand would grow more or less balanced at a CAGR rate of 15% (Compound Annual Growth Rate) between 2015 and 2028. From next year to 2040, a large gap is created, but the growth rate of CAGR is rated slightly lower at 12%. From today and for the next five years, supply and demand will be almost balanced, with a small surplus of supply.

This certainly "recommends" that Serbia should approve the opening of the Jadarite mine near Loznica. Within these frameworks, it should be understood why a *letter of intent* was signed between Serbia and the European Commission in September 2023. *A letter of intent* was signed to "initiate a strategic partnership in the field of batteries and critical materials, including lithium." In July 2024, the European Union and the Republic of Serbia signed a *Memorandum of Understanding* on the strategic partnership between Serbia and the European Union in the field of sustainable raw materials, battery value chains and electric vehicles [7]. In addition to the potential exploitation of lithium, Serbia has only one other metal from the list of strategic raw materials. It's copper, by the way, which is produced by a Chinese company. In this sense, it would be outside the strategic partnership and would be part of the EU's dependence on the supply from China. However, more curiously, lithium will not be outside the influence of China[7].

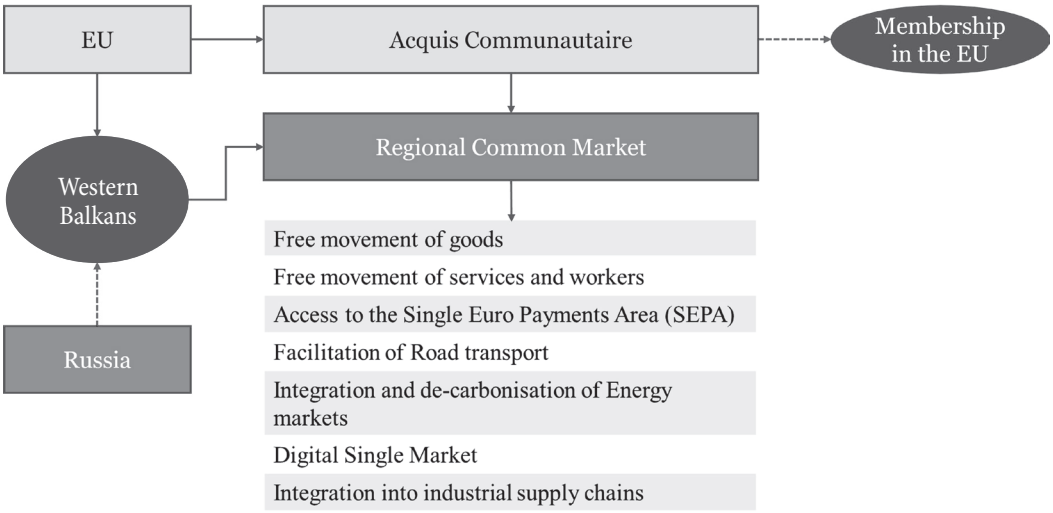
The EU is working on a policy of ensuring safe production chains with the Western Balkans. The "New Growth Plan for the Western Balkans" envisages seven areas that are a priority for rapid harmonization with EU rules. This is shown in Figure 9. The plan should eliminate Russia's influence in the Western Balkans and speed up the process of its EU accession.

The seventh priority of the Plan reads "Integration into industrial supply chains," [5, p. 5]:

- "(i) Develop strategic partnerships on sustainable raw material supply chains, following an initial focus on identifying specific joint industrial projects...
- The development of strategic partnerships on sustainable raw material supply chains will be based on the identification and implementation of joint sustainable projects for raw materials and batteries covering all stages of the *relevant value chains*, i.e. research, extraction, processing/production and recycling; as well as supporting Western Balkan

7 Rio Tinto is a dual-listed company consisting of Rio Tinto Ltd, Australia and Rio Tinto plc, England. According to Microsoft's "Copilot in Windows" artificial intelligence program, Chinese capital has already largely entered Rio Tinto: China Baowu Steel Group Co. Ltd. (state steel giant) owns a 9.8% stake in Rio Tinto Ltd. while another metal company Chinalco (also state-owned) holds its 14.5% stake. Rio Tinti plc (the largest shareholder of Aluminium Corporation of China Limited with 14.59% share) is the owner of Rio Tinto Minerals Development Limited, England and Rio Tinto Nominees Limited, England – which are co-owners of Rio Sava, Belgrade. This means that the potential production of lithium in Serbia will also be under the state influence of China.

Figure 9: The New Growth Plan for the Western Balkans



Source: Author

companies/ organisations to join *the EU Raw Materials* Alliance and *the EU Battery Alliance*."

The entire production chain has multiple links: 1) Extraction of jadarite ore and its chemical processing into lithium carbonate, 2) production of components for batteries, 3) battery production, 4) battery packaging, 5) installation of batteries in electric cars and 6) recycling of used batteries.

The EU committed itself to the formation of a lithium production chain, and not only to the digging and processing of jadarite ore into lithium carbonate. This could be good news if it came true. The direct financial benefits of lithium extraction are small for Serbia but significant for the EU. If the lithium production chain were rounded up, the financial benefits for Serbia would also be serious. However, the latest development does not support that.

There is a strong public disagreement in Serbia regarding the opening of the Jadar mine in Loznica. The above paragraph from the "New Growth Plan for the Western Balkans" provides some hope. Since strategic relations are proposed and formalized, the EU cannot neglect the implementation of its standards on environmental protection in Serbia. Possible soil, water and air pollution is the biggest unknown in the whole project, given that the proposed mining technology – based on the work of a chemical factory that uses sulfuric acid to extract lithium carbonate from jadarite ore – has not been applied anywhere in the world so far. It provokes people to think about the risks to the natural environment and health, [18] and [13][8].

Consulting company *Ergo Strategy Group* assessed the direct and indirect financial benefits for Serbia if the project of opening the Jadarit mine in Loznica was realized, [2]. Of course, like any other assessment, it is based on certain assumptions. These assumptions are correct according to market conditions in 2022, except for the overestimated value of the multipliers[9].

It is estimated that the total value of production will be $1,000 m. (at assumed prices and quantities should be $1,098 m.). The share of new value in total production is estimated at 69% (in Rio Tinto it is 70%), and the share of costs at 31%. These are acceptable assumptions, because according to the input-output table for 2020, the share of the new value of Serbia is 59% in relation to the value of

8 The Jadar mine is not a classic mine due to its dependence on its chemical plant. According to the structure of production, it is a chemical factory based on jadarite ore. The planned production is 285,000t of boric acid (47% of production), 260,000t of sodium sulphate (43% of production) and 58,000t of lithium carbonate (10% of total production). However, due to its high value, lithium accounts for over 80% of the total value of production. Experience with polluting the natural environment and privatizing RTB Bor could be very instructive.

9 The assumed price for lithium carbonate is $15,600 per ton, for boric acid $614 per ton and sodium sulphate $70 per ton. The assumed output multiplier is 2.74 and the labour multiplier is 3.51. However, according to the input-output tables for Serbia for 2020, these multipliers are much lower: 1.94 and 1.91 if the complete matrix of 62 sectors is considered. If, on the other hand, this matrix is aggregated to 31 sectors, for comparability with other statistics, the respective multipliers are much smaller 1.33 and 1.50. In any case, the estimated overall effects on GDP and employment are overestimated.

production, [16]. The study states that such a high share of new value in production (output) is due to the high capital intensity of the project, which connects mining and the chemical industry. However, in Serbia, the share of new value in the production of the chemical industry is only 24%. The chemical section of the mine may be much more capital-intensive than the average chemical factory in Serbia.

Since the estimates of the overall effects are unreliable, we consider only the direct effects of the Jadar project. From $695 m. of new value, $145 m. (0.24% GDP) goes to taxes, mine rent accounts for $40 m. (0.07% GDP), gross salaries $30 m. (0.05% GDP), capital costs and dividends $450 m. (0.74% GDP) and $30 m. on reinvested profits (0.05% GDP). Therefore, the share of the new value of the Jadar project in GDP is 1.15%, while the share of income belonging to the state of Serbia and workers is 0.36% of GDP. After six to seven years, the invested capital will be repaid, so the share of the state will increase based on profit tax and dividend raising.

What can we conclude? Europeans make plans and adopt legislation, while the Chinese do things. As of the strategic raw materials, Serbia has only copper and potentially lithium. Copper production is controlled by the Chinese, so the EU will not be able to establish a secure supply chain here. The situation with lithium is similar. With this rare metal, Serbia could be a strategic partner of the EU, providing adequate protection for health and the environment. However, this production will not be outside the indirect influence of China due to its serious stake in the ownership of Rio Tinto. Economically speaking, the Jadar project itself would mean more to Europe than to Serbia. However, if the lithium production chain were rounded up, then it would be an investment worthy of attention.

Right now, there are no such chances. Two major battery manufacturers, China's CATL and Japan's Envision AESC, have decided to build new factories in Debrecen, Hungary. The third major battery manufacturer, the Chinese company Eve Energy, has long considered whether to open its factory in Serbia or Hungary and has also opted for Debrecen. In Hungary, BMW is building a large electric car factory, where Mercedes already operates (in which two Chinese companies have a 20% stake). China's largest electric car company BYD has decided to make its new factory in Szeged, Hungary. Thus, Serbia has lost the opportunity to combine its potential production of lithium with the expansion of the production chain of batteries and electric cars. In that sense, the economic benefits of lithium mining in Serbia are dramatically losing value. However, the huge risks remain.

Conclusion

The first part of the article explains why the strategic position of Serbia is hardly sustainable in the new international framework (Figure 5). The second part of the article talks about strategic raw materials, particularly lithium. The Chinese bought the RTB Bor mine (copper) in 2018 and recently entered into strategic ownership of Rio Tinto (lithium). Whatever Serbia does, the EU will not be independent of China on that account.

Globalization encompasses three areas: economic, cultural and geopolitical. In this text, we have shown that the process of globalization is a complex and dynamic process, in which there are cooperation and conflicts between trade and geopolitical components. Globalization as we know it no longer exists. A new global movement has been formed based on strategic competition, which, in one segment, encourages cooperation, while in the other segment, it is limited or even excluded. This was created before the outbreak of the war in Ukraine, but it was especially intensified during this war. It seems to us that the world is getting divided into two large trading blocs, what we call the Bipolar World instead of the Global World. Given how things have unfolded in the past, the New Berlin Wall between those blocks will last for at least twenty years.

Based on geopolitical interests, the EU wants to tie Serbia to its global bloc (with the USA, Canada and Japan). As the second global bloc consists of China and Russia (BRICS countries), Serbia's economic and political cooperation with it represents a clear obstacle to its EU membership. Mining of lithium will not remove it. The latest EU initiative refers to *the New Growth Plan of the Western Balkans*, which formally requires modifications

in the existing SAA treaty, and in essence a change of Serbia's policy towards Russia and China. That is why this whole process remains open-ended. Serbia has an economic interest in continuing cooperation with Russia and China[10]. At the same time, there is a growing public request to protect public health and the environment. Mining of lithium is a great challenge which, contrary to some expectations, cannot fix Serbia's unsustainable strategic position.

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10 *The Free Trade Agreement* between the People's Republic of China and Serbia entered into force on July 1, 2024.

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was a professor of Economics at the Faculty of Law, University of Belgrade, until he retired in October 2015, and former Deputy Prime Minister of Serbia. He has received BA in law and PhD in economics from the University of Belgrade. Miroljub Labus' current research is focused on dynamic macroeconomics, and economic analysis of anti-trust cases. He has valuable experience in statistics and applied general equilibrium modelling (CGE and DSGE). He set up statistical journal Economic trend, business survey Market barometer, and served as editor of the Annals of the Faculty of Law in Belgrade. As Deputy Prime Minister, Miroljub Labus was instrumental in negotiating Serbia's return to international financial institutions after a period of sanctions, settling the Country's huge foreign debts, and promoting the SAA with the EU. After resigning from politics, Miroljub Labus founded in 2007 consulting firm Belox Advisory Services.

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SUSTAINABLE TRADE FACILITATION: EVIDENCE FROM SMALL AND MEDIUM ENTERPRISES IN SERBIA AND CEFTA 2006 REGION

Održivo olakšavanje međunarodne trgovine na primeru malih i srednjih preduzeća u Srbiji i regionu CEFTA 2006

Abstract

This paper analyses the wide range of trade facilitation measures implemented by small and medium-sized enterprises (SMEs) with a focus on the CEFTA 2006 region. Generally, SMEs are more exposed to numerous impediments provoked by customs administration activities than large enterprises. Among them, trade costs seem to be more significant barriers to SMEs enrollments into international market than tariffs. The problem of trade costs may be partially overcome due to implementation of trade facilitation measures, as essential for SMEs competitiveness on international market and for the deeper regional trade integrations. The analysis is based on a relatively new methodology of the UN Global Survey on Digital and Sustainable Trade Facilitation, as the only source of trade facilitation data for SMEs in observed region. One of the main advantages of this data source is the fact that trade facilitation measures go beyond articles of the World Trade Organization's Trade Facilitation Agreement, meaning that it also covers other specific measures. Some of these specific measures are contained in the Sustainable Trade Facilitation group which is associated with sustainable development goals focused on inclusive economic growth for vulnerable categories, such as SMEs. The results indicate that, within Sustainable trade facilitation group, Serbia and other CEFTA 2006 signatories did not achieve full implementation of most measures which enhance opportunities for SMEs in the observed period 2017-2023. Particularly, the lowest implementation rate was identified in SMEs access to Single Window. Despite these modest results, some progress in implementation of trade facilitation measures for SMEs is evident in relatively short period. This is the case particularly in Serbia with the best performing in 2023 compared not only to CEFTA 2006 average, but to developed countries as well. It was the only CEFTA 2006 signatory with implementation progress in all measures within the sub-group of trade facilitation for SMEs as the main stakeholders in international trade and key for sustainable and inclusive growth.

Keywords: *Sustainable Trade Facilitation, SMEs, Serbia, CEFTA 2006, trade costs*

Sažetak

U ovom radu analizira se veliki broj mera olakšavanja međunarodne trgovine koje su implementirala mala i srednja preduzeća (MSP), sa fokusom na region CEFTA 2006. Uopšteno, MSP su, više nego velika preduzeća, izložena brojnim preprekama izazvanim radom carinske administracije. Među navedenim preprekama, troškovi trgovine su značajnija prepreka za uključivanje MSP u međunarodne tokove trgovine, u odnosu na carine. Problem troškova trgovine može se delimično prevazići zahvaljujući primeni mera olakšavanja međunarodne trgovine, koje su od suštinskog značaja za ostvarenje konkurentnosti MSP na međunarodnom tržištu i dubljih regionalnih trgovinskih integracija. Analiza se zasniva na relativno novoj metodologiji Ujedinjenih nacija u okviru Globalne ankete o digitalnom i održivom olakšavanju međunarodne trgovine, kao jedinom izvoru podataka o olakšavanju trgovine za MSP u posmatranom regionu. Jedna od glavnih prednosti ovog izvora podataka je činjenica da se mere olakšavanja trgovine ne odnose samo na članove Sporazuma o olakšavanju međunarodne trgovine Svetske trgovinske organizacije, već da pored njih obuhvata i druge specifične mere. Neke od tih specifičnih mera su sadržane u grupi pod nazivom Održivo olakšavanje međunarodne trgovine, koja je povezana sa ciljevima održivog razvoja u vezi sa inkluzivnim privrednim rastom za ranjive kategorije, kao što su MSP. Rezultati pokazuju da, unutar grupe Održivo olakšavanje međunarodne trgovine, Srbija i ostale potpisnice CEFTA 2006 nisu u potpunosti primenile većinu mera usmerenih ka poboljšavanju pozicije MSP u posmatranom periodu 2017-2023. Konkretno, najniža stopa primene identifikovana je u domenu pristupa tih preduzeća jedinstvenom šalteru. I pored tako skromnih rezultata, evidentan je određeni napredak u primeni mera olakšavanja međunarodne trgovine za MSP u relativno kratkom periodu. To je posebno izraženo u slučaju Srbije, koja je na kraju perioda postigla najbolji rezultat, ne samo u poređenju sa prosekom CEFTA 2006, već i u odnosu na razvijene zemlje. Srbija je bila jedina potpisnica CEFTA 2006 koja je ostvarila napredak u primeni svih mera u okviru podgrupe olakšavanja međunarodne trgovine za MSP, kao glavnih učesnika u međunarodnoj trgovini i ključnih za održiv i inkluzivan rast.

Ključne reči: *Održivo olakšavanje međunarodne trgovine, MSP, Srbija, CEFTA 2006, troškovi trgovine*

Introduction

At the beginning of the new century, the items of trade transaction costs and trade barriers in international trade started to be observed in relation with the idea for trade facilitation (TF). Trade facilitation process was expected to decrease the role of many heterogeneous barriers with the final purpose to accelerate trade flows. During the last few decades, trade costs are seeing as more intensive impediment to trade than the tariffs. Generally, TF involves many activities in relation with trade costs decrease and trade increase, with more decisive improvements in infrastructure and institutional quality. All this has led to the negotiating process for the facilitation of the international trade flows, which started under the auspices of the World Trade Organization (WTO) in 2004 and successfully concluded with the Trade Facilitation Agreement (TFA) in 2013. All aspects of that process and TFA are oriented towards simplification, standardization and harmonization of trading procedures, especially those "at the border", resulting in lowering trade costs. As the TFA has been implemented gradually, it was necessary to monitor and evaluate it continuously, so that many steps have been done to improve the level of its implementation during the last decade.

Along with increasing integration of individual economies into the global economy, TF has become an important issue in determining a country's export competitiveness, covering various border procedures and TF with paperless trade. This is very important, particularly for Small and Medium-sized enterprises (SMEs), since it would help them to reduce trade costs, enabling their easier integration into global value chains and access to foreign buyers [7]. Beside their role as generators of employment and development, SMEs are also important stakeholders in international trade, mostly as direct exporters and importers, and important part of business ecosystems and the policy environment, certainly. They face many barriers, especially non-tariff barriers, related to numerous trade costs with their fix and variable parts. Increasing both of them, trade costs overall could become significant barrier to SMEs enrollments in trade flows. These costs, also called "at-the-border costs", have dominant impact on the decrease of activities and trade value for all trade enterprises. They are provoked mostly by numerous non-tariff barriers which are trade distortive. Hence, SMEs are the most affected by this phenomenon [18].

Trade facilitation process especially applied for SMEs could bring them to the position they should have as the creators of values and new jobs. Since large share of enterprises, particularly SMEs, in many countries, is integrated into international trade system, relevant question could be how measures from TF domain reflect on SMEs. To this aim, the analysis of relationship between TF, trade costs and exports, with special focus on the TF measures implementation for SMEs, is conducted in this paper. Particularly, we are pointing results for SMEs in Serbia within CEFTA 2006 integration, having in mind the fact that Serbia is a signatory of that agreement, and its trade is significantly oriented towards other CEFTA 2006 signatories. Therefore, functioning of this regional integration heavily depends on facilitation of trade flows between signatories, and hence the implementation of TF is very important issue, as in case of other regional economic integrations.

This is the first research which is focused on the implementation of the TF for SMEs in CEFTA 2006 using new methodology developed by the United Nations within the UN Global Survey on Digital and Sustainable Trade Facilitation. That is the novelty and contribution of the paper compared to previous literature. The UN Global Survey is the only source of detailed data for various sustainable and digital TF indicators in specific areas, such as TF measures for SMEs, and therefore is not limited only to measures of the WTO TFA.

The paper is structured as follows. After introduction, the first part is dedicated to the TF performance and its effects on trade costs and exports, while the second part represents a short methodology overview focused on calculation of TF measures for monitoring TF level implementation. The rest of the paper is about position of Serbia in CEFTA 2006 regarding the stage of TF implementation, as well as about TF progress of SMEs in the observed region. The last part contains concluding remarks.

Trade facilitation and its effects on exports and trade costs

During the last few decades the role and significance of tariffs as dominant trade barriers was slowing down, while some new factors influencing the trade have appeared in the meantime. Some of these factors are infrastructure and institutional quality which have decisive impact on the export, even more dominant comparing to variations in tariffs [3]. For instance, some studies have indicated that the reduction of tariffs by 10% would increase trade volumes by approximately only 2% [4]. Contrary, improvements of the Logistic Performance Index (as one of indicators of infrastructure quality) in low-income countries to the level of high-income countries, would cause the increase of their trade flows by 50% and more. This is an extreme example, pointing out the fact that trade costs provoked by the low level of the infrastructure and institutional quality have larger negative impact on international trade comparing to tariffs impact. All this implies the necessity of the trade costs decrease, as one of important preconditions for decisions of firms to invest abroad, or to export [4].

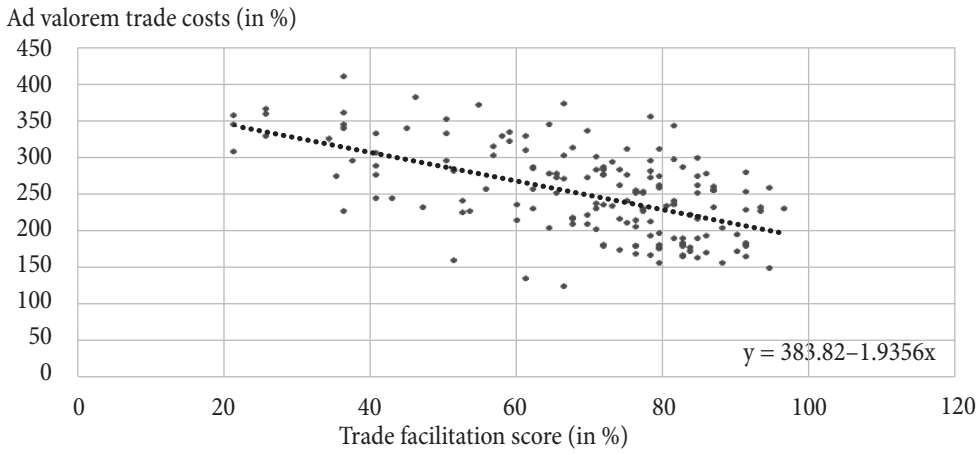
The lower level of trade costs, as well as the decisions to enter the international market with the role in exporting, are connected with higher productivity. That is the motivation for orientation of many national governments towards reforming processes, since only more productive firms would be motivated to start exporting or enter the international market. On the other side, less productive firms would still be oriented only towards domestic markets, while the least productive ones would be forced to exit very soon [8].

Some trade costs arise during the realization of the trading process, especially as the result of slow customs procedures and at the border agencies work. Many instruments for the decrease of these impediments to trade were generated under the Trade Facilitation Agreement (TFA), adopted in 2013 under the auspices of the WTO. The TFA entered into the force in 2017, after its ratification by two-thirds of WTO members. This Agreement is the legal form for many measures, instruments and actions which could be called Trade Facilitation Process. Numerous articles of this Agreement confirm the heterogeneity of TF measures: provisions for expediting the movement, cooperation between customs administrations and authorities, release and clearance of goods, with special reference to transit. Trade facilitation could be widely defined as "any policy measure aimed at diminishing trade costs" [19]. It covers "transparent, predictable and straightforward border procedures that expedite the movement of goods" [12]. The reforms from TF domain are considered as "good for trade" [22]. The measurement and estimation of their impact on international trade is especially challenging since there is no unique definition of TF process. According to UNCTAD, trade facilitation could be seen as the process which includes transparency, simplification, harmonization and standardization of trade procedures [22]. More comprehensive definition considers TF as the process of the simplification, harmonization and standardization of procedures, with added measures and information, along with the trading process during the realization of exports, imports, or transit [23].

Complexity of TF process can be seen in various TF areas defined and analyzed in numerous researches. It can be observed through its division into two main dimensions: "hard" (Physical infrastructure and Information and Communications Technology (ICT)) and "soft" (Border and transport efficiency and Business and regulatory environment). Among them, improvements of physical infrastructure have the greatest positive impact on exports [19]. Some other indicators of TF, similar in structure to mentioned researches, have also been considered in the literature, such as Port Efficiency, Customs Environment, Regulatory Environment and E-business Infrastructure [28].

The impact of the TF measures implementation on the trade costs decrease and trade increase is obvious in many countries in the world, with different extent both across countries and TF indicators. According to some estimates for OECD countries, the most significant impact on the trade costs had the implementation of streamline procedures with the potential to reduce trade costs by 5.4%, followed by advance rulings by 3.7%, automation by 2.7% and measures to streamline fees and charges by 1.7%. If all TFIs are observed together, estimated potential for overall trade costs reduction by 10% would be even

Figure 1: Trade facilitation performance and trade costs for goods, selected economies 2017-2021



Notes: The last available data for trade costs are in 2021. The list of countries is available upon request.
Source: Authors' calculation based on UN ESCAP –World Bank Trade Costs Database and UN Survey on trade facilitation and paperless trade implementation measures database

larger, pointing out significant impact of TF on trade costs level [9]. In addition to the streamlining of procedures and automated process, some further OECD findings have highlighted availability of trade-related information and simplification and harmonization of documents as policy areas with the significant impact on the increase in trade volume and the reduction in trade costs. Similarly to mentioned research, recent OECD estimates indicate that the combined effects of improvement in all mentioned TF areas on the reduction of total trade costs were also larger comparing to simple sum of individual improvements in these areas, depending on the level of development of the country. Namely, implementation of TFA reduces trade costs between 14% and 18% and increases world trade by 0.6%. The largest gains in trade costs reduction from full implementation of TFA were in lower-middle income countries (17.4%) and in the low income countries (16.5%), whereas the smallest effect is in the group of upper-middle income countries (14.6%) and OECD countries (11.8%) [11]. Furthermore, full implementation of next-generation digital trade facilitation measures, like cross-border paperless trade measures, could even double trade costs reduction [1].

In line with the results of mentioned OECD studies and according to the newest TFIs and trade costs data for economies for which data are available, a continuation of negative relationship between TFA measures and trade costs is obvious (correlation coefficient in the period 2017-2021 was −0.564; Figure 1).

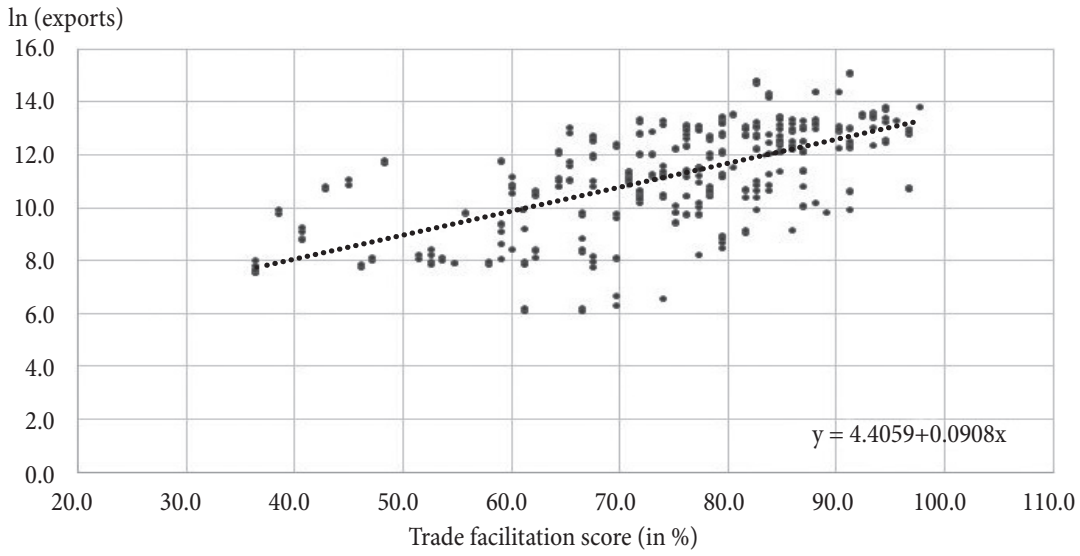
The newest data confirm that implementation of the TFA measures has further impact not only on trade costs, but on export value, too (correlation coefficient between TF score and export value was 0.640 in the period 2017-2023; Figure 2). Regarding the effects on trade value, the largest TF impact had harmonization and simplification of documents (for low income countries), streamlining of procedures (for lower- and upper-middle income countries) and availability of trade related information, automated processes and good governance and impartiality [10].

Decrease of trade costs and trade growth are important targets for all enterprises, especially for small firms and start-ups and for female entrepreneurs, since their inclusion in the global economy significantly depends on the costs level. Having the strong impact on trade flows, trade facilitation has the critical impact on inclusiveness of these vulnerable categories of enterprises and entrepreneurs. For these enterprises the costs of trading are marked as "disproportionately large", indicating necessity to reduce many unnecessary costs provoked by complicated trading procedures [12]. This issue is considered in more details within the section of this paper related to SMEs in trading world and TF.

Trade facilitation measures: Methodology overview

Monitoring of the stage of TF measures implementation has become an important issue along with increasing interest

Figure 2: Trade facilitation performance and exports in selected economies, 2017-2023



Notes: The last available data for export value are in 2023. Exports of goods in million USD; logarithms of export data are presented. The list of countries is available upon request.
Source: Authors' calculation based on UNCTADstat database and UN Survey on trade facilitation and paperless trade implementation measures database

in trade facilitation. For that purpose, many indicators have been developed by several international institutions. Currently, most commonly used TF indicators are from OECD trade facilitation database, as well as from UN Global Survey on Digital and Sustainable Trade Facilitation. The former indicators show the extent to which countries have introduced and implemented the WTO TFA measures and are formed by aggregating 133 variables across 11 areas,[1] whereas the later are more focused on implementation of specific TF measures from the UN Global Survey. There also are indicators from other sources, like trading across borders indicators of Doing Business Survey, Logistics performance index (LPI), or World Economic Forum Enabling Trade Index (ETI). However, most of them are not usable in recent years due to several reasons, such as changes in methodology, creating the problem with indicators` mutual comparability as in the case of the Trading across borders indicators, or unavailability of some indicators, as happened with the ETI whose latest data were collected for 2016.

Data from the UN Survey on Digital and Sustainable Trade Facilitation are available for the most of countries from 2015 and are collected every two years. The survey includes measures in accordance with relevant articles of the WTO TFA, but also more advanced TF measures. Namely, the scope of mentioned UN survey overcomes measures included in the WTO TFA, meaning that some of measures covered by that survey are not specifically captured by the agreement (e.g. most of measures in the Sustainable TF group). Despite that fact, their implementation can certainly support better implementation of TFA [24]. Along with specific sustainable TF measures, it contains information on the implementation level of various digital TF measures. The latest survey from 2023 contains data on TF measures, divided into the following groups:

(A) General trade facilitation measures: Transparency, Formalities, Institutional arrangement and cooperation and Transit facilitation;

(B) Digital trade facilitation: Paperless trade measures (related to the implementation level of information and communication technologies to trade formalities, such as customs automation or availability of internet connection at border-crossings) and Cross-border paperless trade measures (e.g. regulations for electronic transactions, implementation of systems for exchange of documents across borders and electronic trade-related data);

(C) Sustainable trade facilitation: Trade Facilitation for Small and Medium-sized enterprises (SMEs),

1 These areas are: Information availability; Involvement of the trade community; Advance rulings; Appeal procedures; Fees and charges; Formalities (Documents, Automation, Procedures); Internal border agency co-operation; External border agency co-operation; and Governance and impartiality. More about OECD TF indicators in [12].

Agricultural Trade Facilitation, Women in Trade Facilitation. This group of TFIs is relatively new compared to groups (A) and (B). Its inclusion into UN Survey is encouraged by new concept of Industry 5.0 (I5.0), with orientation to environment and society and final task to achieve sustainable development [6].

(D) Other trade facilitation: Trade Finance Facilitation, Trade Facilitation in Times of Crisis-emergency measures [24]. This group of indicators is expanded by two new measures, added to the survey in 2023 on a pilot basis: Trade facilitation for e-commerce and Wildlife trade facilitation (related to cross-border e-commerce and implementation of electronic CITES certificates and permits [27]). Consequently, totally 60 TF measures for 161 countries are encompassed by the survey.[2]

In order to calculate TF implementation rate for each measure across countries, each question in questionnaire is rated in the following way: score 3 is assigned to "fully implemented" measure, score 2 for "partially implemented", score 1 for "pilot stage" in implementation and score 0 for "not implemented" measure. Within each question, for subquestion scores 1 and 0 as assigned to answers "yes" and "no". Implementation rate for each TF measure is calculated relative to fully implemented score 3, also enabling calculation of the average implementation rate for sub-groups, groups of TF measures and overall implementation rate (expressed in percentages).[3] These rates are calculated by the following formula:

$$TF\_rate_k = \sum_n \frac{Q_n}{3 \cdot m_k}$$

where mk is number of measures in sub-group k and Q_n refers to scores of question number n. Trade facilitation rates are usually calculated for sub-groups: transparency (m_1=5), formalities (m_2=8), institutional arrangement and cooperation (m_3=3), paperless trade (m_4=9), cross-border paperless trade (m_5=6), trade facilitation for SMEs (m_6=5), agricultural TF (m_7=4), women in TF (m_8=5) and overall TF implementation rate (m_9=31). According to the methodology of the UN Global Survey, TF for SMEs, agricultural and women TF sub-groups, implementation rate is calculated only if data are available for more than half of measures in the sub-group.

Regarding TF for SMEs which is in the focus of this paper, five sub-groups of measures are developed: (1) trade-related information measures for SMEs, indicating the extent to which national government has developed TF measures - ensuring easy and affordable access for SMEs to trade-related information; (2) SMEs in Authorized Economic Operator (AEO) scheme – indicating whether national government developed TF measures which enable SMEs to benefit from authorized operator scheme; (3) SMEs access Single Window –referring to the actions that are conducted to make Single Window more accessible to SMEs; (4) SMEs in National Trade Facilitation Committee – the level of undertaken actions enabling SMEs to be well represented at the National Trade Facilitation Committee; (5) Other special measures for SMEs which are possibly implemented to decrease SMEs costs related to trade procedures.

Based on mentioned TF measures, the analyses of overall TF process itself and TF implementation specific to SMEs in Serbia and other CEFTA 2006 signatories, are conducted in this paper. Monitoring and evaluating the success of that process is important because Serbia is a signatory of CEFTA 2006 and its SMEs are very intensively included in trading with enterprises of other CEFTA 2006 signatories.

The position of Serbia in CEFTA 2006 integration - a comparative analysis of trade facilitation measures implementation

Although CEFTA 2006 signatories have a share of only 0.2% in international trade, the existence of this agreement is important for its signatories and resulted in continuous increase of their intra-trade. This was particularly obvious in the first years after the signing of CEFTA 2006, with accelerated intra-trade growth. Slowing down of that

2 UN survey is conducted through three steps: 1. data collection by the Economic and Social Commission for Asia and the Pacific (ESCAP) sub-regional consultants (completing the questionnaire); 2. Data verification by ESCAP secretariat; 3. Data validation by national Governments [26].

3 According to the methodology of the UN Global Survey on Digital and Sustainable Trade Facilitation, the answer „do not know" is also treated as "not implemented" with score 0, only when calculating the overall implementation rate.

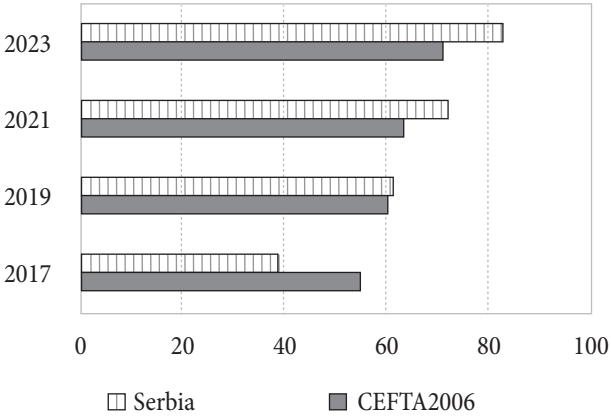
growth during the 2009 crisis and after Croatia became the EU member, has provoked the increase of EU share in regional trade structure and the decrease of the share of the intra-trade. Within CEFTA 2006 Serbia was the only country with constantly registered surplus. Signing this agreement, Serbia and other signatories started TF process even before the TFA was adopted, since in many regional trade agreements (RTAs), formed during last two decades, TF issue was early recognized as the instrument for accelerating trade flows. The provisions of TFA became very important part of many RTAs, including CEFTA 2006 [21]. Comparing the implementation level of TF measures in Serbia and other CEFTA 2006 signatories during the period with available data (2017-2023), a few conclusions can be derived. Firstly, based on five standard sub-groups (within General TF and Digital TF groups; Figure 3a), both Serbia and other CEFTA 2006 parties have registered an increase of the overall TF implementation rate, with the fastest progress in Serbia (from 39% to 83%).

When TF implementation rate is calculated based on all groups of TF measures, including relatively new group of Sustainable TF measures (TF for SMEs, Women in TF and Agriculture TF), situation is similar to previous described, though with slightly lower implementation rates for all observed countries (Figure 3b). This can be expected since these newly included important TF areas, at least during the first years of their inclusion, were not as much in the focus of TF implementation as other standard TF measures introduced many years before. Lower average implementation rate influenced by inclusion of new TF measures is the case not only in CEFTA 2006 region, but also in other regions in the world, with significant decrease in developed economies as well [25].

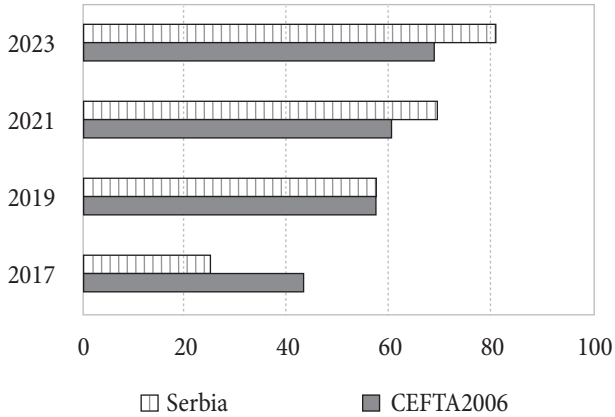
The whole observed period is characterized by different implementation rate across mentioned eight sub-groups of TF measures. For instance, in 2019 as the year before the Covid-19 pandemic, the share of implemented TF measures in Serbia was higher than in other CEFTA 2006 signatories in five sub-groups, particularly in the area of Formalities and Women in TF. On the other side, TF score in three sub-groups was under CEFTA 2006 average, with the lowest TF rate in TF for SMEs and Paperless Trade (Figure 4). However, in the following years up to 2023, in response to Covid-19 pandemic, countries all over the world have been more focused on implementation of digital TF measures to improve efficiency of cross-border trade. This was also the case in CEFTA 2006, particularly in Serbia, where TF implementation rates for Paperless trade and Cross-border paperless trade have increased from 52% and 33% in 2019 to 74% and 67% in 2023, respectively. Positive trends have also been registered in implementation of sustainable TF measures in Serbia, that is in TF for SMEs, Women in TF and Agricultural TF measures, with the growth of TF implementation rate from 27%, 56% and 58%, to 67% for the first two measures and 83% for the last one in 2023, which was the highest of all CEFTA 2006 parties (Figure

Figure 3: TF implementation rate for CEFTA 2006 and Serbia, 2017-2023

a. based on transparency, formalities, institutional arrangement and cooperation, paperless trade and cross-border paperless trade (in %)

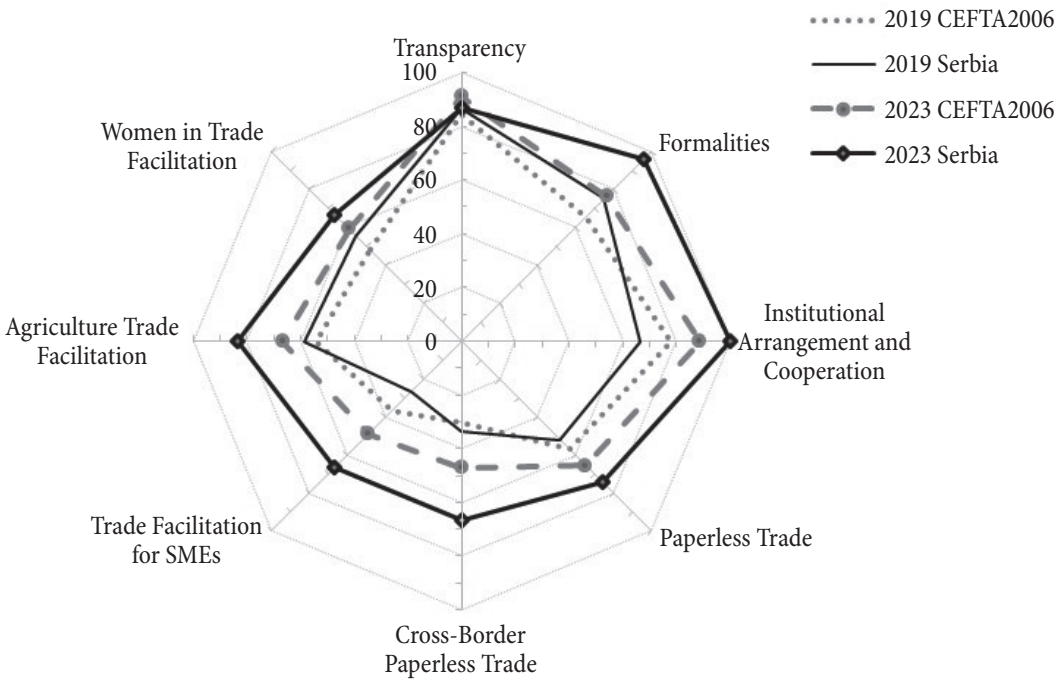


b. based on five sub-groups in a. extended by Sustainable TF measures for SMEs, Agricultural TF and Women in TF (in %)



Source: The UN Global Survey on Digital and Sustainable Trade Facilitation; https://www.untfsurvey.org/

Figure 4: TF implementation rate by sub-groups of TF measures in CEFTA 2006 and Serbia in 2019 and 2023 (in %)



Source: The UN Global Survey on Digital and Sustainable Trade Facilitation; https://www.untfsurvey.org/

4). Despite different implementation rate across TF sub-groups, the improvement of the position of Serbia was obvious and notably faster than CEFTA 2006 overall.

SMEs in contemporary trading world and trade facilitation

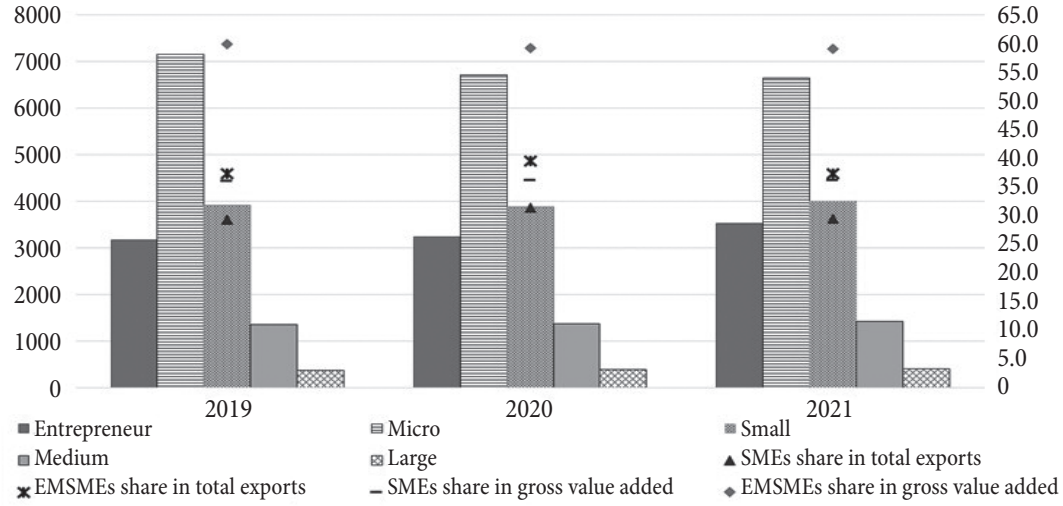
The group of SMEs is very heterogeneous in terms of productivity, wages and international competitiveness and many aspects, depending on enterprises` sectors, ways they are facing and overcoming inefficiencies in the environment and their sizes. During the last few decades, even in developed countries, SMEs have been more exposed to numerous problems compared to large enterprises, due to persistent differences in productivity and wage gaps. These gaps are less obvious for SMEs engaged in export. However, SMEs in trade and services are more affected by obstacles to bank financing [5].

SMEs are seen as the source for the creation of new jobs, mostly in low-wage sectors. These enterprises are more dependent on business ecosystems and the policy environment than larger companies, entailing their particular vulnerability [13]. This vulnerable category of enterprises is faced with many risks. One of the most contemporary challenges is the fact that these enterprises, having some intellectual property rights (IPR), are faced with the risks of the illicit trade, or trade in counterfeit goods. SMEs whose intellectual property was infringed, have 34% less chances of survival at the market and business world, compared to those who do not have such experience [17]. Furthermore, SMEs mostly do not know how to take the advantage of having these assets, because only 45% of registered IPR owners made some attempts to profit from these assets, while only 10% of these enterprises in EU own registered IP rights [2].

In OECD countries, SMEs have important role, as the basic and dominant form of organizing the business, because about 99% of all firms in these countries are SMEs, employing over two thirds of the total workforce.[4] They contribute in gross exports with 40% and even more, with 50% of the value added of gross exports. This confirms the usual, well known contribution of SMEs as a subcontractors and sub-suppliers of larger exporters [17].

4 "According to most definitions, small and medium-sized enterprises (SMEs) are companies with fewer than 250 employees and either an annual turnover not exceeding EUR 50 million or a total balance sheet not exceeding EUR 43 million" [17].

Figure 5: Number of exporting enterprises and the shares in Serbia`s exports value, 2019-2021



Notes: EMSME – entrepreneurs, micro, small and medium enterprises.
Left scale: Number of exporters, *Right scale*: The shares of SMEs and EMSMEs export value in total Serbia`s exports of goods.
Source: Authors' presentation based on data from Statistical office of the Republic of Serbia, 2023 [20]

This category of enterprise is also dominating the Serbian economy, with the share of 99% including micro enterprises and entrepreneurs, similarly to the OECD overall [14]. This category gave the similar contribution to the Serbian economy, as in OECD countries, employing around 65% of the workforce in 2021, with the share of 59% in the total gross value added and 37.4% in total exports value (Figure 5) [20].

Within the CEFTA 2006 region, SMEs contribution to employment and export performance varied significantly across signatories. For instance, SMEs in Bosnia and Herzegovina contributed the least to overall employment (around 63%), whereas SMEs in Albania accounted for 82% of total employment. Concerning export performance, the share of SMEs in Bosnia and Herzegovina was approximately 50% of total export value, in Albania around 64% and in North Macedonia above 20% in 2020 [16].

The analysis of the connection of SMEs with TF process in CEFTA 2006 region, especially those included in foreign trade business, was initiated by OECD research pointing out that SMEs benefited more from the implementation of TF measures than larger trade companies [15]. It is particularly important, since the majority of enterprises engaged in the foreign trade operations realization belong to this category of enterprises. Numerous barriers enterprises face with, particularly administrative non-tariff barriers, are analyzed from the perspective of all sizes of enterprises, including SMEs. This issue had been broadly discussed even before the WTO TFA was adopted in 2013, as the legal basis for the decrease of these barriers in international trade. Hence, there is the need for special monitoring of the role and the impact of TF process on further normal functioning and survival of SMEs all around the world. Many TF measures implementation can directly help SMEs better participating the foreign trade, by increasing trade volume and decreasing trade costs. The TF measures have stronger impact on the fixed costs which make larger pressure on SMEs activities, compared to variable costs [7]. That points out the specificity of TF measures effects on trade costs for SMEs, compared to larger enterprises. Among these measures, streamlining of procedures, automation of the border process, simplification of fees, or consultations with traders, appear to have the largest differentiated impacts on SMEs relative to larger firms [7].

Some of these TF measures with special focus on SMEs are encompassed by UN Survey on TF and Paperless Trade as quite new and modern approach. In that survey SMEs are seen as one of the three sub-groups for measuring the level of the achieved sustainable trade facilitation, along with the issues of Women in TF and Agriculture TF. They are used for evaluation of TF implementation success concerning SMEs in the signatories of CEFTA 2006. The analysis is motivated by the fact that Serbian SMEs, as members of trade network are faced with many

at-the-border barriers, which should be at least decreased, if not completely eliminated, especially at borders of their CEFTA 2006 trading partners.

Trade facilitation progress of SMEs in Serbia and CEFTA 2006

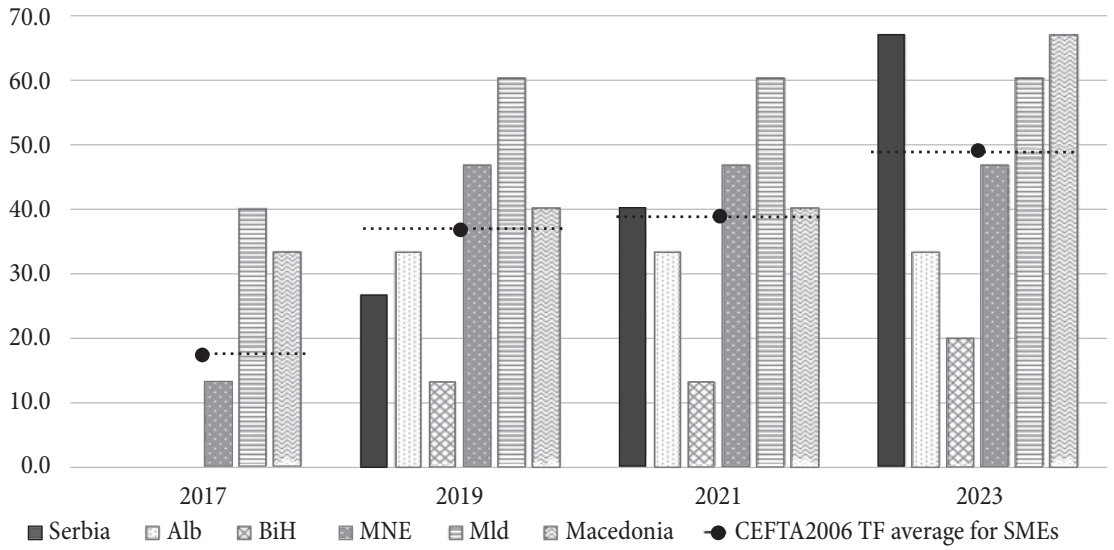
Sustainable TF goals are connected with the trade agenda which recognized the importance of SMEs facilitation as the contribution to the inclusive trade. Starting from 2017, the UN Global Survey monitors progress in the implementation of TF measures for SMEs in numerous countries of the world. Measures which would enable trade facilitation of SMEs as the sub-group of the Sustainable TF, generally are implemented at the very low level compared to other TF sub-groups. Trade facilitation measures for SMEs have also been monitored for CEFTA 2006 region by UN Global Survey on Digital and Sustainable Trade Facilitation starting from 2017. Based on this data source, the average TF scores for SMEs are calculated using only economies where information on TF measure implementation is available, that is where the answers in the survey are: not implemented, planning stage, partially implemented, or fully implemented.

The greatest progress in the implementation of TF measures for SMEs has been registered in Serbia during the observed period with the increase from 27% in 2019 to 67% in 2023, thus, achieving the highest level of implementation along with North Macedonia compared to other CEFTA 2006 signatories. The level of implementation in 2023 in these two countries and Moldova as well, was above CEFTA 2006 average (Figure 6). However, these results are still far from full implementation level of TF measures for SMEs, which could imply that there is still a lack of policies and initiatives dealing with inclusive trade facilitation, not only in this region, but also around the world [25].

Five representative indicators for SMEs trade facilitation`s measurement in the UN Global Survey are: Trade-related information measures for SMEs, SMEs in Authorized Economic Operator (AEO) scheme, SMEs access Single Window, SMEs in National Trade Facilitation Committee and Other special measures for SMEs. As mentioned in the methodology section, each of these measures are marked as: Not implemented, to be in the Pilot stage of implementation, Partially implemented and Fully implemented. The implementation level significantly varies across these five TF categories for all observed countries (Figure 7).

Trade related information measures for SMEs are implemented in CEFTA 2006 with the highest level compared to all other individual indicators. The average implementation scores for this TF category in CEFTA 2006 were 2.17 in 2019 and 2.33 in 2023, being slightly under the

Figure 6: Progress in implementation of TF for SMEs by CEFTA 2006 signatories in 2017-2023, in percentages



Note: Data for Serbia, Albania and Bosnia and Herzegovina are not available in 2017.
Source: The UN Global Survey on Digital and Sustainable Trade Facilitation, https://www.untfsurvey.org/

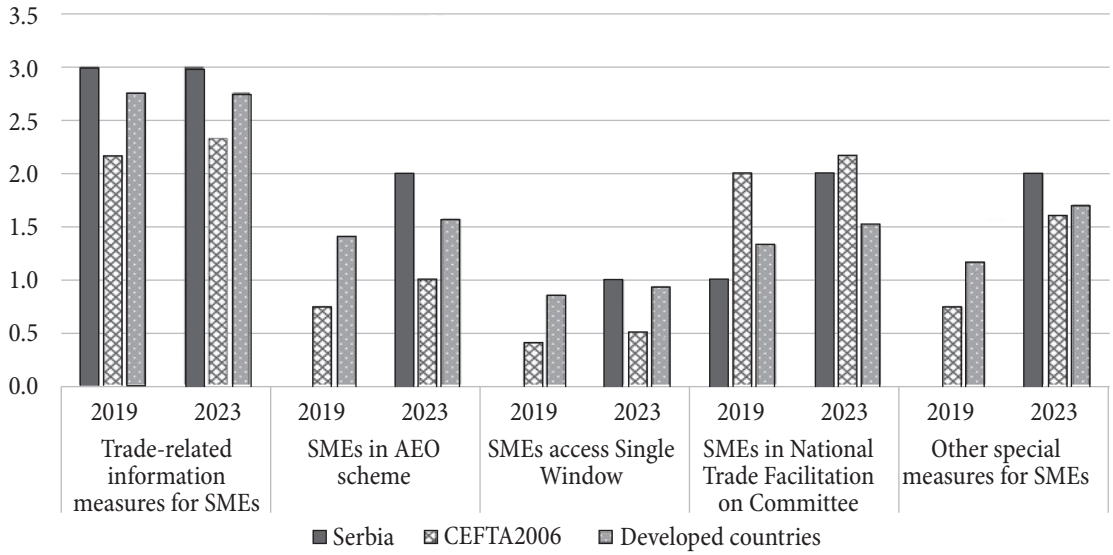
averages of developed countries (the average score 2.76 in both years). This measure is fully implemented in Serbia, Bosnia and Herzegovina and Moldova (Table 1). During the ten-year implementation of TF measures, it was logical to expect National Committees would be established very quickly, as the first step for implementation of the WTO TFA, that should bring each country closer to achieving the multilateral TFA goals. However, the number of countries in the world, including developed ones, with fully and partially implemented TF measure for *SMEs in National Trade Facilitation Committees*, represents a surprisingly modest share. Although the increasing implementation in this area was noticeable in observed period, the scores for Serbia, CEFTA 2006 and developed countries in 2023 were only 2, 2.2 and 1.5 respectively. This is the only TF measure for SMEs with score in Serbia lower than CEFTA 2006 average.

The degree of implementation of the rest three TF measures for SMEs, requiring a high level of ICT development, is even more modest (Figure 7). Among them, the *Other special measures for SMEs* have achieved a somewhat better level of implementation (scores for Serbia, CEFTA 2006 and developed countries are 2, 1.6 and 1.7, respectively). They are connected with many activities whose implementation would facilitate the participation of SMEs in trade. These other special measures, such as the creation of special action plans for the TF of small businesses or the postponement of customs duties payment, form a heterogeneous group of measures expected to facilitate further inclusion of SMEs in trade. Among all TF measures for SMEs, *SMEs access to Single Window* was at the lowest level in the majority of countries in the world. Even in developed countries, the score for that TF measure was under 1, whereas in CEFTA 2006 was 0.5 in 2023 (Figure 7). Possible reason for its low implementation could be the fact that it requires large amount of financial resources for the Single Window establishing. This instrument speeds up trading process, since it enables traders to enter data into the Single Window system only ones, and system further distributes them towards institutions involved in that process.

SMEs in Authorized Economic Operator Scheme (AEO), especially for CEFTA 2006 region, has also achieved very modest level of implementation, with full implementation only in Moldova, partially implementation in Serbia, planning stage in North Macedonia, while the other CEFTA 2006 have not implemented it yet (Figure 7 and Table 1).

The AEO scheme and SMEs are in deep connection because the issue of the AEO certificates recognition could become the entry barrier for SMEs. The increased

Figure 7: Progress in implementation of individual trade facilitation measures for SMEs - Serbia, CEFTA 2006 and developed countries



Note: Data for Serbia for three TF measures for SMEs are not available in 2019. Degree of implementation (from 0 = not implemented to 3 = fully implemented). Totally 28 economies have been selected by the UN Global Survey into the group of developed countries in 2019, whereas 33 economies in 2023.
Source: The UN Global Survey on Digital and Sustainable Trade Facilitation, https://www.untfsurvey.org.

Table 1: Implementation of trade facilitation measures for SMEs in 2023, CEFTA 2006 signatories

Measure	SRB	Change*	BIH	Change*	ALB
Trade-related information measures for SMEs*	Fully implemented		Fully implemented	↑	Partially implemented
SMEs in AEO scheme*	Partially implemented	↑	Not implemented		Not implemented
SMEs access Single Window*	Planning stage	↑	Not implemented		Not implemented
SMEs in National Trade Facilitation Committee*	Partially implemented	↑	Not implemented		Partially implemented
Other special measures for SMEs	Partially implemented	↑	Not implemented		Planning stage
Measure	**MNE**		**MKD**		**MDA**
Trade-related information measures for SMEs*	Partially implemented		Planning stage		Fully implemented
SMEs in AEO scheme*	Not implemented		Planning stage	↑	Fully implemented
SMEs access Single Window*	Not implemented		Partially implemented		Not implemented
SMEs in National Trade Facilitation Committee*	Fully implemented		Fully implemented		Fully implemented
Other special measures for SMEs	Partially implemented		Fully implemented	↑	Do not know

* Change in 2023 compared with 2019.
Source: https://www.untfsurvey.org/

number of the AEO Mutual Recognition Agreements was signed during very short period and introduced as one of the basic models for speeding up the TF process from the perspective of SMEs. However, it is important to note that this scheme was very recently established, and its full contribution should be expected in future. This status could be granted to an enterprise as a result of meeting the requirements and internationally recognized standards, and it has to be approved by customs. The enterprise with AEO certificate is considered as the secure partner in trade and gets many TF benefits concerning fewer customs checks, formalities and procedures, and rapid clearances. These TF benefits provoke the reduction of both fixed and variable trade costs [7]. In order to achieve facilitative character, it is very important to recognize and accept AEO status mutually, between the trading partner countries of origin.

Conclusion

The role of trade costs, as more intensive impediments to trade compared to tariffs, and their negative impact on trade volumes dynamics, has been the basis of many researches during last few decades. One of ways for trade costs decrease is seen through trade facilitation process under the auspices of the WTO, which contributes to the productivity and better competitiveness. It is expected that decrease of trade costs after the TF implementation, *inter alia*, would lead towards further trade volumes increase. Successful implementation of TF measures is especially important for SMEs, because trade costs, provoked by insufficient facilitated trade, have stronger pressure on SMEs compared to larger enterprises. Consequently, SMEs get more benefits after the implementation of TF measures. This point of view is important for research having in mind the fact that SMEs are the most numerous trading enterprises in the world, including CEFTA 2006 region and particularly Serbia.

Using UN indicators of the TF measures implementation, country performance on trade facilitation with a special focus on SMEs in CEFTA 2006 region is investigated. This helped us to highlight achieved progress during the first decade of the WTO TFA implementation, as well as remaining challenges, as the basis for further evaluation of the TF implementation. The analysis for CEFTA 2006 has shown that Serbia realized very dynamic progress in overall implementation TF level (General, Digital and Sustainable TF measures) compared to other signatories in relatively short period, achieving the level above the CEFTA 2006 average, with the highest TF implementation score in 2023 along with North Macedonia.

Concerning most of TF measures for SMEs within Sustainable TF group, Serbia and other signatories did not achieve full implementation. The result is similar for many countries including developed ones. One of the reasons for that result may be very short observed period after the introduction of these measures, whereas the other could be related to the lack of financial sources for their implementation and policies and initiatives dealing with inclusive trade facilitation, not only in this region, but also around the world. Namely, some challenges for all CEFTA 2006 signatories, provoked by high expenses

for the implementation of TF measures such as the Single Window are spotted. The introduction and use of ICT and the establishment of Single Window as a part of a soft infrastructural upgrade are challenging elements of TF, mostly from the financial aspect requiring advanced investments in ICT. Despite these facts, some progress in implementation of TF measures for SMEs in Serbia and other CEFTA 2006 signatories is evident in observed period. This is the only sub-group within Sustainable TF measures, where Serbia has achieved the increase from the implementation level bellow CEFTA 2006 average in 2019, to the best performing in 2023 along with North Macedonia. This progress in TF implementation was more dynamic not only comparing to CEFTA 2006 average, but comparing to developed countries, as well. The research also implies improvement in implementation of Digital TF (Paperless trade and Cross-border paperless trade) as the response to numerous challenges of SMEs during the Covid-19 pandemic years. This is precondition for improvement of TF for SMEs, as was indicated by analysis in case of Serbia and CEFTA 2006.

Within the sub-group of TF for SMEs, Serbia was the only CEFTA 2006 signatory which has made the implementation progress in all measures, except for Trade related information measures, where full implementation has already been achieved in 2019. This conclusion is very important considering the fact that SMEs are dominant in the structure of enterprises as the main stakeholders in international trade, both in Serbia and other signatories, as well as the fact that these enterprises are the key for sustainable and inclusive growth.

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BANK PROFITABILITY BEFORE AND DURING THE COVID-19 CRISIS: THE ROLE OF INTELLECTUAL CAPITAL

Profitabilnost banaka pre i tokom COVID-19 krize – uloga intelektualnog kapitala

Abstract

The banking sector, recognized as a knowledge-intensive sector, largely relies on the use of intellectual capital as a key factor for sustainable and profitable growth. The aim of the paper is to determine the contribution of intellectual capital and its components to the profitability of banks in stable and crisis situations, influenced by the COVID-19 pandemic crisis. The sample includes 21 banks that operated in Serbia in the period before the pandemic crisis (2017-2019) and during the crisis (2020-2022). The MVAIC method was applied in the paper to measure the value of intellectual capital and its components. The results of the regression analysis indicate that intellectual capital contributes to profitability both in the period before the crisis and in the period of the crisis. Structural capital had a dominant influence on profitability before the pandemic crisis, while during the crisis period, capital employed efficiency had a decisive influence.

Keywords: *intellectual capital, bank profitability, COVID-19 crisis*

Sažetak

Bankarski sektor, prepoznat kao sektor zasnovan na znanju, dobrim delom se oslanja na upotrebu intelektualnog kapitala kao ključnog faktora održivog i profitabilnog rasta. Cilj rada jeste da utvrdi koliki je doprinos intelektualnog kapitala i njegovih komponenti profitabilnosti banaka u stabilnim i kriznim situacijama, uslovljenih pandemijskom krizom COVID-19. Uzorak obuhvata 21 banku koje su poslovale u Srbiji u periodu pre pandemijske krize (2017-2019) i periodu tokom krize (2020-2022). U radu je primenjen MVAIC metod za merenje vrednosti intelektualnog kapitala i njegovih komponenti. Rezultati regresione analize ukazuju da intelektualni kapital doprinosi profitabilnosti u periodu pre krize, kao i u periodu krize. Dominantan uticaj na profitabilnost pre pandemijske krize ima strukturni kapital, dok u periodu krize efikasnost angažovanog kapitala ima presudan uticaj.

Ključne reči: *intelektualni kapital, profitabilnost banke, COVID-19 kriza*

Introduction

With rapid technological change and the continued growth of digital transformation initiatives around the world, the banking industry has become more exposed to change than ever before [1]. For emerging countries, the banking sector is particularly important for the smooth functioning of the economy, since it plays a key role in providing finance, ensuring the safety of savings, and stimulating the economy [11]. Such is the situation in Serbia, where the financial market is primarily bank-centric [16], [19]. With the debt moratorium and the redirection of consumer needs towards the purchase of basic products during the COVID-19 pandemic, there was a significant drop in the turnover and total income of the banks, which required the restructuring of the banks to cope with the financial consequences of the crisis [16]. According to data from the National Bank of Serbia, 21 banks were operating in 2022, while 26 banks were operating in 2019, the year before the outbreak of the crisis [14]. In percentage term, the number of banks decreased by 23% in this period. The decrease in the number of banks occurred as a result of reduced demand for banking products, which resulted in mergers and acquisitions of banks.

Intellectual capital (IC) is part of the intangible assets of banks, which plays a key role in business crisis situations. The literature confirms the contribution of IC to the growth of profitability and its positive impact on the growth and sustainability of banks [15]. Weqar et al. [27] consider that analyzing and monitoring the effectiveness of IC use by different types of banks is an essential area of research as academics, policymakers, and researchers wish to investigate the importance of IC in improving the efficiency of the banking sector [27]. El-Bannany [5] agrees with this, stating that the banking sector is an ideal area for IC research since the business nature of the banking sector is intellectually intensive [5]. Banks' focus on IC will increase their ability to innovate and learn through the transformation of knowledge and ideas into new products and services that will improve the banks' business performance and create satisfied stakeholders [1].

Several research gaps have been observed in the literature. The pandemic crisis left a negative impact on the banking sector of Serbia, which indicates the need to analyze the profitability of this sector and the contribution of material and intellectual resources to this result. Previous studies have analyzed the impact of IC on bank profitability before and during the COVID-19 crisis [6], but the focus of their research was a narrower time period (2019 and 2020). The study seeks to overcome this gap by including a wider time period in the analysis (2017-2022). Second, most research on IC uses the VAIC model [4] which is based on the analysis of the efficiency of the use of two components of IC (human and structural capital). As the VAIC model has been criticized for missing the value of relational capital [26], [21], the study seeks to overcome this shortcoming by analyzing the IC of banks by applying the MVAIC method and observing IC through the components – human, structural, and relational capital. Thirdly, the literature points out that there is a positive relationship between the better performance of the banking sector and the economic development of the country [10], so it is necessary to investigate the results of bank operations in emerging countries. Majumder et al. [11] also believe that it is necessary to analyze the banking sector of emerging economies since research related to international industry and bank performance is scarce. Also, different banking practices in different countries lead to different research findings due to economic, political, and national cultural differences [11]. Therefore, consideration of the importance and role of IC in the banking sector implies consideration of the wider context of the environment in which business is carried out.

The study aims to answer the following research questions:

- Does IC affect the profitability of the Serbian banking sector before the pandemic crisis of COVID-19?
- Does IC affect the profitability of the Serbian banking sector during the COVID-19 pandemic crisis?
- What is the contribution of IC components to banks' profitability before and during the crisis?

The contribution of the study is reflected in determining the importance and role of IC profitability in the banking sector in an emerging country such as Serbia. Secondly, the paper investigates whether IC will be a key factor of sustainability and profitability in stable business conditions

as well as in crisis conditions. Third, in the paper, IC is observed in a more comprehensive way, compared to previous studies, because the analysis includes, in addition to human and structural capital, the value of relational capital.

Literature review

Intellectual capital in the banking sector

Banks are the lifeblood of an economy [27] that provide financial services to stimulate economic growth [13]. Majumder et al. [11] state that banks dominate financial markets and are considered the nerve of the financial system, especially in emerging countries [11]. Financial institutions, especially those in the banking industry, have experienced a dynamic and competitive environment [13] which has forced banks to adjust their competitive position by achieving sustainable financial performance [13]. The pandemic has led to increased business uncertainty and numerous pressures, as a result of which crisis management has been introduced in most organizations [7]. It is assumed that the key resources for the survival of companies in crisis conditions will be IC, which leads to the need to analyze the contribution of IC to banks' operations before and during the crisis.

In industries such as banking, IC is much more important than physical capital in the wealth creation process [5] since banking is recognized as a knowledge-intensive sector [13]. As the economic growth of a country is affected by the performance of banks and the business results of other organizations of the economy dependent on the services provided by the banking sector, it is important to examine the extent to which banks are able to use intellectual property [13]. IC enhances and maintains rare and imitative comparative advantages of banks, builds organizational competencies, and encourages the creation of added value [15] thus contributing to strengthening its competitive position [12].

IC is a part of intangible assets that includes knowledge and experience that skilled personnel use to gain a competitive advantage by applying some creative strategies [5]. IC constitutes all factors of production that are invisible in the traditional balance sheet, but decisive for the long-term profitability of banks [13]. According to the resource-based view, firm performance is driven by unique resources such as IC [22]. Consequently, IC becomes a key resource that contributes to banks' sustainable competitive advantage.

IC includes human capital, structural capital, and relational capital. Human capital includes the knowledge, skills, experience, and abilities of employees [8], [9]. It has a key role in reducing the bank's costs and differentiating banking products, which should attract more customers and ensure greater market share [5]. Structural capital includes non-physical assets created by employees and owned by the bank. It represents the organizational infrastructure necessary for the smooth functioning of human capital, such as processes, databases, and organizational culture [27]. Relational capital represents knowledge or value created in interaction with external parties of the company [22] such as suppliers, customers, creditors, trade associations and government bodies [21].

Profitability of the banking sector

Profitability is the most commonly used measure of financial performance [22]. It shows the value of the profit that the bank makes in performing its activities, describing the degree to which the bank can manage its operations [22]. The two most common measures of bank profitability are Return on asset (ROA) and Return on equity (ROE) [27]. ROA measures the company's ability to gain profit on assets over a certain period while ROE represents a return to a common shareholder [22, p.1089]. ROA is the ratio of net income divided by total assets [27]. ROE is the ratio of net income divided by stockholder's equity [28].

The literature recognizes IC as a key capital that drives bank performance [4]. Duho [4] views IC as a strategic tool for bank management with the potential to increase shareholder value and even boost banks' competitive advantage. The ability of bank managers to understand the impact of IC performance on business results is useful in making strategic decisions aimed at improving performance [4]. Therefore, with greater investment of banks in IC components, profitability

increases, and such banks have better financial performance [13].

Regarding the empirical results of the impact of IC and its components on bank performance, a mostly positive relationship is established, but the results differ depending on the context, the data set used, or the component of IC considered [4]. Previous studies confirm the impact of IC on bank profitability before the pandemic crisis [11], [13]. The influence of IC on the profitability of banks in emerging countries was also confirmed [22], [27]. Considering that the literature confirms that the efficient use of IC can improve the performance of banks [17] and considering that the banking structure of Serbia was significantly changed during the pandemic crisis, it is necessary to investigate the impact of this capital on the profitability of banks before the pandemic crisis. Accordingly, the following hypothesis is defined:

H_1: IC contributes to the profitability of banks before the pandemic crisis

As IC constitutes a significant part of the value of the total assets of banks, it is necessary to examine what contribution to the profitability of the IC component was made before the pandemic crisis. The value of human, structural, and relational capital will be monitored through the efficiency coefficient of their use: human capital efficiency (HCE), structural capital efficiency (SCE), relation capital efficiency (RCE), and capital employed efficiency (CEE). Accordingly, the following research hypotheses are defined:

H_{1a}: HCE contributes to the profitability of banks before the pandemic crisis

H_{1b}: SCE contributes to the profitability of banks before the pandemic crisis

H_{1c}: RCE contributes to the profitability of banks before the pandemic crisis

H_{1d}: CEE contributes to the profitability of banks before the pandemic crisis

Previous studies show that IC contributes positively to bank performance even during the pandemic crisis [1], [7]. Banna & Alam (2021) conclude that the acceleration of digital financing in ASEAN countries is a key factor in maintaining the stability of the banking system leading to economic and financial resilience in crisis situations [2]. The results of the study by Ilić & Lepojević showed that the relationship between bank performance and the compensation of top managers (base salary, bonus, and total compensation) was positive even during the COVID-19 pandemic [7]. Crisis situations, such as the COVID-19 pandemic, require appropriate strategies that will ensure the viability of banks. It is also necessary to determine which business resource becomes crucial in crisis situations and how much it contributes to the sustainability and stability of banks' operations. Accordingly, the following research hypothesis is defined:

H_2: IC contributes positively to the profitability of banks during the pandemic crisis

According to the position of IC in the structure of banks' balance sheets, it is necessary to investigate how each of the components of IC contributes to the banks' profitability during the pandemic crisis. Accordingly, the following hypotheses are defined:

H_{2a}: HCE contributes to the profitability of banks during the pandemic crisis

H_{2b}: SCE contributes to the profitability of banks during the pandemic crisis

H_{2c}: RCE contributes to the profitability of banks during the pandemic crisis

H_{2d}: CEE contributes to the profitability of banks during the pandemic crisis

Methodology and measurement

Data collection and sample characteristics

The research in the paper was conducted on a sample of 21 banks that operated at the end of 2022 in the Republic of Serbia, and their operations in the period from 2017 to 2022 were covered. According to data from the National Bank of Serbia, at the end of 2022 there were 17 banks majority owned by foreign shareholders, 2 banks with majority private domestic capital, and 2 banks majority owned by the Republic of Serbia. At the end of 2022, the balance sheet of the banking sector increased by 407.5 billion dinars compared to 2021, while the balance sheet capital increased by 0.5 billion dinars [14, p. 43]. Bank operations in the period from 2017 to 2019 are considered

in the paper as operations before the onset of the COVID-19 pandemic. Business in the period from 2020 to 2022 is viewed as business during the COVID-19 pandemic. Individual financial reports of banks, which are publicly available at the Serbian Business Registers Agency, were used as a data source for research purposes.

Methodology

VAIC is one of the most commonly used quantitative models for measuring the effectiveness of IC use [4] which is based on value-added, as the most appropriate measure of business success [18]. VAIC measures the value creation efficiency from both intangible and tangible assets of the firms [18], [21]. In order to eliminate the shortcomings of the VAIC model, researchers use MVAIC as a model that includes relational capital and to measure value-added efficiency in a more comprehensive way [21]. Thus, VAIC is an aggregation of human capital, structural capital, and capital employed, while MVAIC is an aggregation of human capital, structural capital, relational capital, and capital employed [23].

In order to calculate MAVIC, it is necessary to first calculate value added (VA) [18]:

$$VA = OP + EC + D + A$$

OP – operating; EC – Employee costs; D – Depreciation; A – Amortization.

Then it is necessary to calculate the efficiency of use of all IC components. Human capital efficiency (HCE) is calculated as follows [18]:

$$HCE = VA/HC$$

HC (Human capital) – total salaries and wages for the company.

The second component of IC, structural capital (SC) is calculated as the difference between value-added and the value of human capital [18]:

$$SC = VA - HC$$

Structural capital efficiency (SCE) is calculated as the ratio of the value of structural capital (SC) and value-added (VA) [18]:

$$SCE = SC/VA$$

Relational capital is important for creating and maintaining relationships with external parties. The costs of maintaining such a relationship include the costs of marketing, sales and advertising, which represent the proxy of relationship capital (RC) [21]. Relation capital efficiency (RCE) is calculated as [21]:

$$RCE = RC/VA$$

RC - marketing, selling, and advertising costs.

Based on the above, intellectual capital efficiency (ICE) is calculated as the sum of indicators of the efficiency of the use of three IC components [21], [23]:

$$ICE = HCE + SCE + RCE$$

Efficiency of value-creating resources also requires the calculation of the efficiency of the use of physical and financial capital, since IC cannot independently create value. it is necessary to determine capital employed efficiency (CEE) as the ratio of value-added (VA) and book value of the net assets of the bank (CE) [18]:

$$CEE = VA/CE$$

Accordingly, MVAIC represents the sum of all the coefficients of resource use efficiency calculated above [21], [23]:

$$MVAIC = HCE + SCE + RCE + CEE$$

For the purposes of statistical data processing, the statistical package for social sciences IBM SPSS Statistics, version 23, and EViews, version 12 were used. Descriptive statistics, correlation analyses and multiple regression panel analysis were used for data analysis. Accordingly, general regression panel models were formed:

$$\text{Model 1: } PROF_{it} = \beta_0 + \beta_1 HCE_{it} + \beta_2 SCE_{it} + \beta_3 RCE_{it} + \beta_4 CEE_{it}$$

$$\text{Model 2: } PROF_{it} = \beta_0 + \beta_1 MVAIC_{it}$$

where PROF represents ROA and ROE.

Results

The results of the descriptive analysis, before and during the COVID-19 pandemic, are shown in Table 1. Based on the results, it can be concluded that the dominant role in the IC structure is human capital. There was a drop in the mean of all IC components during the crisis compared to the period before the crisis. Just as there was a decrease in the average value of individual MVAIC components during the pandemic, there was also a decrease in the average value of MVAIC during the observed period. It is interesting that the mean ROE increased during the crisis period.

Table 1: Descriptive statistics

	Mean	Std. Deviation	Minimum	Maximum
Before COVID-19 crisis				
HCE	4.7974	2.0816	1.9698	15.5499
SCE	0.7624	0.0828	0.4923	0.9357
RCE	0.0166	0.0226	0.0008	0.1552
CEE	0.4064	0.2148	0.1434	1.0625
MVAIC	5.9827	2.1228	2.7591	16.8151
ROA	0.0081	0.0283	-0.0806	0.1205
ROE	0.0425	0.1453	-0.6363	0.4766
During COVID-19 crisis				
HCE	4.6032	1.7008	1.9424	12.0785
SCE	0.7546	0.0895	0.4852	0.9172
RCE	0.0082	0.0061	0.0002	0.0249
CEE	0.4048	0.1843	0.1643	0.9560
MVAIC	5.7771	1.7387	2.7061	13.3051
ROA	0.0071	0.0151	-0.0345	0.0634
ROE	0.0538	0.0840	-0.1412	0.3382

Source: Authors

The direction and strength of the relationship between the observed variables will be examined using correlation analysis. Before the onset of the COVID-19 pandemic, it was identified the existence of a strong, positive, and statistically significant correlation between the components of HCE and SCE and indicators of bank profitability, while RCE achieves a strong and statistically significant but negative correlation with these indicators. In the same period, no statistically significant correlation was identified between CEE and both indicators of bank profitability, as well as between CEE and components of intellectual capital. In the period during the COVID-19 pandemic, HCE and SCE have a strong, positive, and statistically significant correlation with bank profitability indicators, while RCE and CEE have no significant correlation with these indicators.

Before and during the COVID-19 pandemic, MVAIC achieves a strong, positive and statistically significant correlation with the coefficients of HCE and SCE. RCE and CEE coefficients do not have a statistically significant correlation with MVAIC, neither before nor during the pandemic.

As can be seen from Table 2, the Random Effect model is more suitable compared to the Fixed Effect model when examining the impact of IC on bank profitability before the COVID-19 pandemic. On the other hand, the Fixed Effect model is more suitable compared to the Random Effect model when examining the impact of IC components on bank profitability before the COVID-19 pandemic.

During the COVID-19 pandemic, the Random Effect model is more suitable compared to the Fixed Effect model when investigating the influence of IC on bank profitability, as well as when examining the impact of MVAIC components on bank profitability measured by ROE (Table 3). The Fixed Effect model is more suitable compared to the Random Effect model when examining the impact of IC components on bank profitability measured by ROA.

The Augmented Dickey-Fuller (ADF) test determined that all variables the period before and during the COVID-19 crisis are stationary.

Table 2: Hausman test results the period before the COVID-19 crisis

	Model 1 (ROA)	Model 2 (ROA)	Model 1 (ROE)	Model 2 (ROE)
Chi-sq. statistic	2.198	14.867	0.906	14.475
Chi-sq. d.f.	1	4	1	4
p-value	0.138	0.005	0.341	0.006
Effect	Random	Fixed	Random	Fixed

Source: Authors

Table 3: Hausman test results for the period during the COVID-19 crisis

	Model 1 (ROA)	Model 2 (ROA)	Model 1 (ROE)	Model 2 (ROE)
Chi-sq. statistic	2.560	9.622	0.073	7.577
Chi-sq. d.f.	1	4	1	4
p-value	0.11	0.047	0.785	0.108
Effect	Random	Fixed	Random	Random

Source: Authors

Based on the results shown in Table 4 for the period before the pandemic crisis, it can be concluded that MVAIC has a statistically significant effect on both indicators of profitability, and hypothesis H_1 *is accepted*. In the same period, only SCE has a positive influence on the value of both bank profitability indicators, so hypothesis H_{1b} *is accepted*. HCE does not significantly contribute to bank profitability indicators, so hypothesis H_{1a} *is rejected*. RCE had a negative impact on ROE value before the pandemic while CEE had a positive impact only on ROA value. Thus, the hypotheses H_{1c} *and* H_{1d} *are partially accepted.*

The results of the research for the period during the pandemic crisis are shown in Table 5. The impact of MVAIC on the profitability of Serbian banks was also proven during the pandemic period, thus hypothesis H_2 *is accepted*. The impact of the HCE, RCE, and CEE components on the banks' ROE was realized, while the impact of these components on the ROE was rejected. Thus, hypotheses H_{2a}, H_{2c}, H_{2d} *are partially accepted*. SCE has a positive impact on the value of ROA during the pandemic, so hypothesis H_{2b} *is partially accepted*. The influence of the other three components of MVAIC on the value of the ROA indicator is not statistically significant.

Discussion

The research results provided answers to the research questions. Since the hypotheses H1 and H_2 are accepted, it can be concluded that IC becomes a key factor in the sustainable and profitable operation of banks in both stable and crisis conditions. The same results were obtained by the authors Weqar et al. [27].

Before the COVID-19 pandemic. The results show that human capital does not contribute enough to the profitability of banks, which the authors Tran & Vo also noted in their study [24]. Such results are worrying since banking is recognized as a knowledge-intensive activity [13], where human capital should be the key driver of profitability and competitiveness. The absence of an impact of HCE on the profitability of banks can be explained by the "delayed effect" of human capital investment on the profitability of banks because research shows that investment in human capital in the present brings future benefits [24]. Soewarno & Tjahjadi explain these results by the fact that shareholders do not have enough guarantees from the human capital that they will receive an appropriate return on their investments [22]. The results of this study show that SCE affects the profitability of banks, which has been proven in studies [22], [27]. As an important

Table 4: Regression analysis results for the period before the COVID-19 crisis

Variables	Model 1 ROA	Model 2 ROA	Model 1 ROE	Model 2 ROE
C	-0.053 (-5.594)***	-0.219 (-4.810)***	-0.202 (-3.677)***	-0.979 (-3.627)***
MVAIC	0.010 (7.168)***		0.041 (4.950)***	
HCE		0.004 (1.683)		0.016 (1.236)
SCE		0.257 (3.769)***		1.265 (3.129)***
RCE		-0.154 (-1.676)		-1.307 (-2.396)**
CEE		0.038 (2.697)***		-0.002 (-0.001)
Adj. R^2	0.443	0.862	0.275	0.814
F-Value	(50.385)***	(17.103)***	(24.544)***	(12.343)***

****-shows significance at 1% level*
***-shows significance at 5% level*
**-shows significance at 10% level*
Source: Authors

Table 5: Results of the regression analysis for the period during the COVID-19 crisis

Variables	Model 1 ROA	Model 2 ROA	Model 1 ROE	Model 2 ROE
C	-0.022 (-4.022)***	-0.044 (-1.197)*	-0.100 (-3.141)***	-0.194 (-1.835)*
MVAIC	0.005 (5.549)***		0.027 (5.043)***	
HCE		-0.004 (-1.092)		0.023 (2.211)**
SCE		0.097 (1.521)*		0.157 (0.805)
RCE		-0.723 (-1.231)		-2.905 (-2.072)**
CEE		0.006 (0.272)		0.117 (2.410)**
Adj. R^2	0.329	0.343	0.286	0.354
F-Value	(31.462)***	(2.350)***	(25.825)***	(9.507)***

****-shows significance at 1% level*
***-shows significance at 5% level*
**-shows significance at 10% level*
Source: Authors

infrastructural asset that enables employees to work [27], the development of structural capital supports employees to improve productivity and profitability [3], [22]. The results also indicate that RCE contributes negatively to ROE, both before and during the COVID crisis. Previous studies [25] also prove the influence of RCE on ROE, but in a positive direction, explaining this relationship by the fact that the growth of bank profitability requires building a good relationship with external stakeholders. The obtained results actually indicate that with higher investment growth in RC, the profitability of banks decreases. The study partially proves the impact of CEE on the profitability of Serbian banks. The impact of CEE on ROA is also proven by [22] stating that such results are due to good capital management. Better use of capital employed creates higher profits, which is in accordance with financial theory [22].

During the COVID-19 pandemic. The results show that HCE, RCE and CEE contribute statistically significantly to ROE, while the impact of these components on ROA was absent. This result is a consequence of the increase in the value of ROE during the pandemic period, while the value of ROA decreased in the same period. The impact of HCE on the ROE of banks was also proven in the study of Mondal & Ghosh [13]. The absence of HCE's impact on ROA can be justified by the fact that in the previous period the merger and takeover of banks was carried out, on the basis of which the costs of employees increased due to the payment of severance pay and other benefits [24]. If banks plan to maintain or increase their profitability in crisis periods, more attention should be paid to human capital [25]. During the crisis period, the influence of SCE on the profitability of banks was partially proven. This may be the result of reduced investment in organizational infrastructure during periods of crisis. As the COVID-19 crisis caused certain changes in the banking sector, primarily the orientation towards electronic banking and business without branches [20], effective the use of structural assets will be the main priority of banking operations in the future. The results indicate that CEE contributes positively to banks' ROE in crisis periods, and according to the value of the β coefficient, this IC component contributes the most to profitability compared to others. Uslu [25] came to similar results, stating that if banks want to increase profitability, they must concentrate on the growth of CEE rather than HCE and SCE [25].

Practical implications

The research results show that structural capital plays a dominant role in stable business conditions. However, in crisis conditions, the impact of this IC component has only been partially proven. On the other hand, in times of crisis, CEE and HCE have a dominant influence on bank profitability. This means that bank management can insist on the development of structural and relational capital in stable business conditions in order to increase profitability. In crisis periods, banks can only rely on the knowledge, experience, and competence of their employees, who will ensure the sustainable operation of banks with appropriate strategies, plans and actions. Stocks of physical and financial capital appear as support for the operation of human capital, the rational and efficient use of which can ensure the implementation of the stability strategy. The recommendation to bank managers is to improve the synergistic effects between IC components since MVAIC has been found to have a positive effect on bank profitability.

Limitations and future research directions

First, the financial reports of the banks did not show the costs of research and development, so it was not possible to examine the impact of innovation capital on the profitability of the banks. Therefore, the influence of this component of IC should be considered in future research. Second, historical data on bank profitability indicators were used for research purposes. Therefore, the results of the banks' operations in the previous period, were used. That is why, in the next research studies, the influence of IC components on current business indicators, such as net present value, economic value added, cash flow return on investment, should be considered.

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APPLICATION OF ARTIFICIAL INTELLIGENCE IN LOGISTICS 4.0: DHL CASE STUDY ANALYSIS

Primena veštačke inteligencije u Logistici 4.0 – analiza studije slučaja DHL

Abstract

This paper analyzes the transformational role of AI in logistics within the context of Logistics 4.0. Spectrum of artificial intelligence technologies reinforces both operational efficiencies and reduces overall cost. The integration of technologies such as machine learning, predictive analytics, and robotics brings a new revolution to the logistics process. Also, case studies will be elaborated on in order to explain how a leading logistics company, as DHL, applies new technologies, such as artificial intelligence, to optimize delivery routes, real-time tracking, and inventory management while bringing great improvement in customer interaction. It further discusses a number of challenges and opportunities linked to the integration of AI, thus trying to present a wide overview of its influence on modern logistics and future trends. Special attention is paid to how these technologies can revolutionize supply chain management. Artificial intelligence is driving innovation and setting new standards for efficiency and effectiveness in logistics operations. This paper provides further analysis highlighting the ways in which artificial intelligence can make practices more sustainable and international supply chains more resilient to external shocks, and therefore be a cornerstone of any future logistics strategy. The paper ends by underlining the strategic importance of adopting these technologies in preserving competitiveness on the market.

Keywords: *Artificial intelligence (AI), Logistics 4.0, DHL, route optimization, predictive analytics, supply chain management*

Sažetak

Ovaj rad analizira transformacionu ulogu veštačke inteligencije u logistici u kontekstu Logistike 4.0. Spektar tehnologija veštačke inteligencije jača i operativnu efikasnost i smanjuje ukupne troškove. Integracija tehnologija kao što su mašinsko učenje, prediktivna analitika i robotika donosi novu revoluciju u logistički proces. Takođe, biće razrađene studije slučaja kako bi se objasnilo kako vodeća logistička kompanija, kao što je DHL, primenjuje nove tehnologije, kao što je veštačka inteligencija, da optimizuje rute isporuke, praćenje u realnom vremenu i upravljanje zalihama, istovremeno donoseći veliko poboljšanje u interakciji sa klijentima. Dalje, raspravlja se o brojnim izazovima i mogućnostima vezanim za integraciju AI, predstavljajući tako pregled njenog uticaja na modernu logistiku i buduće trendove. Posebna pažnja posvećena je tome kako ove tehnologije mogu revolucionirati upravljanje lancem snabdevanja. Veštačka inteligencija pokreće inovacije i postavlja nove standarde za efikasnost i efektivnost u logističkim operacijama. Ovaj rad pruža dalju analizu naglašavajući načine na koje veštačka inteligencija može učiniti prakse održivijima, a međunarodne lance snabdevanja otpornijim na eksterne šokove, te stoga biti kamen temeljac svake buduće logističke strategije. Rad završava isticanjem strateškog značaja usvajanja ovih tehnologija u očuvanju konkurentnosti na tržištu.

Ključne reči: *veštačka inteligencija (VI), Logistika 4.0, DHL, optimizacija ruta, prediktivna analitika, upravljanje lancima snabdevanja*

Introduction

While the development of artificial intelligence took place, it revolutionized many industries, among which is logistics. Generally speaking, in today's business environment logistics means not only transportation and storage of goods but also a wide range of actions and procedures which need to be made by immediate decisions and problem-solving in real time. AI can predict the outcome and optimize processes to become an incredibly powerful tool in transforming complex processes and their standardization. The models of AI, which learn from data, are much easier to adapt to the specific business needs of a company.

The industry is under increasing pressure in terms of speed, cost efficiency, and precision in managing the whole supply chain, drawing much attention to AI in logistics. The desire for speed by consumers in delivery and the efficiency of the operations of supply chains, having digitalized the purchasing process, propel companies forward. Machine learning technologies such as machine learning, predictive analytics, and robotics can effectively solve these problems by enabling intelligent logistics solutions that improve inventory forecasting accuracy, delivery route optimization, and product packaging process efficiency. Various studies show significant improvements in operational efficiency with the help of the application of various forms of artificial intelligence in logistics processes.

Artificial intelligence has emerged as one of the innovative forces driving national economies [9] and also the transformation of modern logistics. As discussed in the paper [26], AI has a key role in revolutionizing logistics practices. Several key advantages of the integration of artificial intelligence into the information system of companies are listed, such as the enrichment of data flows, easier monitoring and definition of sales prices in real time. Furthermore, AI-driven systems can streamline the process of contracting with clients. The ultimate effects of applying AI in logistics are huge and impactful. From procurement to customer relationship management (CRM), AI-driven solutions are reshaping traditional practices, optimizing operations and driving efficiencies across the supply chain.

In today's dynamic business environment, the application of AI within logistics operations is set as a strategic imperative. The disruptive potential of this technology goes beyond traditional supply chain management. The dynamic nature of artificial intelligence enables agility and adaptation to various operational and strategic issues such as demand volatility and unpredictability, supply chain disruptions and changing consumer preferences.

Theoretical background

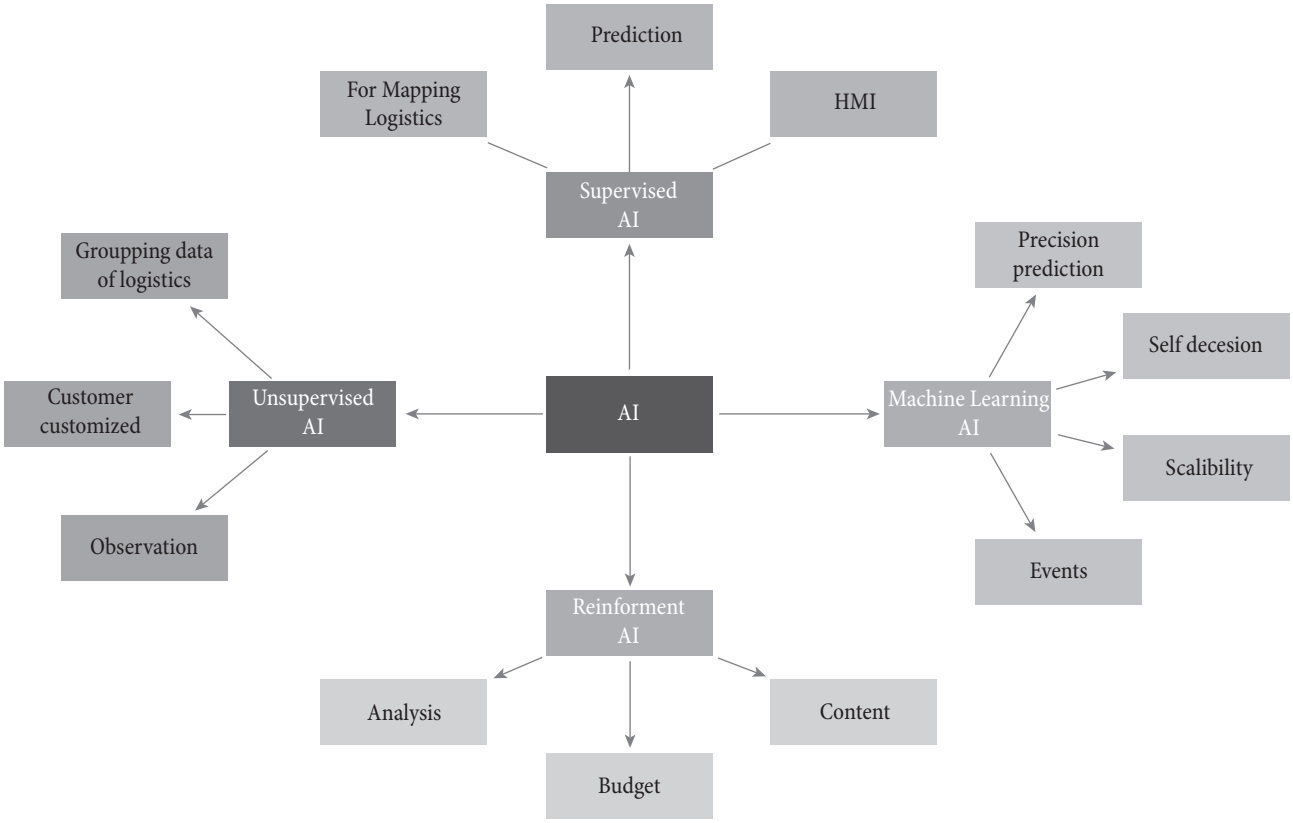
Artificial intelligence has become the reason for the revolution of many industries; among them, the leading position belongs to logistics. Logistics, in the modern business world, doesn't mean just the transportation of goods and their storage but also includes many activities and processes requiring urgent decisions and solving various problems right on the spot. AI can predict outcomes and then optimize the processes. This potentially very powerful tool might be in the position to transform complex processes and standardize them. AI models can actually learn from data, and hence adapting it to specific business needs becomes far easier for a company.

AI systems are divided into four groups [37]: supervised AI, unsupervised AI, Machine Learning AI and reinforcement AI. Supervised AI focuses on forecasting and mapping logistics, helping to optimize routes and demand forecasting needs. Unsupervised AI handles logistics data clustering, customer customization and pattern observation without predefined labels, facilitating personalized solutions and improving operational efficiency. Reinforcement AI emphasizes continuous improvement through analysis and budgeting, using feedback to improve decision-making and strategic planning. Together with Machine Learning, these AI methodologies enable a more efficient, responsive and adaptive logistics network, driving the evolution of modern supply chains. A detailed breakdown can be seen in Figure 1 [37].

Machine learning in Logistics 4.0

Machine learning, one of the core technologies of artificial intelligence, has naturally assumed a key role in improving the logistics processes. AI and Machine Learning enable

Figure 1: Use of the AI system in different parts of logistics



Source: Ramirez-Asis et al., 2022 [37]

improved data analytics by providing actionable insights from complex data sets [43]. By processing historical data, machine learning algorithms significantly improve route planning and cargo management. Machine learning is a powerful tool, as it has the ability to analyze and process large amounts of traffic, weather, and delivery information to define the most efficient routes and schedules. In this way, operating costs and delivery delays are reduced. The benefits of using this technology extend beyond finding optimal routes. Various major companies use machine learning algorithms to adjust inventory levels based on current and anticipated consumer demand. In addition, it is possible to predict the movement of the level of demand for different products and services, taking into account seasonal and other types of variations that influence consumer decisions [31].

The symbiosis of machine learning and data analysis is revolutionizing all logistics operations. The big advantage of this approach is that machine learning algorithms improve themselves when they have access to huge data sets. With the help of precise analysis of historical records, determination of existing delivery and traffic patterns, route optimization and cargo management are possible. Machine learning algorithms improve operational efficiency. By training models on historical data, these models evolve and adapt better to the demands of a dynamic market. With the application of non-relational databases, these algorithms can help companies make decisions based on real-time messages. In this way, space is opened for further innovation and efficiency improvement.

Predictive analytics in Logistics 4.0

Predictive analytics predicts future outcomes based on historical data, which with the help of machine learning enables companies to become proactive in solving operational problems. The ability to predict future outcomes is an invaluable resource that allows maintaining and improving the efficiency of the supply chain, preventing and mitigating the effects of potential disruptions [43]. By taking a proactive approach, companies can adjust strategic decisions, thereby influencing the long-term economic condition of the company. Predictive analytics anticipates spikes in demand, which can be critical when planning inventory within warehouses. Artificial

Intelligence and Machine Learning can lead to efficient allocation of resources [43].

Furthermore, predictive analytics combined with machine learning opens up space for companies to direct their resources towards customers and strategic development. By analyzing historical data and determining patterns of consumer behavior, it is possible to respond to all market changes in a timely manner. In addition, a proactive approach enables the prediction of equipment failures and the planning of regular maintenance activities in order to find the optimal process downtime that will minimally affect the functionality of the entire system [48]. The integration of predictive analytics provides companies with increased agility and resilience to unforeseen events, which can lead to a significant improvement in market position.

Robotics in Logistics 4.0

Another transformative force in logistics is robotics. Automated robots, with the help of the Internet of Things, surpass the human ability to solve a large number of tasks, especially in warehouse environments [36]. Robotized warehouses reduce the possibility of errors and unplanned operating costs, from picking and packing products, to overall inventory management. In modern warehouses, robots move around spacious halls to guide the process of storing and transporting goods, which significantly simplifies the process of managing large warehouses. The integration of robotics can significantly reduce costs and thus provide additional funds for further strategic development of the company [50], [51].

Except for predictive analytics and machine learning, robotics actually forms the base for most innovations in logistics. Adoption of robotics in logistics operations simplifies and quickens business processes that result in increasing overall productivity. Workers get more space to work on higher-value activities, such as service delivery or making strategic decisions, by automating repetitive processes. This also leads to maximum use of the warehouse space due to the utilization of robots. This, in turn, reduces the cost of storing goods and supports convenient inventory management. Many machine learning and predictive analytics algorithms can be run on data collected from robotic systems to find a pattern. In this way, it is possible to optimize and adapt the system to new market and operational challenges. This iterative process ensures adaptability of logistics operations and enables timely response to dynamic market development [44], [45].

The integration of robotics and artificial intelligence represents a complete paradigm shift in the field of logistics. By harnessing the power of AI-driven automation, companies can simplify and streamline processes, reduce costs, and improve overall efficiency across the entire supply chain. As technological progress accelerates, the role of robotics is expanding significantly, fueling innovation and shaping the future of entire industries [49], [52].

Applications and impact of AI in Logistics 4.0

AI integrated into logistics could maintain a wide range of applications that contribute to the improvement of operation efficiency and enhancement of service quality. Latest research results indicated that AI could be used in various aspects of the logistics industry, hence proving its potential to revolutionize it. Figure 2 illustrates the primary use of AI in logistics, shipping and transportation, supplier selection, inventory management, and other critical functions.

According to the survey results shown in Figure 2, AI is primarily used in logistics, delivery and transportation (34%), supplier selection and due diligence (33%), inventory management (27%), and consumer behavior monitoring (24%) [47]. These results range from several applications in AI, at different parts of logistics, and hence prove the transformative potential. Companies like DHL lead in the implementation of artificial intelligence to optimize routes, automate warehousing tasks, and improve customer interaction, hence creating new standards of operational excellence in service delivery.

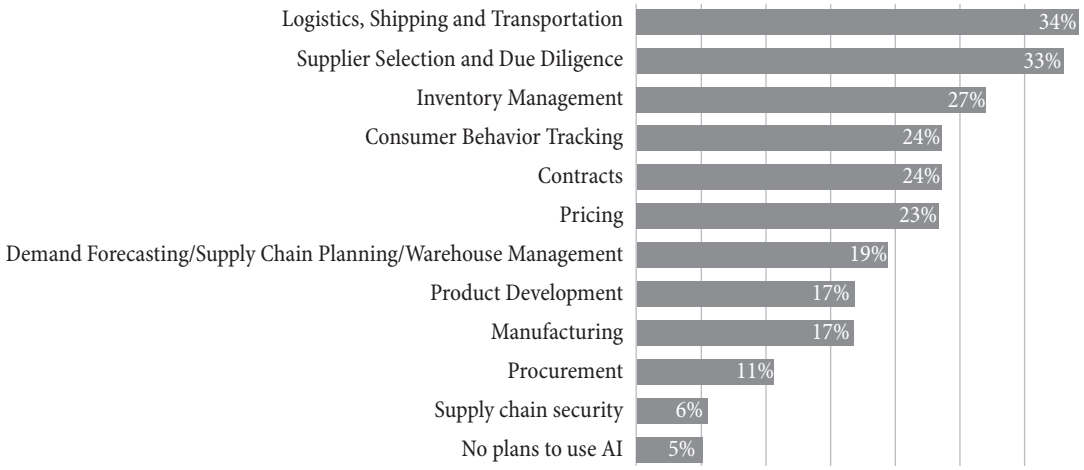
AI is also extremely helpful for demand prediction, where it analyzes historical data and market trends for more accurate forecasting of future demands. This helps a logistics company, in this regard, to manage its stock much more effectively without overstocking or facing a shortage of any item. Another critical application of the AI-driven predictive maintenance in which AI systems continuously monitor equipment health and predict failures much in

advance so that necessary steps could be undertaken to minimize downtime and reduce the cost of maintenance. AI will, with the enhancement of these core logistics functions, improve not only operational workflows but also agilities and resilience in supply chains, enabling a coping mechanism to be more effective in dealing with market fluctuations and customers' needs [22], [24].

GenAI, or generative artificial intelligence, is a subset of artificial intelligence that focuses on creating new data, ideas or solutions based on existing data. These models learn patterns and structures from input data and then produce new, similar outputs. In logistics, GenAI can significantly contribute through optimizing operations, forecasting demand and reducing costs [35]. Figure 3 shows a GenAI implementation value curve that explains the timeline and implementation phases of this technology [47].

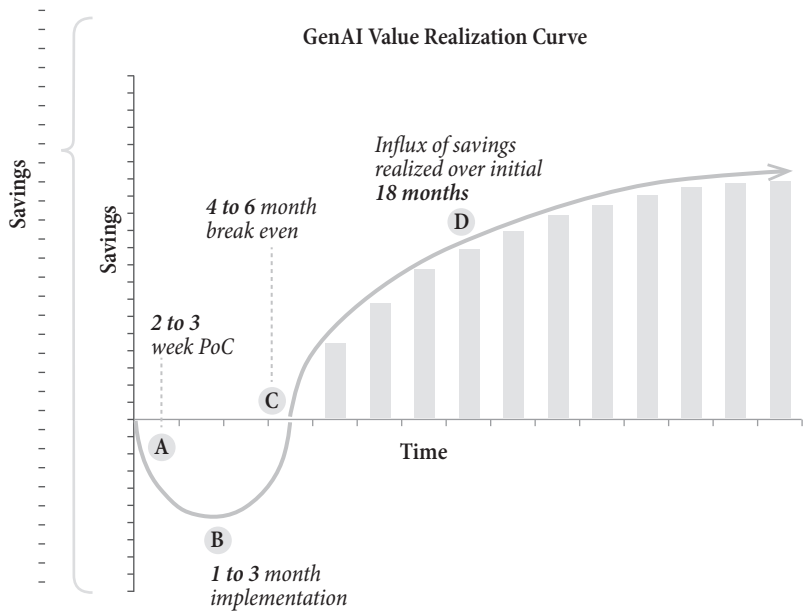
The GenAI Realization Value Curve illustrates how GenAI can quickly bring value to organizations, with significant savings realized within the first year and a half of implementation. In the first phase (A), initial implementation takes 1 to 3 months, followed by a 2-to-3-week payback period (B). The equalization period lasts 4 to 6 months (C), while the final inflow of savings is realized during the first 18 months (D). These graphs and data highlight the importance and effectiveness of applying

Figure 2: Different usage of artificial intelligence in logistics and supply chain management



Source: The 2024 MHI Annual Industry Report [47]

Figure 3: GenAI value realization curve in logistics



Source: The 2024 MHI Annual Industry Report [47]

AI technologies in logistics, demonstrating the concrete benefits that organizations can expect from investing in these advanced systems. GenAI is crucial for logistics. It enables faster analysis and adaptation of operational processes, reducing costs and increasing efficiency with more accurate predictions and optimization of resources [19].

Challenges and opportunities of applying AI in Logistics 4.0

Artificial intelligence in logistics promises massive leaps and a new frontier of efficiency; however, it also brings forth some massive challenges that are necessary to consider and work out. One major issue that arises is the possible lay-off of workers [33]. Automation can result in workforce restructuring challenges and the dramatic alteration of specific job positions, even though it simplifies most procedures, decreases operating costs, and lessens the possibility of human error [40]. To lessen the impact of artificial intelligence on the need for jobs, businesses must fund retraining and upskilling programs to assist their staff as they adjust to the new and dynamic logistical structure [41], [42].

But another point of concern on the AI-driven decision-making process in logistics is algorithmic bias. Algorithmic bias is such a tendency of AI systems to produce results disproportionately biased toward certain groups or features. This may lead to a set of unjust or discriminatory outcomes [7]. For example, an AI system trained on inadequate data may develop biased preferences toward specific routes, suppliers, or methods of delivery. Such decisions based on criteria that reflect logistical needs or constraints relatively poorly will be considered to be unfair or discriminatory decisions [15], [16], [17].

Issues of privacy and security of data arise when artificial intelligence technologies are used in logistics. The incidence of data breach and other cyber risks becomes much more probable due to integrated AI-driven systems that gather huge amounts of private data. The protection of data for consumers, another critical factor that has markedly gained importance, needs the proper implementation of cybersecurity practices combined with adherence to data protection laws such as General Data Protection Regulation GDPR [46].

Serious ethical issues of AI utilization in logistics are still a concern for business decision-makers. Transparency of the decision-making process is becoming increasingly important as artificial intelligence systems are becoming more complex and autonomous [39]. Data privacy, algorithmic bias, and moral consequences of AI-driven decision-making are issues that have to be taken into proper consideration to make sure that AI technologies are used responsibly and ethically. Therefore, on this matter, very clear ethical standards and regulatory frameworks should be integrated, which could effectively prevent the misuse of artificial intelligence in logistics for reasons pertaining to justice, accountability, and transparency [12].

The benefits of artificial intelligence in logistics are clear, even in the face of several obstacles [33]. Businesses can improve customer service standards, boost forecasting accuracy and efficiency, and optimize supply chain operations with the help of AI technologies [20], [32], [34]. With machine learning and predictive analytics on insights from Big Data sets, logistics companies can make informed decisions and have effective, timely reactions with respect to market dynamics. Due to continuous progress in the AI ecosystem, innovation opportunities within the space of logistic operations are endless, considering that AI-driven solutions hold much promise for the total reinvention of every component of supply chains [25], [27], [28].

The future of artificial intelligence in logistics is huge. With further advancement and integration, AI in logistics will surely continue bringing productivity gains, cost savings, and competitiveness to businesses. Yet, for the full realization of benefits from AI in logistics, collaboration among industry participants, policymakers, and academics in addressing opportunities and issues that AI-driven automation has brought are needed. AI in logistics, for the benefit of business and larger society, can be developed only by collaboration on ethical guidelines, regulatory frameworks, and skills development programs. This would again open a new frontier toward more intelligent and efficient logistics operations [11].

The future of AI in logistics, indeed, looks bright. With further development and full integration into logistics, the business world should continue to benefit from the increase in efficiency, cost savings, and competitiveness

[4]. However, embracing AI in logistics actively requires that the industry players, the decision-makers, and the academics collaborate with one another in an effort to find solutions to the opportunities and problems brought about by AI-driven automation [28], [29], [54]. The pace at which we start building a shared vision of ethical principles, legal frameworks, and programs for workforce development that may enable AI in logistics to serve the interests of business is also serving the interests of society-opening up an entirely new frontier of smarter, more efficient logistics operations.

AI integration in Logistics 4.0: DHL case study

Application of different AI technologies in logistics stands for more than just technological advancement; it is actually a conceptual shift in the supply chain management processes. Whether it be efficiency, accuracy, or agility, whatever the aim of the companies is, AI can act as an innovative solution to such problems. The potential for AI is huge and further growing, and so is the number of organizations recognizing the transforming power of AI interventions in their logistics frameworks. Starting with predictive analytics and going up to robotic automation, AI technologies offer an unparalleled opportunity for process optimization, disruption prediction, and better decision-making at each touchpoint of the supply chain. Moreover, since AI keeps getting better and more mature, its application has been extended from conventional logistics functions to customer relationship management and strategic planning. The tremendous spread of AI in the principles of technology reflects the fundamental alteration in the mode of thinking and usage of technology by companies: not only as a tool for efficiency gains but also as a strategic imperative in gaining an enhanced market position. With Industry 4.0 continuing to evolve, together with continuous improvements in AI capabilities, this means companies are better positioned for this transformative technology in driving innovation, efficiency, and growth within the logistics sectors and beyond.

In order to make more concrete the influence of AI on logistics, one needs to focus on some specific financial and operational indicators. DHL is one of the leaders in global logistics who has been making huge investments in AI and ecologically clean transport technologies. Key financial and operational data are summarized in the Table 1, for 2022-2023, in order to provide a better picture of how such investments influenced results:

Table 1: Key financial and operational metrics for DHL (2022-2023)

Category	2022	2023	% Change
Total Capex Investment (€m)	7,862	6,709	-14.70%
Free Cash Flow (€m)	3,067	2,942	-4.10%
CO2 Emissions (million tons)	33.27	34.9	4.90%
Lost time injury frequency rate (LTIFR)	3.1	3.3	6.50%
Total Assets (€m)	68,476	66,814	-2.40%
Net Debt (€m)	15,856	17,739	11.90%

Source: DHL Annual Report 2023 [10]

Table 1 offers an overview of the financial and operational impact of AI and related technologies in DHL's logistics operations, showing that overall capital expenditure is somewhat reduced while investments into key areas remain consistent. It also points out that CO2 emissions and the rate of injuries at work have increased, suggesting two areas where further improvements could be made. The basis for the selection of these metrics was largely informed by providing a comprehensive perspective on how investments in artificial intelligence and technology are shaping the logistics landscape at DHL. This data, as represented by Table 1, together with other key metrics, complements the analysis of the impact of AI on logistic requirements and provides the right platform for deeper debate on specific technologies and innovations that have been introduced by DHL. The selected indicators are total capital expenditure, CO2 emissions, and workplace injury frequency-basic pointers to some positive results and other challenges that DHL faces regarding its AI-driven transformation. They provide a way to assess the effectiveness of AI investments in operational efficiency improvement, sustainability, and safety. Apart from this, it provides the following critical financial health indicators: free cash flow, total assets, and net debt. It concretely gives the basis necessary to evaluate how AI is driving operational efficiency, cost reduction, and business growth.

DHL's AI-powered route optimization

DHL, the world's leading provider of logistics services, has been leading the transition in its delivery operations

through the deployment of AI-powered route optimization technologies. The technology developed by DHL works on constantly refining enormous amounts of data regarding traffic patterns, weather, and tracking information in real time through highly elaborate machine learning algorithms. Such elaborate analytics automatically perform the repositioning of equipment to change the delivery path, if need be, to ensure delays are at their bare minimum.

The major ideas of the DHL AI route optimization system make it possible to reduce delivery time by optimizing routes with the highest fuel efficiency, hence reducing operational costs to a minimum and increasing the quality of the services.

This artificial intelligence technology can predict traffic congestion and thus offer alternative routes the driver should take to avoid delays. By analyzing historic delivery data, the system finds patterns that optimize future delivery schedules. It allows for routing on the road in real time to avoid updates regarding live traffic and road closures in richly variable urban traffic conditions. This capability ensures timely deliveries even in unforeseen disruptions, while this capability will further improve customer satisfaction with more accurate delivery times that also contribute to sustainability by reducing fuel consumption and, subsequently, emissions. DHL uses advanced software powered by Wise Systems, which optimizes last-mile delivery routing by applying AI. It can also allow for personalization in delivery-for instance, urgent medical deliveries or deliveries at a certain time of the day or night. By offering real-time delivery updates to customers through the feature Track My Package, customer experience at DHL improves and gets closer to estimating exact delivery times [3]. Because this AI system changes the routes on the go, DHL can quickly respond to traffic changes or any unplanned accidents that may occur and thus maintain efficient operations at high service levels [5], [6].

DHL's AI raises the level of customer satisfaction by considering improved delivery times and on-time delivery in the face of potential disruption. For instance, chatbots have turned into tools for companies to relate to their customers. In 2020, the rate of start-to-finish completion of chats was 68.9% - up from 2017 by 260%. The technologies are increasing areas within which customers can get immediate and satisfactory responses to queries. That way, they get better service. DHL's AI-powered route optimization system is built to effectively integrate into other management tools used in logistics. Thus, it lays the base for a very efficient operational framework that ensures better coordination between different segments of the supply chain right from warehousing to last-mile delivery. Hence, a strong and agile logistics network is achieved which is able to meet the modern-day demands related to e-commerce and global trade.

Historically and in real time, the machine learning algorithms used by the DHL system learn from the data to continuously improve the route planning accuracy and efficiency. Besides lowering operating costs-with the system's calculated routes optimized to reduce fuel consumption-it is also reducing the environmental impact of its delivery operations and therefore aligns with wider goals on sustainability. Logistics represents one of the most important areas of application of artificial intelligence. Hence, the adoption rate of artificial intelligence in industry is expected to reach 42.9% Compound Annual Growth Rate and attain a value of 6.5 billion USD by 2023 [20]. The adoption of interactive AI technology helps the logistics industry to effectively address the operational challenges arising out of growing B2B and B2C demand for instant delivery of goods [8].

Continuous development and implementation of the top in AI-based logistics ensure even more efficiency and perspectives. It is due to advancing algorithms in machine learning that other opportunities arise for further optimization of delivery routes and supply chain operations, setting DHL at the very edge of innovation in Logistics 4.0. DHL's AI Route Optimization system marks one huge leap forward in logistics technologies, with its real-time dynamic routing for efficiency, cost reduction, and customer satisfaction. The system is continuously learning and integrates well with other logistics tools, hence assurance of the future in smart and sustainable logistics management.

DHL AI-driven robotics in warehousing

DHL made great enhancements to the warehouse operations by adding AI-driven robotics to automate the core processes

of packing, sorting, and picking. These include advanced machine vision systems featuring algorithms that improve operational accuracy and efficiency while contributing to business success.

Perhaps most prominent among these is the deployment of LocusBots at DHL's warehouse in Beringe, Netherlands. Autonomous robots travel along the floor of the warehouse, picking items and bringing them to humans to pack. Productivity with the Locus robots can be tripled by reducing the time employees waste walking around a facility in search of items. Instead, the robots bring items directly to them [14]. Currently, DHL operates more than ten locations in North America with more than 2,000 LocusBots that have cumulatively picked over 100 million units [14].

DHL also deploys collaborative robots that work alongside the employees to handle repetitive tasks, thereby leaving the human workers free to deal with more complex activities [14]. This collaborative approach not only increases productivity but also enhances job satisfaction due to reduced physical effort by employees. The impact of this AI-driven robotics on the operations of DHL is profound. The LocusBots increased the efficiency in collections by 50% during introduction, thus enabling DHL to handle larger volumes of orders without increasing its workforce [13]. Further, the accuracy of the robots reduced picking errors by 25% [13], thereby greatly increasing the accuracy of the orders and improving customer satisfaction. The financial flow of the automation of repetitive tasks had an implication of a 20 percent reduction in labor costs [13], a great contribution to general cost savings by the firm. Further, the academic research into the use of the LOCUS 2.0 technologies pursues further advances in robotic agility and efficiency. It shows that the use of LOCUS 2.0 plays an important role in real-time 3D mapping within complex environments, therefore enhancing the navigational and operational capabilities of a robotic system under severe computational and memory constraints [38]. This is another indication of DHL's commitment to leveraging the newest technologies to stay on top in logistics innovation, a must for efficiency, reliability, and competitiveness on world marketplace.

This radical change brought in by these technologies is further retracted in a research paper published in Systems Research and Behavioral Science [23], where the integration of artificial intelligence with the IoT in logistics operations was marked as a disruptive force. Two-dimensional code technology, sensor technology, intelligent control technology, artificial intelligence, and wireless communication, so this study says, are the main technologies for the development of intelligent logistics robots. These technologies further facilitate operational efficiency by perfecting human-computer interaction, exactly evading security obstacles, and effectively detecting the position. DHL's proactive adoption of such innovative technologies improves not just operational capabilities but also ensures that at the same time, it remains ahead of the competition in this fast-evolving field of logistics-firmly positioning the company for leadership in logistics innovation.

Besides robotics, DHL has embraced the vision of picking technology to take its operations a notch higher. This includes smart glasses that enable workers to scan a bar code and receive picking instructions in their field of vision without handheld scanners. The hands-free approach speeds up the picking process, cuts down on errors, and generally enhances efficiency. Workers using such glasses are able to locate their items more quickly and identify them much faster, raising their productivity since it lowers time consumption for a particular task. Order fulfillment accuracy will also be improved with the introduction of the vision picking technology. Smart glasses offer immediate feedback and guidance as to whether an employee is picking an item correctly and in the right quantities. This minimizes the chances of errors, hence improving customer satisfaction since the order filling is both accurate and timely. Besides that, the use of this vision dialing technology reflects DHL's bigger strategy in using high-end digital tools to optimize its logistics operations and keep its leading position in the industry.

In the study [18], one may clearly observe that with vision picking technology, improvements in the accuracy and time of picking processes will be huge. The research concludes that smart glasses provide real-time feedback and guidance during picking to ensure employees pick the right items and quantities. This reduces the chances of errors and improves customer satisfaction by filling orders correctly and swiftly. In addition to this, the use of the

Vision Selection technology is part of the larger strategy of DHL to deploy high level advanced digital tools in the pursuit of efficiency in the logistics operations and at the same time staying ahead of the competition.

DHL's AI-driven innovations in customer interaction and support

The main use of AI-driven chat-bots and virtual assistants in DHL is to automate customer engagement by responding to customer inquiries immediately, comprehensively, and precisely. Applying machine learning concepts to previous interactions continuously improves the performance of these AI bots. Such facilities are immensely useful in executing some pretty complicated urgent tasks, like customs clearance of international shipments. In this regard, by automating such processes at DHL, it ensures that all incoming inquiries by customers are dealt with and responded to in a timely and expeditious manner. This accelerates response times and heightens customer satisfaction.

This is not all since AI at DHL can do much more for customer support. The chat-bots in DHL are also used to track shipments to get real-time updates and to resolve issues automatically without any human intervention. It therefore improves efficiency in the running of the customer service and also releases human agents to attend to complex issues that may require personal touch. As this is enhanced by DHL to the capabilities of the virtual assistants, it enables them to facilitate a more seamless and better experience for the customers; information will be given out right on due time as the customers interact with it.

Logistics companies definitely need customer service departments. These are the first touches when some problems appear. Chat-bots can help logistics companies handle small and mid-volume call center inquiries such as requests of deliveries, editing orders, tracking shipments, and answering FAQs. The chat-bots can also present meaningful data that enable a company to better understand the needs of customers and improve the customer experience. As such, chat-bots are, at the moment, the fastest-growing brand communication channel, having a 90% customer response rate for the best chat-bots. Also, the estimated increase in sales is 67% after implementing a chat-bot, and 57% of businesses report that chat-bots drive huge ROI with minimal investment [21].

Automation of customer service through interactive AI goes further in processing customer input on other common communication channels through the use of instant email responses, automated phone services, and integration into the most used text messaging platforms. This expands the scope under which customers can expect rapid and satisfactory responses to questions. Artificial intelligence also powers Load Building Optimization - an extremely important area within logistics that encompasses the organization of shipments by weight, size, and destination. It allows a vehicle to be completely full, reducing trips, hence operation costs. DHL reduces costs by minimizing the number of journeys. This saves on fuel and labor while at the same time providing a leaner operation. It is sustainable because fewer trips reduce carbon emissions, minimizing impacts on the environment while truly allowing cost-effective logistics operations.

More importantly, optimization of load construction using AI helps in better planning and scheduling of routes with the aim of ensuring that deliveries are made in the most efficient manner. Through an analysis of traffic patterns, delivery times, and vehicle availability, amongst other factors, AI will chart out optimum routes that will save time and resources. This kind of precision in logistics planning raised the bars for higher reliability, adding to the efficiency in the supply chain that benefited not only the company but also the customers.

Conclusion

Artificial intelligence has brought a new era of efficiency, effectiveness, and speed towards this sector. Nowadays, logistics consists of many activities that require fast decisions and solve problems in real time. Artificial intelligence has standardized these complex operations into more efficient ones by predicting the outcome and optimizing each process.

Growing demands for speed, cost efficiency, and precision underline the increasing role of AI in logistics management. For instance, some technologies such as machine learning, predictive analytics, and robotics have met these demands in areas like the accuracy of inventory forecasts, route optimization, and efficiently packed

products. Several studies prove the application of AI in logistics to result in huge improvements in operational efficiencies.

Artificial intelligence embeds new meanings into logistics, saturated with enriched data flows, easier tracking, and real-time price adjustments. AI-powered systems further simplify the management of contracts and improve CRM. The impact of AI in logistics thus translates into optimized operations, better decision-making, and efficiency up the value chain.

In the dynamics of the business environment, AI is indeed emerging as a strategic imperative in logistics operations. While demands for volatility and disruptions continue to increase in supply chains, AI has emerged as an effective tool that works in tandem with modern logistics. Further evolution and integration of AI technologies foretell continued improvements in logistics, increasing their applicability from traditional functions to more forward-thinking areas like strategic planning and customer relationship management.

The future potential of AI in logistics is huge. As AI technologies mature and integrate, companies will continue to reap efficiency benefits and cost savings, resulting in higher competitiveness. Realization of this full artificial intelligence potential in logistics needs a concerted effort by stakeholders in the industry, policy makers, and researchers regarding the following opportunities and challenges. Ethics in regard to taking responsibility in the development of AI in logistics, therefore, work towards the implementation of regulatory frameworks and workforce development initiatives which might benefit business and society through developing new eras of smarter and more efficient operations.

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BLOCKCHAIN INTEGRATION IN PUBLIC SECTOR: A COMPREHENSIVE REVIEW OF ECONOMIC AND LEGAL CHALLENGES

Integracija blokčejna u javnom sektoru – sveobuhvatan pregled ekonomskih i pravnih izazova

Abstract

This paper presents a comprehensive analysis of the benefits, obstacles, and ramifications of integrating blockchain technology into public sector functions, specifically focusing on economic and legal aspects. The discussion commences with an examination of the societal relevance of blockchain technology, as it is poised to dramatically enhance procedural efficiency within public sector organizations. Subsequently, the paper delineates the primary research objectives, which encompass identifying the multitude of benefits of blockchain technology for the public sector, investigating its legal and economic consequences, and scrutinizing the challenges that public sector organizations might face during implementation. Research methodologies employed to attain these objectives consist of an extensive literature review and qualitative primary data acquisition from field experts. Findings reveal that blockchain technology holds the potential to augment the swiftness and dependability of administrative procedures while bolstering data security within public sector organizations, albeit some legal and economic apprehensions persist. Regardless of these challenges, the authors maintain that the public sector is poised to reap significant rewards from blockchain technology deployment due to its capacity to modernize and streamline operations, as well as its capabilities for precise and verifiable data storage. Research limitations include a scarcity of available primary data and reliance on a singular data collection method. Suggestions for future research involve conducting additional studies addressing the questions raised in this research and supplementing the findings with user perspectives.

Keywords: *blockchain, public sector integration, legal challenges, economic ramifications, big data*

Sažetak

Ovaj rad predstavlja sveobuhvatnu analizu prednosti, prepreka i posledica integracije blokčejn tehnologije u funkcije javnog sektora, sa posebnim fokusom na ekonomske i pravne aspekte. Diskusija započinje ispitivanjem društvenog značaja blokčejn tehnologije, koja ima potencijal da dramatično poboljša proceduralnu efikasnost unutar organizacija javnog sektora. Zatim, rad definiše osnovne istraživačke ciljeve, koji obuhvataju identifikaciju mnogih prednosti blokčejn tehnologije za javni sektor, istraživanje njenih pravnih i ekonomskih posledica i proučavanje izazova s kojima se organizacije javnog sektora mogu susresti tokom implementacije. Istraživačke metodologije koje su korišćene za postizanje ovih ciljeva su opsežni pregled literature i kvalitativno prikupljanje primarnih podataka od stručnjaka iz polja. Rezultati otkrivaju da blokčejn tehnologija ima potencijal da poboljša brzinu i pouzdanost administrativnih procedura dok jača sigurnost podataka unutar organizacija javnog sektora, iako neke pravne i ekonomske bojazni i dalje postoje. Bez obzira na ove izazove, autori smatraju da javni sektor ima potencijal da ostvari značajne koristi od primene blokčejn tehnologije zbog njenog potencijala da modernizuje i pojednostavi operacije, kao i zbog njenih sposobnosti za precizno i proverljivo skladištenje podataka. Ograničenje ovog istraživanja je oskudnost dostupnih primarnih podataka. Predlozi za buduća istraživanja su sprovođenje dodatnih studija koje bi se bavile pitanjima postavljenim u ovom istraživanju i dopunjavanje nalaza sa perspektivama korisnika.

Ključne reči: *blokčejn, integracija u javni sektor, pravni izazovi, ekonomske posledice, veliki podaci*

Introduction

Blockchain technology, as described by Laroiya et al. [61], refers to an advanced digital ledger system enabling secure and immutable recording of transactions across a distributed network of computers. This decentralized characteristic ensures unchangeable transactions, protection against unauthorized access, and exceptional resistance to fraudulent activities or tampering [46], [42]. As a result, this technological innovation has led to a paradigm shift in data storage, sharing, and protection within the digital domain [20].

In the field of public administration, blockchain technology offers significant potential for improving government services and operations [83]. Key areas such as tax collection, land registry, identity verification, and asset registry can greatly benefit from its implementation [26]. By introducing innovative methods for managing, monitoring, and validating data, blockchain technology can enhance operational efficiency, strengthen security measures, and foster increased trust and integrity within the public sector [12].

As a distributed ledger technology, blockchain provides a wide range of potential applications within the public sector, encompassing government recordkeeping, financial services, digital identity, and public sector operations [23]. This technology's greatest strengths derive from its decentralized and distributed nature. Unlike traditional linear databases stored on central servers that are prone to data loss and vulnerable to cyberattacks, blockchain's infrastructure ensures robust security measures and resilience against data breaches, establishing a secure and efficient system for managing public data and information [31].

Many countries' public sectors face common issues such as bureaucratic inefficiency, corruption, and lack of accountability [58]. In this regard, blockchain technology offers a promising solution by providing a secure and transparent method of recording transactions and data. This technology has been employed due to its potential to streamline processes, reduce costs, and increase accountability in the public sector. This innovative approach could yield significant improvements in the quality of life by reducing corruption and protecting projects from information manipulation. As literature explains, blockchain serves as a digital ledger that continuously updates economic transactions among numerous users, rendering it virtually immune to corruption. This continuous record of blocks guarantees the integrity and reliability of the data; consequently, blockchain's key features, such as immutability and decentralization, make it an effective tool for promoting transparency and combating corrupt practices [53].

Specifically, blockchain technology has been identified as a potential solution to various positive economic outcomes [38], endorsing this technology as a potential game changer for the public sector with high promises of improving efficiency in administrative processes, reducing bureaucracy, and cutting costs. Numerous sources (see [17], [84], [59], [33], [29], [54], [100], [44], [40]) have reported that different countries, aiming to leverage the advantages and minimize the risks associated with this technology, are already witnessing the development of various blockchain solutions within public sectors and public administrations.

However, despite blockchain's immense potential in the public sector, its effective deployment necessitates careful reasoning and planning [92]. Implementing blockchain technology in public sector systems is often not a straightforward task due to significant challenges accompanying its implementation in real environments [66]. Although there are numerous advantages, such as security, transparency, and immutability, the public sector must be aware of the drawbacks of blockchain technology, including scalability and interoperability [109]. Furthermore, the relatively immature and complex technology may limit the effectiveness of its implementation in certain contexts. Hence, the appropriate implementation of blockchain in public service depends on the public sector's ability to assess the risks and rewards of the technology and ensure its effective and secure deployment [19]. Generally, the current state of blockchain-driven innovation in the public sector primarily focuses on automating transaction enforcement [51], [52], with limited but promising digital transformation of public services. Besides understanding how blockchain technology can bring economic benefits, recent literature also concentrates on reflecting on the

main issues and potential failures within the public sector that could result in economic challenges and costs [8].

In addition, without proper regulatory oversight and security measures, blockchain technology could pose a significant risk to the anticipated economic outcomes of its implementation, thereby maximizing positive effects of blockchain technology is inherently linked to the legal aspects of its implementation. Based on the primary insight into the literature, this study aims to provide answers related to the challenges and advantages of blockchain deployment in the public sector, specifically focusing on law and economy-related issues, thereby addressing the following questions:

RQ1: What has been the scientific production related to blockchain in the public sector from 2016 to 2022?

RQ2: What are the main topics examined by scientific inquiries related to the deployment of blockchain in the public sector?

RQ3: What are potential economy-related advantages, challenges, and risks related to the deployment of blockchain technology in the public sector?

RQ4: What legal implications, issues, and challenges exist when utilizing blockchain technology in the public sector?

Methodology

This study employs a systematic literature review methodology to trace and review the existing literature on the main topics related to blockchain technology in the public sector, analyzing the arguments presented by various manuscripts. To ensure the validity of the collected data, several factors were considered. First, the research included only peer-reviewed manuscripts from journals published between 2016 and 2022. Second, the search was conducted through a systematic approach, identifying reliable and valid information from key players in the field. Third, the inclusion criteria required the analyses to focus on the legal and economic aspects of blockchain in the public sector.

Regarding research design, this paper presents a systematic literature review methodology aimed at searching, selecting, reading, and evaluating existing peer-reviewed manuscripts to identify emerging trends and discussion topics. The research was conducted in several steps, beginning with searching for manuscripts in the following databases: Scopus, Web of Science, EBSCO, Emerald, ScienceDirect, and Google Scholar.

The search terms used were "blockchain, law, economy, public sector, and governance." Subsequently, the selected manuscripts were read thoroughly and synthesized. During this step, relevant information was extracted, categorized, and grouped into sections related to legal, economic, advantages, and disadvantages. The final step involved conducting a qualitative analysis of the literature. This analysis entailed comparing and contrasting the various arguments presented in the chosen manuscripts to identify the main themes and major findings.

The selected manuscripts were comprehensively analyzed, and different aspects were categorized into four primary sections. This process allowed for a comprehensive evaluation of the most critical findings, answering the major research questions.

Results and discussion

RQ1: What has been the scientific production related to blockchain in the public sector from 2016 to 2022?

Between 2016 and 2022, an impressive 228 scientific papers were published on the topic of blockchain deployment in the public sector. Among these papers, 44 were open access, 21 were 'Gold' open access, 8 were 'Hybrid Gold' open access, and 20 were 'Green' open access. The most popular year for publications was 2022, with the number of publications nearly doubling those of 2020 (59 vs. 30), as seen in Figure 1.

The most popular subject area was Computer Science (139), followed by Engineering (60), Social Sciences (44), and Business, Management and Accounting (42), as depicted in Figure 3. The most common document types for these papers were Conference Papers (72) and Articles (60), as illustrated in Figure 2. The majority of these papers were sourced from the 'ACM International Conference Proceeding Series' (12) and the 'Lecture Notes in Computer Science, Including Subseries Lecture Notes in

Artificial Intelligence and Lecture Notes in Bioinformatics' (9). Leading outlets for blockchain research in the public sector are presented in Figure 5.

As expected, 'blockchain' (124) was the most popular keyword in the publications, followed by 'public sector' (65). Other recurring keywords included 'block-chain' (35), 'blockchain technology' (18), 'e-government' (18), 'bitcoin' (15), and 'distributed ledger' (13), as shown in Figure 6.

Notable universities involved in the research on this topic included the University of Bayreuth (5) and the University of Luxembourg (4), while major sponsors of the research included the European Commission (5) and the European Regional Development Fund (3). Finally, India led in research with 25 papers published, followed by the United States with 17 papers, and the United Kingdom with 15 papers, as presented in Figure 4.

RQ2: What are the main topics examined by scientific inquiries related to the deployment of blockchain in the public sector?

As expected, the most frequently addressed topics within papers related to blockchain technology applications in the public sector included terms such as blockchain, distributed ledger, and electronic government. However,

Figure 1: Years of scientific production related to blockchain and public sector

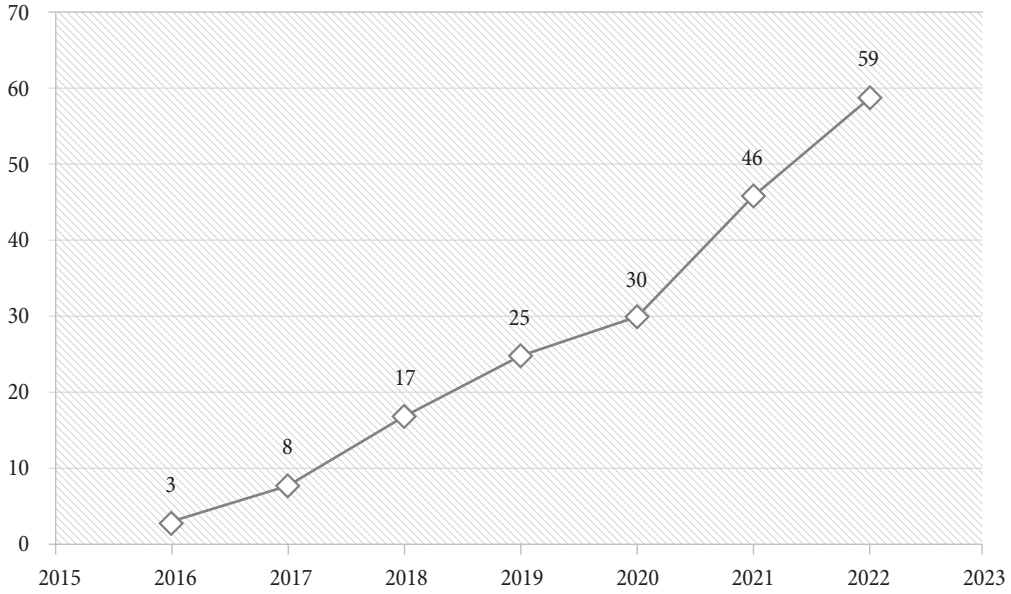
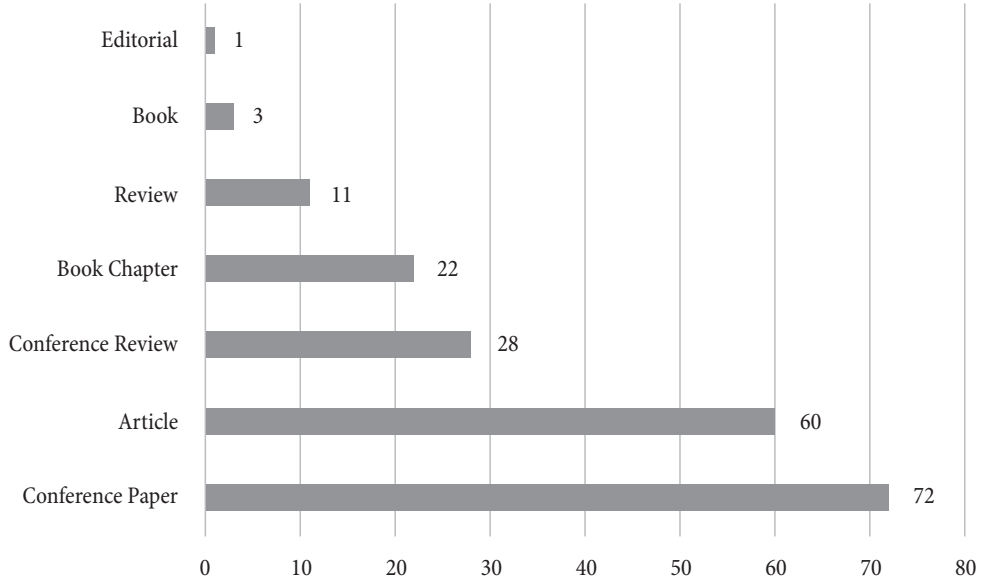


Figure 2: Types of scientific publications about blockchain and public sector



other prevalent topics encompassed the public sector, public administration, public services, and smart contracts. Given that the analyzed papers focus on implementing blockchain in the public sector to enhance public services, key themes that emerged include government service, electronic money, government transactions, government data processing, electronic data interchange, service industries, digital signature, and technology adoption.

Importantly, significant keywords that surfaced include legal regulation, financial fraud, data privacy, and security, highlighting the legal aspect of implementing blockchain and the importance of secure implementation

Figure 3: Subjects areas that are covered in scientific publications related to blockchain and public sector

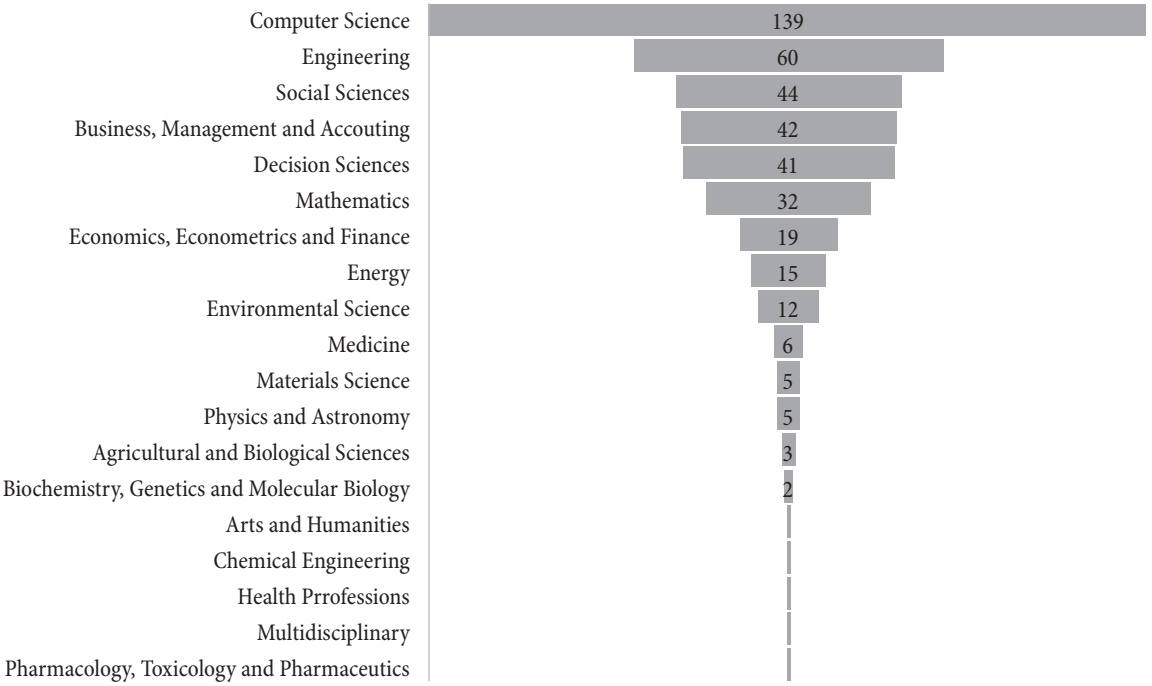
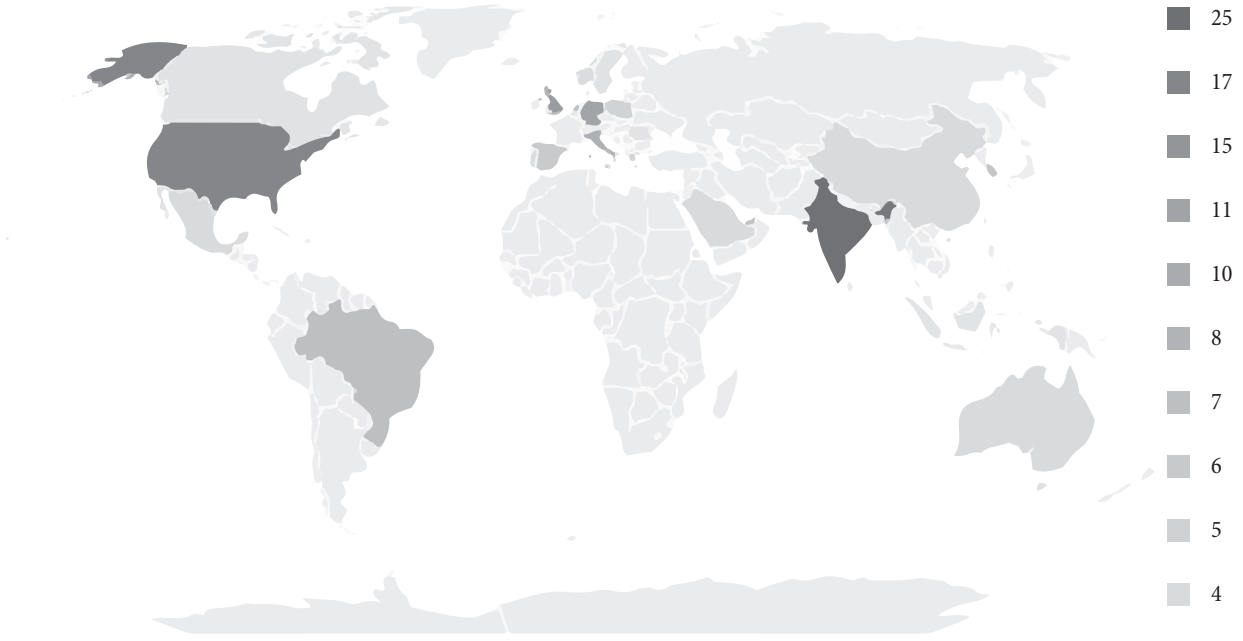


Figure 4: Countries from which publications related to blockchain and public sector come from



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of this technology in the public sector [21]. Enhanced data security and verification can have numerous applications in the public sector [99]. For instance, blockchain can be utilized to securely store and transfer government data, such as sensitive documents, while also being employed to develop digital identities. This allows government agencies to issue digital certificates, which can then be authenticated by users on a trusted network [66]. Furthermore, blockchain can facilitate other government operations through efficient contract management [94]. By using smart contracts, legal agreements can be digitally recorded and tracked, allowing parties to access data transparently and reducing the cost of dispute resolution [4].

The implementation of blockchain in the public sector can help increase transparency and participation by citizens, as blockchain-enabled applications enable them to access their data and make more informed decisions [10]. Moreover, with distributed ledgers and digital identity management, governments can enhance transparency in the usage of their funds by providing traceability and auditability to citizens [16]. In addition, the adoption of blockchain in the public sector allows governments to stay

Figure 5: Outlets in which the papers related to blockchain and public sector are published

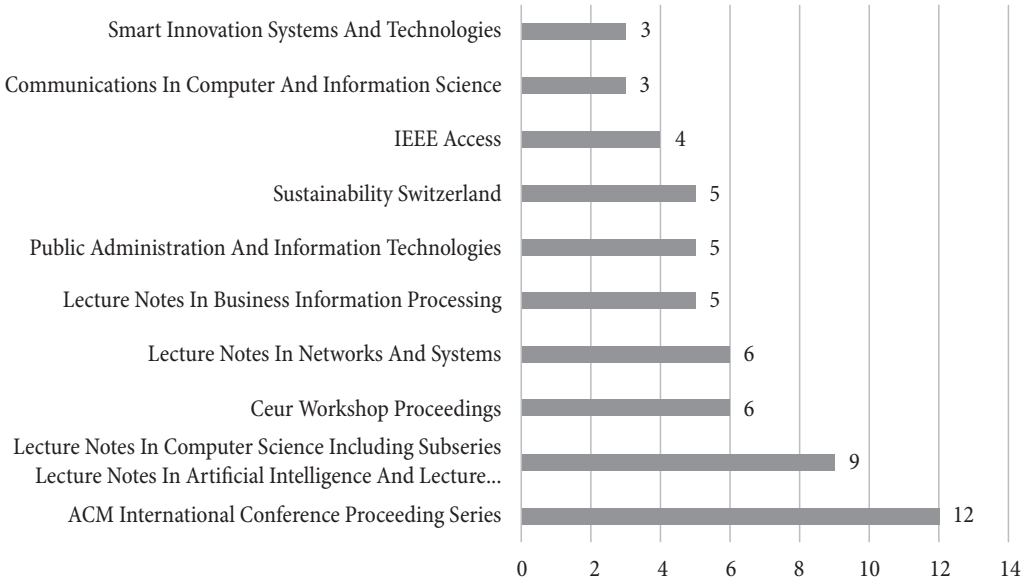

Figure 6: Graphical depiction of keywords in publications about blockchain and the public sector

up-to-date with current technologies. By familiarizing themselves with applications, they can increase their internal capabilities and efficiency while developing more cost-effective solutions for their citizens [6].

In conclusion, scientific inquiries suggest that blockchain can revolutionize governments' capabilities through its distributed ledger and secure encryption, enhancing transparency, data protection, and efficiency in public operations [99]. Furthermore, researching the use of blockchain can enable governments to explore new avenues for revenue and cost-saving opportunities. For example, blockchain-enabled applications for revenue generation, grant management, or payroll can be explored to help public agencies save money in the long run. Therefore, the investigation of blockchain use in the public sector is a necessary and important area for research, as it holds the economic potential to deliver benefits to both the public sector and society as a whole.

RQ3: What are potential economy-related advantages, challenges, and risks related to the deployment of blockchain technology in the public sector?

The traditional public sector is a complex and multifaceted system responsible for governance and the provision of numerous public services. Despite its centralized accountability, it often faces challenges related to organizational fragmentation and information exchange capacity, resulting in disconnection and inefficiencies that are undesirable from an economic perspective. Blockchain technology is perceived as an innovative framework for governments to increase efficiency and improve their services (dos Santos et al. [27] and Sobolewski & Allessie [90] made a distinction between the quantitative and qualitative benefits of introducing blockchain technology in the public sector). Quantitative benefits encompass cost savings from reduced transaction processing costs without intermediaries compared to traditional systems and efficiency gains through reduced transaction completion time [89]. Qualitative benefits include reliability gains, decreasing the risks of cyber-attacks, system breakdowns, or data leaks, and transparency and accountability gains, characterized by increased oversight of the system's current state and transaction history. Blockchain technology provides tangible advantages beyond operational efficiency, including strategic benefits such as creating a competitive edge and generating improved or novel products and services. Blockchain corrects inefficiencies within the public sector by offering more efficient patterns and establishing prerequisites for the introduction of better public services.

From an economic point of view, blockchain technology's automation of processes and transactions can lead to significant time and cost savings for governments and their agencies. The automation of various administrative procedures can reduce costs and increase efficiency, leading to better outcomes for service providers and end-users alike [41]. Furthermore, a significant advantage of blockchain's application in the public sector is the reduction of bureaucracy, streamlining complex government processes. Blockchain technology can potentially lead to a reduction of operating costs, particularly those arising from fraud and error correction, as blockchain-based systems provide immutable and tamper-proof records that reduce the likelihood of fraudulent activities, minimize error rates, and enhance accountability. Successful implementation of blockchain technology can lead to decreased intentional or unintentional human errors, and improved reliability, resiliency, and audibility. Transactions processed within the public sector can be validated and authenticated by all participating nodes in the network, making the stored information authentic and of high quality. Embracing innovation and leveraging blockchain technology within the public sector results in process enhancement by eradicating errors, achieving standardization, offering improved services to citizens, ensuring trustworthy and efficient information sharing among institutions [77], reducing costs, providing faster services, and enabling 24/7/365 days a year service availability [14], [105]. Blockchain can enhance transparency, allow individuals to have direct control over their information [88], and increase public trust [108].

Considering other cost-related benefits, blockchain-based systems' transparency can improve the management of funds. Currently, there is a lack of traceability and transparency in the allocation of funds in the public

sector, with pervasive issues of corruption, leading to a lack of accountability and financial mismanagement [79]. In contrast, blockchain technology offers transparency in public money allocation, simplifies manual activities, reduces operational costs, and produces data to support aggregate analysis of benefits arising from the allocation of public resources [65]. Furthermore, blockchain-based systems can enable governments to boost tax revenues [46], reduce tax evasion [24], and curb the informal economy, leading to an overall increase in economic productivity. Specific sub-areas that blockchain could enhance are payroll [68], withholding taxes, value-added taxes, transfer pricing, and information sharing between federal, state, and local governments, as well as foreign countries [91], [55].

Data protection is a significant area where blockchain technology can provide advantages, which can also be related to reducing costs. Blockchain-based systems can offer secure data exchange and storage, enabling governments to manage sensitive data while minimizing costs related to data protection. Furthermore, blockchain technology can safeguard critical infrastructure, providing an additional layer of security and ensuring the continuity of services. Blockchain is viewed as a straightforward economic advancement, and efforts have been made to boost the efficiency of current services and maximize cost savings by implementing blockchain technology [66]. In addition to highlighting cost savings, some authors also emphasize increased resilience to spam and DOS attacks as an important benefit of using blockchain in the public sector [70].

In the long term, blockchain technology has the potential to transpose comprehensive data from the public sector into trusted data marketplaces (see [82], [43], [28], and [39]). From a wider perspective, blockchain can enable secure data sharing among different stakeholders, including government organizations and agencies, citizens, businesses, academia, and others. Blockchain-based data marketplaces create a secure and standardized platform for stakeholders to share and access data while ensuring data privacy and confidentiality, leading to increased collaboration, innovation, and efficiency in the public sector [37].

Through a decentralized platform that validates transactions, data, and information independently and securely without any third-party control, and within a verifiable, secure, transparent, and permanent system, blockchain technology leads to the elimination of rent-seeking and other inefficient forms of resource utilization [57], [58]. For example, blockchain in public procurement can automate the management process and provide tamper-proof record-keeping, real-time audibility, and automated smart contracts, resulting in uniformity, objectivity, and transparency [22]. Additionally, within the procurement process, blockchain technology can prevent the deletion or modification of public comments and offers, leading to decentralized decision-making, oversight, and record-keeping [30]. Therefore, from the literature point of view, blockchain technology is considered a promising solution for public e-procurement [85].

Some empirical research has already confirmed the positive impacts of blockchain technology in the public sector (see [98], [64], [26]). This technology is being experimented with in various areas of public services, including but not limited to digital currency/payments, land registration, identity management, notarization, supply chain traceability, healthcare [74], education [78], [49], corporate registration, data management, auditing [11], energy markets, taxation, voting, and legal entity management [102]. Within the realm of blockchain technology adoption, the sectors with the highest number of records are public management and healthcare. Still, a diverse range of sectors, including international trade and customs, voting, environmental protection, food safety, digital identities, energy, social protection, and public procurement, among others, is also identified as having significant potential for blockchain applications [19]. Considering government domains with the largest blockchain applications so far, Maragno et al. [63] highlight general public services, economic affairs, health sector, data and documents management, traceability of products, digital voting systems, and digital identity management.

Although the application of blockchain in these domains brings the aforementioned economic benefits, some inherent challenges occur in blockchain implementation. The first obstacle relates to resources needed for blockchain

applications, as deploying and maintaining the technology is costly, and not all governments have the resources to do it (many confront digitalization issues) [18]. Other challenges related to the economic perspective primarily start with technological barriers to widespread adoption of blockchain technology in the public sector, such as scalability, interoperability, flexibility, and security concerns (see [13], [50], and [1]). There are also organizational issues that are often described as obstacles to blockchain applications. Organizational readiness for blockchain adoption has been explored in studies by Ølnes et al. [69] that investigated acceptability issues. Business model and organizational transformation implications of blockchain have been examined by Ahram et al. [2] and Ølnes et al. [69]. The risk of errors in complex business rules when implementing blockchain has been addressed by Engelenburg et al. [32].

A key concern is blockchain technology's scalability in handling high volumes of transactions. The public sector is characterized by diverse and complex service offerings spanning different departments, agencies, and levels of government, leading to a complex web of interdependencies and integration challenges. Integrating blockchain technology into these existing systems may require significant technical modifications and adaptations to ensure seamless interoperability, which can be time-consuming, costly, and challenging to implement [71]. Moreover, the high volume of transactions and interactions may not be handled by many existing blockchain networks, which can result in delays, inefficiencies, and bottlenecks in transaction processing that may hinder widespread adoption of blockchain in high-volume public-service contexts [62].

The fragmentation of public services across different departments, agencies, and levels of government can pose challenges in terms of standardization and coordination. Ensuring consistency, coherence, and interoperability across different public services can be challenging as it requires coordination, consensus building, and alignment among various stakeholders [72]. Additionally, a common challenge is the lack of long-term experience in blockchain implementation, which could lead to imperfect management [53].

While blockchain has the potential to enable secure and transparent collaboration among stakeholders, the practical implementation of such collaboration can be complex and challenging. Firstly, setting up stakeholder collaboration on a blockchain requires the establishment of a consensus mechanism among stakeholders, which can be time-consuming and may involve negotiation and agreement on various technical, operational, and governance aspects [97]. This process may require substantial effort and coordination to ensure that all stakeholders are aligned and committed to the collaborative effort. Secondly, scaling up stakeholder collaboration on a blockchain can be challenging due to technical limitations [34]. The technology currently faces scalability issues, as the processing speed and capacity of many blockchain networks are relatively limited compared to traditional centralized systems [1]. As a result, accommodating a large number of stakeholders and processing a high volume of transactions may pose technical challenges and hinder the scalability of stakeholder collaboration on a blockchain.

A neglecting challenge in blockchain application is interoperability with existing centralized systems, as integrating blockchain into established systems may require substantial technical modifications and adaptations [47]. Additionally, the need to develop new technical skills and infrastructure to support blockchain implementation can pose obstacles, as it may involve substantial investment in infrastructural upgrades. Establishing an entirely new framework within the public system may incur high costs, including initial setup costs and ongoing maintenance expenses, which could pose financial challenges for budget-constrained public entities [53]. These challenges highlight the complexities and costs associated with the adoption of blockchain technology in the public sector and underscore the importance of careful planning and strategic considerations in implementing blockchain solutions in a public service context.

Although blockchain is often associated with strong security guarantees [7], its effectiveness depends on the size of the ledger. Smaller ledgers are more vulnerable to manipulation, so there is a risk that an entity or hacker could gain control of a majority of the ledger's node network (known as the "51 percent rule"), resulting in fraudulent transactions and misuse of public resources [31]. The lack of standards and regulations undermines

trust in the adoption of blockchain, ultimately impacting scalability and the full implementation of this technology in environments where it is expected to bring greater benefits. Thus, to achieve the widest possible advantages from the application of blockchain, it is necessary to establish an adequate institutional and regulatory framework for its application in the public sector.

RQ4: What legal implications, issues, and challenges exist when utilizing blockchain technology in the public sector?

The economic outcomes of blockchain applications within the public sector depend on legal aspects and regulations concerning the use of this technology. Legal contexts of blockchain applications are often associated with accountability in governance, referring to the regulation and enforcement of rules such as dispute resolution and change management. In blockchain governance, there are four forms of accountability mechanisms identified based on Treib's et al. [106] typology: coercion, voluntarism, targeting, and framework regulation. Coercion is manifested through "lex cryptographic," which involves legally binding regulations prescribing specific fixed standards implemented through code. However, converting law into code is a challenge since code-based rules must be predictable and leave no room for interpretation, limiting their applicability in contingent and conditional scenarios. By contrast, voluntarism relies on non-binding instruments exemplified by soft forks, while targeting uses detailed recommendations, often employed through community consensus. Framework regulation, embodied by hard forks, establishes binding rules while giving users the choice to accept or reject policy options, occasionally resulting in permanent splits if consensus is not achieved [102].

Developing countries frequently face challenges in public sector infrastructure projects, leading to delays and other issues. Blockchain-based project management promises numerous legal advantages for addressing these challenges. E-procurement, for example, allows organizations to save time and resources by moving processes online, ensuring prompt tendering and promoting transparency [95]. Additionally, blockchain technology facilitates improved accountability and addresses the issue of the lowest bidder by imposing consequences for vendors who fail to fulfill projects within their contracted time and cost without valid reasons [53].

Blockchain technology provides numerous services independently, without the need for direct interaction with specific businesses or organizations, made possible through the use of smart contracts [53]. Smart contracts automate tasks, increasing efficiency and accuracy in various processes and eliminating manual intervention after their creation.

Corruption, a widespread issue in the public sector, often arises from information manipulation, ambiguity, and uncertainty. Blockchain technology can help reduce corruption, serving as a digital ledger that records all transactions, ensuring data integrity and preventing double spending. The transparent, immutable, and decentralized characteristics of blockchain have the potential to mitigate corruption across diverse settings [38].

Online voting has gained momentum in modern society, reducing costs and increasing voter participation by eliminating physical ballots and polling stations. Blockchain technology offers decentralized nodes and end-to-end verification, providing a potential solution for legitimate, accurate, secure, and user-friendly electronic voting systems [48].

However, several challenges and limitations exist related to blockchain systems and failures in legal and regulatory frameworks. Interoperability challenges may arise when implementing blockchain technology, affecting its scalability and the establishment of a blockchain infrastructure in the public sector [102]. Concerns regarding government control, abuse of blockchain technology, and potential illegal activities such as money laundering, illegal trade, and tax evasion must also be addressed [58], [25].

Adopting automated solutions in public sector organizations must consider both embedded public values and existing capacities and practices regarding digital governance. The replacement of certain functions and organizations with non-human controlled Decentralized Autonomous Organizations (DAOs) or automated agents may face political challenges and raise concerns about accountability in public management [73].

Additional technologies like artificial intelligence may be necessary to facilitate automated decision-making and enhance the flexibility of blockchain systems. Public agencies involved in blockchain implementations should carefully evaluate and design decision-making processes, clearly defining the interfaces of formal and informal processes to prevent premature decisions from being added to the blockchain [16].

Conclusion

The Blockchain concept has become increasingly popular over the past few years, not only in the business world but also among potential investors and the public. The surge of interest has spurred significant research into the potential of blockchain to revolutionize the digital realm, specifically in the public sector (see [43], [12], and [36]. The previous research concluded that, when used correctly, pairing blockchain with digital systems has the potential to positively transform public services and enhance the trust of citizens while encouraging further political activity [9], [64]. However, beyond theoretical insights, empirical data is crucial to understanding how blockchain is used in the public sector and to identify associated benefits and challenges. Additionally, technological developments need to consider the privacy and confidentiality of data, ensuring the secure sharing of data between services and devices. To this end, designing a security model that combines digital assets within a blockchain could provide a trustless layer for protecting data, improving the security of data sharing [107]. At the same time, deploying blockchain technology requires adequate legal foundations, reliable infrastructure, public trust, and socio-economic conditions to be successfully implemented [86], [75], [56], [76]. Concretely, governments could benefit from pairing blockchain with modern information systems, such as AI, IoT, and blockchain technology, to provide innovative, faster, and more secure ways of accessing different types of data in public sectors. Furthermore, introducing a blockchain-based identity management system could also facilitate the delivery of public services, reduce the time and cost needed, and increase the efficiency of operations. Research is also needed in this field to provide insight into the governmental adoption of such technology, exploring the implications of such adoption, and the preliminary application of models such as the technology acceptance model and adoption models for studying cryptocurrencies. Ultimately, the successful integration of blockchain into the public sector calls for broad and profound research that explores ttechnology from various perspectives and its various contexts of use.

Blockchain's unique advantages, such as digital trust, immutability, and decentralization of data, have enabled it to enable governments to securely store & transfer data, enable secure, efficient, and transparent voting, enable citizens to own and control their data securely, enable improved coordination and accuracy with respect to service delivery, and create secure pipelines for the valuation and taxation of assets [5]. AI technologies such as machine learning & natural language processing can be used to enable governments to better predict market trends, manage their data, and realize cost savings in terms of human resources, by replacing manual labor with automated and data-driven processes [60], [45].

This paper seeks to summarize the current and potential applications of blockchain technology in the public sector, emerging trends and challenges, and the research done and proposed for their implementation by focusing on law and economic aspects related to the use of blockchain in the public sector. We hope to review the impact of blockchain on the public sector and offer potential recommendations for future research in this field.

So far, research has shown that the use of blockchain in the public sector has the potential to offer significant advantages to government operations that can help improve efficiency, reduce costs, and streamline processes. Also, blockchain has the ability to revolutionize the public sector by allowing more secure, transparent, and accountable systems. By researching the use of blockchain in the public sector, government officials can better understand its potential and how it can be leveraged to benefit their operations.

A growing belief is prevailing that blockchain creates an ecosystem that provides new economic opportunities in the public and private sectors alike [96]. The introduction of this new technology within the public sector improves

existing processes and creates innovative new services [62]. However, previous practices indicate that, so far, rationales for blockchain adoption in the public sector were primarily oriented toward reducing bureaucracy and the costs of administrative processes. By leveraging blockchain technology, governments can streamline transactions, eliminate intermediaries, and improve efficiency in record-keeping and financial management.

An economic perspective always captures the concept of efficiency, which takes into account the trade-off between the benefits and costs associated with implementing and managing blockchain networks in comparison to more centralized arrangements. While blockchain technology manages information in a decentralized manner, it often incurs higher costs compared to centralized architectures. Therefore, despite the desirable functions of blockchain networks, such as security, transparency, and immutability, the application of the blockchain framework within some public sector settings may still be considered less economically efficient [18].

In addition, the lack of standards and trusted hosting infrastructure poses obstacles to achieving interoperability, scalability, and security of blockchain networks. Gaps in essential functionality, such as smart contract capabilities, also hinder the full potential of blockchain in government services, inhibiting blockchain from unleashing the full economic benefits of its application in the public sector. Conversely, this leads to mistrust in the positive effects of technology and underscores the legal aspects of the blockchain application within complex public sector systems. The adoption of blockchain technology in public services brings about significant technological developments and changes. As such, the governance of public service should encompass the governance of blockchain as well [16].

Despite its potential benefits, blockchain governance remains a controversial aspect for public sector organizations. A systematic analysis tool is necessary to address governance challenges and ensure the effective design, operation, and maintenance of blockchain-based systems. As a technology that aims to build trust in governance processes without the involvement of a trusted third party, it is crucial to determine what to govern (or not to govern) and how to govern when adopting blockchain in the public sector [102].

To successfully implement blockchain technology in the public sector, several measures must be taken. Firstly, there is a lack of awareness and education about technology among policymakers, businesses, and the public, which poses a significant challenge. It is crucial to educate stakeholders about the technology's benefits, limitations, and potential use cases to build trust and understanding. Secondly, the regulatory framework for blockchain technology is still in its infancy, causing uncertainty in its further application within the public sector. Clear and consistent regulations are needed to ensure citizens' rights are protected, promote innovation, and encourage investment. Additionally, the technical infrastructure required for blockchain technology, such as high-speed internet and advanced computing power, may not be available to all parts of the public sector. Therefore, investment in infrastructure is necessary to support the technology's deployment. Moreover, adequate training and guidance for employers are required to ensure the technology is used effectively. This technology, like many others, is dependent on the human factor, and accurate and well-managed information is essential to provide satisfactory results.

The research was limited to exploring the use of blockchain technology in the public sector, specifically focusing on legal and economic aspects of their deployment and adoption. Furthermore, this research does not address the technological and organizational barriers to successful blockchain deployment or the potential socio-economic implications of their integration into public sector contexts. Despite mentioned examples, there is still a lack of empirical evidence to understand the actual benefits or drawbacks of blockchain technology in the public sector, as well as an absence of any publicly verifiable case studies or success stories. Additionally, more research is needed on integrating these technologies into existing public sector structures and developing a secure and reliable ecosystem for citizens' data ownership.

Overall, research has shown that the use of blockchain technology in the public sector offers numerous benefits ranging from improving data security to speeding up processes. Furthermore, the exploration of legal and economic aspects related to their use and adoption could

allow for their successful and secure deployment in the public sector. By researching the use of blockchain technology, governments can better understand the potential benefits and challenges so that they can be used to their full advantage. Ultimately, such research could help unlock the massive potential of blockchain and other emerging technologies within the public sector to revolutionize the digital realm and provide trust, transparency, and efficiency.

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DIGITAL ENTREPRENEURSHIP AND SUSTAINABLE DEVELOPMENT

Digitalno preduzetništvo i održivi razvoj

Abstract

The primary goal of the research is to identify the role of entrepreneurship based on high technology and digitalization in sustainable development. Sustainable development is a multidimensional phenomenon that includes economic, social, and environmental components, and it is viewed in the paper as a result of basic entrepreneurial activities and entrepreneurship in the high-tech sector, which significantly implies business/entrepreneurial processes supported by digitalization. The establishment and growth of entrepreneurial organizations represent the principal drivers of structural changes towards sustainable development. Accordingly, sustainable development needs the support of innovative activities as carriers of changes in the new development paradigm to adjust to current and future challenges. The area of research in the paper consists of the previously mentioned three research units represented by 16 fundamental variables. In the paper three new variables were generated as a result of a regression factor by grouping the previously mentioned individual variables while using multiple regression as the primary method. A check of the research hypothesis was carried out, whose primary specificity is that all independent variables are simultaneously entered into the equation, which evaluates the predictive power of each independent variable. The paper used a sample of 49 countries classified into three groups according to the methodology of the World Economic Forum (WEF). The database for the needs of quantitative procedures concerning the variables of entrepreneurship and high-tech entrepreneurship is from the GEM project. For the variables of sustainable development, the following databases were used: the International Monetary Fund (IMF), IMF World Economic Outlook Data Base, Human Development Report, UNDP, Environmental Performance Index, and Yale University in collaboration with the WEF. Respecting the previously defined model in which sustainable development represents the function of entrepreneurship and high-tech (digital) entrepreneurship, the fundamental research assumption was confirmed, that is, it was determined that there is a positive correlation at the level of statistical significance between sustainable development as a dependent variable, and entrepreneurship and high-tech (digital) entrepreneurship as a group of independent variables.

Keywords: *sustainable development, entrepreneurship, high technology (digital) entrepreneurship, multiple regression*

Sažetak

Osnovni cilj istraživanja u radu predstavlja identifikovanje uloge preduzetništva zasnovanog na visokoj tehnologiji i digitalizaciji u održivom razvoju. Kako je održivi razvoj višedimenzionalan fenomen koji uključuje ekonomsku, socijalnu i komponentu okruženja, u radu je razmatran kao posledica

osnovnih preduzetnički aktivnosti i preduzetništva u visokotehnološkom sektoru koji u značajnoj meri podrazumeva poslovne/preduzetničke procese podržane digitalizacijom. Osnivanje i rast preduzetničkih organizacija predstavljaju glavne nosioce strukturnih promena ka održivom razvoju. U skladu sa tim, održivi razvoj ima potrebu za podrškom inovativnih aktivnosti kao nosilaca promena u novoj razvojnoj paradigmi kako bi se adekvatno odgovorilo na sadašnje i buduće izazove. Područje istraživanja u radu čine prethodno pomenute tri istraživačke celine koje su predstavljene sa 16 osnovnih varijabli. U radu su u vidu regresionog faktorskog rezultata generisane tri nove varijable grupisanjem prethodno navedenih pojedinačnih varijabli, dok je pomoću višestruke regresije kao osnovne metode sprovedena provera istraživačke pretpostavke, čija je osnovna specifičnost da se sve nezavisne promenljive istovremeno unose u jednačinu čime se ocenjuje prediktivna moć svake nezavisne promenljive. U radu se koristio uzorak od 49 zemalja razvrstanih u tri grupe prema metodologiji Svetskog ekonomskog foruma (WEF). Baza podataka za potrebe kvantitativnih postupaka kada su u pitanju varijable preduzetništva i visokotehnološkog preduzetništva je GEM projekat, dok su za varijable održivog razvoja korišćene baze Međunarodnog monetarnog fonda (IMF), IMF World Economic Outlook Data Base, Human Development Report, UNDP, Environmental Performance Index, Yale University u saradnji sa WEF. Uvažavajući prethodno definisani model u okviru koga održivi razvoj predstavlja funkciju preduzetništva i visokotehnološkog (digitalnog) preduzetništva, potvrđena je osnovna istraživačka pretpostavka, odnosno utvrđeno je da postoji pozitivna korelaciona veza na nivou statističke značajnosti između održivog razvoja kao zavisne promenljive i preduzetništva i visokotehnološkog (digitalnog) preduzetništva kao grupe nezavisnih promenljivih.

Ključne reči: *održivi razvoj, preduzetništvo, visokotehnološko (digitalno) preduzetništvo, višestruka regresija*

Introduction

Entrepreneurship as a function of sustainable development is a multidimensional phenomenon that connects the social, economic, and environmental dimensions between the entrepreneurial process, market transformation, and large-scale social development [17]. The profound changes occurring in the modern world over the last few decades demand a reassessment brought by digitization and the IV Industrial Revolution in the field of economy [29]. Digitalization is part of the overarching global trend of the IV Industrial Revolution (Industry 4.0), and simultaneously, the primary reason why more than half of the Fortune 500 companies ceased to exist over the last two decades [27]. Primarily, sustainable development implies not disrupting and endangering future development with current operations, so entrepreneurial ventures that are highly specific about the degree of innovation, especially in the domain of high technologies and the digital area, precisely generate the assumptions of the mentioned concept. By identifying the environmental problems that appear within a specific economy and the possibility of endangering the living conditions of future generations, the traditional goals of economic growth have been replaced with the goals of sustainable development. One of the concepts that generically supports sustainable development is the concept of corporate social responsibility, which refers to the awareness and obligation of companies to take steps towards sustainable business practices that consider economic, social, and environmental aspects [1]. In achieving these goals, entrepreneurship should be considered a significant factor since activities aimed at improving the living environment, at the same time, represent entrepreneurial business opportunities [9].

In general, development implies continuous changes, which primarily means a high degree of innovation leading to discontinuity, displacing the existing state of economic balance, and establishing new business circumstances at a higher qualitative and quantitative level. Thus, entrepreneurship represents a factor that gives incentive to sustainable development [10]. The establishment and growth of entrepreneurial organizations constitute the key drivers of structural changes towards sustainable development. In line with previous, sustainable development needs support in innovative activities as carriers of change in new development paradigms to respond to current and future challenges [11].

Bearing in mind the importance of the final result, a lot of research aims to identify the role of entrepreneurship in developing the economy towards sustainable development since much earlier the potential of entrepreneurship has been recognized not only as economical but also as an overall social transformation that had a significant role in today's post-transitional countries. Entrepreneurship is generally recognized as a bearer of transformational processes of society and economy from one epoch to another.

Discontinuity as a precondition for development is provided by the entrepreneurial manner of doing business, which, if recognized as such, has built-in elements of innovation with high intensity in the domain

of high technologies and digitalization, resulting in an inevitable destructive effect on the current state in the effort to establish a new equilibrium state at a higher level that makes development sustainable. Both public and private entities increasingly rely on high and digital technologies to encourage entrepreneurial activities to achieve sustainable development goals, including economic, social, and environmental segments [6].

The paper aims to identify the role of entrepreneurship based on high technology and digitalization in sustainable development.

In addition to the introduction and conclusion, the paper consists of three principal parts. The second part presents the theoretical foundation of the connection between the concept of entrepreneurship in the high-tech sector and the degree of digitalization and sustainable development exhibited. In the third part of the paper, the methodology applied in the paper based on the regression factor result (Regression factor score) is presented to generate new variables, as well as the standard multiple regression under the conceptual framework of the research, which will represent individual research sub-units, namely entrepreneurship, high technological (digital) entrepreneurship and sustainable development that forms a unique research area. The fourth part contains the analysis and interpretation of the research results, while the fifth part consists of the conclusion.

Theoretical background and hypothesis development

The area of sustainable development is still a relatively current area of interest for scientists, particularly compelling in the last two decades because it can be said that in 2002, only a few scientific papers were published on the topic of sustainable development and entrepreneurship [14]. One of the first definitions of sustainable development interpreted this concept in the following way, sustainable development is economic development that meets the needs of the present generation without endangering possibilities of satisfying the needs of the future generations [28].

Entrepreneurs can reposition themselves in the business environment by improving their competencies and ultimately restructuring their economic sector in the direction of sustainability. Many authors share this point of view, who see market imperfection not only as a source of environmental degradation but also as a driver of innovation and sustainability or as a social entrepreneurial opportunity [22]. Numerous previous studies show that entrepreneurship has a significant contribution to sustainable development (Table 1) in developed countries, which has not been proven for developing markets [16].

It can be said that there is an increasing number of opinions that not all forms of business activities can be called entrepreneurship since not all forms of "entrepreneurship" have identical consequences regarding economic growth [26].

For entrepreneurship to achieve goals within the concept of sustainability, it is necessary to possess certain specificities such as social responsibility, competitiveness, progressiveness, creation and use of knowledge, innovation, and dynamism, which are dominant characteristics of the high-tech sector and digital entrepreneurship. It should be emphasized that there is a wide complementarity between the possibilities of digital technologies and the value of a social way of thinking within the value creation framework [12]. Digitalization is often defined as digital connectivity, internet use, e-business, e-commerce, and e-government

Table 1: The role of entrepreneurship in ensuring sustainable development

Dimensions of sustainable development	Contribution of entrepreneurship
Economic	… entrepreneurship drives economic growth by creating jobs, promoting decent work and sustainable agriculture and fostering innovation...
Social	… positive contribution that entrepreneurship can make in promoting social cohesion, reducing inequalities and expanding opportunities for all, including women, young people, persons with disabilities and the most vulnerable people…
The environment dimension	… entrepreneurship can help to address environmental challenges through the introduction of new climate change mitigation and adaptation technologies and resilience measures, as well as by promoting environmentally sustainable practices and consumption patterns…

Source: [28]

[13]. The concept of digitalization, as previously defined, refers to enabling or improving processes using digital technology and digital data.

Combining multiple digital factors and infrastructure (such as blogs, boards, and platforms) creates a space for social interaction and opportunities for engaging in co-creation activities and expanding stakeholder integration. With this digital-based practice, sustainable entrepreneurs successfully define the boundaries of their business environment, making it more dynamic and open [2].

Digitalization brought by the high-tech sector as the main destructive factor that shapes our current lives positively affects and drives entrepreneurial activity and sustainable development [6]. Over the past decade, the world has witnessed rapid growth in the diffusion and use of digital technologies, which have gradually become an essential dimension of a country's pursuit of a more inclusive, competitive, and above all, sustainable economy, and society [11]. The digitalization process includes activities that directly generate information and communication products and services with a direct contribution to increasing productivity and growth. Previous research confirms the positive impact of digital technologies on economic growth, although the importance of this impact depends on the economy to economy, i.e., in developing countries, this impact is smaller than in developed countries [4].

From the economic growth perspective, digitalization is considered a crucial factor for achieving sustainable economic development. Digitalization can be directed as a driver of sustainable development that includes economic, social, and environmental components [19]. The research concept defined in this way enables a broader understanding of the concept of development that goes beyond its economic value and includes social and environmental dimensions and shows how entrepreneurship and digitalization contribute to creating conditions for sustainable development [6].

Digitalization is a global concept with significant heterogeneity between different geographic regions based on six pillars: accessibility, reliability, capacity, access, use, and skills [19]. The unique characteristics of digital technologies create digital benefits that relate to new business opportunities concerning a competing user or to competing uses that can be exploited by economic participants such as entrepreneurs [21]. In this way, we arrive at the phenomenon we call digital entrepreneurship, which can be defined as entrepreneurial opportunities that are created and realized using technological platforms and other information and communication equipment [3]. However, it is, of course, not the only accepted definition of digital entrepreneurship. There are numerous definitions of digital entrepreneurship, while the research contribution can be classified into two main categories: (a) research on whether and how digitalization has transformed new business ventures as we know them (which is primarily enabled by high digital technology); (b) research on entrepreneurial opportunities generated owing to digital technological innovations and the creation of a new business venture within the digital sector (where digital technologies appear as generators and as outcomes) [23]. Thus, digital entrepreneurship can be considered as all new ventures and the transformation of existing companies that represent carriers of economic and social value by creating and using new digital technologies. Digital companies are characterized by a high intensity of using new digital technologies to improve operational capabilities, create new business models, improve business intelligence, and establish contact with clients and interested parties. In this way, they create jobs and future economic growth [7].

Entrepreneurial activities constitute the dominant source of social and environmental sustainability, thus, contributing to sustainable development within the entrepreneurial ecosystem [6]. By observing previous processes in the domain of the high-tech sector and based on the previous research, it can be said that digitalization contributes to the renewal of entrepreneurial activity and the growth of the number of initial entrepreneurial ventures with the indispensable support of the political, economic, and social environment. Some results confirm that the digital revolution provides considerable support for the development and rapid expansion of the private sector, where there are numerous digital platforms and low barriers to access to digital infrastructure, thereby further contributing to the growth of the entrepreneurial

environment [15]. It is easy to see here that innovation, entrepreneurship, and digitalization as factors of sustainable development strongly contribute to social transformation, which is of specific importance for developing countries [30]. Due to the results of the abovementioned processes, intensive changes in the attitudes towards the newly created economic segment by all social factors can be observed. Thus, entrepreneurship in the digital sphere appears as a support and central force of social development that naturally strives towards sustainability. A crucial role in the digitalization process plays the developed internet infrastructure, which directs future economic development in the direction of sustainability, which results in a significant change in the economic structure, primarily through the creation of new markets, the emergence of digital innovations and companies based on digital technology [15].

The convergence of sustainability and digitalization is inevitably becoming imperative in all segments of society [20]. If we include the entrepreneurship component, we arrive at the social entrepreneurship category, which finds its initiatives through solving complex social and environmental problems [25].

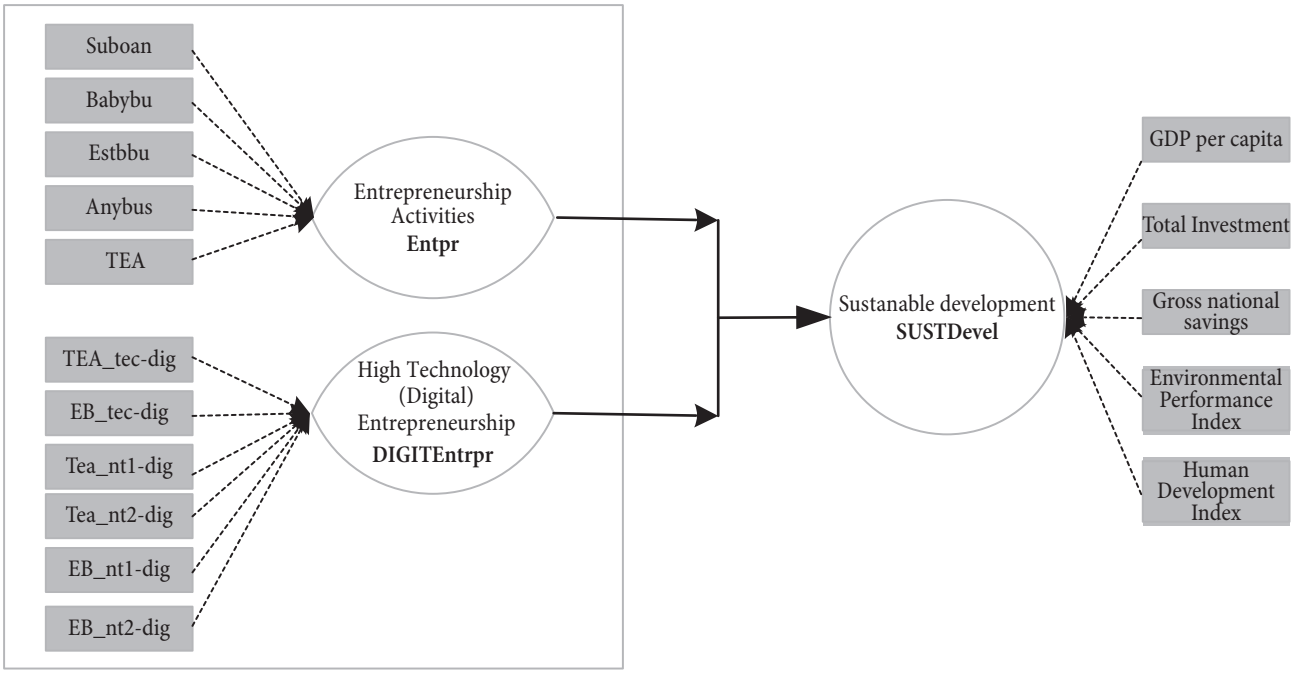
Looking through the prism of sustainable development based on high (digital) technology and focusing on entrepreneurial activities based on digital innovations to create social value, we immediately come to solving problems and creating conditions for sustainability. This implies that solving some, primarily social, economic, and environmental problems leads to sustainable development based on innovative and creative application of digital technologies. Most participants whom we can state as relevant examples in this new field of digital sustainability were entrepreneurs and, what is more, initial entrepreneurial ventures that create social value around which an economic initiative develops [10].

Some studies confirm the direct connection between sustainable development and information and communication technologies. This connection indicates that digitalization impacts the employment rate through the education process, while education directly depends on the level of investment in research and development [5].

Respecting the previously defined model (Figure 1) within which *Sustainable Development* represents the function of *Entrepreneurship and High-tech* (*digital*) *entrepreneurship*, we set the basic research hypothesis:

H1: *There is a positive correlation at the level of statistical significance between Sustainable Development as a dependent variable and Entrepreneurship and High-tech (digital) entrepreneurship as a group of independent variables.*

Figure 1: Conceptual framework



Source: Authors

Methodology

Data and variables

For research conducted based on secondary databases, a sample of 49 countries was analysed based on the available database of the GEM project. Countries are classified into three fundamental groups: 1) factor-driven economies: Angola, Egypt, India, Indonesia, Madagascar, Morocco, and Sudan, which make up 14.28% of the sample; 2) efficiency-driven economies: Brazil, Bulgaria, China, Colombia, Guatemala, Iran, Lebanon, Peru, Russia, Thailand, Turkey, which make up 20.40% of the sample; 3) innovation-driven economies: Argentina, Austria, Canada, Chile, Croatia, Cyprus, France, Germany, Greece, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Netherlands, Panama, Poland, Puerto Rico, Qatar, Saudi Arabia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Taiwan, United Arab Emirates, United Kingdom, Uruguay, USA, which make up 61.22% of the sample) in accordance with the WEF methodology. From the abovementioned database, two groups of variables were separated concerning measures of the scope and structure of entrepreneurial activities, while the second group consists of variables from the field of high-tech (digital) entrepreneurship. The third group of variables is related to sustainable development and includes all three conceptual dimensions. For the economic dimension of the concept, the IMF World Economic Outlook Data Base with the GDP per capita variable was used; for the social dimension of the concept, the Human Development Report, UNDP, was used. Publications and the Environmental Performance Index variable, Yale Centre for Environmental Law and Policy, Yale University in collaboration with the World Economic Forum were used for the environment component.

For the research, a list of 16 variables from three research units was selected. Since there are many variables, the selection of variables was done based on the research concept, and a quantitative analysis was carried out to group the selected variables using the regression factor score (*Regression factor score*). As a result of the analysis of the mentioned method, three factors (groups of variables) were differentiated, that is, three new variables were formed: entrepreneurship, high-tech (digital) entrepreneurship, and sustainable development. The advantage of forming new variables using the regression factor score is reflected in the possibility of forming new, more complex variables in the form of economic or social phenomena, unlike the available types of regression analyses that examine the interdependence of individual features.

The entrepreneurship construct contains individual variables within the REGR factor score 1 (Table 2):

Table 2: Entrepreneurship activities - Entrep

Suboan	% 18-64 pop: STEART-UP/NASCENT (SU): active past year, (part) owner, no wages yet
Babybu	% 18-64 pop: BABY BUS OWNER (BB): owns-manages business with income < 3.5 years
Estbbu	% 18-64 pop: ESTABL BUS OWNER (EB): owns-manages business with income > 3.5 years
Anybus	% 18-64 pop: Entrepr active: either nascent (SU), baby (BB) or established (EB)
TEA	% 18-64 pop: Setting up firm or owner of young firm (SU or BB)

Source: GEM Project Data Base

Out of 49 cases, the analysis considers all 49 cases valid, which is 100.00% of the sample. Chrombach Alpha for this variable is 0.894, which shows acceptable reliability and internal agreement of the Entrepreneurship activities scale for this sample. Although values of 0.70 are considered acceptable, values above 0.80 are desirable.

The high-tech (digital entrepreneurship) construct consists of individual variables within the REGR factor score 2 (Table 3):

Table 3: High technology (digital entrepreneurship) activities - DIGITEntrpr

TEA_tec	% within TEA: Active in technology sectors (high or medium)
EB_tec	% within EB: Active in technology sectors (high or medium)
Tea_nt1	% within TEA: Uses very latest technology (only available since last year)
Tea_nt2	% within TEA: Uses new technology (1 to 5 years)
EB_nt1	% within EB: Uses very latest technology (only available since last year)
EB_nt2	% within EB: Uses new technology (1 to 5 years)

Source: GEM Project Data Base

Out of 49 cases, the analysis considers 49 cases valid, which is 100.00% of the sample. Chrombach Alpha for this variable is 0.676, which shows acceptable reliability and internal agreement of the high-tech (digital) entrepreneurship scale of the sample.

The construct of sustainable development is a single variable within the REGR factor score 3 (Table 4):

Table 4: Sustainable development - SUSTDevel

GDP per capita	Gross domestic product per capita, current prices
TotInv	Total investment
GNS	Gross national savings
EPI	Environmental Performance Index
HDI	Human Development Index

Source: IMF World Economic Outlook Data Base; Human Development Report UNDP; Environmental Performance Index WEF

Out of 49 cases, the analysis considers 45 cases valid, which is 91.08% of the sample. Chrombach Alpha for this variable is 0.675, which shows acceptable reliability and internal agreement of the sustainable development scale for this sample.

The new variables result from the high linear interdependence of the individual measures that were separated within the above three factors, which is also indicated by the high-value factors.

Research method

Standard multiple regression, applied in this paper, enables the prediction of a particular outcome by a specific set of predictor variables as presented in the model in the form of functional interdependence of variables of total entrepreneurial activities by different phases of the entrepreneurial process and high-tech (digital entrepreneurship) both by different stages of the entrepreneurial process and by the level of usage of high-tech (digitalization), as well as which variable, individually observed is the best predictor. Also, by using this method, we can find out how much of the dependent variable variance, which in this case is sustainable development, explains each of the independent variables individually.

Research results and discussion

When interpreting the results of multiple regression, it is necessary to examine first the fulfilment of the hypothesis that multiple regression should fulfil, since in this way the credibility of the implemented quantitative procedures is ensured, which indicates the reliability of the set model and the inference process based on the obtained research results. Primarily, one thing that needs to be considered when it comes to the mentioned hypothesis is the correlation between the variables in the set model. The independent variables must have a minimum weak connection with the dependent variable, that is, the values of the correlation coefficient must be above 0.3. In this example, the values of the said coefficient are 0.44 and go up to the value of 0.58. Within the existing analysis, it must be ensured that the linear correlation between the variables does not amount to 0.7 or more, which does not apply in this case. The next condition that is part of the procedure of this method is the diagnosis of collinearity of variables, which can indicate problems with multicollinearity that are often not visible in the correlation matrix. The results of that diagnosis are presented in Table 7, under the title Coefficients in the *Tolerance* and *VIF* (*Variance inflation factor*) columns. *Tolerance* shows how much of the dependent variable is not explained by the variances of the independent variables in the model. When this value is low (lower than 0.1) it indicates a significant correlation with other variables. The second value VIF is the reciprocal of *Tolerance,* and values over 10 would be problematic here. Based on the values from Table 7, we can conclude that the considered model has no problem with multicollinearity. Other important prerequisites are untypical points, normality, linearity, and variance homogeneity. After analysing the *Normal P-P Plot* diagram, we can say that all points lie in a straight diagonal line from the lower left to the upper right corner, which indicates no significant deviation from normality. In the scatterplot of the standardized residuals, the residuals are approximately rectangularly distributed and most of the results are clustered in the centre, which tells us that none of the hypotheses of the model are infringed.

Table 5: Summary of the model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.700[a]	.489	.466	.73544323

a. Predictors: (Constant), REGR factor score for analysis DIGITEntr, REGR factor score for analysis ENTRGroup
b. Dependent Variable: REGR factor score for analysis SUSTDevel
Source: Authors

After the analysis and verification of the model's hypotheses of this statistical method, the evaluation of the model follows. The starting point for this step is the squared value of the coefficient of determination found

in Table 5, under the name Summary of the model in the R Square column and is r2 = 0.489. This indicator shows how much of the dependent variable variance *Sustainable Development* is explained by the model that includes the group of independent variables *Entrepreneurship* and *High-tech (digital) entrepreneurship*. The value of this indicator is 48.90%, which means that the model set in this paper explains 48.90% of the variance of *Sustainable Development*, which is a very significant result. Since the size and characteristics of the sample are quite significant, it is not necessary to include the adjusted value of the given indicator *(Adjusted R Square)*.

Table 6: ANOVA[a]

	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	22.802	2	11.401	21.079	.000[b]
	Residual	23.799	44	.541		
	Total	46.601	46			

a. Dependent Variable: REGR factor score for analysis SUSTDevel
b. Predictors: (Constant), REGR factor score for analysis DIGITEntr, REGR factor score for analysis ENTRGroup
Source: Authors

The statistical significance of the value of the coefficient of determination for the set model is visible in Table 6, ANOVA – analysis of variance, where the results of the tests of the null hypothesis that $r^2 = 0$ are found. Since the value of Sig p = 0.000, which means that $p < 0.05$, the model reaches statistical significance. To establish the contribution of each variable in the model of the predictive dependent variable Sustainable Development, it is necessary to analyse the values presented in Table 7, in the Beta column, in the segment of standard coefficients that allow the comparison. To establish the contribution of each variable in the prediction model for the dependent variable *Sustainable Development*, it is necessary to analyse the values presented in Table 7, in the Beta column, in the segment of standard coefficients that allow the comparison. To determine the contribution of each independent variable, we first find the highest Beta value, which is 0.543 for the Entrepreneurship variable, which means that this variable individually contributes the most to the explanation of the dependent variable, in a relative amount of 54.3%. If we add the value from the column Sig, which is p = 0.000, we can conclude that it is a statistically significant individual contribution in predicting the dependent variable.

Next in size from the aspect of the set model and correlation coefficient is the variable *High-tech (digital) entrepreneurship*, where the value of Beta coefficient is 0.357, which in a relative sense amounts to 35.7% of contribution to predicting the dependent variable with the level of statistical significance in individual contribution based on the value from column Sig, which is p = 0.000. Based on previously analysed data, the set model is completely confirmed.

Conclusion

As a general statement about the conducted research within the set model and the obtained results, we can derive that the set research hypothesis has been confirmed in the form of the existence of a positive correlation at the level of statistical significance between sustainable development as a dependent variable and entrepreneurship and high-tech (digital) entrepreneurship as groups of independent variables. Also, the general goal of the paper as the fundamental motif for research ensured a sizeable understanding of the role of entrepreneurship based on high technology

Table 7: Coefficients[a]

	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-.001	.107		-.009	.993	-.217	.215					
	REGR factor score ENTRGroup	-.547	.109	-.543	-5.015	.000	-.767	-.327	-.584	-.603	-.540	.989	1.01
	REGR factor score DIGITEntr	-.390	.109	-.387	-3.575	.001	-.610	-.170	-.444	-.474	-.385	.989	1.01

a. Dependent Variable: REGR factor score for analysis SUSTDevel
Source: Authors

and digitalization in sustainable development. We are led to this conclusion by the results of the application of the basic research method applied in the paper, standard multiple regression, primarily in the form of the square coefficient of determination, which is R Square, r2=0.489, the interpretation of which leads us to the conclusion that the selected independent variables in the set model explain 48.9% of the variance of the dependent variable in this case of sustainable development. The abovementioned indicator is acceptable due to the high level of variance that is interpreted by the predictor variables, besides the stated indicator and its value which point to the predictive power of each independent variable but within the given combination. By observing the predictive power of each variable, we can say that the correlation coefficients are at a desirable level. Thus, the value of Beta is 0.543 for the entrepreneurship variable, which means that this variable individually contributes most to explaining sustainable development, which in the form of relative value amounts to 54.3%. The variable high-tech (digital) entrepreneurship, where the value of the Beta coefficient is 0.357, which in relative terms, amounts to 35.7% of the contribution to the understanding of sustainable development.

The stated results and their values confirm the research results up to the present, as well as the statements on which the conceptual framework of the paper is based, that entrepreneurial ventures that are to the greatest extent specific in terms of the degree of innovation, especially in the domain of high technologies and the digital area, precisely generate the hypotheses of the concept of sustainable development.

As a limitation of the conducted research, a lack of studies related to digitalization, entrepreneurial activities, and sustainable development can be mentioned. While the conducted research is mostly a one-time occurrence, it also indicates that there is a lack of long-term research that would result in more information for a better understanding of the phenomena within the defined research area.

As future research, we can state that these and similar topics within a narrow area of research are not the result of random selection but can be used as transferable abstract concepts for improving sustainability and digitalization in general. Also, long-term research can be interesting to identify whether and how sustainable business changes occur over time due to the application of digital technologies. Additional research is needed in this area to better understand the relationship between digitalization and sustainability.

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INNOVATIVENESS OF THE AGRI-FOOD SECTOR AS A FUNCTION OF SUSTAINABLE DEVELOPMENT

Inovativnost poljoprivredno-prehrambenog sektora u funkciji održivog razvoja

Abstract

Innovation is very important for sustainable development of countries. In agriculture, innovations shift the focus from mere productivity-based technology to the economic, ecological and social aspects of sustainable development. Given that there is no unique framework for measuring innovation in the agri-food sector, and no single conclusion can be drawn as to which country is the most innovative in agriculture, the subject of the paper is the measurement of innovation in the agri-food sector of the most innovative countries and the Republic of Serbia. The aim of the paper is to prove the necessity of introducing innovations in the agricultural sector of the Republic of Serbia, in accordance with the innovations introduced by more agriculturally innovative countries. Innovative approaches such as precision agriculture and others, which are in line with sustainable development, play an increasingly important role in agriculture. The OLS panel regression on the example of innovative countries and the Republic of Serbia proved that the introduction of innovation in agriculture has a positive impact on sustainable development. Only in the case of inputs used in agriculture, this impact was negative, which is why it is important to introduce modern technologies and innovative approaches in order to increase their productivity, optimization and less use. The Kruskall-Wallis test proved that the Republic of Serbia lags behind agriculturally innovative countries, which is why it is important to follow the example of innovative countries in terms of introducing innovative approaches in agriculture and increasing input productivity.

Keywords: *agri-food sector, innovations, conceptual framework, Republic of Serbia vs. innovative countries, precision agriculture, sustainable development*

Sažetak

Inovacije su veoma važne za održivi razvoj zemalja. Inovacije u poljoprivredi pomeraju akcenat sa tehnologije, koja se odnosi na produktivnost, na ekonomske, ekološke i socijalne aspekte održivog razvoja. S obzirom na to da ne postoji jedinstven okvir za merenje inovativnosti u poljoprivredno-prehrambenom sektoru i ne može se izvesti jedinstven zaključak koja je zemlja najinovativnija u poljoprivredi, predmet rada je merenje inovativnosti u poljoprivredno-prehrambenom sektoru najinovativnijih zemalja i Republike Srbije. Cilj rada je da dokaže neophodnost uvođenja inovacija u poljoprivredni sektor Republike Srbije, u skladu sa inovacijama koje uvode poljoprivredno inovativnije zemlje. Inovativni pristupi kao što su precizna poljoprivreda i drugi, koji su u skladu sa održivim razvojem, igraju sve značajniju ulogu u poljoprivredi. OLS panel regresija na primeru inovativnih zemalja i Republike Srbije dokazala je da uvođenje inovacija u poljoprivredu pozitivno utiče na održivi razvoj. Samo kod inputa koji se koriste u poljoprivredi ovaj uticaj je bio negativan, zbog čega je važno uvesti savremene tehnologije i inovativne pristupe u cilju povećanja njihove produktivnosti, optimizacije i manje upotrebe. Kruskall-Wallis test je pokazao da Republika Srbija zaostaje za poljoprivredno inovativnim zemljama, zbog čega je važno slediti primer inovativnih zemalja u pogledu uvođenja inovativnih pristupa u poljoprivredi i povećanja produktivnosti inputa.

Ključne reči: *poljoprivredno-prehrambeni sektor, inovacije, konceptualni okvir, Republika Srbija naspram inovativnih zemalja, precizna poljoprivreda, održivi razvoj*

Introduction

The agri-food sector is very important in countries, contributing to GDP and national welfare. Constant supply of food results in enormous environmental costs. Improving the system of food production is key to sustainable development. That is why innovations that lead to the sustainable development of the agri-food sector are important [22]. Innovation leads to increased competitiveness of the agri-food sector and overall economic development [13]. Improving the competitiveness of the economy is achieved through the development of innovations and innovative activities [29].

Innovations in agriculture have mostly been related to technology, with the aim of achieving economic goals and increasing productivity. Innovations in agriculture shift the emphasis from technology and productivity to balance in nature and between economic, ecological and social goals of sustainable development [1].

There is a growing interest for these sustainable development goals in the agri-food supply chain. Also, there is an increasing use of new technologies within agriculture 4.0, which significantly affect the sustainability of supply chains [28]. Innovations in the agrarian value chain include agricultural producers, suppliers of agricultural inputs, as well as processors and distributors of finished products [32].

Traditionally, the agri-food sector has a low level of connectivity and application of innovations in business. On the other hand, agriculture is one of the biggest polluters, which is why the application of innovations, in order to reduce soil degradation, water pollution and biodiversity, is very important to achieve the mentioned goals of sustainable development and reduction of climate change. That is why economic and environmental goals, such as profitability and environmental protection, should be linked [23].

The 21st century is characterized by intensive agricultural production that leads to major environmental problems. Such agricultural systems with excessive use of pesticides and fertilizers have negative consequences for biodiversity. This requires a radical transformation of agriculture in order to reduce synthetic inputs [39].

Organic agriculture can be of great importance in overcoming these challenges. A low level of chemical inputs minimizes environmental pollution. That is why "Organic 3.0" is said to be an innovation [26]. The transition from a linear to a circular economy in agriculture can significantly affect the reduction of environmental pollution, while innovations play a significant role in that transition. The application of the circular economy in agriculture means as little as possible external inputs in the production [19]. But these approaches generally do not achieve satisfactory economic results. In contrast to them, precision agriculture, with help of variable application of inputs, achieves both economic and ecological goals [33] and is in line with sustainable development. Automated and autonomous agricultural equipment has the potential to ensure food safety for consumers, reduce environmental pollution and increase labor productivity [15], as well as reduce production costs and maximize profits [16]. In that sense, for the purpose of mapping and monitoring of different crop yields, remote sensing [20] which use the satellite remote sensing [6], as well as geographic information system (GIS) technology [12], unmanned aerial vehicle (UAV), artificial intelligence (AI) [4], [46] etc., are used.

Bearing in mind that the agri-food sector mainly consists of small and medium sized enterprises, greater connection and cooperation between them can lead to the development of technological and eco-innovations, which will further increase their competitive advantage and enable them to use limited resources efficiently [24]. The non-competitiveness of small agricultural households requires solutions such as the development of a Food Hub, digital store, the association of all participants in agribusiness, maintain the connection between the producers and the consumers etc. [30].

The agri-food sector is currently in the era of the development of "Agriculture 4.0", which implies efficient use of resources, automation and digitalization. This implies the use of modern machines, ICT technologies, Internet of Things (IoT), etc. [17]. Innovations driven by digital transformation in agri-food supply chains are the main objective of "Agri-Food 4.0". Cyber-physical systems are the main strengths in applications in precision agriculture, such as robots, drones, sensors, etc. [7].

The fourth agricultural revolution brought technological innovations, such as the IoT, Cloud Computing, artificial intelligence (AI) and etc., which have the potential to improve agriculture. Smart agriculture can provide huge benefits for sustainable agriculture development, in line with increasing productivity and environmental protection [27]. The agri-food sector has a responsible function to provide quality and safe food for the growing population. However, various constraints such as the global pandemic and climate change highlight the importance of innovation in order to overcome them and build an efficient supply chain. That is why it is crucial that manufacturers adopt new technologies and follow the innovative potential of Industry 4.0 technologies in the agri-food sector [21]. Opportunities should be sought in a potential such as better access to new technologies, as well as development of strategic relationships within food supply chain, creating value added products [25]. Further development of information technologies is expected, especially in sectors that modestly used the support of information technologies in their activities, such as agriculture [45].

The subject of the paper, which is based on the author's PhD thesis, is the review and measurement of innovativeness in the agri-food sector of the most innovative countries and the Republic of Serbia (RS), while the goal of the paper is to prove the necessity of introducing innovations into the agricultural sector of RS, in line with the innovations introduced by more agriculturally innovative countries.

According to the defined subject and research goal, the following hypotheses were defined:

H1: The introduction of innovations in the agri-food sector has a positive impact on the economic and sustainable development of countries.

H2: RS lags significantly behind more agriculturally innovative countries.

Material and methods

Innovation in agriculture is challenging for several reasons. First of all, it is important to point out that agri-food systems include many different sub-sectors. Innovations occur along the entire value chain. Therefore, a model

Table 1: Definition of used variables

Label	Definition	Source
	Dependent variables	
HDI	Human Development Index	[36]
GDP_pc	Gross domestic product per capita (GDP per capita)	[43]
	Agricultural independent variables	
Ag_gradu	Share of graduated students in the fields of agriculture, forestry, fisheries and veterinary, in the total number of graduated students of higher education (%)	[37]
Ag_cred	Loans to agriculture, mil. US $	[11]
Ag_fert	The use of mineral fertilizers - t	[38]
Ag_mac	Use of agricultural machinery	[38]
Ag_reg_pla	Registered plant varieties	[41]
Ag_gva/pw	Gross value added per worker in agriculture (productivity)	[43]
Agf_exp	Export of agri-food products (HS classification)	[35]
Ag_In_des	Agri-food industrial design (Locarno classification)	[41]
Ag_tradem	Agri-food trademarks (Nice classification)	[41]
	Control variables	
Ino	Innovation countries vs. Republic of Serbia – Dummy variable	Author's research.
GERD	Expenditure on research and development (% of GDP)	[43]
Ter_enr	Enrollment of students in higher education institutions	[43]
Cred	Domestic loans to the private sector (% of GDP)	[43].
ICT_imp	Import of high technology	[43].
GDP_pc_gr	GDP growth per capita	[43]
Patent	Patents by origin	[41]
Hi_tec_ex	Export of high technology products	[43]
Ind_des	Industrial design	[41]
Tradem	Product trademarks	[41]

Source: Author's research

based on the GII (Global Innovation Index) framework is proposed for measuring innovations in the agri-food sector [8, p. 74]. Based on the GII framework adapted to agri-food sector (Appendix 1), agricultural variables, as well as their associated control variables from GII framework, were used (Table 1).

The research refers to the introduction of innovation in the agri-food sector of RS and ten the most innovative countries [42]: Switzerland, Sweden, USA, UK, Netherlands, Denmark, Finland, Singapore, Germany and Republic of Korea, and its impact on sustainable development. The research was conducted with the OLS panel regression, for the time period 1999-2019. Due to the Hausman test, a random effect was used. The multicollinearity of the variables (Appendix 2) determined research models. This research was conducted with econometric software EViews.

In the second part of the research, the agriculture of RS was compared with the most innovative countries in the field of agriculture. For the comparison of agricultural indicators, for the period 1999-2019, the non-parametric Kruskall-Wallis test was used. This research was conducted with SPSS.

Results and discussions

The general public sees innovation as a key driver of sustainability [31]. In both developed and developing countries it has an important role in achieving sustainable development. Agricultural innovation brings new products and processes to socio-economic use [18].

The impact of innovation on the economic and sustainable development of innovative countries and RS was examined using the following regression equations:

$$GDP\_pc_{i,t} = \alpha + \beta_1 AGRICULTURE_{i,t} + \beta_2 Ino_{i,t} + \beta_{3GERDi,t} + \beta_{4ter\_enri,t} + \beta_{5credi,t} + \beta_{6ICT\_impi,t} + \beta_{7GDP\_pc\_gri,t} + \beta_{8patenti,t} + \beta_{9hi\_tec\_exi,t} + \beta_{10ind\_desi,t} + \beta_{11trdemi,t} + \varepsilon_{i,t} \quad (1)$$

$$HDI_{i,t} = \alpha + \beta_1 AGRICULTURE_{i,t} + \beta_2 Ino_{i,t} + \beta_{3GERDi,t} + \beta_{4ter\_enri,t} + \beta_{5credi,t} + \beta_{6ICT\_impi,t} + \beta_{7GDP\_pc\_gri,t} + \beta_{8patenti,t} + \beta_{9hi\_tec\_exi,t} + \beta_{10ind\_desi,t} + \beta_{11trdemi,t} + \varepsilon_{i,t} \quad (2)$$

where agriculture refers to Ag_gradu, Ag_cred, Ag_fert, Ag_mac, Ag_reg_pla, Ag_gva/pw, Agf_exp, Ag_In_des, Ag_tradem country i in the year t.

As for the introduction of innovations in the agricultural sector and its impact on economic development (Table 2 and Table 3), all agricultural indicators are statistically significant as well as the research models. The share of agricultural, forestry, fishery and veterinary graduates in the total number of higher education graduates (%), the number of agricultural machines, as well as the amount of fertilizer used in agriculture showed a statistically negative impact on economic development, while agricultural loans, registered plant varieties, GVA per to the worker in agriculture

Table 2: Significance of agricultural innovation for economic development of RS and innovative countries - models 1-4

Label	Dependent variable GDP_pc			
	Model 1	Model 2	Model 3	Model 4
Intercept	**-39733.38 (-2.25)	-8034.81 (-0.63)	-462.51 (-0.05)	1215.22 (0.13)
Ag_gradu	***-6057.67 (-3.36)			
Ag_cred		***0.47 (6.65)		
Ag_fert			*-0.01 (-1.66)	
Ag_mac				***-0.01 (-2.62)
Ter_enr	***51156.00 (4.48)			
GERD	-510.41 (-0.27)	***8824.86 (3.82)	387.39 (0.22)	486.05 (0.27)
Cred		***209.24 (5.12)	***211.28 (6.11)	***220.50 (6.37)
ICT_imp		***-661.12 (-4.78)	***-731.37 (-5.01)	***-729.31 (-5.04)
GDP_pc_gr	-333.00 (-1.22)	*458.11 (1.89)	*297.17 (1.35)	*299.79 (1.38)
Ind_des	***0.15 (4.01)		***0.17 (5.72)	***0.16 (5.52)
Ino	***32804.31 (3.23)	-2404.47 (-0.16)	**21345.76 (1.95)	**20608.08 (1.91)
Adjusted R^2	0.49	0.52	0.53	0.54
F-statistic	***21.16	***22.26	***26.37	***27.55

Source: Author's research

Note: beta coefficients in front of parentheses, t-values in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

(productivity), export of agri-food products, agricultural trademarks and industrial design in agriculture showed a statistically positive impact on economic development. In contrast to highly automated production processes, agriculture, despite the automation increase, is still a labor-intensive activity. Raising the level of competitiveness of Serbian agriculture implies increasing the productivity and cost-effectiveness of processes, with the achievement of the lowest possible unit price of production [2]. In order to increase productivity, it is necessary to increase the financing of innovation [40].

Considering that only agriculture inputs had a negative impact on economic development, increasing their productivity by introducing new technologies and efficient use must be imperative. Given that the world's population is expected to grow and there are significant climate changes, the digitization of agriculture can help to overcome these challenges. Digital tools will enable

Table 3: Significance of agricultural innovation for economic development of RS and innovative countries - models 5-9

Label	Dependent variable GDP_pc				
	Model 5	Model 6	Model 7	Model 8	Model 9
Intercept	-839.33 (-0.06)	-1516.15 (-0.17)	529.68 (0.04)	-4693.19 (-0.55)	-6172.91 (-0.58)
Ag_reg_pla	*3.92 (1.70)				
Ag_gva/pw		**0.12 (2.25)			
Agf_exp			***0.01 (4.11)		
Ag_In_des				***1.33 (5.57)	
Ag_tradem					***0.08 (4.86)
GERD	*3598.11 (1.80)	1499.01 (1.01)	1522.36 (1.09)	**3039.50 (2.08)	***3445.92 (2.38)
Cred	*79.80 (1.66)	***189.43 (5.92)	***106.76 (3.51)	***257.97 (7.74)	***221.56 (6.35)
ICT_imp	224.50 (0.73)	***-680.45 (-4.86)		***-791.28 (-5.58)	-10.75 (-0.07)
GDP_pc_gr		*313.06 (1.51)		**436.88 (2.02)	192.35 (1.02)
Hi_tec_ex			0.01 (0.65)		
Ind_des		***0.15 (5.20)			
Ino	*27173.93 (1.79)	*15177.26 (1.53)	*21685.06 (1.65)	*16194.09 (1.66)	12314.48 (1.04)
Adjusted R^2	0.17	0.54	0.23	0.52	0.34
F-statistic	***4.38	***30.81	***8.26	***32.71	***13.95

Source: Author's research

Note: beta coefficients in front of parentheses, t-values in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table 4: Significance of agricultural innovation for sustainable development of RS and innovative countries – models 1 - 4

Label	Dependent variable HDI			
	Model 1	Model 2	Model 3	Model 4
Intercept	***0.73 (21.14)	***0.78 (67.07)	***0.77 (73.67)	***0.77 (75.65)
Ag_gradu	***-0.02 (-4.73)			
Ag_cred		***0.01 (3.63)		
Ag_fert			**-0.01 (-2.34)	
Ag_mac				***-0.01 (-3.12)
Ter_enr	***0.07 (3.12)			
GERD	***0.01 (3.05)	*0.01 (1.43)	***0.01 (3.27)	***0.01 (3.30)
Cred		0.01 (0.19)	***0.01 (3.76)	***0.01 (3.99)
ICT_imp		***-0.01 (-7.69)	***-0.01 (-8.69)	***-0.01 (-8.69)
GDP_pc_gr	0.00 (-0.77)	0.01 (0.78)	0.01 (1.25)	0.01 (1.23)
Ind_des	***0.01 (3.95)		***0.01 (5.51)	***0.01 (5.61)
Ino	***0.08 (4.36)	***0.13 (8.11)	***0.10 (7.89)	***0.10 (7.86)
Adjusted R^2	0.63	0.61	0.68	0.68
F-statistic	***37.23	***31.49	***48.71	***50.33

Source: Author's research

Note: beta coefficients in front of parentheses, t-values in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

production to grow in a way that reduces the stress on ecosystems [14], in line with sustainable development.

Regarding the impact of innovation in agriculture on sustainable development of the RS and innovative countries (Table 4 and Table 5), in relation to economic development, there are no significant differences. All observed models, as well as agricultural indicators, except registered plant varieties, are statistically significant. Agriculture inputs (agricultural students, number of agricultural machines, amount of fertilizer used in agriculture) have a statistical negative impact on sustainable development, while agricultural loans, registered plant varieties, GVA per worker in agriculture (productivity), export of agri-food products, agricultural trademarks and industrial design in agriculture, have a statistically positive impact on sustainable development. In that sense, innovative approaches must be introduced in agriculture in order to reduce and efficiently use inputs, which will also increase the productivity of agriculture (GVA per worker), as well as registered plant varieties, agricultural trademarks and design etc.

The agri-food sector requires a good technological, social, economic and ecological connection [10]. Sustainable agriculture is based on quality, environmentally friendly and more socially responsible system. Therefore, there are more and more initiatives in agri-food sector towards sustainable development [5].

All agricultural indicators used to analyze the introduction of innovation in the agricultural sector had a statistically positive impact both on economic and sustainable development, except the inputs. In the continuation of the research, the agriculture of RS was compared with the most innovative countries in the field of agriculture.

The agriculture of RS lags behind the agriculturally innovative countries according to all observed indicators, observed in relation to each agriculturally innovative country separately (Table 6), as well as in relation to agriculturally innovative countries in total (Appendix 3). The agri-food sector is very complex and constantly changing. Today, robotics, biotechnological and digital technologies are applied in all areas, including agri-food production, especially in developed countries [8]. Although agriculture has experienced significant changes, it is still going through the age of innovation, digital development and environmental protection. The development of this sector moves from economic to sustainable development [3]. Smart agriculture enables such goals and implies the modernization and use of 4.0 technologies, which include IoT, big data, digitization, which further facilitates the use of data and leads to new innovations [21]. The Republic of Serbia should follow the development of the fourth industrial revolution and apply important technologies

Table 5: Significance of agricultural innovation for sustainable development of RS and innovative countries - models 5 - 9

Label	Dependent variable HDI				
	Model 5	Model 6	Model 7	Model 8	Model 9
Intercept	***0.79 (59.93)	***0.77 (75.33)	***0.78 (82.37)	***0.77 (87.44)	***0.76 (69.35)
Ag_reg_pla	0.01 (0.87)				
Ag_gva/pw		***0.01 (4.50)			
Agf_exp			**0.01 (1.97)		
Ag_In_des				***0.01 (5.90)	
Ag_tradem					***0.01 (6.58)
GERD	0.01 (1.20)	***0.01 (4.45)	**0.01 (1.90)	***0.01 (4.57)	***0.01 (4.06)
Cred	-0.01 (-1.55)	***0.01 (2.86)	0.00 (-0.27)	***0.01 (4.41)	***0.01 (3.68)
ICT_imp	0.01 (1.40)	***-0.01 (-8.51)		***-0.01 (-9.59)	***-0.01 (-2.42)
GDP_pc_gr		*0.01 (1.89)		*0.01 (1.54)	*0.01 (1.44)
Hi_tec_ex			0.00 (-1.04)		
Ind_des		***0.01 (4.63)			
Ino	***0.14 (7.98)	***0.09 (6.71)	***0.13 (9.97)	***0.10 (9.14)	***0.09 (6.33)
Adjusted R^2	0.57	0.68	0.63	0.67	0.59
F-statistic	***22.57	***54.20	***42.46	***61.37	***35.91

Source: Author's research

Note: beta coefficients in front of parentheses, t-values in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

in its business, such as artificial intelligence, blockchain, robotics, cloud computing, etc. [34]. Innovation data sources focus mainly on the industrial production and services sector, often excluding primary agriculture. However, innovations are also introduced at the farm level, not only in agricultural enterprises, which makes it difficult to collect data on it. From a statistical point of view, the recording of activities on farms has its own specificities in relation to legal entities. As a result, the perception of innovation in the agri-food system is difficult [8]. Precisely because of this, the unavailability of certain data is a limitation of this paper, especially

Table 6: The difference in terms of agricultural innovation in RS and countries that are innovative in the field of agriculture

Name	Country	Mean Rank
ODA education in agriculture	Afghanistan	75.35
	Ethiopia	66.44
	China	55.08
	Indonesia	31.95
	Uganda	72.33
	Serbia	22.72
Chi-Square		***43.179
Expenditure on research and development in agriculture (in US$ 000)	India	44.00
	Korea	31.79
	China	19.20
	Netherlands	33.71
	Australia	20.33
	Serbia	7.71
Chi-Square		***34.418
ODA research and development in agriculture	Nigeria	45.24
	Argentina	21.05
	India	83.95
	Uganda	66.37
	Ethiopia	71.48
	Serbia	14.22
Chi-Square		***66.858
Percentage of graduated students in agricultural sciences (calculation based on the share of graduated students in the field of agriculture, forestry, fisheries and veterinary science in the total number of graduated students of higher education, in %)	Ethiopia	40.14
	Uzbekistan	42.75
	Cambodia	16.00
	Vietnam	35.13
	Albania	19.92
	Serbia	12.82
Chi-Square		***30.346
Loans to agriculture (calculation based on loans to agriculture in million US $)	USA	80.57
	Germany	61.14
	Australia	51.38
	France	81.88
	New Zealand	32.00
	Serbia	6.50
Chi-Square		***65.125
Loans to agriculture (calculation based on participation in total US$ loans, in %)	New Zealand	70.29
	Uruguay	60.52
	Kyrgyzstan	55.52
	Tajikistan	75.25
	Bolivia	41.33
	Serbia	16.83
Chi-Square		***32.467
Fertilizer application -t	China	99.50
	India	75.44
	USA	69.56
	Brazil	45.33
	Indonesia	27.67
	Serbia	9.50
Chi-Square		***101.273
Use of machines	China	89.67
	India	70.39
	USA	66.06
	Japan	38.61
	Poland	22.78
	Serbia	6.50
Chi-Square		***89.773
Productivity in agriculture - GVA per worker	Slovenia	39.71
	Bahrain	38.07
	Luxembourg	74.81
	Belgium	80.10
	Serbia	11.00
Chi-Square		***84.201
Export of agri-food products - mil. US $	USA	55.50
	Netherlands	44.20
	Germany	36.40
	Brazil	18.85
	China	16.55
	Serbia	11.50
Chi-Square		***50.502
Registered plant varieties - overall application	Netherlands	46.83
	China	40.17
	USA	36.00
	France	19.94
	Germany	17.06
	Serbia	5.00
Chi-Square		***46.509
Trademark - application in the agri-food sector (Nice classification)	China	86.13
	Korea	45.38
	Turkey	42.38
	Italy	63.88
	Russia	44.63
	Serbia	8.63
Chi-Square		***68.131

Source: Author's research, based on [11], [37], [38], [41], [43], [44]
Note: *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

for precision agriculture, such as number of drones, multipurpose machines etc.

Conclusions

When researching innovation in agriculture, one of the main limitations is that there is no unique framework, nor a precise measure of innovation. In the GII framework, adapted to the agri-food sector, indicators are used do not reflect innovation in the best way, and even can show a negative impact on sustainable development, such as the use of inadequate mechanization, given that this indicator covers the use of all machines in agriculture, such as tractors, attachment machines, etc., which from the aspect of innovation should be replaced by new ones, for example, multipurpose machines with automatic guidance, drones, machines that use renewable energy sources and thus do not pollute the environment. Also, experts who are able to use these technologies and who can create them should be educated. The use of chemical fertilizers should be reduced and replaced with organic fertilizers, in line with sustainable development. This is the only way to change the currently used inputs in agriculture and to increase their productivity, in line with sustainable development. Also, only education in this direction can create experts capable of such technologies. On the other hand, many developed countries record a decrease in the use of agricultural machinery and fertilizers, which are replaced by modern technologies. Today, robotics, biotechnological and digital technologies are applied in the agri-food sector, especially in developed countries, and indicators of their application, which can be used to quantify these changes, are not entirely available.

Furthermore, not every GII indicator has the same indicator adapted for the agri-food sector, which is why the GII framework for the agri-food sector is incomplete, but there is no better generally accepted framework. On the other hand, in this research, it was not possible to point out to the agriculturally innovative countries within one sample, like innovative countries, because, depending on the observation indicators, these are different countries. In contrast to the innovative countries of the world that can be more simply ranked, this cannot be also refers to agriculturally innovative countries, so it was therefore not possible to draw a single conclusion as to which country is the most innovative in agriculture.

The special contribution of this paper, which is based on the author's PhD thesis, is that the innovativeness of the agri-food sector of RS was investigated in a new way and compared with other innovative countries in this sector, which gave clear recommendations for the creators of the agrarian policy of RS and other countries. Also, for the first time, with this framework, the impact and importance of innovation in agri-food sector on the sustainable development of countries was examined. The introduction of new and sustainable approaches in agricultural development is a topic that has not been sufficiently researched, especially empirically. At the same time, measuring agricultural innovation represents an important challenge, because a unique system for measuring innovation in the agri-food sector has not yet been developed. It is a topic that, as it is estimated, will be increasingly relevant in the future, and accordingly, it will require new approaches and knowledge, applicable in practice. The measurement of innovation, both in the primary and in other economic sectors, is a recommendation for future research, given the unexplored nature of this topic and its great importance.

Measuring innovation in agriculture is a challenge, and the GII framework adapted to the agri-food sector was used to prove hypotheses and measure innovation. Regarding the first hypothesis, the research indicated that the agricultural indicators used to show the introduction of innovation in agriculture have a positive impact, both on economic and sustainable development, except the agriculture inputs. That is why it is important to innovate inputs, in order to increase their productivity, and not only increase their number, which can often create additional costs and have a negative impact on productivity, as well as on economic and sustainable development. Also, it is important to introduce innovative approaches in agricultural production, such as precision agriculture, considering the positive impact on sustainable development, as well as increasing the productivity of inputs, considering that the productivity of agriculture inputs also has a positive impact on both the economic

and sustainable development of the observed countries. All of this is especially important to apply and introduce more intensively in RS, considering that it lags significantly behind more agriculturally innovative countries, which also proves the second hypothesis.

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Appendix 1

Adaptation of the GII framework for the agri-food sector

GII pillars	GII indicator	Are indicators available for the agri-food sector?	Appropriate indicator in the agri-food sector	Additional indicators
Human capital and research	Expenditure on education	For just a few economies	/	/
	Tertiary enrollment	Yes	Tertiary education students on agricultural programs	/
	Graduate students	Yes	ODA for agricultural education / training	/
	Researchers	Yes	Agricultural researchers	/
	Gross expenditure on R&D	Yes	Expenditure on R&D in agriculture	ODA for agricultural research
	Global spending by companies on R&D, average spending	Not	/	/
	QS (Quacquarelli Symonds) university rankings	Not	/	/
Market sophistication	Ease of getting a loan	For just a few economies	/	/
	Domestic loans to the private sector	Yes	Loans to agriculture	/
	Gross microfinance loans	For just a few economies	/	/
	Venture Capital Offers	Not	/	/
	Customs duty rate applied	Yes	Applied customs rate for agricultural and food products	/
	Intensity of local competition	Not	/	/
Business sophistication	Knowledge - intensive employment	/	/	/
	Firms that offer formal training	Yes	Firms that offer formal training in food processing	/
	GERD (Gross expenditure on research and development) business derived	For just a few economies	/	/
	GERD funded from operations	Not	/	/
	Employed women with / diplomas of higher education	Not	/	/
	University / industrial cooperation in research	Not	/	/
	State of cluster development	Not	/	/
	Foreign funded GERD	Not	/	/
	JV (Joint Ventures) – joint investments	Not	/	/
	Patents	Yes	Agricultural and food patents	/
	International payments	Not	/	/
	Import of high technology	Yes	Import of high technology for the agricultural and food sector	Fertilizer use, machinery in use
	Net inflow of FDI	Yes	Inflows of foreign investments in the agricultural and food sector	/
Results of knowledge and technology	Patents by origin	Yes	Agricultural and food patents according to origin	Registered plant varieties
	PCT (Patent Cooperation Treaty) patent applications	Yes	Agri-food PCT patent applications	/
	Useful models by origin	Yes	Agricultural and food utility models according to origin	/
	Scientific and technical works	Yes	Scientific and technical works in agriculture	/
	Available documents by H index	Yes	Available documents in the agricultural and food sector	/
	Growth rate of GDP per worker, PPP (purchasing power parity) $	Yes	Growth of labor productivity in agriculture	/
	New businesses	Not	/	/
	ISO 9001 quality certificates	Not	/	/
	IP receipts	Not	/	/
	Export of high technology	Yes	Export of agricultural and food products	/
	Net FDI outflows	Yes	FDI outflows from agriculture	/
Creative output	Trademarks	Yes	Agricultural and food protective trademarks	It does not register geographical indications
	Industrial design	Yes	Agricultural and food industrial design	/
	ICT and business model creation	Not	/	/
	ICT and the creation of an organizational model	Not	/	/

Source: [8, p. 74]

Appendix 2

Multicollinearity of variables

Label	GDP_pc	HDI	Ag_gradu	Ag_cred	Ag_fert	Ag_mac	Ag_reg_pla	Ag_gva/pw	Agf_exp	Ag_In_des	Ag_tradem	GERD	Ter_enr	Cred	ICT_imp	GDP_pc_gr	Patent	Hi_tec_ex	Ind_des	Tradem	Ino
GDP_ Pc	1.00																				
HDI	*** 0.87	1.00																			
Ag_gradu	*** -0.54	*** -0.56	1.00																		
Ag_cred	* 0.36	** 0.36	*** -0.55	1.00																	
Ag_fert	** 0.38	0.20	** -0.42	*** 0.85	1.00																
Ag_mac	* 0.32	0.16	** -0.39	*** 0.86	*** 0.99	1.00															
Ag_reg_pla	* 0.36	* 0.27	*** -0.48	*** 0.95	*** 0.94	*** 0.95	1.00														
Ag_gva/pw	*** 0.65	*** 0.62	* -0.26	*** 0.58	*** 0.67	*** 0.64	*** 0.59	1.00													
Agf_exp	** 0.37	** 0.37	*** -0.44	*** 0.96	*** 0.82	*** 0.83	*** 0.91	*** 0.59	1.00												
Ag_In_des	* 0.30	* 0.36	* -0.26	*** 0.74	*** 0.48	*** 0.48	*** 0.61	** 0.41	*** 0.80	1.00											
Ag_tradem	* 0.34	*** 0.45	*** -0.43	*** 0.78	*** 0.45	*** 0.45	*** 0.60	*** 0.46	*** 0.83	*** 0.86	1.00										
GERD	*** 0.49	*** 0.65	-0.23	* 0.25	0.11	0.11	* 0.27	* 0.32	0.20	0.10	0.05	1.00									
Ter_enr	0.11	-0.18	0.07	0.02	** 0.38	* 0.34	0.10	** 0.40	0.09	0.02	0.04	*** -0.65	1.00								
Cred	*** 0.69	*** 0.60	*** -0.85	*** 0.67	*** 0.66	*** 0.63	*** 0.67	*** 0.57	*** 0.57	* 0.30	*** 0.44	* 0.32	0.09	1.00							
ICT_ imp	* 0.35	** 0.41	*** -0.75	** 0.44	** 0.39	** 0.38	** 0.45	0.11	** 0.39	0.18	0.18	* 0.33	-0.20	*** 0.50	1.00						
GDP_pc_gr	** -0.40	* -0.32	-0.09	0.14	0.04	0.07	0.11	* -0.33	0.05	0.04	0.01	-0.20	-0.18	-0.05	0.20	1.00					
Patent	* 0.34	* 0.27	*** -0.50	*** 0.94	*** 0.94	*** 0.95	*** 0.99	*** 0.58	*** 0.87	*** 0.55	*** 0.53	* 0.32	0.05	*** 0.68	*** 0.49	0.13	1.00				
Hi_tec_ex	** 0.35	*** 0.44	*** -0.67	*** 0.91	*** 0.64	*** 0.65	*** 0.82	* 0.33	*** 0.89	*** 0.71	*** 0.77	* 0.34	-0.24	*** 0.61	*** 0.65	0.19	*** 0.80	1.00			
Ind_des	* 0.32	** 0.44	*** -0.57	*** 0.93	*** 0.63	*** 0.65	*** 0.83	** 0.44	*** 0.88	*** 0.75	*** 0.83	** 0.39	* -0.25	*** 0.62	** 0.42	0.15	*** 0.82	*** 0.93	1.00		
Tradem	*** 0.43	** 0.40	*** -0.54	*** 0.97	*** 0.85	*** 0.85	*** 0.91	*** 0.66	*** 0.96	*** 0.78	*** 0.84	0.12	0.21	*** 0.68	** 0.36	0.05	*** 0.88	*** 0.84	*** 0.88	1.00	
Ino	*** 0.81	*** 0.97	*** -0.64	** 0.40	0.23	0.19	* 0.30	*** 0.62	** 0.38	* 0.30	*** 0.44	*** 0.68	-0.22	*** 0.68	*** 0.45	* -0.29	* 0.32	*** 0.48	*** 0.48	** 0.41	1.00

Source: Author's research

Note: *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Appendix 3

The difference in the agricultural innovation of RS and agriculturally innovative countries

Label	Country	Mean Rank
ODA education in agriculture	Agriculturally innovative	58.97
	Serbia	22.72
	Chi-Square	***18.894
Expenditure on research and development in agriculture (in US$ 000)	Agriculturally innovative	29.40
	Serbia	7.71
	Chi-Square	***27.206
ODA research and development in agriculture	Agriculturally innovative	57.65
	Serbia	14.22
	Chi-Square	***16.150
Percentage of graduated students in agricultural sciences (calculation based on the share of graduated students in the field of agriculture, forestry, fisheries and veterinary science in the total number of graduated students of higher education, in %)	Agriculturally innovative	28.53
	Serbia	12.82
	Chi-Square	***10.311
Loans to agriculture (calculation based on loans to agriculture in million US $)	Agriculturally innovative	58.50
	Serbia	6.50
	Chi-Square	***31.543
Loans to agriculture (calculation based on participation in total US$ loans, in %)	Agriculturally innovative	59.21
	Serbia	16.83
	Chi-Square	***19.524
Fertilizer application -t	Agriculturally innovative	63.50
	Serbia	9.50
	Chi-Square	***44.587
Use of machines	Agriculturally innovative	57.50
	Serbia	6.50
	Chi-Square	***31.456
Productivity in agriculture - GVA per worker	Agriculturally innovative	60.00
	Serbia	11.00
	Chi-Square	***49.00
Export of agri-food products - mil. US $	Agriculturally innovative	34.30
	Serbia	11.50
	Chi-Square	***14.217
Registered plant varieties - overall application	Agriculturally innovative	32.00
	Serbia	5.00
	Chi-Square	***22.093
Trademark - application in the agri-food sector (Nice classification)	Agriculturally innovative	56.48
	Serbia	8.63
	Chi-Square	***39.341

Source: Author's research, based on [11], [37], [38], [41], [43], [44]
Note: *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

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