Vol. 57 No. 3/2024

ISSN 1821-2573
ISSN 2560-3949 (online)

ECONOMIC ANALYSIS

1958
COGNOSCERE EST MUTARE

Institute of Economic Sciences

Vol. 57 No. 3/2024
Economic Analysis: ***Applied Research in Emerging Markets***
ISSN 1821-2573 = Economic Analysis
ISSN 2560-3949 (online)
UDC 33
COBISS.SR-ID 169576460
First Published 1967

PUBLISHER
Institute of Economic Sciences
12 Zmaj Jovina street
11000 Belgrade, Serbia
www.ien.bg.ac.rs

Publishing of this issue of the Economic Analysis: Applied Research in Emerging Markets is financed by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia

Our journal is indexed in international databases: EBSCO Publishing Inc, ERIH PLUS, CEEOL and Research Papers in Economics (RePEc), Directory of Open Access Journals (DOAJ).

The Journal is approved by the Ministry of Education, Science and Technological Development Republic of Serbia. In 2018 it has been in category M51.

1958
INSTITUT
EKONOMSKIH
NAUKA
COGNOSCERE EST MUTARE

EDITORIAL BOARD

Dalibor Tomaš, Faculty of Economics, Univesity of Banja Luka, Republic of Srpska
Elena Nikolova, College of Interdisciplinary Studies at Zayed University, UAE

C O N T E N T S

Vol. 57 **No. 3/2024**

DOI: 10.28934/ea.24.57.3.pp1-8 First Online: May 6, 2024

ORIGINAL SCIENTIFIC PAPER

Public Revenue and Public Expenditure as Predictors of Economic Growth: The Case of BRICS Countries

Jadranka Đurović Todorović[1] | **Marina Đorđević**[1] | **Branimir Kalaš**[2]*

[1] University of Niš, Faculty of Economics, Department for National Economy and Finance, Niš, Serbia
[2] University of Novi Sad, Faculty of Economics in Subotica, Department for Financial and Banking Management, Subotica, Serbia

ABSTRACT
Public revenue and public expenditure represent essential components for economic progress and prosperity. The optimal balance between public revenue and public expenditure could have positive and lucrative implications for economic growth. This paper aims to highlight the interaction between these components analyzing their relationship in the short- and long-run. The subject of the research implies the nexus between public revenue, public expenditure and economic growth in BRICS countries from 2006 to 2023. We applied static and dynamic panel models to provide a detailed analysis of potential indications of public revenue and public expenditure on economic growth. The obtained findings point out that public revenue and public expenditure significantly affect economic growth, with the greatest impact registered in China and India. The contribution of the research implies new specific insights and perspectives for policymakers in BRICS from the aspect of identifying optimal fiscal policy, as well as making decisions related to revenue-expenditure components and their implications on economic growth.

Keywords: *public revenue, public expenditure, economic growth, BRICS countries*

JEL Classification: H20, H50, O40

INTRODUCTION

The term BRICS was initially defined by Jim O'Neill in his report (Jim O'Neill, 2001) to refer to a collective of nations comprising Brazil, Russia, India, China, and South Africa. Namely, Molefe and Mah (2020) and Banday et al. (2021) define this group as a partnership recognized for its rapidly expanding economies, which have substantial effects on local and global economic activities. Similarly, Zharikov (2021) highlights the positive potential of BRICS in reshaping the global economic system and supporting the world economy. Accordingly, BRICS stands out as one of the dominant trade integration blocks (Chhabra et al. 2023) and plays a substantial role in the global economy (Li, 2021), with significant contributions in terms of population, gross domestic product, land coverage, world trade, and global exchange reserves (Iqbal, 2021). Therefore, the issue of economic growth of BRICS is gaining more place and importance in theoretical and empirical studies. In our study, we focus on fiscal and government determinants such as public revenue and public expenditure that can influence overall economic growth. Public revenue and public expenditure play crucial roles in influencing economic growth. Based on Glavaški et al. (2022),

* Corresponding author, e-mail: branimir.kalas@ef.uns.ac.rs

determining the causal relationship between revenue and expenditure may seem straightforward at first glance. Ensuring an adequate revenue collection and productive expenditure level creates preconditions for intensive economic growth and development. Arvin et al. (2021) highlighted that tax revenue and public expenditure are important drivers of economic growth in the long run. When the government collects more revenue than it spends, it can decline budget deficits, lower public debt levels, and potentially stimulate economic growth through increased investment. On the other hand, excessive government spending without sufficient revenue can lead to budget deficits, greater inflation, and crowding out private investment, which may hinder economic growth. Therefore, the composition of public expenditure also matters for economic growth. Conversely, excessive spending on unproductive sectors or inefficient programs may not yield significant economic benefits and could potentially crowd out private investment. Likewise, Nzimande and Ngalawa (2022) indicate that any rise in current expenditure would inevitably require a subsequent increase in future taxation. Based on the above-mentioned, we can conclude that a balanced approach to public revenue generation and public expenditure management is essential for sustainable economic growth. By ensuring that public revenue is efficiently collected and spent on productive investments, governments can create an enabling environment for economic progress and development.

The paper's structure is outlined as follows. After the introduction, a literature review includes previous empirical studies on the nexus between public revenue, public expenditure and economic growth. The third section covers methodology and data with variable selection and description and developed hypotheses. The fourth section presents the empirical results of applied dynamic models to provide the effects of public revenue and public expenditure on economic growth in BRICS countries (Brazil, Russia, India, China, and South Africa) from 2006 to 2023. The last section provides a summary of findings and conclusions, along with recommendations for future research.

LITERATURE REVIEW

The interaction between public revenue, public expenditure and economic growth is often the subject of theoretical and empirical analyses aimed at identifying their potentially causal relationship. Đurović Todorović et al. (2019) confirmed a positive correlation between direct tax revenue and GDP growth rate in OECD countries from 1996 to 2016. Furthermore, Joseph and Omodero (2020) identified the positive influence of tax revenue on gross domestic product in Nigeria for the period 1981-2018. In contrast, Onifade et al. (2020) found no causality between public expenditure and real GDP in Nigeria for the period 1981-2017. The study of Chu et al. (2020) confirmed the significance of public expenditure for economic growth in the sample of 59 countries (37 high-income and 22 low—to middle-income countries) for the period 1993-2012. Neog and Gaur (2020) found a positive impact of tax revenue such as taxes on property and taxes on capital transactions, as well as a negative influence of income tax and service taxes on economic growth. For instance, Gurdal et al. (2021) investigated the relationship between tax revenue, public expenditure and economic growth in G7 economies for the period 1980-2016. Their findings of applied frequency domain causality indicated short-run and long-run causality between economic growth and tax revenue, and long-run causality between economic growth and public expenditure. Also, Ansari et al. (2021) confirmed the unidirectional causality between public spending and economic growth in the analysis of the BRICS-SAARC-ASEAN region for the period 1991-2019. Bidirectional causality between GDP and public expenditure was also found in the study of Ghazy et al. (2021) which analyzed their relationship in Egypt from 1960 to 2018. Using the Generalized Linear Model, the results of Onofrei et al. (2022) verified the significant and positive impact of selected revenue and expenditure indicators on GDP per capita in 21 EU countries from 2001 to 2019. Kirikkaleli and Ozbeser (2022) conducted research on the relationship between public expenditure and economic growth in the U.S. from 1960 to 2019. Their findings identified that economic growth stimulates public expenditure in the long run,

while public expenditure positively affects economic growth in the short run. Employing the ARDL model, Poku et al. (2022) confirmed that public expenditure has a positive effect on economic growth in the short run in Ghana for the period 1970-2016. Tendengu et al. (2022) confirmed a positive relationship between fiscal policy indicators and economic growth in South Africa for the period 1988-2018. On the other hand, Nguyen and Ngyen (2023) suggest that there is a positive effect of government spending on economic growth, while tax revenue negatively changes with economic growth in Vietnam.

Based on the cited studies, one can observe the importance of the relationship between public revenue and public expenditure and its significance for economic growth. Examining these components through the sample of BRICS countries expands the existing theoretical opus and contributes to new insight regarding the relationship of these variables.

METHODOLOGY AND DATA

The paper analyzes the relationship between public revenue, public expenditure and economic growth in BRICS countries (Brazil, Russia, India, China, and South Africa). We used an annual data series from the International Monetary Fund Database for the period 2006-2023. The variable selection and description are presented in Table 1.

Table 1. Variable description

Variable	Abbreviation	Calculation	Expected effect
Gross domestic product	GDP	annual rate	/
Public revenue	GR	% of GDP	+
Public expenditure	GE	% of GDP	-

Source: Authors' illustration

Considering the identified research's objective, the paper includes one general hypothesis and two auxiliary hypotheses:

H_1: There is a significant relationship between public revenue, public expenditure and economic growth in BRICS countries in the long run.

$H_{1.1}$: Public revenue positively affects the economic growth in BRICS countries in the long run.

$H_{1.2}$: Public expenditure negatively affects the economic growth in BRICS countries in the long run.

RESULTS AND DISCUSSION

This section of the paper comprises descriptive analysis, panel unit root tests and static and dynamic models to estimate the potential effects of public revenue and public expenditure on economic growth in BRICS for the period 2006-2023. Descriptive analysis is presented in Table 2.

Table 2. Descriptive statistics

Variable	Mean	Std. dev.	Max.	Min.
Brazil				
GR	40.023	1.291	43.278	38.046
GE	44.941	3.074	49.915	41.581
GDP	2.063	3.168	7.528	-3546
Russia				
GR	34.422	1.668	37.527	31.887
GE	34.615	2.398	39.153	29.04

Variable	Mean	Std. dev.	Max.	Min.
GDP	2.069	4.018	8.55	-7.821
India				
GR	19.616	0.814	21.962	18.177
GE	27.563	1.279	31.057	26.22
GDP	6.541	3.571	10.26	-5.831
China				
GR	25.905	3.521	29.232	17.195
GE	28.975	5.286	35.403	18.151
GDP	7.854	2.987	14.247	2.242
South Africa				
GR	34.422	1.668	37.527	31.887
GE	34.615	2.398	39.153	29.04
GDP	1.759	2.639	5.604	-5.963
BRICS				
GR	30.877	7.518	43.278	17.195
GE	34.142	6.891	49.915	18.151
GDP	4.057	4.160	14.247	-7.821

Source: Authors' calculation

Table 2 includes individual and group descriptive analysis of public revenue, public expenditure and gross domestic product for BRICS countries from 2006 to 2023. The average GDP growth rate was 4.057%, where China and India registered the greatest growth rates of 7.85% and 6.541% at average level. For instance, Brazil and Russia had similar mean growth rates of around 2%, while South Africa achieved an average GDP growth of 1.76%. Analyzing public revenue and public expenditure, the average shares were 30.88% and 34.14 of GDP. The highest shares of these variables were identified in Brazil (40.02% and 44.94% of GDP). At the same time, India registered the smallest shares of public revenue (19.62% of GDP) and public expenditure (27.56% of GDP) in the observed period.

Table 3. Panel unit root tests

Variable	GDP	GR	GE
LLC test			
Level	-6.428***	-5.957***	-4.389***
First diff.	-11.235***	-8.516***	-8.483***
IPS test			
Level	-3.465***	-2.799***	-2.820**
First diff.	-6.661***	-3.956***	-4.844***
Breitung test			
Level	-1.767	-0.444	-0.151
First diff.	-6.836***	-4.312***	-5.424***

Source: Authors' calculation

The results of applied unit root tests indicated that selected variables are stationary (LLC test), and non-stationary (Breitung test) at a significance level of 1%. The values of the IPS test indicate that GDP and GR are stationary at a level of 1%, while GE is stationary at a level of 5%.

Table 4. Static models

Model / Variable	RE	FE
GR	0.382***	0.461***
GE	-0.796***	-0.830***
R-squared	0.383	0.341
Hausman test	63.58 (0.000)	

Source: Authors' calculation

Table 4 includes a random-effects model and a fixed-effects model to identify how public revenue and public expenditure influence economic growth, measured by the GDP growth rate. The results of the Hausman test showed that the fixed-effects model is an appropriate model which confirmed a significant and positive impact of public revenue. Specifically, a 1% increase in GR leads to a GDP growth rate increase of 0.46%. Conversely, public expenditure negatively affects GDP, which implies that a higher GE level of 1% declines GDP by 0.83%.

Table 5. Dynamic models

Model	PMG		MG	
Variable	**Short-run**	**Long-run**	**Short-run**	**Long-run**
GR	0.062	0.350***	0.139	0.563***
GE	-0.642**	-0.703***	-0.571	-0.684***
ECT	-1.040***		-1.147***	
Hausman test	1.02 (0.601)			

Source: Authors' calculation

After static models, we applied dynamic models such as Pooled Mean Group Estimators (PMG) and Mean Group Estimator (MG) to identify the effect of public revenue and public expenditure on economic growth in the short-run and long-run. Based on the Hausman test, PMG is a proper model for estimating the influence of selected variables on economic growth. The speed of adjustment (ECT) is significant and negative and affirms a long-run equilibrium between observed variables. The effects of public expenditure are significant in the short run and long run, while public revenue significantly affects economic growth only in the long run. Specifically for the long-run period, a 1% increase in GR enhances GDP by 0.35%, while the same growth of GE decreases GDP by 0.70%. This means that public revenue has a greater impact on economic growth compared to public revenue in BRICS countries for the observed period.

Table 6. PMG estimator by country

Variables	Brazil	Russia	India	China	South Africa
ΔGR	0.195*	0.246*	0.451**	0.566***	0.372**
ΔGE	-0.247*	-0.412*	-0.764***	-0.602***	-0.183***
ECT	-1.027	-1.289	-0.890	-1.159	-0.837

*Note: the asterisks *, **,*** indicate significance level of 10%, 5% and 1%*

Source: Authors' calculation

Table 6 represents the results of the selected PMG estimator by country to provide a detailed analysis of the potential relationship between public revenue and public expenditure and economic growth measured by gross domestic product by country. We can notice that the value of ECT is negative, which implies the presence of dynamic stability among observed variables. Therefore, we can conclude that public revenue and public expenditure significantly affect

economic growth in BRICS countries in the long run. However, it is necessary to indicate the greatest impact of public revenue on economic growth in China (0.566), while public expenditure mostly influences economic growth in India (0.764). Also, the impacts of public revenue and public expenditure become significant for Brazil and Russia only at a level of 10%.

CONCLUSION

The global economic landscape is undergoing significant transformation with emerging economies such as those in BRICS countries. These economies (Brazil, Russia, India, China and South Africa) have more and more influential roles in the international economic system in terms of shaping global economic trends and policies and making a diversified economic environment. Therefore, BRICS becomes an interesting area for investigating and estimating macroeconomic structure and trends. The paper conducts empirical research on the relationship between public revenue, public expenditure and economic growth in BRICS (Brazil, Russia, India, China and South Africa) for the period 2006-2023. The results of applied analysis have shown that public revenue and public expenditure significantly affect economic growth in the long run. It denotes that general hypothesis H_1 can be validated. Furthermore, public revenue positively influences economic growth, where the highest impact is identified in China (0.566). It denotes that auxiliary hypothesis $H_{1.1}$ can be validated. Likewise, government expenditure negatively affects economic growth with the highest impact in India (0.764). Therefore, based on the obtained findings, we can accept auxiliary hypothesis $H_{1.2.}$ Although we identified a negative effect of public expenditure on economic growth, it is necessary to carefully consider the types of expenditures which directly or indirectly contribute to generating economic growth. It implies that governments should focus more on productive expenditure to provide substantial positive indications for economic development. Hence, Chu et al. (2020) indicated that a reallocation of public expenditure from nonproductive to productive forms is linked to higher levels of economic growth. Therefore, governments that make strategic public expenditure choices can effectively support economic growth (Ma and Qamruzzaman, 2022). It is imperative for policymakers in BRICS to establish transparent and stable economic policies that help stimulate investment activities and foster economic growth (Buhtelezi, 2023). By effectively managing public revenue and public expenditure, policymakers can support economic development, enhance social welfare, and create a conducive environment for overall economic progress. The paper provides an additional empirical approach for nexus revenue-expenditure-growth, as well as a fresh interpretation of existing data. Likewise, the research manifests specific insights and perspectives for policymakers in BRICS. Understanding how revenue generation and expenditure allocation affect growth can lead to more effective economic policies and strategies aimed at fostering sustainable development. Based on the significant effects of public revenue and public expenditure, BRICS countries should focus on revenue growth and expenditure control to provide favorable implications for economic growth. The limitation of the research can be partial considering economic determinants focusing only on public revenue and public expenditure as one of the most essential fiscal policy components. That particularly refers to the structure of public expenditure which play an important role in the influence on the economic growth. Future research will focus on a comparative analysis between BRICS and G7 economies in terms of the effects of fiscal determinants on economic growth.

REFERENCES

Ansari, M.A., Khan, F., Singh, M.K. (2021). Public expenditure and economic development: New evidence from the BRICS-SAARC-ASEAN region. *Theoretical and Applied Economics*, 28(2), 155-174.

Arvin, M.B., Pradhan, R.P., Nair, M.S. (2021). Are there links between institutional quality, public expenditure, tax revenue and economic growth? Evidence from low-income and lower middle-

income countries. *Economic Analysis and Policy* 70, 468-489. https://doi.org/10.1016j.eap.2021.03.011

Banday, U.J., Murugan, S., & Maryam, J. (2021). Foreign direct investment, trade openness and economic growth in BRICS countries: evidence from panel data. *Transnational Corporations Review*, 13(2), 1-11. https://doi.org/10.1080/19186444.2020.1851162

Buthelezi, E.M. (2023). BRICS Economies: Assessing the Influence of Economic Policy Uncertainty and Fiscal Consolidation on Government Debt and Economic Growth. *Millennial Asia*. Online First. https://doi.org/10.1177/09763996231184569

Chhabra, M., Giri, A.K., & Kumar, A. (2023). What Shapes Economic Growth in BRICS? Exploring the Role of Institutional Quality and Trade Openness. *Economic papers*, 42(4), 347-365.

Chu, T.T., Hölscher, J. & McCarthy, D. (2020). The impact of productive and non-productive public expenditure on economic growth: an empirical analysis in high-income versus low- to middle-income economies. *Empirical Economics* 58, 2403–2430.. https://doi.org/10.1007/s00181-018-1616-3

Đurović Todorović, J., Milenković, I., & Kalaš, B. (2019). The relationship between direct taxes and economic growth in OECD countries. *Economic themes*, 57(3), 273-286. https://doi.org/10.2478/ethemes-2019-0016

Ghazy, N.H., Ghoneim, H., & Paparas, D. (2021). The validity of Wagner's law in Egypt from 1960-2018. *Review of Economics and Political Science*, *6*(2), 98-117. https://doi.org/10.1108/REPS-01-2020-0004

Glavaški, O., Beker Pucar, E., & Stojkov, S. (2022). Public Revenues and public expenditure nexus: evidence of Eurozone heterogeneity. *The Annals of the Faculty of Economics in Subotica*, 58(48), 83-99. https://doi.org/10.5937/AnEkSub2248083G

Gurdal, T., Aydin, M., & Inal, V. (2021). The relationship between tax revenue, public expenditure, and economic growth in G7 countries: new evidence from time and frequency domain approaches. *Economic Change and Restructuring*, 54, 305-337. https://doi.org/10.1007/s10644-020-09280-x

Iqbal, B.A. (2021). BRICS as a Driver of Global Economic Growth and Development. *Global Journal of Emerging Market Economies*, 14(1). https://doi.org/10.1177/09749101211067096

Joseph, F.I., & Omodero, C.O. (2020). The nexus between public revenue and economic growth in Nigeria. *Economics and Business*, 34 35-45. https://doi.org/10.2478/eb-2020-0003

Kirikkaleli, D., & Ozbeser, B. (2022). New insights into an old issue: exploring the nexus between public expenditures and economic growth in the United States. *Applied Economic Letters*, *29*(2), 1-16. https://doi.org/10.1080/13504851.2020.1859448

Li, J. (2021). Sustainable Development in BRICS Countries: From Concept to Practice. In: Bolov, R., Atnashev, V., Gladkiy, Y., Leete, A., Tsyb, A., Pogodin, S., & Znamenski, A. (Eds). Proceedings of Topica Issues in International Political Geography. https://doi.org/10.1007/978-3-030-78690-8_21

Ma, R., & Qamruzzaman, M. (2022). Nexus between government debt, economic policy uncertainty, government spending, and governmental effectiveness in BRIC nations: Evidence for linear and nonlinear assessments. *Frontiers in Environmental Science: Environmental Economics and Management*, 10, 1-19. https://doi.org/10.3389/fenvs.2022.952452

Molefe, E.K., & Mah, G. (2020). Fiscal deficits and interest rates in BRICS economies: Testing the Keynesian-Ricardian opposition. *Journal of Life Economics*, 7(2), 177-188. https://doi.org/10.15637/jlecon.7.012

Neog, Y., & Gaur, A.K. (2020). Tax structure and economic growth: a study of selected Indian states. *Journal of Economic Structures*, 9(38), 1-12. https://doi.org/10.1186/s40008-020-00215-3

Nguyen, D.X., & Nguyen, T.D. (2023). The Relationship of Fiscal Policy and Economic Cycle: Is Vietnam Different? *Journal of Risk and Financial Management*, 16(5), 281. https://doi.org/10.3390/jrfm16050281

Nzimande, N.P., & Ngalawa, H. (2022). Tax-Spend or Spend-Tax? The Case of Southern Africa. *Economies*, 10(4), 85. https://doi.org/10.3390/economies10040085

O'Neill, J. (2001). *Building Better Global Economic BRICs*. Global Economics Paper No: 66, Goldman Sachs Global Research Centre London.

Onofrei, M., Oprea, F., Iaţu, C., Cojocariu, L., & Anton, S.G. (2022). Fiscal Decentralization, Good Governance and Regional Development – Empirical Evidence in the European Context. *Sustainability*, 14(12), 7093. https://doi.org/10.3390/su14127093

Onifade, S. T., Çevik, S., Erdoğan, S., Asongu, S., & Bekun, F.V. (2020). An empirical retrospect of the impacts of public expenditures on economic growth: new evidence from the Nigerian economy. *Journal of Economic Structures*, 9(1), 1-13. https://doi.org/10.1186/s40008-020-0186-7

Poku, K., Opoku, E., & Agyeiwaa Ennin, P. (2022). The influence of public expenditure on economic growth in Ghana: An ARDL approach. *Cogent Economics & Finance*, 10(1), https://doi.org/10.1080/23322039.2022.2160036

Tenedengu, S., Kapingura, F.M., & Tsegaye, A. (2022). Fiscal Policy and Economic Growth in South Africa. *Economies*, 10(9), 204. https://doi.org/10.3390/economies10090204

Zharikov, M. (2021). A Debt Market Model for the BRICS. *Economies*, 9(1), 1-12. https://doi.org/10.3390/economies9010004

International Monetary Fund. (2023). https://www.imf.org/en/Publications/WEO/weo-database/2023/October/select-country-group

Article history:	Received: 17.4.2024.
	Revised: 6.5.2024.
	Accepted: 20.5.2024

DOI: 10.28934/ea.24.57.3.pp9-26 First Online: August 1, 2024

REVIEW REPORT

Serbia-China Economic Cooperation: A Balance of Payments Perspective

Božidar Čakajac[1]* | Nenad Janković[1] | Nenad Stanišić[1]

[1] The University of Kragujevac, Faculty of Economics, Kragujevac

ABSTRACT

The more intensive economic presence of China in the Balkan, within the Belt and Road Initiative, has influenced China to become one of Serbia's most significant economic partners. The more dynamic economic cooperation between these economies is evident both from the perspective of foreign trade and capital flows. The focus of this study is to determine how the intensified economic cooperation between Serbia and China reflects on the domestic balance of payments position. Research results suggest that the growing economic cooperation of the observed economies negatively affects the domestic balance of payments position, both in terms of trade in goods and services and in terms of the income account sub-balance. At the same time, the increasing inflow of capital, primarily based on foreign direct investment from China, has provided financing for a significant portion of Serbia's current account deficit over the past few years. However, the ultimate effects on Serbia's balance of payments position will largely depend on whether Chinese investments in the coming period will further deepen the deficit in the primary income account.

Keywords: *Serbia, China, balance of payments, foreign direct investments*

JEL Classification: F21, F59, O57

INTRODUCTION

The integration of the national economy into global economic flows has created a need to maintain external economic balance. This is particularly delicate for developing countries, as these economies are often faced with current account deficits (external imbalance) and relatively limited options for financing balance of payments imbalances (Dugalić et al., 2023). This is also the case with Serbia, which has faced a current account deficit since gaining its independence. The balance of payments imbalance became a particularly pronounced problem for the Serbian economy during 2007 and 2008 when the current account deficit reached record levels and exceeded sustainable limits (Kovačević, 2017). At the same time, during the global financial crisis and the public debt crisis in the Eurozone, Serbia faced a reduced inflow of foreign capital, which further complicated the financing of the current account deficit.

Finding alternative sources of external financing and financing economic development as a whole was aligned with the global expansion of the Chinese economy in the middle of the last decade (Ivanović & Zakić, 2023). Since then, more intensive cooperation between Serbia and China began, which was formalized by Serbia's accession to the Belt and Road Initiative in 2016 (Stojanović-Višić et al, 2023). This resulted in a more intensive economic presence of China in the

* Corresponding author, e-mail: bozidar.cakajac@kg.ac.rs

domestic market, both in terms of foreign trade exchange and participation in infrastructure projects, along with an increasing inflow of capital, primarily through foreign direct investment (Marjanović et al, 2021).

The subject of the study is based on examining how the intensified economic cooperation with China affects Serbia's balance of payments position, specifically the current account. More precisely, the study aims to determine how the economic cooperation between the Serbian and Chinese economies impacts Serbia's current account deficit by analyzing its main components. Accordingly, the research goal is to establish whether the increased economic presence of China in the domestic market has negatively affected the current account deficit. Analogously, the main research hypothesis is formulated as follows:

H1: *Intensified economic cooperation between Serbia and China negatively affects Serbia's balance of payments position.*

The research covers the period from 2007 to 2023 and is based on the annual dynamics of data. In line with the defined subject, goal, and research hypotheses, the paper consists of four parts, in addition to the introduction and conclusion. The first part of the paper analyzes the key characteristics of the goods trade between the Serbian and Chinese economies. The second part of the research focuses on the analysis of service exchange between the observed economies. The third part of the paper is dedicated to identifying the significance of China as a foreign investor in the domestic market. In the fourth part of the paper, the Serbian-Chinese economic cooperation is observed from the perspective of the secondary income balance, specifically the transfer of remittances as the most significant component of this sub-balance. The final part of the research presents concluding considerations.

CHINA-SERBIA TRADE RELATIONS

For years, China has maintained a high level of savings and pursued a policy of currency depreciation, which means that exports and investments are the main drivers of its economic growth (Deb et al., 2019). Therefore, it is not surprising that China's economic position in global terms is largely determined by the fact that it is the world's largest exporter (Matthes, 2024). Thanks to a higher value of exports compared to imports, China ranks among the top countries with the highest current account surpluses (Beirne et al., 2021). The high and growing surpluses of the Chinese economy simultaneously negatively affect the balance of payments position of many countries, and global economic equilibrium as a whole. (Wang, 2020; Goulard, 2020). The same can be confirmed in the case of the Republic of Serbia, given the multi-year deficit in goods trade with China (Figure 1). Significantly higher import values compared to export values have resulted in the fact that during all the years of the observed period, the trade deficit with China exceeds the value of Serbian exports to China. At the same time, during the observed period, the value of imports from China increased by approximately 3.5 billion dollars, while exports achieved a somewhat modest increase of 1.2 billion dollars.

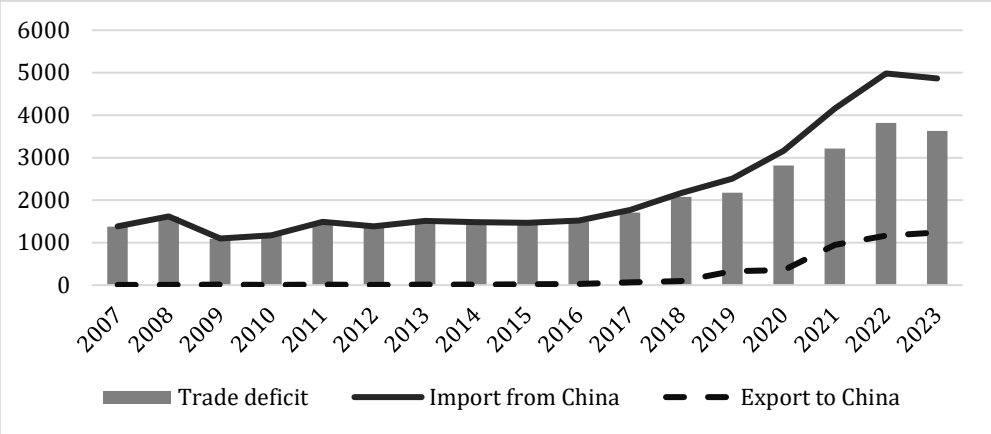


Figure 1. Trade in goods between Serbia and China (million USD)
Source: Statistical Office of the Republic of Serbia, (2023)

Observing the dynamics of the trade deficit with China, it can be noted that until 2018, the deficit was lower than 2 billion dollars, with the lowest value in 2009 (1.1 billion dollars). However, since 2018, due to faster growth in imports compared to exports, there has been a more dynamic increase in the trade deficit, which reached a record value of 3.8 billion dollars in 2022. In the same year, a record value of imports from China was recorded at 4.9 billion dollars. On the other hand, looking at the dynamics of Serbian exports to China, from 2007 to 2018, the total value of Serbian exports to China was only 272 million dollars, while in 2019 alone, goods worth 329 million dollars were exported (Zubalova et.al, 2023). During the last two years of the observed period, the value of Serbian exports to China exceeded one billion dollars, with a record value in 2023 of 1.2 billion dollars, primarily thanks to the exports of Chinese companies operating in Serbia (Serbia Zijin Mining d.o.o, Serbia Zijin Bor Copper, and HBIS Group Serbia).

The rapid increase in imports and exports between Serbia and China has resulted in China becoming an increasingly significant trade partner in terms of goods exchange (Jovičić et al., 2020). At the beginning of the observed period, trade with China accounted for only 5.4% of Serbia's total trade. However, with the intensification of economic and political relations between the two countries since 2016, China has become an increasingly significant trading partner for Serbia, reflected in the fact that at the end of the observed period, trade with China accounted for 9% of Serbia's total trade (Figure 2). The majority of this increase can be attributed to the growing imports from China, with significant contributions from the increase in Serbian exports to China during the last two years of the observed period.

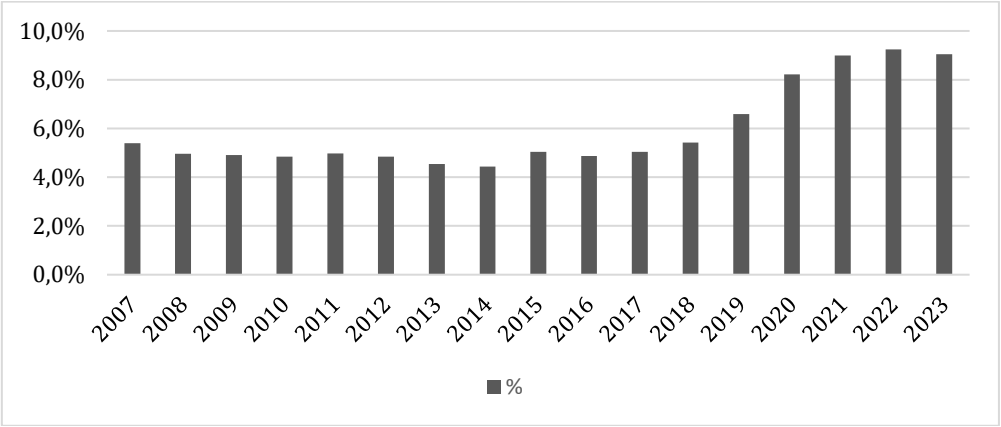


Figure 2. Structure of trade between Serbia and China in 2023 (%)
Source: Authors' calculation

From a balance of payments perspective, the fact that Serbia records a trade deficit with China is not so unfavorable, considering that this is also the case with far more developed economies. The problem lies in the fact that during the observed period, the deficit in trade with China has become the most significant cause of Serbia's overall trade deficit (Jovičić & Marjanović, 2024).

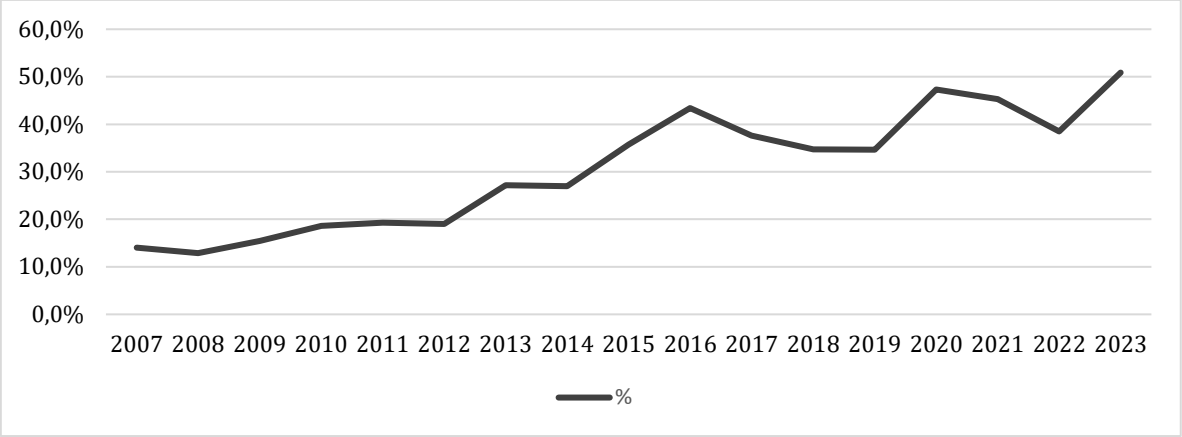


Figure 3. The share of the trade deficit with China in the overall trade deficit of the Republic of Serbia (in %)

Source: Authors' calculation

Until 2014, the trade deficit with China accounted for less than 30% of the total trade deficit of the Republic of Serbia (Figure 3). However, since Serbia formally joined the Belt and Road Initiative in 2016, this indicator has significantly increased, so that by the end of the observed period, the trade deficit with China makes up over 50% of Serbia's total trade deficit. Considering that the trade deficit is the primary cause of Serbia's external imbalance, it is inevitable that the trade deficit with China represents an important determinant of the domestic balance of payments imbalance.

Simultaneously, when observing Serbia's foreign trade with its most significant partners (Table 1), it can be noted that Serbia recorded the highest deficits with China for the majority of the observed period. Except for short-term surpluses in trade with Italy (thanks to Fiat), Serbia has a trade deficit with all other observed economies. Initially, in the early years of the observed period, the highest trade deficits were recorded with Russia, but since 2012, China has taken the lead (Vasa & Angeloska, 2020). Moreover, compared to the beginning of the observed period, Serbia has reduced its trade deficit with Germany and Russia, while the trade deficit with China has increased by $2.2 billion. Another interesting observation is that during the last four years of the observed period, Serbia had a larger trade deficit with China than with Italy, Germany, and Russia combined.

Table 1. Trade Balance with the Most Significant Foreign Trade Partners of the Republic of Serbia (billion USD)

Year	Germany	Italy	Russia	China
2007	-1.28	-0.74	-2.22	**-1.38**
2008	-1.75	-1.07	-2.97	**-1.61**
2009	-1.07	-0.71	-1.62	**-1.09**
2010	-0.72	-0.27	-1.62	**-1.17**
2011	-0.82	-0.47	-1.86	**-1.47**
2012	-0.75	-0.63	-1.21	**-1.38**
2013	-0.52	0.21	-0.84	**-1.50**
2014	-0.59	0.30	-1.30	**-1.47**
2015	-0.54	0.27	-1.02	**-1.44**

Year	Germany	Italy	Russia	China
2016	-0.48	0.21	-0.71	**-1.50**
2017	-0.64	0.30	-0.59	**-1.71**
2018	-1.18	-0.66	-1.01	**-2.08**
2019	-0.97	-0.34	-1.6	**-2.18**
2020	-1.06	-0.57	-0.66	**-2.81**
2021	-1.21	-0.55	-0.81	**-3.21**
2022	-0.72	-0.62	-1.89	**-3.82**
2023	-0.55	-0.99	-0.53	**-3.63**

Source: Statistical Office of the Republic of Serbia, (2023)

Increased cooperation between Serbia and China, manifested in the growth of trade volume, has reflected in China's position as Serbia's foreign trade partner (Dimitrijević, 2017). This progress is particularly evident in terms of exports. In the initial years of the observed period, China represented a significantly less important export market for Serbia compared to the end of the observed period. Since 2016, China has become increasingly significant as an export market for Serbia, and high values of Serbian exports to China during the last two years of the observed period have positioned China as Serbia's seventh most important foreign trade partner in terms of exports of goods (Table 2).

Regarding imports, until 2015, China was the fourth most important foreign trade partner of Serbia (behind Germany, Italy, and Russia). However, since 2016, China surpassed Russia to take the third position. Since 2020, China has become Serbia's second most important foreign trade partner in terms of imports, and it is interesting to note that in 2022, the highest import value was recorded with China.

Table 2. Position of China as the most significant import/export partner of the Republic of Serbia

Year	Import	Export
2007	4	50
2008	4	50+
2009	4	42
2010	4	48
2011	4	36
2012	4	50+
2013	4	50+
2014	4	50
2015	4	44
2016	3	37
2017	3	30
2018	3	30
2019	3	19
2020	2	19
2021	2	9
2022	1	9
2023	2	7

Source: Statistical Office of the Republic of Serbia, (2023)

The high values of Serbian exports to China during the last two years of the observed period are primarily due to the fact that Chinese companies are the largest exporters in Serbia (Todorović & Mrdaković, 2021). Looking at the list of the top 15 exporters in Serbia during 2022 and 2023, the first three places belong to Chinese companies: Serbia Zijin Mining d.o.o, Serbia Zijin Bor Copper, and HBIS Group Serbia (Table 3). Another Chinese company (Minth Automotive Europe d.o.o.)

was also on the list of top exporters in 2023. The progress of Chinese companies on the list of top exporters was achieved in 2016 with the sale of the Smederevo Steel Plant to Hesteel (HBIS), and in 2018 when Zijin Mining Group acquired the Bor Mining and Smelting Complex. Since entering the Serbian market, HBIS Group has consistently been among the top Serbian exporters, just behind Fiat, and was the largest Serbian exporter from 2019 to 2021. However, during the last two years of the observed period, there has been a slight decline in HBIS Group's ranking on the list of top Serbian exporters, as Serbia Zijin Mining and Serbia Zijin Bor Copper have taken the lead.

During the last two years of the observed period, the export value of these Chinese companies in Serbia has increased by $600 million, with HBIS Group being the only one to experience a decrease in exports in 2023 compared to 2022. Additionally, in both years, the exports of Chinese companies account for approximately 40% of the total exports of the largest domestic exporters.

Table 3. The largest exporters in Serbia in 2022 and 2023

Rank	2022 (jan - sep)		2023	
	Name	**Export value (mln eur)**	**Name**	**Export value (mln eur)**
1.	Serbia Zijin Mining d.o.o	769.5	Serbia Zijin Mining d.o.o	1.152
2.	HBIS Group Serbia	679.5	Serbia Zijin Bor Copper	746.3
3.	Serbia Zijin Bor Copper	676.4	HBIS Group Serbia	549.1
4.	NIS	484.2	ZF Serbia d.o.o.	504.8
5.	Tigar Tyres	370.8	Leoni Wiring Systems Southeast	489.3
6.	Henkel Serbia	368.9	Tigar Tyres	454.9
7.	Leoni Wiring Systems Southeast	309.1	Robert Bosch	453.1
8.	ZF Serbia d.o.o.	273.2	Henkel Serbia	405.0
9.	Robert Bosch	241.8	Yura Corporation	394.3
10.	HIP	241.5	NIS	386.6
11.	Yura Corporation	233.3	Hemofarm	351.9
12.	Hemofarm	213.1	SCM Power d.o.o.	298.3
13.	Grundfos Srbija	195.7	Philip Morris	288.7
14.	Philip Morris	175.4	Minth Automotive Europe d.o.o.	277.9
15.	Gorenje	172.7	Gorenje	277.5

Source: Ministry of Finance of Serbia (2023)

Observing the structure of trade between Serbia and China based on the most significant export and import products, it can be noted that lower technological intensity products dominate the export structure, such as copper ores, concentrates, and copper itself (Zhemelinska & Hong Song, 2021). These two product categories accounted for over 90% of Serbia's total exports to China. On the other hand, when considering the import structure, consumer goods and telecommunications equipment dominate (Figure 4).

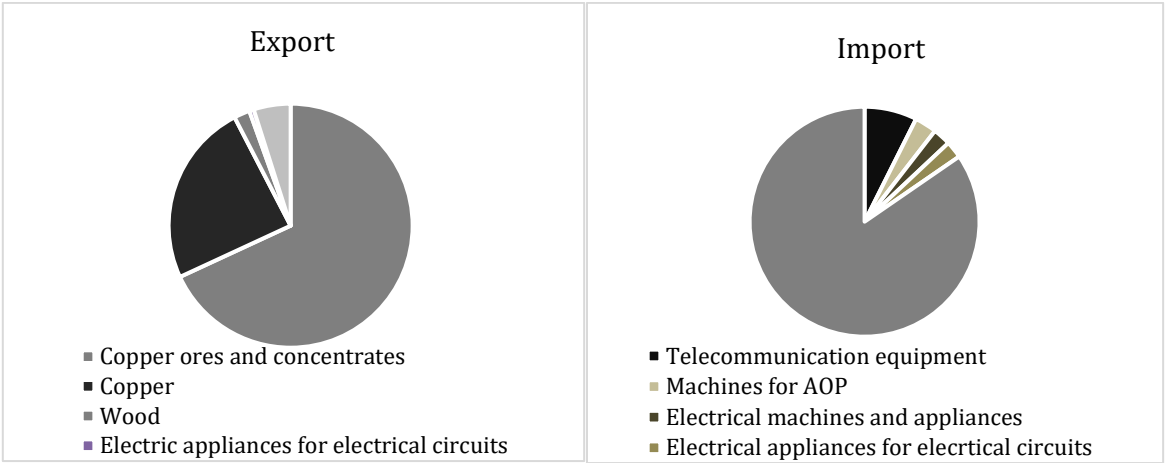


Figure 4. Structure of trade between Serbia and China in 2023 (%)

Source: Ministry of Finance of Serbia (2023)

TRADE IN SERVICES

Balance of services represents an increasingly significant segment of the current account of the Republic of Serbia. Surpluses achieved in this account have over time become a very important factor in balancing the domestic balance of payments (Janković et al., 2022; Kalinović et al., 2022). In the services trade with China, Serbia has recorded deficits for most of the observed period. An exception is the period from 2011 through 2019 (excluding 2015), during which mild surpluses were achieved in the services trade. Since 2020, there has been a trend of increasing deficits in the exchange of services, with the highest deficit value in services trade with China recorded in 2022 (Figure 5).

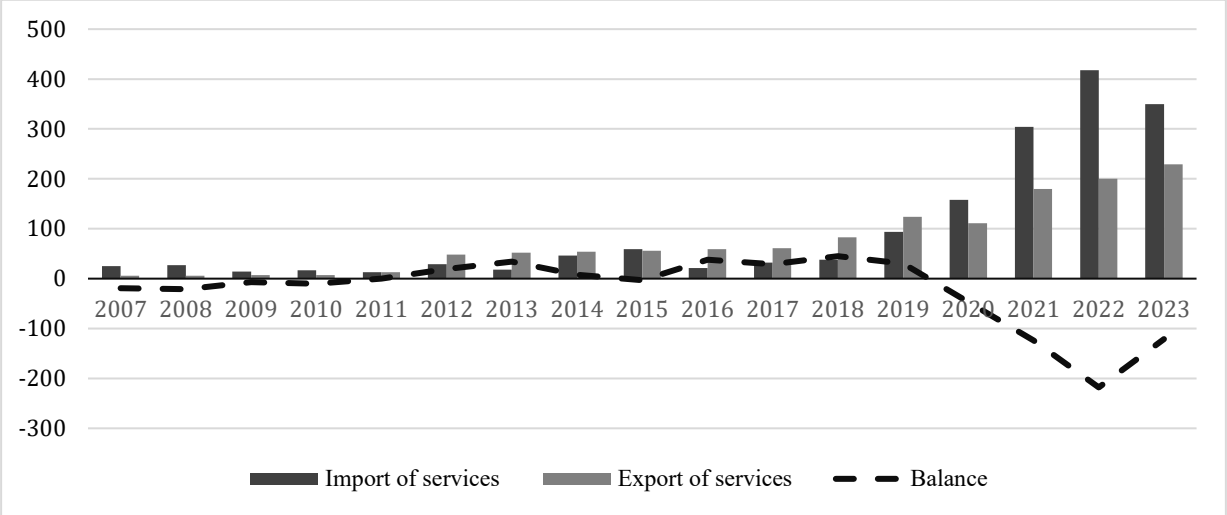


Figure 5. Trade in services between Serbia and China (mln eur)

Source: NBS (2023)

In comparison to its share in goods trade, China's share in the total services trade of the Republic of Serbia is considerably lower (Figure 6). Moreover, China's participation is higher in the import of services compared to their export. Over the observed period, the average share of China in the import of services was 1.6%, while on the export side, their average share was slightly lower at 1.2%.

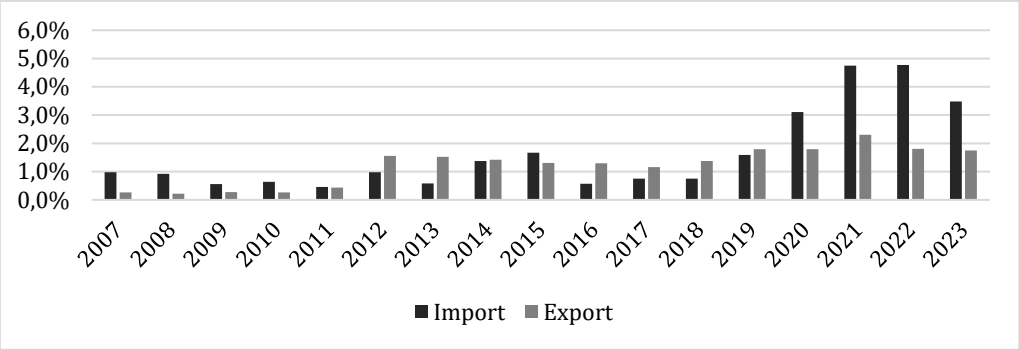


Figure 6. The participation of China in total imports and exports of services (in %)

Source: Authors' calculation, based on NBS (2023)

The relatively low deficit in the services trade with China is realized primarily thanks to the surpluses in the exchange of tourist services. Since 2018, there has been rapid growth in the export of tourist services to China, with the highest value recorded in 2023 - 121 million euros. Over the observed period, a surplus in the trade of tourist services with China amounts to 310 million euros.

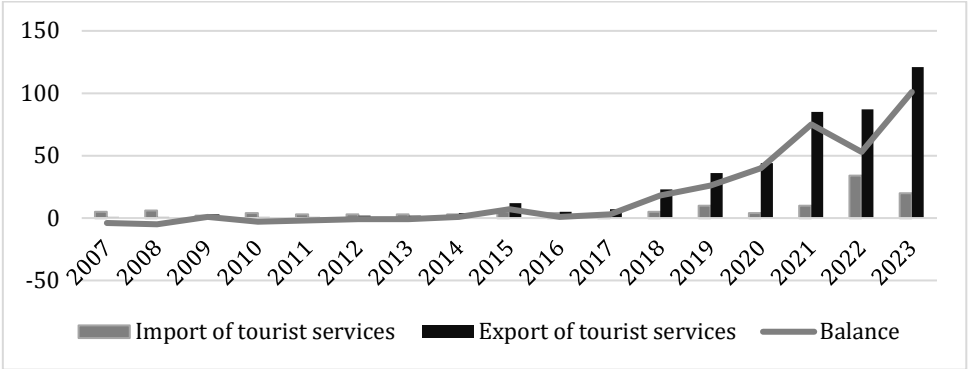


Figure 7. Exchange of tourist services with China (million eur)

Source: NBS (2023)

Tourist services also represent the most significant segment in terms of service exports to China (Figure 8). The importance of tourist services in the total service exports to China has varied significantly over the observed period. The lowest share of tourist services in total service exports to China was recorded in 2012 and 2013 (4%), while the highest share of tourist services in total service exports to China was recorded in 2023 when tourist services accounted for more than half of the service exports to China. Over the observed period, the average share of tourist services in total service exports to China was 23%.

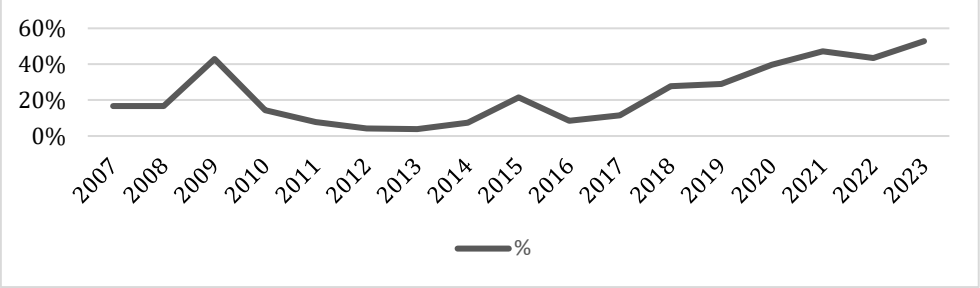


Figure 8. The share of tourist services in total service exports to China (in %)

Source: Authors' calculation, based on NBS (2023)

Although the deficit in services trade with China is much smaller compared to the deficit in goods trade, it is still unfavorable that there is a negative balance in this segment as well. A particularly pronounced issue is that since 2018, the deficit in services trade has been increasing, putting additional pressure on the country's balance of payments position and diminishing the positive results achieved in the services account overall. In this domain, it is desirable to create conditions for a more dynamic growth in service exports in the coming period. Given their significance in the current structure of service exports, this primarily applies to tourist services. Accordingly, possible improvements could focus on further enhancing the tourist offerings tailored to the preferences of Chinese tourists.

THE ROLE OF CHINA AS A FOREIGN INVESTOR

Besides more intensive foreign trade, the economic cooperation between Serbia and China is also evident from the perspective of capital flows (Bugarčić et al., 2020). Since joining the Belt and Road Initiative, there has been a noticeable increase in Chinese capital inflows into the Serbian economy, both through loans and foreign direct investments (Vladisavljev, 2022). Given that the focus of this study is on analyzing Serbian-Chinese economic cooperation from a balance of payments perspective, this part will emphasize the inflow of foreign direct investments from China and their significance as a source of financing for Serbia's current account deficit.

Since 2010, net inflows of foreign direct investments from China have shown significant growth. Specifically, until 2016, net inflows of foreign direct investments from China were less than 200 million euros annually. A more rapid increase in net inflows of foreign direct investments from China occurred in 2018 when the total net inflow of FDI amounted to 686.6 million euros. The record value of net inflows of foreign direct investments from China was recorded during the last two years of the observed period, with a slightly higher value in 2022 (1.377 billion euros) compared to 2023 (1.372 billion euros). Between 2010 and 2023, the total value of net inflows of foreign direct investments from China exceeded 5.5 billion euros (Figure 9).

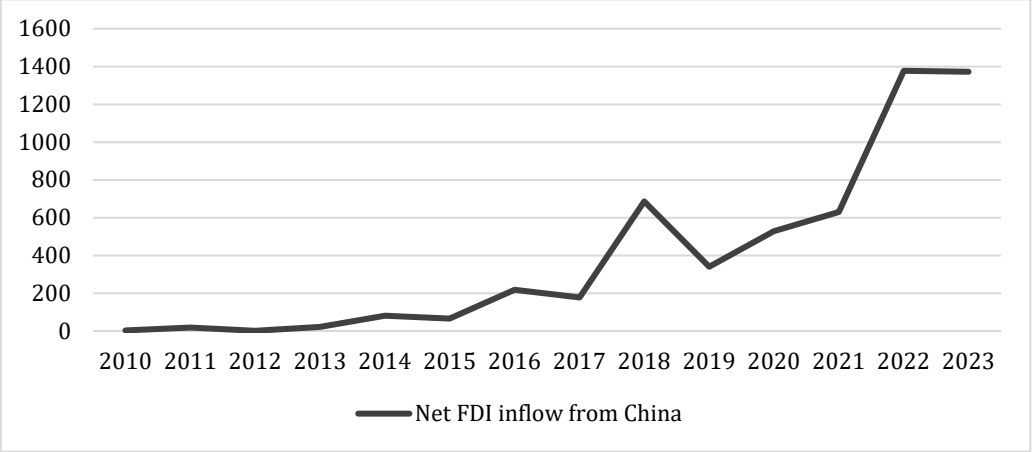


Figure 9. Net FDI inflow from China (million EUR)

Source: NBS (2023)

Alongside the increasing net inflow of foreign direct investment from China, the significance of China as a foreign investor in the domestic market has become more pronounced (Figure 10). In 2010, Chinese foreign direct investments accounted for just 0.2% of the total net FDI inflows in Serbia, whereas by 2023, this share had increased to 32.5%. To put it more precisely, in 2023, every third euro of net foreign direct investment inflow into Serbia came from China.

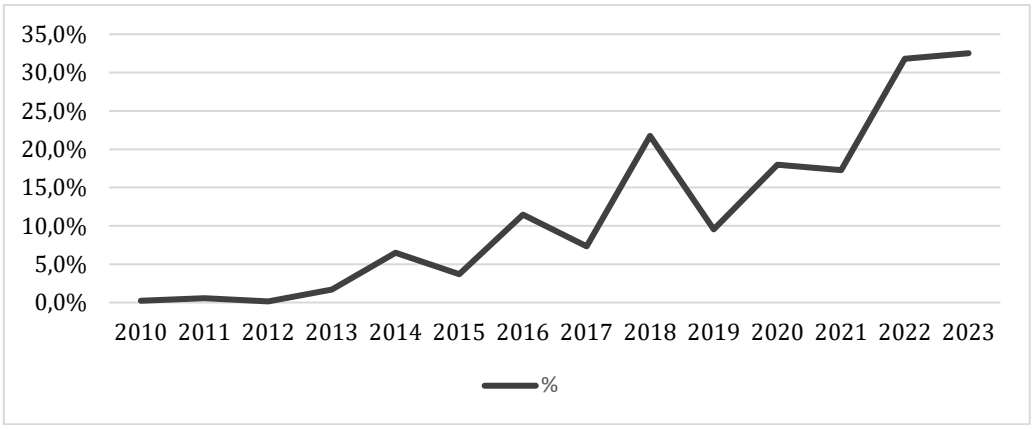


Figure 10. The share of net inflows of FDI from China in the total net inflows of FDI in Serbia (in %)

Source: Authors' calculation, based on NBS (2023)

The significance of China as a foreign investor in Serbia can be observed when looking at the geographical structure of the most significant foreign investors (Figure 11). According to the total number of realized projects, China ranks third immediately after Germany and Italy. However, when considering the value of projects (million EUR) as a criterion, China is positioned somewhat lower, belonging to the lower half of the list of the largest investors in Serbia. Apart from Germany and Italy, the United States and Russia are better positioned than China, while France and Austria are slightly less well-positioned.

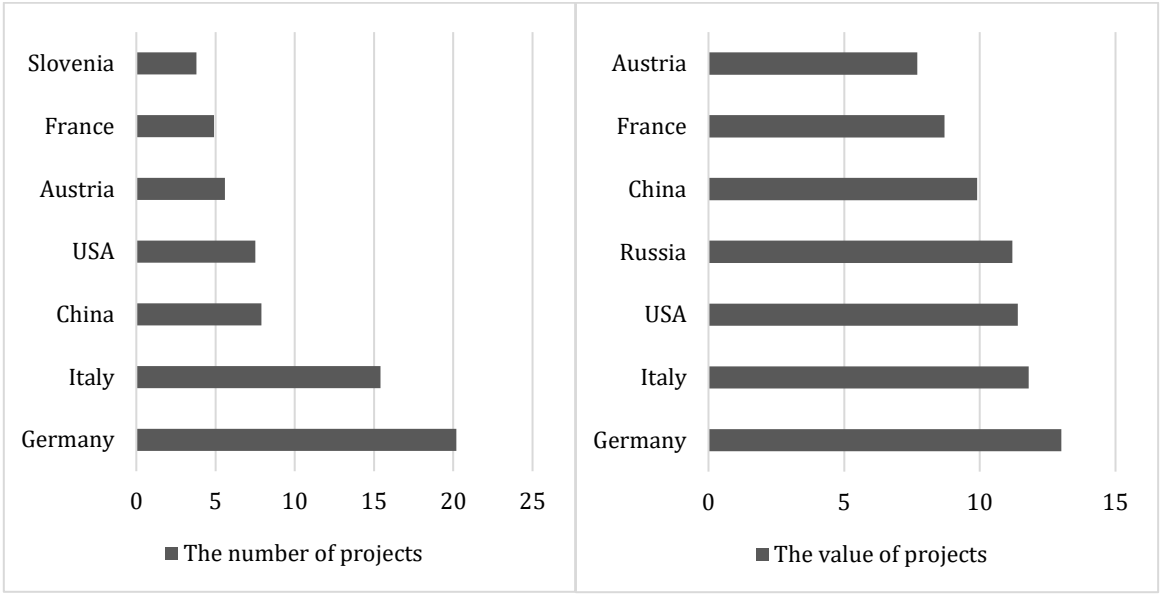


Figure 11. The most significant investors in Serbia

Source: Development Agency of Serbia (2023)

Looking at the largest Chinese investments in Serbia (Figure 12), the first position is held by Zijin Mining, which acquired the Mining and Smelting Basin Bor in 2018 (Zakić & Radišić, 2019). This is also the only Chinese investment in Serbia that has exceeded one billion euros, specifically totaling 1.26 billion euros. The second largest Chinese investment in Serbia is from Linglong Tire, with an investment value of 800 million euros, while the third position is held by HBIS Group, which acquired Smederevo Steelworks for 466 million euros in 2016 (Mitrović, 2023). Analyzing

the structure of the largest Chinese investments, it can be concluded that the majority of investments were made in the form of foreign direct investments, predominantly focused on the automotive industry (Linglong Tire, Mei Ta, Minth Group, Yangfeng, Xingyu Automotive, BMTS, Johnson Electric) (Ivanović & Zakić, 2023). The total value of the top ten largest Chinese investments in Serbia amounts to 3.3 billion euros.

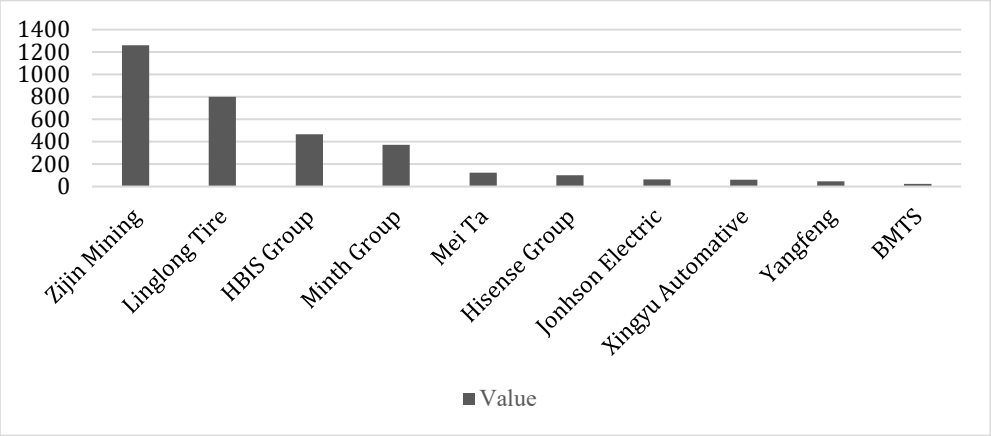


Figure 12. The largest Chinese investments in Serbia (million EUR)
Source: Development Agency of Serbia (2023)

The growing influx of Chinese capital in the form of foreign direct investment since 2016 is very important from the perspective of financing Serbia's current account deficit. From the standpoint of financing Serbia's current account deficit, the net inflow of foreign direct investment from China is becoming an increasingly significant source of funding for external imbalances (Figure 13). Until 2015, the net inflow of Chinese foreign direct investment provided relatively low coverage of the current account deficit (below 10%). This was influenced by both the low values of FDI inflows from China and the relatively high values of the current account deficit.

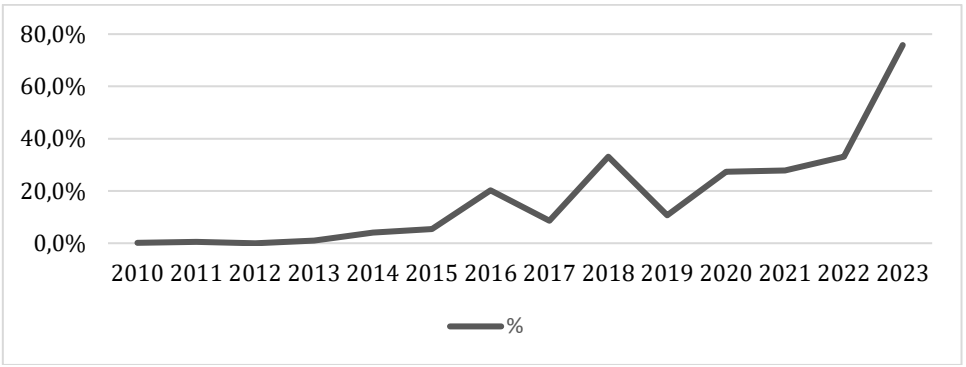


Figure 13. Coverage of Serbia's current account deficit by net inflows of Chinese FDI (in %)
Source: Authors' calculation, based on NBS (2023)

During 2016, net inflows of Chinese foreign direct investment covered one-fifth of Serbia's current account deficit, with this indicator fluctuating until 2019. However, from 2019 to 2023, net inflows of FDI from China increasingly covered Serbia's current account deficit. The largest contribution to financing Serbia's current account deficit through Chinese FDI was recorded in 2023 when these investments covered three-quarters of the deficit. However, the ultimate impact of Chinese FDI on Serbia's current account will primarily depend on the outflow of income from these investments (Kovačević, 2022; Čakajac et al., 2024). If these outflows become too high, they will further deepen the balance of payments imbalance through the primary income account

deficit. As long as inflows of foreign direct investment from China exceed the outflows of income derived from these investments, Chinese FDI will positively impact Serbia's balance of payments by financing the current account deficit. In the opposite scenario, Chinese foreign direct investment will cease to be a source of external financing and become an additional generator of balance of payments imbalance.

THE EFFECTS ON SECONDARY INCOME

For many developing countries facing a current account deficit, the balance of secondary income is a crucial component of their balance of payments. The importance of the secondary income account for developing countries lies in the fact that these economies typically record surpluses in this account, which significantly mitigates the problem of balance of payments imbalances (Ahmed et al., 2020). Globally, over 70% of total remittance inflows are directed towards developing countries (World Bank, 2023). Additionally, remittances are a very significant source of financing for the balance of payments deficit in developing countries because they generally exhibit far less volatility compared to other sources of external financing, primarily foreign direct investments (Bucevska, 2022).

Remittances represent a very important source of foreign exchange inflow for Serbia (Jushi, et al., 2021; Đukić & Bodroža, 2022). During the observed period, the total inflow of remittances into the Republic of Serbia amounted to over 54 billion euros. On the other hand, the total outflow of remittances during the same period amounted to 3.3 billion euros. This high inflow of remittances and the positive balance in their flows are primarily a result of a strong emigrant base, primarily in Western European countries. This can be confirmed by observing the geographical structure of remittance inflows (Table 4). The largest inflows of remittances to Serbia come from Germany, Switzerland, and Austria (Čakajac et. al., 2023). Additionally, there is a significant trend of increasing remittance inflows from the United States, Croatia, Russia, and Slovenia.

Table 4. Geographical structure of remittance inflows into the Republic of Serbia (million EUR)

Country	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Germany	828.5	882.7	631.0	714.4	729.1	836.3	1,016.0	1,058.9	863.0	992.6	1,373.8	1,341.4
Switzerland	324.7	343.8	378.8	441.8	424.8	494.1	535.2	547.2	409.3	443.1	681.3	636.7
Austria	436.0	475.1	234.0	259.5	235.5	240.3	303.9	289.4	278.1	302.9	503.5	500.0
France	218.1	232.4	226.4	280.1	160.8	161.3	202.2	210.4	191.2	233.5	305.6	293.5
USA	86.6	103.9	123.3	152.7	154.7	179.5	178.6	190.8	243.0	301.2	305.4	225.2
Croatia	98.1	97.2	200.8	134.8	154.9	141.7	158.8	146.7	148.1	164.3	183.4	244.3
Russia	60.8	81.9	124.8	84.0	58.3	70.7	85.5	83.6	52.2	82.4	284.3	251.1
Sweden	135.3	111.2	56.4	63.9	60.6	67.0	75.0	71.5	54.8	63.7	78.3	98.5
Slovenia	53.1	51.4	64.4	63.9	59.7	69.8	86.1	81.3	74.4	85.2	84.9	115.3
Italy	49.8	51.1	59.8	66.0	65.0	66.5	82.7	87.8	62.6	79.0	127.4	92.3
China	4.2	5.5	5.3	8.3	9.5	10.3	12.9	11.7	8.5	15.2	14.4	22.3
Other	302.8	419.9	499.0	586.0	575.4	621.6	795.8	736.4	735.3	871.9	1,086.6	1,177.1
Total	2,598.0	2,856.0	2,604.2	2,855.6	2,688.2	2,959.2	3,532.8	3,515.7	3,120.5	3,635.0	5,028.7	4,997.6

Source: NBS (2023)

When it comes to remittance inflows from China, based on the data in Table 4, a relatively small amount of remittances can be observed. Between 2012 and 2023, the total inflow of remittances from China to Serbia amounted to just over 128 million euros. However, what is certainly positive is that there has been a significant increase in remittance inflows from China during this period, with a record high observed in 2023. In comparison to the beginning of the observed period, remittance inflows from China have increased more than fivefold, or by approximately 18 million euros in absolute terms.

On the other hand, when considering the geographical structure of remittance outflows (Table 5), the situation is somewhat different. Throughout most of the observed period, the highest amount of remittances from Serbia was directed towards China (Čakajac et al., 2023). This can be explained by the presence of many Chinese nationals working and residing in Serbia who transfer funds to their families (Božić-Miljković & Jovičić-Vuković, 2021). Interestingly, the outflow of remittances to China has decreased over time, reaching its lowest value in 2023 at 18.7 million euros. Significant changes are also noticeable in the geographical structure of remittance outflows, as towards the end of the observed period, more remittances from Serbia are being transferred to the economies of Germany and the United States than to China.

Table 5. Geographical structure of remittance outflow from the Republic of Serbia (million eur)

Country	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
China	30.3	48.8	36.6	40.4	32.6	26.9	22.9	23.7	29.6	29.8	29.3	18.7
Germany	14.9	13.7	15.2	17.2	19.5	21.8	21.0	25.0	30.9	33.0	37.3	41.8
USA	15.4	15.5	15.7	17.9	18.4	25.5	30.1	24.4	20.8	26.4	39.1	40.6
Italy	5.5	4.7	6.7	6.4	7.7	7.8	9.0	9.6	10.0	38.2	18.4	16.5
Canada	5.8	6.7	7.7	8.8	9.1	9.7	11.9	11.3	11.7	11.8	15.0	14.6
UK	6.2	6.8	7.0	9.8	8.0	9.5	9.0	10.2	11.9	11.9	21.8	19.4
Switzerland	4.6	5.4	7.1	10.0	8.8	10.9	7.6	11.6	10.7	12.9	23.4	25.9
France	5.7	5.5	5.7	7.5	8.6	6.7	7.9	15.4	8.4	11.8	15.0	13.9
Montenegro	5.0	4.7	7.3	5.9	6.9	7.1	9.2	9.3	12.6	15.0	28.1	13.0
Austria	5.1	5.0	5.6	6.1	6.2	6.8	8.6	10.2	13.4	13.6	13.8	14.8
Other	40.1	38.1	47.4	54.5	52.7	68.1	70.1	82.0	101.7	120.3	157.8	176.6
Total	138.5	154.9	161.8	184.4	178.4	200.9	207.2	232.5	261.8	324.8	399.2	395.9

Source: NBS (2023)

Looking at the dynamics of remittances inflow and outflow between Serbia and China (Figure 14), it can be noticed that throughout the entire observed period, more remittances were transferred to China compared to the inflow of remittances. The exception is only year 2023 when the inflow of remittances from China exceeded the transfer of remittances to this economy. In 2023, the highest inflow of remittances from China was recorded (22.3 million euros), while the highest remittances to China were transferred in 2013 – 48.8 million euros. Over the observed period, almost 370 million euros were transferred to China through remittances, indicating that a deficit was also recorded in this component of the current account (241.5 million euros).

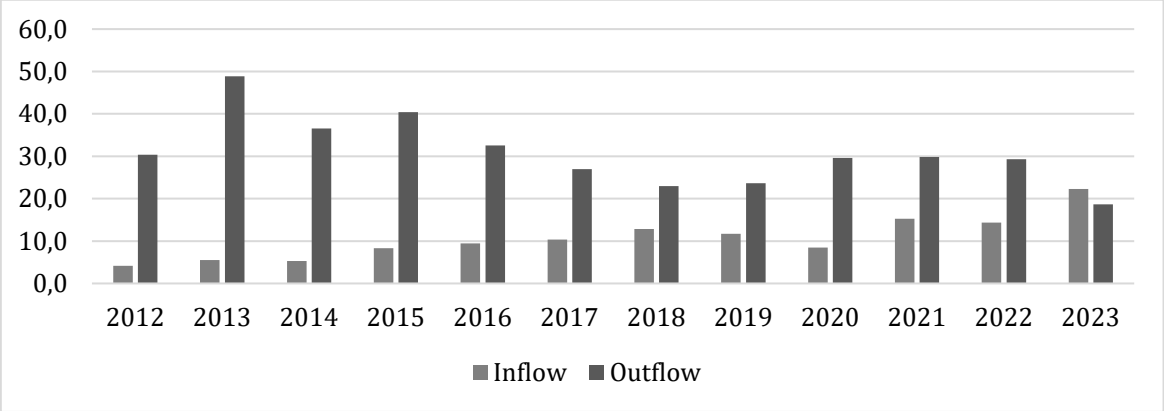


Figure 14. Remittances inflow and outflow between Serbia and China (million EUR)

Source: NBS (2023)

What is certainly positive is that since 2013, fewer remittances have been transferred from Serbia to China (Figure 15). In 2013, remittances transferred to China accounted for 31.5% of the total outflow of remittances, while at the end of the observed period, their share was only 4.7%. It is desirable that this trend continues in the future, meaning that higher remittance inflows from China compared to their outflow should be ensured. This can be achieved by reducing the costs of remittance transfers from China to Serbia, as well as by developing financial platforms for easier money transfers.

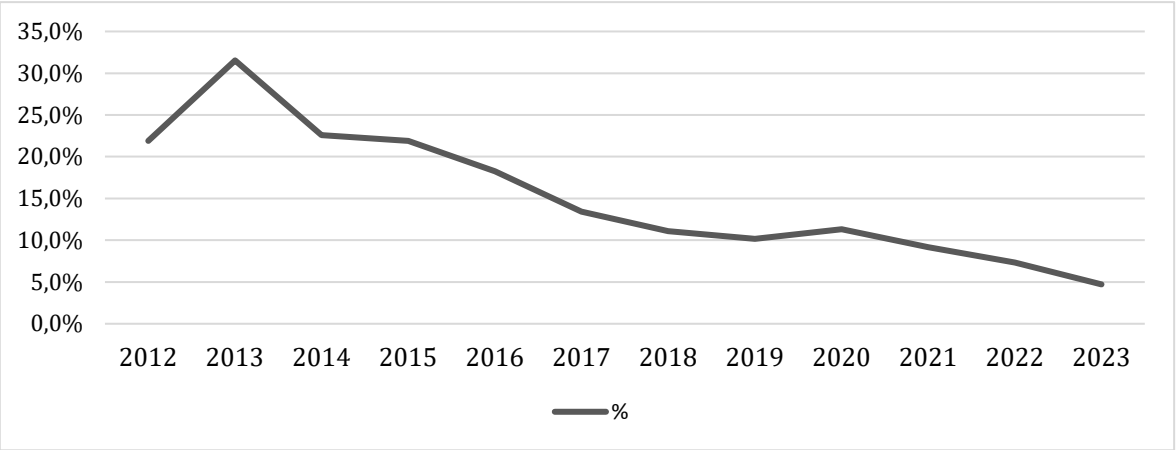
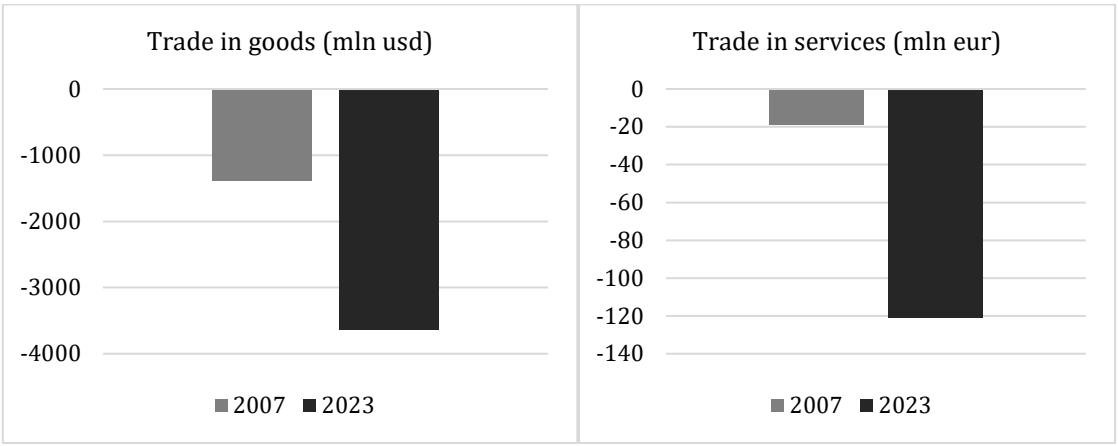


Figure 15. Share of remittance outflow to China in total remittance outflow from the Republic of Serbia (in %)

Source: Authors' calculation, based on NBS (2023)

Despite positive trends and a record inflow of remittances from China in 2023, it is unfavorable that negative effects are also manifesting in the secondary income account. When observing the geographical structure of remittance outflows, Serbia is the only country experiencing a negative balance with China. Although there is a larger transfer of remittances towards the United States, Germany, and Italy towards the end of the observed period, the inflow of remittances from these countries is significantly higher. Overall, the deficit in remittance transfers with China has negatively affected Serbia's secondary income balance, slightly reducing its significance as a primary source of balancing the domestic balance of payments position.



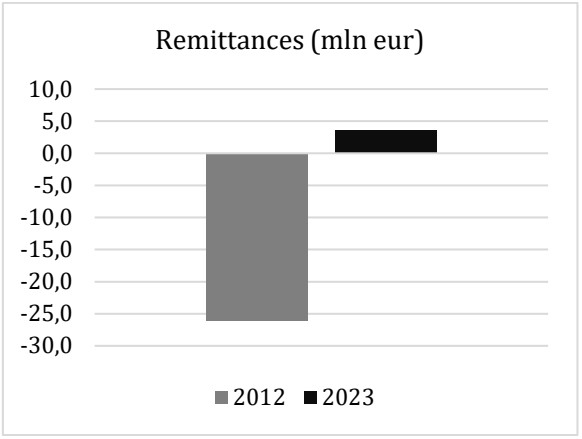


Figure 16. Effects of economic cooperation with China on Serbia's current account
Source: Authors' calculation

Summarizing all the above, it can be concluded that the intensification of economic cooperation with China has had a negative impact on Serbia's current account (Figure 16). The most pronounced effects have been in the area of trade in goods, where compared to the beginning of the observed period, there has been an increase in the deficit of 2.2 billion dollars. A slightly smaller increase in the deficit was recorded in trade in services, with the deficit in services trade with China increasing to 121 million euros by 2023 compared to 2007. Modest positive effects can be observed in remittance transfers, the most significant component of the secondary income account, with a surplus in remittance transfers between Serbia and China recorded at the end of the observed period. However, since 2012, a negative balance in remittance transfers with China has been recorded (241.5 million euros), which diminishes the high surpluses of the secondary income account as the most significant component of balancing the domestic balance of payments position. Despite the record influx of foreign direct investment from China in 2022 and 2023, these funds are still insufficient to fully cover Serbia's current account deficit. Between 2010 and 2023, net inflows of foreign direct investment from China averaged 17.7% of Serbia's current account deficit. Based on the above, it can be concluded that the intensification of economic cooperation with China since 2016 has contributed to a worsening of Serbia's current account deficit and has negatively affected the country's balance of payments position. Considering this, **the main research hypothesis can be confirmed**.

CONCLUSION

By joining the Belt and Road Initiative in 2016, conditions were created for intensified economic cooperation between the Serbian and Chinese economies. Until then, China's economic presence in the Serbian economy was very modest and primarily based on the fact that China was Serbia's fourth most significant trading partner in terms of imports. However, since 2016, there has been much more dynamic economic cooperation between the observed economies, both in terms of foreign trade and the increasing inflow of Chinese capital into the Serbian economy. In terms of foreign trade, China has become one of the two most significant trading partners in terms of imports of goods and has also become one of Serbia's most significant export markets, primarily due to the arrival of Chinese companies in the domestic market, which is a key driver of export growth to the Chinese economy.

From a balance of payments perspective, it can be concluded that the Chinese economy currently benefits more from intensified economic cooperation. Despite the increasing exports to the Chinese market, there has been a significant increase in imports from China, which has led to an increase in the trade deficit between the observed economies. Today, the deficit in trade in goods with China accounts for more than half of Serbia's trade deficit. Similar trends, but of a

smaller magnitude, can be confirmed in the case of trade in services, with the deficit in services trade with China increasing by just over 100 million euros during the observed period. Partially positive developments can be observed in the secondary income account, particularly in remittance transfers, the most significant component of this sub-account. The outflow of remittances from Serbia to China has decreased year by year, unlike the inflow of remittances from China, which allowed for a slight surplus in remittance transfers in 2023. However, there is still a deficit in this area, as between 2012 and 2023, remittance transfers from Serbia to China exceeded remittance inflows from China by just over 240 million euros.

The growing capital inflows from China through foreign direct investment are certainly a positive development. Chinese investments provide increasing coverage of Serbia's current account deficit and thereby create conditions for a more relaxed balance of payments position. However, caution is needed here, as foreign direct investments can produce a negative effect in the future if Chinese investors repatriate a larger share of profits to their home economy compared to reinvesting profits in the Serbian economy. The ultimate effects on Serbia's current account will depend on the value of annual net inflows of foreign direct investment from China and the outflow of income resulting from them (primarily due to profit reinvestment in the home economy).

The presented results should be viewed through the prism of certain limitations. The primary limitation encountered by the authors is the unavailability of data for certain segments of the balance of payments for the entire observation period, such as remittances and foreign direct investments. Additionally, the research is characterized by a relatively short time period based on annual data dynamics. Furthermore, remittance transfers between Serbia and China only consider official data from the National Bank of Serbia, while a significant portion of remittance transfers may occur through unofficial channels for which data is not available. Moreover, data on the geographic breakdown of expenses for foreign direct investments are not available, which would accurately assess the net ultimate effect of Chinese foreign direct investments on financing Serbia's current account deficit. Ultimately, the research is based on qualitative methodology and descriptive statistical analysis. In future research, it would be desirable to include quantitative methodology and sophisticated statistical techniques and analyses.

Despite these limitations, it is important to emphasize that these limitations do not diminish the relevance of the obtained results. At the same time, the research provides significant implications primarily for economic policymakers in Serbia. It is undeniable that China will be an even more significant economic partner for Serbia in the future, so efforts should be made to identify opportunities to further intensify economic cooperation between the observed economies without further negatively impacting Serbia's balance of payments position. In the short term, conditions should be created to increase the export of services to the Chinese economy and facilitate easier remittance transfers from China to Serbia. This would create conditions for reducing deficits or increasing surpluses in the services and secondary income accounts. It is also desirable to create stimulating conditions for Chinese investors to reinvest a higher share of profits earned in the domestic market, rather than repatriating it to the home economy. Given the increasing inflows of Chinese capital into the Serbian economy, this would reduce expenditures on foreign direct investments, contribute to the reduction of the primary income account deficit, and simultaneously increase the importance of Chinese investments in financing Serbia's current account deficit. In the end, in the field of trade in goods, it is very difficult to expect that Serbia will be able to achieve a surplus with China in the future. From a long-term perspective, it would be desirable to change the structure of Serbian exports to China towards a higher share of technologically intensive products, as opposed to products in lower stages of processing, which are currently the most significant segment of Serbian exports to the Chinese market.

REFERENCES

Ahmed, J. Mughai, M., & Martinez-Zarzoso, I. (2020). Sending money home: Transaction cost and remittances to developing countries. *World Economy,* 44(1), 2433-2458.

Beirne, J., Renzhi, N., Volz, U. (2021). Persistent current account imbalances: Are they good or bad for regional and global growth? *Journal of International Money and Finance.* 115(2021), 1-18.

Božić-Miljković, I., Jovičić-Vuković, A. (2021). Chinese Diaspora in Serbia. *Megatrend Review.* 18(3), 267-289.

Bucevska, V. (2022). Impact of Remittances on Economic Growth: Empirical Evidence From South-East European Countries. *South East European Journal of Economics and Business.* 17(1), 79-94.

Bugarčić, F., Jureviciene, D., Janković, N. (2020). The new „Silk Road" global aspect, EU position and economic role of Serbia. 11th International Scientific Conference „Business and Management 2022", pp. 17-27.

Čakajac, B., Janković, N., Luković, S. (2023). The Role of Remittances in Financing the Current Account Deficit: The Case of Serbia. *Our Economy.* 69(3), 35-44.

Čakajac, B., Janković, N., Dimitrijević, M. (2024). Challenges of financing the current account deficit of the Republic of Serbia. *The European Journal od Applied Economics.* 21(1), 95-109.

Deb, P., Gjonbalaj, A., Ahmed Hannan, S. (2019). The Drivers, Implications and Outlook for China's Shrinking Current Account Surplus. IMF Working Paper, No. 19/244.

Development Agency of Serbia (2023). Why invest in Serbia. https://ras.gov.rs/publikacije

Dimitrijević, D. (2017). Chinese Investments in Serbia – A Joint Pledge for the Future of the New Silk Road. *Baltic Journal of European Studies.* 7(1), 64-83.

Dugalić, V., Kovačević, R., Janković, N. (2023). *International finances.* Faculty of Economics, University of Kragujevac.

Đukić, M., Bodroža D. (2022). Diaspora Contribution to the Economic Development of the Republic of Serbia: Remittances and Investments. In: Redžepagić, S. et al. (Eds), *Economic and Financial Implications of Covid-19 Crises,* pp. 181-199. Nica: Université Côte d'Azur.

Goulard, S. (2020). The Impact of US-China Trade War on the European Union. *Global Journal of Emerging Market Economies.* 12(1), 56-68.

Ivanović, V., Zakić, K. (2023). Belt and Road investments in Serbia: Is China a new savior or a new threat? *International affairs.* 75(1), 65-92.

Janković, N., Čakajac, B., Luković, S. & Mitrašević, M. (2022). The tourism sector as a determinant of reducing the balance of payments deficit in the Republic of Serbia. *Hotel and Tourism Management.* 10(2), 137-151.

Jovičić, E., Stevanović, S., Beraha, I. (2020). Serbia-China bilateral trade relations: major challenges and opportunities. *Economic Analysis.* 53(2), 133-144.

Jovičić, E., Marjanović, D. (2024). The Contemporary Development of Serbia-China and Serbia-Russia Relations: Is This the Opportune Moment for Economic Cooperation Expansion? *The Review of International Affairs* 75(1190), 109-137.

Jushi, E., Hysa, E., Cela, A., Panait, M., & Catalin Voica, M. (2021). Financing Growth through Remittances and Foreign Direct Investment: Evidence from Balkan Countries. *Journal of Risk and Financial Management.* 14(3), 1-17.

Kalinović, M., Todorović, M., Marković, I. (2022). The Significance of ICT Services for the Balance of Payments in the Republic of Serbia. *Economic Themes* 60(2), 187-204.

Kovačević, R. (2017). Financing the current account deficit in Southeastern European countries. *Banking.* 46(3), 96-111.

Kovačević, R. (2022). The effects of FDI net inflow on the current account of Southeast Europe countries – a panel causality analysis. *Economic Annals* 67(235), 95-122.

Marjanović, D., Jovičić, E., Stojanović, D. (2021). The Global Distribution of Chinese Investments- Importance for the Economy of Serbia. *Ekonomika.* 67(1), 43-55.

Matthes, J. (2024). China's Trade Surplus- Implications for the World and for Europe. *Intereconomics.* 59(2), 104-111.

Ministry of Finance of Serbia (2023). *Current macroeconomic trends. https://www.mfin.gov.rs/dokumenti2/tekuca-makroekonomska-kretanja-prezentacija*

Mitrović, D. (2023). The dynamics of the Republic of Serbia's cooperation with China via the Belt and Road Initiative and the "Sixteen plus One" platform. *Journal of Contemporary East Asia Studies.,* 12(1), 148-178.

National Bank of Serbia (2023). *Balance of Payments Statistics*. https://www.nbs.rs/sr/drugi-nivo-navigacije/statistika/platni_bilans/

Statistical Office of the Republic of Serbia. (2023). *External trade. https://data.stat.gov.rs/Home/Result/170401?languageCode=sr-Cyrl*

Stojanović-Vršić, B., Jelisavac Trošić, S., Simić, M. (2023). Development of the Belt and Road Initiative in Serbia. *Ekonomika preduzeća*. 71(3-4), 230-242.

Todorović, M., Mrdaković, S. (2021). Serbia's Approach to China's Silk Road: Opportunities and Risks. *Themes.* 45(2), 661-680.

Zakić, K., Radišić, B. (2019). China's Belt and Road Investment Projects in the Balkan Countries: Six Years After. *The Review of International Affairs.* 70(1175), 48-68.

Zhemelinska, Y., Hong, Song, L. (2021). China-Serbia Cooperation: Restrictions and Challenges. *Young Scientist.* 10(98), 183-187.

Zubalova, L., Drienikova, K., Ujlaky, L., Dureckova E.M. (2023). The European Union and China Trade Presence in Serbia. *Journal of Liberty and International Affairs.* 9(3), 370-405.

Vasa, L., Angeloska, A. (2020). Foreign direct investment in the Republic of Serbia: Correlation between foreign direct investments and the selected economic variables. *Journal of International Studies.* 13(1), 170-183.

Vladisavljev, S. (2022). China and Serbia Strategic Investment? Foundation BFPE for a Responsible Society and Center for International Private Enterprise.

Wang, Y. (2020). Causes of U.S. – China trade imbalances: a review. *Journal of Chinese Economic and Foreign Trade Studies.* 13(1), 37-44.

World Bank – Knomad (2023). Remittances Remain Resilient but Are Slowing. Migration and Development Brief 38. https://knomad.org/publication/migration-and-development-brief-38

Article history:	Received: 25.5.2024.
	Revised: 8.7.2024.
	Accepted: 9.7.2024

DOI: 10.28934/ea.24.57.3.pp27-37 First Online: August 19, 2024

ORIGINAL SCIENTIFIC PAPER

Exploring the Interrelationship between Scientific Knowledge and Economic Growth in Serbia: Empirical Insights

Nikola Vasilić[1*] | **Petar Veselinović**[2]

[1] Institute of Economic Sciences, Innovation Economics Department, Belgrade, Serbia
[2] University of Kragujevac, Faculty of Economics, Department of General Economics and Economic Development, Kragujevac, Serbia

ABSTRACT
The primary objective of this study is to examine the nature of the relationship between the production of scientific knowledge and economic growth in Serbia during the period 1996-2022. For this purpose, the Vector Autoregression approach, along with the impulse response function and forecast error variance decomposition, was employed. Results suggest an impact of economic growth on the production of scientific knowledge, while no impact in the opposite direction is detected. The Serbian government should persist in investing in science and work closely with the scientific community to overcome barriers to scientific knowledge's full contribution to economic prosperity.

Keywords: *scientific knowledge, scientific output, economic growth, VAR, impulse response, Serbia*

JEL Classification: O30, O40, C32

INTRODUCTION

Numerous potential benefits that national economies derive from economic growth, such as increased wages, reduced unemployment, improvements in education and healthcare systems, increased public investments, etc., rightfully position achieving dynamic and intensive economic growth as a priority goal of economic policy. The societal benefits of economic growth also represent the main reasons for decades-long research into economic growth generators. An inference drawn from prior theoretical and empirical investigations is that technological changes, or innovations, serve as one of the major contributors to economic growth.

Technological changes were first explicitly considered as a source of economic growth by proponents of Neoclassical economic theory in the mid-20th century (Solow, 1956; Solow, 1957). By modeling the relationship between labor, capital, technological changes, and economic growth, it was concluded that over 50% of the growth in most countries stems from technological changes. According to this approach, technological changes are exogenously determined. This limitation paved the way for new research aimed at endogenizing technological progress, or discovering the forces driving innovation. In the 1980s, Endogenous Growth theory, also known as New Growth theory, emerged. The endogenous approach to economic growth identifies research and development activities, among others, emphasizing their quantity, as one of the most important

* Corresponding author, e-mail: nikola.vasilic@ien.bg.ac.rs

drivers of economic growth (Lucas, 1988; Romer, 1990; Aghion and Howitt, 1992). Actually, knowledge is seen as a factor generated internally as a result of incentives for research and development (Romer, 1986). Therefore, the increasing research and development, which in large part is constituted by the production of scientific knowledge, plays a role in driving technological advancements and fostering economic growth.

Scientific knowledge facilitates innovation and spurs economic growth through various pathways.

The knowledge created through the process of scientific research boosts the quality of human capital. Researchers expand their knowledge through reading existing literature (Hatemi-J et al., 2016). This facilitates the recognition of existing gaps, thereby motivating researchers to embark on new scientific inquiries aimed at filling these gaps within the existing body of literature. In this way, scientists enhance their expertise and become valuable resources in addressing various social challenges. University professors who are more productive in publishing scientific papers are likely to transfer creative knowledge and skills to their students (Jin and Jin, 2013). Additionally, scientific knowledge is utilized in informal learning programs (e.g., IT retraining programs, advanced level training for programming), enabling continuous enrichment of human capital with current insights. All of this contributes to the development of human capital with the qualifications and capacities necessary to respond to the dynamic changes occurring in the economy and society.

Scientific output enhances the reservoir of valuable knowledge for the business sector. Newly created scientific knowledge amplifies the pool of information accessible to firms for technological endeavors (Martin et al., 1996). The business sector predominantly requires knowledge resulting from problem-solving-oriented scientific activities. These are mainly research in the applied sciences and engineering disciplines (Rosenberg and Nelson, 1994). This kind of scientific knowledge can serve as a foundation for the development or offer ready-made new methods and analytical techniques that can enable firms to raise the productivity of production factors and improve the quality of or produce new products and services, which can enhance their position in domestic and international markets (Antonelli and Fassio, 2016; Azmeh, 2022).

Scientific research can equip policymakers with in-depth knowledge about complex societal challenges. It helps understand specific problems, develop policy responses based on evidence, and measure the effects of the policy after its implementation. The recent crisis caused by the COVID-19 pandemic best exemplifies the importance of consulting scientific knowledge in the policymaking process. As stated in the European Commission report, scientific modeling, combining the insights of epidemiology, virology, and mathematics, helped policymakers to foresee the spread of COVID-19, as well as timing the introduction and lifting of restrictions (European Commission, 2022). Science helped policymakers alleviate strain on healthcare systems, achieve a low case fatality rate, and avoid catastrophic economic consequences. In addition to the aforementioned fields of science, accumulated and newly created scientific knowledge in other scientific disciplines was also used to mitigate more serious consequences across various spheres of social life. For instance, economic science played a considerable role in selecting a set of measures to provide support to citizens and businesses during the crisis. One of the measures taken by central banks worldwide was the reduction of the reference interest rate. The decision to adjust the reference rate downwards is definitely based on scientific knowledge grounded in previous research on the implications of the interest rate on consumption and investment.

In the past, scientific research was primarily conducted in the developed world. The availability of substantial financial resources enables developed countries to allocate much more funding towards enhancing the capacity of public research institutions. Governments of advanced economies often allocate significant funds to support the research and development activities of private sector firms. Additionally, private companies themselves (for example, in the fields of pharmacology, IT, etc.) invest considerable resources in creating new knowledge. In comparison

to developed countries, developing nations have significantly fewer resources available for scientific research. However, research indicating positive experiences regarding the role of science in achieving economic growth has encouraged governments of developing countries to increasingly allocate funds in collaboration with international donors for the needs of the scientific sector. Greater allocation of resources to research activities, along with increasing access to the internet and other advanced technologies, enables research organizations from developing countries to partner with reputable leading institutions from developed countries and to collaborate more closely with industry (Solarin and Yen, 2016). All of this could contribute to building capacity for generating new scientific knowledge. However, previous papers provide evidence that developing countries have yet to experience noteworthy economic benefits from scientific knowledge. Some of the reasons could be the divergent expectations that policymakers and scientists have, regarding the role of science in socio-economic development (Ogot and Onyango, 2023), the structure of generated knowledge, which is mostly non-applicative (Solarin and Yen, 2016), and unsupportive institutional environment (Oluwatobi et al., 2020).

Over the past decade, there has been a relatively modest number of research endeavors addressing the relationship between scientific knowledge and economic growth in developing countries. This research aims to bridge that gap by providing insights into the relationship between these two phenomena in Serbia, focusing on the time frame from 1996 to 2022. Why Serbia? First, as a developing country with pronounced political and economic turbulence in its recent past, it significantly lags behind the advanced world in terms of innovation performance. Second, Serbia has candidate status for membership in the European Union. In all strategic documents of the European Union since 2000, the creation and advancement of knowledge are among the priority objectives. Accordingly, Serbia must swiftly diminish the share of traditional production factors in economic growth in favor of knowledge to prepare its economy in time for entry into the European Union's single market. Third, the subject of research, as conceived in this paper, has not yet been the focus of interest among researchers. Fourth, there is a noticeable increase in the dynamics regarding the production of scientific knowledge and economic growth. Given all of the above, taking the initial steps in this topic will provide at least indicative insight into the relationship between scientific knowledge and economic growth for policymakers. Additionally, this research may inspire scientists to delve deeper into this issue in Serbia.

The rest of the paper is organized as follows. In section 2, an overview of the empirical literature is presented. Section 3 introduces the methodology. Section 4 provides an analysis of the results. Finally, section 5 concludes the research.

REVIEW OF THE EMPIRICAL LITERATURE

This section presents empirical literature addressing the relationship between scientific knowledge and economic growth. Since the research aim is to determine how the production of scientific knowledge impacts Serbia's economic growth, the focus is exclusively on reviewing studies that have addressed the same topic in developing countries. To focus on relatively fresh empirical insights, the restrictive criterion for selecting studies was set at the year 2010. All studies conducted before 2010 were not taken into consideration. Some might think that this is a long period to consider from the perspective of freshness of the results. However, even within the chosen time frame, the number of conducted studies on the subject is scant.

Studies utilize variations in the number of published scientific papers to quantify the production of scientific knowledge (Table 1). The most commonly used indicator is the total number of published papers. In a few studies, authors have used published scientific papers per million inhabitants and the total number of publications in relation to the rest of the world. Also, one study was identified that used the total number of citations to evaluate the quality of scientific publications and to establish a link between scientific knowledge and economic growth. GDP and GDP per capita, calculated in constant prices to mitigate the influence of price fluctuations, are

predominantly used as indicators of economic growth. Only one study used GDP calculated in current prices.

Table 1. Review of the selected empirical studies

Author	Sample	Time frame	Variables	Method	Inference
Lee et al. (2011)	Western European and Asian countries	1981-2007	Total number of publications; Nominal GDP	Granger causality	PUB ⇔ GDP in Brazil; GDP => PUB in China; PUB => GDP in India; PUB <≠> GDP in Poland
Inglesi-Lotz & Pouris (2013)	South Africa	1980-2008	Publications in relation to the rest of the world; Real GDP	ARDL	PUB => GDP
Kim & Lee (2015)	East Asia and Latin America	1960-2005	Number of SCI journal articles per million people; Real GDP per capita	OLS, FE	PUB ≠> GDP
Inglesi-Lotz, Chang & Gupta (2015)	BRICS	1981-2011	Publications in relation to the rest of the world; Real GDP	Bootstap panel causality	PUB <=> GDP in India; PUB <≠> GDP in Brazil, Russia, China, South Africa
Ntuli et al. (2015)	34 OECD	1981-2011	Total number of publications; Real GDP	Bootstrap panel causality	PUB => GDP in Mexico and Hungary; GDP => PUB in Poland; PUB <≠> GDP in Turkey, Chile, Czechia, Estonia, Slovakia
Odhiambo & Ntenga (2016)	South Africa	1986-2012	Total number of publications; Real GDP per capita	ARDL; Granger causality	PUB => GDP in the short and long run
Oluwatobi et al. (2018)	Sub-Saharan Africa	1996–2012	Scientific and Technical Journal Articles; Real GDP growth rate	System GMM	PUB ≠> GDP
Azmeh (2022)	15 MENA	2000-2017	Total number of publications; Total number of citations; Real per capita GDP growth	System GMM	PUB - => GDP; CIT + => GDP

Note: + and - are signs of the impact. The arrows indicate the direction of impact. Some countries that are now classified as developed, such as Poland, Czechia, etc., were classified as developing within the time frames considered in the studies.

Source: Author compilation.

The literature encompasses studies that focused on individual countries (only one or a larger number of individual countries) and countries grouped into specific regions and organizations. Depending on this, the methods used to analyze the relationship between scientific knowledge and economic growth differ. Authors who examined these phenomena in individual countries used causality tests and the Autoregressive Distributed Lag (ARDL) approach. In contrast, studies based on panel data relied on the application of the Generalized Method of Moments (GMM) and Fixed Effects (FE) regression approaches.

Authors applying causality tests state varied findings. Lee et al. (2011) reported unidirectional causality from scientific knowledge to economic growth in India, the opposite direction in China, and bidirectional causality in Brazil, while Inglesi-Lotz, Chang & Gupta (2015) found causality (bidirectional) only in India. Lee et al. (2011) and Ntuli et al. (2015) observed different results in Poland. The former indicates the absence of a causal relationship, while the latter emphasizes that there is a unidirectional causality from economic growth to scientific knowledge. One possible reason for the mismatch in results is that Lee et al. (2011) used GDP expressed in current prices, while other studies utilized GDP at constant prices. Additionally, Lee et al. (2011) used the standard Granger causality test, while the other two studies relied on a panel data approach based on Seemingly Unrelated Regressions (SUR) systems and Wald tests with country-specific bootstrap critical values. Except in Poland, Ntuli et al. (2015) provided evidence of causality from scientific knowledge to economic growth in Mexico and Hungary; however, in other countries, there is no evidence of a causal relationship.

Investigating the case of South Africa, Inglesi-Lotz & Pouris (2013) and Odhiambo & Ntenga (2016) found that there is a long-term impact of scientific output on economic growth, and the latter also identified short-run causality in the same direction. In a study conducted two years later, using different research methods, Inglesi-Lotz & Pouris (2015) found no connection between scientific output and economic growth, despite using the same set of indicators.

Kim & Lee (2015) and Oluwatobi et al. (2018) did not find a causal relationship between scientific knowledge production and economic growth in East Asia and Latin America, and in Sub-Saharan Africa. Azmeh (2022) reports that in MENA countries, scientific production leads to a decline in economic growth, while the increased quality of scientific knowledge positively influences economic growth.

Summarizing the results of the listed studies, it can be concluded that the relationship between scientific production and economic growth may be multifaceted. Most evidence supports the absence of any relationship between scientific knowledge and economic growth, followed by results confirming the existence of a relationship where scientific production influences changes in economic growth. An equal number of pieces of evidence confirm the existence of bidirectional causality and causality from economic growth to scientific production. There is the least evidence suggesting that scientific knowledge negatively impacts economic growth.

All studies, except one, focused on examining the direction of causality, without determining the magnitude and type of relationship, which is a gap that this paper aspires to fill.

Methodology

The annual data used in this study cover the period from 1996 to 2022 for the Republic of Serbia. The variables include real GDP, as a proxy for economic growth, and the total number of published scientific papers (PUB), which is used as a measure of scientific production. Data on scientific publications are from the Scopus database (SCImago, n.d.), while data on real GDP comes from the World Development Indicators (World Bank, 2024). All data were transformed into a natural logarithm.

The econometric approach utilized in this paper is a Vector Autoregression (VAR) model. VAR model depicts the progression of multivariate time series involving *m* numbers of endogenous

variables. The behavior of these variables within the system depends on their own lagged values and the past values of all endogenous variables.

The VAR model with p number of lags for m number of variables can be expressed as:

$$\mathcal{Z}_t = c_0 + \sum_{i=1}^{p} \omega \mathcal{Z}_{t-i} + \pi_t \quad (1)$$

Where: $\mathcal{Z}_t$ is a (m × 1) vector of endogenous variables; c is a (m × 1) vector of constants; ω is the i^{th} (m × m) matrix of autoregressive parameters for i = 1, 2, 3,..., p, and $\pi_t = (\pi_{1t}, ..., \pi_{kt})$ represents the (m × 1) vector of serially uncorrelated error terms.

This study applies the VAR model specified in levels, which is considered valid even in cases where the underlying variables are non-stationary, as confirmed in previous studies (Gospodinov et al., 2013; Ashley & Verbrugge, 2009; Kilian & Lütkepohl, 2017).

To analyze the dynamic behavior of the estimated bivariate VAR(p) model, we utilized the impulse response function and forecast error variance decomposition.

We selected the cumulative impulse response function to demonstrate the accumulation of disturbance effects on our variables over time. Utilizing Cholesky decomposition to orthogonalize the covariance matrix in the VAR model alleviates the issue of contemporaneous correlation among the variables. Within this methodological framework, the variables are arranged in a specific order (Sims, 1980). Given our case, the variables are arranged as follows: [GDP PUB]. By arranging the variables in this order, we proceeded from the assumption that changes in GDP in the current period may directly influence publications in the same period, while for scientific production, it takes some time for the impact on GDP to materialize. To draw appropriate conclusions based on the impulse response function, confidence intervals were calculated using a two-stage bias-adjusted approach with 1,000 bootstrap replications and 500 double-bootstrap replications. The primary advantage of this method is its explicit accommodation of the bias and skewness inherent in the small-sample distribution of the impulse response estimator (Killian, 1998).

We used forecast error variance decomposition to estimate how much of a variable's change can be attributed to its own disturbances and those from other variables within the system. The standard error distribution for the forecast error variance decomposition was derived from 1000 Monte Carlo simulations.

Results

The optimal lag order for the VAR model, performance indicators, residual and stability tests are given in Table 1. The lag length was determined using the Akaike information criterion (AIC)[1]. It indicates that the optimal number of lags in the model is one. Adjusted R^2 values imply that the model has a good fit. Residual tests confirmed that there is no evidence that residuals are not independent of each other, nor is there evidence that the variance of the residuals is not consistent across all predicted values. The stability of the VAR(1) was checked by estimating the inverse roots of the autoregressive characteristic polynomial. The results satisfy the stability conditions of the model as all the roots of the characteristic polynomial have a modulus of less than one.

[1] Kilian (1998) and Berkowitz & Kilian (2000) suggest using the AIC because it does not exhibit bias in underestimating the genuine lag order, especially in small samples. This is of great importance, particularly in the context of sampling with replacement, where the lag length is estimated twice, potentially aggravating any downward bias.

Table 1. Optimal lag order, performance of VAR model, residual and stability tests

Lag selection criterion	**Value**	
AIC	-5.133 (1)	
Goodness of fit	**Value**	
Adjusted R^2	0.97; 0.99	
Residual tests	**Value**	
LM – p-value	0.897	
White – p-value	0.362	
Stability test	Root	Modulus
	0.948	0.948
	0.839	0.829

Note: 0.97 and 0.99 are values for equations where GDP and PUB are dependent variables, respectively. () – selected number of lags.

Table 2 presents the results of the impulse response function. The corresponding bootstrap confidence intervals are shown in the APPENDIX. The positive reaction of scientific production occurs two years after the shock in economic growth and continues throughout the entire observed period. On the other hand, scientific production does not contribute to Serbia's economic growth.

Table 2. Two-stage bias-adjusted bootstrap cumulative impulse response function

Impulse => response	**¥**	**τ**
GDP => PUB	+	2-12
PUB => GDP	-	/

Note: ¥ is a sign of the cumulated impulse response parameters. τ – the time interval within the forecast horizon (f = 12) during which the impact has been recorded.

The results of the forecast error variance decomposition are reported in Table 3. The initial impact of economic growth on the forecast error variance of scientific production is approximately 7%, after which it continues to increase until it reaches its peak in the 12th period, when it amounts to around 88%. Scientific knowledge explains an extremely small part of the forecast error variance of economic growth, accounting for around 3% in the long term.

Table 3. Forecast error variance decomposition of GDP and PUB in %

Variables	**FEVD of PUB**				
	f = 1	**f = 3**	**f = 6**	**f = 9**	**f = 12**
PUB	93.35	62.11	27.69	15.62	11.55
GDP	6.65	37.89	72.32	84.38	88.45
Variables	**FEVD of GDP**				
	f = 1	**f = 3**	**f = 6**	**f = 9**	**f = 12**
PUB	0	0.52	1.69	2.69	3.44
GDP	100	99.48	98.31	97.3	96.57

Note: f – forecast horizon.

CONCLUSION

The study adopted the impulse response function and forecast error variance decomposition to investigate the relationship between scientific knowledge and economic growth in Serbia. The empirical estimations have shown that economic growth, expressed in real GDP, stimulates the production of scientific knowledge, measured by the total number of published scientific papers. On the other hand, generating scientific knowledge does not lead to economic growth. Similar

results were reported by Lee et al. (2011), Kim & Lee (2015), Ntuli et al. (2015), Oluwatobi et al. (2018).

The economic growth that Serbia achieved in the previous period enabled it to allocate considerably more resources to the scientific sector. In response to this favorable stimulus, scientists have drastically increased their productivity in terms of the number of published scientific papers. However, what emerged as output did not contribute to a higher growth of the Serbian economy. Just as there are numerous channels through which scientific knowledge finds its way to economic growth, there are equally many reasons why it may fail to do so.

One of the potential reasons for the absence of a positive impact of scientific knowledge on economic growth is the pronounced outward migration, characterized by a predominance of highly educated people. Through emigration, individuals with advanced education carry the knowledge they have acquired during their studies at Serbian universities, thus contributing to the economic growth of the destination country. In recent years, the Serbian government has been making considerable efforts to create conditions that would primarily retain young highly educated people, but also to attract back those who already live abroad. If these efforts yield results, it will reflect on the strengthening of the innovation potential of the Serbian economy, further contributing to its more dynamic growth.

The modest level of collaboration between universities and industries in the domain of research and development can serve as an additional argument for elucidating the absence of a significant contribution of scientific knowledge in promoting economic growth. In 2023, Serbia scored 44.5/100 on this indicator, positioning it at the 65th rank out of a total of 129 countries for which data on this indicator are available (WEF, 2023). The lack of communication and consequent cooperation between the industry and the scientific sector can lead to research activities that fail to address specific industry-related problems. One possible explanation may be what experiences from developing countries show, namely that their economies rely much more on foreign than on domestic research for innovation and growth (Barrett et al., 2021). The business sector in these countries may recognize that customizing foreign knowledge to indigenous conditions is a more effective strategy for development than investing in domestic scientific production. A potential approach for addressing this issue involves increasing the number of project calls from the Science Fund of the Republic of Serbia, aimed at fostering collaboration between universities and industries.

It is also questionable to what extent policymakers rely on scientific knowledge in formulating policies. Responsibility in this segment is twofold. The practice, especially in developing countries, is that policymakers more often rely on the input from political staff and senior civil servants when formulating policies (Ogot & Onyango, 2023), than on scientists. On the other hand, there may be difficulties for policymakers to find common ground with researchers. For example, researchers may simply lack the inclination to participate in the development of public policy documents, such as strategies as fundamental documents, and specific documents such as reform programs, action plans, etc., but are primarily interested in scientific research. Accordingly, aiming for the country's economic progress, both sides should make adjustments to their current practices.

The Serbian government needs to continue investing in science and, in close collaboration with the scientific community, strive to find effective mechanisms to address the issues that hinder scientific knowledge from making its full contribution to economic prosperity.

The research has several limitations that simultaneously serve as a roadmap for future endeavors in this field in Serbia. The study employs the total number of published scientific papers across all scientific fields as an indicator of scientific knowledge. This may lead to a loss of insight into the specificity and role of various scientific fields in economic growth. Therefore, it would be desirable to examine the relationship between scientific knowledge from different scientific fields and economic growth. Furthermore, the empirical results are based on a bivariate VAR model, which means that some variables that could be related to both the production of scientific knowledge and economic growth are omitted. By including human capital and institutional

environment-related variables, a more holistic picture could be provided. Additionally, alternative proxies for scientific knowledge could be used. Relying solely on the number of published papers, no distinction is made among them in terms of impact. Therefore, as an alternative, the total number of papers published in the most reputable journals (Q1 in Scopus), and the total number of citations or cited papers should be considered.

ACKNOWLEDGMENTS

The research presented in this paper was funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia under contract number 451-03-47/2023-01/200005.

REFERENCES

Aghion, P., & Howitt, P. (1992). A Model of Growth Through Creative Destruction. *Econometrica*, 60(2), 323–351.

Antonelli, C., & Fassio, C. (2016). Academic knowledge and economic growth: are scientific fields all alike?. *Socio-Economic Review*, 14(3), 537–565. https://doi.org/10.1093/ser/mwv025

Ashley, R. A., & Verbrugge. R. J. (2009). To difference or not to difference: a monte carlo investigation of inference in vector autoregression models. *International Journal of Data Analysis Techniques and Strategies*, 1(3), 242–274.

Azmeh, C. (2022). Quantity and quality of research output and economic growth: empirical investigation for all research areas in the MENA countries. *Scientometrics,* 127, 6147–6163 https://doi.org/10.1007/s11192-022-04512-5

Barrett, P., Hansen, N. J., Natal, J. M., & Noureldin, D. (2021). Why Basic Science Matters for Economic Growth?. Available at: https://www.imf.org/en/Blogs/Articles/2021/10/06/blog-ch3-weo-why-basic-science-matters-for-economic-growth

European Commission (2022). Evidence-informed policymaking: a new document to foster discussion on a better use of scientific knowledge in policy. Available at: https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/evidence-informed-policymaking-new-document-foster-discussion-better-use-scientific-knowledge-policy-2022-10-26_en

Gospodinov, N., Marı´a Herrera, A., & Pesavento, E. (2013). Unit roots, cointegration, and pretesting in VAR models. In: Fomby, T.B., Kilian, L., & Murphy, A. (Eds.), VAR Models in Macroeconomics—New Developments and Applications: Essays in Honor of Christopher A. Sims. Emerald Group Publishing Limited, 81–115.

Hatemi-J, A., Ajmi, A. N., El Montasser, G., Inglesi-Lotz, R., & Gupta, R. (2016). Research output and economic growth in G7 countries: new evidence from asymmetric panel causality testing. Applied Economics, 48(24), 2301–2308. https://doi.org/10.1080/00036846.2015.1117052

Inglesi-Lotz, R., Chang, T., & Gupta, R. (2015). Causality between research output and economic growth in BRICS. *Quality & Quantity*, 49(1), 167–176.

Inglesi-Lotz, R., & Pouris, A. (2013). The influence of scientific research output of academics on economic growth in South Africa: An autoregressive distributed lag (ARDL) application. *Scientometrics*, 95(1), 129–139.

Jin, J. C., & Jin, L. (2014). On the relationship between university education and economic growth: The role of professors' publication. *Education Economics*, 22(6), 635–651.

Kilian, L., & Lütkepohl, H. (2017). *Structural Vector Autoregressive Analysis*. Cambridge University Press, Cambridge.

Kim, Y. K., & Lee, K. (2015). Different impacts of scientific and technological knowledge on economic growth: Contrasting science and technology policy in East Asia and Latin America. *Asian Economic Policy Review*, 10(1), 43–66.

Lee, L. C., Lin, P. H., Chuang, Y. W., & Lee, Y. Y. (2011). Research output and economic productivity: A Granger causality test. *Scientometrics*, 89(2), 465–478.

Lucas, R. E. (1988). On the mechanics of economic development. *Journal of Monetary Economics*, 22, 3–42.

Martin, B., Salter, A., Hicks, D., Pavitt, K., Senker, J., Sharp, M., & Von Tunzelmann, N. (1996). The Relationship between publicly funded basic research and economic performance: A SPRU Review. HM Treasury, London.

Ntuli, H., Inglesi-Lotz, R., Chang, T., & Pouris, A. (2015). Does research output cause economic growth or vice versa? Evidence from 34 OECD countries. *Journal of the Association for Information Science and Technology*, 66(8), 1709–1716.

Odhiambo, N. M., & Ntenga, L. (2016). Research publications and economic growth in South Africa: An empirical investigation. *International Journal of Social Economics*, 43(7), 662–675.

Ogot, M., & Onyango, G. M. (2023). Does Universities' Research Output Aligned to National Development Goals Impact Economic Productivity? Evidence from Kenya. *Journal of Asian and African Studies*, 58(6), 1005-1020. https://doi.org/10.1177/00219096221080196

Oluwatobi, S., Olurinola, I., Alege, P., & Ogundipe, A. (2020). Knowledge-driven economic growth: The case of Sub-Saharan Africa. *Contemporary Social Science*, 15(1), 62–81.

Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, 71–102.

Romer, P. M. (1986). Growth based on increasing returns due to specialization. *American Economic Review*, 77, 56–62.

Rosenberg, N., & Nelson, R. R. (1994). American universities and technical advance in industry. *Research Policy*, 23(3), 323–348.

SCImago. (n.d.). SJR – SCImago journal & country rank [Portal]. http://www.scimagojr.com

Sims, C. A. (1980). Macroeconomics and reality. *Econometrica*, 48, 1–48.

Solarin, S. A., & Yen, Y. Y. (2016). A global analysis of the impact of research output on economic growth. *Scientometrics*, 108, 855–874. https://doi.org/10.1007/s11192-016-2002-6

Solow, R. (1957). Technical Change and the Aggregate Production Function. *The Review of Economics and Statistics*, 39(3), 312–320

Solow, R. (1956). A Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics*, 70(1), 65–94.

World Bank (2024). World Development Indicators. https://databank.worldbank.org/source/world-development-indicators

World Economic Forum (2023). Global Innovation Index. Available at: https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000-2023-en-main-report-global-innovation-index-2023-16th-edition.pdf

APPENDIX

Table A1. 99% Two-Stage Bias-Adjusted Bootstrap Confidence Intervals with 1,000 Bootstrap Replications and 500 Double-Bootstrap Replications

	f = 1	**f = 2**	**f = 3**	**f = 4**	**f = 5**	**f = 6**
GDP => PUB	0, 0.1	0, 0.2	0, 0.3	0, 0.5	0, 0.7	0, 0.9
PUB => GDP	/	-0.01, 0.01	-0.04, 0.03	-0.07, 0.05	-0.11, 0.07	-0.17, 0.09

Table A1. (Continued)

	f = 7	**f = 8**	**f = 9**	**f = 10**	**f = 11**	**f = 12**
GDP => PUB	0, 1.2	0.1, 1.6	0.1, 1.9	0.1, 2.3	0.1, 2.6	0.1, 3
PUB => GDP	-0.23, 0.11	-0.3, 0.14	-0.38, 0.17	-0.47, 0.2	-0.57, 0.23	-0.69, 0.27

Note: f – forecast horizon.

Table A2. 95% Two-Stage Bias-Adjusted Bootstrap Confidence Intervals with 1,000 Bootstrap Replications and 500 Double-Bootstrap Replications

	f = 1	**f = 2**	**f = 3**	**f = 4**	**f = 5**	**f = 6**
GDP => PUB	-0.01, 0.05	0, 0.14	0.03, 0.27	0.07, 0.42	0.12, 0.6	0.17, 0.82
PUB => GDP	/	-0.01, 0.01	-0.03, 0.02	-0.06, 0.03	-0.1, 0.04	-0.15, 0.06

Table A2. (Continued)

	f = 7	**f = 8**	**f = 9**	**f = 10**	**f = 11**	**f = 12**
GDP => PUB	0.23, 1.07	0.3, 1.34	0.37, 1.61	0.44, 1.9	0.48, 2.22	0.54, 2.53
PUB => GDP	-0.2, 0.08	-0.27, 0.09	-0.33, 0.11	-0.41, 0.13	-0.48, 0.15	-0.56, 0.17

Note: f – forecast horizon.

Table A3. 90% Two-Stage Bias-Adjusted Bootstrap Confidence Intervals with 1,000 Bootstrap Replications and 500 Double-Bootstrap Replications

	f = 1	**f = 2**	**f = 3**	**f = 4**	**f = 5**	**f = 6**
GDP => PUB	-0.01, 0.05	0.02, 0.14	0.05, 0.25	0.09, 0.4	0.15, 0.57	0.21, 0.77
PUB => GDP	/	-0.01, 0.01	-0.03, 0.02	-0.05, 0.03	-0.08, 0.04	-0.12, 0.06

Table A3. (Continued)

	f = 7	**f = 8**	**f = 9**	**f = 10**	**f = 11**	**f = 12**
GDP => PUB	0.26, 0.99	0.33, 1.24	0.39, 1.5	0.45, 1.76	0.51, 2.06	0.56, 2.37
PUB => GDP	-0.17, 0.07	-0.21, 0.08	-0.27, 0.1	-0.32, 0.11	-0.39, 0.13	-0.46, 0.15

Note: f – forecast horizon.

Article history:	Received: 8.5.2024.
	Revised: 12.7.2024.
	Accepted: 17.7.2024.

DOI: 10.28934/ea.24.57.3.pp38-51 First Online: August 29, 2024

ORIGINAL SCIENTIFIC PAPER

National Fiscal Rules, Maastricht Fiscal Criteria and Non-linear Public Debt Dynamics in Serbia

Vladimir Andrić[1]*

[1] Institute of Economic Sciences, Economic History and Theory Department, Belgrade, Serbia

ABSTRACT

The aim of the paper is to assess the reaction of fiscal policymakers in Serbia when the public debt-to-GDP ratio is above the 45% limit set in the national fiscal rules. The paper proposes a two-regime nonlinear self-exciting threshold autoregressive (SETAR) model as an appropriate econometric framework for modeling the asymmetries in the dynamics of the public debt/GDP ratio with respect to the 45% public debt limit. The empirical evidence suggests that fiscal policymakers in Serbia do not adhere to the 45% public debt/GDP ceiling and instead use the Maastricht limit of 60% as a target reference point for public debt management. The article contributes to the current policy debate by providing empirical evidence to support the claim that the behavior of fiscal policymakers in Serbia between 2001Q1 and 2023Q2 could jeopardize the credibility of fiscal policy and increase the probability of default by the Serbian government on its maturing public debt.

Keywords: *national fiscal rules, Maastricht fiscal criterion, SETAR model, fiscal crisis*

JEL Classification: H12, H63

INTRODUCTION

In the second quarter of 2008, the public debt of the Republic of Serbia amounted to around 25 percent of GDP. Primarily as a result of the Great Recession, public debt soared to around 70% of GDP at the beginning of 2015. The ratio of public debt to GDP in Serbia recorded the fastest increase among all emerging economies in Central, Eastern and South-Eastern Europe (Andric and Minovic, 2022). The escalating dynamics of public debt in Serbia have violated both the national fiscal rule limit of 45% public debt/GDP and the upper limit of 60% public debt/GDP from the Maastricht fiscal criteria. The described fiscal trends could have a negative impact on both economic growth (OECD, 2015), the probability of default (Badia et al., 2022) and the credibility of fiscal policy (Davoodi et al, 2022) in Serbia. Therefore, the aim of this paper is to assess the reaction of fiscal policymakers in Serbia when the public debt-to-GDP ratio is above the 45% limit set in the national fiscal rules. The paper proposes a two-regime nonlinear self-exciting threshold autoregressive (SETAR) model as an appropriate econometric framework for modeling the asymmetries in the dynamics of the public debt/GDP ratio with respect to the 45% public debt limit. The empirical evidence suggests that fiscal policymakers in Serbia do not adhere to the 45% public debt/GDP ceiling and instead use the Maastricht limit of 60% of public debt/GDP as a target reference point for public debt management.

* E-mail: vladimir.andric@ien.bg.ac.rs

Although the institutional fiscal framework of the European Union (EU) is based on the general government debt limit of 60% of GDP and the overall deficit limit of 3% of GDP, as established by the Maastricht Treaty (1992), the Stability and Growth Pact (1997) and the Fiscal Compact (2012), these supranational agreements still leave room for unsustainable fiscal practices at the national level. This is because many of the discretionary fiscal tools and instruments are delegated to the member state level, which is not the case for monetary policy within the European Monetary Union (EMU), for example. The heterogeneity of fiscal policy rules and objectives is also notable in the case of Serbia, even though Serbia is not an official EU member state. For example, the general fiscal rules in Serbia include the public debt-to-GDP ratio ceiling of 45% and the overall deficit ceiling of 1% (Fiscal Council, 2024). The stricter general national fiscal rules have some justification in economic theory and practice, as the probability of sovereign default in emerging and developing countries occurs, on average, at lower levels of public debt (Badia et al., 2022). From the point of view of fiscal sustainability and the credibility of national fiscal institutions, it is important to assess the behavior of public debt in relation to GDP given the 45% public debt threshold, especially since Glavaski and Beker Pucar (2020) argue that the process of EU accession does not necessarily lead to greater fiscal prudence in the case of five Western Balkan economies from 1995-2018.

The article is structured as follows: Section 2 familiarizes the reader with the main contributions to modeling asymmetries in sovereign debt dynamics.[1] Section 3 describes the dataset, presents key stylized facts, and proposes an econometric methodology that is most consistent with the underlying trends in the public debt-to-GDP ratio relative to the national fiscal rule limit of 45%. Section 4 presents and discusses the results of the analysis in detail. Section 5 outlines policy recommendations that are consistent with prudent debt targets, macroeconomic stabilization measures and countercyclical fiscal management in an environment of adverse economic shocks.

RELATED LITERATURE

One of the first contributions to model the asymmetries in the dynamics of the public debt/GDP ratio is Sarno (2001). Sarno (2001) uses an exponential smooth transition autoregressive (ESTAR) model to describe the dynamics of the US government debt/GDP ratio between 1916 and 1995. The results of Sarno (2001) provide an empirical justification for a nonlinear mean-reversion behavior for the US public debt/GDP ratio in a symmetric fashion, i.e., the larger the deviation of the public debt/GDP ratio from its mean, the larger the magnitude of the nonlinear fiscal correction towards the mean value of the public debt/GDP.

Considine and Gallagher (2008) apply the same econometric methodology as Sarno (2001) to model a non-linear mean-reversion in the dynamics of the UK's public debt/GDP ratio for the period 1919-2001. The estimated ESTAR model of Considine and Gallagher (2008) provides evidence in favor of the active debt management hypothesis, i.e., it provides evidence against the tax smoothing hypothesis of Barro (1979).[2]

In contrast to Sarno (2001) and Considine and Gallagher (2008), Legrenzi and Milas (2011) use a logistic smooth transition autoregressive (LSTAR) model for the public debt time series of

[1] I will use the terms government debt, public debt and sovereign debt interchangeably throughout the text. In each case, government debt is measured as the ratio of total central government debt to GDP. Note that central government debt in Serbia is roughly equal to general government debt, as local government debt is relatively low. See Koczan (2015) for details.

[2] Barro (1979) argues that governments try to smooth taxes in order to reduce the overall burden on taxpayers. As a consequence of the government's assumed objective function, the tax/GDP ratio and the public debt/GDP behave like random walks. The active debt management hypothesis, on the other hand, states that discretionary fiscal policy measures turn public debt into a mean-reverting stationary stochastic process.

Portugal, Ireland, Italy, Greece and Spain (PIIGS). Legrenzi and Milas (2011) opted for the LSTAR specification instead of the ESTAR specification due to the asymmetric transition function of the LSTAR model: the size of the fiscal correction towards the mean value of public debt/GDP varies depending on whether the current debt value is below or above the estimated threshold. The results of Legrenzi and Milas (2011) provide evidence of fiscal sustainability in the PIIGS economies, although the authors express certain concerns about the sustainability of Italian and Greek public finances.

The aforementioned studies used smooth transition autoregressive (STAR) models to capture non-linearities in the dynamics of public debt/GDP. On the other hand, Gnegne and Jawadi (2013) model the asymmetries in the public debt/GDP ratio using a SETAR model specification. The SETAR model, unlike the ESTAR and LSTAR smooth transition specifications, uses a discrete transition function to capture regime shifts. Using the SETAR modeling framework, Gnegne and Jawadi (2013) find nonlinear mean reversion of a discrete nature in the cases of the US and the UK after the collapse of Bretton Woods.

Cuestas and Regis (2018) focus on the case of China. The results of Cuestas and Regis (2018) urge caution regarding the sustainability of public finances in China after 2014. Since the empirical framework chosen by the authors focuses on nonlinear unit root tests, Cuestas and Regis (2018) do not report endogenously determined thresholds for public debt that characterize asymmetries in fiscal policy.

Finally, Cuestas (2019) applies several structural break procedures to examine fiscal sustainability in Central and Eastern Europe before and after the Great Recession. The study by Cuestas (2019), which comes closest to this study in terms of geographical and temporal coverage, distinguishes between two types of economies: countries that managed to stabilize their public debt-to-GDP ratio after 2008 and those where fiscal sustainability may be at risk, with a particular emphasis on Croatia, Lithuania, Romania and Slovenia. Although the structural break tests of Cuestas (2019) correctly identify the timing of the structural break due to the Great Recession, it is worth noting that tests for structural breaks using dummy variables are not very meaningful when the data are generated by a threshold process (Carrasco, 2002). A test for a threshold process using a lagged dependent variable as the threshold variable is able to detect both threshold behavior and structural changes. Carrasco (2002) therefore recommends using the threshold model as a general test for parameter instability.

In light of the above literature review, this paper makes two potential contributions to the study of the asymmetric behavior of public debt relative to GDP. First, we focus in great detail on an emerging small open economy from the Western Balkans, while other related studies, with the exception of the study by Cuestas (2019) to a certain extent, focus on developed and large economies. Second, while previous papers use long annual time series data sets, this paper focuses on a specific period of economic transition, the Great Recession and the COVID-19 pandemic at quarterly business cycle frequency, which allows the model estimates to be readily used by researchers and policymakers for fiscal policy tracking and forecasting.

DATA AND METHODOLOGY

Due to data availability, the beginning of the sample (2001Q1) corresponds to the beginning of political and market reforms in Serbia in the early 2000s. The end of the sample (2023Q2) marks the end of the COVID-19 pandemic officially announced by the World Health Organization (WHO).[3] Public debt data is taken from the monthly Public Finance Bulletin published by the

[3] The WHO announced the end of the global COVID-19 pandemic in May of 2023.

Ministry of Finance of the Republic of Serbia, while GDP data is taken from the Statistical Office of the Republic of Serbia.[4]

Figure 1 shows the dynamics of the public debt-to-GDP ratio in Serbia for the period 2001Q1-2023Q2. It also shows the fixed 45% ratio of public debt/GDP, which corresponds to the national fiscal rule, and the fixed 60% ratio of public debt/GDP, which results from the Maastricht fiscal criteria. From Figure 1, the reader can see that between 2001Q1 and 2008Q2, the public debt/GDP ratio in Serbia declined sharply due to debt relief programs approved by international creditors and strong economic growth driven by domestic absorption. From 2008Q2 to 2014Q4, Serbia's public debt ratio recorded extraordinary growth of around 45 percentage points.[5] In 2012Q1, the public debt/GDP ratio breached the 45% public debt-to-GDP threshold of the national fiscal rules, while in 2014Q2 it breached another 60% ceiling from the Maastricht fiscal criteria. In early 2015, the Serbian government launched a three-year fiscal consolidation program, which resulted in the public debt-to-GDP ratio falling below 60% of GDP again in early 2018.

From 2018 until the end of the sample, the public debt-to-GDP ratio in Serbia remained below 60% of GDP, even during the COVID-19 pandemic, but it never returned below the 45% threshold set in the national fiscal rules. Overall, Figure 1 shows that the dynamics of the public debt/GDP ratio exhibit a pronounced non-linear pattern with several structural breaks in the trend function, stabilizing around the 60% public debt/GDP threshold towards the end of the sample.

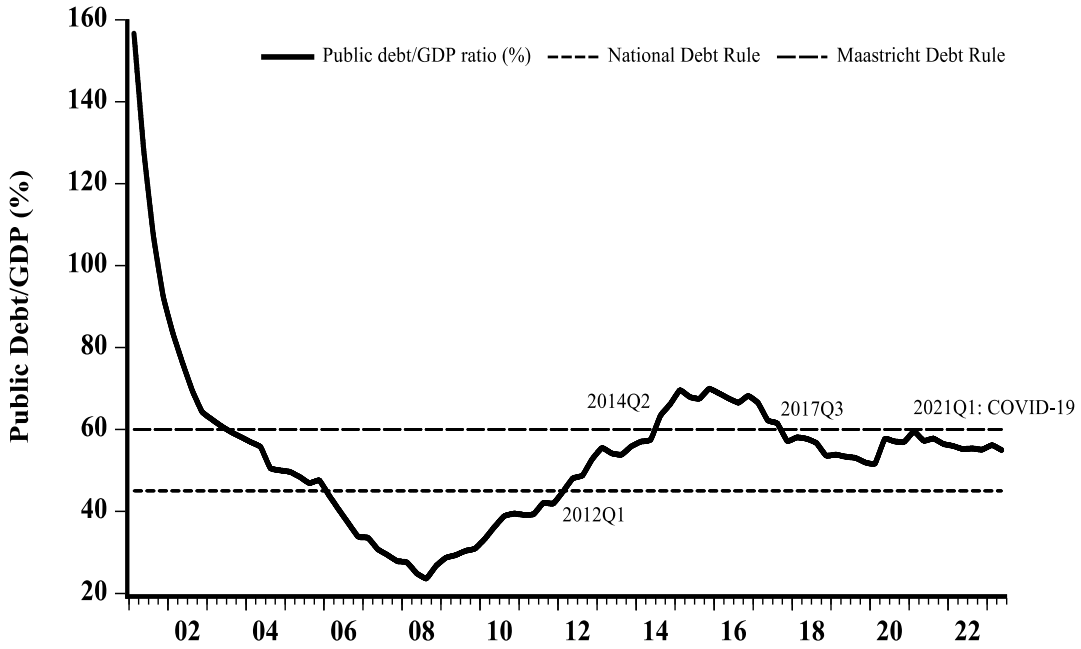


Figure 1. The Dynamics of Public Debt/GDP ratio in Serbia, 2001Q1-2023Q2.

Source: Author's calculations.

To complement the results from Figure 1, Table 1 contains autocorrelation and partial autocorrelation coefficients for the public debt/GDP ratio up to 11 quarters. The number of lags is taken from Schwert (1989), who recommends that the number of lags should be equal to $lags =$

[4] Various issues of the Public Finance Monthly Bulletin are publicly available and can be downloaded from https://www.mfin.gov.rs/en/activities/bulletin-public-finance-2. The data for the quarterly nominal GDP according to the expenditure approach (SNA 2008/ESA 2010 methodology) are publicly available and can be downloaded in Excel format from the National Accounts database.

[5] For a more comprehensive overview of the underlying fiscal and macroeconomic trends, see Andric and Minovic (2022).

$[12 \times ((T+1)/100)^{0.25}]$, where T (T=89) is the sample size and $[\cdot]$ denotes the floor function. The analysis of the autocorrelation and partial autocorrelation functions from Table 1 shows that the government debt/GDP ratio exhibits very persistent behavior with a partial first-order autocorrelation coefficient of 0.82 and an associated 95% ($1.96/\sqrt{T}$) confidence interval of [0.61, 1.03].

Since the upper 95% confidence interval for the first-order autocorrelation coefficient includes a unit root, Table 2 shows the results of the unit root tests by Elliott et al. (1996) and the results of the stationarity test by Kwiatkowski et al. (1992). The results from Table 2 overwhelmingly support the notion that the public debt/GDP ratio in Serbia is better characterized as a persistent stationary AR(1) process rather than an AR(1) process with a unit root.

It is important to emphasize some statistical points in relation to the results from Table 2. First, the choice of a particular set of deterministic components determines to a considerable extent the power of the unit root test (stationarity test) in question. Consequently, and given the dynamics of the public debt/GDP ratio from Figure 1, both a constant and a linear time trend are included when performing the tests from Table 2 for the levels of the public debt/GDP ratio. Similarly, in the case of first-differenced debt, which approximates the value of the overall fiscal balance corrected for stock-flow discrepancies, only an intercept term is used. Second, as Chortareas et al. (2008) emphasize, the particular choice of a non-linear alternative hypothesis also influences the power of the respective unit root test. Since this paper is concerned with testing the null hypothesis of a unit root against the alternative of a non-linear mean reversion, the natural choice for an alternative hypothesis would be to use regression specifications with (a)symmetric fit as defined in Enders and Granger (1998).

Table 1. Autocorrelations & partial autocorrelations for public debt/GDP ratio

Lags	1	2	3	4	5	6	7	8	9	10	11
B_t	0.82 **0.82** 63.30 (0.00)	0.69 0.04 108.5 (0.00)	0.60 0.04 142.2 (0.00)	0.52 0.03 168.2 (0.00)	0.45 0.01 188.3 (0.00)	0.40 0.00 203.8 (0.00)	0.35 0.01 215.9 (0.00)	0.31 0.01 225.5 (0.00)	0.27 -0.01 232.9 (0.00)	0.23 -0.02 238.2 (0.00)	0.18 -0.02 241.8 (0.00)

Notes: Author's calculations. First cell entry: autocorrelation coefficient; second cell entry: partial autocorrelation coefficient; third cell entry: Ljung-Box portmanteau Q-statistics for the null hypothesis that there is no autocorrelation up to the prespecified lag; fourth cell entry: p-values associated with the Ljung-Box Q-statistics.

Note, however, that Enders (2001) reports that the traditional Dickey-Fuller unit root test of Dickey and Fuller (1981) has higher power than the unit root tests proposed by Enders and Granger (1998). The problem, however, with the Dickey-Fuller unit root test is that it has low power in the case of AR(1) processes with an AR(1) coefficient close to one. Following the recent recommendations of Bec et al. (2022) regarding the choice of unit root tests in the case of very persistent AR(1) processes, the analysis in this paper focuses on the unit root tests proposed in Elliott et al. (1996). The maximum number of lags in both tests is set to 11, as in Table 1. The optimal number of lags in both tests is based on the modified AIC criterion (MAIC) of Ng & Perron (2001), while the estimation of the long-run variance is done using AR spectral GLS detrending. Third, according to Bohn (2007), stationarity is the most important econometric condition if one is interested in analyzing nonlinear fiscal adjustments given the public debt-to-GDP ceiling, The results of the stationarity test of Kwiatkowski et al. (1992) are also reported, where Andrews's bandwidth for the truncation lag and the quadratic spectral kernel for estimating the long-run variance are used (the results are robust when opting for the Bartlett kernel and the Newey-West bandwidth). In summary, the results of the KPSS test complement the results of the unit root tests of Elliott et al. (1996) by rejecting the unit root type behavior of the government debt/GDP ratio in Serbia from 2001Q1 to 2023Q2.

Although the results of the unit root and stationarity tests from Table 2 are consistent with the finding that the shocks to the government debt/GDP ratio are transitory in nature, they are linear and do not provide much insight into the nonlinear behavior of the public debt/GDP ratio for the period in question. To test for the presence of potential nonlinearities in the behavior of government debt/GDP, Table 3 contains the results of Tsay's (1989) nonlinearity test. The essence of the test is to compare the null hypothesis of linear autoregressive behavior with the alternative of the SETAR-type behavior. The rows of Table 3 correspond to a lag (*d*) at which the threshold change potentially occurs, while the columns of the table correspond to an autoregressive order (*p*) whose maximum value is set to four (*p=4*) since quarterly data are analyzed. Each of the entries in the table corresponds to a particular *F*-statistic (*p*-values in [ ]) from the corresponding autoregression with an intercept term as the only deterministic component. From Table 3, the reader can see that the highest value of the *F*-statistic (the lowest *p*-value) is for the rejection of the null hypothesis of a linear AR(1) process versus the alternative of a SETAR (2, 1, 1) behavior for the case *p*=*d*=1. In other words, the statistical evidence supports the rejection of the linear AR(1) process with a constant in favor of a nonlinear SETAR (2, 1, 1) process with level shifts.[6]

Table 2. Unit root and stationarity tests for public debt/GDP ratio $\boldsymbol{B_t}$ and $\Delta\boldsymbol{B_t}$

Series/Test	DF-GLS	ERS	KPSS	Result
B_t	-1.43	235.72***	0.11	**I(0)**
ΔB_t	0.09***	127.95***	0.44*	**I(0)**

*Notes: Author's calculations. *** 1% significance level, ** 5% significance level, * 10% significance level. Unit root test regressions include a constant and linear time trend for levels, and only a constant for the first difference. The maximum number of lags in test regressions is 11, according to the Schwert (1989) criterion. The optimal number of lags in test regressions determined by the MAIC criterion of Ng & Perron (2001) for DF-GLS and ERS unit root tests of Elliott et al. (1996), and by Andrews's bandwidth for the KPSS stationarity test of Kwiatkowski et al. (1992). The long-run variance estimation method is AR spectral GLS detrending in the case of DF-GLS and ERS unit root tests, and quadratic spectral kernel in the case of KPSS stationarity test.*

Given the results of Tsay's (1989) nonlinearity test, this paper presents estimates for the SETAR (2, 1, 1) model specification with an exogenously imposed public debt-to-GDP threshold of 45%, which represents the current upper bound of national fiscal rules on the dynamics of public debt-to-GDP. In particular, following Bai & Perron (2003), equation (1) is estimated via conditional least squares

$$B_t = \begin{cases} \phi_0^{(1)} + \phi_1^{(1)} B_{t-1} + \varepsilon_t^{(1)} & B_{t-1} \leq 45\% \\ \phi_0^{(2)} + \phi_1^{(2)} B_{t-1} + \varepsilon_t^{(2)} & 45\% < B_{t-1}. \end{cases} \quad (1)$$

The estimated SETAR (2, 1, 1) specification from equation (1) implies the existence of two regimes for the government debt/GDP dynamics: one above the 45% ceiling and the other below the 45% public debt/GDP ratio. Note that the exogenous 45% public debt/GDP limit is motivated not only by national fiscal rules, but also by the economic considerations of Badia et al. (2022), who find a higher probability of default for emerging markets when public debt exceeds 40% of GDP. Given the threshold, the public debt/GDP ratio in each of the regimes follows an AR(1) process, which is captured by the regime-specific parameters $\phi_1^{(1)}$and $\phi_1^{(2)}$. In addition, the model contains regime-specific intercept terms $\phi_0^{(1)}$ and $\phi_0^{(2)}$, which represent the mean levels around

[6] Tsay (1989) does not consider linear time trends in the construction of his test statistics. However, one could linearly detrend the original data on public debt relative to GDP and then perform Tsay's (1989) test on the residual values of such a regression. As for the robustness of the results presented in Table 3, the results do not change in the case of this study.

which the stationary public debt/GDP series fluctuates. The regime-specific independently and identically distributed (i.i.d) residual values with zero mean are denoted by $\varepsilon_t^{(1)}$ and $\varepsilon_t^{(2)}$, respectively. Finally, the lag parameter (d) for the threshold variable is set to one, so that the threshold switching occurs in B_{t-1} which further implies that the public debt/GDP ratio values from the previous quarter have the greatest statistical impact on the contemporaneous dynamics of the public debt/GDP ratio, (B_t), as noted in Table 3.

Table 3. Tsay's non-linearity test

p/d	**1**	**2**	**3**	**4**
1	**31.55 [0.00]**	-	-	-
2	4.13 [0.01]	1.95 [0.13]	-	-
3	2.05 [0.09]	1.20 [0.32]	0.16 [0.96]	-
4	1.93 [0.10]	1.49 [0.20]	0.77 [0.58]	0.80 [0.57]

Notes: Author's calculations. Tsay's (1989) "arranged" autoregressions include only a constant term. p-AR order; d-delay parameter. Table entries correspond to Tsay's (1989) F-statistics, while [ ] denotes corresponding p-values

RESULTS AND DISCUSSION

Table 4 shows the estimates of equation (1). The estimated values for the parameters $\phi_1^{(1)}$and $\phi_1^{(2)}$ are 0.99 and 0.74, respectively. The estimated values for the parameters $\phi_1^{(1)}$ and $\phi_1^{(2)}$ imply that the underlying SETAR (2, 1, 1) process is ergodic and globally stationary. Both estimates are statistically significant at the 1% significance level.[7] The reader should focus on a value of 0.99 for $\hat{\phi}_1^{(1)}$which is close to a unit root, with a 95% confidence interval of [0.79, 1.19], allowing for the possibility of both unit-root and explosive-root in the stochastic process for public debt.[8]

Even at a significance level of 10%, the result of the Wald coefficient restriction test (p=0.93 for the $\chi^2(1)$ test statistic) cannot reject unit root type behavior for government debt below the threshold of 45% for government debt/GDP, i.e., the results are consistent with the hypothesis that $\hat{\phi}_1^{(1)} = 1$. This finding is consistent with the tax smoothing hypothesis of Barro (1979), which

[7] The results do not change if we allow the error distributions to differ across the 45% public debt/GDP threshold, as in Bai and Perron (2003). Since the residuals of equation (1) show a slight autocorrelation, the standard errors are corrected according to the Newey-West correction with the quadratic spectral kernel for the long-run covariance matrix estimate, along with the Andrews's bandwidth for lag truncation and single pre-whitening lag.

[8] Theorem 2.1. by Petrucelli and Woolford (1984) states the following necessary and sufficient condition for the ergodicity and global stationarity of the SETAR (2, 1, 1) process: $\phi_1^{(1)}$ <1, $\phi_1^{(2)}$ <1 and $\phi_1^{(1)}\ \phi_1^{(2)} < 1$. See also Theorem 2.1. in Chan et al. (1985) for conditions including a SETAR model with an intercept term. Moreover, Theorems 3.1. and 3.2. from Petrucelli and Woolford (1984) and Chan et al. (1985) imply that if conditions for ergodicity and global stationarity are satisfied, then the coefficient estimates $\hat{\phi}_1^{(1)}$ and $\hat{\phi}_1^{(2)}$are consistent and asymptotically normally distributed. More importantly, in the case of a known exogenous threshold, González and Gonzalo (1997) report that the coefficient estimates $\hat{\phi}_1^{(1)}$and $\hat{\phi}_1^{(2)}$ are consistent and asymptotically normally distributed *even* in the case of the self-exciting threshold unit root (SETUR) model which allows for a possibility of a unit root in one of the regimes (partial unit root), given that conditions of Theorem 2.1. from Chan et al. (1985) are satisfied. Finally, Hansen (2017) treats the US sovereign debt/GDP ratio after World War II as near-unit root, but globally ergodic and stationary, stochastic process, consistent with the approach taken in this paper.

postulates that there is no "target" value for the public debt/GDP ratio. Instead, the government debt/GDP ratio moves randomly in line with movements in transitory government spending and cyclical output shocks. The government debt/GDP ratio essentially "mimics" the random behavior of the tax/GDP ratio - the government sets the tax rate to smooth the overall tax burden over time, but GDP shocks lead to unpredictable behavior of tax dynamics.

Although the statistical evidence cannot refute the notion of a unit root in the dynamics of the public debt/GDP ratio below the 45% threshold, this result seems unlikely for several reasons. First, due to political frictions, it is questionable whether governments smooth taxes over time to reduce the overall tax burden. Roubini and Sachs (1989) were the first to argue against optimal intertemporal optimizing behavior of governments due to problems related to political fragmentation, coalition management, and the expected tenure of governments in OECD countries after 1973. One could reasonably assume that these political considerations are only more pronounced in relatively young market economies such as Serbia's. For example, Arsic et al. (2017) find that governments in Central and Eastern Europe tended to engage in pre-election fiscal manipulation prior to the Great Recession, which is inconsistent with Barro's (1979) tax-smoothing approach and unit-root type public debt/GDP behavior. Second, the idea that the public debt/GDP ratio contains a unit root would mean that a) given enough time, the public debt could break through any ceiling with probability one and b) the variance of the public debt/GDP ratio approaches infinity over time. Such behavior is difficult to reconcile with documented fiscal developments in both advanced and emerging economies (Jiang et al., 2024). Instead, one can observe in the data that arbitrarily high ratios of public debt-to-GDP are followed by either a) market reactions of government bonds b) fiscal consolidations; c) financial repression; and d) accelerating inflation, as Jiang et al. (2024) document.

The explosiveness of public debt in relation to GDP ($\hat{\phi}_1^{(1)} > 1$) below the 45% threshold also seems unlikely for both economic and econometric reasons. On economic grounds, one would expect to find an explosive ($\hat{\phi}_1^{(2)} > 1$) root in the upper regime (above the 45% threshold) consistent with the fiscal fatigue hypothesis of Ghosh et al. (2013). The fiscal fatigue hypothesis of Ghosh et al. (2013) implies that above a certain public debt/GDP threshold sovereign debt becomes explosive because the government is incapable of further increasing primary fiscal balances in order to finance current interest expenses and consequently stabilize public debt/GDP ratio. On a related issue, there is an economic rationale that the public debt/GDP ratio could exhibit *mildly explosive* behavior in some periods of the sample under study, but one would expect to find such public debt behavior during wars (Yoon, 2012; Esteve and Prats, 2023) and economic downturns (Creel et al., 2023), i.e., during periods of escalating public deficits and debts at public debt/GDP ratios above the 45% threshold.

On econometric grounds, the explosiveness of public debt in relation to GDP ($\hat{\phi}_1^{(1)} > 1$) below the 45% threshold would imply that past shocks to the public debt/GDP ratio have an increasingly stronger influence on the current dynamics of the public debt/GDP ratio. For example, an exogenous shock to the public debt/GDP ratio due to the Great Recession in 2008Q2 would have an increasing impact on current public debt/GDP ratio values over time.[9] As Figure 1, Table 1 and Table 2 show, there is no evidence of such behavior in the sample examined in this study.[10]

The exclusion of a potential unit root as well as an explosive root in the case of the coefficient $\hat{\phi}_1^{(1)}$ implies that the government debt/GDP ratio below the 45% threshold exhibits behavior close to a unit root, which is consistent with the theoretical predictions of Aiyagari et al. (2002) and

[9] Explosive roots are usually a feature of macroeconomic time series during hyperinflations. Evidence for this can be found in Juselius and Mladenovic (2002).

[10] If an underlying time series exhibits explosive behavior, than differentiating the series does not eliminate the stochastic trend (Juselius and Mladenovic, 2002). This is not the case with the public debt/GDP ratio in Serbia between 2001Q1 and 2023Q2, as the reader can see from Figure 1 and Table 1.

Bhandari et al. (2017). Aiyagari et al. (2002) claim that the behavior of the public debt/GDP ratio close to the unit root is a consequence of incomplete markets in the sense that governments cannot issue state-contingent debt, which imputes, consequently, a relatively high degree of persistence in the dynamics of sovereign debt.[11] The persistence of public debt dynamics is directly and proportionally related to a) higher persistence and volatility of government spending shocks and b) debt limits imposed on governments.[12]

Table 4. SETAR (2, 1, 1) model for public debt/GDP with exogenous 45% threshold

Regressors	***Coefficients***	***Standard errors***	$t-stat$
$B_{t-1} \leq 46.87$ $(N_1 = 25)$			
c	0.57	4.37	0.13
B_{t-1}	0.99***	0.13	7.36
$46.87 < B_{t-1}$ $(N_2 = 64)$			
c	14.74***	1.29	11.39
B_{t-1}	0.74***	0.02	42.91

*Notes: Author's calculations. *** 1% significance level, ** 5% significance level, * 10% significance level for t-statistics with heteroscedasticity and autocorrelation (HAC) standard errors and heterogeneous error distributions across 45% public debt/GDP threshold from Bai and Perron (2003). B_t: dependent variable (public debt as % of GDP). B_{t-1}: threshold variable. N_1: number of observations below the fixed 45% public debt/GDP threshold. N_2: number of observations above the fixed 45% public debt/GDP threshold.*

Both features could be important in assessing the fiscal policy stance in Serbia, as a) government spending is more volatile in emerging markets (Koczan, 2015); and b) international creditors and investors, who hold a large share of Serbia's foreign currency-denominated sovereign debt, could impose additional public debt ceilings on policymakers to protect the market value of their bond holdings (Koczan, 2017).

The estimated value for the parameter $\phi_1^{(2)}$, $\hat{\phi}_1^{(2)}$, that denotes the AR(1) coefficient in the upper regime, equals 0.74 and is statistically different from $\hat{\phi}_1^{(1)}$ at the significance level of 10% (p=0.06 for the $\chi^2(1)$ test statistic) according to the results of the Wald coefficient restriction test. The estimated coefficient $\hat{\phi}_1^{(2)}$ implies a lower persistence in the upper regime above the 45% public debt/GDP threshold. This result is to some extent consistent with the theoretical predictions of Blanchard (1990) and Sutherland (1997).[13] Although the models in Blanchard (1990) and Sutherland (1997) imply a consolidation of public debt, the empirical evidence in this paper shows that the government failed to stabilize public debt at 45% of GDP after exceeding the national fiscal rule. In fact, from the upper regime estimates presented in Table 4, the reader can deduce that the long-term target for the public debt-to-GDP ratio is 14.74/(1-0.74)=56.7 percent, which is slightly below the 60% target for the public debt-to-GDP ratio defined in the Maastricht fiscal criteria. Figure 2 and Figure 3 below provide further evidence for this assertion. In particular, Figure 2 shows the residual values of the public debt/GDP ratio (y-axis) from an AR(1)

[11] Bhandari et al. (2017) relax the unrealistic assumption of Aiyagari et al. (2002) that the government can only trade in riskless securities and investigate optimal fiscal policy in a more general setting of incomplete markets. However, their results also imply an ergodic but highly persistent stochastic process for government debt.

[12] Aiyagari et al. (2002) define two debt limits: 1) a natural debt limit, which is a maximum debt limit that a government can almost certainly repay under an optimal fiscal policy, and 2) an ad hoc debt limit, which is always stricter than the natural debt limit.

[13] Blanchard (1990) develops a theoretical framework in which the government runs a deficit so that the national debt increases. When public debt reaches a certain level, the government raises taxes to stabilize the ratio of government debt to GDP. Sutherland's (1997) model is a stochastic version of Blanchard's (1990) model with similar policy prescriptions.

autoregression of the form $B_t = c + B_{t-1} + e_t$ as a function of B_{t-1}(*x*-axis), a one-quarter lagged sovereign debt/GDP ratio. Note that AR(1) autoregression in question is identical to our preferable Tsay's (1989) arranged autoregression from Table 3. From Figure 2 it is evident that the residual values of sovereign debt/GDP ratio cluster around the threshold value of approximately 60%.

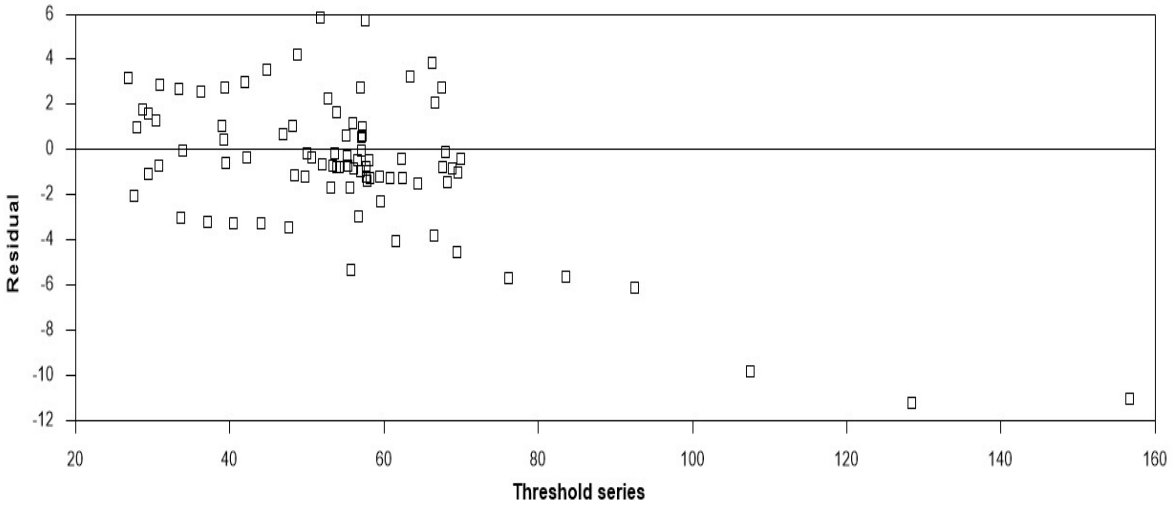


Figure 2. Scatter Plot from Tsay "arranged" autoregression $\boldsymbol{B_t = c + B_{t-1} + e_t}$. *y*-axis: residuals from the AR(1) autoregression. *x*-axis: lagged public debt/GDP ratio.

Source: Author's calculations.

Consistent with Figure 2, Figure 3 depicts standardized values of cumulative sums of recursive residuals (CUSUM) on the *y*-axis as a function of time (*x*-axis) from the estimated SETAR (2, 1, 1) model presented in Table 4.[14] The bold line on the graph plots the values of the CUSUM test statistics of Durbin et al. (1975). The dashed lines from Figure 3 correspond to the 5% significance level lines computed by connecting the points $\left[k, \pm -0.948(T-k)^{1/2}\right]$ and $\left[T, \pm 3 \times 0.948(T-k)^{1/2}\right]$ where k denotes the number of estimated coefficients and T denotes the sample size.

The recursive residuals from Figure 3 convey three important messages. First, the estimated coefficients show signs of instability from 2008Q2 onwards, corresponding to the arrival of the global financial crisis in Serbia. Second, the CUSUM test statistic breaks the 5% significance line in 2011Q4-2012Q1, corresponding to a quarter in which the public debt/GDP ratio exceeded the 45% threshold of the national fiscal rules for the public debt/GDP ratio. Third, the observed coefficient instability continues across the entire sample and only slowly returns to the area of coefficient stability represented by two dashed lines. Overall, the results from Figure 3 are consistent with our earlier conclusion that fiscal policymakers in Serbia are not complying with the 45% public debt to GDP limit, which could jeopardize the credibility of fiscal policy in the eyes

[14] The recursive least squares method involves repeated estimation of the relevant regression equation using larger and larger subsets of the sample data. If the number of coefficients in the regression equation is *k*, then the first *k* observations are used to produce the first estimate of the coefficient vector. Then the next observation is added, and *k+1* observations are used to create the second estimate of the coefficient vector. The process continues until the end of the sample *T* is reached, resulting in *T-k+1* estimates of the coefficient vector. At each step, the last estimate of the coefficient vector can be used to predict the next value of the dependent variable. The one-step-ahead forecast error, divided by its standard deviation, represents a recursive residual. Consequently, the standardized values of the recursive residual sums correspond to the recursive residual sums divided by their respective standard deviations.

of sovereign bond investors, creditors and international financial institutions (Davoodi et al., 2022).

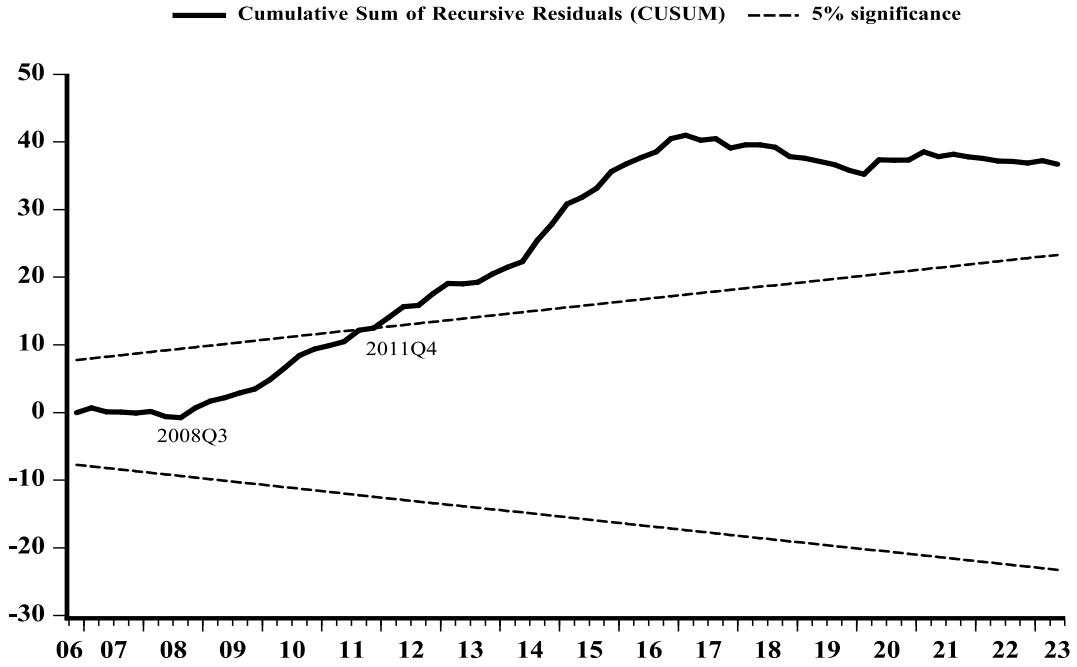


Figure 3. Cumulative Sum of Recursive Residuals (*y*-axis) with respect to time (*x*-axis) from SETAR (2, 1, 1) Model with 45% exogenous public debt/GDP Threshold.

Source: Author's calculations.

CONCLUSIONS

In this paper, the question was asked whether policymakers in Serbia complied with the 45% public debt-to-GDP limit between 2001Q1 and 2023Q2. The answer is that they did not. The paper finds little statistical evidence to support the claim that fiscal policy is more prudent when the public debt-to-GDP ratio is above the 45% threshold. Instead, fiscal policymakers in Serbia focused on targeting the 60% government debt ratio defined in the Maastricht fiscal criteria. One possible explanation for this focus on the 60% public debt threshold is that the European Commission, international financial institutions, rating agencies and foreign investors, who hold a significant share of Serbia's government debt, tend to use the widely known and generally accepted Maastricht fiscal criteria when assessing the fiscal position of a given economy in terms of its ability to repay maturing public debt.

However, Davoodi et al. (2022) report that deviations from the debt limits are very difficult to reverse. Given the recent findings of the OECD (2015) and Badia et al. (2022), which find that the probability of sovereign default increases when public debt exceeds 30-40% of GDP in emerging economies, it is clear that the past behavior of policymakers in Serbia does not contribute to the credibility of its fiscal institutions. Policymakers in Serbia should therefore make greater fiscal efforts to reduce the government debt-to-GDP ratio below the fiscal rule limit of 45%, while maintaining macroeconomic stability and promoting economic growth in line with OECD (2015) recommendations. Focusing on prudent debt targets below the 45% public debt limit would allow fiscal policymakers to assess uncertainties in a timely manner regarding adverse macroeconomic shocks and provide additional fiscal space for conducting counter-cyclical fiscal policy.

Given the evidence presented in this paper, it appears that the announced suspension of the general fiscal rules on public debt and the overall budget deficit until 2029 would further

undermine the credibility of fiscal institutions in Serbia. Although such a suspension was probably justified in the previous period due to the COVID-19 pandemic, in the current economic environment it is relatively difficult to find a solid economic justification for such behavior by the fiscal authorities (Fiscal Council, 2024). Fiscal authorities should therefore strive to comply with national fiscal limits by simultaneously 1) making efficient and prudent infrastructure investments that could have high multiplier effects in the medium to long term; 2) keeping the growth of public wages and pensions in line with the targets set in the special fiscal rules; and 3) restructure and/or privatize state-owned enterprises, which in the case of Serbia represent the largest fiscal risk and have cost taxpayers in Serbia on average around 1.9% of GDP annually over the last 10 years (Balaban and Grubisic, 2021).

Finally, the empirical analysis presented in this paper has at least two limitations. First, the study in question uses only a particular nonlinear framework, specifically the specification of the SETAR model, while the estimates of other nonlinear models, such as Markov regime-switching models, are not examined. Billio et al. (2013) show that a complementary use of SETAR and Markov regime-switching models allows for a more accurate and robust detection of turning points in the business cycle in the case of the Eurozone after 1970. In the context of the present work, Markov switching models could potentially be useful to identify the transition probabilities between states in which government debt/GDP expands and in which it collapses. Second, the present analysis does not use real-time fiscal data, so it essentially assesses the *ex-post* behavior of fiscal policymakers between 2001Q1 and 2023Q2. The creation of a real-time fiscal policy dataset in the case of Serbia, which would be an important policy contribution in itself (see Cimadomo, 2014, for an overview), would allow for more precise identification of fiscal shocks and an *ex-ante* assessment of fiscal policy decisions in Serbia.

ACKNOWLEDGMENTS

The Ministry of Science, Technological Development and Innovation of the Republic of Serbia funded the research presented in this paper under contract number 451-03-47/2023-01/200005.

REFERENCES

Aiyagari, R., Marcet, A., Sargent, T., & Seppälä, J. (2002). Optimal Taxation without State-Contingent Debt. *Journal of Political Economy*, 110(6), 1220-1254.

Andric, V., & Minovic, J. (2022). The Sources of Serbian Budgetary Imbalances in a Time of Transition, Crisis and Global Pandemics. In *Economic and Financial Implications of COVID-19 Crises*, ed. S. Redzepagic, A. P. Duarte, M. Siničáková, & D. Bodroza, 107-125. Nice: Université Côte d'Azur.

Arsic, M., Nojkovic, A., & Randjelovic, S. (2017). Determinants of discretionary fiscal policy in Central and Eastern Europe. *Economic Systems*, 41(3), 367-378.

Badia, M. M., Medas, P., Gupta, P., & Xiang, Y. (2022). Debt is not free*. Journal of International Money and Finance*, 127(C), 102654.

Bai, J., & Perron, P. (2003). Computation and analysis of multiple structural change models. *Journal of Applied Econometrics*, 18(1), 1-22.

Balaban, M., & Grubisic, Z. (2021). Monitoring Fiscal Risks in the National Economy. *Economic Analysis*, 54(2), 128-138.

Barro, R. (1979). On the Determination of the Public Debt. *Journal of Political Economy*, 87(5), 940-971.

Bec, F., Guay, A., Nielsen, H. B., & Säidi, S. (2022). *Power of unit root tests against nonlinear and noncausal alternatives*. THEMA Working Paper 2022/14.

Bhandari, A., Evans, D., Golosov, M., & Sargent, T. (2017). Fiscal Policy and Debt Management with Incomplete Markets. *The Quarterly Journal of Economics*, 132(2), 617-663.

Billio, M., Ferrara, L., Guégan, D. & Mazzi, G.L. (2013). Evaluation of Regime Switching Models for Real-Time Business Cycle Analysis of the Euro Area. *Journal of Forecasting*, 32(7), 577-586.

Blanchard, O. J. (1990). Comment on "Can Severe Fiscal Contractions be Expansionary?". In *NBER Macroeconomics Annual*, ed. O. Blanchard, & S. Fisher, 111-117. Cambridge, MA: MIT Press.

Bohn, H. (2007). Are stationarity and cointegration restrictions really necessary for the intertemporal budget constraint? *Journal of Monetary Economics*, 54(7), 1837-1847.

Brown, R. L., Durbin, J., & Evans, J. M. (1975). Techniques for Testing the Constancy of Regression Relationships Over Time. *Journal of the Royal Statistical Society, Series B*, 37, 149-192.

Carrasco, M. (2002). Misspecified Structural Change, Threshold, and Markov-switching Models. *Journal of Econometrics*, 109(2), 239-273.

Chan, K. S., Petruccelli, J. D., Tong, H. & Woolford, S. W. (1985). A Multiple-Threshold AR(1) Model. *Journal of Applied Probability*, 22(2), 267-279.

Chortareas, G., Kapetanios, G., & Uctum, M. (2008). Non-linear Alternatives to Unit Root Tests and Public Finances Sustainability: Some Evidence from Latin American and Caribbean Countries. *Oxford Bulletin of Economics and Statistics*, 70(5), 645–663.

Cimadomo, J. (2014). Real-Time Data and Fiscal Policy Analysis: A Survey of the Literature. *Journal of Economic Surveys*, 30(2), 302-326.

Considine, J., & Gallagher, L. A. (2008). UK Debt Sustainability: Some Non-linear Evidence and Theoretical Implications. *The Manchester School*, 76(3), 320–335.

Cuestas, J. C. (2020). Changes in sovereign debt dynamics in Central and Eastern Europe. *International Journal of Finance & Economics*, 25(1), 63-71.

Cuestas, J. C., & Regis, P. J. (2018). On the dynamics of sovereign debt in China: Sustainability and structural change. *Economic Modelling*, 68(C), 356–359.

Creel, J., Dabrowski, M., Farvaque, E., Janus, J., & Stanek, P. (2023). *A stringent necessity: Addressing fiscal bubbles with fiscal rules in Central and Eastern Europe*. Sciences Po OFCE Working Paper 11/2023.

Davoodi, H. R., Elger, P., Fotiou, A., Garcia-Macia, D., Han, X., Lagerborg, A., Lam, R. W., & Medas, P. (2022). *Fiscal Rules and Fiscal Councils: Recent Trends and Performance during the Covid-19 Pandemic.* IMF Working Paper 22/11.

Dickey, D. A. & Fuller, W. A. (1981). Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. *Econometrica*, 49(4), 1057-1072.

Elliott, G., Rothenberg, T. J., and Stock, J. H. (1996). Efficient Tests for an Autoregressive Unit Root. *Econometrica*, 64(4), 813-836.

Enders, W. (2001). Improved critical values for the Enders-Granger unit-root test. *Applied Economics Letters,* (8)4, 257-261.

Enders, W., & Granger, C. J. W. (1998). Unit-root Tests and Asymmetric Adjustment with an Example Using the Term Structure of Interest Rates. *Journal of Business & Economic Statistics*, 16(3), 304-311.

Esteve, V., & Prats, M. A. (2023). Testing explosive bubbles with time-varying volatility: The case of Spanish public debt. *Finance Research Letters*, 51, 103330.

Fiscal Council. (2024). *Opinion on Fiscal Strategy Draft for 2025 with Projections for 2026 and 2027*. Fiscal Council Reports.

Ghosh, A. R., Kim, J. I., Mendoza, E. G., Ostry, J. D., & Qureshi, M. S. (2013). Fiscal Fatigue, Fiscal Space and Debt Sustainability in Advanced Economies. *Economic Journal*, 123, F4-F30.

Glavaski, O., & Pucar Beker, E. (2020). Fiscal Adjustments in the European Union versus West Balkan Economies: Evidence from Heterogeneous Panels. *Economic Analysis*, 53(1), 149-162.

Gnegne, J., & Jawadi, F. (2013). Boundedness and non-linearities in public debt dynamics: A TAR assessment. *Economic Modelling*, 34(C), 154–160.

González, M., & Gonzalo, J. (1997). *Threshold Unit Root Models*. DES Working Paper 97-50.

Hansen, B. (2017). Regression Kink With an Unknown Threshold. *Journal of Business & Economic Statistics*, 35(2), 228-240.

Jiang, Z., Lustig, H., Van Nieuwerburgh, S., & Xiaolan, M. Z. (2024). What Drives Variation in the U.S. Debt-to-Output Ratio? The Dogs that Did not Bark. *Journal of Finance*, 79(4), 2603-2665.
Juselius, K., & Mladenovic, Z. (2002). *High Inflation, Hyperinflation and Explosive Roots: The Case of Yugoslavia*. Department of Economics University of Copenhagen Discussion Paper 02-23.
Koczan, Z. (2015). *Fiscal Deficit and Public Debt in the Western Balkans: 15 Years of Economic Transition.* IMF Working Paper 15/172.
Koczan, Z. (2017). *Late to the game? Capital flows to the Western Balkans*. IMF Working Paper 17/92.
Kwiatkowski, D., Phillips, P. C. B., Schmidt, P. & Shin, Y. (1992). Testing the Null Hypothesis of Stationarity against the Alternative of a Unit Root. *Journal of Econometrics*, 54(1-3), 159-178.
Legrenzi, G., & Milas, C. (2011). *Debt Sustainability and Financial Crises: Evidence from the GIIPS*. CESifo Working Paper No. 3594.
Ministry of Finance of the Republic of Serbia. (2024). Public Finance Bulletin. Available at https://www.mfin.gov.rs/en/activities/bulletin-public-finance-2.
Ng, S., and Perron, P. (2001). Lag Length Selection and the Construction of Unit Root Tests with Good Size and Power. *Econometrica*, 69(6), 1519-1554.
OECD. (2015). *Achieving prudent debt targets using fiscal rules*. OECD Economics Department Policy Notes No. 28.
Petruccelli, J. D. & Woolford, S. W. (1984). A Threshold AR(1) Model. *Journal of Applied Probability*, 21(2), 270-286.
Roubini, N., & Sachs, J. D. (1989). Political and economic determinants of budget deficits in industrial economies. *European Journal of Political Economy*, 33(5), 903-933.
Sarno, L. (2001). The behavior of US public debt: a non-linear perspective. *Economics Letters*, 74(1), 119–125.
Schwert, G. W. (1989). Tests for Unit Roots: A Monte Carlo Investigation. *Journal of Business & Economic Statistics*, 7(2), 5–17.
Statistical Office of the Republic of Serbia. (2024). Quarterly Gross Domestic Product by Expenditure Approach (SNA 2008/ESA 2010). Available at Dissemination database search (stat.gov.rs).
Sutherland, A. (1997). Fiscal crises and aggregate demand: can high public debt reverse the effects of fiscal policy? *Journal of Public Economics*, 65(2), 147-162.
Tsay, R. S. (1989). Testing and modeling threshold autoregressive processes. *Journal of the American Statistical Association*, 84(405), 231–240.
Yoon, G. (2012). War and peace: Explosive US public debt, 1791–2009. *Economics Letters*, 115(1), 1–3.

Article history:	Received: 9.8.2024.
	Revised: 23.8.2024.
	Accepted: 28.8.2024.

DOI: 10.28934/ea.24.57.3.pp52-69 First Online: September 13, 2024

ORIGINAL SCIENTIFIC PAPER

Farming Standards as a Catalyst for Food Export: Middle-Income European Countries Case Study

Vesna Paraušić[1]* | Nataša Kljajić[1] | Ivana Domazet[2]

[1] Institute for Agricultural Economics, Belgrade, Serbia
[2] Institute of Economic Sciences, Belgrade, Serbia

ABSTRACT

IFA GLOBALG.A.P. is a leading private and voluntary worldwide standard for sustainable agriculture. Its implementation and certification are increasingly becoming a prerequisite for exporting food and vegetables to EU countries and other high-income markets. The aim of the paper is to examine farmers' progress in sustainable agriculture as part of the production certification within the IFA GLOBALG.A.P. standard for fruit and vegetables in 13 middle-income European countries. At the same time, the authors examine whether this progress can act as a "catalyst" which improves the export performance of these national economies in the sector of fruit and vegetables. The export performance was represented by the following criterion variables: (a) annual values of fruit and vegetable export in thousand US dollars; (b) annual values of fruit and vegetable export to high-income importing markets, in thousand US dollars and (c) the percentage share of food and vegetable export to high-income markets in the total food and vegetable export. The predictor variable was defined as the number of IFA GLOBALG.A.P. certified farmers. All variables were presented per country and year. The research included the period from 2010 to 2021, while the hypotheses were tested using the panel regression analysis. Individual models were tested for each criterion variable, and all three models were adequate. The results show that the rise of IFA GLOBALG.A.P. certified producers increases the values of all three studied criterion variables. The results that were obtained complement and enrich the scarce academic literature in this field related to developing countries in Europe. In addition, the research offers guidelines and recommendations for directing national policies toward greater implementation of private and voluntary farm certification schemes for sustainable agriculture.

Keywords: *sustainable agriculture, export performance, IFA GLOBALG.A.P. certification standard, developing countries, fruit and vegetables*

JEL Classification: Q17, Q18, Q50

INTRODUCTION

Producing safe and high-quality food, along with positive economic, trade, social, health, and environmental effects of primary agricultural production, is becoming increasingly significant in local and global supply chains. The European Commission, international institutions, and the scientific community clearly and unequivocally believe that agriculture has to meet the growing global demand for food and address the following challenges at the same time: (a) ensure profitability and farmer fair practice rules, (b) strengthen its environmental, social, and health components, (c) adopt green and organic agricultural practices and promote sustainable and

* Corresponding author, e-mail: vparausic@gmail.com

resilient agri-food systems and food supply chains to protect the environment and restore biodiversity (UN, 2015; Latruffe et al., 2016; FAO, 2018; EC, 2019; EC 2020; Lykogianni et al., 2021; World Bank, 2021; Rad, Ray & Barghi, 2022; Knapp & Sciarretta, 2023).

One way of transforming the agricultural sector into a sustainable system is by implementing different certification schemes for sustainable agriculture. There are as many as 198 of these schemes in the countries of the European Union and third countries (EU, 2022). Private bodies established more than two-thirds of the certified schemes, while one-third are established by public entities (EU, 2022). A number of schemes, which have a large scope of responsibilities for farmers, contribute directly and substantially to nearly all EU sustainability aims in the agricultural sector. Other schemes help to achieve one to three sustainability aims (mainly resource management, environmental protection, animal health and welfare, and, less frequently, climate change). The remaining schemes focus on a single aim, i.e., animal welfare or climate (EU, 2022).

"*Good Agricultural Practices for primary production and the supply chain*" (abbr. GLOBALG.A.P.) is the leading global, private, and, voluntary standard and farm certification scheme for sustainable agriculture and food safety and quality (EU, 2022, p. 39). More than 200,000 agricultural producers worldwide certify their agricultural production according to the GLOBALG.A.P. standard (GLOBALG.A.P. organization, data obtained on request). This standard focuses on sustainable agricultural practices, supply chain traceability, food security and safety, workers' well-being, and, animal welfare (FAO, 2016; EU, 2022; GLOBALG.A.P. organization website). Integrated Farm Assurance (IFA) for fruit and vegetables (F&V) is one of the GLOBALG.A.P.'s core solutions, resulting in the largest number of certificates. Of the total number of IFA certificates, 96.5% are under the IFA F&V scheme, covering four million certified hectares annually (GLOBALG.A.P. organization, data obtained on request; GLOBALG.A.P. organization website). This is a global standard for "*safe and responsible farming practices at primary production level. It is built on a holistic approach that covers the key topics of food safety, environmental sustainability, workers' well-being, production processes, and traceability*" (GLOBALG.A.P. organization website).

The implementation and certification of agricultural production according to different private farm certification schemes are increasingly becoming a precondition for exporting food to high-income markets and for raising the country's competitiveness on the global market of agricultural products (FAO, 2016; Popović & Paraušić, 2016; Niemiec et al., 2019; Flachsbarth, Grassnick & Brümmer, 2020; Rao, Bast & De Boer, 2021). For example, the GLOBALG.A.P. IFA standard for F&V has a substantial impact on the global chain of fresh F&V, considering that certification of production according to this standard is increasingly becoming a prerequisite for entering the EU-15 market and other high-income markets, particularly for lower-income countries (Andersson, 2019; Flachsbarth, Grassnick & Brümmer, 2020; Amekawa et al., 2021). Today, this standard is requested as a trading requirement from farmers and exporters primarily by retailers, supermarkets, and processors in the EU (Flachsbarth, Grassnick & Brümmer, 2020; EU, 2022; GLOBALG.A.P. organization website). As stated by Masood & Brümmer (2014, p. 15), "*Since private standards directly affect trade, even if the adoption of GlobalG.A.P. is voluntary in nature, its compliance could be quasi-mandatory for exporters competing in the international market.*"

Bearing in mind the above-mentioned points, the authors used a sample of 13 middle-income European countries to examine the impact of the GLOBALG.A.P. IFA certification scheme for F&V on national export results in the F&V sector during the period 2010-2021. The authors studied the statistical significance of the impact that changes in the number of GLOBALG.A.P. IFA-certified producers in the sector of F&V have on: (a) the realized export value in the F&V sector; (b) the realized F&V export value to high-income markets, and (c) the percentage share of the realized F&V export value to high-income markets in the total F&V export values. Descriptive statistics and panel regression were used for this analysis.

The aim of the research is to investigate whether the implementation of GLOBALG.A.P.'s flagship standard (IFA for F&V) among farmers in 13 middle-income European countries correlates with improved export performance in the F&V sector of these national economies. The selection of the countries in the sample was determined by the fact that no author had previously considered this group of countries in their studies. On the other hand, there is comprehensive literature on the impact of farm certification schemes on the export performance of farmers and national economies in Africa's and Asia's developing countries.

LITERATURE REVIEW

Examining the impact of GLOBALG.A.P. certification on the export performance of farmers and national economies, a large number of authors unambiguously highlighted its positive effects. A chronological review of the most significant recent research results is given below:

- Using three-year panel data (2010 – 2012) for 74 banana exporting countries, Masood & Brümmer (2014) concluded that the advancement of the countries in terms of GLOBALG.A.P. certification (measured by the number of certified producers and certified area in hectares) was correlated with greater banana export to the EU market;
- Andersson (2019) highlighted that GLOBALG.A.P. acted more as a catalyst than as an obstacle to trade, and that this standard was important for primary producers in the F&V sector who wanted to enter the EU-15 market. The author's findings confirmed the positive relationship between GLOBALG.A.P. certification and trade for high-income and low-income countries. It was estimated that the positive trade impact was higher for low-income countries. Therefore, certification according to private standards might be particularly significant for developing countries which want to enter high-income markets;
- According to Laosutsan, Shivakoti & Soni (2019), the income variable and higher prices on export markets were the most significant factors affecting the adoption of good agricultural practices (GLOBALG.A.P.) by small-scale vegetable farmers in Thailand; also, importers were more confident about the quality and safety of certified vegetables and were willing to pay more for it;
- A study in Poland (Niemiec et al., 2019) showed that the GLOBALG.A.P. standard implementation contributed to greater product safety; significantly increased producers' chances for introducing their products to the international market (through commercial networks); and strengthened farmers' position in export markets;
- A valuable study realized by a group of authors Fiankor et al. (2020) using a sample of 120 countries assessed the impact of GLOBALG.A.P. certification on the export of apples, bananas and grapes to the global market. The authors considered the GLOBALG.A.P. standards to be trade catalysts, indicating that **"***the trade effects are higher for exports to high-value EU and OECD markets, but interestingly, they are substantial even for exports to markets outside these regions***"** (Fiankor et al., 2020, p. 268);
- According to Flachsbarth, Grassnick & Brümmer (2020, p. 20) **"**Certification entails substantial benefits, such as better working conditions for farmers and workers, an increase in productivity levels and access to high-value (export markets) with their inherent positive effects for farm income, as well as environmental protection**";**
- The results of Krauss & Krishnan (2022) indicate that although GLOBALG.A.P. certification did not significantly increase the income of Kenyan farmers and did not strengthen their bargaining capacity, the farmers who invested in the certification were able to expand their export markets and sell into growing regional markets, including Kenyan supermarkets.

There are authors who highlight the negative effects of GLOBALG.A.P. implementation, contrasting with the positive attitudes mentioned above. These authors highlight that private standards do not represent/do not have to represent a trade catalyst for developing countries or a source of strengthening the market and competitive position of farmers and national economies. They state that, due to various factors (extensive demands for farmers and high implementation costs, low total resources of farmers and national economies, non-renewal of certification and contracts with exporters and alike), private standards lead to the exclusion and/or marginalization of small-scale farmers in the international market, as well as to the concentration of agriculture in these countries (Schuster & Maertens, 2015; Kleemann, 2016; Capobianco-Uriarte et al., 2021; Kassem et al, 2021). Using company-level data for 87 export asparagus firms in Peru during the period 1993–2011, Schuster & Maertens (2015, p. 208) analyzed the impact of private standards on the export performance of the firms, and they stated the following: "*We do not find any evidence that certification to private standards in general and to specific individual private standards, has an effect on firms' export performance, neither at the extensive margin nor at the intensive margin, and neither on export volumes nor on export values*". Also, using the example of banana exporting countries and the GLOBALG.A.P. standard implementation, Masood & Brümmer (2014, p. 1) also indicated that "*Small farmers in developing countries who find it difficult to comply with the GlobalG.A.P. standard requirements are driven out of the international banana market*."

Moderate attitudes indicate that it is not easy to establish and measure the trade and export effects of agricultural products under the GLOBALG.A.P. certification scheme or other farm certification schemes. For example, the GLOBALG.A.P. certification scheme's impact on the export performance of farmers, export companies and national economies depends on various factors, such as: product type, the destination of export markets, location of agricultural production, prices in the mainstream market, price premium, etc. (Subervie & Vagneron, 2013; Laosutsan, Shivakoti & Soni, 2019; Fiankor et al., 2020). Examining the trade (export) effects of GLOBALG.A.P. certification on lychee farmers in Madagascar, Subervie & Vagneron (2013) concluded that this certification had a positive effect on the sales volume and farm gate prices obtained by certified lychee farmers. However, they also stated that positive effects were felt by only a small number of certified farmers who were able to transport their products to the port. In addition, these authors indicated that GLOBALG.A.P. certification had a small effect on the production stage and was more focused on post-harvest requirements (mainly concerning exporters). Consequently, exporters undertook most of the efforts for certification (for example, investing, selecting, and training farmers), and therefore gained most benefits from it (Subervie & Vagneron, 2013).

In general, an interesting observation is that none of the papers show an actual reduction in exports, although they do note some negative effects, especially in developing countries (such as the exclusion and/or marginalization of small-scale farmers in the international food market, and increased concentration in agribusiness, etc.). Otherwise, the authors share opinions that are in the group of moderate attitudes, according to which the impact of the implementation of the GLOBALG.A.P. certification scheme on the export performance (of farmers, export companies and national economies) depends on many factors, different influences and circumstances.

DATA AND METHODOLOGY

In order to investigate the impact of implementing the IFA GLOBALG.A.P. certification scheme (crops base) on the national export results in the F&V sector, using a sample of European developing countries during the period 2010-2021, the authors proposed the following three hypotheses, whose statistical significance was examined:

- $H_1/1$ – Changes in the number of IFA GLOBALG.A.P. certified producers have a positive impact on the realized export value in the F&V sector;

- *$H_1/2$* – Changes in the number of IFA GLOBALG.A.P. certified producers have a positive impact on the realized F&V export value to high-income markets;
- *$H_1/3$* – Changes in the number of IFA GLOBALG.A.P. certified producers positively impact the percentage share of the F&V export value to high-income markets in the total F&V export value (to all markets).

To this aim, the following variables were defined per country and year:

- The predictor variable was represented by the number of producers under the IFA GLOBALG.A.P. standard (crops base);
- The criterion variables were represented by: (a) F&V export value, in thousands of US dollars; (b) F&V export value to high-income importing markets, in thousands of US dollars; (c) the percentage of F&V export value to high-income importing markets in the total F&V export value.

The analysis included the 13 middle-income countries of the European continent: Albania, Armenia, Azerbaijan, Bosnia & Herzegovina, Bulgaria, Georgia, Moldova, North Macedonia, Romania, Russian Federation, Serbia, Turkey and Ukraine. The sample was formed based on the World Bank country classification by region and income (World Bank Country and Lending Groups, official website presentation).

As for the group of high-income economies, according to the classification of the World Bank, the threshold for inclusion of countries in this group, as well as for the other groups of economies by income (GNI per capita) varies by years (World Bank Country and Lending Groups, official website presentation). For the 2022 fiscal year, high-income economies are those with a GNI per capita of $12,695 or more. That is a total of 80 countries in the world (EU-15 + 65 others). Middle-income economies are those with a GNI per capita between $1,046 and $12,695 according to the World Bank Country and Lending Groups, official website presentation.

The data on the number of IFA GLOBALG.A.P. certified producers (crops base) per country for the analyzed period were obtained from the global organization GLOBALG.A.P. at the request of the authors (GLOBALG.A.P. organization, data obtained on request).

The data on the export values in the F&V sector were provided by the International Trade Centre (Trade Map, database) for the customs tariffs HS 07 (Edible vegetables and certain roots and tubers) and HS 08 (Edible fruit and nuts; peel of citrus fruit or melons).

Descriptive statistics and panel regression were used for this analysis. The analysis was conducted in the statistical software STATA 12.

RESULTS AND DISCUSSION

Descriptive statistics (presented in Table 1 below, as well as in Table 1 in the Annex and in Figures 1-3 in the Annex) offer good insights into the predictor and criterion variables across the sample of European developing countries from 2010 to 2021.

The average number of IFA GLOBALG.A.P. certified producers (crops base) is 282, with considerable variation between countries (*SD*=694.2). By country (Figure 1 in the Annex), the greatest average number of certified producers in the analyzed period was found in Turkey (2,537), followed by Serbia (508) and Bosnia and Herzegovina (265). The smallest average number of IFA GLOBALG.A.P. certified producers was recorded in Armenia (1), followed by Azerbaijan (4), Georgia (5), Russian Federation (6), and Moldova (12).

The average export value of F&V in the studied period amounted to 658,252.8 US$, 000, also with considerable variation between countries (*SD*=1,451,431). Figure 2 in the Annex shows that the lowest average value of this variable is recorded by Armenia (46,282.17 US$, 000), followed by Albania (53,796.73 US$, 000), and Bosnia and Herzegovina (77,503.25 US$, 000). The highest average value of F&V exports is recorded by Turkey (5,442,604.83 US$, 000). Turkish export of

F&V is even 8 times higher than in Serbia (679,123.25 US$, 000), which is right behind Turkey in terms of the value of this indicator (Figure 2 in the Annex).

The average export value of F&V to high-income markets in the analyzed period amounted to 345,255.6 US$, 000, also with considerable variation between countries as the previous one (*SD*=808,029.2) (Table 1). The highest average value of this variable is recorded by Turkey (3,001,435.83 US$, 000), behind which is Serbia with an export value of 464,171.42 US$, 000. The lowest values of this variable are shown by Armenia (950.58 US$, 000) (Figure 2 in the Annex).

Finally, the average share of F&V export value to high-income markets in the total F&V export value by country amounted to 46.4% (*SD*=25.1). The highest value of this variable is achieved by Romania (84.7%), followed by Bulgaria (76.5%) and Serbia (68.4%). The lowest values are observed in Armenia (2.2%), and Azerbaijan (11.6%) (Figure 3 in the Annex).

Table 1. Descriptive statistics

Variables		M	SD	Min	Max	N
Predictor variable						
IFA GLOBALG.A.P. producers (crops base), No.	Overall	282	693.2	0	3,299	154
	Between		694.2	1	2,537	13
Criterion variables						
F&V export value, US $, 000	Overall	658,252.8	1,424,234	8,289	7,120,504	154
	Between		1,451,431	46,282.2	5,442,605	13
F&V export value to high-income markets, US $, 000	Overall	345,255.6	791,517.8	76	3,876,365	154
	Between		808,029.2	950.6	3,001,436	13
F&V export value to high-income markets in the total export value of F&V, %	Overall	46.4	25.1	0.1	93.6	154
	Between		24.5	2.2	84.7	13

Source: Authors' calculations. For Albania and North Macedonia data are given for the period 2010-2020.

The correlation coefficients shown in Table 2 reveal strong positive correlations between the predictor variable (GLOBALG.A.P. certified producers, crops base) and F&V export values, both overall and specifically to high-income markets. The correlation with the percentage share of F&V export value to high-income markets is positive but weaker. These findings align with existing literature supporting the positive impact of GLOBALG.A.P. certification on export performance in the F&V sector.

Table 2. Correlation coefficients

	IFA GLOBALG.A.P. producers	F&V export value to high-income markets	F&V export value to high-income markets in the total export value of F&V, %
F&V export value	0.952 (0.000)**	0.994 (0.000)**	0.112 (0.165)
IFA GLOBALG.A.P. producers, crop base		0.963 (0.000)**	0.212 (0.008)**
F&V export value to high-income markets			0.185 (0.022)*

Source: Authors' calculations.

As the data in Table 2 show, certification under the GLOBALG.A.P certification scheme is positively and strongly correlated with the F&V export value (r=0.952; p=0.00), as well as with the F&V export value to high-income markets (r=0.963; p=0.00). At the same time, the certification has a positive but weak correlation with the changes in the percentage share of the F&V export to high-income markets in the total F&V export value (r=0.212; p=0.01). There is also a statistically significant, strong and positive correlation between the F&V export value and F&V export value

to high-income markets (r=0.994; p=0.00). The following diagrams show the correlation between the predictor variable and the criterion variables (Figure 1, Figure 2, Figure 3).

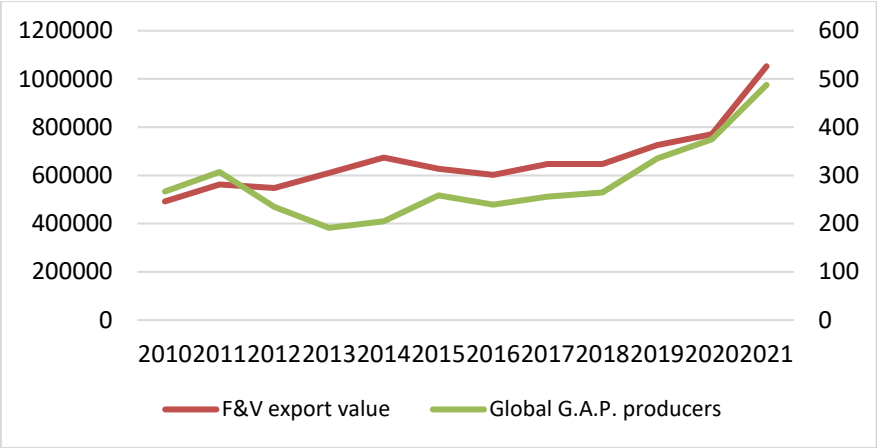


Figure 1. IFA GLOBALG.A.P. producers and F&V export values

Source: Authors' calculations.

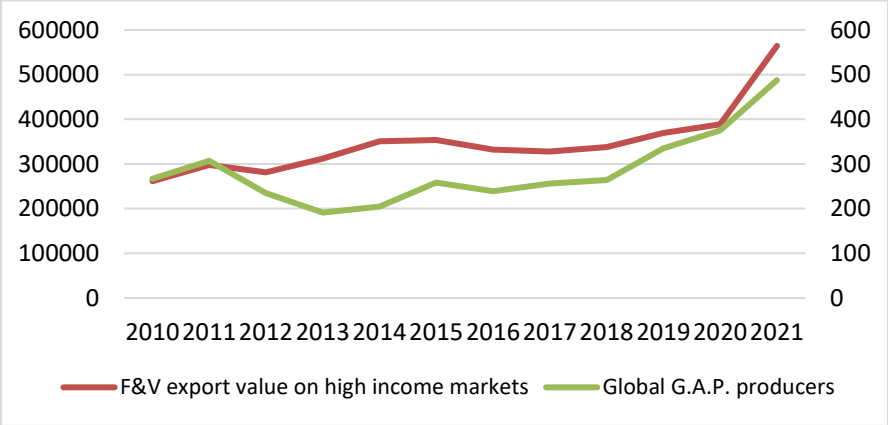


Figure 2. IFA GLOBALG.A.P. producers and F&V export value to high-income markets

Source: Authors' calculations.

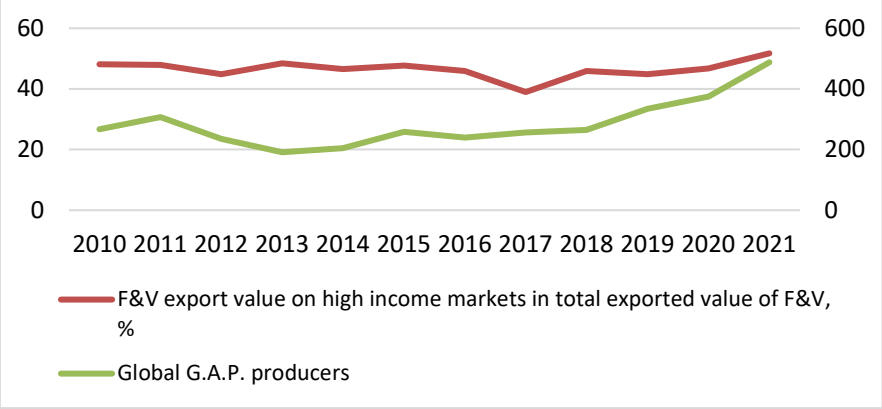


Figure 3. IFA GLOBALG.A.P. producers and F&V export value to high-income markets in the total export value of F&V, %

Source: Authors' calculations.

The panel regression analysis was used to assess the impact of the predictor variable on the criterion variables. Individual models were tested for each dependent (criterion) variable (Table 3).

A fixed effects model (FE robust) is suitable for estimating the impact of the predictor variable on the export value in the F&V sector, as confirmed by the results of the *Breusch-Pagan LM* ($\chi^2(1)=96.15$; $p=0.00$) and Hausman test ($\chi^2(1)=63.93$; $p=0.00$) (Table 3).

A fixed effects model (FE robust) is suitable for estimating the impact of the predictor variable on the F&V export value to high-income markets, as confirmed by the results of the *Breusch-Pagan LM* ($\chi^2(1)= 36.25$; $p=0.00$) and Hausman test ($\chi^2(1)=79.08$; $p=0.00$) (Table 3).

Finally, a random effects model is suitable for estimating the impact of the predictor variable on the percentage share of the F&V export value to high-income markets in the total F&V export, as confirmed by the results of the *Breusch-Pagan LM* ($\chi^2(1)= 653.81$; $p=0.00$) and Hausman test ($\chi^2(1)=0.31$; $p=0.58$) (Table 3).

Panel regression confirms the positive impact of GLOBALG.A.P. certification on F&V export outcomes. The results indicate that an increase in the number of certified producers leads to significant increases in both total F&V export value and F&V export value to high-income markets. Additionally, there is a slight but significant increase in the percentage share of F&V export value to high-income markets. The results prove the stated hypotheses and show that when the number of GLOBALG.A.P. certified producers is increased by one (Table 3):

- the total export value of the F&V sector increases by US$ 370,819 on average;
- the F&V export value to high-income markets increases by US$ 224,766 on average;
- the percentage share of the F&V export value to high-income markets in the total F&V export increases by 0.003 percentage points on average.

Table 3. Regression coefficients

	F&V export value	**F&V export value to high-income markets**	**F&V export value to high-income markets in the total export value of F&V, %**
Constant	553,523 [8,357.867] (0.000)**	281,775.4 [10,300.93] (0.000)**	45.442 [3.121] (0.000)**
GLOBALG.A.P. producers	370,819 [29.593] (0.000)**	224,766 [36.473] (0.000)**	0.003 [0.001] (0.011)*
R^2	0.586	0.806	0.586
Test	F(1, 12)= 157.02	F(1, 12)=37.98	$\chi^2(1)=6.45$
P	0.000	0.000	0.011
Wooldridge	F(1, 12)= 2,480.51, p=0.000	F(1, 12)= 290.05, p=0.000	F(1, 12)=6.38, p=0.027
Wald	$\chi^2(13)$= 6.6e+05; p=0.000	$\chi^2(13)$= 1.4e+10; p=0.000	$\chi^2(13)$= 37,808.66; p=0.000
F test	F(12, 140)=36.52; p=0.000	F(12, 140)=33.09; p=0,000	F(12, 140)=91.92; p=0.000
LM test	$\chi^2(1)$= 96.15; p=0.000	$\chi^2(1)$= 36.25; p=0.000	$\chi^2(1)$= 653.81; p=0.000
Hausman test	$\chi^2(1)$= 63.93; p=0.000	$\chi^2(1)$= 79.08; p=0.000	$\chi^2(1)$= 0.31; p=0.579

*Note: ** level of significance α=0.01; * level of significance α=0.05.*

Source: Authors' calculations. Output from the statistical software STATA 12.

The obtained data are in concordance with the studies of numerous authors who tried to prove the positive impact of GLOBALG.A.P. certification on the export performance of farmers and national economies in the F&V sector (Masood & Brümmer, 2014; Andersson, 2019; Laosutsan, Shivakoti & Soni, 2019; Niemiec et al., 2019; Fiankor et al., 2020; Flachsbarth, Grassnick &

Brümmer, 2020; Krauss & Krishnan, 2022). On the other hand, our results do not align with the attitudes of the authors stating that GLOBALG.A.P. certification in the F&V sector does not act as a catalyst for trade and export, primarily due to the small number of certified farmers and the fact that certification is extremely demanding in terms of implementation and costs, particularly for small-scale farmers (Schuster & Maertens, 2015; Kleemann, 2016; Capobianco-Uriarte et al., 2021; Kassem et al, 2021).

Nevertheless, one should be aware that the implementation of GLOBALG.A.P. standards is particularly significant for all developing countries, which have weak food safety and quality standards, as well as other standards related to the environment, social elements of hiring workers and animal welfare, alongside fragmented agriculture with poor application of contracts (Kleemann, 2016; Fiankor, Martínez-Zarzoso & Brümmer, 2019; FAO, 2020; Ramirez-Hernandez et al., 2020; Oppong & Bannor, 2022). In these countries, standards represent a catalyst for transforming production systems into safe and sustainable ones; they serve as a surrogate for undeveloped institutions and a "ticket" for marketing F&V through the global supply chain (Kleemann, 2016; Andersson, 2019; Fiankor, Martínez-Zarzoso & Brümmer, 2019; Flachsbarth, Grassnick & Brümmer, 2020; Oppong & Bannor, 2022). At the same time, in most developing countries it is necessary to promote public policies (those stimulating more effective implementation of environmental regulations, those encouraging investment in clean energy and alike) that give equal emphasis to economic growth and environmental protection (Mitić, Fedajev & Kojić, 2023).

In the agricultural sector, public policies should, among other things, be directed at encouraging farmers to adopt different private and voluntary farm certification schemes (i.e. stimulating the increase in the number of farmers under these schemes, as well as the increase in certified areas in ha). In the process, policymakers should bear in mind that the requirements of private standards are frequently very demanding for small-scale farmers (both in terms of finances and administration). In addition, the standard implementation is hindered by numerous obstacles such as: lack of human, physical, and financial capital, low social capital, low productivity and profitability of agricultural production, etc. (Kleemann, 2016; Annor, Mensah-Bonsu & Jatoe, 2016; Niemiec et al., 2019; Capobianco-Uriarte et al., 2021; Malkanthi, Thenuwara & Weerasinghe, 2021). Also, it is necessary to keep in mind that often "higher prices of the certified products did not compensate the costs connected with certification and adaptation of the farm to the requirements of the standard" (Niemiec et al., 2019, p. 438).

Therefore, future support for farmers should focus not only on financial assistance (subsidies on certification costs), but also on logistic and professional encouragement (through agricultural extension services). This involves educating farmers and strengthening farmers' awareness of the environmental and social components of agriculture, the significance of associating, requirements of international markets, etc. (Laosutsan, Shivakoti & Soni, 2019; Paraušić & Roljević Nikolić, 2020; Amekawa et al., 2022). Agricultural policy measures must ensure investment activities on the farm whose purpose is to adapt the production to the standards' requirements (Niemiec et al., 2019; Oppong & Bannor, 2022). Other crucial activities include undertaking systemic reforms, having strong institutions, improving national competitiveness, fostering a stimulating business environment and developing comprehensive innovation and other infrastructure in the country (Domazet & Marjanović, 2018; Paraušić & Domazet, 2018; Laosutsan, Shivakoti & Soni, 2019; Flachsbarth, Grassnick & Brümmer, 2020; Domazet et al., 2022; Jovanović, Domazet & Marjanović, 2023).

The limitations of the study primarily refer to the impossibility of generalizing the conclusions. Namely, the authors are aware of the fact that the impact of the GLOBALG.A.P. certification scheme on the export performance of farmers, export companies and national economies varies significantly depending on numerous factors, such as: product type, export market destination, location of agricultural production (for example, vicinity of ports, roads, etc.), prices in the

mainstream market, price premium, etc. (Subervie & Vagneron, 2013; Laosutsan, Shivakoti & Soni, 2019; Fiankor et al., 2020).

An additional restriction of the study is the fact that there is only one predictor variable in the model. Therefore, future research will focus on introducing additional predictor variables, particularly in the segments of the F&V prices on the domestic and international market, as well as the F&V production volume in exporting countries.

Also, the authors' intention is to observe the share of certified Global GAP farmers in the total number of farmers in the following work, as well as to form a sample of countries taking into account their similar characteristics (spatial, economic, demographic), in order to avoid very large size of between variations in data.

CONCLUSION

Private and voluntary farm certification schemes are created to support food traceability, safety and security. They contribute to efficient, responsible, resistant and sustainable agriculture. At the same time, their implementation, particularly in developing countries, represents a catalyst for making agricultural systems more efficient and organized, environmentally sustainable and socially equitable, while contributing to the export performance of national economies.

The IFA GLOBALG.A.P. standard is the leading private standard in F&V production, focused on the holistic approach to sustainability and environmental responsibility on farms. The implementation of this standard is increasingly becoming a prerequisite for F&V export to EU countries and other high-income countries.

This study investigates the impact of implementing the IFA GLOBALG.A.P. certification scheme on F&V export outcomes in thirteen European middle-income countries from 2010 to 2021 by employing panel regression analysis on data sourced from GLOBALG.A.P. and the International Trade Centre's Trade Map database. National export performance in the F&V sector was expressed by the following criterion variables: (a) annual export value in the F&V sector; (b) annual F&V export value to high-income markets and (c) the percentage share of F&V export to high-income markets in the total F&V export. The panel regression analysis was used to test individual models for each criterion variable, and all three models were adequate. The results indicate that if the number of GLOBALG.A.P. certified producers increases by one, the total export value in the F&V sector rises by US$ 370,819 on average; the F&V export value to high-income markets rises by US$ 224,766 on average, while the share of the F&V export to high-income markets in the total F&V export increases by 0.003 percentage points on average.

The obtained results add to and enrich the scarce academic literature dealing with the GLOBALG.A.P. standard as a catalyst for trade and export in the developing countries of the European continent. In addition, the research provides guidelines and recommendations for directing national politics toward greater implementation of private and voluntary farm certification schemes for sustainable agriculture.

ACKNOWLEDGMENTS

The research presented in this paper was funded by the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia under contracts number 451-03-66/2024-03/200009 and 451-03-47/2023-01/200005. The authors are very grateful to Pia Thauer, Standards and Data Quality Liaison Coordinator from the GLOBALG.A.P. organization (GLOBALG.A.P. c/o FoodPLUS GmbH, Germany) for support during data collection.

REFERENCES

Amekawa, Y., Bumrungsri, S., Wayo, K., Gebre, G. G., & Hongsibsong, S. (2022). Pesticide use under public good agricultural practices standard: A comparative study in Thailand. *Agriculture*, *12*(5), 606. doi: https://doi.org/10.3390/agriculture12050606

Amekawa, Y., Hongsibsong, S., Sawarng, N., Yadoung, S., & Gebre, G. G. (2021). Producers' perceptions of public good agricultural practices standard and their pesticide use: The case of Q-GAP for cabbage farming in Chiang Mai Province, Thailand. *Sustainability*, *13*(11), 6333. https://doi.org/10.3390/su13116333

Andersson, A. (2019). The trade effect of private standards. *European Review of Agricultural Economics*, *46*(2), 267-290. doi:10.1093/erae/jby027

Annor, B. P., Mensah-Bonsu, A., & Jatoe, J. B. D. (2016). Compliance with GLOBALGAP standards among smallholder pineapple farmers in Akuapem-South, Ghana. *Journal of Agribusiness in Developing and Emerging Economies*, *6*(1), 21-38. doi: 10.1108/JADEE-05-2013-0017

Capobianco-Uriarte, M. D. L. M., Aparicio, J., De Pablo-Valenciano, J., & Casado-Belmonte, M. D. P. (2021). The European tomato market. An approach by export competitiveness maps. *PloS one*, *16*(5), 1-27, doi: https://doi.org/10.1371/journal.pone.0250867

Domazet, I. **Marjanović, D., Ahmetagić, D. & Antonijević, M**. (2022) Does the Increase in the Number of Registered Patents Affect Economic Growth? Evidence from Romania and Bulgaria. *Economic Analysis*, *55 (2),* 49-65. doi: 10.28934/ea.22.55.2.pp49-65

Domazet, I. S., & Marjanović, D. M. (2018). FDI as a Factor of Improving the Competitiveness of Developing Countries: FDI and Competitiveness. In V. Malepati & M. Gowri (Eds.), *Foreign direct investments (FDIs) and opportunities for developing economies in the world market* (pp. 82-104). USA: IGI Global.

EC (2020). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system. Brussels, 20.05.2020. COM(2020) 381 final. Available online: https://food.ec.europa.eu/system/files/2020-05/f2f_action-plan_2020_strategy-info_en.pdf

EC (2019). Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. The European Green Deal. Brussels, 11.12.2019. COM(2019) 640. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2019%3A640%3AFIN

EU (2022). Farm certification schemes for sustainable agriculture. Policy Department for Structural and Cohesion Policies. Directorate-General for Internal Policies. PE 699.633, August 2022. Available online: https://www.europarl.europa.eu/RegData/etudes/STUD/2022/699633/IPOL_STU(2022)699633_EN.pdf

FAO (2020). *Empowering Smallholders and Family Farms in Europe and Central Asia. Regional Synthesis Report 2019 based on country studies in eight countries in Europe and Central and Asia.* Food and Agriculture Organization of the United Nations: Budapest, 2020. https://doi.org/10.4060/ca9586en

FAO (2018). Transforming food and agriculture to achieve the SDGs. 20 interconnected actions to guide decision-makers. Food and Agriculture Organization of the United Nations Rome, 2018. Available online: https://www.fao.org/3/I9900EN/i9900en.pdf

FAO (2016). A Scheme and Training Manual on Good Agricultural Practices (GAP) for fruits and vegetables. Volume 1 The scheme – standard and implementation infrastructure. Food and Agriculture Organization of the United Nations. Regional Office for Asia and the Pacific, Bangkok, 2016. Available online: https://www.fao.org/3/i6677e/i6677e.pdf

Fiankor, D. D. D., Flachsbarth, I., Masood, A., & Brümmer, B. (2020). Does GlobalGAP certification promote agrifood exports? *European Review of Agricultural Economics*, *47*(1), 247-272. doi:10.1093/erae/jbz023

Fiankor, D. D. D., Martínez-Zarzoso, I., & Brümmer, B. (2019). Exports and governance: the role of private voluntary agrifood standards. *Agricultural Economics*, *50*(3), 341-352. doi: 10.1111/agec.12488

Flachsbarth, I., Grassnick, N., & Brümmer, B. (2020). *The uneven spread of Global GAP certification*. GlobalFood Discussion Paper 137, University of Goettingen. Available online: https://ageconsearch.umn.edu/record/300904/

GLOBALG.A.P. organization, data obtained on request. Statistics of crops certified GlobalG.A.P. IFA producers, by country, for 2010-2021. February 2023.

GLOBALG.A.P. organization website. GLOBALG.A.P. c/o FoodPLUS GmbH, Germany, https://www.globalgap.org/what-we-offer/solutions/

Jovanović, M., Domazet, I., & Marjanović, D. (2023) Quality of Government as an Attracting Factor of FDI - Evidence from Chosen Southeastern European Countries. *Economic Analysis,* 56 (2), 1-18, DOI: 10.28934/ea.23.56.2.pp1-18

Kassem, H. S., Alotaibi, B. A., Aldosari, F. O., Herab, A., & Ghozy, R. (2021). Factors influencing smallholder orange farmers for compliance with GobalGAP standards. *Saudi Journal of Biological Sciences*, *28*(2), 1365-1373. doi: https://doi.org/10.1016/j.sjbs.2020.11.070

Kleemann, L. (2016). The relevance of business practices in linking smallholders and large agro-businesses in Sub-Sahara Africa. International Food and Agribusiness *Management Review*, 19(1030-2017-2126), 65-78. doi: 10.22434/IFAMR2015.0204

Knapp, J., & Sciarretta, A. (2023). Agroecology: protecting, restoring, and promoting biodiversity. *BMC Ecology and Evolution, 23(1),* 23-29, https://doi.org/10.1186/s12862-023-02140-y

Krauss, J. E., & Krishnan, A. (2022). Global decisions versus local realities: Sustainability standards, priorities and upgrading dynamics in agricultural global production networks. *Global Networks*, *22*(1), 65-88. DOI: 10.1111/glob.12325

Laosutsan, P., Shivakoti, G. P., & Soni, P. (2019). Factors Influencing the Adoption of Good Agricultural Practices and Export Decision of Thailand's Vegetable Farmers. International Journal of the Commons, 13(2), 867–880. doi: https://doi.org/10.5334/ijc.895

Latruffe, L., Diazabakana, A., Bockstaller, C., Desjeux, Y., Finn, J., Kelly, E., … & Uthes, S. (2016). Measurement of sustainability in agriculture: a review of indicators. *Studies in Agricultural Economics*, 118(3), 123-130. http://dx.doi.org/10.7896/j.1624

Lykogianni, M., Bempelou, E., Karamaouna, F., & Aliferis, K. A. (2021). Do pesticides promote or hinder sustainability in agriculture? The challenge of sustainable use of pesticides in modern agriculture. *Science of the Total Environment*, *795*, 148625. https://doi.org/10.1016/j.scitotenv.2021.148625

Malkanthi, S. H. P., Thenuwara, A. M., & Weerasinghe, W. A. R. N. (2021). Attitude of Vegetable Farmers in Galle District in Sri Lanka Towards Good Agricultural Practices (GAP). *Contemporary Agriculture*, *70*(1-2), 54-66, doi: 10.2478/contagri-2021-0010

Masood, A., & Brümmer, B. (2014). *Impact of GlobalGAP certification on EU banana imports: a gravity modeling approach* (No. 49). GlobalFood Discussion Papers. Available online: http://hdl.handle.net/10419/103985

Mitić, P., Fedajev, A., & Kojić, M. (2023). Exploring the Economy–Environment Interactions in the Western Balkans: A Panel Data Analysis. *Economic Analysis: journal of emerging economics*. 56(1), 43-56, doi: 10.28934/ea.23.56.1.pp43-56

Niemiec, M., Komorowska, M., Kuboń, M., Sikora, J., Ovcharuk, O., & Gródek-Szostak, Z. (2019). Global Gap and Integrated Plant Production as a Part of the Internalization of Agricultural Farms. In *SOCIETY. INTEGRATION. EDUCATION. Proceedings of the International Scientific Conference,* Vol. 6, 430-440. doi: http://dx.doi.org/10.17770/sie2019vol6.3902

Oppong, D., & Bannor, R. K. (2022). Bibliometric analysis and systematic review of compliance with agricultural certification standards: evidence from Africa and Asia. *All Life*, *15*(1), 970-999. doi: https://doi.org/10.1080/26895293.2022.2124317

Paraušić, V., Roljević Nikolić, S. (2020). Šeme sertifikacije poljoprivredno prehrambenih proizvoda u Srbiji i podrška udruženjima poljoprivrednika. In M. Jeločnik (ed.), *Unapređenje transfera znanja radi dobijanja bezbednih i konkurentnih poljoprivrednih proizvoda koji su dobijeni preradom na malih gazdinstvima u sektorima mleka, mesa, voća i povrća* (147-176). Institut za ekonomiku poljoprivrede, Beograd. Available online: https://www.iep.bg.ac.rs/images/stories/izdanja/Monografije/2%20knjiga%20Unapredjenje%20transfera%20znanja%20+%20korice%202020%20-%20monografija.pdf

Paraušić, V. & Domazet, I. (2018). Cluster Development and Innovative Potential in Serbian Agriculture. *Ekonomika poljoprivrede, 65 (*3), 1159-1170, doi 10.5937/ekoPolj1803159P

Popović, V. & Paraušić, V. (2016). Unapređenje trgovanja u poljoprivredno prehrambenom sektoru Srbije/Improvement of trade in the agricultural and food sector of Serbia (eng.). In J. Subić, S. Janković, Z. Vasiljević, M. Lukić (Eds.), *Unapređenje finansijskih znanja i evidencije na poljoprivrednim gazdinstvima u Republici Srbiji,* 23-54. Institut za ekonomiku poljoprivrede, Beograd. Available online: https://www.iep.bg.ac.rs/images/stories/dokumenti/Monografije/Unapre%C4%91enje%20finansijskih%20znanja%20i%20evidencije%20na%20poljopri%20vrednim%20gazdinstvima%20u%20Republici%20Srbiji.pdf

Rad, S. M., Ray, A. K., & Barghi, S. (2022). Water pollution and agriculture pesticide. *Clean Technologies*, 4(4), 1088-1102. https://doi.org/10.3390/cleantechnol4040066

Ramirez-Hernandez, A., Galagarza, O. A., Álvarez Rodriguez, M. V., Pachari Vera, E., Valdez Ortiz, M. D. C., Deering, A. J., & Oliver, H. F. (2020). Food safety in Peru: A review of fresh produce production and challenges in the public health system. *Comprehensive Reviews in Food Science and Food Safety*, *19*(6), 3323-3342. doi: 10.1111/1541-4337.12647

Rao, M., Bast, A., & De Boer, A. (2021). European private food safety standards in global agri-food supply chains: a systematic review. *International Food and Agribusiness Management Review*, *24*(5), 739-754. doi: 10.22434/IFAMR2020.0146

Schuster, M. & Maertens, M. (2015). The impact of private food standards on developing countries' export performance: An analysis of asparagus firms in Peru. World Development, 66, 208–221, http://dx.doi.org/10.1016/j.worlddev.2014.08.019

Subervie, J., & Vagneron, I. (2013). A drop of water in the Indian Ocean? The impact of GlobalGap certification on lychee farmers in Madagascar. World Development, 50, 57-73, doi: http://dx.doi.org/10.1016/j.worlddev.2013.05.002

Trade Map database, International Trade Centre (ITC). Available on line: https://www.trademap.org/Index.aspx, date of access 10.01.2023

UN (2015). Transforming our world: the 2030 Agenda for Sustainable Development. General Assembly. United Nations, 21 October 2015, A/RES/70/1. Available online: https://documents-dds-ny.un.org/doc/UNDOC/GEN/N15/291/89/PDF/N1529189.pdf?OpenElement

World Bank (2021). Greening the Recovery. Western Balkans. Regular Economic Report No. 20. Fall 202. Washington: International Bank for Reconstruction and Development / The World Bank. Available online:

https://documents1.worldbank.org/curated/en/900381634670558017/pdf/Greening-the-Recovery.pdf

World Bank Country and Lending Groups. Official website presentation, https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

ANNEX

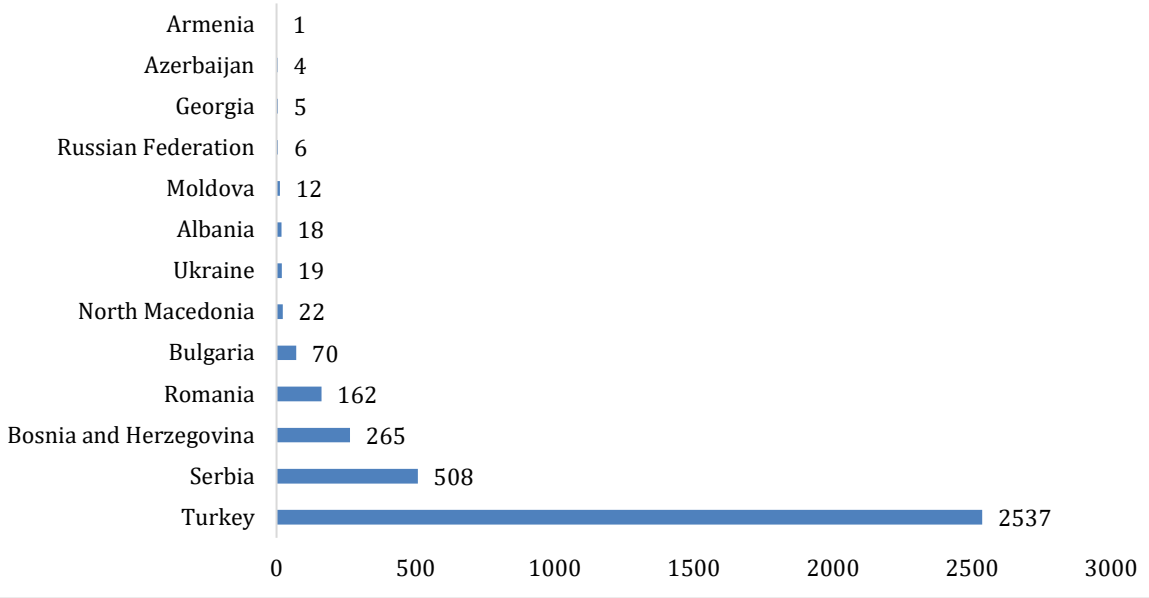
Table 1. Descriptive statistics

	M	SD
Albania		
F&V export value, US $, 000	53,796.73	35,584.19
F&V export value to high-income markets, US $, 000	16,454.82	11,068.72
F&V export value to high-income markets in the total export value of F&V, %	32.74	6.96
IFA GLOBALG.A.P. producers (crops base), No.	18	34.93
Armenia		
F&V export value, US $, 000	46,282.17	33,741.60
F&V export value to high-income markets, US $, 000	950.58	596.22
F&V export value to high-income markets in the total export value of F&V, %	2.18	1.20
IFA GLOBALG.A.P. producers (crops base), No.	1	0.95
Azerbaijan		
F&V export value, US $, 000	398,487.67	171,608.79
F&V export value to high-income markets, US $, 000	46,244.58	24,533.04
F&V export value to high-income markets in the total export value of F&V, %	11.57	5.22
IFA GLOBALG.A.P. producers (crops base), No.	4	4.85
Bosnia and Herzegovina		
F&V export value, US $, 000	77,503.25	24,920.01
F&V export value to high-income markets, US $, 000	48,886.83	11979.67
F&V export value to high-income markets in the total export value of F&V, %	65.32	9.68
IFA GLOBALG.A.P. producers (crops base), No.	265	106.95
Bulgaria		
F&V export value, US $, 000	224,547.75	53,103.62
F&V export value to high-income markets, US $, 000	172,776.58	50,477.89
F&V export value to high-income markets in the total export value of F&V, %	76.51	5.89
IFA GLOBALG.A.P. producers (crops base), No.	70	58.56
Georgia		
F&V export value, US $, 000	158,230.58	51,052.59
F&V export value to high-income markets, US $, 000	90,335.17	42,827.02
F&V export value to high-income markets in the total export value of F&V, %	55.23	13.47
IFA GLOBALG.A.P. producers (crops base), No.	5	5.32
Moldova		
F&V export value, US $, 000	211,291.67	21,683.66
F&V export value to high-income markets, US $, 000	84,707.17	17,196.04
F&V export value to high-income markets in the total export value of F&V, %	40.12	7.50
IFA GLOBALG.A.P. producers (crops base), No.	12	14.70
North Macedonia		
F&V export value, US $, 000	135,989.45	12,737.69
F&V export value to high-income markets, US $, 000	47,135.64	16,045.23
F&V export value to high-income markets in the total export value of F&V, %	34.23	11.45
IFA GLOBALG.A.P. producers (crops base), No.	22	7.48
Romania		
F&V export value, US $, 000	194,041.67	33,110.76
F&V export value to high-income markets, US $, 000	164.328.33	30,369.22

	M	SD
F&V export value to high-income markets in the total export value of F&V, %	84.69	6.48
IFA GLOBALG.A.P. producers (crops base), No.	162	147.56
Russian Federation		
F&V export value, US $, 000	477,472.67	207,710.93
F&V export value to high-income markets, US $, 000	129,242.00	53,294.59
F&V export value to high-income markets in the total export value of F&V, %	30.29	12.01
IFA GLOBALG.A.P. producers (crops base), No.	6	8.21
Serbia		
F&V export value, US $, 000	679,123.25	188,528.34
F&V export value to high-income markets, US $, 000	464,171.42	145,581.16
F&V export value to high-income markets in the total export value of F&V, %	68.36	5.09
IFA GLOBALG.A.P. producers (crops base), No.	508	351.93
Turkey		
F&V export value, US $, 000	5,442,604.83	752,981.74
F&V export value to high-income markets, US $, 000	3,001,435.83	382,284.88
F&V export value to high-income markets in the total export value of F&V, %	55.29	3.08
IFA GLOBALG.A.P. producers (crops base), No.	2,537	473.51
Ukraine		
F&V export value, US $, 000	364,021.00	89,099.92
F&V export value to high-income markets, US $, 000	169,410.92	87,524.35
F&V export value to high-income markets in the total export value of F&V, %	44.51	12.71
IFA GLOBALG.A.P. producers (crops base), No.	19	18.73

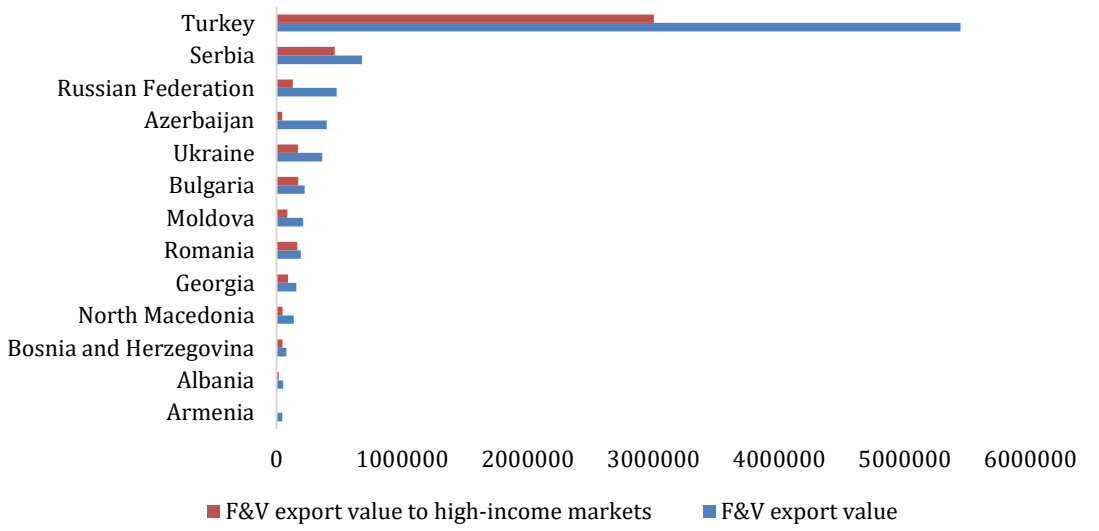
Source: Authors' calculations. For Albania and North Macedonia, the average is given for the period 2010-2020.

Figure 1. IFA GLOBALG.A.P. producers (crops base), average number, 2010-2021.



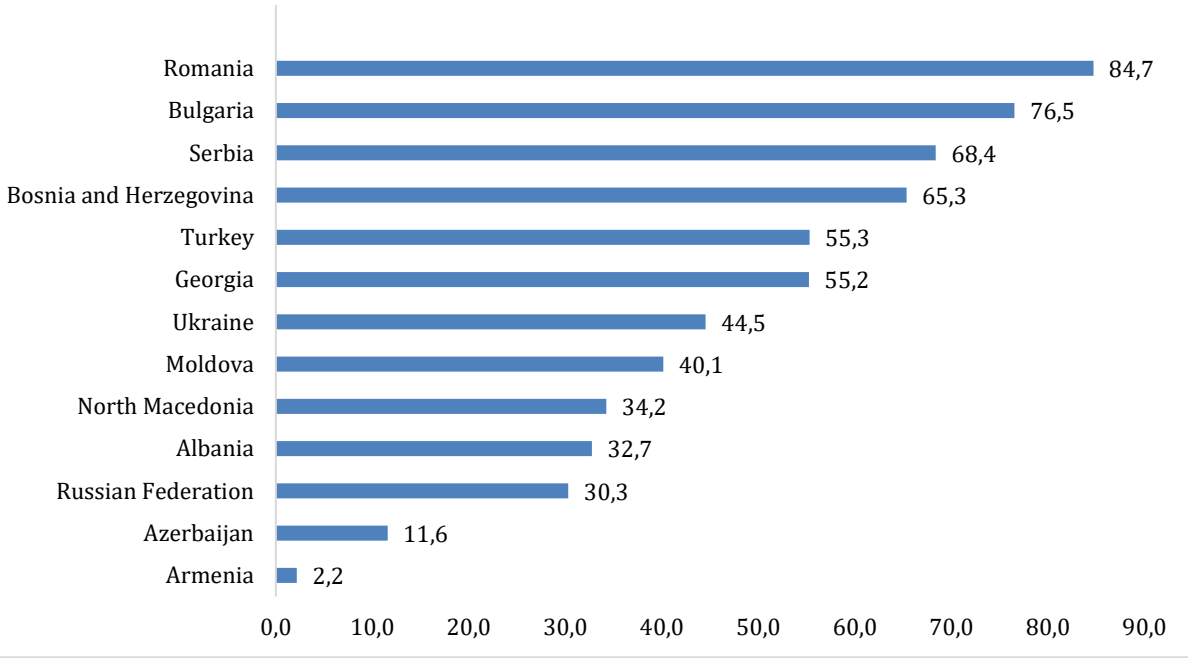
Source: Authors' calculations. For Albania and North Macedonia, the average is given for the period 2010-2020.

Figure 2. F&V export value & F&V export value to high-income markets, average values, 2010-2021, US $, 000



Source: Authors' calculations. For Albania and North Macedonia, the average is given for the period 2010-2020.

Figure 3. F&V export value to high-income markets in the total export value of F&V, average %, 2010-2021.



Source: Authors' calculations. For Albania and North Macedonia, the average is given for the period 2010-2020.

Table 2. Feasible GLS

	F&V export value	**F&V export value to high-income markets**	**Share of F&V export value to high-income markets in the total export value of F&V**
Constant	103,223 [21021.37] (0.000)**	1,415.656 [1139.797] (0.214)	45.442 [3.121] (0.000)**
IFA GLOBALG.A.P. producers, no	41.584 [20.831] (0.046)*	43.888 [17.436] (0.012)**	0.003 [0.001] (0.011)*
R^2	0.964	0.922	0.874
Wald	$\chi^2(1)$= 3.98; p=0.046	$\chi^2(1)$= 6.34; p=0.012	$\chi^2(1)$= 6.45; p=0.011

Table 3. Panel Corrected Standard Errors

	F&V export value	**F&V export value to high-income markets**	**Share of F&V export value to high-income markets in the total export value of F&V**
Constant	105,829.4 [17877.87] (0.000)**	34,701.9 [11,670.12] (0.003)**	44.237 [0.886] (0.000)**
IFA GLOBALG.A.P. producers, no	1955.976 [114.863] (0.000)*	1,099.58 [62.656] (0.000)**	0.008 [0.001] (0.000)*
R^2	0.907	0.928	0.044
Wald	$\chi^2(1)$= 289.98; p=0.000	$\chi^2(1)$= 307.28; p=0.000	$\chi^2(1)$= 78.16; p=0.000

Checking the results obtained by panel regression with fixed and random effects was done using the Feasible GLS and Panel Corrected Standard Errors estimators. The results of the analyses are presented in Table 2 and Table 3 in the Annex, from which it can be seen that these estimators also confirm the results obtained using fixed and random effects estimators. All models are significant, and the variable `IFA GLOBALG.A.P. producers` significantly contributes to explaining the variation of the dependent variables. Also, all models, except the one where the dependent variable is the F&V export value to high-income markets as a percentage of the total F&V export value, using the PCSE estimator, have a high coefficient of determination, which indicates that the models explain the variation of the dependent variables well.

Article history:	Received: 13.2.2024.
	Revised: 5.7.2024.
	Accepted: 3.9.2024.

DOI: 10.28934/ea.24.57.3.pp70-86 First Online: October 8, 2024

ORIGINAL SCIENTIFIC PAPER

Evaluation of Population Projections for Serbia 2011-2041 after the 2022 Census Results

Dragana Paunović Radulović[1]* | **Marko Vladisavljević**[2]

[1] The University of Belgrade, Faculty of Economics, Department for Statistics and Mathematics, Belgrade, Serbia
Statistical Office of the Republic of Serbia
[2] The University of Belgrade, Faculty of Economics, Department for Statistics and Mathematics, Belgrade, Serbia

ABSTRACT
Following the 2022 Population Census, the first assessment of Serbia's official population projections based on data from the 2011 Census and other vital statistics and migration sources has become feasible. According to the Census results, the population of Serbia in 2022 is approximately 2.3% below the projected values for that year, according to the closest projection variant – the constant variant. This paper explores the differences in terms of projected and realized values of fertility, mortality, and migration balance. Hypotheses regarding the total fertility rate and the number of live births were largely confirmed. However, a notable deviation was observed in mortality rates, primarily attributed to the COVID-19 pandemic period, during which life expectancy decreased by nearly two years. Apart from the pandemic's effect, the deviation between projected and realized population values is also due to the assumption of a positive migration balance for the period 2011-2022. Contrary to this optimistic assumption, the vital statistics method reveals negative external migration during this period.

Keywords: *demographic projections, population census, components of demographic changes*

JEL Classification: C13, J10, J11, J13

INTRODUCTION

The study of population, particularly its size and optimal growth, has captivated scholars in the social sciences since ancient civilizations (Devedžić, 2006). Planning for the future dimensions of the population, including its total number and demographic composition, is imperative due to its fundamental impact on society (Nikitović, 2010). Population projections represent calculations of future demographic trends based on hypotheses - assumptions that depict potential outcomes influenced by anticipated changes in fertility, mortality, and migration patterns (CDI-IDN, 1971; Kicošev Golubović, 2004; Radivojević, 2018).

Creating demographic projections requires knowledge of long-term fertility, mortality and migration trends and all factors that influence population changes. This includes a good understanding of natural population movement and societal changes, i.e., the interdependence of demographic and social development (Rančić, 1979). For authors of hypotheses about future population trends, it is crucial to correctly assess the essence of current demographic trends, whether they are short-term changes, continuations, or beginnings of long-term trends (Penev,

* Corresponding author, dragana.paunovic-radulovic@stat.gov.rs

2013). On a local level, demographic projections are essential for all areas of human activity that involve planning, such as employment, education, healthcare, social security, spatial and urban planning, and more (Radivojević, 2018). Therefore, it is important that the projections are based on the most accurate assumptions about future trends in fertility, mortality and migration.

In the Republic of Serbia, official population projections are made every ten years – after each population census. In 2014, the Statistical Office of the Republic of Serbia (SORS) published the latest demographic projection results, covering the projection period 2011-2041. An analytical method was applied using a decomposition approach, which means that hypotheses were set for regions, and the projected population of Serbia represents the sum of the population projections of its constituent parts. Projections were made as a result of five defined scenarios that represent a combination of different levels of fertility, mortality and migration.

The subject of this paper is the evaluation of real and reconstructed values of the demographic components in the first ten years of the projection period and the decomposition of the difference between the projected population and population from Census 2022. Projected births, deaths, and net migrations were reconstructed based on existing documentation. The paper will present the projection methodology, the evaluation method, and the results of the analysis conducted. Since projections are not predictions but rather attempts to create credible scenarios based on assumptions regarding population growth components, the evaluation does not criticize the projection methodology. It serves as the first step in analyzing the factors that led to deviations from long-term trends. Projections are also subject to uncertainty, so it cannot be claimed that the projected values will always remain within the range of low and high growth scenarios. Unforeseeable circumstances occur, such as the COVID-19 pandemic, which caused "excess mortality" and influenced changes in migration trends (Marinković & Galjak, 2021). Therefore, the goal of this research is to highlight the problems and challenges in the mentioned process, while also showcasing examples of good practice in overcoming them, by evaluating the projection creation process and scenario definition processes.

THEORETICAL BACKGROUND

Population Projections in Serbia - Methodological Concept

Official population projections for the Republic of Serbia are prepared by the Statistical Office of the Republic of Serbia (SORS) after each population census. The latest results of demographic projections were published after the 2011 Census. These are long-term projections covering a period of 30 years (from 2011 to 2041). When creating population projections, an analytical method (cohort-component method) was applied, using the so-called decomposition approach. The analytical method of demographic projections implies that the hypotheses refer to future changes in the determining components of the population movement, i.e. fertility, mortality and migration, by age and gender. Due to the acceptance of the decomposition approach, hypotheses were set for regions (Belgrade region, Vojvodina region, Šumadija and Western Serbia region and Southern and Eastern Serbia region)[1], so the projected population of Serbia represents the sum of the population projections of its constituent parts, rather than the result of specifically set hypotheses (SORS, 2014, p. 8).

The projections were made in five variants: low, medium, high, constant fertility and mortality and zero migration balance variant (SORS, 2014, p. 8). Defining multiple variants of hypotheses results in different projection scenarios, named after the fertility hypotheses. Variants illustrate alternative scenarios of future demographic behavior, similar to projection methodology applied

[1] Given that the Census of Population, Households and Dwellings in 2011 was not conducted on the territory of AP Kosovo and Metohija, population projections were made for the Republic of Serbia without AP Kosovo and Metohija

by all relevant institutions in Europe and worldwide (e.g. Eurostat, UN Department of Population Statistics, national statistics).

The first three projection variants have the same combination of hypotheses about expected mortality and expected migrations and differ from each other only in fertility hypotheses. The fourth variant is based on the assumed constant fertility and mortality and expected migrations. The fifth variant, compared to the medium variant, differs only in terms of the migration hypothesis - this time a zero net migration was assumed. The last two variants have an analytical character, not a prognostic one (SORS, 2014, p. 8). The selection of scenarios was based on empirical data from vital statistics on total fertility rates and expected life expectancy in the previous period and theoretical knowledge about the factors of changes in all three population development components. Migration data are available from SORS research on internal migrations (data from the Ministry of Interior of RS on notification of change of address), and external migration is the result of the population difference between two censuses, adjusted for natural increase.

Although different variants for the other two components (mortality and migration) are assumed for the future age structure of the population, the most important thing is to define the future fertility trends. Biological determinants of reproduction (e.g., potential fertility, life span) change only over very long periods (Breznik, 1977, p. 56). The greatest uncertainty in population forecasts is usually associated with cohorts not born in the base (initial) year. Therefore, estimates of the number of children in the population are usually the most uncertain part of any medium-term forecast. Moreover, the margin of error significantly increases in long-term forecasts because their results increasingly depend on the accuracy of predicting births by women who have not yet been born.

Assumptions about Future Trends of Demographic Components

Fertility Hypotheses

Assumptions about the future movement of fertility were defined through the value of the total fertility rate[2] (TFR) by region (Table 1). In the base year, fertility is at the level of realized values in 2011, while the assumptions for the last projection year are given in four variants: low, medium, high and constant. Other values of TFR, in the 2011-2041 interval, represent the result of linear interpolation between the initial and final set values. In the fertility hypotheses, age-specific fertility rates, representing the distribution of births by mother's age, were also assumed. These assumptions are not presented with the presentation of the official results, but are stated to be modeled after the current values of specific rates at the beginning of the projection period.

Table 1. Hypothesis on the values of total fertility rate by variants and regions

Region	2011	2041			
		Low	Medium	High	Constant
Belgrade region	1.41	1.30	1.80	2.16	1.41
Vojvodina region	1.35	1.30	1.75	2.16	1.35
Šumadija and Western Serbia region	1.36	1.20	1.75	2.11	1.36
Southern and Eastern Serbia region	1.33	1.20	1.65	2.11	1.33

Source: Population projections of the Republic of Serbia 2011-2041, SORS, 2014, p. 9

[2] The total fertility rate represents the total number of live births per woman under fertility conditions by age from the year of observation.

Variations in assumed TFR are consistent with the spectrum of realistically achievable fertility levels within the European context. For instance, some European countries, such as Hungary, Romania, and Latvia, recorded a TFR of approximately 1.3 children per woman around 2010. Even lower levels, reaching as low as 1.1 children per woman, were observed in a broader range of countries during the 1990s and the early 2000s. These trends notably affected former socialist nations like Bulgaria, Czech Republic, Slovakia, Poland, Slovenia, Latvia, Lithuania, Russia, Ukraine, Belarus, and Moldova, as well as southern European countries such as Greece, Italy, and Spain. Conversely, Western European and Scandinavian countries generally achieved or exceeded a maximum assumed fertility level of 1.8 children per woman around 2010. Many of these countries had already reached this level during the 1990s and 2000s. Notably, Serbia also achieved this fertility level during the 1980s (Penev, 2013).

Mortality Hypotheses

Assumptions regarding future mortality trends were outlined in two scenarios: constant and variable, based on life expectancy values. Initial mortality data from approximate mortality tables[3] for 2011 served as the starting point for projections. Under the constant scenario, it was assumed that these rates would persist unchanged throughout the projection period. In contrast, the variable scenario posited mortality trends akin to those observed in Serbia in the decade leading up to the 2011 Census, aligning with broader trends in life expectancy across former socialist countries. Projections for 2041 incorporated an anticipated increase in average life expectancy across all age groups, based on empirical evidence. Consequently, the projection envisages a continuous linear decline in population mortality until the end of the forecast period (Table 2) (SORS 2014, p. 10).

Table 2. Life expectancy at live birth (variant of „expected" mortality)

Region	**Sex**	**Beginning and end of the projected period**	
		2011	**2041**
Belgrade region	male	72.7	79.1
	female	77.8	82.2
Vojvodina region	male	70.5	76.2
	female	76.3	81.7
Šumadija and Western Serbia region	male	72.1	79.5
	female	76.9	84.0
Southern and Eastern Serbia region	male	71.4	76.3
	female	76.5	81.9

Source: Population projections of the Republic of Serbia 2011-2041, SORS, 2014, p. 10

The lowest value of life expectancy was recorded in Vojvodina in 2011, and the highest in Belgrade, for both sexes. Regional differences are expected to decrease by the end of the projection period, that is, life expectancy in Vojvodina and the Southern and Eastern Serbia region will equalize, and the longest life expectancy is predicted for the Šumadija and Western Serbia region: 79.5 years for men and 84.0 years for women (SORS, 2014, p.11).

[3] Mortality tables statistically show the relationships that exist between mortality, age and sex. They are calculated based on population estimates and vital statistics data. Life expectancy is the result of mortality tables that show how long a person of a certain age (0, 1, 5,..., 85 and more years) will live on average if the mortality conditions exist as at the time the tables were created.

Migration Hypotheses

Assumptions about future migration trends were formulated based on comprehensive statistical data, including the results of the last two Censuses in 2002 and 2011, internal migration statistics, natural population movement data, and information on registered internally displaced persons from Kosovo and Metohija. Hypotheses about migration are expressed through net migration and specific migration balance rates, by gender and age groups, at the regional level. (SORS, 2014, p. 11).

Assumptions about migration in the first and last five years of the projection period, by region, are presented in Table 3.

Table 3. Annual migration balance by region (variant of "expected" migration)

	Period	
	2011-2016	**2036-2041**
Belgrade region	9 692	14 867
Vojvodina region	-3 193	6 088
Šumadija and Western Serbia region	-3 540	10 127
Southern and Eastern Serbia region	-2 445	1 867
REPUBLIC OF SERBIA	514	32 949

Source: Population projections of the Republic of Serbia 2011-2041, SORS, 2014, p.11

According to the assumptions, under the expected migration scenario, the initial positive net migration in Belgrade offsets negative net migration in other regions, resulting in an overall net immigration of approximately 500 persons for Serbia. This assumption is grounded in anticipated improvements in living standards and economic recovery by 2026, with the expectation that the Republic of Serbia will accede to the European Union. The migration trends projected for 2014 draw insights from the experiences of countries like the Czech Republic, Hungary, and Slovakia, which transitioned to net immigration in the early 21st century. Additionally, given Serbia's aging population, the projections suggest a diminishing potential for emigration (Penev, 2013).

In addition to Serbia's ongoing population aging and the various demographic and economic implications that accompany this trend (a significantly aging population typically reduces emigration potential), the assumption was made that by the end of the projection period, Serbia will transform into an immigration destination (SORS, 2014, 12).

As an analytical variant, one projection scenario includes the hypothesis of a zero migration balance in the entire projection period. This implies that population changes are solely influenced by natural growth, specifically fertility and mortality rates.

Evaluation of Demographic Projections of National Statistics

In the existing literature, several methods have been developed for creating population projections, accompanied by various approaches to evaluating their accuracy. For decades, the United Nations' population projections for all countries have been scrutinized in scientific research. Pflaumer (1993) emphasizes the importance of quantifying the precision of demographic projections through error measurement. This study aims to improve future projections by assessing deviations in predicted population growth rates compared to actual rates published in multiple editions of the UN Demographic Yearbook. The results indicate overall satisfactory forecasting performance across most countries. However, notable forecast errors were observed primarily in African nations, where population growth was consistently underestimated.

In addition to evaluating the accuracy of specific methods for population projections, research also aims to identify the most effective techniques for forecasting. For instance, Morgenroth (2002) conducted a study assessing the performance of different demographic forecasting methods in Ireland. The study analyzed forecast errors of each method from 1991 to 1996, comparing projected populations with the 1996 census data. Interestingly, the results indicate that simple proportion extrapolation techniques often outperform the more complex cohort component models typically used for national projections.

George (2001) emphasizes several critical steps in the evaluation of population projections. Firstly, it's essential to select the scenario—whether medium, high, low, or all scenarios—to be evaluated. Secondly, choosing the appropriate evaluation method is crucial. Thirdly, identifying the specific demographic variable or component—such as fertility, mortality, migration, or age groups—that requires assessment is important. In his analysis of Canadian population projections before 1972, George evaluates their accuracy retrospectively in terms of population size, age structure, and growth components. The findings reveal significant variability in errors across different age groups, with projections published later generally proving more accurate than earlier ones. The inaccuracies in earlier projections are attributed to several factors. These include the failure to anticipate the postwar baby boom, underestimated fertility assumptions during the 1940s, and overestimations during the subsequent fertility decline starting from 1959. George argues that projection inaccuracies are inevitable due to uncertainties in future trends. To manage this uncertainty, he suggests publishing multiple scenarios that encompass a range of possible growth component trends. This approach allows for a more comprehensive understanding of potential future population dynamics.

In the work of researchers who evaluated the population projections of Norway between 1996 and 2018 (Thomas et al., 2022), most analyses are based on simple comparisons of projected and registered population components. The results of the evaluation indicate that the expected life expectancy was consistently lower than the actual life expectancy. Several systematic deviations in fertility were observed until 2009, but thereafter fertility was consistently overestimated. Significantly larger deviations were observed for net international migration. Projections produced between 1996–2005 underestimated long-term population growth primarily due to an unanticipated increase in immigration after EU enlargement in 2004. More recent projections do not consistently underestimate or overestimate net migration, and deviations for the total population are moderate.

DATA AND METHODOLOGY

Data Sources

Following the release of the final results of the 2022 Census, an evaluation of demographic projections becomes possible. This assessment will compare the projected figures with the actual demographic data recorded in the census, examining deviations in assumptions regarding fertility, mortality, and migration trends. Alongside the population census results, officially published data on fertility and mortality during the inter-census period were used in the evaluation of hypotheses. In the absence of official research on external migration in Serbia, the migration balance for the Republic of Serbia used for hypothesis evaluation is the result of vital statistics methods.

Methodology for the Evaluation of the Hypothesis of Projections of the Serbian Population 2011-2041

In 2014 projections, assumptions regarding future demographic trends are primarily derived from historical trends of TFR and life expectancy. Migration projections, on the other hand, rely on alternative data sources for analysis. However, official publications do not provide exact

projected figures for live births and deaths. To address this gap, a reconstruction of these series was conducted using available vital statistics and demographic indicators published by the Statistical Office of the Republic of Serbia (SORS).[4]

The reconstruction involved interpreting the hypothesis of change in demographic components based on available data. This approach acknowledges potential deviations from actual values in the projections. Specifically, to estimate projected live births, a model incorporated age-specific fertility rates from 2011 and the number of women of childbearing age, alongside assumptions about TFR. The resulting estimates were then compared with actual vital statistics data on live births.

Regarding migration, projected net migration values were reconstructed using official publication data. For the initial five years of projections (2011-2016), the migration balance level was set at 514 based on official data, with subsequent years interpolated linearly between this value and the value for the final projection period (2036-2041). However, it's important to note the lack of an official source for monitoring migration, there is no official number of emigrants and immigrants of Serbia, on the basis of which the migration hypothesis could be evaluated. For this purpose, the total external migration was calculated based on the vital statistics method:

$$S = P_2 - P_1 - (N - M) \qquad (1)$$

where: S is the net migration; P_1 and P_2 are numbers of inhabitants according to the results of the 2011 and 2022 Census, respectively[5]; N is the number of live births and M is the number of deaths in the inter-census period, based on vital statistics.

Finally, the estimation of projected deaths is based on the basic demographic equation (Radivojević, 2018). This equation utilizes projected values of population size over successive years, along with live births and migration balances reconstructed according to previously described assumptions. The projected number of deaths is thus residual population change after accounting for live births and migration. The projected number of deaths derived from this method was then compared against official vital statistics data. Reconstructed projected number of deaths could have been refined using inverse biometric functions based on assumed age-specific mortality rates or by incorporating data on person-years lived between exact ages x and x+1 (denoted usually as Lx in Life tables), which are essential for calculating survival rates. Such data would have facilitated a more precise reconstruction of death numbers by aligning them with assumptions about life expectancy at birth and age-specific Lx values. However, this level of detail was not available in the population projection method and results, primarily because the software used relies on pre-set mortality patterns deemed most representative for different regions (such as European countries, African regions, etc.).

It is important to note that the methodology used for reconstructing projected values of live births, deaths, and migration balances may not precisely match the actual values used in the projections. Discrepancies arise due to the use of available documentation and the reliance on the Spectrum application software for the population projections from 2011 to 2041. As already

[4] Demographic statistics, Press release (RZS, 2019; RZS, 2021; RZS, 2022)

[5] It is important to note that different values of the number of inhabitants for 2011 can be found in the publications of the SORS. These are estimates made based on the 2002 and 2011 Censuses, and after an expert assessment of the number of inhabitants for Bujanovac, Medveđa and Preševo, at the critical moment of the 2011 Census, the estimates were subsequently revised. All these changes in the total number of inhabitants refer to differences in the structure by age, which can affect the differences in the value of derived demographic indicators, specific fertility and mortality rates. Projections were made immediately before the publication of the latest data on population estimates for 2011, which are still relevant as official data.

mentioned, this software incorporates a model of mortality tables that can yield results differing from those presented in this study.

The evaluation of official population projection results was conducted at the regional level, with assumptions regarding the expected future trends in fertility, mortality, and migration (the medium variant of population projections). This paper focuses on presenting key national-level findings from the analysis. Throughout this paper, all comparisons between projected and realized demographic component values pertain to aggregate numbers of live births, deaths, and migration balances, without gender or age-specific analysis.

RESULTS AND DISCUSSION

Results of the 2022 Census and the Difference Compared to the Projected Population

According to the final results of the 2022 Population Census, the Republic of Serbia has a population of 6 647 003 inhabitants. This figure reflects a decrease of 539 859 people, or 7.5%, compared to the 2011 Census. The population declined across all regions by approximately 10%, except in the Belgrade region, where there was a modest increase of about 1.3% (Table 4). It is important to note that during the 2011 Census, the municipalities of Bujanovac, Preševo, and Medveđa experienced a significant undercount of approximately 46 800 individuals due to a boycott by the Albanian ethnic population. Adjusting for this, an estimated total of 7 233 619 people can be considered for 2011, revealing a larger decrease of 586 616 inhabitants. Additionally, the total population reported in the 2022 Census includes both enumerated individuals and adjustments from administrative sources for those not initially counted, a practice not applied in previous censuses (RZS, 2023).

Table 4. Population according to 2022 and 2011 censuses, by regions

	Number of inhabitants		Absolute growth/fall	Change index
	2011 Census[6]	2022 Census	2022-2011	2011=100
REPUBLIC OF SERBIA	7 186 862	6 647 003	-539 859	92.5
Belgrade region	1 659 440	1 681 405	21 965	101.3
Vojvodina region	1 931 809	1 740 230	-191 579	90.1
Šumadija and Western Serbia region	2 031 697	1 819 318	-212 379	89.5
Southern and Eastern Serbia region	1 563 916	1 406 050	-157 866	89.9

Source: Author's calculations based on SORS data.

Table 5 indicates that all projection variants anticipate a higher population count than the one obtained in the census. In other words, all projection variants from 2014 overestimated the population figures for 2022. The constant variant shows the smallest deviation, overestimating the census count by about 2.3% (approximately 154 000 inhabitants). The low and no-migration variants exceed the census count by 3.2% and 3.4%, respectively, while the medium and high variants overestimate by 4.1% (around 284 000 inhabitants).

At the regional level, the constant variant also exhibits the closest alignment with the census population in 2022. Variations between the census and projections range from -2.5% to -1.7% across regions (Table 1 in the Appendix), indicating smaller discrepancies compared to other projection scenarios.

[6] An expert estimate of the population is available at the link http://www.kt.gov.rs/sr/news/arhiva-vesti/saopstenje-za-javnost-procenjen-broj-stanovnika-u-opstinama-presevo-bujanovac-i-medvedja/

Table 5 provides a comprehensive view of the differences between demographic projections and the 2022 Census results, allowing for a clear comparison and analysis of projection accuracy across different scenarios.

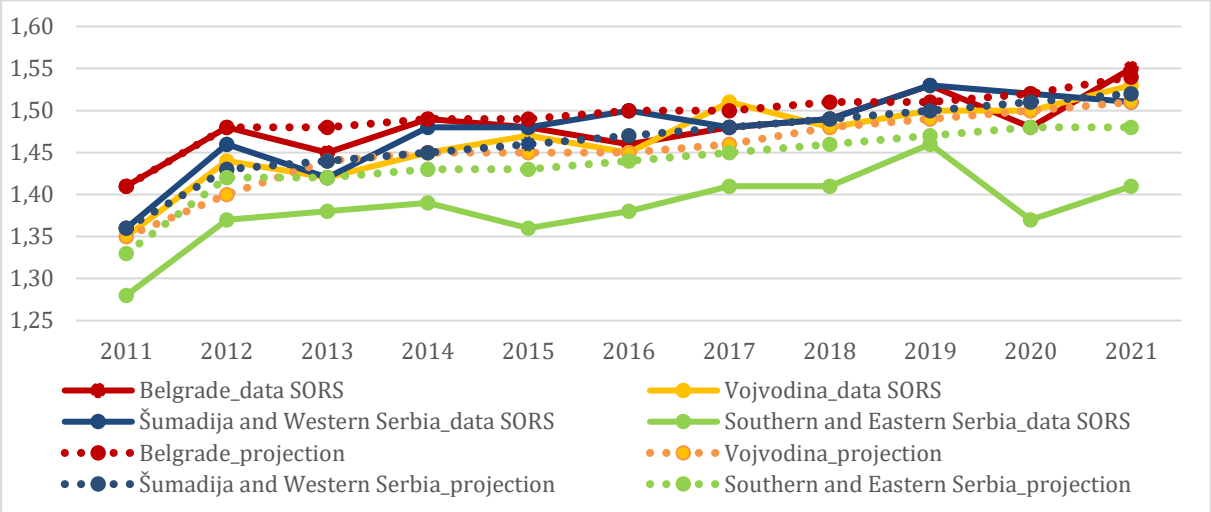
Table 5. Total population of Serbia in 2022, demographic projections and Census 2022

Projection scenario variants	Population number in 2022		Difference	
	Population projection	2022 Census	Absolute value	%
REPUBLIC OF SERBIA				
Low variant	6 869 483	6 647 003	-222 480	-3.2
Medium variant	6 930 363	6 647 003	-283 360	-4.1
High variant	6 930 768	6 647 003	-283 765	-4.1
Constant variant	6 800 950	6 647 003	-153 947	-2.3
Variant without migrations	6 884 005	6 647 003	-237 002	-3.4

Source: Author's calculations based on SORS data

Fertility Indicators - Comparison of Projected and Realized Values

Comparing the projected and realized total fertility rates, in most cases, reveals insignificant deviations (Graph 1). This observation underscores the gradual nature of fertility rate changes, largely influenced by natural birth dynamics (Breznik, 1977). However, an exception is noted in the projections for the Southern and Eastern Serbia region, where the total fertility rate is slightly higher, reaching 1.5 in 2021, compared to the achieved fertility level of 1.4 children per woman. In essence, the projections slightly overestimated the actual fertility level. Graph 1 also illustrates that while deviations occurred throughout the projection period in this region, they were most pronounced during the years of the COVID-19 pandemic.

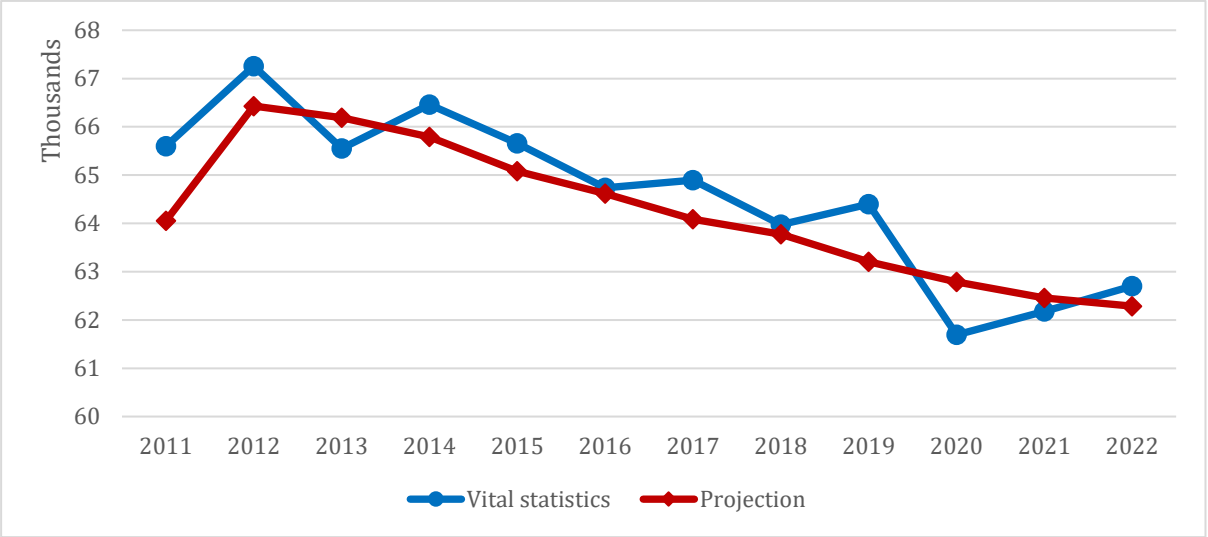


Graph 1. Projected (medium variant) and realized values of TFR

Source: SORS, author's processing

As previously noted, official publications do not provide data on projected live births. For this study, the number of live births was reconstructed using the Total Fertility Rate (TFR) obtained upon special request from the author of the official projections. Comparison of these reconstructed values with data from a survey on births spanning 2011-2022 (Graph 2) reveals minimal deviations between projected and realized fertility rates. On an annual basis, these

deviations hover around ±2%, translating to approximately 300 live births relative to realized values. Notably, during the COVID-19 pandemic, it was anticipated that birth rates would decline compared to the periods immediately preceding and following the pandemic, thereby resulting in overestimations in projected live birth numbers for that timeframe (Penev, 2021).



Graph 2. Number of live births, 2011-2022
Source: Author's calculation based on SORS data

Migration of the Population - Comparison of Projected and Realized Values

The realized net migration was calculated using the vital statistics method (Table 6). This calculation indicates that external migration between September 30, 2011, and September 30, 2021 (key points coinciding with the 2011 and 2022 censuses), amounted to approximately -120 000 persons.

Table 6. Population migrations between two successive population censuses in 2011 and 2022

The result of the vital statistics method_total net migration of the Republic of Serbia	2011-2021
30 September 2011, value based on the 2011 Census	7 186 862
The value from the 2011 Census corrected for the municipalities of Preševo, Bujanovac and Medveđa	7 233 619
30 September 2022, value based on the 2022 Census	6 647 003
Difference	-586 616
Natural increase 30 September 2011 - 30 September 2022	-466 175
Migration balance (external migration)[7]	-120 442

Source: SORS, author's presentation
*Notes: [1]The total values of the changes were obtained by the formula 1/4*2011+ ∑(2012,2021) +3/4*2022*

[7] The more accurate value of the natural increase is -469 133 if the exact values of live births and deaths in the periods October-December 2011 and January-September 2022 are taken into account. The realized value of the migration balance then amounts to -117 483. However, in order to be consistent with the methodology applied in the estimation of the effects related to the projections, we use the method shown in Table 6.

Based on predefined migration patterns from 2011 to 2041, as detailed in Table 3, a reconstructed projection of net migration was employed for evaluation purposes. This reconstruction involved adopting specified values for the years 2011 to 2016 and applying linear interpolation at the regional level from 2016 to 2036. The annual migration values reconstructed for the period 2011 to 2022 are provided in Table 7. According to these reconstructed projections, it was anticipated that a net emigration of approximately 35 000 individuals would occur during the inter-census period (see Table 8 for the cumulative calculation during this period).

Table 7. Migration balance 2011-2022

	Republic of Serbia	Belgrade region	Vojvodina region	Šumadija and Western Serbia region	Southern and Eastern Serbia region
2011-2016	514	9 692	-3 193	-3 540	-2 445
2017	2 136	9 951	-2 729	-2 857	-2 229
2018	3 758	10 210	-2 265	-2 174	-2 013
2019	5 380	10 469	-1 801	-1 491	-1 797
2020	7 002	10 728	-1 337	-808	-1 581
2021	8 624	10 987	-873	-125	-1 365
2022	10 246	11 246	-409	558	-1 149

Source: SORS, authors' presentation

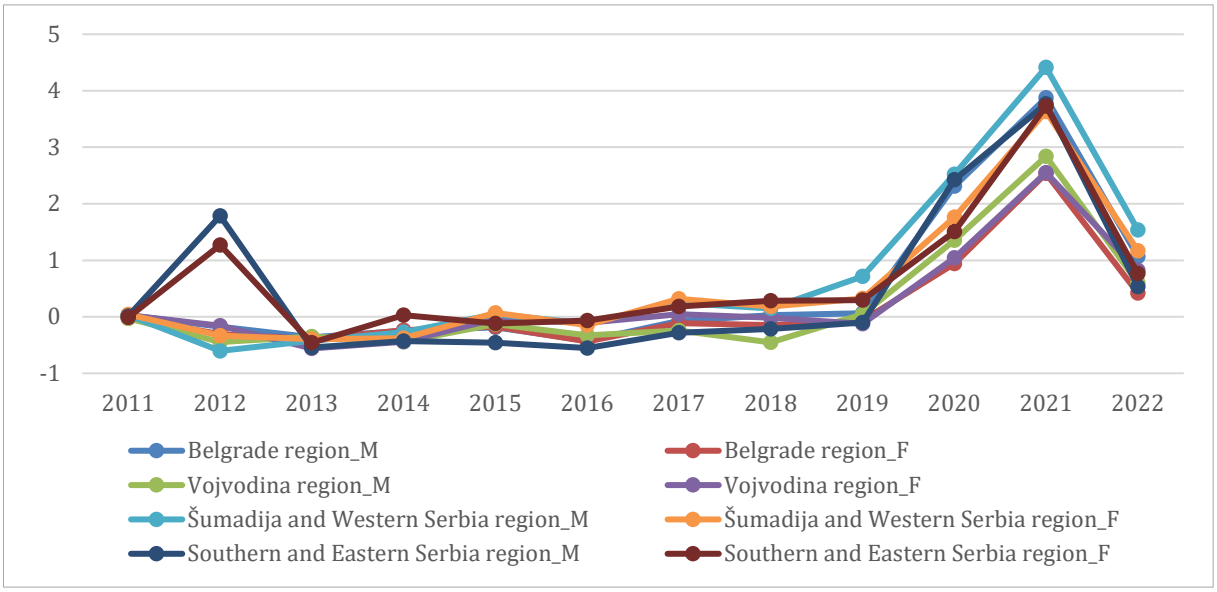
Note: The data presented are based on projected values for expected migrations.

The previous analysis, based on the hypotheses presented in the projections and evaluated using the vital statistics method, reveals that the assumption of positive net migration was incorrect in terms of both direction and intensity. The actual net migration was observed to be overestimated by approximately 155 000 inhabitants, as the projections assumed a net immigration of 35 000 inhabitants while a net emigration of 120 000 inhabitants was estimated via the vital statistics method. However, it's important to note that evaluating the migration component using the vital statistics method has its limitations. Net migration is calculated as a residual value based on differences in population counts between two censuses (which can vary due to methodological factors) and natural population change.

Mortality Indicators - Comparison of Projected and Realized Values

A comparison of projected and realized values of life expectancy indicates that the deviations between these values are not high until 2019 (Graph 3), which occurred due to the effects of the COVID-19 pandemic.

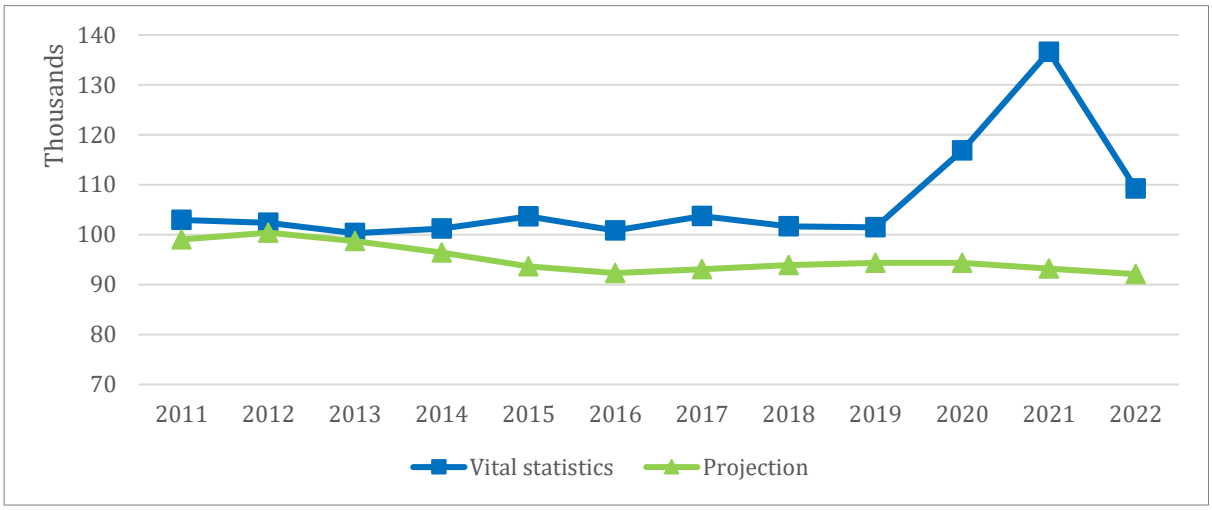
Considering that mortality assumptions are based on historical trends in life expectancy, it is important to assess whether deviations in the number of deaths have occurred, as these directly influence projections. As previously mentioned, official projection reports do not provide direct data on the number of deaths, making it impossible to reconstruct them directly from projections. Therefore, this study opted to estimate the number of deaths as a residual part of projected population growth each year, factoring in reconstructed projections of live births (as shown in Graph 2) and migration balances (Table 7).



Graph 3. The difference between the projected (medium variant) and realized values of life expectancy

Source: Author's calculation based on SORS data

The resulting estimated number of deaths is presented in Graph 4, alongside actual recorded values. The COVID-19 pandemic significantly impacted life expectancy, reducing it by nearly two years. Analysis of death statistics between the 2011 and 2022 censuses indicates that mortality rates during the pandemic years far surpassed pre-pandemic averages, resulting in approximately 50 000 excess deaths in 2020 and 2021 (UNDP, 2022), with an additional 8 000 excess deaths in 2022. Until 2019, prior to the onset of the COVID-19 pandemic, projected deaths were slightly lower than realized, with an average deviation of approximately 6% and a maximum deviation of around 10%. During this period, actual annual deaths exceeded projections by an average of about 6 300.



Graph 4. Number of deaths, 2011-2022.

Source: Author's calculation based on SORS data

Decomposition of the Difference between the Projected and Censused Population

Table 8 presents the series derived from the reconstruction of projected demographic components, alongside official vital statistics data and assessment of net migration using the vital statistics method. In this way, we disaggregate the total difference in population decline between the projected and realized numbers of inhabitants from the 2011 to 2022 censuses to its components. It's important to note that projected annual population values represent yearly averages, while census figures for 2011 and 2022 reflect counts at the critical census moment (September 30). Therefore, when summing realized values for census years, demographic component values were adjusted to one quarter or three quarters in 2011 and 2022, respectively. In contrast, projections, which are calculated for mid-year, use half-year values for census years.

Table 8. Demographic components and number of inhabitants according to the projections of Serbia

	Census and vital statistics				**Projected value - medium variant**			
Year	**Population number (Census)**	**Live births**	**Deaths**	**Migration**	**Population number (projection)**	**Live births**	**Deaths**	**Migration**
2011	7 233 619	65 598	102 935		7 234 099	64 052	99 049	514
2012		67 257	102 400		7 200 033	66 430	100 400	514
2013		65 554	100 300		7 167 188	66 188	98 687	514
2014		66 461	101 247		7 136 063	65 794	96 432	514
2015		65 657	103 678		7 106 941	65 083	93 666	514
2016		64 734	100 834		7 079 925	64 614	92 301	514
2017		64 894	103 722		7 052 596	64 084	93 059	2 136
2018		63 975	101 655		7 026 247	63 775	93 893	3 758
2019		64 399	101 458		6 999 877	63 207	94 383	5 380
2020		61 692	116 850		6 974 655	62 790	94 355	7 002
2021		62 180	136 622		6 950 752	62 459	93 230	8 624
2022	6 647 003	62 700	109 203		6 930 361	62 286	92 098	10 246
Change 2011-2022	-586 616	710 228[1]	1 176 402[1]	-120 442	-303 738	707 593[2]	1 045 977[2]	34 850[2]
					Deviations of projected and realized values in the observed period			
					-282 878	- 2 635	-130 425	-155 292

Source: SORS, presentation of additional authors' calculation

*Notes: [1]The total values of the changes were obtained by the formula 1/4*2011+ ∑ (2012,2021) +3/4*2022, because the critical moment of the census is 30 September. [2]The total values of the changes were obtained by the formula 1/2*2011+ ∑ (2012,2021) +1/2*2022 because the projected population refers to the middle of the year.*

Births, deaths, and migrations are aggregated for easier overall comparison of changes, considering the different time points referenced by various data sources. According to census data, Serbia's population decreased by 586 616 (adjusted the correction for municipalities of Bujanovac, Preševo, and Medveđa) from September 30, 2011, to September 30, 2022. Conversely, projections made in 2014 anticipated a population decline of 303 738 (annual average) during

the same period. This results in a difference of 282 878 between realized and projected population decline figures.[8]

The projected number of births falls short by 2 635 compared to the official count. This discrepancy would have been even smaller if not for the effects of the COVID-19 pandemic, which slightly reduced fertility levels during that period. Thus, the set fertility rate values proved adequate, resulting in minor deviations in the number of live births.

As per projections, migrations were expected to contribute positively to population change, estimating a net immigration of approximately 35 000 individuals based on available data. However, the vital statistics method calculated a net migration of about -120 000 for the inter-census period from 2011 to 2022. This indicates that projections overestimated the potential for population growth from this component. Considering the divergent migration flows between projections and vital statistics results, migration accounts for a total contribution of approximately -155 000 to the difference between projected population decline and the actual decline observed between the 2011 and 2022 censuses.

It's important to note that external migration data scarcity makes this component the most challenging to estimate and forecast accurately. The only official document providing a comprehensive overview of migration statistics for the Republic of Serbia is the Migration Profile, published annually by the Commissariat for Refugees and Migration. It states that Serbian citizens who go abroad with the intention of staying for more than 90 days must register their extended stay with the relevant authorities through diplomatic or consular representatives. However, this is not the case in practice. Serbia, as an emigration country, lacks complete records of its emigrants; therefore, the Migration Profile relies on Eurostat data on the number of immigrants published by EU member states for the current year (KIRS, 2023).

Except for the mentioned document, there is no official estimate of the extent of migration movements outside of national borders. On the other hand, there are unofficial studies on migration estimates conducted for various analytical purposes. In 2019, the Statistical Office of the Republic of Serbia (SORS), with support from UNFPA, conducted a study aimed to investigate alternative data sources beyond those provided by the Ministry of Interior RS. Key data sources included Eurostat databases, national statistics, the population census, student records by nationality, and vital events based on the usual resident concept. Covering the period from 2011 to 2018, the study projected migration trends up to 2021 and assessed Serbia's total migration relative to each of the analyzed countries identified as the most frequent destinations for Serbian migrants, using the "mirror statistics" method (UNFPA, 2019).

It must be said that managing migration is a challenge from both a regional and global perspective. For example, national migration statistics in former Yugoslav countries, excluding Croatia and Slovenia, are often inaccurate, incomplete, or unavailable. In contrast, EU member states have a more systematic approach, collecting and submitting migration data to Eurostat based on Regulation 862/2007[9]. Generally, data sources used are diverse, encompassing statistical and administrative records, such as population registers and residence permits for reasons like education, family reunification, and work, as well as border crossing data, special surveys, and "big data" from digital devices and online platforms.

Having in mind the projected values for the number of births and migration balance, both of which were previously described, the discrepancy between the projected and actual number of

[8] The evaluation of each of the demographic components resulted in a total difference in the population decline according to projections and census results of about -288 000 persons. The difference of about 5 000 (about 1.7%) can be attributed to numerous factors such as: 1) the lack of exact projected values for demographic components, which were reconstructed based on the methodological solutions presented in this paper, and official demographic projections 2) the differences in the timing of the inter-census period (September 30, 2011 and 2022) and 3) methodological differences that exist between the two censuses.

[9] http://data.europa.eu/eli/reg/2007/862/oj

deaths during the inter-census period amounts to approximately 130 000 individuals. A significant portion of this difference, approximately 58 000 deaths, can be attributed to excess mortality resulting from the COVID-19 pandemic. The remaining overestimation in mortality amounts to about 72 000 individuals, translating to roughly 6 000 people annually (approximately 6% of the total number of deaths).

Graph 3 illustrates that the most substantial deviations in life expectancy occurred during the pandemic years, whereas there were no significant deviations in predicted versus realized life expectancy in the period preceding the pandemic. Hence, the lower-than-expected number of deaths is likely due to differences between the realized and projected age structures of the population. These differences can stem from various factors, partly influenced by migration assumptions. Specifically, the migration hypotheses assumed not only a positive migration balance but also a more favorable age structure for Serbia's population, resulting in slightly lower mortality rates.

Finally, in this research, the reproduced number of deaths was derived as an unknown value in the demographic equation, based on the population size (according to projections) for two consecutive years, and reconstructed projected births and net migration. Migration values were interpolated between the initial and final values of the projection interval.

CONCLUSION

According to the 2022 Census results, Serbia's population stood at 6 647 003, which is approximately 2.3% (about 154 000 inhabitants) lower than the projected values for that year under the closest variant of projections—the constant variant. The low variant and variant without changes in net migration overestimated the census result by 3.2% and 3.4%, respectively, while for the medium and high variants projected population figures for 2022 were 4.1% higher (about 284 000 inhabitants).

The overestimation in the projections during the first decade of the projection period can be partly attributed to "excess mortality" during the COVID-19 pandemic. However, the more significant deviation is due to the fact that negative net migration occurred, while positive net migration was projected. These circumstances were unforeseen at the time of making the demographic projections following the 2011 Census. However, considering the registered number of live births and deaths in 2022, and the rebound in life expectancy to pre-pandemic levels, we can view the COVID-19 pandemic as an external shock affecting long-term demographic trends.

The lack of research on external migration presents a specific challenge in predicting future migration flows. Similar assumptions regarding migration were also utilized in the national study "Population Projections of Serbia from 2010 to 2060," published by the Fiscal Council of the Republic of Serbia. Improvement in assumptions could be made based on diverse data sources, such as the number of enrolled foreign students, Ministry of Interior databases on foreigners, statistics on deregistrations and registrations of residence, "Mirror statistics" from Eurostat on migration flows, residence permits, national statistical data, UN recommendations, and ad-hoc research on external migration.

It's important to acknowledge the limitations of this study. The evaluation of population projections from 2014 was based on reproducing projected population figures for Serbia from 2011 to 2022 using available data. The relevance of this evaluation depends on the accuracy of the reproduced series. To enhance future assessments, greater transparency and availability of population projection data would facilitate more precise and comprehensive evaluations.

REFERENCES

Breznik, D. (1977). *Demografija: analiza, metode i modeli*. Beograd: Institut društvenih nauka, Centar za demografska istraživanja.

CDI-IDN. (1971). *Višejezički demografski rečnik*. Centar za demografska istraživanja Instituta društvenih nauka.

Devedžić, M. (2006). *O prirodnom kretanju stanovništva*. Beograd: Zavod za udžbenike.

George, M. V. (2001). Population forecasting in Canada: Conceptual and methodological developments. *Canadian Studies in Population [ARCHIVES]*, 28(2), 111-154.

Kicošev, S, Golubović, P., (2004). *Geodemografija.* Niš: Prirodno-matematički fakultet.

KIRS (Komesarijat za izbeglice i migracije). (2023). *Migracioni profil*. https://kirs.gov.rs/media/uploads/1Migracioni%20profil.pdf

Marinković, I., & Galjak, M. (2021). Excess mortality in Europe and Serbia during the COVID-19 pandemic in 2020. *Stanovnistvo*, *59*(1), 61–73. https://doi.org/10.2298/STNV2101061M

Morgenroth, E. (2002). Evaluating methods for short to medium term county population forecasting. *Dublin: Journal of the Statistical and Social Inquiry Society of Ireland, Vol. XXXI,* 2001/2002, pp110-145

Nikitović, V. (2010). *Demografska budućnost Srbije: Imigracija kao izvesnost?,* Beograd: Službeni glasnik, Institut društvenih nauka.

Penev, G. (2013). *Projekcije stanovništva Srbije od 2010. do 2060. godine*. Fiskalni savet, Beograd.

Penev, G. (2021). Demografski bilans Srbije u prvoj godini pandemije COVID-19. *Demografija*, *18*, 1-18. https://doi.org/10.5937/demografija2118002P

Pflaumer, P. (1993). Measuring the accuracy of population projections: An application of exploratory data analysis (No. 199). *Diskussionsbeiträge-Serie II*.

Radivojević, B., 2018. *Demografska analiza*. Beograd: Ekonomski fakultet.

Rančić, M. (1979). *Statistika stanovništva*. Viša škola za primenjenu informatiku i statistiku.

RZS (2019). Elektronska baza podataka. Beograd: Republički zavod za statistiku Srbije. https://data.stat.gov.rs/?caller=SDDB&languageCode=sr-Latn

RZS (2021). *Vitalni događaji u Republici Srbiji,* Saopštenje, Beograd

RZS (2022). *Demografska statistika u Republici Srbiji, 2022***,** Beograd

RZS (2023). *Nacionalna pripadnost, 2022: Knjiga Popisa stanovništva, domaćinstava i stanova 2022.*, Beograd: Republički zavod za statistiku Srbije

SORS. (2014). *Population projections of the Republic of Serbia 2011–2041*. Statistical Office of the Republic of Serbia.

Thomas, M., Syse, A., Rogne, A. F., & Gleditsch, R. (2022). Assessing the accuracy of national population projections: A case study of Norway. *Finnish Yearbook of Population Research*, 56 (2021-2022): 31-64

UNDP (United Nations Development Programme). (2022). *Serbia national human development report 2022*. United Nations Development Programme. New York.

UNFPA. (2019). *Project on international migration: Estimation and correction of population estimates*. https://serbia.unfpa.org/en/publications/project-international-migration-estimation-and-correction-population-estimates

APPENDIX

Table 1. Total population of Serbia in 2022, demographic projections and Census 2022

Projection scenario variants	Population number in 2022		Difference	
	Population projection	2022 Census	Absolute value	%
REPUBLIC OF SERBIA				
Low variant	6 869 483	6 647 003	-222 480	-3.2
Medium variant	6 930 363	6 647 003	-283 360	-4.1
High variant	6 930 768	6 647 003	-283 765	-4.1
Constant variant	6 800 950	6 647 003	-153 947	-2.3
Variant without migration	6 884 005	6 647 003	-237 002	-3.4
Belgrade region				
Low variant	1 748 270	1 681 405	-66 865	-3.8
Medium variant	1 750 042	1 681 405	-68 637	-3.9
High variant	1 750 059	1 681 405	-68 654	-3.9
Constant variant	1 722 572	1 681 405	-41 167	-2.4
Variant without migration	1 615 628	1 681 405	65 777	4.1
Vojvodina region				
Low variant	1 805 678	1 740 230	-65 448	-3.6
Medium variant	1 823 334	1 740 230	-83 104	-4.6
High variant	1 826 340	1 740 230	-86 110	-4.7
Constant variant	1 784 858	1 740 230	-44 628	-2.5
Variant without migration	1 846 499	1 740 230	-106 269	-5.8
Šumadija and Western Serbia region				
Low variant	1 875 111	1 819 318	-55 793	-3.0
Medium variant	1 898 216	1 819 318	-78 898	-4.2
High variant	1 896 768	1 819 318	-77 450	-4.1
Constant variant	1 850 789	1 819 318	-31 471	-1.7
Variant without migration	1 938 392	1 819 318	-119 074	-6.1
Southern and Eastern Serbia region				
Low variant	1 440 424	1 406 050	-34 374	-2.4
Medium variant	1 458 771	1 406 050	-52 721	-3.6
High variant	1 457 601	1 406 050	-51 551	-3.5
Constant variant	1 442 731	1 406 050	-36 681	-2.5
Variant without migration	1 483 486	1 406 050	-77 436	-5.2

Source: SORS, authors' calculation

Article history:	Received: 3.7.2024.
	Revised: 24.9.2024.
	Accepted: 7.10.2024

DOI: 10.28934/ea.24.57.3.pp87-100 First Online: November 4, 2024

PRELIMINARY REPORT

The Use of Information and Communication Technologies Among Generation X in Serbia: A Comparison Before and After the COVID-19 Pandemic

Đina Ivanović[1] | **Jelena Banović**[2]* | **Aleksandra Bradić-Martinović**[2]

[1] Institute of Economic Sciences, Digital Economics Department, Belgrade, Serbia
[2] Institute of Economic Sciences, Innovation Economics Department, Belgrade, Serbia

ABSTRACT
The aim of this paper is to examine the use of information and communication technologies (ICT) among Generation X in the years before and after the COVID-19 pandemic. The pandemic brought significant changes in digital technology usage and accelerated shifts in work, communication, and societal functioning. Generation X, comprising individuals born between the 1960s and 1980s, grew up during a time when digital technologies and the internet were not as prevalent. Given that they now live and work in a digital era, it is crucial to understand how they adapt to the rapid changes driven by digitalization. For this research, microdata from the survey "The Usage of Information and Communication Technology by Individuals/Households in the Republic of Serbia" were analyzed for the years 2019 and 2023. Results show a slight increase in internet and computer use, particularly among younger members of Generation X. Additionally, there was a significant increase in online shopping and the use of communication services in 2023, which gained popularity during the lockdown. Regarding public administration services, respondents in 2023 primarily accessed services related to the pandemic, such as vaccine information and green certificates. However, a significant number of respondents, 49%, did not use public services in either 2019 or 2023, suggesting potential issues with trust or perceived complexity. The main contribution of this paper is a detailed analysis of this group's behavior before and after the pandemic, focusing on ICT usage and responses to changes triggered by the COVID-19 pandemic.

Keywords: *ICT, digital technologies, generation X, COVID-19*

JEL Classification: O33, J11, I15

INTRODUCTION

The COVID-19 pandemic brought global changes that introduced the world into a new era of digitalization, where information and communication technologies (ICT) have become essential tools for the functioning of society. The acceleration of digital transformation was inevitable as social and economic systems worldwide were forced to rapidly transition to online formats. Adapting to new circumstances was challenging for individuals across all generations, which is understandable due to their different backgrounds, levels of education, and social statuses. Consequently, each generation has developed distinct patterns of adopting and utilizing digital technologies. While younger generations, who were raised in technology-rich environments,

* Corresponding author, e-mail: jelena.banovic@ien.bg.ac.rs

exhibited greater flexibility in embracing new digital solutions, older generations encountered a variety of challenges, both technical and psychological. In order to better understand generational behavior patterns, a classification system has been developed. This system identifies five generational groups: Builders, Baby Boomers, Generation X, Generation Y, and Generation Z (Berkup, 2014; Strauss & Howe, 1992). The literature does not establish uniform time frames for these generations; rather, various accepted interpretations are available. For instance, Berkup (2014) defines Builders as those born between 1900 and 1945, Boomers between 1946 and 1964, Generation X between 1965 and 1979, Generation Y (Millenials) from 1980 to 1994, and Generation Z from 1995 to the present. Although these time frames differ slightly across sources, they do not pose significant challenges to the observation and analysis of core characteristics and behavior patterns of these groups. Each generation has been shaped by specific historical and social events, which have greatly influenced their attitudes toward change, particularly those changes associated with the rise of the modern digital era. In this context, the ability of different generations to adapt to technological changes is particularly significant. Generational differences have tangible implications in various aspects of life, particularly during times of crisis, such as the COVID-19 pandemic, when technological adaptation becomes a crucial factor for social and economic resilience. This paper focuses on Generation X, a cohort that came of age during significant social and technological shifts. Generation X witnessed the beginning of the digital era, marked by the advent of personal computers, the Internet, and mobile technologies. As a result, members of this generation often exhibit a degree of skepticism toward technology, stemming from their upbringing in a pre-digital world. This skepticism is not merely technological but often relates to concerns over privacy and the complexities associated with the use of new tools.

The COVID-19 pandemic significantly impacted the ways Generation X engages with ICT, as it rapidly accelerated the process of digital transformation. Although this generation may have been less prepared at the outset, they were compelled to adapt to changes, with many encountering advanced digital tools for work and communication for the first time. The challenges were especially pronounced in the fields of work and education, where the transition to digital tools and platforms was both rapid and, for many, unexpected. Given the impact of the pandemic, it is critical to examine how Generation X adapted to these new conditions, particularly in Serbia, where social and economic circumstances played a significant role in shaping the adoption of digital technologies. Serbian society, with its distinct transitional challenges, provides a unique context for analyzing digital adaptation, particularly among older generations who have experienced the shift from an analog to a digital age. Understanding how Generation X adapted to these changes is essential for identifying the specific barriers they faced and for assessing the long-term effects of the pandemic on their work, education, and consumer habits.

The aim of this study is to determine whether there has been a noticeable change in ICT usage among Serbian citizens before and after the pandemic, with a specific focus on Generation X. By analyzing various areas of ICT application, including education, work, and consumer habits, this study seeks to provide insights into how this cohort adapted to new conditions and what the long-term implications of these changes might be for society. This analysis is not only relevant in the context of the pandemic but also for broader discussions about ICT literacy among older generations, which is critical for future strategies of digital inclusion and development.

LITERATURE REVIEW

Generation X

The classification of different generations was first mentioned in 1992 by Strauss & Howe (1992). Current scientific literature records several different opinions on the time frames that define each generation. Taking into consideration Generation X, Gurau (2012) defines the key years as the period from 1961 to 1979, while Basantes-Andrade et al (2020) highlight the time frame between 1966 and 1976. Gao (2023) cites that Generation X includes individuals born

between 1965 and 1980. According to Berkup (2014), Stjepić, Vukšić, & Suša Vugec (2019), Generation X includes individuals born between 1965 and 1979. Different opinions on the time frames for defining generations come from various socio-cultural changes, criteria, and regional boundaries. Elagin & Mikirtumov (2020) note that time frames can vary and need to be adjusted based on the region and social group of the individual. Despite the different time frames for defining various generations, the available literature generally agrees on the overall characteristics and behaviors of individuals (Lissitsa & Kol, 2016). Regardless of which time frame is chosen, the characteristics of the observed group will remain unchanged. For the purposes of this paper, we will use the time frame that defines Generation X as those born between 1965 and 1979. This classification is widely accepted in scientific literature and provides a solid foundation for analyzing the specific behaviors and characteristics of this generation.

Coklar & Tatli (2021) noted that members of Generation X experienced the rise of new digital technologies and observed their impact on social life. They are generally more skeptical about digital technologies, use them less, and adapt to them based on their circumstances, compared to members of other generations. Since they grew up during significant social and technological changes, such as the advent of computers, the Internet, and changes in work conditions, this generation has had to adapt to new situations. Due to their lifestyle, Kittelson (2023) suggests that this generation may experience a gap in connecting with technologies and other generations around them, as each reacts differently to new technologies. Weeks and Schaffert (2019) indicate that the ideal job for members of Generation X is one that allows the development and achievement of individual goals while supporting flexibility, innovation, and independence. They value autonomy and independence at work (Eyoun et al., 2020), have a strong work ethic, and are satisfied with their jobs, appreciating external rewards when they achieve satisfactory results (King et al., 2017). Prensky (2001) and Palfrey & Gasser (2010) refer to them as "digital immigrants," representing individuals born before the 1980s, prior to the existence of digital technologies.

Using of ICT and COVID-19

In today's world, having ICT skills is crucial for quality education, healthcare, and functioning in modern society. According to Banović & Pavlović (2021), these skills are necessary for individuals to access information online and identify reliable data. Recent studies have shown that age plays a significant role in encouraging the use of ICT (Niesel & Nili, 2021), with different age groups adapting to changes in their environment in various ways. The pandemic significantly impacted how people work, learn new skills, and perform daily tasks. ICT has become a vital tool for handling these challenges, allowing daily life to continue. The pandemic led to a global increase in digital technology use (Neena Pandey & Pal, 2020), with usage rising from 40% to 100% compared to pre-pandemic levels (Roy, 2021). Many people used the Internet for daily activities like buying supplies and accessing services such as e-banking and online payments. They also used digital platforms for information, news, communication, and education through online courses. The rise in Internet and computer use during the pandemic was especially noticeable in business. The pandemic accelerated digital transformation and introduced new business models (Golinelli et al., 2020; Zeynalli & Zeynalli, 2022; Burlea-Schiopoiu et al., 2023). Remote work, once uncommon, became standard for many employees (Kossek & Lautsch, 2018; Van der Loop, Willigers, & Haaijer, 2019). The shift to remote work replaced the traditional office with working from home (Sarfraz et al., 2021). In this context, Coklar & Tatli (2021) highlight that Generation X has developed an adaptive system for digital technologies based on their circumstances. This system has proven essential during the pandemic. Konig & Seifert (2022) note that most older workers who switched to full-time remote work reported acquiring new computer skills, reflecting Generation X's effective adaptation. Online education, enabled by ICT (Bick et al., 2020; Johnson, 2020), also faced challenges as universities quickly adapted to new conditions. Johnson et al. (2020) observed that most universities moved to online teaching, even if they had little prior

experience. Staff lacking online teaching experience had to learn new methods. Despite the push for fast adaptation, a digital divide was evident between older and younger staff. Samifanni & Gumanit (2021) and Khan et al. (2021) found that older professors, mainly from Generation X, struggled more with the transition to online education compared to their younger colleagues.

There was also a notable increase in ICT usage for entertainment and communication purposes (Petrosyan, 2023), as people widely used video calls and social media to stay connected (Nguyen et al., 2020; Silva et al., 2021). On the other hand, Hashem (2020), Ivanovic & Antonijevic (2020), Moon et al. (2021), Wiścicka-Fernando (2021), and Young et al. (2022), report a significant rise in online shopping. All these activities, from work to education and shopping, require strong ICT skills and the effective use of digital technologies.

The impact of pandemic-induced changes has not been the same for everyone, particularly considering factors such as gender, age, or demographic category. This study emphasizes age as a key factor, specifically examining Generation X, whose early life and educational background are notably different from today's younger generations. These differences may influence how Generation X adapts to changes in the digital environment and their ability to effectively use modern technologies. Due to frequent challenges in adopting and utilizing digital technologies, it is crucial to analyze technology usage in the year before the pandemic and to determine whether there were changes in usage in the years that followed. These results could highlight potential gaps and provide insights into the long-term effects of the pandemic on work, education, and consumer habits, as well as identify specific barriers that this generation had to overcome. Understanding these challenges can aid in developing strategies to facilitate the transition and enhance digital inclusion for Generation X in the post-pandemic period.

DATA AND METHODOLOGY

For this research, microdata from the survey "*The Usage of Information and Communication Technology by Individuals/Households in the Republic of Serbia*" for 2019 and 2023 were used. The data were provided by the Statistical Office of the Republic of Serbia (SORS), and the study is conducted according to Eurostat methodology in the territory of the Republic of Serbia. The authors chose to include 2019, the last year before the pandemic, and 2023, to obtain a more comprehensive view of the long-term impact of COVID-19 on ICT usage. While 2020 and 2021 were characterized by a rapid and often disruptive shift to digital technologies, analyzing data from 2023, which represents a more stable period, enables a deeper insight into the enduring shifts in ICT usage patterns and adaptations that took place beyond the initial aftermath of the pandemic. This approach provides clearer insights into the long-term effects and trends in digital behavior that have emerged as societies adjusted to the new normal. Due to the newly arisen situation caused by the pandemic, the survey conducted in 2023 underwent minor changes. These changes were found in several different segments of the survey. They mostly pertained to the frequency of various activities carried out on the Internet and computers, as well as the types of actions performed online. In the 2023 survey, a noticeable trend in the offered responses was directly influenced by the pandemic, such as those related to the use of e-government for green certificates, vaccination information, and similar topics.

The main objective of SORS in the process of conducting annual research is to provide data on the use of information and communication technologies among individuals/households, as well as enterprises in the Republic of Serbia. The reference period covered the three months prior to the telephone interviews (SORS, 2023). The research is conducted with a sample of 2,800 individuals, targeting those aged 16 to 74. For 2019, the year before the pandemic started, the response rate was 93.8%, with 2.627 individuals participating. Among them, 37.6% were men and 62.4% were women out of the total population (SORS, 2019). In 2023, the response rate remained high at 93.3%, with 2.612 participants. Of these, 40.8% were men and 59.2% were women out of

the total population (SORS, 2023). Descriptive statistics were used to present the analysis, and cross-tabulation was utilized to explore more detailed information within specific segments.

Taking into consideration socio-demographic data for Generation X in 2019, 51.1% of the respondents were women, and 48.9% were men. A similar situation was noticed in 2023, where 50.8% of respondents were women, and 49.2% were men. The majority of this generation in both years completed secondary vocational school or high school; most of them were employed, and more than 50% were employed in both observed years. Detailed socio-demographic data are presented in Table 1.

Table 1. Socio-demographic characteristics of Generation X in 2019 and 2023

GENDER	**2019**	**2023**
Male	48.9%	49.2%
Female	51.1%	50.8%
EDUCATION		
Lower than secondary	19.8%	14.6%
Secondary	60.9%	60.5%
Tertiary	19.3%	24.9%
WORK STATUS		
Employed	57.6%	53.5%
Self-employed	2.6%	6.8%
Unemployed	25.7%	24.5%
Retired	4.8%	6.6%
Disabled	2.6%	/
Serving military duty	0.1%	/
Housewife	4.7%	5.6%
Other	1.9%	3%

Source: Authors' calculations based on SORS data

Table 1. shows a balanced gender distribution in both years, with slightly more women than men. The educational attainment indicates a shift towards higher education, with an increase in tertiary education from 19.3% in 2019 to 24.9% in 2023. Employment status remains stable, but there is a notable rise in self-employment and retired individuals, reflecting broader socio-economic trends and possibly the impact of the pandemic on job markets.

RESULTS AND DISCUSSION

When it comes to computer use in the past three months, the majority of Generation X used a computer every day or almost every day in the year before the pandemic, with 65.2% of respondents. After the pandemic, this number slightly increased, and in 2023, 68.4% of respondents used a computer every day or almost every day. The slight increase can be attributed to the continuity of computer use among individuals who had previously engaged in work or other activities involving computers, extending into the year following the pandemic. Additionally, in recent years, the use of other devices, such as smartphones, smart TV and tablets, which have become increasingly accessible, may have influenced computer usage. Many tasks that once required a computer can now be performed on mobile devices. Eurostat stated that mobile devices were used to connect to the Internet by 9 out of 10 EU users (Eurostat, 2024).

In this context, 83% of individuals in Serbia access the Internet via mobile phones, while desktop computers are used by 39% of citizens. In neighboring countries, mobile phone usage for internet access stands at 88% in Montenegro and 81% in Bosnia and Herzegovina. The highest rates of mobile device usage are found in Scandinavian countries, where it exceeds 95%, with Norway reaching 99% (Eurostat, 2024).

On the other hand, 79.6% of individuals used the Internet every day or almost every day in 2019. According to new trends in 2023, SORS modified the questionnaire and included the response option "I used the Internet multiple times per day". In the mentioned year, 85.3% of respondents used the Internet daily or multiple times a day. Data show that in the years following the pandemic, the use of the Internet and computers increased. These findings are satisfactory but not sufficient. According to Eurostat (2024), Serbia remains near the bottom of the list when it comes to Internet usage. In many European countries, Internet use is present in daily activities for over 90% of the population. The results presented in Table 2 refer to Internet and computer usage in 2019 and 2023 for the total population of Generation X.

Table 2. Computer and Internet usage in the previous 3 months in 2019 and 2023

Computer usage in the previous 3 months			**Internet usage in the previous 3 months**		
	2019	**2023**		**2019**	**2023**
Multiple times per day	.	.	Multiple times per day	.	85.3%
Every day or almost every day	65.2%	68.4%	Every day or almost every day	79.6%	3.5%
At least once per week	10.5%	8.5%	At least once per week	5.8%	3.5%
At least once per month	3.0%	3.0%	At least once per month	1.7%	0.4%
Less than once per month	1.5%	0.5%	Less than once per month	0.5%	/

*Missing value computer usage 2019 - 19.9%; **Missing value computer usage 2023 – 19.6%
***Missing value Internet usage 2019 - 12.3%; ****Missing value Internet usage 2023 – 7.2%

Source: Authors' calculations based on SORS data

For a detailed analysis of the Internet and computer usage in the specified years, Generation X was categorized by age groups, providing insights into changes in usage patterns between 2019 and 2023. We divided individuals into two groups: the "younger" group, consisting of individuals aged 40 to 46, and the "older" group, comprising individuals aged 47 to 54. In 2019, over 80% of individuals in both groups used a computer every or almost every day, with a minimal difference of 1.3%. In terms of Internet use, the "younger" group used the Internet every or almost every day slightly more than the "older" group in 2019, which was anticipated. The results for 2023 are consistent with this pattern, despite the changes in methodology. Specifically, the "younger" group continues to have an advantage in terms of using the Internet multiple times a day.

Table 3. Computer and Internet usage in the previous 3 months for specific groups of Generation X in 2019 and 2023

Computer usage in the previous 3 months					**Internet usage in the previous 3 months**				
	2019		**2023**			**2019**		**2023**	
	40-46	**47-54**	**40-46**	**47-54**		**40-46**	**47-54**	**40-46**	**47-54**
Multiple times per day	.	.	.	.	Multiple times per day	.	.	93.5%	89.8%
Every day or almost every day	82.3%	81.0%	89.1%	81.5%	Every day or almost every day	94.3%	88.5%	2.6%	5.2%
At least once per week	12.6%	13.2%	9.1%	11.7%	At least once per week	3.1%	9.2%	3.8%	4.4%
At least once per month	2.8%	4.6%	1.8%	5.8%	At least once per month	1.6%	2.1%	.	.
Less than once per month	2.3%	1.2%	0.2%	1.0%	Less than once per week*	1.0%	0.1%	0.2%	0.7%

*Change in methodology in 2023 (previously, it was categorized as "less than once per month")

Source: Authors' calculations based on SORS data

In both years, individuals with tertiary education used computers and the Internet more frequently, with over 90% in each observed year. The analysis also revealed that in 2019, more men than women used a computer every day, with 51.6% of men compared to women. However, a slight reversal occurred in 2023, when more women used a computer every day, with 51.3%.

Table 4. Computer and Internet usage in the previous 3 months according to education in 2019 and 2023

Computer usage in the previous 3 months					**Internet usage in the previous 3 months**				
	2019		**2023**			**2019**		**2023**	
	secondary	**tertiary**	**secondary**	**tertiary**		**secondary**	**tertiary**	**secondary**	**tertiary**
Every day or almost every day	63%	92.5%	91.4%	96.1%	Multiple times per day	84.4%	99.3%	95.8%	99.5%

Source: Authors' calculations based on SORS data

The analysis of results provided insights into the habits of Generation X regarding online ordering of goods and services for personal use. In 2019, 30.4% of respondents ordered goods and services online in the previous three months, and this number significantly increased to 43.4% in 2023. These results are in line with the findings of Young (2022); Svatošova (2022); Waqas et al. (2023); Jensen et al. (2021), who also observed a significant increase in online shopping during the pandemic. Moreover, a gender shift occurred. In 2019, 54.9% of purchases in the previous three months were made by men, while women made 45.1%. By 2023, the trend reversed, with 51.4% of purchases being made by women, and a slightly lower percentage of men, at 48.6%. These results align with the findings of Kireyeva et al. (2022). After gaining experience with online shopping during the pandemic, many consumers continued to use these services even after the restrictions were lifted. This observation is also supported by Shaw et al. (2022) who highlighted that a large number of respondents plan to remain online shoppers in the years following the pandemic. As a result of the overall situation, there has been a significant decrease in the number of Generation X individuals who have never ordered goods and services online. In 2019, 35.9% did not engage in this activity, but this number highly changed in 2023, with 24.8%.

Table 5. Purchasing/ordering goods or services online for personal purposes in 2019 and 2023

	2019*	**2023****
In the previous three months	30.4%	43.4%
More than three months ago (less than a year)	10.0%	13.5%
More than a year	11.8%	12.8%
Never	35.9%	24.8%

*Missing value 11.9%
**Missing value 5.6%

Source: Authors' calculations based on SORS data

An analysis of the frequency of online purchases of goods and services was conducted for two distinct groups within Generation X. In 2019, the "older" group demonstrated a higher average rate of purchases in the previous three months, accounting for 39.5%. However, by 2023, the younger group became more prominent, with 55.6% of respondents reporting purchases during the same period.

When examining education levels, individuals with tertiary education were more likely to purchase goods and services across both years. This proportion increased from 54.4% in 2019 to 67.2% in 2023, highlighting a notable rise in online purchasing activity among the higher-educated population.

Table 6. Purchasing/ordering goods or services online for personal purposes for specific groups of Generation X in 2019 and 2023

	2019		2023	
	40-46	**47-54**	**40-46**	**47-54**
In the previous three months	33.7%	39.5%	55.6%	34.0%
More than three months ago (less than a year)	11.6%	9.9%	14.7%	14.3%
More than a year	14.1%	10.4%	18.1%	11.4%
Never	40.6%	40.2%	18.5%	33.5%

Source: Authors' calculations based on SORS data

Given the above-mentioned results, the findings regarding the frequency of ordering goods and services in 2023 compared to the year before the pandemic were expected. In 2019, 14.8% of Generation X representatives ordered online 1 or 2 times per month. This number increased to 22.9% in 2023, while there was a 5.2% increase in respondents who ordered 3 to 5 times in 2023 compared to 2019. These findings are in line with the statements of Lu et al. (2021), Yuliana & Adityawati (2023), Fittler et al. (2022).

Table 7. How frequently did you Purchase or order goods or services online in the previous 3 months in 2019 and 2023

	2019*	**2023****
1-2 times	14.8%	22.9%
3-5 times	11.4%	16.6%
6-10 times	2.6%	3.2%
More than 10 times	1.6%	0.8%

*Missing value 69.6%
**Missing value 56.6%

Source: Authors' calculations based on SORS data

When discussing activities conducted via the Internet, Table 8 shows an increase in almost all activities. This result is not surprising, especially in the context of business communication (sending and receiving emails), with an 8.3% increase observed in Generation X due to the shift to remote work. Individuals who were previously less dependent on computers in their work environment became more reliant on them while working from home. Additionally, there was a noticeable rise in the use of Internet communication applications, whether for personal or business communication. Results were expected, primarily due to the shift to remote work, followed by lockdowns and subsequent additional restrictions on movement. These results are consistent with the findings of Moawad (2022), World Economic Forum (2020), and Barayev et al. (2021). Generation X uses social media for communication with friends and family, networking, and consuming news and entertainment content (Media Culture Report, 2023). However, the lower use in 2023 compared to 2019 is not surprising. This generation is inclined towards in-person social gatherings, and although they are present on social media, they use it significantly less compared to younger generations. Moreover, this trend can be explained by digital fatigue observed during the pandemic and post-pandemic period, as there was an oversaturation with social media. As a result, social media became one of the areas where users made cuts in their usage, as confirmed by Gregersen et al. (2023), Sharma (2021), Romero-Rodriguez (2023), and Sunil (2022).

Table 8. Activities done by Internet for personal purposes in the previous 3 months in 2019 and 2023

Activity	2019	2023
Sending/receiving emails	50,9%	59,2%
Communicating by Internet (WhatsApp, FaceTime, Viber, Skype...)	19,5%	30,3%
Social media (Facebook, Twitter, Instagram)	5,7%	1,6%
Other	23,9%*	8,9%

Source: Authors' calculations based on SORS data

*Summarized activities that have less than 5% per each (Sending online messages through Skype, reading newspapers and journals, Web banking, selling goods or services through websites or applications like eBay, etc.)

In 2019, Generation X primarily used public administration services to obtain information and stay informed. However, it is noteworthy that 49.1% of respondents did not engage in any of the activities offered that year. The pandemic has significantly altered how society interacts with public services, leading to changes in the response patterns observed in 2023. For instance, the response options provided by SORS were updated in 2023 to reflect these changes, recognizing the new context. In 2019, respondents could not indicate whether they accessed personal information through public services, such as vaccination records or green certificates. By 2023, this activity became the most common among Generation X, with 29.1% reporting it. Nonetheless, it remains concerning that nearly 50% of respondents did not participate in any of the activities offered. This could suggest a lack of trust in public services, a sentiment supported by Garcia-Rio et al. (2023) and Hooda et al. (2022), who identified trust as a crucial factor influencing attitudes toward using such services.

Table 9. Activities done in the previous 12 months by public services online for personal purposes in 2019 and 2023

Activity	2019	Activity	2023
Obtaining information on the website or applications	26.8%	Access personal information stored by public authorities (vaccination information, green certificate, etc.)	29.1%
Downloading or printing templates	2.4%	Access to information from public databases or registers (land registries, company registers)	5.6%
Sending filled templates	0.2%	Obtaining information (about services, benefits, rights, laws, working hours)	5.8%
None of the above	49.1%	I have not used public administration services	49.5%

*Missing value 21,5% (2019)
*Missing value 10% (2023)

Source: Authors' calculations based on SORS data

CONCLUSION

This paper aimed to examine the use of ICT among Generation X in the years before and after the COVID-19 pandemic. Studying the use of digital technologies among this generation is crucial due to their characteristics and life experiences, as they grew up before the dominance of the Internet and digital technologies. This generation faced the need to adapt to the rapid changes brought about by digitization, raising questions about how members of this group dealt with the challenges arising from the pandemic-induced changes in societal functioning. The COVID-19

pandemic led to the increased use of the Internet and computers, a shift to remote work, online education, digital shopping, and the use of public administration portals. The analysis presented in this paper shows that the period from 2019 to 2023 brought some changes in ICT usage, particularly in the areas of work, education, and consumer habits. Before the pandemic, Generation X largely relied on traditional methods of work and communication. However, pandemic challenges, including the need for remote work, digital education, online shopping, and the use of public administration services, forced this generation to adapt more quickly than ever before and to adopt new digital tools and technologies. Regarding the use of the Internet and computers, there was a slight increase in the number of people who used them every day or almost every day. The changed SORS methodology due to the pandemic also brought a new finding: in 2023, 85.3% of Generation X used the Internet and computers, with the "younger" members of this generation, i.e., individuals aged 40 to 46, being the majority. Online shopping also increased, with a significant reduction in the number of people who had never ordered goods or services online by 2023. It is expected that most of these individuals will continue shopping online in the future. The pandemic also impacted Internet-based activities, with the Internet being used for both business and personal communication—online communication networks became very popular. The results indicate that, although they found themselves in a new situation, individuals managed to adapt quickly. A somewhat different distribution of responses was observed regarding the use of public services, where a large number of respondents had never used any of the offered public service options, neither in 2019 nor in 2023. This may indicate insufficient knowledge of the basic functions of public administration but also a lack of trust in using these services. Therefore, the primary recommendation is to work on informing citizens about the various functions of public administration and providing simplified access, given that the use of digital public administration services is expected to increase in the future.

Further research could focus on differences in the adaptation of digital technologies among different subgroups within Generation X, such as additional differences by education, geographic location, or work sectors. It would also be useful to compare the adaptation of Generation X in Serbia with similar generations in other Balkan and European countries to gain a broader understanding of global and regional trends in ICT usage, given that they represent a generation that has experienced numerous changes throughout their lives, requiring rapid adaptation.

Acknowledgments: The research presented in this paper was funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia under contract number 451-03-47/2023-01/200005.

REFERENCES

Banović, J., Pavlović, D. (2021). Information and Communication Technology's Skills among the Working Population of Serbia. *Economic Analysis*, 54(2), 118-127. https://doi.org/10.28934/ea.21.54.2.pp118-127

Barayev, E., Shental, O., Yaari, D., Zloczower, E., Shemesh, I., Shapiro, M., Glassberg, E., Magnezi, R. (2021). WhatsApp Tele-Medicine – usage patterns and physicians views on the platform. *Israel Journal of Health Policy Research,* 10(34). https://doi.org/10.1186/s13584-021-00468-8

Basantes-Andrade, A., Cabezas-Gonzalez, M., Casillas-Martin, S. (2020). Digital Competences Relationship between Gender and Generation of University Professors. International Journal on Advanced Science Engineering Information Technology, 10(1), 205-211

Berkup, B. S. (2014). Working With Generations X and Y In Generation Z Period: Management of Different Generations in Business Life. *Mediterranean Journal of Social Sciences*, 5(19), 218-229, ISSN 2039-2217

Bick, A., Blandin, A., Mertens, K. (2020). Work from Home Before and after the Covid-19 Outbreak. CERP Discussion Paper No. DP15000, https://ssrn.com/abstract=3650114

Burlea-Schiopoiu, A., Borcan, I., Ovidiu Dragan, C. (2023). The Impact of the COVID-19 Crisis on the Digital Transformation of Organizations. *Electronics*, 12(5), 1205, **https://doi.org/10.3390/electronics12051205**

Coklar, A. N., Tatli, E. (2021). Factors affecting technology leadership self-efficacy and technology integration of Generation X and Y teachers. *Education and Information Technologies*, 26, 751-770.

Coklar, A.N., Tatli, A. (2021). Examining the Digital Nativity Levels of Digital Generations: From Generation X to Generation Z. International Journal of Education, 9(4), 433-444. https://doi.org/10.34293/ education.v9i4.4224

De', R., Pandey, N., & Pal, A. (2020). Impact of digital surge during Covid-19 pandemic: A viewpoint on research and practice. *International Journal of Information Management*, 55, 102171 - 102171. https://doi.org/10.1016/j.ijinfomgt.2020.102171.

Elagin G.B., Mikirtumov I.B. (2020). Internet Debates: Generations X, Y and Z, *Discourse* 6(6), 5-19. https://doi.org/10.32603/2412-8562-2020-6-6-5-19

Eurostat (2024). Individuals – Internet use. Accessed 30.8. 2024. At https://ec.europa.eu/eurostat/databrowser/view/isoc_ci_ifp_iu/default/table?lang=en

Eurostat (2024). Digital economy and society statistics – households and individuals. Accessed 30.8. 2024. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Digital_economy_and_society_statistics_-_households_and_individuals#Internet_access_of_individuals.2C_2010_and_2023

Eyoun, K., Chen, H., Ayoun, B., & Khliefat, A. (2020). The relationship between purpose of performance appraisal and psychological contract: Generational diff erences as a moderator. *International Journal of Hospitality Management*, 86 https://doi.org/10.1016/j.ijhm.2020.102449

Fittler, A., Ambrus, T., Serefko, A., Smejkalová, L., Kijewska, A., Szopa, A., & Káplár, M. (2022). Attitudes and behaviors regarding online pharmacies in the aftermath of COVID-19 pandemic: At the tipping point towards the new normal. *Frontiers in Pharmacology*, 13. https://doi.org/10.3389/fphar.2022.1070473.

Garcia-Rio, E., Palos-Sanchez, P.R., Baena-Luna, P., Agauayo-Camacho, M. (2023). Different approaches to analyzing e-government adoption durign the Covid-19 pandemic. Government Information Quarterly, 40(4). https://doi.org/10.1016/j.giq.2023.101866

Golinelli D, Boetto E, Carullo G, Nuzzolese AG, Landini M.P, Fantini M.P. (2020). Adoption of Digital Technologies in Health Care During the COVID-19 Pandemic: Systematic Review of Early Scientific Literature. *Journal of Medical Internet Research*. 22(11), https://doi.org/10.2196/22280

Gregersen, E., Astrupgaard, S., Jespersen, M., Gårdhus, T., & Albris, K. (2023). Digital dependence: Online fatigue and coping strategies during the COVID-19 lockdown. *Media, Culture, and Society*, 45, 967 - 984. https://doi.org/10.1177/01634437231154781.

Gurau, C. (2012). A life-stage analysis of consumer loyalty profile: comparing Generation X and Millennial consumers, *Journal of Consumer Marketing*, 29(2), 103-113. https://doi.org/10.1108/07363761211206357

Hooda, A., Gupta, P., Jeyaraj, A., Giannakis, M., Dwivedi, Y.K. (2022). The effects of trust on behavioral intention and use behavior within e-government context. *International Journal of Information Management*, 67, https://doi.org/10.1016/j.ijinfomgt.2022.102553

Ivanović, Đ., Antonijević, M. (2020). The Role of Online Shopping in the Republic of Serbia During COVID-19. Economic Analysis, 53(1), 28-41. https://doi.org/10.28934/ea.20.53.1.pp28-41

Jensen, K., Yenerall, J., Chen, X., & Yu, T. (2021). US Consumers' Online Shopping Behaviors and Intentions During and After the COVID-19 Pandemic. *Journal of Agricultural and Applied Economics*, 53, 416 - 434. https://doi.org/10.1017/aae.2021.15.

Johnson, N., Veletsianos, G., Seaman, J. (2020). U.S. faculty and administrators' experiences and approaches in the early weeks of the COVID-19 Pandemic. Online Learning, 24, 6–21

Khan, A.M., Patra, S., Vaney, N., Mehndiratta, M., Chauhan, R. (2021). Rapid transition to online practical classes in preclinical subjects during COVID-19: Experience from a medical college in North India. *Medical Journal Armed Forces India*, 77(1), S161-S167 https://doi.org/10.1016/j.mjafi.2020.12.030

King, C., Murillo, E., & Lee, H. (2017).The eff ects of generational work values on employee brand attitude and behavior: A multi-group analysis. *International Journal of Hospitality Management* 66, 92-105. http://dx.doi.org/10.1016/j.ijhm.2017.07.006

Kireyeva, A., Satpayeva, Z., Kenzhegulova, G., Kangalakova, D., & Jussibaliyeva, A. (2022). Kazakhstani women's participation in online marketplaces: Benefits and barriers. *Asia & the Pacific Policy Studies*. https://doi.org/10.1002/app5.361.

Kittelson, A. (2023). Generational Differences in Technology Usage. Midwest Medical Edition. https://www.midwestmedicaledition.com/articles/generational-differences-in-technology-usage#:~:text=Millennials%2C%20or%20members%20of%20Generation,a%20desire%20to%20use%20them.

Konig, R., Seifert, A. (2022). Digitally Savvy at the Home Office: Computer Skills of Older Workers During the COVID-19 Pandemic Across Europe. *Frontiers in Sociology*. https://doi.org/10.3389/fsoc.2022.858052

Kossek, E.E., & Lautsch, B.A. (2018). Work-life flexibility for whom? Occupational status and work-life inequality in upper, middle, and lower level jobs. *Academy of Management Annals*, 12(1), 5–36. http://dx.doi.org/10.5465/annals.2016.0059

Lissitsa, S., Kol, O. (2016). Generation X vs. Generation Y – A decade of online shopping, *Journal of Retailing and Consumer Services*, 31, 304-312, https://doi.org/10.1016/j.jretconser.2016.04.015

Lu, M., Wang, R., & Li, P. (2021). Comparative analysis of online fresh food shopping behavior during normal and COVID-19 crisis periods. *British Food Journal*, 124(3), 968-986. https://doi.org/10.1108/BFJ-09-2020-0849.

Media Culture Report (2023). From Analog to Streaming: The Evolution of Gen X Media Habits. https://www.mediaculture.com/insights/from-analog-to-streaming-evolution-of-gen-x-media-habits

Moawad, R. (2022). Using WhatsApp During the COVID-19 Pandemic and the Emotions and Perceptions of Users. *Psychology Research and Behavior Management*, 15, 2369 - 2381. https://doi.org/10.2147/PRBM.S367724.

Moon, J., Choe, Y., Song, H. (2021). Determinants of Consumers' Online/Offline Shopping Behaviours during the COVID-19 Pandemic. *International Journal of Environmental Research and Public Health,* 18(4), 1593. **https://doi.org/10.3390/ijerph18041593**

Nguyen, M., Gruber, J., Fuchs, J., Marler, W., Hunsaker, A., & Hargittai, E. (2020). Changes in Digital Communication During the COVID-19 Global Pandemic: Implications for Digital Inequality and Future Research. *Social Media + Society*, 6. https://doi.org/10.1177/2056305120948255.

Niesel, C. & Nili, A. (2021). Older Professionals' Adaptation to New Information Technologies: A Study in the Context of Non-Standard Employment. Proceedings of the 54th Hawaii International Conference on System Sciences, ISBN 978-0-9981331-4-0

Palfrey, J. and Gasser, U. (2010), Born Digital: Understanding the First Generation of Digital Natives, Basic Books, New York, NY.

Petrosyan, A. (2023). Coronavirus: Impact on Online Usage in the U.S. – Statistics & Facts. https://www.statista.com/topics/6241/coronavirus-impact-on-online-usage-in-the-us/#topicOverview

Prensky, M. (2001). Digital Natives, Digital Immigrants Part 1, *On the Horizon* 9(5), 1-6. https://doi.org/10.1108/10748120110424816

Romero-Rodriguez, J.M., Hinojo-Lucena, F.J., Kopecky, K. (2023). Digital fatigue in university students as a consequence of online learning during the Covid-19 pandemic. *Education XX1,* 26(2), 165-184. https://doi.org/10.5944/educxx1.34530

Roy, G. (2021). Criticality of E-Privacy and Data Leakage Amid the Pandemic. *Advances in Medical Technologies and Clinical Practice*. https://doi.org/10.4018/978-1-7998-7188-0.ch013

Samifanni, F., Gumanit, R.L.R. (2021). Survival with Technology: Elderly Teachers' Perspective Towards Emergency Online Learning During the Covid-19 Pandemic in the Philippines. *Studies in Learning and Teaching,* 2(3), 98-114. https://doi.org/10.46627/silet.v2i3.87

Sarfraz, M., Ivascu, L., Khawaja, K.F., Vevera, A.V., Dragan, F. (2021). ICT Revolution from Traditional Office to Virtual Office: A Study on Teleworking During the COVID-19 Pandemic. *Studies in Informatics and Control*, 30(4), 77-86, https://doi.org/10.24846/v30i4y202107

Sharma, M., Sunil, S., Anand, N., Amudhan, S., & Ganjekar, S. (2021). Webinar fatigue: fallout of COVID-19. *Journal of the Egyptian Public Health Association*, 96. https://doi.org/10.1186/s42506-021-00069-y

Shaw, N., Eschenbrenner, B., Baier, D. (2022). Online shopping continuance after COVID-19: A comparison of Canada, Germany and the United States. *Journal of Retailing and Consumer Services*, 69, https://doi.org/10.1016/j.jretconser.2022.103100

Silva, C., Ferrari, A., Osinski, C., & Pelacini, D. (2021). The Behavior of Internet Traffic for Internet Services during COVID-19 Pandemic Scenario. *ArXiv*.

SORS (2019). The Usage of Information and Communication Technology by Individuals/Households in the Republic of Serbia https://publikacije.stat.gov.rs/G2019/Pdf/G201916014.pdf Accessed 10.8.2024.

SORS (2023). The Usage of Information and Communication Technology by Individuals/Households in the Republic of Serbia https://publikacije.stat.gov.rs/G2023/Pdf/G202316018.pdf Accessed 10.8.2024.

Stjepić, A.M., Vukšić, M., Suša Vugec , D. (2019). Digital literacy of the generation Z students and their attitudes and beliefs towards ICT knowledge and skills, International Journal Vallis Aurea 5(1), 17-29, https://doi.org/10.2507/IJVA.5.1.2.56

Strauss W. & Howe N. (1992). Generations: The History of America's Future, 1584 to 2069, William Morrow & Company, ISBN 0-688-11912-3, USA: New YorK

Sunil, S., Sharma, M., Amudhan, S., Anand, N., & John, N. (2022). Social media fatigue: Causes and concerns. *International Journal of Social Psychiatry*, 68, 686 - 692. https://doi.org/10.1177/00207640221074800

Svatošová, V. (2022). Changes in Online Shopping Behavior in the Czech Republic During the COVID-19 Crisis. *Journal of Competitiveness*, 14(1), 155-175. https://doi.org/10.7441/joc.2022.01.09.

Van der Loop, H., Willigers, J.& Haaijer, R. (2019). Empirical Estimation of Effects of Flexible Working on Mobility and Congestion in the Netherlands 2000 to 2016. *Transportation Research Record*, 2673(6), 557-565. https://doi.org/10.1177%2F0361198119845889

Waqas, M., Rafiq, S., & Wu, J. (2023). Online shopping: a systematic review of customers' perceived benefits and challenges during COVID-19 pandemic. *Global Knowledge, Memory and Communication*. https://doi.org/10.1108/gkmc-04-2023-0129.

Weeks, K.P., Schaffert, C. (2019). Generational Differences in Definitions of Meaningful Work: A Mixed Methods Study. *Journal of Business Ethics,* 156(4), 1045-1061.

Wiścicka-Fernando, M. (2021). The use of mobile technologies in online shopping during the Covid-19 pandemic – an empirical study. *Procedia Computer Science,* 192, 3413-3422. https://doi.org/10.1016/j.procs.2021.09.114

World Economic Forum (2020). https://www.weforum.org/agenda/2020/03/infographic-apps-pandemic-technology-data-coronavirus-covid19-tech/ (9. Sept)

Young, M., Soza-Parra, J., Circella, G. (2022). The increase in online shopping during COVID-19: Who is responsible, will it last, and what does it mean for cities? *Regional Science Policy & Practice,* 14(1), 162-178. **https://doi.org/10.1111/rsp3.12514**

Yuliana, R., & Adityawati, S. (2023). Online Buying and Selling Transactions during The Covid-19 Pandemic. *International Research Journal of Business Studies*, 5(3), 241-253. https://doi.org/10.21632/irjbs.15.3.241-253

Zeynalli, L. & Zeynalli, A. (2022). The Effects of the Pandemic on the Digital Workplace. *Managing the Digital Workplace in the Post-Pandemic*

Article history:	Received: 15.09.2024.
	Revised: 16.10.2024.
	Accepted: 4.11.2024.

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

33

ECONOMIC Analysis / editor-in-chief Ivan Stošić. - Vol. [42], no. 1 (2009)- . - Belgrade : Institute of Economic Sciences, 2009- (Belgrade : Donat graf). - 29 cm

Polugodišnje. - Je nastavak: Economic Analysis and Workers' Management = ISSN 0351-286X. –
Drugo izdanje na drugom medijumu: Economic Analysis (Belgrade. Online) = ISSN 2560-3949
ISSN 1821-2573 = Economic Analysis (Belgrade)
COBISS.SR-ID 169576460