ISSN 0350-137X UDK: 338 (497,1)

ЕКОНОМИКА

2

LXXI NIŠ, 2025

МЕЂУНАРОДНИ ЧАСОПИС
ЗА ЕКОНОМСКУ ТЕОРИЈУ И ПРАКСУ И ДРУШТВЕНА ПИТАЊА

ЕКОНОМИКА

Часопис излази четири пута годишње Година LXXI, IV-VI 2025, број 2

ИЗДАВАЧ: Друштво економиста "Економика" Ниш
СУИЗДАВАЧИ: Институт за економику пољопривреде - Београд, Економски факултет у Суботици, Друштво економиста Ниша, Факултет за примењени менаџмент економију и финансије МЕФ - Београд

1. Часопис "Економика" покренут је јула 1954. године и под називом " Нишки привредни гласник" излазио је до јуна 1957. године, а као "Привредни гласник" до краја 1969. године. Назив "Наука и пракса" носио је закључно са бројем 1/1973. год. када добија назив "Економика" који и данас има.

2. Часопис су покренули Друштво економиста Ниша и Друштво инжињера и техничара Ниша (остало као издавач до краја 1964. године). Удружење књиговођа постаје издавач почев од броја 6-7/1958. године. Економски факултет у Нишу на основу своје одлуке броја 04-2021 од 26.12.1991. године постао је суиздавач "Економике". Такође и Економски факултет у ПриШтини постао је суиздавач од 1992. године. Почев од 1992. године суиздавач "Економике" је и Друштво за маркетинг региона Ниш. Као суиздавач "Економике" фигурирали су у току 1990-1996. године и Фонд за научни рад општине Ниш, Завод за просторно и урбанистичко планирање Ниш и Корпорација Винер Брокер Ниш.

3. Републички секретаријат за информације СР Србије својим Решењем бр. 651-126/73-02 од 27. новембра 1974. године усвојио је захтев "Економике" за упис у Регистар новина. Скупштина Друштва економиста Ниша на седници од 24. априла 1990. године статутарном одлуком потврдила је да "Економика" има статус правног лица. На седници Скупштине Друштва економиста Ниш од 11. новембра 1999. године донета је одлука да "Економика" отвори посебан жиро-рачун.

4. Према Мишљењу Републичког секретаријата за културу СР Србије бр. 413-516/73-02 од 10. јула 1973. године и Министарства за науку и технологију Републике Србије бр. 541-03-363/94-02 од 30. јуна 1994. године "Економика" има статус научног и ранг националног часописа "Економика" је почев од 1995. добила статус међународног економског часописа.

5. УРЕДНИЦИ: др Јован Петровић (1954-1958), Миодраг Филиповић (1958-1962), Благоје Матић (1962-1964), др Драгољуб Стојићковић (1964-1967), др Миодраг Николић (1967-1973), др Драгољуб Симоновић (1973-1984), др Миодраг Јовановић (1984-3-4/1988), др Драгољуб Симоновић (1990-2019), др Зоран Симоновић (2019-до данас).

ЧАСОПИС ЈЕ ИНДЕКСИРАН У СЛЕДЕЋИМ БАЗАМА:

ERIH Plus	RePEc	DOAJ
Index Copernicus	CEEOL	SHERPA / ROMEO
EBSCO host	EconPapers	ProQuest
J-Gate	CABI	EZB
SSRN	ECONLIT	CNKI

Лектор за енглески језик
ВЛАДИМИР ИВАНОВИЋ

Компјутерска обрада текста и графике:
МИЛАН Д. РАНЂЕЛОВИЋ

Ликовна опрема:
ПЕТАР ОГЊАНОВИЋ, ДРАГАН МОМЧИЛОВИЋ

Адреса:
"Економика" Друштво економиста
18000 Ниш, Максима Горког 5/36

Телефон Редакције: +381 (0)18 4245 763; 211 443
е-маил: zoki@medianis.net; ekonomika@sbb.rs WEB: http://www.ekonomika.org.rs
Жиро рачун: динарски 160-19452-17

Штампа:
"MEDIVEST"
18000 Ниш
Тираж: 300 примерака

INTERNATIONAL JOURNAL
FOR ECONOMIC THEORY AND PRACTICE AND SOCIAL ISSUES

ЕКОНОМИКА

The Journal is issued four times a year. Year LXXI, IV-VI 2025, Vol. 2

PUBLISHER: Society of Economists "Ekonomika", Nis
COPUBLISHERS: Institute of agricultural economics - Belgrade, Faculty of Economics - Subotica, Economic Association of Nis, Faculty of Applied Economics and Management Finance MEF - Belgrade

1. The journal EKONOMIKA was initiated in July 1954. It was published as “Nis Economic Messenger” till June, 1957 and as “The Economic Messenger” till the end of 1969. The title “Science and Practice” it had till the issue 1/1973 when it changed its name into EKONOMIKA as it entitled today.

2. The Journal was initiated by the Society of Economists of Nis and the Society of Engineers and Technicians of Nis (the latter remaind as the publisher till the end of 1964). The Society of Accountants became its publisher starting from the issue no. 6-7/1958. The Faculty of Economics, Nis, on the basis of its Resolution No. 04-2021 from December 26, 1991, became the co-publisher of EKONOMIKA. Likewise, the Faculty of Economics of Pristina became the co-publisher since in 1992. Starting from 1992, the co-publisher of EKONOMIKA has been the Society for Marketing of the Region of Nis. Other co-publishers of EKONOMIKA included, in the period 1990-1996, the Foundation for Scientific Work of the Municipality of Nis, the Institute for Spatial and Urban Planning of Nis and the Corporation Winner Broker, Nis.

3. The Republic Secretariat for Information of the Socialist Republic of Serbia, by its Resolution No. 651-126/73-02 from November, 27, 1974, approved of EKONOMIKA's requirement to be introduced into the Press Register. The Assembly of the Society of Economists of Nis, at its session on April 24, 1990, by its statutory resolution, confrmed the legal status of EKONOMIKA. At the session of the Assembly of the Society of Economists, Nis, on November 11, 1999, the resolution was adopted the EKONOMIKA was to open its own bank account.

4. According to the Opinion of the Republic Secretariat for Culture of the Socialist Republic of Serbia No. 413-516/73-02 from July 10, 1973 and the Ministry for Science and Technology of the Republic of Serbia No. 541-03-363/94-02 from June 30, 1994, EKONOMIKA has the status of a scientific and national journal. Starting from 1995, EKONOMIKA has been having the status of international economic journal.

5. EDITORS: dr Jovan Petrovic (1954-1958). Miodrag Filipovic (1958-1962), Blagoje Matic (1962-1964), dr Dragoljub Stojiljkovic (1964-1967), dr Miodrag Nikolic (1967-1973), dr Dragoljub Simonovic (1973-1984), dr Miodrag Jovanovic (1984-3-4/1988), dr Dragoljub Simonovic (1990-2019), dr Zoran Simonovic (2019-till the present day).

THE JOURNAL IS INDEXED IN THE FOLLOWING BASES:

ERIH Plus	RePEc	DOAJ
Index Copernicus	CEEOL	SHERPA / ROMEO
EBSCO host	EconPapers	ProQuest
J-Gate	CABI	EZB
SSRN	ECONLIT	CNKI

Lector
VLADIMIR IVANOVIC

Prepress:
MILAN D. RANDJELOVIC
Cover:
PETAR OGNJANOVIC, DRAGAN MOMCILOVIC

Address:
"EKONOMIKA", Society of Economists
18000 Nis, Maksima Gorkog 5/36

Phone: +381 (0)18 4245 763; 211 443
e-mail: zoki@medianis.net; ekonomika@sbb.rs WEB: http://www.ekonomika.org.rs

Bank Account: 160-19452-17

Printed by:
“MEDIVEST”
18000 Niš
Copies: 300

САДРЖАЈ / CONTENT

ОРИГИНАЛНИ НАУЧНИ РАДОВИ / ORIGINAL SCIENTIFIC ARTICLE

Jadranka Đurović Todorović, Marina Đorđević, Branimir Kalaš, Milica Ristić Cakić
TAX REVENUE INSIGHTS: ANALYSIS OF DETERMINANTS IN WESTERN BALKAN COUNTRIES 1

УВИДИ У ПОРЕСКЕ ПРИХОДЕ: АНАЛИЗА ДЕТЕРМИНАНТИ У ЗЕМЉАМА ЗАПАДНОГ БАЛКАНА 1

Slobodan Bundalevski, Martin Gjorgjiev
THE INFLUENCE OF OCCUPATIONAL SAFETY TRAINING MANAGEMENT ON THE PERCEPTION OF SAFETY AMONG CONSTRUCTION WORKERS ... 13

УТИЦАЈ МЕНАЏМЕНТА ОБУКЕ ЗАШТИТЕ НА РАДУ НА ПРЕЦЕПЦИЈУ БЕЗБЕДНОСТИ МЕЂУ ГРАЂЕВИНСКИМ РАДНИЦИМА 13

Vahid Ibrulj, Zoran Nešić, Zoran Papović
DEVELOPMENT OF AN INTELLIGENT DECISION SUPPORT SYSTEM FOR IMPROVING THE OPERATIONS OF PUBLIC UTILITY COMPANIES 23

РАЗВОЈ ИНТЕЛИГЕНТНОГ СИСТЕМА ЗА ПОДРШКУ ОДЛУЧИВАЊА У ФУНКЦИЈИ УНАПРЕЂЕЊА ПОСЛОВАЊА ЈАВНИХ КОМУНАЛНИХ ПРЕДУЗЕЋА 23

Milica Cvetković, Vladimir Đorđević, Zoran Simonović
INFLUENCE OF HUMAN CAPITAL ON COMPANY PERFORMANCE 45

УТИЦАЈ ЉУДСКОГ КАПИТАЛА НА ПЕРФОРМАНСЕ ПРЕДУЗЕЋА 45

Aluncedo Nqunqa, Steven Kayambazinthu Msosa
ASSESSING THE RELATIONSHIP BETWEEN CUSTOMER SATISFACTION AND CUSTOMER LOYALTY IN THE SOUTH AFRICAN RETAIL SECTOR 55

ПРОЦЕНА ОДНОСА ИЗМЕЂУ ЗАДОВОЉСТВА И ЛОЈАЛНОСТИ КУПАЦА У СЕКТОРУ МАЛОПРОДАЈЕ ЈУЖНЕ АФРИКЕ 55

Lidija Madžar, Drinka Peković, Ivan Đekić
ASSESSMENT OF SUSTAINABLE DEVELOPMENT IN SELECTED COUNTRIES OF SOUTHEAST EUROPE 73

ПРОЦЕНА ОДРЖИВОГ РАЗВОЈА У ОДАБРАНИМ ЗЕМЉАМА ЈУГОИСТОЧНЕ ЕВРОПЕ 73

Bojan Stoiljković, Marijana Joksimović, Suzana Balaban
ANALYSIS OF PROFITABILITY OF SERBIAN MANUFACTURING COMPANIES BEFORE AND DURING COVID-19 PANDEMIC 89

АНАЛИЗА ПРОФИТАБИЛНОСТИ ПРЕДУЗЕЋА ПРЕРАЂИВАЧКЕ ИНДУСТРИЈЕ У СРБИЈИ ПРЕ И ТОКОМ ПАНДЕМИЈЕ ЦОВИД-19 89

ЕКОНОМИКА
ISSN 0350-137X, EISSN 2334-9190, UDK 338 (497,1)
Vol. 71, april-june 2025, № 1
P. 1-12

Jadranka Đurović Todorović[1]
Marina Đorđević[2]
University of Niš, Faculty of Economics in Niš

Branimir Kalaš[3]
University of Novi Sad, Faculty of Economics in Subotica

Milica Ristić Cakić[4]
University of Niš, Faculty of Economics in Niš

ORIGINAL SCIENTIFIC ARTICLE
DOI: 10.5937/ekonomika2502001D
Received: February 17, 2025
Accepted: April 18, 2025

TAX REVENUE INSIGHTS: ANALYSIS OF DETERMINANTS IN WESTERN BALKAN COUNTRIES

Abstract

The purpose of this research is to analyze the determinants of tax revenue in Western Balkan countries during the period 2006–2023, focusing on the relationship between tax revenue and macroeconomic factors such as economic growth, inflation, government expenditure, and government debt. The study uses panel regression techniques to test hypotheses on the positive and significant impact of macroeconomic factors on tax revenue. Empirical results confirm that all examined factors significantly influence tax revenue, with economic growth and government debt having the strongest positive effects, while inflation and government expenditure also show significant impacts. The findings provide policymakers in the Western Balkans with practical insights into optimizing tax systems by prioritizing growth-oriented policies, prudent debt management, and efficient public expenditure, as well as improving tax compliance. This research is original as it fills a gap in the literature by focusing on the fiscal dynamics of Western Balkan countries, contributing to a better understanding of how macroeconomic determinants influence tax revenue and offering valuable guidance for policy design in similar transitional economies.

Key words: *tax revenue, performance, determinants, panel approach, Western Balkan*

JEL classification: *H20, C23, E62*

УВИДИ У ПОРЕСКЕ ПРИХОДЕ: АНАЛИЗА ДЕТЕРМИНАНТИ У ЗЕМЉАМА ЗАПАДНОГ БАЛКАНА

Апстракт

Сврха овог истраживања је анализа детерминанти пореских прихода у земљама Западног Балкана, у периоду од 2006. до 2023. године, са фокусом на

[1] jadranka.djurovic@eknfak.ni.ac.rs ORCID ID 0000-0002-8910-2067

[2] marina.djordjevic@eknfak.ni.ac.rs ORCID ID 0000-0002-9909-315X

[3] branimir.kalas@ef.uns.ac.rs ORCID ID 0000-0002-9141-7957

[4] milica.ristic@eknfak.ni.ac.rs ORCID ID 0000-0003-3665-2361

однос између пореских прихода и макроекономских фактора као што су економски раст, инфлација, државни расходи и државни дуг. Истраживање користи технике панел регресије за тестирање хипотеза о позитивном и значајном утицају макроекономских фактора на пореске приходе. Емпиријски резултати потврђују да сви испитивани фактори значајно утичу на пореске приходе, при чему економски раст и државни дуг имају најснажнији позитиван ефекат, док инфлација и државни расходи такође показују значајан утицај. Налази пружају практичне увиде креаторима политика у земљама Западног Балкана о оптимизацији пореских система кроз приоритизацију политика усмерених на раст, пажљиво управљање дугом и ефикасну јавну потрошњу, као и унапређење пореске дисциплине. Овај рад је оригиналан јер попуњава празнину у литератури фокусирајући се на фискалне динамике земаља Западног Балкана, доприноси бољем разумевању утицаја макроекономских детерминанти на пореске приходе и пружа вредне смернице за креирање политика у сличним транзиционим економијама.

Кључне речи: *порески приходи, перформанце, детерминанте, панел приступ, Западни Балкан*

Introduction

Tax revenue is a cornerstone of public finance, enabling governments to deliver essential services, develop infrastructure, and maintain economic stability. Central and local governments around the world rely heavily on taxation for governance (Abubakari et al., 2024), Taxes have a vital role in fostering economic growth and development, serving as a key area of focus in economic policymaking across numerous countries (Akitoby et al., 2021). The effective mobilization of these revenues is essential for financing public services and responding to various economic, financial, and health challenges that nations may face (Gnangnon, 2022). Additionally, it is essential for any state to maintain consistent and strong economic growth over the long term (Adedeji et al. 2023), with government revenues serving as a key financial support for this growth (Nyarkpoh et al. 2023). Also, Adeleke (2022) highlights the importance of geographical location and the socio-economic well-being of citizens in boosting government revenue within this context. The relationship between tax revenues and economic growth is complex and government spending aimed at boosting growth does not always lead to the anticipated rise in tax revenues, and delays in revenue responsiveness further contribute to the challenge. For instance, Gnangnon (2024) discusses the instability of tax revenues and their potentially harmful effects on economic growth. Additionally, various tax types exhibit differing adjustment rates, making timing critical, especially during economic recoveries, and prolonging the process of achieving a stable balance (Sinaga et al., 2023). This complexity underscores the necessity of analyzing how different taxes respond to economic fluctuations.

Understanding the factors that influence tax revenue is critical, particularly as nations aim to optimize their fiscal policies. In the Western Balkans, where economies are transitional and face structural reforms and fiscal constraints, examining tax revenue dynamics becomes

even more vital. These countries encounter challenges such as high public debt, extensive informal economies, and fluctuating economic growth, all of which affect their ability to sustain tax revenue. Investigating the drivers of tax revenue in this context can provide key insights for policymakers and support the development of more effective and equitable fiscal strategies.

The Western Balkans, comprising Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, and Serbia, has experienced significant economic and political changes over the last two decades. Despite strides in market reforms and EU integration, these nations continue to struggle with issues like weak tax compliance, heavy reliance on consumption taxes, and uneven public spending efficiency. Given these challenges, understanding the influence of macroeconomic factors such as GDP growth, inflation, government expenditure, and government debt on tax revenue is essential for promoting economic stability and enhancing fiscal outcomes. These variables are particularly critical in this region, where governments must balance growth-oriented initiatives with the need for fiscal discipline.

Research on tax revenue determinants in the Western Balkans remains sparse, creating a knowledge gap about the unique fiscal dynamics of these economies. Most studies focus on broader European trends, neglecting the region's specific challenges. This study addresses this gap by analyzing how key macroeconomic variables affect tax revenue in the Western Balkans. Using panel data from 2006 to 2023, sourced from the World Bank and IMF, the research employs rigorous econometric methods to examine the roles of GDP growth, inflation, government expenditure, and government debt.

The contribution and novelty of this study lie in its focused examination of tax revenue determinants using a model that incorporates GDP growth, inflation, government expenditures, and public debt, applied specifically to the unique context of Western Balkan countries. This region, often overlooked in fiscal research, presents distinct economic and institutional challenges that make such an analysis particularly valuable. By utilizing panel data, the study offers new insights into how these macroeconomic variables shape tax revenue in transitional economies, filling a significant gap in the literature. Furthermore, the findings provide a practical framework for enhancing tax systems in similar developing regions, offering both academic and policy-oriented contributions.

This paper is organized into the following sections: Section 2 provides a literature review, highlighting key findings on tax revenue determinants in similar contexts. Section 3 explains the research design and methodology, including data sources, variable definitions, and econometric approaches. Section 4 presents the results and discusses their implications for fiscal policy in the Western Balkans. Finally, Section 5 concludes by summarizing the main findings, addressing study limitations, and suggesting directions for future research.

Literature review

Fiscal stability is crucial for maintaining a secure macroeconomic environment, and an economy is considered sustainable when it has a consistent fiscal policy (Mobosi and Okonta, 2024). The relationship between macroeconomic indicators and tax revenue has been extensively studied in economic literature, highlighting key factors such as GDP, inflation, government expenditures, and public debt. These variables are commonly examined due to their direct influence on the tax base, revenue collection, and fiscal policy. GDP serves as

a measure of economic activity, directly shaping the capacity for generating tax revenue, while inflation impacts the real value of collected taxes and taxpayer behavior. Government expenditures are often linked to the efficiency of public administration and enforcement of tax policies, whereas public debt reflects fiscal sustainability and influences policy priorities.

This literature review explores the role of these macroeconomic factors in shaping tax revenues worldwide/across the world. Analyzing recent studies no older than five years, empirical findings can be chronologically observed and examined year by year. For instance, Kalaš et al. (2020) examined the factors that determine tax revenue within the European Union over the period from 2006 to 2018. They discovered that variables such as GDP, government spending, total investment, and population size had a significant positive impact on tax revenue. On the other side, they found that inflation, unemployment, and gross national savings negatively influence tax revenue. Moreover, Nalyanya et al. (2020) investigated macroeconomic determinants on tax revenue in Kenya for the period 2008-2018 and identified positive influence of GDP per capita and negative impact of inflation rate on tax revenue. Contrary, Tujo (2021) highlighted that inflation show no significant relationship with tax revenue in Ethiopia from 2000 to 2019.

Moreover, the study of Saptono and Mahmud (2021) identified positive and significant impacts of per capita income, manufacturing, and trade openness on both the actual tax-to-GDP ratio and tax effort in Southeast Asian countries from 2008-2019. Conversely, they indicated inflation is deemed an unnecessary factor due to its negligible influence on tax performance indicator. Minh Ha et al. (2022) identified that the openness of the economy, foreign direct investment, the ratio of foreign debt to GDP, and the share of value added in industry to GDP have positive impacts on tax revenue. The authors analyzed Southeast Asian countries from 2000 to 2016 and concluded that implementing policies to promote trade openness and attract foreign direct investment can significantly enhance tax revenue performance. The study of Neog and Gaur (2020) aims to identify the key macroeconomic factors influencing tax revenue performance in India from 1981 to 2016. This research introduces a dynamic simultaneous equation model and empirical findings indicate that growth, foreign aid, and trade have a positive impact on tax revenues, while inflation, development expenditure, and the contribution of agriculture had negative impact on tax revenue performance. A study analyzing the period from 1985 to 2019 using the GMM method highlights the negative impact of low inflation and external debt on domestic tax revenues, while showing that external debt positively affects trade taxes. The findings suggest that balanced inflation and productive debt management can stimulate economic activity and enhance tax revenue mobilization, particularly during devaluation periods (Salhi and El Aboudi, 2021).

The study of Chetttri et al. (2023) conducted a research on the factors influencing tax revenues across South Asian nations for the period from 2008 to 2017. Their research reveals that elements such as trade openness, the development of the banking sector, foreign direct investment, life expectancy, and mortality rates have a significant place in determining tax revenues in these countries. In a related study, Mirović et al. (2023) found that in the Baltic states, GDP per capita, the contribution of industry to value added, trade, and government expenditure are significant drivers of tax revenue from 1995 to 2020. Nugraha and Wijaya (2023) identified positive impact of external debt on tax revenue on the sample of Latin America and Caribbean regions for the period 2002-2019. Employing an ECM model, Anastasiou et al. (2024) discovered that factors such as GDP per capita, public debt, levels of corruption, the government effectiveness index, tax rates, and the efficiency of tax

administration have a significant impact on tax revenue mobilization across 26 European nations from 2015 to 2018. Meanwhile, using a PMG model, Đurović Todorović et al. (2024) established that gross domestic product, population size, inflation, unemployment rates, government revenues, and European Union enlargement serve as significant predictors of tax revenues in the Visegrad group countries from 1994 to 2024.

Research Methodology and Hypothesis Formulation

This study examines the determinants of tax revenue in the Western Balkan countries, focusing on the influence of GDP growth, inflation, government expenditure, and government debt. The research utilizes annual panel data covering the period from 2006 to 2023, sourced from the World Bank and the International Monetary Fund (IMF). The sample includes five Western Balkan countries: Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, and Serbia.

Table 1: Variable description

Variable	Symbol	Measure	Source
Tax revenue	TXR	% GDP	World Bank
Gross domestic product	GDPgrowth	annual rate	IMF
Inflation	INF	annual rate	IMF
Government expenditure	GE	% GDP	IMF
Government debt	GD	% GDP	IMF

Source: Authors calculation

The dependent variable is tax revenue, measured as a percentage of GDP, while the independent variables include GDP growth (annual %), inflation (consumer price index, %), government expenditure (% of GDP), and government debt (% of GDP). The methodological approach involves panel regression techniques, specifically employing Pooled Ordinary Least Squares (POLS), Fixed Effects (FE), and Random Effects (RE) models to account for individual country-specific effects and temporal variations.

We established a primary hypothesis and four auxiliary hypotheses by drawing on existing empirical research. (Đurović Todorović et al. 2024; Mirović et al. 2023; Kalaš et al. 2020):

H_1: Macroeconomic determinants such as economic growth, inflation, government expenditure and government debt significantly impact on tax revenue in Western Balkan countries.

$H_{1.1}$: GDP growth positively affects tax revenue in Western Balkan countries.

$H_{1.2}$: Inflation positively affects tax revenue in Western Balkan countries.

$H_{1.3}$: Government expenditure positively affects tax revenue in Western Balkan countries.

$H_{1.4}$: Government debt positively affects on tax revenue in Western Balkan countries

Research results and Discussion

The descriptive analysis provides an overview of the key variables influencing tax revenue in Western Balkan countries, offering a foundation for deeper econometric exploration. This section highlights the trends, variability, and ranges of GDP growth, inflation, government expenditure, government debt, and tax revenue over the period 2006–2023. The data reveal notable differences across countries, reflecting unique economic structures and fiscal policies within the region

Table 2: Descriptive analysis

Country	TXR	GDPgrowth	INF	GE	GD
Albania					
Mean	18.44	3.48	2.63	30.20	65.66
Std. dev.	1.43	2.69	1.37	1.43	7.40
Min.	15	-3.3	1.29	28.23	53.55
Max.	20.11	8.91	6.73	32.68	75.77
Bosnia and Herzegovina					
Mean	20.02	2.72	2.36	44.11	35.42
Std. dev.	0.87	2.69	3.89	3.51	7.70
Min.	18.8	-3.01	-1.58	38.87	18.71
Max.	21.7	7.39	14.01	49.42	45.86
Montenegro					
Mean	20.62	2.99	3.20	46.37	61.20
Std. dev.	2.49	6.10	3.59	3.13	19.33
Min.	17.2	-15.31	-0.71	42.52	31.76
Max.	25	13.04	13.05	54.35	107.35
North Macedonia					
Mean	17.07	2.62	3.11	32.85	36.79
Std. dev.	0.88	2.55	3.96	1.86	10.50
Min.	15.7	-4.69	-0.74	30.27	20.64
Max.	19.1	6.47	14.21	36.40	53.41
Serbia					
Mean	22.06	2.49	6.17	43.30	50.64
S.Dev.	2.07	2.83	4.21	2.08	12.03
Min.	18.6	-2.73	1.12	40.08	30.56
Max.	26	7.55	12.41	48.21	69.85
WB countries					
Mean	19.64	2.86	3.58	41.06	50.38
Std. dev.	2.36	3.17	3.75	7.21	20.98
Min.	14.2	-15.31	-1.6	28.23	12.43
Max.	26	13.04	17.69	60.27	107.35

Source: Authors calculation

Table 2 provides a descriptive analysis of variables —tax revenue (TXR), gross domestic product (GDPgrowth), inflation (INF), government expenditure (GE), and government debt (GD)—for Western Balkan countries between 2006 and 2023. Serbia recorded the highest average tax revenue (22.06%), while North Macedonia had the lowest (17.07%), with Montenegro showing the widest range (17.2% to 25%). This region exhibited an average annual GDP growth rate of 2.86% during the study period, with notable variation among countries. Albania demonstrated the strongest economic performance at 3.48%, while Serbia recorded the most modest growth at 2.49Inflation rates were generally low, with Serbia averaging the highest (6.17%) and Bosnia and Herzegovina experiencing occasional deflation (-1.58%). Government expenditure as a percentage of GDP was highest in Montenegro (46.37%) and lowest in Albania (30.20%), while Montenegro also had the highest average government debt (61.20%) and the largest recorded maximum (107.35%). In contrast, Bosnia and Herzegovina maintained the lowest average debt levels (35.42%) and a minimum of 18.71%. Regional averages indicate moderate tax revenues (19.64%), GDP per capita (21,229 USD), and inflation (3.58%), with balanced government expenditure (41.06%) and debt (50.38%), though significant disparities exist between countries. Montenegro and Serbia stand out for their higher fiscal pressures, with Montenegro's high debt and Serbia's inflation reflecting occasional economic stress. Meanwhile, Albania and North Macedonia show relatively stable and moderate indicators, highlighting diverse fiscal strategies across the region. Overall, the data reflects moderate economic growth, price stability, and manageable fiscal policies, but with significant variability in debt, expenditure, and inflation among countries.

Table 3: Estimation of unit root tests in panel data

Variable	**LLC**	
	Level	**First diff.**
TXR	-1.784 (0.037)	-3.919 (0.000)
GDP	-4.531 (0.000)	-7.420 (0.000)
INF	1.542 (0.938)	-2.611 (0.004)
GE	-2.487 (0.006)	-6.386 (0.000)
GD	-2.552 (0.005)	-2.532 (0.005)

Source: Authors calculation

Table 3 shows results from the Levin-Lin-Chu (LLC) test for stationarity across five variables: TXR, GDP, INF, GE, and GD, with values provided at the level (Level) and after first differencing (First diff.). TXR is non-stationary at the level (LLC = -1.784, p = 0.037) but becomes stationary after first differencing (LLC = -3.919, p = 0.000). GDP is stationary at the level (LLC = -4.531, p = 0.000) and even more so after first differencing (LLC = -7.420, p = 0.000). INF is non-stationary at the level (LLC = 1.542, p = 0.938) but achieves stationarity after differencing (LLC = -2.611, p = 0.004). GE is stationary at the level (LLC = -2.487, p

= 0.006) and further confirmed after differencing (LLC = -6.386, p = 0.000). Similarly, GD is stationary at the level (LLC = -2.552, p = 0.005) and remains so after differencing (LLC = -2.532, p = 0.005). Low p-values (<0.05) indicate rejection of the null hypothesis of a unit root, confirming stationarity where applicable.

Table 4: Multicollinearity analysis

Variable	**VIF**	**1/VIF**
GDPgrowth	1.11	0.902
GE	1.07	0.938
INF	1.06	0.941
DEBT	1.05	0.953
Mean VIF	1.07	

Source: Authors calculation

Table 4 presents the results of a Variance Inflation Factor (VIF) analysis, which is used to detect multicollinearity among independent variables in a regression model. Each variable (GDPgrowth, GE, INF, and DEBT) has a corresponding VIF value and its reciprocal (1/VIF). A VIF value close to 1 indicates low multicollinearity, meaning the variables are not highly correlated. The Mean VIF of 1.07 suggests that there is no problem of multicollinearity among explanatory variables.

Table 5: Panel data estimation

Variable	**POLS**	**FE**	**RE**
GDPgrowth	0.118 (0.000)	0.197 (0.000)	0.091 (0.074)
INF	0.091 (0.068)	0.096 (0.065)	0.058 (0.206)
GE	0.022 (0.000)	0.117 (0.003)	0.052 (0.460)
DEBT	0.005 (0.000)	0.056 (0.000)	0.081 (0.000)
R-squared	0.296	0.474	0.327
F-value	0.000	0.000	0.000
Hausman test		12.61 (0.0134)	

Source: Authors calculation

Table 5 manifests the outcomes of applied regression models examining the relationship between various independent variables—GDP growth, inflation, government expenditure (GE), and government debt (DEBT)—and their effects on tax revenue. The coefficients indicate the expected change in tax revenue for a one-unit change in each independent variable, with the values in parentheses representing p-values that indicate statistical significance. For GDP growth, the coefficients are 0.118, 0.197, and 0.091 across

three models, with p-values of 0.000, indicating a highly significant positive effect on tax revenue at the 1% level. It denotes that auxiliary hypothesis $H_{1.1}$ can be confirmed. Inflation shows coefficients of 0.091, 0.096, and 0.058, with p-values of 0.068, 0.065, and 0.206, suggesting that the first two models have a marginal significance at the 10% level, while the last model does significantly affect tax revenue at 10%. Therefore, we can confirm auxiliary hypothesis $H_{1.2}$. Government expenditure has coefficients of 0.022, 0.117, and 0.052, with p-values of 0.000, 0.003, and 0.460, indicating that the first two models show a significant positive relationship at the 1% and 5% levels, respectively, while in the third model the effect is not statistically significant. Based on mentioned, auxiliary hypothesis $H_{1.3}$ can be confirmed. Government debt has coefficients of 0.005, 0.056, and 0.081, all with p-values of 0.000, indicating a significant positive effect on tax revenue across all models at the 1% level. Thus, we can infer that auxiliary hypothesis $H_{1.4}$ can be accepted. The R-squared values (0.296, 0.474, and 0.327) suggest that the models explain a moderate amount of the variance in tax revenue, with the second model being the most explanatory. The F-value of 0.000 across all models indicates that the overall regression is statistically significant. The Hausman test result of 12.61 with a p-value of 0.0134 suggests that there are significant differences between the fixed and random effects models, indicating that a fixed effects model may be more appropriate for this analysis. In summary, GDP growth, government expenditure, and government debt significantly and positively influence tax revenue, while inflation shows mixed significance across the models. It means that general hypothesis H_1 can be confirmed.

Conclusion

Effective tax revenue mobilization is a cornerstone of sound fiscal policy and a key driver of economic stability and growth. Understanding the macroeconomic factors that shape tax revenues is crucial for designing policies that ensure fiscal sustainability and economic resilience. This study confirms that macroeconomic determinants, particularly GDP growth, inflation, government expenditure, and government debt, significantly affect tax revenues in Western Balkan countries. Among these factors, GDP growth stands out as having the most substantial positive effect, highlighting the critical role of economic expansion in broadening the taxable base and enhancing fiscal capacity. Economic growth not only increases individual and corporate incomes but also boosts consumption and investment, all of which contribute to higher tax revenues. Inflation also exhibits a positive relationship with tax revenues, as rising nominal prices lead to greater revenue collection through value-added and income taxes. However, the extent of this effect depends heavily on the efficiency and responsiveness of tax collection systems, as poorly managed systems may fail to capture the full benefits of inflation. Government expenditure positively influences tax revenue, reflecting increased fiscal activity and the mobilization of resources for public services. This finding suggests that investments in key areas such as education, healthcare, and infrastructure foster economic growth and enhance the government's ability to collect taxes. Similarly, government debt shows a positive association with tax revenues, potentially because fiscal pressures from debt repayment obligations motivate stricter enforcement of tax policies and efforts to expand the tax base.

While this relationship is encouraging, it also underscores the importance of sustainable debt management to ensure long-term fiscal stability. The results of this study

carry important policy implication for the Western Balkan region. Policymakers should focus on implementing growth-oriented strategies that drive GDP expansion, such as increasing investment in infrastructure, fostering innovation, and enhancing workforce skills. These measures can indirectly strengthen the fiscal base by creating a more dynamic and productive economy. Additionally, reforms aimed at improving the efficiency of tax administration systems are essential. Modernizing tax collection methods, reducing evasion, and streamlining compliance procedures can ensure that revenue gains from inflation and debt-financed activities are maximized and not undermined by inefficiencies.

Governments in the region should also adopt prudent fiscal management practices to balance the benefits of borrowing with sustainable revenue generation. This includes setting realistic debt levels and focusing on investments that yield long-term economic benefits, which, in turn, boost tax revenues. Moreover, policymakers must prioritize the development of transparent and effective institutions to ensure that increased government spending translates into measurable improvements in public services and economic outcomes. To address the potential risks associated with inflation, governments should aim to maintain moderate and stable inflation rates. Excessively high inflation could erode purchasing power and lead to public discontent, while very low inflation may limit the growth of nominal tax revenues. Striking the right balance is essential for maximizing fiscal benefits without destabilizing the economy.

Finally, this study emphasizes the need for a holistic approach to fiscal policy in the Western Balkans, where growth-oriented strategies, efficient tax administration, and prudent debt management work in tandem to enhance tax revenue collection. Such policies will not only improve fiscal capacity but also contribute to sustainable economic development across the region. Despite these insights, several limitations of this study warrant caution. First, the analysis is based on aggregate panel data, which might mask country-specific nuances or variations in tax policy. Second, the study assumes linear relationships between macroeconomic variables and tax revenue, which may oversimplify complex dynamics such as non-linear or lagged effects. Third, unobserved variables like the informal economy or tax evasion, which are prevalent in the Western Balkans, were not explicitly analyzed. These factors may significantly influence the effectiveness of macroeconomic determinants on tax revenue. Future research should address these limitations by incorporating country-specific case studies or employing non-linear modeling techniques to capture more complex relationships. Expanding the scope to include additional factors, such as institutional quality, corruption, or international trade dynamics, could offer a more comprehensive understanding of fiscal performance. Finally, a comparative analysis with other regions in similar stages of economic development could highlight unique challenges and opportunities in the Western Balkans, contributing to more tailored and effective policy activities.

References

Abubakari, M., Boakye, Y.K., Blay, A.A., Attuquaye, E.C., & Agyemang, F.Y. (2024). Technology for revenue mobilization: the case of the Ghana Revenue Authority. *SN Social Sciences* 4, 1-5. https://doi.org/10.1007/s43545-024-00993-8

Adedeji, A.A., Oyinlola, M.A., & Adeniyi, O. (2023). Public debt, tax and economic

growth in Sub-Saharan African countries. *Journal of Social and Economic Development,* 1-67. https://doi.org/10.1007/s40847-023-00295-4

Adeleke, R. (2022). Spatial variability of the predictors of government tax revenue in Nigeria. *SN Business & Economics,* 2(2), https://doi.org/10.1007/s43546-021-00173-3

Akitoby, B., Baum, A., Hackney, C., Harrison, O., Primus, K., & Salins, V. (2020). Tax revenues mobilization episodes in developing countries. *Policy Design and Practice,* 3(1), 1-29. https://doi.org/10.1080/25741292.2019.1685729

Anastasiou, A., Kalligosfyris, C., & Kalamara, E. (2024). Determinants of Tax Revenues Performance in European Countries: A Panel Data Investigation. *International Journal of Public Administration,* 47(4), 227-242. https://doi.org/10.1080/01900692.2022.2111578

Chettri, K.K., Bhattarai, J.K., & Gautam, R. (2023). Determinants of Tax Revenues in South Asian Countries. *Global Business Review*, Online first. 1-15. https://doi.org/10.1177/09721509231177784

Đurović Todorović, J., Đorđević, M., Mirović, V., Kalaš, B., & Pavlović, N. (2024). Modeling Tax Revenues Determinants: The Case of Visegrad Group Countries. *Economies,* 12(6), 1-15. https://doi.org/10.3390/economies12060131

Gnangnon, S.K. (2022). Tax revenues instability and tax revenues in developed and developing countries. *Applied Economic Analysis,* 30, 18-37. https://doi.org/10.1108/AEA-09-2020-0133

Gnangnon, S.K. (2024). Poverty Volatility and Tax Revenue Instability in Developing Countries. *Fudan Journal of the Humanities and Social Sciences,* 17, 279-311. https://doi.org/10.1007/s40647-023-00377-x

Kalaš, B., Đurović Todorović, J., & Đorđević, M. (2020). Panel estimating effects of macroeconomic determinants on tax revenue level in European Union. *Industry,* 48(3), 41-57. https://doi.org/10.5937/industrija48-27820

Minh Ha, N., Tan Minh, P., & Binh, Q. M. Q. (2022). The determinants of tax revenue: A study of Southeast Asia. *Cogent Economics & Finance*, 10(1), 2026660. https://www.tandfonline.com/doi/pdf/10.1080/23322039.2022.2026660

Mirović, V., Kalaš, B., Milenković, N., & Andrašić, J. (2023). Different modelling approaches of tax revenues performance: The case of Baltic countries. *E&M Economics and Management*, 26(3), 20–32. https://doi.org/10.15240/tul/001/2023-3-002

Mobosi, I.A., & Okonta, P.O. (2024). Revenue structure and budgetary choice in Nigeria: implication for fiscal sustainability of the states government. *International Tax and Public Finance,* 1-23. https://doi.org/10.1007/s10797-024-09851-y

Nalyanya, K., Byaruhanga, J., Rutto, R., & Simiyu, E. (2020). Effects of inflation on tax revenue performance in Kenya. *International Journal of Economics, Business and Management Research,* 4(5), 111-122.

Neog, Y., & Gaur, A.K. (2020). Macro-economic determinants of tax revenue in India: an application of dynamic simultaneous equation model. *International Journal of Economic Policy in Emerging Economies,* 13(1), 13-35. https://doi.org/10.1504/IJEPEE.2020.106679

Nugraha, H.T., & Wijaya, S. (2023). The Determinants of Tax Revenue in the Context of International Transactions in the Latin America and Caribbean (LAC) Regions 2002-2019. *Ilomata International Journal of Tax and Accounting,* 4(3), 613-627. https://doi.org/10.5278/ijtc.v4i3.843

Nyarkpoh, M.K., Turkson, D., & Buaka, E.S. (2023). Tax compliance in Ghana: does corruption and trust in the government matter? *SN Social Science,* 3, 1-19. https://doi.org/10.1007/s43545-023-00746-z

Salhi, S.E., El & Aboudi, S. (2021). Inflation, External Debt, and Fiscal Mobilization in Morocco: The Transmission Channels of Devaluation and the Inflationary Part. *Asian Economic and Financial Review,* 11(7), 545-562. https://doi.org/10.18488/journal.aefr.2021.117.545.562

Saptono, P.B., & Mahmud, G. (2021). Macroeconomic determinants of tax revenue and tax effort in Southeast Asian countries. *Journal of Developing Economies,* 6(2), 253-274.

Sinaga, S.T., Ekananda, M., Gitaharie, B.Y., & Setyowati, M. (2023). Tax Buoyancy in Indonesia: An Evaluation of Tax Structure and Policy Reforms. *Economies*, 11(12), 1-18. https://doi.org/10.3390/economies11120294

Stojanović, M., & Đorđević, M. (2016). The role of environmental taxes in Serbian tax system. *Ekonomika*, *62*(4), 75-84 https://doi.org/10.5937/ekonomika1604075S

Tujo, D.B. (2021). Tax revenue Determinants and Tax Efforts in Ethiopia from 2000 – 2019 – ARDL Approach. *International Journal of Public Administration and Management Research,* 7(2), 1-18. https://www.journals.rcmss.com/index.php/ijpamr/article/view568

ЕКОНОМИКА
ISSN 0350-137X, EISSN 2334-9190, UDK 338 (497,1)
Vol. 71, april-june 2025, № 1
P. 13-22

Slobodan Bundalevski[1]
Faculty of Technical Science and Informatics, International Slavic University, Sveti Nikole – Bitola, North Macedonia

ORIGINAL SCIENTIFIC ARTICLE
DOI: 10.5937/ekonomika2502013B
Received: March 17, 2025
Accepted: April 18, 2025

Martin Gjorgjiev[2]
Faculty of Economics and Organization of Entrepreneurship, International Slavic University, Sveti Nikole – Bitola, North Macedonia

THE INFLUENCE OF OCCUPATIONAL SAFETY TRAINING MANAGEMENT ON THE PERCEPTION OF SAFETY AMONG CONSTRUCTION WORKERS

Abstract

Construction is one of the riskiest professions and unfortunately, every year a large number of deaths and injuries are reported during the performance of work tasks. Legal regulations mandate that all workers undergo mandatory occupational safety and health training, but there is still a certain number of workers who are untrained and without adequate knowledge and skills to perform the given work. Working at height in the construction industry is one of the most dangerous professions and must not be performed without proper equipment or without the use of protective devices. Occupational safety and health training reduces accidents and fatalities and should be designed and implemented in a way that enables employees to identify and effectively eliminate hazards. In this paper, research was carried out, in which 7 questions were asked to two groups of workers about: safety knowledge, safety behavior, self-confidence and safety awareness, commitment, risk acceptance, work practices, and risk and accident reduction and it was concluded that workers with training showed a higher perception of safety and health at work compared to those workers without training.

Key words: Construction, safety at work, perception of safety

JEL classification: *J28, L74, M53*

УТИЦАЈ МЕНАЏМЕНТА ОБУКЕ ЗАШТИТЕ НА РАДУ НА ПРЕЦЕПЦИЈУ БЕЗБЕДНОСТИ МЕЂУ ГРАЂЕВИНСКИМ РАДНИЦИМА

Апстракт

Грађевинарство је једна од најризичнијих професија и, нажалост, сваке године се пријави велики број погинулих и повређених радника током обављања радних задатака. Законска регулатива налаже да сви радници

[1] bobobundalevski@yahoo.com, ORCID ID 0009-0005-8084-5760

[2] martinstip@hotmail.com ORCID ID 0009-0005-2604-7661

прођу обавезну обуку из области безбедности и здравља на раду, али и даље постоји одређени број радника који су необучени и немају одговарајућа знања и вештине за обављање датог посла. Рад на висини у грађевинарству је једна од најопаснијих професија и не сме се обављати без одговарајуће опреме или без употребе заштитних средстава. Обука о безбедности и здрављу на раду смањује несреће и смртне случајеве и треба да буде осмишљена и спроведена на начин који омогућава запосленима да идентификују и ефикасно елиминишу опасности. У овом раду спроведено је истраживање у коме је постављено 7 питања двема групама радника о: знању о безбедности, безбедном понашању, самопоуздању и свести о безбедности, посвећености, прихватању ризика, радној пракси и смањењу ризика и незгода и закључено је да радници са обуком показују већу перцепцију безбедности и здравља на раду у поређењу са радницима без обуке.

Кључне речи: *Изградња, заштита на раду, перцепција безбедности*

Introduction

Considering that work is a significant part of people's lives and that people spend a large part of their time at work, occupational health and safety in any industry is of paramount importance (Gjorgjev & Byanov, 2022; Christian et al., 2009). Like some other professions, construction is a very risky profession and unfortunately, a large number of deaths and injuries are reported each year while performing work tasks (Dodoo & Al-Samarraie, 2019).

Although legal regulations require all workers to undergo mandatory training on occupational safety, there are still a certain number of workers who are untrained and lack the appropriate knowledge and skills to perform the given job (Taylor, 2015). For these reasons, in some industries and branches of industry there are still a significantly high number of accidents and deaths to this day (Ricci et al., 2016).

Working at height in the construction industry is one of the most dangerous professions, and one of the main hazards is falling. Current knowledge shows that falls from height are a problem that is encountered worldwide, with the construction industry being the one in which this risk is most often present (Guo et al., 2016; Evanoff et al., 2016). However, workers in other industries, such as the electrical industry, who are entrusted with installing, testing, repairing, monitoring and maintaining electrical equipment, are also at risk of falling from height. In addition, utility pole workers and communication tower technicians work at height, performing various tasks. Workers involved in commercial buildings, such as window cleaners, also have to work at significant heights (Dodoo & Al-Samarraie, 2019). Also, mountaineering instructors work at considerable heights and are exposed to the risk of falling, as are workers involved in forestry (Barling et al., 2003).

In addition to the loss of life and permanent disability, falls from height also affect the economic plan of countries and companies, all of which contributes to the prevention of falls becoming a top priority for company managements around the world (Borger et

al., 2011). Hence, we can say that there are many professions that require knowledge of safe working at height. Some of the construction site tasks associated with a high risk of causing injuries are (Sokas et al., 2009):

- erecting steel frames on large buildings
- erecting and dismantling scaffolding
- working on ladders that are not properly secured
- roofing
- dismantling machinery on the roof of a building
- welding carried out at height
- fixing pipes and painting at height.

Previous research suggests that occupational safety and health training reduces accidents and fatalities due to falls from height (Amde et al., 2019; Floyde et al., 2013; Nkomo et al., 2018; Vignoli et al., 2015; Taylor, 2015). During training, workers acquire knowledge such as (Leiter et al., 2009):

- recognition of dangerous situations and tasks where there is a risk of falling from a height
- correct selection of protective equipment for working at height
- method of checking the correctness of the equipment for working at height
- correct selection of the rope attachment points
- correct use of protective equipment
- understanding the limitations of protective equipment
- recognition of other hazards that may have an impact, such as slippery floors, toxic and suffocating gases, electrical hazards, etc.
- determination and reduction of the free fall distance
- interpretation of the evacuation plan.

Research also suggests that training should be repeated periodically.

Safety when working at height

Any work in which the performer could fall from one level to another and be injured is classified as work at height, which includes work (Ai Lin et al., 2005):

- above ground or floor level
- at an edge where a worker could fall through an opening or fragile surface
- above ground or floor level
- at ground level where a worker could fall through a hole or opening.

Working at height is very common in the construction industry and is classified as a very high-risk job. The largest number of fatal injuries at construction sites occur precisely due to falls from height and it is responsible for 28% of fatal and 7% of non-fatal injuries to workers worldwide (Edvards & Holt, 2008).

Work at height must not be performed without appropriate equipment or without the use of protective devices such as: safety baskets, platforms, safety nets, etc. In the event that the use of such equipment or devices is not possible due to the nature of the work, appropriate safety should be ensured in another way and by other means. The most

important factors for the successful and safe performance of work at height are compliance with the basic rules for safety at work and possession of the necessary equipment, use of personal protective equipment, training of workers and compliance with the prescribed measures during design, supervision and execution of the work. In this regard, the obligations and responsibilities fall on both the employer and the worker (Guo et al., 2016). The division of protection systems, according to the technique of working with equipment is: access restriction, work positioning, rope access and fall arrest.

Health and safety training is one way to enable employees to recognize and eliminate hazards in order to control risks in the workplace (Gjorgjev, 2023). To achieve this goal, training programs should be designed and implemented in such a way that they enable employees to identify hazards and effectively eliminate them through the successful involvement of employers, government and unions, if necessary. Health and safety training programs, which are designed according to legislation, help employees take action and reduce the risks that come with work (Mustard, 2019). Hence, occupational safety and health training provides an essential basis for educating employees about the risks in their workplaces.

Given the importance of occupational safety and health training, the most important question is what medium of instruction should be used to train employees. Some research has shown that the training program should be designed taking into account the level of education of the employees and the teaching should be at that level in order to be effective (Ricci et al., 2016). Research also shows that training of workers by colleagues achieves the best effectiveness. This type of training encourages and supports collective learning through problem solving, discussion and can sometimes give workers the knowledge and confidence to negotiate with employers to implement a workplace safety system (Slatin, 1995).

Statement of the problem, objective and task of the study

The main problem addressed by this research is whether occupational safety training in construction is effective in improving various aspects of safety when working at height and does it determine the impact of barriers and facilitating factors for the implementation of acquired occupational safety knowledge.

The aim of the research is to gain insights into the effectiveness of occupational safety training in construction, i.e., its impact on improving various aspects of safety when working at height, as well as the perception of obstacles and factors that hinder or facilitate the implementation of acquired occupational safety knowledge. In this regard, the differences between construction workers who have undergone training and those who have not undergone occupational safety training have been investigated in terms of safety knowledge, safety behavior, self-confidence and awareness, commitment to OSH, risk acceptance, work practices and the reduction of risks and accidents. The research also investigates the effectiveness of training in reducing or increasing the impact of hindering factors and facilitating factors for the application of the knowledge acquired from it.

Results and analysis

In order to observe the impact of construction workers' training on their perception of safety, research was conducted using survey questionnaires on two groups of workers of 30 respondents each, one with and the other without training. Seven questions were asked about: safety knowledge, safety behavior, self-confidence and safety awareness, commitment, risk acceptance, work practices, and risk and accident reduction. The collected data were processed using the SPSS software package and inferential statistics were applied, with a t-test for independent samples used to determine the statistical significance of differences between the arithmetic means of two groups of respondents.

Table 1 contains the result of the t-test for the statistical significance of the obtained difference in the arithmetic means between the two groups of workers, in terms of safety knowledge, proving that there is a statistically significant difference between workers who have OSH training compared to their colleagues who have no training, at a level of less than 0.01.

***Table 1**: Difference between workers with and without OSH training in terms of safety knowledge*

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	3,906	,053	8,428	58	,000	4,667	,554	3,558	5,775
Equal variances not assumed			8,428	52,767	,000	4,667	,554	3,556	5,777

Table 2 contains the result of the t-test for the statistical significance of the obtained difference in the arithmetic means between the two groups of workers, in terms of safety behavior, proving that there is a statistically significant difference between workers who have OSH training compared to their colleagues who have no training, at a level of less than 0.01.

***Table 2**: Difference between workers with and without occupational safety and health training in terms of safety behavior*

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	,531	,469	7,434	58	,000	3,767	,507	2,752	4,781
Equal variances not assumed			7,434	57,667	,000	3,767	,507	2,752	4,781

***Table 3**: Difference between workers with and without OSH training in terms of self-confidence and safety awareness*

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	1,503	,225	2,591	58	,012	1,133	,437	,258	2,009
Equal variances not assumed			2,591	56,345	,012	1,133	,437	,257	2,009

Table 3 contains the result of the t-test for the statistical significance of the obtained difference in the arithmetic means between the two groups of workers, in terms of self-confidence and safety awareness, proving that there is a statistically significant difference between workers who have OSH training compared to their colleagues who have no training, at a level less than 0.05 ($p = 0.012$).

***Table 4**: Difference between workers with and without OSH training in terms of commitment to occupational safety and health*

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	1,398	,242	4,545	58	,000	2,067	,455	1,157	2,977
Equal variances not assumed			4,545	55,750	,000	2,067	,455	1,156	2,978

Table 4 contains the result of the t-test for the statistical significance of the obtained difference in the arithmetic means between the two groups of workers, in terms of commitment to occupational safety and health, proving that there is a statistically significant difference between workers who have OSH training compared to their colleagues who have no training, at a level of less than 0.01.

***Table 5**: Difference between workers with and without OSH training in terms of risk acceptance at work*

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	,483	,490	2,447	58	,017	,767	,313	,140	1,394
Equal variances not assumed			2,447	57,799	,017	,767	,313	,140	1,394

Table 5 contains the result of the t-test for the statistical significance of the obtained difference in the arithmetic means between the two groups of workers, in terms of risk acceptance at work, proving that there is a statistically significant difference between workers who have OSH training compared to their colleagues who have no training, at a level less than 0.05 (p = 0.017).

Table 6 contains the result of the t-test for the statistical significance of the obtained difference in the arithmetic means between the two groups of workers, in terms of work practices, proving that there is a statistically significant difference between workers who have OSH training compared to their colleagues who have no training, at a level of less than 0.01.

***Table 6**: Difference between workers with and without OSH training in terms of work practices*

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	,053	,820	4,559	58	,000	3,467	,760	1,945	4,989
Equal variances not assumed			4,559	57,902	,000	3,467	,760	1,944	4,989

***Table** 7: Difference between workers with and without OSH training in terms of risk and accident reduction*

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	1,401	,241	6,323	58	,000	2,567	,406	1,754	3,379
Equal variances not assumed			6,323	55,187	,000	2,567	,406	1,753	3,380

Table 7 contains the result of the t-test for the statistical significance of the obtained difference in the arithmetic means between the two groups of workers, in terms of risk and accident reduction, proving that there is a statistically significant difference between workers who have OSH training compared to their colleagues who have no training, at a level of less than 0.01.

The results of the research show that across all questions, workers with training showed a greater perception of occupational safety and health than those workers without training.

Conclusion and recommendations

Construction is a very risky profession and unfortunately, a large number of deaths and injuries are reported every year while performing work tasks. Although legal regulations require all workers to undergo mandatory training on occupational safety, there are still a certain number of workers who are untrained and lack the appropriate knowledge and skills to perform the given work.

Working at height in the construction industry is one of the most dangerous professions, and one of the main hazards is falling. Working at height must not be performed without appropriate equipment or without the use of protective devices such as: safety baskets, platforms, safety nets, etc.

Previous research suggests that occupational safety and health training reduces accidents and fatalities due to falls from height. Health and safety training is one way to enable employees to recognize and eliminate hazards in order to control risks in the workplace. To achieve this goal, training programs should be designed and implemented in such a way that they enable employees to identify hazards and eliminate them effectively through the successful involvement of employers, government and unions, if necessary.

In this paper, research was conducted using questionnaires on two groups of workers of 30 respondents each, one with and the other without training. In doing so, 7 questions were asked about: safety knowledge, safety behavior, self-confidence and

safety awareness, commitment, risk acceptance, work practices and risk and accident reduction. The results show that in all questions, workers with training showed a greater perception of safety and health at work compared to those workers without training.

Future research in this area could cover larger number of workers and other variables, which would increase the possibility of generalization of research results.

References

Ai Lin Teo, E., Yean Yng Ling, F., & Sern Yau Ong, D. (2005). Fostering safe work behavior in workers at construction sites. Engineering, Construction and Architectural Management, 12(4), 410-422. doi:10.1108/09699980510608848

Amde, W. K., Marchal, B., Sanders, D., & Lehmann, U. (2019). Determinants of effective organisational capacity training: lessons from a training programme on health workforce development with participants from three African countries. BMC Public Health, 19(1), 1557. doi:10.1186/s12889-019-7883-x

Barling, J., Kelloway, E. K., & Iverson, R. D. (2003). High-Quality Work, Job Satisfaction, and Occupational Injuries. Journal of Applied Psychology, 88(2), 276-283. doi:10.1037/0021-9010.88.2.276

Borger, J., Sun, Y., Bochmann, F., Guldner, K., Ponto, K., & Rose, B. (2011). Reduction of occupational injuries by conduction of a preventive training programme – an epidemiological follow-up study in the German glass industry. Occupational and Environmental Medicine, 68(Suppl_1), A25. doi:10.1136/oemed-2011-100382.77

Christian, M., Bradley-Geist, J., Wallace, C., & Burke, M. (2009). Workplace Safety: A Meta- Analysis of the Roles of Person and Situation Factors. The Journal of applied psychology, 94, 1103-1127. doi:10.1037/a0016172

Dodoo, J., & Al-Samarraie, H. (2019). Factors leading to unsafe behavior in the twenty first century workplace: a review. Management Review Quarterly. doi:10.1007/s11301-019-00157-6

Edwards, D., & Holt, G. (2008). Construction workers' health and safety knowledge. Journal of Engineering, Design and Technology, 6(1), 65-80. doi:10.1108/17260530810863343

Evanoff, B., Dale, A. M., Zeringue, A., Fuchs, M., Gaal, J., Lipscomb, H. J., & Kaskutas, V. (2016). Results of a fall prevention educational intervention for residential construction. Safety Science, 89(C), 301-307. doi:10.1016/j.ssci.2016.06.019

Floyde, A., Lawson, G., Shalloe, S., Eastgate, R., & D'cruz, M. (2013). The design and implementation of knowledge management systems and e-learning for improved occupational health and safety in small to medium sized enterprises. Safety Science, 60(C), 69-76. doi:10.1016/j.ssci.2013.06.012

Guo, B. H. W., Yiu, T. W., & Gonzalez, V. A. (2016). Predicting safety behavior in the construction industry: Development and test of an integrative model. Safety Science, 84, 1-11. doi:10.1016/j.ssci.2015.11.020

Gjorgjev, M., & Byanov, I. (2022). Impact of Investments in Healthy and Safe Working Conditions on Increasing Productivity and Effectiveness of Light and Heavy Industry Enterprises in the Republic of North Macedonia Compared to the Republic of Germany. Великотърновски университет „Св. св. Кирил и Методий".

Gjorgjev, M. (2023). State and Impact of Investments from the Application of Safety Measures at Work in Large and Medium-Sized Enterprises in the Republic of North Macedonia. St. Cyril and St. Methodius University of Veliko Tarnovo. https://doi.org/10.54664/ZFRL1371

Leiter, M. P., Zanaletti, W., & Argentero, P. (2009). Occupational risk perception, safety training, and injury prevention: testing a model in the Italian printing industry. J Occup Health Psychol, 14(1), 1-10. doi:10.1037/1076-8998.14.1.1

Mustard, L. R. a. C. (2019). Evaluation of the Implementation and Effectiveness of the Ontario Working at Heights Training Standard: Final Report. Retrieved from Toronto

Nkomo, H., Niranjan, I., & Reddy, P. (2018). Effectiveness of Health and Safety Training in Reducing Occupational Injuries Among Harvesting Forestry Contractors in KwaZulu- Natal. Workplace Health & Safety, 66(10), 508-508. doi:10.1177/2165079918774367

Ricci, F., Chiesi, A., Bisio, C., Panari, C., & Pelosi, A. (2016). Effectiveness of Occupational Health and Safety Training: A Systematic Review with Meta-Analysis. Journal of Workplace Learning, 28(6), 355. doi:10.1108/JWL-11-2015-0087

Slatin, C. (1995). Health and Safety training: Listening to your workers voice. NEW SOLUTIONS: A Journal of environmental and Occupational Health, 5, 4-5

Sokas, R. K., Emile, J., Nickels, L., Gao, W., & Gittleman, J. L. (2009). An intervention effectiveness study of hazard awareness training in the construction building trades. Public health reports (Washington, D.C. :1974), 124 Suppl 1(Suppl 1), 160-168. Retrieved from https://pubmed.ncbi.nlm.nih.gov/19618818

Taylor, E. L. (2015). Safety benefits of mandatory OSHA 10h training. Safety Science, 77, 66- 71. doi:10.1016/j.ssci.2015.03.003

Vignoli, M., Punnett, L., & Depolo, M. (2014). How to measure safety training effectiveness? Towards a more reliable model to overcome evaluation issues in safety training. Chemical Engineering Transactions, 36, 67-72. doi:10.3303/CET1436012

ЕКОНОМИКА
ISSN 0350-137X, EISSN 2334-9190, UDK 338 (497,1)
Vol. 71, april-june 2025, № 1
P. 23-43

Vahid Ibrulj[1]
JKP Zelenilo Arandjelovac

Zoran Nešić[2]
Institution/University of Kraguejvac
Faculty of technical science, Cacak

Zoran Papović[3]
Academy of Vocational Studies of Kosovo and Metohija

ORIGINAL SCIENTIFIC ARTICLE
DOI: 10.5937/ekonomika2502023I
Received: December 24, 2025
Accepted: Februry 18, 2025

DEVELOPMENT OF AN INTELLIGENT DECISION SUPPORT SYSTEM FOR IMPROVING THE OPERATIONS OF PUBLIC UTILITY COMPANIES

Abstract

The purpose of this paper is to develop and present a decision support system for improving the operations of public utility companies that deal with solid waste management. The proposed system was developed on the basis of a decision system model based on solving a limited linear optimization problem, taking into account all the specifics of the operation of public utility companies in the Republic of Serbia, which originate from the legal regulation of waste management, up to the purpose and specifics of the existence of public companies. The originality of the work is reflected in the fact that there are no similar solutions. The implementation of the proposed system will significantly contribute to the reduction of the operating costs of public companies that deal with municipal waste management.

Key words: *decision support system, waste management, public companies, Republic Serbia*

JEL classification: *O31, O32.*

РАЗВОЈ ИНТЕЛИГЕНТНОГ СИСТЕМА ЗА ПОДРШКУ ОДЛУЧИВАЊА У ФУНКЦИЈИ УНАПРЕЂЕЊА ПОСЛОВАЊА ЈАВНИХ КОМУНАЛНИХ ПРЕДУЗЕЋА

Апстракт

Сврха овог рада јесте да се развије и представи систем за подршку одлучивања за унапређење пословања јавних комуналних предузећа која се баве управљањем чврстог отпада развијен. Предложени систем развијен на основама модела система одлучивања заснованом на решавању ограниченог проблема линеарне оптимизације, уз уважавање свих специфичности пословања јавних

[1] arzelenilo@gmail.com, ORCID ID 0009-0005-1501-9067

[2] zoran.nesic@ftn.kg.ac.rs, ORCID ID 0000-0001-6004-373X

[3] 1zoranpapovic@gmail.com, ORCID ID 0009-0005-1501-9067

комуналних предузећа у Републици Србији, а која потичу од законске регулативе управљања отпадом, па до сврхе и специфичности битисања јавних предузећа. Оригиналност рада огледа се у чињеници да нема сличних решења. Примена предложеног система у значајној мери ће допринети редуковању трошкова пословања јавних предузећа која се баве управљањем комуналним отпадом.

Кључне речи: *систем за подршку одлучивања, управљање отпадом, јавна предузећа, Република Србија*

Introduction

The aim of this paper is to develop an efficient Decision Support System (DSS) designed to improve the operations of public enterprises in the Republic of Serbia involved in municipal waste management, including activities such as incineration, disposal, treatment, and recycling. The treatment of waste encompasses a range of processes, such as separation, the production of refuse-derived fuel (RDF), energy recovery through incineration, organic material processing, and sanitary landfilling. According to the World Bank (2024), the global volume of solid waste amounts to approximately 2.5 billion tons, while in the Republic of Serbia, it reached about 174 million tons in 2022 (Statistical Office of the Republic of Serbia (SORS), 2024). There is a noticeable trend of continuous growth in both the quantity and complexity of waste composition, driven by the increased use of plastic and electronic products, as noted by Herva et al. (2014). This trend has led to significant concern and a heightened focus in recent years, both globally and locally, on solving issues related to solid waste management. Urbanization and population growth in cities are the main drivers of waste generation patterns and waste toxicity (Eriksson and Bisaillon, 2003, 2011; Herva et al., 2014; Emkes et al., 2015). Consequently, the treatment of solid waste has become one of the most challenging service sectors for municipal authorities in the 21st century (Zaman, 2014). Furthermore, when considering the emission of waste into air, water, and soil—posing serious risks to public health, environmental hazards both locally and globally, and socio-economic challenges (Ikhlayel et al., 201)—the issue of efficient solid waste management becomes even more critical and complex.

These complex management requirements are better controlled when supported by tools for evaluating the overall system performance, including administrative, financial, legal, and planning aspects (Mendes et al., 2013). According to Eriksson et al. (2003), the main advantages of waste management models lie in their ability to handle complexity and uncertainty. Therefore, the development of appropriate systems based on modern ICT for solid waste management is essential. One potential solution is the development of a Decision Support System (DSS). The primary goal of a DSS is to plan municipal waste management, define the waste flows that need to be directed toward recycling or various treatment and disposal facilities, and propose the optimal number, types, and locations of facilities that need to be operational. A specific goal of the research is to develop a software solution that will enable the effective implementation of the model.

The idea is to develop a DSS as a decision-making system based on solving a constrained nonlinear optimization problem using two types of variables: binary and

continuous. This approach would rely on the use of a genetic algorithm for optimization, as such an algorithm can efficiently handle different types of variables and return an optimal solution regardless of the starting point. The objective function would take into account all possible economic costs, while the constraints would arise from technical, regulatory, and environmental considerations. For this purpose, a linear or quadratic optimization model can be used. Thus, the combination of genetic algorithms with optimization techniques can be an effective approach to solving complex decision-making problems in the field of waste management. Simply put, the decision-making model must consider all factors significant for making decisions related to waste management, ensuring that the outcome is a decision that minimizes total costs while addressing all aspects of waste management and adhering to constraints arising from technical, regulatory, and environmental issues. For example, technical constraints relate to the capacity of waste treatment facilities, the technology used, and similar factors. Regulatory constraints include legal regulations and standards that must be met during waste management. Environmental constraints relate to protecting the environment and minimizing negative impacts on the surroundings.

Therefore, the aim of this paper is to develop a decision-support model that accounts for both environmental and economic aspects of waste management in local governments. The application of this approach will enable the modeling and analysis of a heterogeneous set of subsystems affected by decisions related to solid waste management. By integrating all subsystems into the decision-making process, it will be possible to make optimal decisions regarding the size and typology (e.g., separators, incinerators, etc.) of various treatment facilities, based on a detailed analysis of waste composition. Ultimately, this will result in improved operations of public utility companies in the Republic of Serbia.

Literature review

In recent years, numerous papers can be found that have the development of solid waste management models as their subject. Most of these models are based on decision support models. The basic idea behind the authors of these papers in developing the model is to create an optimal trade-off between reality and the computational complexity of the model. In other words, they are guided by the requirement that the model reflects the real situation as realistically as possible, without being too complex for data processing. Since solid waste management in urban areas represents a very complex problem that includes various aspects of the functioning of society, starting from economic and technical issues, up to compliance with human and environmental protection standards, the development of a model that will reflect the optimal trade-off between reality and computational complexity represents a very difficult task. Therefore, it is not surprising that many authors have not been successful in achieving this requirement.

The consequence of the above mentioned is that the authors have mainly focused on one aspect of the functioning of a society due to the fact that solid waste management, from its generation to final treatment, is very complex (Chen & Wang, 2017). In addition, it should be added that solid waste management is further complicated by the lack of awareness and community participation, the mind set and commitment of staff, the lack

of improved collection equipment, the lack of human resources, the lack of landfill land, inexperienced operation and maintenance of the landfill, financial constraints, staff training, the shortage of basic studies and insufficient data on solid waste, etc. (Santibanez-Aguilar et al., 2017). For this reason, as a rule, many authors have focused on the development of economically based optimization models for the allocation of municipal waste streams. The first such model was presented by Chang & Chang (1998). The model is based on the minimization of the total costs of waste management. The minimization of the objective function is achieved by solving a constrained nonlinear optimization problem. The cost function includes the costs of transportation, treatment, maintenance and recycling and takes into account the possible benefits from the sale of electricity. However, the main drawback of this model is that it does not take into account other aspects of society, such as environmental protection, as well as technological aspects of waste treatment. Based on this model, Fiorucci et al., (2003) developed a similar model, which takes into account different classes of constraints, such as regulations on minimum recycling requirements, incineration process requirements, landfill conservation and mass balance. However, the cost function which should be minimized only includes the costs of recycling, transportation, and maintenance.

It can be stated that a large number of studies focusing solely on the economic criterion, primarily the selection of the optimal location for an inter-municipal landfill, are based on the application of AHP and fuzzy methods. Such models were presented by Afzali et al. (2014), Kahraman et al. (2017), Kharat et al. (2019), Rani et al. (2021), Das et al. (2022), Kabir et al. (2022), Musart et al. (2022), Demircan and Yetilmezsoy (2023), Aghad et al. (2024), Kang et al. (2024), Sadati et al. (2024), Shukor et al. (2024), and others. However, an approach based solely on economic considerations cannot be considered fully satisfactory when addressing waste management issues. In fact, a broad range of potential developments must be considered. Above all, modeling the impact of solid waste management on the environment requires modeling and analysis of a fairly heterogeneous set of subsystems influenced by decisions related to solid waste management. In this context, multi-criteria decision models are effective because they allow decision-makers to assess existing or potential alternatives while simultaneously considering and applying multiple conflicting criteria (Belton & Stewart, 2002; Kou et al., 2011; Zhou et al., 2010). Due to their ability to process several criteria, these models are considered highly efficient for decision support in solid waste management (Soltani et al., 2015). Based on this, the model presented by Garcia-Garcia (2022) represents an attempt to incorporate a greater number of social aspects and utilization. However, the main drawback of this model is that it does not cover all relevant aspects of society and relies on simple techniques of the Analytical Hierarchy Process (AHP) (multi-criteria decision-making). A similar model, integrating more sustainability criteria in waste management, was presented by Torkayesh et al. (2022). Their model includes environmental, social, and economic criteria and is based on a combination of multi-criteria decision-making models and life cycle assessment models that evaluate the sustainability of waste management systems. However, the model does not include the technical-technological aspects of solid waste management.

The most comprehensive solid waste management model currently available is presented by Shaban et al. (2022). The authors developed a generic optimization model suitable for developing an efficient solid waste management system in developing

countries. A mixed-integer linear programming model has been formulated for a solid waste management system configuration that integrates waste generation sources, collection/transfer stations, recycling facilities, incineration plants, and landfills. The proposed model is designed to determine the optimal number and locations of various facilities, as well as the optimal waste flow within the system, aiming to minimize the net daily costs incurred by the system. However, the model does not incorporate legal regulations. A similar model was presented by Ahani et al. (2019), Anwar et al. (2018), and Yousefloo & Babazadeh (2019).

In recent years, with the development of machine learning (ML) and artificial intelligence, an increasing number of researchers have focused on developing IT-based models for waste management. This is because the quantification and prediction of solid waste play a vital role in the efficient planning of solid waste management systems (Singh & Satija, 2017). The application of neural networks, as opposed to traditional statistical analysis techniques, enables effective analysis of sophisticated nonlinear functions in multidimensional spaces (Kannangara et al., 2017), providing a solid foundation for analyzing the multidimensional problem of waste management. Similar perspectives are shared by Younes et al. (2015) and Yusoff et al. (2018). Therefore, this approach offers a strong basis for studying issues such as solid waste management (Jalili & Noori, 2004; Ponce, 2004; Kurtulus et al., 2006; Yamin et al., 2008; Noori et al., 2010; Oliveira et al., 2018), despite the fact that predicting solid waste remains uncertain due to the dynamic and unpredictable nature of social, economic, and demographic factors (Chhay et al., 2018). Furthermore, accelerated economic development and urbanization add to the already complex nature of solid waste (Shams et al., 2017). Hoque et al. (2020) utilized artificial intelligence to predict landfill surface area based on solid waste collection forecasting. Meza et al. (2019), Camero et al. (2019), and Kulisz and Kujawska (2020) focused on predicting solid waste quantities, while Batinić et al. (2011) used AI to predict waste characteristics. Gue et al. (2022) developed a machine learning model based on rule-based analysis to evaluate the impact of city and country attributes on waste management. Unfortunately, their model identified local governance and technological research as key attributes influencing sustainable waste management but did not offer strategies for managing waste at the enterprise level under local government jurisdiction, either directly or indirectly. A similar effort was presented by Mishra et al. (2022), who introduced a Smart Waste Management Model. This model combines the concepts of the Internet of Things (IoT) and artificial intelligence. The core idea of their model is to leverage the predictive capabilities of AI-based models and apply these advantages in automated decision-making. However, their model focuses solely on prioritizing bin emptying decisions rather than addressing the entire waste management flow at the local governance level. The idea for their model was inspired by works of various authors, such as Alizadeh et al. (2018), Ayeleru et al. (2021), and Fan et al. (2022a, b), who used neural network models to solve specific problems in urban management. Among the pioneers using neural network models based on multi-layer perceptron (MLP) for waste management were Alidoust et al. (2021) and Lin et al. (2022). The model developed by Lin et al. (2022) is particularly noteworthy because it incorporates criteria related to storage, transportation, and disposal of waste into the decision-making process. Alidoust et al. (2021) used their model for modeling physical properties of waste, while Ayeleru et al. (2021) applied it for quantity prediction. A notable challenge with ML models is

their limited interpretability for decision-makers (Rudin, 2019). Rule-based "if-then" systems, on the other hand, allow for easier subjective interpretation because causal relationships are inherently expressed in linguistic form (Gue et al., 2022).

However, regardless of the purpose for which neural network models are used in solid waste management, a common issue is that the model's performance depends on the historical length and quality of the data (Masebinu et al., 2017). Supporting the use of neural networks are the findings of Sun and Chungpaibulpatana (2017), who demonstrated that artificial neural networks (ANN) provide highly accurate predictions of waste generation. They also highlighted that influential factor such as total population, age, number of households, household income, and similar variables significantly contribute to waste generation. Similar arguments supporting the use of neural networks have been presented by Abdoli et al. (2011), Shahabi et al. (2012), Antanasijević et al. (2013), Shamshiry et al. (2014), Azadi and Karimi-Jashni (2016), and Abbasi and Hanandeh (2016).

The increase in municipal solid waste (MSW) generation has become not only a significant sustainability challenge but also a major financial burden for municipalities worldwide. Therefore, it is insufficient to focus solely on waste quantity prediction; it is equally important to involve the public in the waste management process, as they are key stakeholders. This has led to the development of a second group of waste management models that incorporate public participation in decision-making processes. These models aim to achieve a compromise among stakeholders, given that conflicts often arise from the complex network of stakeholder values. Such conflicts can impact the feasibility of implementing any decision (Ananda et al., 2003). Models of this kind have been presented by Hung et al. (2006), Morrissey and Browne (2004), and Wilson et al. (2001). These models are typically based on a combination of multi-objective programming methods and multi-criteria decision-making approaches. The primary drawback of these models lies in determining the degree of consensus required among stakeholders. As a result, their application in municipal-level solid waste management remains debatable.

Few studies have focused on the development of ICT-based decision support systems (DSS) for solid waste management in local governments. Decision support systems are valuable tools that assist managers in ensuring compliance with solid waste management regulations proposed by governments. Pires et al. (2011) and Souza Melaré et al. suggested that DSS can be developed using ICT and optimization algorithms. Building on these ideas, it is possible to develop an ICT-based decision support system that would be effective in public enterprises in the Republic of Serbia engaged in solid waste treatment. Despite the fact that various stakeholders are involved in solid waste management in the Republic of Serbia, each with different concerns and criteria encompassing economic, environmental, political, and social aspects, an efficient system can be developed. Such a system would allow for the classification and analysis of alternative solutions while respecting the wide range of conflicting criteria. In developing the system, a systemic approach will be adopted, as proposed by various authors, including Staples and Niazi (2008), Kitchenham and Charters (2007), Guessi et al. (2011), and Souza Melaré et al. (2017).

Model Development and object function

The model development assumes that urban planning documents in the municipalities of the Republic of Serbia have designated locations for the construction of certain types of facilities. Since these facilities may or may not be built, binary variables are introduced into the model (whether they will be built or not). Therefore, the problem of making optimal decisions is reduced to solving an optimization problem with nonlinear functions and integer decision variables.

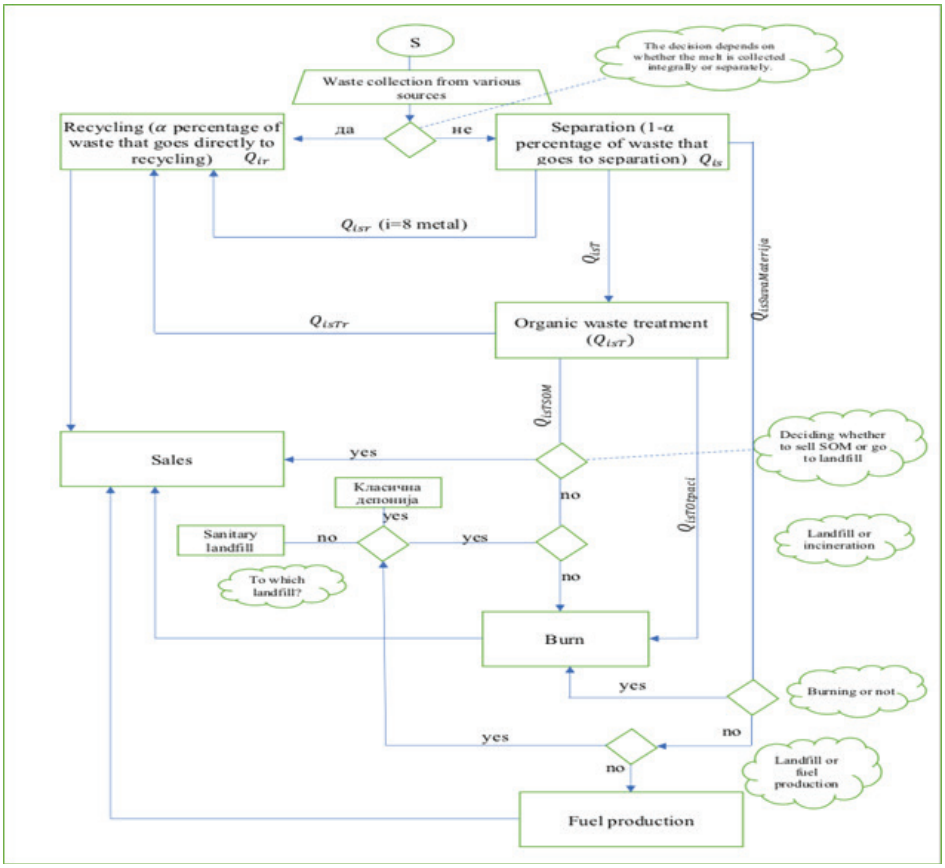
The first step in model development is to consider the process of solid waste treatment. Given that the Republic of Serbia is aligning its regulations with those of the European Union, the model is based on the classification of solid waste as prescribed by the EU. According to EU regulations, solid waste is classified into 11 categories: 1 - paper, 2 - heavy plastic, 3 - plastic bags, 4 - plastic bottles, 5 - glass, 6 - organic, 7 - wood, 8 - metals, 9 - residual waste, 10 - inert materials, and 11 - textiles. It is noted that for each waste category, the calorific value of the waste before and after any treatment is determined based on the chemical composition of the waste. Daily quantities of waste are collected from various locations, with only 9 categories of waste being recyclable, and they can be collected either separately or partially separated (paper, heavy plastic, plastic bags, plastic bottles, glass, organic waste, wood, metals, and textiles). The collected waste undergoes separation, with the separation process depending on the method of collection. The remaining waste, which is collected without separating different materials, is sent for further separation, landfill, or incineration. From the separation process, three types of sorted waste can emerge:

- Metals, which are sent for recycling.
- Organic materials (wet waste), which undergo further treatment:
  - Organic material sent for recycling is used for compost production.
  - Wet material is processed in an organic waste treatment facility, resulting in stabilized organic material (SOM) and residues. SOM can be sold, incinerated in a waste-to-energy facility, or sent to a landfill, while the residues are directly sent to the landfill.
- Other materials (dry waste), which can be incinerated, sent to a facility for fuel production, or disposed of in a landfill.

It is important to note that recycling alters the composition of waste sent for incineration. This means that its calorific value changes after recycling, and consequently, the energy recovery value from waste incineration is also affected. This data is taken into consideration due to the positive benefits of energy recovery through waste incineration. The material sent to the landfill can be directed to either a conventional landfill or a sanitary landfill, with the quantity of waste disposed of being limited by the maximum flow of municipal solid waste that can be sent to the landfill, or equivalently, by the minimum number of years required to completely fill the landfill.

In addition to the aforementioned specifics, the model development takes into account the possibility of multiple locations for each type of facility, including separation, incineration, recycling, landfills, and waste treatment. This means that indicators can be assigned to each facility to handle a specific quantity and type of waste. The existence of different locations increases the waste treatment costs. This concept can be best represented graphically, as shown in Figure 1.

Figure 1. Waste treatment model in public utility companies (PUC)



Note: $Q_{i,R}$ – Quantity of waste of the i-th material that is directly recycled; $Q_{i,S}$ – Quantity of waste of the i-th material that goes to separation; $Q_{i,S,R}$ – Quantity of waste of the i-th material that goes from separation to recycling (metals, i=8); $Q_{i,S,T}$ – Quantity of waste of the i-th material that goes from separation to treatment; $Q_{i,S,T,\ SOM}$ – Quantity of waste of the i-th material from treatment representing stabilized organic material (SOM); $Q_{i,S,T,\ waste}$ – Quantity of waste of the i-th material from treatment representing waste; $Q_{i,S,T,\ Sum\ of\ Materials}$ – Quantity of waste of the i-th material that does not go to treatment from separation due to being dry material and directly goes to either the incinerator, landfill, or fuel production.
Source: Authors

The decision variables related to separation would be: $\psi_s{}^p$, $\psi_{r\varphi}$, $\psi_i{}^n$, $\psi_l{}^m$, and $\psi^t{}_l$. Similarly, variables for landfills, fuel production, waste treatment, and incineration would be defined. Binary variables would refer to all these facilities to describe whether they exist or not, and they would be coded as 1 for existence and 0 for non-existence. Thus, we get: Sp – indicator for the p-th separator (p = 1…P), Rq – indicator for the q-th fuel production facility (q = 1…Q),

In – indicator for the n-th incinerator (n = 1…N), Lm – indicator for the m-th landfill (m = 1…M), Tl – indicator for the l-th organic waste treatment facility (l = 1…L).

Considering the described solid waste treatment process, as well as all the listed constraints, the cost function encompasses all costs, from collection costs, placement, and procurement of various types of containers, to waste recycling. For example, transportation costs represent a function of the number of vehicles (maintenance and fuel costs), employee wages (which depend on the number of trips required for waste transport and the number of trips one driver can make during their working day), and variable costs determined by the distance between different facilities and waste collection points. Therefore, transportation costs can be represented as follows:

$$C^{\mathrm{T}} = \sum_{(s,d)\in X} \frac{\hat{Q}_{s,d} C_{s,d}}{V_{s,d}} \qquad (1)$$

The following symbols represent:

X - *Set of possible connections between two facilities*
s,d - *Connection between two facilities*
$C_{s,d}$ - *Transportation costs between facilities*
$\hat{\mathrm{Q}}_{s,d}$ - *Quantity (volume) of waste transported between facilities on an annual basis*
$\mathrm{V}_{s,d}$ - *Capacity of a single vehicle for waste transportation used on the route between two facilities*

The second group of costs consists of installation and maintenance costs of the facilities. These costs include a fixed component CF and a variable component CV. The fixed cost depends on the decision of whether the facility is included in the system or not and is incorporated into the cost function. This is an integer decision. For example, a decision of 1 means that the facility is used and the fixed cost is included in the cost function. If the decision is 0, the facility is not included and the fixed cost does not contribute to the total cost function. This represents a cost proportional to the amount of material processed by the facility during the year. Therefore, the larger the amount of material entering the facility, the higher the cost will be. The variable cost is calculated as the product of a coefficient (representing the cost per unit mass) and the mass of waste entering the facility. Thus, the installation and maintenance costs of the facility can be represented as:

$$C^{m} = \sum_{p=1}^{P} \sum_{i=1}^{D} Q_{p,i} * price_i + \sum_{p=1}^{P} C_F \qquad (2)$$

The final group consists of recycling costs. These represent a function of different types of separation methods, where the selected method represents the best solution for a given amount of a specific type of waste. Thus, we obtain xi,j, where x is the portion of waste of the i-th material obtained by applying the j-th method. The idea is to consider these proportions as fixed parameters, justifying the fact that, in every case, the most economical waste separation method is chosen, which corresponds to the needs of the local government (urban structure, socio-economic characteristics of the population,

etc.). Thus, the recycling costs on an annual basis can be represented as:

$$C^r = \bar{n} \sum_{i=1}^{11} \left(\left(\sum_{j=1}^{4} C_{i,j}^{x} r_i \alpha_i x_{i,j} \right) - B_i r_i \alpha_i \right) \quad (3)$$

The following variables represent:

C^R - the cost per unit weight of waste per day

B_i - the economic benefit from the sale of the i-th material in the amount of $ri\alpha i$

n̄ - the average number of' days

j - ranges from 1 to 4, as there are 4 types of recycling techniques

Given that there are economic benefits from recycling, both in terms of revenue generated from the sale of recycled materials and from the sale of thermal and other energy, the objective function must incorporate a utility function before the cost functions. Taking into account all potential economic benefits from waste treatment, the function would look as follows:

$$B = \sum_{q=1}^{Q} price_{rec.mat} RM_q + \sum_{n=1}^{N} \tilde{c}_e \left(\frac{\eta_E HV_{l_n} \bar{n}}{f} - E_{c,n} \right) \quad (4)$$

Where the following represent:

$$RM_q = \bar{n} \sum_{p=1}^{P} \sum_{d=1}^{D} \sum_{i=1}^{11} (1 - \alpha_i) r_i \chi \, P_{d,i} \Phi P_{d,} S_p (1 - k_i) \times (1 - \eta_i) \psi S_{p,} C_q \, (1 - \hat{\eta}_i) \Theta_{S_{p,} C_q} \quad (5)$$

$\tilde{C}_e$ - *unit price [E/kWh] for energy sales;*

$E_{c,n}$ - *annual energy consumption [kWh/year] for the n-th incineration unit;*

η_E - *efficiency related to energy production in relation to the heat generated by combustion;*

ff - *conversion factor, equal to 3.6 MJ/kWh;*

HV_{ln} - *total daily thermal energy of waste entering the n-th incineration unit.*

Considering the above, we obtain the following objective function:

$$C = C^t + C^m + C^R - B \quad (6)$$

Since regulations dictate that certain types of waste cannot be collected together and that specific methods must be applied in their treatment, constraints regarding the waste structure (compliance with mass balance equations), space size, etc., such constraints are described as regulatory constraints. Mathematically, they can be represented as follows, with Z representing the percentage corresponding to the prescribed minimum amount of waste that must be recycled, according to the law in the Republic of Serbia.

$$\sum_{i=1}^{11} \alpha_i r_i + \sum_{p=1}^{P}\sum_{d=1}^{D}\sum_{i=1}^{11} k_i(1-\alpha_i) r_i \chi\, P_{d,i}\, \Phi P_{d,} S_p + \sum_{p=1}^{P}\sum_{d=1}^{D}\sum_{i=1}^{11}\sum_{s=1}^{S} (1-\alpha_i)\, r_i \chi\, P_{d,i} \Phi P_{d,} S_p (1-k_i) \eta_i\, \tilde{\eta_i}\, \gamma T_{s,} M$$
$$+ \sum_{p=1}^{P}\sum_{d=1}^{D}\sum_{i=1}^{11}\sum_{q=1}^{Q} (1-\alpha_i)\, r_i \chi\, P_{d,i} \Phi P_{d,} S_p (1-k_i) \times (1-\eta_i) \psi S_{p,} C_q (1-\hat{\eta}_i) \Theta_{C_{q,} M}$$
$$\geq Z \sum_{i=1}^{11} r_i \quad (7)$$

The following symbols represent:

- k_i - *the fraction of material i that is sent for recycling after separation;*
- η_i - *the fraction of material i, relative to the total material not recycled after separation, that is sent (as wet material) for biological treatment;*
- $\tilde{\eta}_i$ - *a parameter representing the fraction of material i that enters the biological treatment facility and remains in the stabilized organic material; note that the dependence of this fraction depends on index i because cleaning operations to remove residues take place in the biological treatment plant, with an efficiency that also depends on index i;*
- $\hat{\eta}_i$ - *the fraction of material i that enters the RDF (Refuse Derived Fuel) facility and remains as a component of the RDF produced in that facility; again, this fraction depends on index i.*

The second group of constraints consists of technical constraints. These are typically limitations related to the amounts of material that can be received, delivery times, raw material quality, and ecological and safety standards that must be adhered to. In solid waste management, such constraints apply to the daily intake of material into incinerators, separators, organic material treatment plants, and fuel production plants. More specifically, the amounts of waste entering these facilities must lie between certain fixed values, which can be mathematically represented as follows:

$$\mathrm{M}_{I_{n,a}} \delta_{I_n} \leq Q_{I_n} \leq \mathrm{M}_{S_{p,b}} \delta_{I_n} \quad (8)$$
$$\mathrm{M}_{S_{p,a}} \delta_{S_p} \leq Q_{S_p} \leq \mathrm{M}_{S_{p,b}} \delta_{S_p} \quad (9)$$
$$\mathrm{M}_{C_{q,,a}} \delta_{C_q} \leq Q_{C_q} \leq \mathrm{M}_{C_{q,b}} \delta_{C_q} \quad (10)$$
$$\mathrm{M}_{\mathrm{T}_{s,,a}} \delta_{T_s} \leq Q_{C_q} \leq \mathrm{M}_{\mathrm{T}_{s,b}} \delta_{T_s} \quad (11)$$

In addition to this constraint, the model also includes a constraint related to the conservation of mass. This constraint can be represented by an equation that ensures the mass of material entering the system is equal to the mass of material leaving the system, plus the mass retained within the system, or mathematically, F_{\text{in}} - F_{\text{out}} = \Delta mass. This constraint occurs at every branching point where the waste flow can be split. Regardless of the branching point, the general constraint can be expressed as the difference between the flow of material entering and exiting the facility being equal to the change in mass within the system over a specific time period.

Since the treatment of solid waste involves the presence of certain facilities when a specific type of solid waste is present, the decision regarding their presence or absence must also be included in the model. The constraint is that when the amount of a

specific type of waste is greater than zero, the corresponding facility must be present, or mathematically: P = \text{sgn}(F_{\text{in}}).

The third group of constraints pertains to environmental standards. In the context of solid waste management, they relate to the chemical content of fuel and SOM (stabilized organic material). In the case of fuel production, these constraints address the chemical characteristics of the fuel in order to minimize ash, Cl, S, moisture, as well as its calorific value, which can be mathematically represented by the following constraint:

$$\sum_{p=1}^{P}\sum_{d=1}^{D}\sum_{i=1}^{11} k_i(1-\alpha_i)r_i\chi\, P_{d,i}\, \Phi P_{d,}S_p(1-k_i)\times(1-\eta_i)\psi S_{p,}C_q(-\hat{\eta}_i)\mathrm{A}_i \geq 0 \quad (12)$$

Where Ai is defined by specific constraints related to heat, Cl and S concentration, moisture, and ash content. Similarly, the constraint related to SOM (Stabilized Organic Material) is defined, concerning the concentration of plastics, pH values, and emissions of unpleasant odors.

$$\left\{\sum_{d=1}^{D}\Phi P_{d,}S_p\,\beta_{S_p,T_s}K\right\} - H\left\{\sum_{p=1}^{P}\sum_{d=1}^{D}\sum_{i=1}^{11}(1-\alpha_i)r_i\,\Phi P_{d,}S_p\,(1-k_i)\eta_i\beta_{S_p,T_s}\hat{\eta}_i(1-h_i)\right\} \quad (13)$$

Given that K and H are constants, hi refers to the moisture content in material i-th after stabilization.

The emission limits from the incinerator related to sulfur oxides, hydrochloric acid, nitrogen oxides, heavy metals, and dust are given by the following expressions: [E_{\text{SOx}} \leq C_{\text{SOx}}^{\max}] Where (E_{\text{SOx}}) represents the total sulfur dioxide emissions from the facility, and (C_{\text{SOx}}^{\max}) is the maximum allowed concentration of SOx in the flue gas; [E_{\text{HCl}} \leq C_{\text{HCl}}^{\max}] In which (E_{\text{HCl}}) represents the total emission of HCl, and (C_{\text{HCl}}^{\max}) is the maximum permitted concentration of HCl: [E_{\text{HF}} \leq C_{\text{HF}}^{\max}] In which (E_{\text{HF}}) represents the total emission of HF, and (C_{\text{HF}}^{\max}) is the maximum permitted concentration of HF; [E_{\text{NOx}} \leq C_{\text{NOx}}^{\max}] In whch (E_{\text{NOx}}) represents the total emission of nitrogen oxides, and (C_{\text{NOx}}^{\max}) is the maximum permitted concentration of Nox; [E_{\text{heavy\ metals}} \leq C_{\text{heavy\ metals}}^{\max}] In which (E_{\text{heavy\ metals}}) represents the total emission of heavy metals, and (C_{\text{heavy\ metals}}^{\max}) is the maximum permitted concentration of heavy metals; [E_{\text{dust}} \leq C_{\text{dust}}^{\max}] in which (E_{\text{dust}}) represents the total dust emission, and (C_{\text{dust}}^{\max}) is the maximum permitted dust concentration.

Since sanitary landfills are not environmentally sustainable over a long period, the model must include a limitation on their saturation. Since such a limitation can be expressed in terms of the minimum filling time, this constraint can be mathematically written as follows: $\hat{}\hat{Q}_{I_n,L_m}+\hat{Q}_{P_d,L_m}+\hat{Q}_{S_p,L_m}+\hat{Q}_{som,L_m}+\hat{Q}_{T_s,L_m}+\hat{Q}_{C_q,L_m} \leq \frac{V_{Lm}}{T_{L_m}}$, where V_{Lm} is the amount of waste that saturates the landfill, and T_{Lm} is the time it takes for the landfill to reach saturation.

Conclusion

The developed model in this paper represents an efficient decision support system (DSS) for improving the operations of public utility companies in the Republic of Serbia. It is essential for optimizing municipal waste management, as well as for integrating recycling and waste disposal. The model is developed based on the formalization of a constrained nonlinear optimization problem, where some decision variables are binary, while others are continuous. The objective function encompasses all potential economic costs, while the constraints are based on technical, regulatory, and environmental aspects. In general, this approach allows for the exploration of various aspects that are important for planning a municipal waste management system. Special emphasis is placed on the precise characterization of the system in terms of the chemical composition of waste, calorific value, material recovery, and available treatment methods. Attention is also given to environmental impacts.

However, like any model, this one also has several shortcomings. The first drawback concerns the complexity of the model. The model contains many variants and functions, including binary and integer variables. This complexity may complicate analysis and implementation, as well as require robust software for solving. Although it is mentioned that the functions are nonlinear, certain assumptions about linearity in the optimization problem may reduce the accuracy of the model. For example, factors such as transportation costs, which may behave nonlinearly as a function of distance, may not be accurately modeled. The model must adapt to constantly changing laws and regulations, which may make its long-term use difficult. If new laws become stricter concerning certain types of waste, the model may not be sufficiently adaptable. Many types of waste are interrelated. For example, recycling one material (e.g., plastic) can affect the availability and processing costs of another material. This interdependence may not be adequately modeled. The waste treatment process is dynamic, with seasonal variations in the quantity and type of waste. The model may fail to capture the timing of these variations and may not easily adjust to changes or events. Additionally, the market for recycled materials and energy can be unstable and subject to fluctuations. This can affect the profitability of the solutions proposed in the model and significantly reduce the attractiveness of certain waste treatment methods.

In summary, while the proposed model offers a comprehensive approach to solid waste management, considering various relevant aspects, it possesses several limitations that could impact its effectiveness and practical implementation. It is recommended that further verification and sensitivity analysis be conducted, and that the model be integrated with empirical data and practical experience to enhance its applicability and contribute more effectively to addressing the challenges of waste management.

References

Abbasi, M., & El Hanandeh, A. (2016). Forecasting municipal solid waste generation using artificial intelligence modelling approaches. *Waste management*, *56*, 13-22.

Abdoli, M., Falah Nezhad, M., Salehi Sede, R., & Behboudian, S. (2012). Longterm forecasting of solid waste generation by the artificial neural networks. *Environmental Progress & Sustainable Energy*, *31*(4), 628-636.

Achillas, C., Moussiopoulos, N., Karagiannidis, A., Banias, G., & Perkoulidis, G. (2013). The use of multi-criteria decision analysis to tackle waste management problems: a literature review. *Waste management & research*, *31*(2), 115-129.

Afzali, A., Sabri, S., Rashid, M., Mohammad Vali Samani, J., & Ludin, A. N. M. (2014). Inter-municipal landfill site selection using analytic network process. *Water resources management*, *28*, 2179-2194.

Aghad, M., Manaouch, M., Sadiki, M., Pham, Q. B., & Al Karkouri, J. (2024). Integrating fuzzy-AHP and GIS for solid waste disposal site selection in Kenitra province, NW Morocco. *Environmental Monitoring and Assessment*, *196*(6), 537.

Agbo, A. A. (2010). Cronbach's alpha: Review of limitations and associated recommendations. *Journal of Psychology in Africa*, *20*(2), 233-239.

Ahani, M., Arjmandi, R., Hoveidi, H., Ghodousi, J., & Miri Lavasani, M. R. (2019). A multi-objective optimization model for municipal waste management system in Tehran city, Iran. *International Journal of Environmental Science and Technology*, *16*, 5447-5462.

Alidoust, P., Keramati, M., Hamidian, P., Amlashi, A. T., Gharehveran, M. M., & Behnood, A. (2021). Prediction of the shear modulus of municipal solid waste (MSW): An application of machine learning techniques. *Journal of Cleaner Production*, *303*, 127053.

Alkan, N., & Kahraman, C. (2022). An intuitionistic fuzzy multi-distance based evaluation for aggregated dynamic decision analysis (IF-DEVADA): Its application to waste disposal location selection. *Engineering Applications of Artificial Intelligence*, *111*, 104809.

Alizadeh, M., Alizadeh, E., Asadollahpour Kotenaee, S., Shahabi, H., Beiranvand Pour, A., Panahi, M., ... & Saro, L. (2018). Social vulnerability assessment using artificial neural network (ANN) model for earthquake hazard in Tabriz city, Iran. *Sustainability*, *10*(10), 3376.

Ananda, J., & Herath, G. (2003). Incorporating stakeholder values into regional forest planning: a value function approach. *Ecological Economics*, *45*(1), 75-90.

Anwar, S., Elagroudy, S., Abdel Razik, M., Gaber, A., Bong, C. P. C., & Ho, W. S. (2018). Optimization of solid waste management in rural villages of developing countries. *Clean Technologies and Environmental Policy*, *20*, 489-502.

Antanasijević, D., Pocajt, V., Popović, I., Redžić, N., & Ristić, M. (2013). The forecasting of municipal waste generation using artificial neural networks and sustainability indicators. *Sustainability science*, *8*, 37-46.

Anthony, M., Boros, E., Crama, Y., & Gruber, A. (2017). Quadratic reformulations of nonlinear binary optimization problems. *Mathematical Programming*, *162*, 115-144

Azadi, S., & Karimi-Jashni, A. (2016). Verifying the performance of artificial neural network and multiple linear regression in predicting the mean seasonal municipal solid waste generation rate: A case study of Fars province, Iran. *Waste management*, *48*, 14-23.

Ayeleru, O. O., Okonta, F. N., & Ntuli, F. (2018). Municipal solid waste generation and characterization in the City of Johannesburg: A pathway for the implementation of zero waste. *Waste Management*, *79*, 87-97.

Ayeleru, O. O., Fajimi, L. I., Oboirien, B. O., & Olubambi, P. A. (2021). Forecasting municipal solid waste quantity using artificial neural network and supported vector machine techniques: A case study of Johannesburg, South Africa. *Journal of Cleaner Production*, *289*, 125671.

Batinić, B., Vukmirović, S., Vujić, G., Stanisavljević, N., Ubavin, D., & Vukmirović, G. (2011). Using ANN model to determine future waste characteristics in order to achieve specific waste management targets-case study of Serbia.

Belton, V., & Stewart, T. (2012). *Multiple criteria decision analysis: an integrated approach*. Springer Science & Business Media.

Bertsimas, D., & Tsitsiklis, J. N. (1997). *Introduction to linear optimization* (Vol. 6, pp. 479-530). Belmont, MA: Athena Scientific.

Camero, A., Toutouh, J., Ferrer, J., & Alba, E. (2019). Waste generation prediction under uncertainty in smart cities through deep neuroevolution. *Revista Facultad de Ingeniería Universidad de Antioquia*, (93), 128-138.

Chang, Y. H., & Chang, N. B. (1998). Optimization analysis for the development of short-team solid waste management strategies using presorting process prior to incinerators. *Resources, Conservation and Recycling*, *24*(1), 7-32.

Charkhgard, H., Savelsbergh, M., & Talebian, M. (2018). A linear programming based algorithm to solve a class of optimization problems with a multi-linear objective function and affine constraints. *Computers & Operations Research*, *89*, 17-30.

Chen, Y. C., & Wang, C. T. (2017). Municipal solid waste (MSW) incineration's potential contribution to electricity production and economic revenue in Taiwan. *Journal of Taiwan Energy*, *4*(1), 93-106.

Chhay, L., Reyad, M. A. H., Suy, R., Islam, M. R., & Mian, M. M. (2018). Municipal solid waste generation in China: influencing factor analysis and multi-model forecasting. *Journal of Material Cycles and Waste Management*, *20*, 1761-1770.

Costi, P., Minciardi, R., Robba, M., Rovatti, M., & Sacile, R. (2004). An environmentally sustainable decision model for urban solid waste management. *Waste management*, *24*(3), 277-295.

Corvellec, H., Bramryd, T., & Hultman, J. (2012). The business model of solid waste management in Sweden–a case study of two municipally-owned companies. *Waste Management & Research*, *30*(5), 512-518.

Curtis, F. E., Johnson, T. C., Robinson, D. P., & Wächter, A. (2014). An inexact sequential quadratic optimization algorithm for nonlinear optimization. *SIAM Journal on Optimization*, *24*(3), 1041-1074.

Das, A. K., Chatterjee, U., & Mukherjee, J. (2022). Solid waste management through multi-criteria decision making: using analytic hierarchy process as an assessment framework for the Hooghly district, West Bengal. *GeoJournal*, *87*(Suppl 4), 911-930.

Demircan, B. G., & Yetilmezsoy, K. (2023). A hybrid fuzzy AHP-TOPSIS approach for implementation of smart sustainable waste management strategies. *Sustainability*, *15*(8), 6526.

Emkes, H., Coulon F., & Wagland, S. (2015). A decision support tool for landfill methane generation and gas collection. *Waste Management,* 43, 07–318.

Eriksson, O., & Bisaillon, M. (2011). Multiple system modelling of waste management. *Wast Management,* 31, 2620–2630.

Eriksson, O., Olofsson M., & Ekvall, T. (2003). How model-based systems analysis can be improved for waste management planning. *Waste Management & Research,* 21, 488–500.

Fan, Y., Jiang, P., Tan, R. R., Aviso, K. B., You, F., Zhao, X., ... & Klemeš, J. J. (2022). Forecasting plastic waste generation and interventions for environmental hazard mitigation. *Journal of hazardous materials*, *424*, 127330.

Fan, Y., Jiang, P., Klemeš, J. J., Liew, P. Y., & Lee, C. T. (2021). Integrated regional waste management to minimise the environmental footprints in circular economy transition. *Resources, Conservation and Recycling*, *168*, 105292.

Fiorucci, P., Minciardi, R., Robba, M., & Sacile, R. (2003). Solid waste management in urban areas: Development and application of a decision support system. *Resources, conservation and recycling*, *37*(4), 301-328.

Fernandez, R. R., Sanchez Cruz, J. J., & Mata, G. V. (1996). Validation of a quality of life questionnaire for critically ill patients. *Intensive Care Medicine*, *22*, 1034-1042.

Floudas, C. A., & Visweswaran, V. (1995). Quadratic optimization. *Handbook of global optimization*, 217-269.

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of marketing research*, *18*(1), 39-50.

Gratton, S., & Toint, P. L. (2020). A note on solving nonlinear optimization problems in variable precision. *Computational Optimization and Applications*, *76*, 917-933.

Gue, I. H. V., Lopez, N. S. A., Chiu, A. S., Ubando, A. T., & Tan, R. R. (2022). Predicting waste management system performance from city and country attributes. *Journal of Cleaner Production*, *366*, 132951.

Guessi, M., Oliveira, L. B. R. D., & Nakagawa, E. Y. (2011). Current state on representation of reference architectures.

Hayes, A. F., & Coutts, J. J. (2020). Use omega rather than Cronbach's alpha for estimating reliability. But…. *Communication Methods and Measures*, *14*(1), 1-24.

Herva, M., Neto, B., & Roca, E. (2014). Environmental assessment of the integrated municipal solid waste management system in Porto (Portugal). *Journal of cleaner production*, *70*, 183-193.

Hung, M. L., Ma, H. W., & Yang, W. F. (2007). A novel sustainable decision making model for municipal solid waste management. *Waste management*, *27*(2), 209-219.

Hochbaum, D. S. (2007). Complexity and algorithms for nonlinear optimization problems. *Annals of Operations Research*, *153*, 257-296.

Hollebeek, L., & Rather, R.A. (2019). Service innovativeness and tourism customer outcomes. *International Journal of Contemporary Hospitality Management,* 31(11), 4227-4246.

Hoque, M. M., & Rahman, M. T. U. (2020). Landfill area estimation based on solid waste collection prediction using ANN model and final waste disposal options. *Journal of Cleaner Production*, *256*, 120387.

Ikhlayel, M., Higano, Y., & Yabar, H. (2013, July). Proposal for a sustainable and integrated municipal solid waste management system in Amman, Jordan based on the life cycle assessment method. In *Proceedings of the 23rd Pacific Conference of the Regional Science Association International (RSAI), Bandung, Indonesia* (pp. 2-4).

Jalali, N & Nouri, E. (2008). Prediction of municipal solid waste generation by use of artificial neural network: A case study of Mashhad.

Jia, Y. B. (2022). Nonlinear optimization.

Kabir, G., Ahmed, S. K., Aalirezaei, A., & Ng, K. T. W. (2022). Benchmarking Canadian solid waste management system integrating fuzzy analytic hierarchy process (FAHP) with efficacy methods. *Environmental Science and Pollution Research*, *29*(34), 51578-51588.

Kahraman, C., Keshavarz Ghorabaee, M., Zavadskas, E. K., Cevik Onar, S., Yazdani, M., & Oztaysi, B. (2017). Intuitionistic fuzzy EDAS method: an application to solid waste disposal site selection. *Journal of Environmental Engineering and Landscape Management*, *25*(1), 1-12.

Kannangara, M., Dua, R., Ahmadi, L., & Bensebaa, F. (2018). Modeling and prediction of regional municipal solid waste generation and diversion in Canada using machine learning approaches. *Waste management*, *74*, 3-15.

Kang, Y. O., Yabar, H., Mizunoya, T., & Higano, Y. (2024). Optimal landfill site selection using arcgis multi-criteria decision-making (mcdm) and analytic hierarchy process (ahp) for kinshasa city. *Environmental Challenges*, *14*, 100826.

Khan, S., & Faisal, M. N. (2008). An analytic network process model for municipal solid waste disposal options. *Waste management*, *28*(9), 1500-1508.

Kharat, M. G., Murthy, S., Kamble, S. J., Raut, R. D., Kamble, S. S., & Kharat, M. G. (2019). Fuzzy multi-criteria decision analysis for environmentally conscious solid waste treatment and disposal technology selection. *Technology in Society*, *57*, 20-29.

Kitchenham, B., & Charters, S. (2007). Guidelines for performing systematic literature reviews in software engineering version 2.3. *Engineering*, *45*(4ve), 1051.

Kou, G., Miettinen, K., & Shi, Y. (2011). Multiple criteria decision making: Challenges and advancements. *Journal of Multi-Criteria Decision Analysis*, *18*.

Kulisz, M., & Kujawska, J. (2020). Prediction of municipal waste generation in Poland using neural network modeling. *Sustainability*, *12*(23), 10088.

Kurtulus, H., et al., (2006). Artificial neural network modeling of methane emissions at Istanbul Kemerburgaz-Odayeri landfill site. *Journal of Scientific & Industrial Research. 65*, 128–134.

Lin, K., Zhao, Y., Kuo, J. H., Deng, H., Cui, F., Zhang, Z., ... & Wang, T. (2022). Toward smarter management and recovery of municipal solid waste: A critical review on deep learning approaches. *Journal of Cleaner Production*, *346*, 130943.

Mahmoodian, V., Charkhgard, H., & Zhang, Y. (2021). Multi-objective optimization based algorithms for solving mixed integer linear minimum multiplicative programs. *Computers & Operations Research*, *128*, 105178.

Masebinu, S. O., Akinlabi, E. T., Muzenda, E., Aboyade, A. O., Mbohwa, C., Manyuchi, M., & Naidoo, P. (2017). Municipal solid waste data quality on artificial neural network performance.

Meza, J. K. S., Yepes, D. O., Rodrigo-Ilarri, J., & Cassiraga, E. (2019). Predictive analysis of urban waste generation for the city of Bogotá, Colombia, through the implementation of decision trees-based machine learning, support vector machines and artificial neural networks. *Heliyon*, *5*(11).

Mishra, S., Jena, L., Tripathy, H. K., & Gaber, T. (2022). Prioritized and predictive intelligence of things enabled waste management model in smart and sustainable environment. *PloS one*, *17*(8), e0272383.

Morrissey, A. J., & Browne, J. (2004). Waste management models and their application to sustainable waste management. *Waste management*, *24*(3), 297-308.

Murray, W., & Ng, K. M. (2010). An algorithm for nonlinear optimization problems with binary variables. *Computational optimization and applications*, *47*(2), 257-288.

Musarat, M. A., Alaloul, W. S., Hameed, N., Qureshi, A. H., & Wahab, M. M. A. (2022). Efficient construction waste management: A solution through industrial revolution (IR) 4.0 evaluated by AHP. *Sustainability*, *15*(1), 274.

Noori, R., Karbassi, A., & Sabahi, M. S. (2010). Evaluation of PCA and Gamma test techniques on ANN operation for weekly solid waste prediction. *Journal of Environmental Management*, *91*(3), 767-771.

Obara, M., Okuno, T., & Takeda, A. (2022). Sequential quadratic optimization for nonlinear optimization problems on Riemannian manifolds. *SIAM Journal on Optimization*, *32*(2), 822-853.

Oliveira, V., Sousa, V., & Dias-Ferreira, C. (2019). Artificial neural network modelling of the amount of separately-collected household packaging waste. *Journal of cleaner production*, *210*, 401-409.

Pan, S., Tan, T., & Jiang, Y. (2008). A global continuation algorithm for solving binary quadratic programming problems. *Computational Optimization and Applications*, *41*, 349-362.

Ponce, E. (2004). *A model for assessing waste generation factors and forecasting waste generation using artificial neural networks: a case study of chile* (Doctoral dissertation, Lincoln University).

Press, W. H. (1988). Numerical recipes in C++: the art of scientific computing. *(No Title)*.

Rani, P., Mishra, A. R., Krishankumar, R., Ravichandran, K. S., & Kar, S. (2021). Multi-criteria food waste treatment method selection using single-valued neutrosophic-CRITIC-MULTIMOORA framework. *Applied Soft Computing*, *111*, 107657.

Dević, Ž., Ćurčić, N., & Radivojević, N. (2014). Creating a concept marketing communication in international business-to-business market. *Ekonomika*, *60*(3), 225-235.

Radivojević, N., Ćurčić, N., & Dević, Ž. (2016). Implementation of the model of 'Transformational managerial competences' in the process of restructuring of 'Zastava machines A.D.', Kragujevac. *Ekonomika*, *62*(1), 23-42. https://doi.org/10.5937/ekonomika1601023R

Rather, R.A., & Sharma, J. (2019). Dimensionality and consequences of customer engagement: A social exchange perspective. *Vision*, 23(3), 255-266.

Ridley, S. A. (1997). Validation of a quality of life questionnaire for critically ill patients. *Intensive care medicine*, *23*(4), 483-484.

Rodriguez Heck, E. (2018). Linear and quadratic reformulations of nonlinear optimization problems in binary variables.

Rudin, C. (2019). Stop explaining black box machine learning models for high stakes decisions and use interpretable models instead. *Nature machine intelligence*, *1*(5), 206-215.

Taherdoost, H. (2016). Validity and reliability of the research instrument; how to test the validation of a questionnaire/survey in a research. *International Journal of Academic Research in Management (IJARM)*, *5*.

Torkayesh, A. E., Rajaeifar, M. A., Rostom, M., Malmir, B., Yazdani, M., Suh, S., & Heidrich, O. (2022). Integrating life cycle assessment and multi criteria decision making for sustainable waste management: key issues and recommendations for future studies. *Renewable and Sustainable Energy Reviews*, *168*, 112819.

Trizano-Hermosilla, I., & Alvarado, J. M. (2016). Best alternatives to Cronbach's alpha reliability in realistic conditions: congeneric and asymmetrical measurements. *Frontiers in psychology*, *7*, 769.

Sadati, S. A., Zaukeri Getabi, P., & Rabbani, M. (2024). A sustainable modelling for solid waste management using analytical hierarchy process, Monte Carlo simulation and NSGA-III. *International Journal of Systems Science: Operations & Logistics*, *11*(1), 2301603.

Santibanez-Aguilar, J.E., Flores-Tlacuahuac, A., Rivera-Toledo, M., Ponce-Ortega, J.M., 2017. Dynamic optimization for the planning of a waste management system involving multiple cities. Journal of Cleaner Production 165, 190e203.

Shaban, A., Zaki, F. E., Afefy, I. H., Di Gravio, G., Falegnami, A., & Patriarca, R. (2022). An optimization model for the design of a sustainable municipal solid waste management system. *Sustainability*, *14*(10), 6345.

Shahabi, H., Khezri, S., Ahmad, B. B., & Zabihi, H. (2012). Application of artificial neural network in prediction of municipal solid waste generation (Case study: Saqqez City in Kurdistan Province). *World Applied Sciences Journal*, *20*(2), 336-343.

Shamshiry, E., Bin Mokhtar, M., & Abdulai, A. (2014, March). Comparison of artificial neural network (ANN) and multiple regression analysis for predicting the amount of solid waste generation in a tourist and tropical area—Langkawi Island. In *proceeding of International Conference on Biological, Civil, Environmental Engineering (BCEE)* (pp. 161-166).

Shams, S., Sahu, J. N., Rahman, S. S., & Ahsan, A. (2017). Sustainable waste management policy in Bangladesh for reduction of greenhouse gases. *Sustainable cities and society*, *33*, 18-26.

Singh, D., & Satija, A. (2018). Prediction of municipal solid waste generation for optimum planning and management with artificial neural network—case study: Faridabad City in Haryana State (India). *International Journal of System Assurance Engineering and Management*, *9*, 91-97.

Shukor, A. A. H. M., Ishak, N. M., Salleh, S. A., & Othman, F. (2024, March). Waste Management: Landfill Selection Using Gis and Analytical Hierarchy Process. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1316, No. 1, p. 012003). IOP Publishing.

Soltani, A., Hewage, K., Reza, B., & Sadiq, R. (2015). Multiple stakeholders in multi-criteria decision-making in the context of municipal solid waste management: a review. *Waste Management*, *35*, 318-328.

Souza Melaré, A. V., González, S. M., Faceli, K., & Casadei, V. (2017). Technologies and decision support systems to aid solid-waste management: a systematic review. *Waste management*, *59*, 567-584.

Staples, M., & Niazi, M. (2008). Systematic review of organizational motivations for adopting CMM-based SPI. *Information and software technology*, *50*(7-8), 605-620.

Yamin, H. Y., Shahidehpour, S. M., & Li, Z. (2004). Adaptive short-term electricity price forecasting using artificial neural networks in the restructured power markets. *International journal of electrical power & energy systems*, *26*(8), 571-581.

Younes, M. K., Nopiah, Z. M., Basri, N. A., Basri, H., Abushammala, M. F., & Maulud, K. N. A. (2015). Prediction of municipal solid waste generation using nonlinear autoregressive network. *Environmental monitoring and assessment*, *187*, 1-10.

Yousefloo, A., & Babazadeh, R. (2020). Designing an integrated municipal solid waste management network: A case study. *Journal of cleaner production*, *244*, 118824.

Yusoff, S. H., Din, U. N. K. A., Mansor, H., Midi, N. S., & Zaini, S. A. (2018). Neural network prediction for efficient waste management in Malaysia. *Indonesian Journal of Electrical Engineering and Computer Science (IJEECS)*, *12*(2), 738-747.

Wilson, E. J., McDougall, F. R., & Willmore, J. (2001). Euro-trash: searching Europe for a more sustainable approach to waste management. *Resources, conservation and recycling*, *31*(4), 327-346.

Zhou, P., Fan, L. W., & Zhou, D. Q. (2010). Data aggregation in constructing composite indicators: A perspective of information loss. *Expert Systems with Applications*, *37*(1), 360-365.

Републички завод за статистику (2024), https://www.stat.gov.rs/vesti/statisticalrelease/?p=13623 датум ажуирирања 30.08.2024. године

World Bank (2024), https://data.worldbank.org датум ажурирања 31.08.2024. године

Apendix

- For the purposes of this work, the limits are set to the following values;
- (g \cdot HVi - 3600 \text{ kcal/kg}), where are:
  - **(HVi)**: Heating value for (i) type of material in MJ/kg.
  - **(g)**: The conversion factor used to convert MJ into kcal, given as (238.9 \text{ kcal/MJ}).
  - Thus, the limitation is imposed that the heating value for a given material must be above (3600 \text{ kcal/kg}).

2. Restriction regarding chloride content (Cli)

- Another limitation refers to the chloride content in the produced RDF, which must be less than (0.9%).
  - (0.009 - Cli): This expression ensures that the chlorophytic content for the (i)th type of material is less than (0.009) (or (0.9%)).

3. Sulfur (Si) content limit

- The third limitation refers to the sulfur content:
  - **(0.006 - Si)**: As with chlorine, this limit ensures that the sulfur content of the RDF is less than (0.6%) ((0.006)).

4. Ash content limitation (Ashi)

- The fourth limitation refers to the ash content:
  - **(0.002 - Ashi)**: This limit ensures that the ash content of RDF is less than (0.2%)

ЕКОНОМИКА
ISSN 0350-137X, EISSN 2334-9190, UDK 338 (497,1)
Vol. 71, april-june 2025, № 1
P. 45-53

Milica Cvetković[1]
Vladimir Đorđević[2]
Faculty of Business Economics and Entrepreneurship, Belgrade

Zoran Simonović[3]
Institute for Agricultural Economics, Belgrade

ORIGINAL SCIENTIFIC ARTICLE
DOI: 10.5937/ekonomika2502045C
Received: Februry 17, 2025
Accepted: April 03, 2025

INFLUENCE OF HUMAN CAPITAL ON COMPANY PERFORMANCE

Abstract

The modern business environment is characterized by the emergence of innovative ways of doing business that are based on new technologies and knowledge. Society is becoming a knowledge society, and companies are beginning to use knowledge resources more and more intensively through human capital. In knowledge-based societies, investing in human capital through education has become a necessary condition for reflecting and increasing the competitiveness of companies. Human capital creates value in a company, but it cannot be created without employees, because human capital is their property. For the successful realization of performance in the company, only competition is not enough, but dedication to the goals is necessary. The work aims to express the importance of human capital for the company and its performance through an analysis of the importance and management of human capital.

Keywords: *human capital, investment, enterprise, competitiveness, performance.*

JEL classification: *J24, L25*

УТИЦАЈ ЉУДСКОГ КАПИТАЛА НА ПЕРФОРМАНСЕ ПРЕДУЗЕЋА

Апстракт

Савремено пословно окружење, карактерише појава иновативних начина пословања која су базирана на новим технологијама и знању. Друштво постаје друштво знања, а предузећа почњу све интензивније да користе ресурс знања кроз хумани капитал. У друштвима која се заснивају на знању, улагање у хумани капитал кроз образовање постали су неопходан услов за одражавање и увећање конкурентности предузећа. Хумани капитал ствара вредност у предузећу, али се та вредност не може створити без запослених, јер је хумани капитал њихово власништво. За успешно остваривање перформасни

[1] milica.cvetkovic@vspep.edu.rs ORCID ID 0000-0002-1235-3570

[2] vladimir.djordjevic@vspep.edu.rs ORCID ID 0000-0002-6906-1712

[3] zoki@medianis.net ORCID ID 0000-0002-2769-6867

у предузећу нису довољне само компетиције, већ је неопходна посвећеност циљевима. Рад има за циљ да кроз анализу значаја и управљана хуманим капиталом искаже његову важност за предузеће и његове перформанце.

Кључне речи: *хумани капитал, улагање, предузеће, конкурентност, перформансе.*

Introduction

Effective use of intangible resources, including human capital, forms the backbone of achieving a competitive advantage for companies operating in the knowledge-based economy. As an integral part of intellectual capital, human capital consists of employees' knowledge and skills, talents, creativity, enthusiasm, and learning ability.

Every company needs to have employees who possess unique human capital, which is reflected in the specific competencies, knowledge, and abilities of employees. The key factor in the success of modern companies is the employees. Human capital as a component of intellectual capital is characteristic of employees, where with the ability to learn, teamwork, flexibility, and commitment to the company, performance is achieved and competitive advantage is reflected. "Human capital, which represents one of the most important and integral components of the intellectual capital and intangible assets of the company, can be defined as a combination of knowledge, skills, experience, ability, and innovation of employees to perform tasks in the company". (Bonits, 2001)

In the era of knowledge-based business, resources that do not have a physical form are the backbone of success and progress. Intangible resources do not have a physical essence but include specific knowledge, patents, knowledge of consumer needs, organizational culture, and other factors that can lead to business success. "The set of knowledge, skills, experience, creativity, and innovation of employees represents human capital." The main carriers of the so-called human capital are employees, who, by implementing specific competencies, enable the creation of company value and the achievement of a sustainable competitive advantage". (Ghorbanhosseini, 2013)

The goal of every organization is to create as much added value as possible with existing capacities and assets. Human capital is largely determined by the knowledge and skills of employees, who can transfer them into value. A very important segment for a successful reduction business is the operational skills that employees must possess. However, possessing relevant operational skills is not enough in itself, because it is very important that employees who are an integral element of human capital also possess certain personal qualities such as endurance, dedication, and motivation.

The importance of human capital for a company

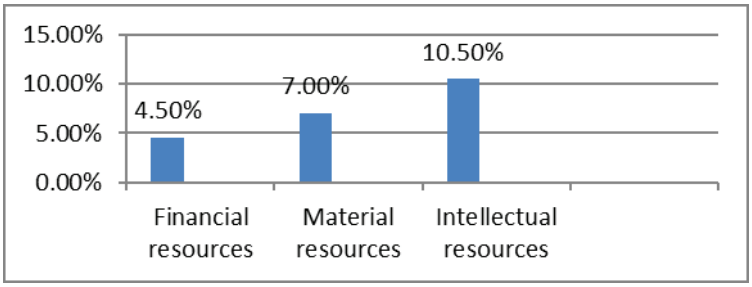
The modern economy is a knowledge economy, which experienced its development through the process of globalization and technological development. In such an economy, new companies appear that are focused on gathering, creating, and

using knowledge to survive in a dynamic market. “Companies are forced to adjust their asset structure due to technical progress and intense competition in modern business conditions.” (Prdić, N., 2017) The use and improvement of the company’s intellectual resources become necessary because the creation of economic value is based on the use of intangible resources.

Human capital is an integral part of intellectual capital, in addition to structural and relational intellectual capital. The existence of human capital in a company implies, first of all, the identification of human capital as an integral part of intellectual capital. According to Rossi, human capital as a building block of intellectual capital is considered a key driver of value creation in a company. “Also, this part of intellectual capital represents the main pillar of innovative business strategies of economic entities”. (Tseng, C.-Y., & Goo, Y.-J.J, 2005)

Successful management of human resources not only brings benefit to the individual who owns intellectual capital, income to the company where that individual works, and to the country but also to the whole world through intellectual innovation and transformation of people. (Anghel, 2008) In addition, Lev (2000) found that there is a difference in the rates of return on investments in financial, material, and intellectual resources of the company, which is shown in graph number 1.

Graph No. 1: Rate of return on investment in acquisition resources



Source: Lev (2000), adapted from Anghel (2008)

Within economic growth theories, human capital is seen as one of the production factors that influence economic growth, along with land, labor, and physical capital. “As such a resource, human capital records a downward trend due to the increase in unemployment, poor attitude of entrepreneurs and negative demographic trends”. (Đekić, 2015). To effectively manage human capital, it is first necessary to determine its economic value. As the most important asset of a company in the knowledge economy, the value of human capital cannot be seen in the balance sheet, because reporting on human capital as an asset of the company has not yet been developed. Companies can use non-standard supplementary financial measures to report on human capital to stakeholders inside and outside the company. “The book value of human capital represents the historical cost of human capital as an asset based on the price paid. The market value of human capital includes the current price at which human capital can be sold, and often the market value does not coincide with the fair value”. (Alkhimenko, 2014)

As a particularly useful benchmark, the so-called VAIC model (Value Added Intellectual Coefficient). According to the mentioned model, value added (VA) is obtained when total costs (IN) are subtracted from sales revenue (OUT), except for those costs related to employee wages, which are not treated as an expense but as an investment in human capital. (Merriman, 2017) The model can be expressed quantitatively as follows:

VA=OUT-IN

Human capital (HCA), which can be quantitatively determined when the previously determined added value (VA) is divided by the total wages paid to employees in one year (HC), which can be quantitatively represented: (Pulić, 2000)

HCE=VA/HC

In order to operate sustainably, businesses must maintain a competitive advantage through constant innovation. Also, an important factor in the competitive advantage of companies in the knowledge economy is learning and knowledge. Petty and Guthrie (2000), believe that the factors that generate company value are the competitive advantage of the company itself. Therefore, the development of specific competencies is a source of sustainable competitive advantage.

The importance of human capital is reflected in the fact that it provides a return on invested capital since its creation implies certain expenses of the company, which must be seen as an investment and not as an expense. That is why it is important to find such measures of human capital that will take into account the value that must be realized to ensure a sustainable competitive advantage. Since human and other intellectual resources represent a key determinant of the success of a company in the modern environment, there is a problem of accurate and reliable financial valuation and inclusion of these resources through the balance sheet. Financial criteria prevail or are exclusively present in reports on the success of most companies' operations. Therefore, reports on the operations of companies dominated by intellectual resources should be supplemented with information on non-financial performance measures, because the existing traditional financial reports are largely outdated and insufficient.

Human capital management

During the formation of human capital, an extremely important issue is to organize a set of human capital management activities in the organization. The primary activity is the provision of the basis for the creation of human capital, as well as the selection of employees, which defines clear criteria for the selection of candidates who have passed specific registration and testing. "The most important resource of the modern economy is knowledge. So, in the past two decades, the concept of knowledge management has gained importance and is recognized as the main factor in the modernization of business". (Milojević, Savićević, Dimitrijević, 2023).

In addition to careful registration, selection, and education of employees, a strategic approach is also needed in defining compositional systems with incentives for employee motivation. Activities useful for the formation and management of human capital include:

- Open and active communication between employees at all levels;
- Formation of cross-functional teams, which, in addition to knowledge for performing their work, acquire knowledge from other functions in the organization;
- Ensuring a balance between the employee's private life and work, by providing flexible free time, the possibility of being absent due to personal obligations, and the like. (Luthans, 2004)

The basic components of human capital are knowledge, competencies, and talents. To develop, it is necessary to manage them and to manage, it is necessary to define strategies and implement them. The knowledge management strategy should be based on knowledge analysis, which identifies deviations or differences between existing and required knowledge. Competence management ensures the development of employees through adaptation to the challenges that arise in the environment. Through the competence management process, performances are managed and deficiencies that limit development are recognized. An increasingly important topic when it comes to human capital management is talent management because it constitutes a company's competitive advantage.

Table No. 1: Model of three stages of human resource management

Phase	Human resource management activities
Pre-combination	Dissemination of knowledge, determination of leaders who will manage the change process, careful assessment of human resources, assessment of organizational culture, creation of knowledge exchange practices.
Combining	Creating a new strategy and practice of human resources management, employee motivation, change management, communication, establishing a new culture, formulating a strategy for reducing employees.
Consolidation	Assessment of new practice and strategy of human resources management, assessment of new organizational culture, creation and exchange of knowledge, knowledge management.

Source: Schuler R., u Jackson, S., (2001). HR issues and activities in mergers and acquisitions. European Management Journal, 19(3), cmp. 243-249.

The human resources management process involves certain activities to ensure a unique flow of information, processes, and activities. Enterprises should effectively provide and direct it based on a systematic assessment of the performance of the use of intellectual resources and the quantification of intellectual capital. Based on these measurements, assessments, and analyses, it is necessary to create a report on the evaluation of intellectual performance. "Efficiency in knowledge management largely depends on the successful application of modern information and communication technologies." (Erceg, Zoranović, 2022)

Intellectual capital is one of the most important drivers of increasing value in a company, so the following table shows the difference between tangible and intangible assets from the point of view of valuation and reporting.

Table No2: Valuation and reporting related to tangible and intangible assets

Valuation of tangible assets	Valuation of intangible assets
Event record	Process record
Just the past	Past + future
Costs	Value
Monetary effects	Non-monetary effects
Periodic reports	Current reporting
Statutory financial statements	Managerial reports

Source: Đuričin, D., Janošević, S.,& Kaličanin, Đ. (2012).Menadžment i strategija. Beograd:Centar za izdavačku delatnost Ekonomskog fakulteta u Beogradu

The main element of human capital is education, which refers to investments and production effects that are measured and expressed in monetary units. "At the micro level, research shows that education and literacy affect variations in earnings. The non-economic consequences of human capital show that a higher level of education has a positive effect on human health, on the reduction of the crime rate as well as on the intensity of social and political participation". (Đorđević, Cvetković, Momčilović, 2021)

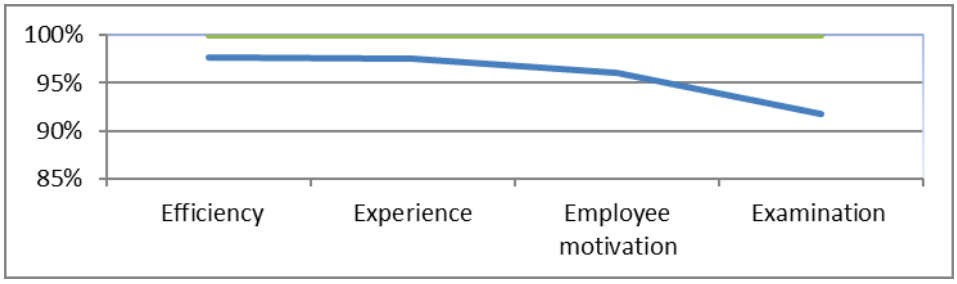
The problem of efficient and effective management of human capital, i.e. intellectual performance is accentuated because of the complex cause-and-effect relationships (connections) between parts of human capital. Therefore, a careful analysis of intellectual capital can reveal the interdependence of its influential elements through the management of knowledge, innovation, and intellectual property.

Intellectual performance of enterprises

The concept of intellectual performance includes two dimensions, namely, the performance of non-intellectual resources, as well as the performance of the use of intellectual resources. "The performance of intellectual resources is their characteristics, whether of a strategic or operational nature." The performance of the use of intellectual resources is the effects - the results of their use, effectiveness, and efficiency. For a company, for example, it is important how many experts, especially professionals, it has and what kind of knowledge and competence profile they have, but what effects they achieve in their work is much more relevant. In the research and development of the company, the competence portfolio of the employees is important, but even more important is the performance - innovative output and productivity. In the case of intellectual property, on the other hand, the number of registered patents is valuable as a performance of these resources, but much more important is the performance of use, such as the number of new products based on patented technologies or revenues generated from licenses for patented technologies. (Krstić, 2009)

To define the performance criteria of intellectual resources, the experiences of other companies, especially successful ones, can be used. Performance measures can be qualitative measures (image) and quantitative non-financial measures (level of employee qualification). What is important to note is that it is not possible to form a single list of intellectual resource performance benchmarks, due to the difference in size, number of employees, and activities between the companies themselves.

Graph No. 2: The influence of human capital factors on company performance



Source:, Editing by the author according to Štebih, S., Uticaj lidersta na razvoj intelektualnog kapitala u savremenim orgabizacijama, Univerzitet Singidunum.

The graphic display shows the key factors of human capital, which have the greatest influence on business results and success in companies. The obtained data are the result of a survey conducted in the Republic of Serbia. In the first place in terms of its influence on the company's performance, the efficiency of employees stands out, followed by experience, motivation, and, finally, expert knowledge. Highlighting the efficiency of employees shows that the management directs responsibility to all individuals in the company, emphasizing that this factor of human capital is the most influential. The encouraging fact is that employee motivation is an influential factor, which indicates the existence of awareness of the importance of employee motivation itself as a powerful tool for regulating relationships and achieving goals in the company.

Intellectual resources must be continuously improved, developed, and increased because competitive advantage depends on their characteristics (performance). Namely, how many barriers a company can create for its rivals in terms of benefits depends on the uniqueness of these resources and capabilities developed based on them and their differentiation from the intellectual resources and capabilities of competitors. Of the total package of benefits it provides to clients. Competitive advantage, here, is derived directly from the performance of intellectual resources and the performance of their productive use, which is reflected through the growth of production and service potential and the development of the company. Intellectual resources, knowledge in the broadest sense, are contained in new products/services that provide desired benefits for consumers. Companies compete based on the differentiation of products and services - quality, reliability, efficiency, ease of use, aesthetic feeling, costs, etc. The combination of these and other product features, which make it more valuable and superior to competitors, creates a relative advantage over rival companies. That advantage, in the end, is affected by a better strategic position and then a higher market value.

Conclusion

The development and generation of human capital is realized through the synergy of several factors, which carry out the transmission of formal and informal knowledge, which further affects the very development of the company in which the workforce exists. Increasing the competitiveness of the organization is conditioned by the knowledge and skills of the employees, representing the primary benefit that comes with the development of human capital. It is precisely this immeasurable value of human capital that influences the creation of additional value through the increase and growth of performance.

In the future, companies will differ in whether and how much they invest in human capital. Given that human capital ensures better market positioning and represents a key determinant of the success of realizing competitiveness, it is necessary to manage this resource. Competent individuals are the most important asset of the company and their knowledge and abilities should be transformed into collective knowledge that remains in the permanent ownership of the company as structural capital. The knowledge economy is based on the human mind, that is, ideas, so companies face the challenges of how to motivate individuals to use their minds in creating value for both the company itself and the entire economy.

Reference

Anghel, I. (2008). *Intellectual capital and intangible assets analysis and valuation*, Theoretical and Applied Economics, 3(520), 75-84.

Alkhimenko, O.N., Asaliev, A.M. & Kuksova, O.D. (2014). *Human capital and its efficiency in the knowledge economy*: the role of continuing education. *Review of European Studies*, 6(4), 277-282.

Bontis, N. (2001). *Assessing knowledge assets: a review of the models used to measureintellectual capital*, International Journal of Management Review, 3(1), 41-60.

Đorđević, V., Cvetković, M., Momčilović, A., (2021). *Uticaj humanog kapitala na privredni razvoj*, Oditor, str.110.

Đekić, I. (2015). Improving human capital in Serbia. *Ekonomika*, *61*(3), 133-150. https://doi.org/10.5937/ekonomika1503133D pp.134.

Đuričin, D., Janošević, S.,& Kaličanin, Đ. (2012). *Menadžment i strategija*, Centar za izdavačku delatnost Ekonomskog fakulteta u Beogradu.

Erceg, V., Zoranović, T., (2022). *Knowledge management and digital business transformation,* Strategic Management, pp. 58.

Ghorbanhosseini, M. (2013). *The effect of organizational culture, teamwork and organizational development on organizational commitment*: the mediating role of human capital. Tehnički Vjesnik, 20(6), 1019-1025.

Guthrie, J., & Petty, R. (2000). *Intellectual Capital*: Australian Annual Reporting Practices. Journal of Intellectual Capital, 1, 241-251.

Janošević, S., & Dženopoljac, V., & Bontis, N. (2013). *Intellectual capital and financial performance in Serbia. Knowledge and Process Management*, 20(1), 1-11.

Krstić, B., (2009). *Upravljanje intelektualnim performansama preduzeća*, Ekonomske teme, Ekonomski fakultet, Niš, str. 61.

Luthans, F., & Youssef, C.M. (2004). *Human, social, and now positive psychological capital management: investing in people for competitive advantage*, Management Department Faculty Publications, 154, 1-27.

Merriman, K.K. (2017). *Valuation of human capital*, Springer International Publishing AG: Palgrave Macmillan.

Milojević, I., Savićević, M., Dimitrijević, M., (2023). *Impact of knowledge transfer on ecological innovations onf acquired companies in Serbia,* The Annals of the Faculty of Economics in Subotica, pp.124.

Pulić, A. (2000). *VAIC - an accounting tool for IC management*, International Journal of Technology Management, 20, 702-714.

Prdić, N. (2017). *Konkurentska prednost preduzeća na onovu benčmarking analize poslovanja*, str.110.

Schulerm, R., & Jackson, S., (2001). *HR issues and activities in mergers and acquisitions*. European Management Journal, 19(3), стр. 243-249.

Štebih, S., (2011). *Uticaj liderstva na razvoj intelektualnog kapitala u savremenim organizacijama,* Univerzitet Singidunut, Beograd, str. 73.

Tseng, C.-Y., & Goo, Y.-J.J. (2005). *Intellectual capital and corporate value in an emerging economy*: empirical study of Taiwanese manufacturers. R&D Management, 35(2), 187-201.

ЕКОНОМИКА
ISSN 0350-137X, EISSN 2334-9190, UDK 338 (497,1)
Vol. 71, april-june 2025, № 1
P. 55-72

Aluncedo Nqunqa[1]
Steven Kayambazinthu Msosa [2]
Mangosuthu University of Technology,
Faculty of Management Sciences, Durban, South Africa

ORIGINAL SCIENTIFIC ARTICLE
DOI: 10.5937/ekonomika2502055N
Received: January 14, 2025
Accepted: May 05, 2025

ASSESSING THE RELATIONSHIP BETWEEN CUSTOMER SATISFACTION AND CUSTOMER LOYALTY IN THE SOUTH AFRICAN RETAIL SECTOR

Abstract

This study examined the relationship between customer satisfaction and customer loyalty in the South African retail sector. A quantitative and descriptive research design was used to collect data from a convenience sample of 150 respondents. Data were analysed using the Statistical Package for Social Sciences (SPSS). The results show a significant positive correlation between customer satisfaction and loyalty, highlighting the importance of quality service, product offerings, and store atmosphere. The findings also reveal that customers prioritize convenience, affordability, and customer support when evaluating retail experiences. The study's outcomes have practical implications for retailers, emphasizing the need to prioritise customer-centric strategies to foster loyalty and retention amongst customers. By comprehending the factors that drive customer satisfaction, retailers can tailor their services to meet the unique needs of their customers. This research contributes to the extant body of literature on customer satisfaction and loyalty, providing insights specific to the retail sector in South Africa. Overall, this study underscores the significance of customer satisfaction in cultivating loyalty amongst customers in the retail sector, thereby informing strategies to enhance customer experiences and drive business success.

Key words: *Customer satisfaction, customer loyalty, retail sector, South Africa, products, services.*

JEL classification: *L15, M300, M31, G21.....*

ПРОЦЕНА ОДНОСА ИЗМЕЂУ ЗАДОВОЉСТВА И ЛОЈАЛНОСТИ КУПАЦА У СЕКТОРУ МАЛОПРОДАЈЕ ЈУЖНЕ АФРИКЕ

Абстракт

Ова студија је испитала однос између задовољства купаца и лојалности купаца у јужноафричком малопродајном сектору. Квантитативни и дескриптивни дизајн истраживања коришћен је за прикупљање података са практичног узорка од 150 испитаника. Подаци су анализирани коришћењем Статистичког пакета за друштвене науке (СПСС).Резултати показују значајну позитивну

[1] anqunqa752@gmail.com, ORCID ID 0009-0004-7773-4165

[2] msosa.steven@mut.ac.za, ORCID ID 0000-0001-9074-5644

корелацију између задовољства купаца и лојалности, истичући важност квалитетне услуге, понуде производа и атмосфере у продавници. Налази такође откривају да купци дају предност погодностима, приступачности и корисничкој подршци када процењују малопродајна искуства. Резултати студије имају практичне импликације за трговце на мало, наглашавајући потребу да се дају приоритет стратегијама усмереним на купца како би се подстакла лојалност и задржавање међу купцима. Разумевањем фактора који утичу на задовољство купаца, трговци на мало могу да прилагоде своје услуге тако да задовоље јединствене потребе својих купаца. Ово истраживање доприноси постојећој литератури о задовољству и лојалности купаца, пружајући увиде специфичне за малопродајни сектор у Јужној Африци. Све у свему, ова студија наглашава значај задовољства купаца у неговању лојалности међу купцима у малопродајном сектору, на тај начин информишући стратегије за побољшање корисничког искуства и подстицање пословног успеха.

Кључне речи: *задовољство купаца, лојалност купаца, малопродајни сектор, Јужна Африка, производи, услуге.*

Introduction

Nowadays, customer satisfaction is essential since it shows whether a company's target market approves a business's product or service. According to research, a high level of customer satisfaction leads to the retention of customers and a strong brand reputation (Franklin, 2023). A company's profitability is positively influenced by customer loyalty, and its profit margin may increase in line with the number of loyal customers. In reality, satisfied customers tend to be more receptive to service providers' relationship marketing efforts, as enhanced customer satisfaction increases the likelihood of potential customers returning in the future. However, customer satisfaction cannot guarantee customers' repeat purchases or the return of potential customers, but it can play a significant role in encouraging customer loyalty (Zephan, 2018). Khairawati (2019) states that a company's ability to retain customers is one of the company's strengths, but sadly, many businesses are unaware that building customer loyalty commences at numerous points, from finding potential clients to developing devoted clients who benefit the business. Customer satisfaction is a critical component or leading indicator for every organization to grow and develop a loyal customer base. As a result, it is critical for businesses to ensure that the needs of customers are attended to. In this 21st century, many businesses are established to compete with one another (Ranabhat, 2018) and how organisations treat or satisfy customers becomes a mark of distinction. Ahlawat (2022) asserts that customer loyalty is a key outcome of relationship marketing, which corresponds with variables such as customer satisfaction, customer expectations and service quality perceptions. Thus, the failure to meet implied expectations, issues with quality and issues with customer services affects customer satisfaction and customer loyalty negatively (Fuchs, 2022). Hotjar (2022) affirms that challenges with customer satisfaction may arise because of ineffective customer services or poor communication with customers, or a negative product experience that prevents buyers from returning. Customers who encounter a

negative experience with a company or company's goods or services are more likely to leave the company. Therefore, companies should ensure that they regularly evaluate customer satisfaction so that the can develop strategies aimed at changing their customers' behavioural intentions. Amha (2020) avers that ensuring client satisfaction should be the primary goal of any business organisation. Customer dissatisfaction affects companies in many different ways since consumers do not buy from untrusted businesses. In the long-run, this negatively impacts companies not only in terms of revenue and sales, but also in terms of a negative company reputation (Longe, 2022).

The aim of this study is to examine the relationship between customer satisfaction and customer loyalty in the South African retail sector. The paper is structured as follows; after the introduction, the first part discusses the theoretical framework that guided this study with specific reference to expectancy disconfirmation and assimilation theory, customer satisfaction, customer loyalty and the relationship between customer satisfaction and customer loyalty. This is followed by the methodology that guided the study, the discussion of results and ends with the conclusion of the study.

Theoretical background and Literature review

This study is based on the Expectancy Disconfirmation Theory and Assimilation Theory. The Expectancy Disconfirmation Theory states that consumers evaluate goods and services based on their preconceived notions about the features or advantages that the good or service will provide (Van Ryzin, 2006). For more than fifty years, the dependent factor called customer satisfaction has become the most essential issue in marketing. Thus, outcomes are compared against expectations once the product or service has been purchased, and disconfirmation occurs when there are differences between expectations and outcomes (Vigneshwran & Mathirajan, 2021). If disconfirmation is measured as the difference between performance and expectation, the score is a linear function of its predecessors, which implies that regression analysis cannot access the linear relationship between the derived operationalization of disconfirmation and antecedents. Regarding global satisfaction predictions or global perceived service quality, the different scores do not produce superior results than those obtained using subjective measures (Isac & Rusu, 2014).

The Expectancy Disconfirmation Theory posits that consumers form judgments about products or services based on their prior expectations about the characteristics or benefits offered by the given goods or services (Oliver, 1980). On the other hand, the Assimilation Theory proposes that customers attempt to adjust their expectations to bring them closer to the product's actual performance (Macri, 2020). The Assimilation Theory is predicated on the Dissonance Theory according to which consumers of a particular product compare expectations of the product and consequently the preserved performance of the product quite intellectually (Jumawan, 2021). The Assimilation Theory has several issues. The theory assumes that expectation and satisfaction are interconnected; however, it fails to elucidate how expectation disconfirmation can result in either satisfaction or dissatisfaction. Moreover, the theory suggests that consumers possess sufficient motivation to adjust their expectations or perceptions concerning the product's performance. Previous scholars have observed that controlling the actual performance of a product can lead to a positive correlation between customer satisfaction and expectations. Therefore, it appears that dissatisfaction can only

arise if the assessment procedures begin with unfavourable customer expectations (Isac & Rusu, 2014).

Customer Satisfaction

Customer satisfaction is the feeling of a consumer after comparing the perceived performance or outcome of a product to their expectations and determining whether they are satisfied or dissatisfied. Customer satisfaction is essential because satisfied customers contribute to customer retention (Raitaluoto, 2023). According to Ginting et al. (2023), it is also a leading indicator of re-purchase intentions and customer loyalty. Thus, the establishment of a trustworthy relationship between a company and consumers is vital since it has a significant impact on customer loyalty (Rane et al., 2023). Extant research has shown that developing customer loyalty is the most favoured strategy to gain a competitive advantage and enhance the company's medium and long-term profitability (Ahlawat, 2022). Bengtsson et al., (2020) state that the term 'customer satisfaction' can be defined as a consumer fulfilment reaction in which customers feel satisfied with the goods or services acquired or purchased. Therefore, it is a measurement of how pleased consumers are with the goods and services provided by a business. Some of the factors or elements of customer satisfaction include the quality, value and expectations that a customer has regarding a business and the goods or services the business offers (Indeed Editorial Team, 2022). Franklin (2023) further states that customer satisfaction is a measure of how well a company's goods and services and customer experience live up to customer expectations. Patil and Rane (2023) aver that customer satisfaction and customer experience can influence customer retention and customer loyalty, as well as positive word-of-mouth. Thus, for a business to attract customers and get repeat business, it is important to focus on customer satisfaction. Customer satisfaction assists in retaining customers, which is much cheaper than acquiring new customers. Similarly, providing excellent customer service is a major motivator for referrals and word-of-mouth marketing. This means that delivering a great customer experience affects business reputation positively (Lumoa, 2023).

Fuller (2022) contends that customer loyalty and business expansion are driven by customer satisfaction. Hence, customers will be highly satisfied if businesses provide high-quality products and well-organized customer support services that are designed to meet customer needs. Indeed Editorial Team (2022) proclaims that customer satisfaction improves customer lifetime value (CLV). Moreover, customer satisfaction can be a key driver of business growth since it assists businesses in increasing customer lifetime value (CLV), which is the total sum of money that customers spend on business goods and services over a customer's lifetime. Generally, businesses can increase CLV by giving customers a satisfying experience (Raitaluoto, 2023). Dikshya (2023) indicates that customer satisfaction and all business operations must be continually enhanced in order for a business to continue operating successfully.

Customer Loyalty

Customer loyalty is the most essential aspect to run the business smoothly. Customer loyalty refers to a company's ability to build enduring relationships with customers and also achieve rewards in interacting with customers (Ranabhat, 2018). Painter (2023) states that customer loyalty is when customers reward a company with repeat purchasing. Loyal customers always choose to do business with a certain company and defend the company against competitors. For a company to gain customer loyalty, it needs to provide an experience that encourages customers to come back.

Enhancing customer loyalty is essential for a company's success and it can be impacted by various factors, namely customer satisfaction, quality of services, customer relationship management, and the experience of customers (Rane et al., 2023). Loyal customers always stay with one product or supplier and also refer others to the product or supplier. The three most significant factors that influence customer loyalty to a particular business are whether the goods and services are considered under the preferences of consumers; whether goods and services are evaluated under customer value; and whether the customers' perceptions, experiences and beliefs about the company are highly valued (Ranabhat, 2018). Customer loyalty is one of the most crucial goals that businesses desire to achieve, and well-established customer loyalty provides a great competitive advantage (Arslan, 2020). Imran (2019) mentions that customer loyalty is the indicator of the trust that a business earns from customers by establishing and maintaining mutually beneficial relationships. Customer loyalty has two dimensions, namely attitudinal and behavioural loyalty (Agyeiwaah et al., 2021).

Customer loyalty is a multi-dimensional concept consisting of altitudinal and behavioural loyalty. Attitudinal loyalty is the degree of commitment processed by customers in order to maintain loyalty to a brand. Thus, customers that exhibit attitudinal loyalty will be immune to competitors; recommend products or services to others; and remain devoted to being loyal customers who will make further purchases in future (Halim & Simamora, 2023). Attitude-based loyalty is described as a deeply held commitment to re-purchase or patronise a preferred product or service consistently in the future, resulting in repetitive purchases of the same brand despite the possibility of switching behaviour due to situational influences and marketing efforts (Saini & Singh, 2020). A customer that demonstrates attitudinal loyalty will have a preference for the brand above competitors, have a positive perception of the brand, and be emotionally and functionally satisfied. In addition, the highest levels of attitudinal loyalty are characterised by a feeling of belonging and genuine brand commitment (Cagnin & Nicolas, 2022). Attitudinal loyalty is psychological and triggers customers to influence another's perspectives by comparing the value and benefits they received from their purchases. Thus, consumer preferences and attitudes are not an independent phenomenon created in a vacuum (Svensson & Lundberg, 2022).

Behavioral loyalty refers to the level at which customers consistently make purchases from a certain company over an extended period of time. Brand trust and behavioural loyalty are closely related because brand trust encourages repeat purchases; builds a sense of dependability; enhances customer lifetime value; and generates positive word-of-mouth (Na et al., 2023). Another school of thought suggests that behavioural loyalty refers to the actions of consumers who consistently purchase from a specific

company, thereby demonstrating their loyalty. Consumers express their loyalty towards a company through repeated purchases (Hermantoro & Albari, 2022). This implies that customers utilise certain products or services on a regular basis (Williams, 2018). Indicators of behavioural loyalty include re-purchasing products, continuing the product as a main option, and encouraging the product to be used even more (Widodo & Jauhari, 2023). The advantages of obtaining behavioural loyalty are that once behaviour becomes habitual through repeated past experiences, it becomes relatively free of cognitive appraisal (Svensson & Lundberg, 2022).

Relationship between customer satisfaction and customer loyalty

Customer satisfaction and customer loyalty have a virtually intuitive relationship. Thus, companies could easily turn satisfied customers into loyal customers based on a positive purchasing experience. A customer's decision to stay loyal depends on customers' level of satisfaction with the goods and services provided (Abu-Alhaija et al., 2019). Zephan (2018) further states that the concepts 'customer satisfaction' and 'customer loyalty' are closely related, hence it is essential to comprehend the relationship that exists between the concept of customer satisfaction and customer loyalty as these two play a crucial part in the success of any business. The role of customer satisfaction in loyalty demonstrates that satisfaction is the key determinant of loyalty. Hohenberg and Taylor 2021 (2019) claim that customer satisfaction is a measurement of a customer's attitude toward a good, service or a brand, whereas customer loyalty refers to a collection of behaviours and attitudes that shows a customer's loyalty to a company, product or service, such as selecting a certain company over a competitor and then engaging in repeat purchases. Zephan (2018) asserts that customer satisfaction provides an understanding of how much the product or service satisfies the expectation of the customer, while customer loyalty is influenced by various factors such as product and quality services.

According to Minta (2018), customer satisfaction has been one of the crucial aspects that managers should focus on, hence some studies have confirmed the connection between customer satisfaction and customer loyalty. Satisfaction is the main variable in learning buying behaviour and in creating habits that lead to loyalty. Customer satisfaction and customer loyalty both aim to assess the state of a business's relationship with customers (Darmayasa & Yasa, 2021). Sharma et al. (2020) state that the relationship between customer loyalty and customer satisfaction influences profits because a highly satisfied customer will spread favourable word-of-mouth, and a loyal customer leads to both sales and profitability in business. Cleave (2023) asserts that in order to improve customer loyalty and customer satisfaction, businesses need to communicate effectively, exceed expectations, reward customers who are loyal, and utilise metrics to improve business.

In a study conducted in Indonesia, Adam et al. (2020) found that customer satisfaction is another factor that strengthens customer loyalty. Zephan (2018) claims that customer satisfaction and customer loyalty must be incorporated together to achieve the desired goals of the business, which are profitability and market share. Satisfaction is an essential indicator of devotion and repeat purchasing. Minta (2018) highlighted that customer loyalty depends to a greater extent on the level of satisfaction derived from the business's services or products. Alain et al. (2021) have noted that it is impossible to have loyalty without satisfaction.

Dam and Dam (2021) claim that some studies have confirmed the relationship between customer loyalty and customer satisfaction. Abu-alhaija et al. (2019) found that satisfaction is considered as one of the antecedents of customer loyalty. Based on the above discussion, the following hypothesis is developed:

H1: Customer satisfaction has a positive and significant relationship with customer loyalty in the South African retail sector

Methodology

This study adopted a quantitative descriptive cross-sectional research design. A research design refers to a framework employed in conducting a study in order to address the research questions or test hypotheses. It entails outlining the overall approach and procedures that will be employed for data collection and analysis (Singh & Jassi, 2023). The three primary types of research designs are causal, descriptive and exploratory (Sreejesh et al., 2014). For this study, a descriptive research design was adopted, which is a research method that outlines the features of the population or phenomenon under study (Manjunatha, 2019). The goal of descriptive research is to uncover answers to the what, when and where questions (Cobanoglu, 2023).

In this study, a probability sampling technique known as simple random sampling was used in order to make sure that the respondents are representative of the larger group and to draw conclusions about the population generally. Its simplicity in selecting respondents and unbiased judgment are two of its major advantages (Horton, 2024). The sample size for this study was 150 respondents since it was anticipated that their input would be sufficient to determine the results. This study employed a self-administered questionnaire as a tool for data collection, and a Likert Scale ranging from strongly agree represented by 1 to strongly disagree represented by 5 was used to gauge customers' feelings on satisfaction and loyalty constructs. For analysis purposes, the Likert Scale was collapsed into three viz. agree, disagree and uncertain. The questionnaire design incorporated the customer satisfaction and customer loyalty scales. The customer satisfaction scale was adapted from Uzir et al. (2020) whereas the customer loyalty scale was adapted from Bobâlcă et al. (2012). Descriptive and inferential statistics were used to analyse data. The Statistical Package for the Social Sciences (SPSS) version 30 was utilised to analyse the data.

Research results and Discussion Characteristics of the sample

As illustrated in Table 1, the sample characteristics of the respondents show that the majority of respondents, 56%, are females and 42. 67% were male, whilst 1.33% of the sample respondents were non-binary (other). The age distribution of respondents shows that the majority (64%) fell within the 18-29 age range, followed by 30-40 years (34%), and a small proportion (2%) were between 41-55 years old. The data further illustrates the racial distribution of the sample respondents in the study, which shows that the majority were African (96. 67%), followed by Coloured (2.57%) and Whites (0. 67%).

Table 1. Demographic profile of respondents

	Description	Frequency	Percentage
Gender Total	Female Male Non-binary	84 64 2 **150**	56% 42.67 1, 33 **100**
Age Group Total	18-29 30-40 41-55	96 51 3 **150**	64% 34% 2% **100**
Race Total	African Coloured Whites	145 4 1 **150**	96, 67% 2, 57% 0,67% **100**

Source: Authors' construct

Reliability analysis

Table 2 illustrates the reliability analysis of the study's measures, employing Cronbach's alpha as the coefficient for ascertaining internal consistency. The results indicate satisfactory reliability estimates for customer satisfaction (0.893) and customer loyalty (0.934), with an overall reliability coefficient of 0.935. These coefficients exceed the conventional threshold of acceptability, thereby substantiating the internal consistency and reliability of the constructs under investigation. Daud et al. (2018) have noted that a Cronbach Alpha coefficient within the range of 0.60 to 0.80 indicates moderate to strong internal consistency reliability, suggesting that the measure is reliable and acceptable for research objectives or purposes.

Table 2. Reliability Analysis

Classification	Cronbach Alpha
Customer satisfaction	0.893
Customer loyalty	0.934
Overall Cronbach Alpha	0.935

Source: Authors' construct

Perception of Customer Satisfaction

The retailer meets the expectations of customers: Respondents were asked whether the retailer met their expectations, as indicated in Table 3. The majority of respondents (63.3%) (n=95) agree, while 19.3% (29) disagree. Furthermore, 17.3% (26) of the respondents were uncertain about whether the retailer met their expectations. Hawkins

and Hoon (2019) emphasize that meeting customer expectations can significantly impact the success and longevity of any business. Moreover, fulfilling customer expectations improves overall brand reputation and generates positive word of-mouth, which aids in attracting new customers. Thus, businesses should prioritize customer expectations in order to stay relevant and grow in a competitive market.

The retailer's staff members are friendly and helpful: The results presented in Table 3 indicate that 64.7% (n= 97) of the respondents agreed that the staff members were friendly and helpful. Additionally, 21.3 % (32) were uncertain, and 14 % (21) disagreed. These findings clearly show that the majority of the respondents perceived the staff members as friendly and helpful. Providing friendly customer service involves interacting with customers in a caring and understanding manner, and making an effort to exceed their expectations. This approach yields positive results as a pleasant customer service interaction can significantly influence a customer's perception of a business and foster long-term loyalty (Gupta, 2024).

The retailer's prices are competitive compared to other retailers: In Table 3, it is shown that 62.7% (n= 94) of the respondents agree that the retailer's prices are competitive compared to other retailers, while 23.3 percent (35) were uncertain, and 14 percent (21) disagreed. These results indicate that the majority of respondents were satisfied with the competitiveness of the retailer's prices compared to other retailers. A competitive pricing strategy enables companies to gain an advantage by setting prices strategically, either above, below or at the same level as their direct competitors. One of the main advantages of competitive pricing is that it helps businesses grasp their market position, attract new customers, and increase profits (Zao et al., 2022).

Customers are satisfied with the quality of products offered by the retailer: Table 3 reveals that 60% (n= 90) of the respondents agree that customers are satisfied with the quality of products offered by the retailer, while 20% (30) were uncertain and another 20% (30) disagreed. These findings imply that the majority of the respondents were satisfied with the quality of products offered by the retailer. Lone and Bhat (2023) pointed out that ensuring the quality of products is the top priority for all organizations as it plays a significant role in achieving customer satisfaction, which is the ultimate objective of all marketing efforts.

Customers are satisfied with the overall experience with the retailer: In Table 3, it is demonstrated that 58% (n= 87) of the respondents agree that customers are satisfied with the overall experience at the retailer, while 24% (36) were uncertain and another 18% (27) disagreed. These findings clearly indicate that the majority of the respondents were satisfied with the overall experience at the retailer. El-Abidin (2024) states that an outstanding customer experience is crucial for the sustained growth of any business. A positive customer experience fosters loyalty, aids in customer retention, and promotes brand advocacy.

Table 3. Frequency distribution of customer satisfaction

Customer satisfaction	Agree		Uncertain		Disagree		Total	
	n	%	n	%	n	%	n	%
The retailer meets my expectations	95	63.3%	26	17.3%	29	19.3%	150	100%
The retailer's staff members are friendly and helpful	97	64.7%	32	21.3%	21	14%	150	100%
The retailer's prices are competitive compared to other retailers	94	62.7	35	23.3%	21	14%	150	100%
I am satisfied with the quality of products offered by the retailer	90	60%	30	20%	30	20%	150	100%
I am satisfied with the overall experience with the retailer	87	58%	36	24%	27	18%	150	100%

Source: Authors' construct

Perception of Customer Loyalty

Customers consider themselves as loyal customers: As illustrated in Table 4, a significant proportion of respondents (59.3%, n=89) affirmatively identified themselves as loyal customers of the retailer. Conversely, 24% (n=37) disagreed, whilst 16% (n=24) were uncertain. These findings suggest that a clear majority of respondents exhibit loyalty towards the retailer. The cultivation of customer loyalty is crucial for achieving business success; leveraging benefits such as increased repeat custom; reduced marketing expenditure; and enhanced brand reputation (Hyseni, 2024).

Customers trust the retailer when it comes to meeting shopping needs: Table 4 indicates that a significant number of respondents (59.3%, n=89) agree that they trust the retailer when it comes to meeting their expectations, while 21. 3% (n=32) disagreed and 19% (n=29) were uncertain. These findings suggest that a clear majority of respondents trust the retailer when it comes to meeting their expectations. Kyamko (2024) notes that customers usually stick to what they are most satisfied with. Hence, it is crucial for businesses to constantly find methods to match customer expectations, which will allow businesses to increase customer loyalty and satisfaction, reach a new audience, and increase sales.

Customers would recommend the retailer to friends and family (positive word-of-mouth): The results illustrated in Table 4 indicate that 64.7% (n= 97) of the respondents expressed a willingness to recommend the retailer to friends and family. Additionally, 18% (27) were uncertain and 17.3% (26) disagreed. These findings clearly show that the majority of respondents were willing to recommend the retailer to friends and family. Consumers engage in word-of-mouth marketing (WOM marketing) by discussing the business's products or services with their friends, family, and others with whom they share close relationships. WOM marketing is one of the most reliable tool of advertising since most of the consumers trust recommendations from relatives and

friends compared to paid traditional. Businesses can encourage WOM marketing by exceeding expectations regarding a product, providing excellent customer service, and offering clear information to customers. (Hayes, 2024).

Customers intend to continue shopping at the retailer in the future: Table 4 demonstrated that 62.6% (n= 94) of the respondents agree that they intend to continue shopping at The retailer in the future, while 18.7% (28) were uncertain and another 18.7% (28) disagreed. These findings imply that the majority of respondents indicated a willingness to continue shopping at the retailer. If a customer remains for a longer period, they are more likely to spend more. In fact, studies consistently demonstrated that satisfied customers tend to spend 140% more. The higher the retention, the less revenue lost to churn. According to Tessitore (2023), a churned customer takes potential business revenue with them.

Customers prefer the retailer over other retailers: According to Table 4, 52% (n= 78) of the respondents agreed that they prefer the retailer over alternative retail options. Additionally, 26.7 % (40) were uncertain and 21.3 % (32) disagreed. These findings reveal that the majority of respondents prefer the retailer over alternative retail options. Fulfilling consumer preferences boosts sales, loyalty and retention, ultimately reducing acquisition costs (Dutta, 2023).

Table 4. Frequency distribution of customer loyalty

Customer loyalty	Agree		Uncertain		Disagree		Total	
	n	%	n	%	n	%	n	%
I consider myself as a loyal customer of the retailer	89	59.3%	24	16%	37	24.7%	150	100%
I trust the retailer when it comes to meeting my shopping needs	89	59.3%	29	19.3%	32	21.3%	150	100%
I would recommend the retailer to my friends and family (positive word-of-mouth)	97	64.7%	27	18%	26	17.3%	150	100%
I intend to continue shopping at the retailer in the future	94	62.6%	28	18.7%	28	18,7%	150	100%
I prefer the retailer over other retailers	78	52%	40	26.7%	32	21.3%	150	100%

Source: Authors' construct

Pearson correlation

The Pearson correlation in Table 5 shows the association between customer satisfaction and customer loyalty. The results indicate that customer satisfaction strongly correlates with customer loyalty and the relationship is significant ($r=0.911$; $p<0.001$). The results in the current study corroborate Dam and Dam (2021), who confirmed a positive and significant relationship between customer loyalty and customer satisfaction.

Table 5. Pearson correlation

		Customer satisfaction	Customer loyalty
Customer satisfaction	Pearson Correlation	1	.911**
	Sig. (2-tailed)		.000
	N	150	150
Customer loyalty	Pearson Correlation	.911**	1
	Sig. (2-tailed)	.000	
	N	150	150
****. Correlation is significant at the 0.01 level (2-tailed).**			

Source: Authors' construct

Linear regression

Table 6 illustrates the effect of customer satisfaction on customer loyalty. The model suggests significant regression ($F(148) = 721.152$; $p<0.001$). The R^2 suggests that customer satisfaction accounts for 83% of the variance in customer loyalty ($R2=0.830$). The beta coefficient ($\beta=0.911$; $p<0.001$) suggests that customer satisfaction significantly predicts customer loyalty and the relationship was positive, implying that as customer satisfaction increases (agreement on positive customer satisfaction), customer loyalty increases (agreement on positive customer loyalty). The VIF and tolerance value measures suggest that there is no collinearity in the dataset. The findings in this study are consistent with Abu-alhaija, Shanak and Allan's (2019) study, which found that satisfaction is considered one of the antecedents of customer loyalty and has a positive relationship. Similarly, the findings of this research are consistent with a previous study conducted by Adam et al. (2020). Based on the above results, the hypothesis of the study is confirmed.

Table 6. Linear regression

Independent variable	Regression	ANOVA	R square	Standardized Coefficients Beta	d1/d2	t	Sig.	Collinearity Statistics	
								Tolerance	VIF
Customer satisfaction	0.911	721.152	0.830	0.911	1;148	26.854	.000	1.000	1.000

Source: Authors' construct

Conclusion

This study sought to analyse the relationship between customer loyalty and customer satisfaction. Based on the findings of this study, retail managers must prioritize understanding customer needs, striving to not only meet but exceed expectations. By actively engaging customers in the value creation process, retailers can identify and address their specific requirements, thus cultivating interdependent relationships. This balanced partnership ultimately drives customer satisfaction and loyalty. The results of this study emphasize the vital role of product quality in ensuring customer satisfaction and loyalty. Retailers have to improve customer experiences in order to cultivate loyalty by prioritizing product quality. This can be achieved through strategic sourcing from reputable suppliers, strict quality control criteria, and regular customer feedback analysis. To implement this recommendation, it is suggested that retailers establish periodic supplier evaluations to ensure compliance with quality standards; train employees on product knowledge and quality control procedures; and establish a customer feedback system to monitor product quality concerns. By so doing, retailers can expect improved customer satisfaction ratings and increased customer retention. Retailers can also implement customer relationship management systems to track preferences and purchasing history. Management should also invest in employee training to enhance service quality and responsiveness. Moreover, there is need to carry out consistent consumer satisfaction surveys to pinpoint avenues for enhancement. It is suggested that in order to maintain competitiveness over their rivals, retailers should always remain vigilant regarding shifts in customer demands. In addition, it is suggested that retailers focus on training employees on customer support skills, empathy, as well as product knowledge. Moreover, it is imperative to consider implementing employee recognition and reward systems to encourage exceptional service. Fostering an organizational culture that prioritizes a customer focus is also imperative.

Further research can be done of a qualitative nature, exploring in-depth customer satisfaction and its impact on customer loyalty in the retail sector. Furthermore, future studies can explore a comparative analysis of customer satisfaction and loyalty across different retail sectors, identifying sector-specific drivers and challenges. In terms of limitations, the present study was based on a simple random sample drawn from 150 customers shopping in the retail sector. Therefore, the findings cannot be generalized to all other retailers in South Africa or beyond this context. However, they can add value and prove meaningful to other retailers with similar functions and management.

References

Abu-Alhaija, A.S., Shanak, H.S. & Abu Allan, A. (2019). Relationship between customer satisfaction and customer loyalty: future directions of its nature and approaches. *Eurasian Journal of Social Sciences,* 7(4): 28-39

Adam, M., Ibrahim, M., Ikramuddin, I. & Syahputra, H., (2020). The role of digital marketing platforms on supply chain management for customer satisfaction and loyalty in small and medium enterprises (SMEs) at Indonesia. *International Journal of Supply Chain Management*, *9*(3), pp.1210-1220.

Agyeiwaah, E., Dayour, F. & Zhou, Y., (2022). How does employee commitment impact customers' attitudinal loyalty?. *Journal of Hospitality and Tourism Insights*, *5*(2), pp.350-376.

Ahlawat, R. (2022). Customer satisfaction and customer loyalty. *Research Gate.* Available online:https://www.researchgate.net/publication/369912869_Customer_Satisfaction_and_Customer_Loyalty (Accessed: 16 March, 2024)

Alain,C.B., Rostin, M.M., Joel, K.N., Hypolite, M.M., Koffi, T.A., & Hippolyte, S.N. (2020). Relationship between customer satisfaction and customer loyalty. *Journal of Economics and International Business Management*, 9(1): 35-43

Arslan, I. K. (2020). The importance of creating customer loyalty In achieving sustainable competitive advantage. *Eurasian Journal of Business and Management*, 8(1): 11-20

Amha, G.G., (2020). Determinants of customer satisfaction and customer loyalty in amhara credit and saving institute (acsi): The case of waghimera zone sekota town. *International Journal of Marketing & Human Resource Research*, *1*(01), pp.34-51.

Bengtsson, S., Hertzberg, J. & Rask, L. (2020). The relationship between service quality, customer satisfaction and brand loyalty. *Diva Portal*. Available: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.divaportal.org/smash/get/diva2:1437946/fulltext01.pdf (Accessed: 24 March, 2024)

Bobâlcă, C., Gătej, C. & Ciobanu, O., (2012). Developing a scale to measure customer loyalty. *Procedia Economics and Finance*, *3*, pp.623-628.

Cagnin, N. & Nicolas, M. (2022). Generation Z and brand loyalty: the influence of gen Z specific expectations on attitudinal and behavioural loyalty. *Diva Portal*. Available online: chrome extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.divaportal.org/smash/get/diva2:1676306/FULLTEXT01.pdf (Accessed: 16 April, 2024)

Cleave, P. (2023). Customer satisfaction vs customer loyalty. *Smart survey*. Available online:https://www.smartsurvey.co.uk/blog/customer-satisfaction-vscustomerloyalty"(Accessed: 5 April, 2024)

Cobanoglu, D. (2023). What is descriptive research: Methods and examples? *Forms App*. Available online: https://forms.app/en/blog/descriptive-research (Accessed: 12 May, 2024)

Saini, S. & Singh, J., (2020). A link between attitudinal and behavioral loyalty of service customers. *Business Perspectives and Research*, *8*(2), pp.205-215.

Dam, S.M. & Dam, T.C. (2021). Relationship between service quality, brand image, customer satisfaction, and customer loyalty. *Journal of Asian Finance, Economics and Business*, 8(3) pp.585-593.

Daud, K.A.M., Khidzir, N.Z., Ismail, A.R. & Abdullah, F.A. (2018). Validity and reliability of instruments to measure social media skills among small and medium entrepreneurs at Pengkalan Datu River. *International Journal of Development and Sustainability*, 7(3): 1026-1037.

Darmayasa, G.N.A.R. & Yasa, N.N.K., (2021). The influence of relationship marketing on customer loyalty: Customer satisfaction as a mediation variable. *International Research Journal of Management, IT and Social Sciences*, *8*(6), pp.648-660

Dikshya, S.B. (2023). Factors influencing customer satisfaction. *Laurea*. Available online https://www.theseus.fi/bitstream/handle/10024/801776/Sharma_Bhandari_Dikshya%20.pdf?sequence=2 &isAllowed=y (Accessed: 24 March, 2024)

Dutta, A. (2023). What is Consumer Preference and Why is it Important? : Cognitive Market Research. *Cognitive Market Research*. Available online: https://www.cognitivemarketresearch.com/blog/what-isconsumer-preference-and-why-it-is-important– (Accessed: 25 September, 2024)

EL-Abidin, R. (2024). Customer Experience: What It Is and Why It's Important. *Hubspot*. Available online: https://blog.hubspot.com/service/what-is-customer-experience (Accessed: 24 September, 2024)

Fuchs, J. (2022). Customer dissatisfaction: how to handle and remedy it. *HubSpot*. Available online:https://blog.hubspot.com/service/customer-dissatisfaction#cause (Accessed: 9 March, 2024)

Franklin, A. (2023). What is customer satisfaction? Definition and importance. *Zendesk Blog*. Available online: https://www.zendesk.com/blog/3-steps achieving customer-satisfaction-loyalty/#importance (Accessed: 9 March, 2024)

Fuller, M. (2022). The importance of customer satisfaction for business. *Influx*. Available online: https://influx.com/blog/why-is-customer-satisfaction-important (Accessed: 24 March, 2024)

Ginting, Y., Chandra, T., Miran, I. & Yusriadi, Y., (2023). Repurchase intention of e-commerce customers in Indonesia: An overview of the effect of e-service quality, e-word of mouth, customer trust, and customer satisfaction mediation. *International Journal of Data and Network Science*, *7*(1), pp.329-340.

Gupta, C. (2024). The importance of friendly customer service. *Zendesk*. Available online:https://www.zendesk.com/au/blog/what-does-friendliness-in-customer service-mean/# (Accessed: 24 September, 2024)

Halim, M., & Simamora, B. (2023).The Impact of Price Perception and Brand Image on Attitudinal Loyalty of Innisfree Skincare Consumers. *Journal of International Conference Proceedings*, 6(1), 86-99

Hayes, A. (2024). Word-of-Mouth Marketing: Meaning and Uses in Business. *Investopedia*. Available online: https://www.investopedia.com/terms/w/word-of-mouth-marketing.asp (Accessed: 25 September, 2024)

Hawkins, D.L. & Hoon, S., (2019). The impact of customer retention strategies and the survival of small service-based businesses. *Available online:* https://ssrn.com/abstract=3445173 .

Hermantoro, M. & Albari, A. (2022). E-service analysis and its effect on perceived value and loyalty on ecommerce online shopping sites in Yogyakarta. *International Journal of Business Ecosystem & Strategy*, 4(4): 39-49

Hohenberg, S. & Taylor, W., (2021). Measuring customer satisfaction and customer loyalty. In *Handbook of market research* (pp. 909-938). Cham: Springer International Publishing.

Horton, M. (2024). Simple Random Sampling Definition, Advantages and Disadvantage. *Investopedia*. Available online: https://www.investopedia.com/ask/answers/042815/what-are-disadvantages using-simple-random-sample-approximate-larger-population.asp (Accessed: 12 May, 2024)

Hotjar. (2022). The eight biggest customer satisfaction challenges and how to overcome them. *Hotjar* Available online: https://www.hotjar.com/customer satisfaction/challenges-andsolutions/ (Accessed: 11 March, 2024)

Hyseni, V. (2024). Why is Customer Loyalty Important for Your Business? *PECB*. Available online:https://pecb.com/article/why-is-customer-loyalty-important-for-your-business (Accessed: 25 September, 2024)

Imran, G.M. (2019). Dimensions of loyalty. *LinkedIn*. Available: https://www.linkedin.com/pulse/dimensionsloyalty imran-gm (Accessed: 29 March, 2024)

Indeed Editorial Team. (2022). What is customer satisfaction (with benefits and tips). Available:https://www.indeed.com/careeradvice/careerdevelopment/what-iscustomer-satisfaction (Accessed: 24 March, 2024)

Isac, F.L. & Rusu, S. (2014). Theories of customer's satisfaction and the operationalization of the expectation disconfirmation paradigm. *University of Targu Jiu*. Available online:https://www.utgjiu.ro/revista/ec/pdf/201402/ (Accessed: 27 March, 2024)

Jumawan, D.P. (2021). A literature study on positive disconfirmation and negative disconfirmation theories and models. *International Journal of Science and Research*, 10(5): 961-966

Khairawati, S. (2019). Effect of customer loyalty program on customer satisfaction and its impact on customer loyalty. *International Journal of Research in Business and Social Science*, 9(1): 15-23.

Kyamko, M. (2024). Meeting Customer Expectations: Importance, Strategies to Exceed Them, and Management Tips. Crowdspring. Available online: https://www.crowdspring.com/blog/customerexpectations/#critical (Accessed: 25 September, 2024)

Lone, R. A., & Bhat, M. A. (2023). Impact of Product Quality on Customer Satisfaction: Evidence from Selected Consumer Durables. *International Journal for Research Trends and Innovation*, *6*(4), pp.1014-1026

Longe, B. (2022). Customer dissatisfaction: The Ultimate Guide. *Formplus*. Available Online:https://www.formpl.us/blog/customer-dissatisfaction (Accessed: 23 March, 2024)

Lumoa. (2023). Why is customer satisfaction important? *Lumoa*. Available online: https://www.lumoa.me/blog/the-importance-of-customer-satisfaction/ (Accessed: 24 March, 2024)

Macri, C. (2020). What you need to learn about theories of customer satisfaction and loyalty. *Business Review*. Available online: https://businessreview.eu/business/what-you-need-to-learn- (Accessed: 27 March, 2024)

Manjunatha, N. (2019). Descriptive Research. *Journal of Emerging Technologies and Innovative Research*, 6(6):.863-867.

Minta, Y. (2018). Link between satisfaction and customer loyalty in the insurance industry: Moderating effect of trust and commitment. *Journal of Marketing Management*, 6(2): 25-33.

Na, M., Rong, L., Ali, M.H., Alam, S.S., Masukujjaman, M., & Ali,K.A. (2023). The Mediating role of brand trust and brand love between brand experience and loyalty: A study on smartphones in China. *Behavioural Sciences*.

Oliver, R. L. (1980). A cognitive model of the antecedents and consequences of satisfaction decisions. *Journal of Marketing Research*, 17(4): 460-469

Painter, L. (2023). Customer loyalty: a guide to types and strategies. *Zendesk Blog*. Available:https://www.zendesk.com/blog/customerloyalty/#customer%20loyaly%20defined (Accessed: 30 March, 2024)

Patil, D.R. & Rane, N.L., (2023). Customer experience and satisfaction: importance of customer reviews and customer value on buying preference. *International Research Journal of Modernization in Engineering Technology and Science*, *5*(3), pp.3437-3447.

Peppler, S. (2022). Competition-Based Pricing: Advantages and Disadvantages. Available:https://www.flintfox.com/resources/articles/competitionbasedpricingguide/#:~:text=One%20of%20the%20key%20benefits,new%20customers%2C20and%20boo st%20profits (Accessed: 24 September, 2024)

Raitaluoto, T. (2023). The importance of customer satisfaction in growth marketing. Available online: https://www.markettailor.io/blog/importance-ofcustomersatisfaction-in-growth-marketing Accessed: 24 March, 2023)

Rane, N., Achari, A., & Choudhary, S.P. (2023). Enhancing customer loyalty through quality service: Effective strategies to improve customer satisfaction, experience, relationship, and engagement. *International Research Journal of Modernization in Engineering Technology and Science*, 5(5) : 27-452

Ranabhat, D. (2018). Customer loyalty in business. *Centria University of Applied Sciences*. Available online: https://core.ac.uk/download/pdf/161424404.pdf (Accessed: 12 March, 2024)

Sharma, A., Gupta, J., Gera,L., Sati,M., & Sharma,S. (2020). Relationship between customer satisfaction and loyalty. *Social Science Research Network*. Available online:https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3913161 (Accessed: 5 April, 2024)

Singh, D.P. & Jassi, J. (2023). Exploring the significance of statistics in the research: a comprehensive overview. *European Chemical Bulletin*, 12(2): 2089-2102 Sreejesh, S., Mohapatra, S., & Anusree, M.R. (2014). Business Research Methods. *Springer.*

Svensson, E. & Lundberg, J. (2022). Does card loyalty increase loyalty? *Portal*. Available online: portal.org/smash/get/diva2:1671363/FULLTEXT01.pdf'https://www.d ivaportalorg/smash/get/diva2:167 1363/FULLTEXT01.pdf (Accessed: 16 April, 2024)

Tessitore, S. (2023). The Benefits of Customer Retention for Your Bottom Line. *Customer Gauge*. Available online: https://customergauge.com/blog/benefits-of-customer retention#:~:text=If%20a%20customer%20hangs%20around,your%2potentia%20revenue%20with%20 them. (Accessed: 25 September, 2024)

Uzir, M.U.H., Jerin, I., Al Halbusi, H., Hamid, A.B.A. & Latiff, A.S.A., (2020). Does quality stimulate customer satisfaction where perceived value mediates and the usage of social media moderates?. *Heliyon*, *6*(12).

Van Ryzin, G.G. (2006). Testing the expectancy disconfirmation model of citizen satisfaction with local government. *Journal of Public Administration Research and Theory*, *16*(4), pp.599-611.

Vigneshwran, S.R. & Mathirajan, M. (2021). A theoretical framework for customer satisfaction and customer loyalty. *International Journal of Innovation, Management and Technology*, 12(1). Available online: https://www.ijimt.org/vol12/903-A1052.pdf (Accessed: 24 March, 2024)

Widodo, T. & Jauhari, R. (2023). The influence of the service quality dimension on attitudinal loyalty and behavioral loyalty moderated by the level of internet usage and switching costs study on Indihome Indonesia. *Jurnal Ekonomi Bisnis & Entrepreneurship*, 13(1): 35-45

Williams, L. (2018). How to win loyalty in the age of the promiscuous consumer. *Marketing Dive.* Available online: https://www.marketingdive.com/news/how-towin-loyalty-in-the-age-of-the-promiscuousconsumer/524403/ (Accessed: 16 April, 2024)

Zhao, C., Wang, X., Xiao, Y. & Sheng, J., (2022). Effects of online reviews and competition on quality and pricing strategies. *Production and Operations Management*, *31*(10), pp.3840-3858.

Zephan, N. (2018). Relationship between customer satisfaction and customer loyalty. *Centria University of Applied Sciences.* Available online: https://www.theseus.fi/bitstream/handle/10024/146823/Relationship%20Betwee n%20Customer%20 Satisfaction%20and%20Customer%20Loyalty%20.pdf?seqence= (Accessed: 8 March, 2024).

ЕКОНОМИКА
ISSN 0350-137X, EISSN 2334-9190, UDK 338 (497,1)
Vol. 71, april-june 2025, № 1
P. 73-88

Lidija Madžar[1]
Drinka Peković[2]
Ivan Đekić[3]
Alfa BK University, Faculty of Finance, Banking and Auditing, *Belgrade*

ORIGINAL SCIENTIFIC ARTICLE
DOI: 10.5937/ekonomika2502073M
Received: March 11, 2025
Accepted: May 05, 2025

ASSESSMENT OF SUSTAINABLE DEVELOPMENT IN SELECTED COUNTRIES OF SOUTHEAST EUROPE

Abstract

The purpose of this article is to examine the possibilities of sustainable development, as well as to assess the impact of certain environmental predictors on the real GDP increase of eight selected countries of Southeast Europe (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, North Macedonia, Romania and Serbia) in the period from 2001 to 2020. Using the Least Squares Dummy Variable (LSDV) panel data method, the article shows that from the aspect of access to safely managed sanitation services, use of renewables and harmful CO_2 emissions, economic development in these countries is not sustainable enough. At the same time, it is sustainable only from the perspective of agricultural methane emissions. Bearing this in mind, economic policy makers from these countries should work more intensively on intra-regional cooperation, as well as on complying with the recommendations from the SEE 2030 Strategy in guiding their countries towards sustainable development pathways.

Key words: *sustainable development, Least Squares Dummy Variable (LSDV) approach, Southeast Europe (SEE), CO_2 emissions, environmental indicators*

JEL classification: *Q01, Q56, Q58*

ПРОЦЕНА ОДРЖИВОГ РАЗВОЈА У ОДАБРАНИМ ЗЕМЉАМА ЈУГОИСТОЧНЕ ЕВРОПЕ

Апстракт

Сврха овог чланка је испитивање могућности одрживог развоја, као и процена утицаја одређених еколошких предиктора на раст реалног БДП-а осам одабраних земаља југоисточне Европе (Албаније, Босне и Херцеговине, Бугарске, Хрватске, Грчке, Северне Македоније, Румуније и Србије) у периоду од 2001. до 2020. године. Применом панел методе Dummy варијабле најмањих квадрата, чланак показује да са аспекта приступа безбедно управљаним санитарним услугама, коришћења обновљивих извора и штетних емисија CO_2 привредни развој ових земаља није довољно одржив, док је одржив само са аспекта емисија

[1] lidi.madzar@gmail.com, ORCID ID 0000-0002-1708-5683

[2] drinkapekovic@gmail.com, ORCID ID 0000-0003-2777-8288

[3] ivan.djekic@alfa.edu.rs, ORCID ID 0000-0002-0369-1455

метана у пољопривреди. Имајући то у виду, креатори економске политике би требало интензивније да раде на унутаррегионалној сарадњи, као и на поштовању препорука из Стратегије ЈИЕ 2030 у усмеравању својих земаља ка путањама одрживог развоја.

Кључне речи: *одрживи развој, ЛСДВ модел фиксних ефеката, југоисточна Европа (ЈИЕ), CO_2 емисије, еколошки показатељи*

Introduction

Although the concept of sustainable development officially appeared only in the second half of the 20th century, it is evident that its forms of expression existed for centuries before then. Even though this term can be described in many ways, its traditional and perhaps the most convincing definition comes from the Brundtland Report of 1987, which states that sustainable development is the type of development that meets the needs of the current generation, but not at the detriment and without compromising the needs of future ones (United Nations, 1987, pp. 2-151). This was the first strategic document that insisted on the integration of developmental and environmental issues, while the Report itself also introduced some of the basic principles of sustainable development, which are still relevant today. These postulates include the Polluter Pays Principle, the principle of universal resources, the principle of non-endangerment and non-exploitation of others, the principle of introducing environmental control measures, the use of renewable energy sources, and many others. Sustainable development, as a long-term interaction of social, economic, environmental and natural systems and a specific response to the complexity of global challenges, requires a carefully managed and gradual development policy (Filipović et al., 2004a, pp. 25-26).

As a somewhat vague concept that implies a symbiosis of environmental protection policies, developmental strategies and general social goals, sustainable development entails the integration of economic development and long-term conservation of natural resources (United Nations, 2015, p. 87). Based on the integration of ecological, economic and social goals, sustainable development has transformed over time into a kind of developmental paradigm that calls for economic progress and improvement of living standards, without jeopardizing the perspective of using resources and the earth's ecosystems (Mensah and Ricart Casadevall, 2019, p. 6). The importance of this concept is reflected in the efficient use of resources and environmental protection, mitigating the negative effects of climate change, maintaining the ecological balance, reducing poverty, encouraging education for all and social inclusion, with the ultimate goal of enabling long-term economic development (Tufaner and Türker, 2016, pp. 300-303). However, while the economic, social and environmental aims of sustainable development are well-founded in theory, the practice of many countries indicates that it is necessary to invest much more long-term efforts towards their achievement (Madžar, 2023, p. 286).

The South-Eastern Europe (SEE) represents a geographically, culturally and historically bounded entity (Muntilak Ivanović et al., 2009, p. 2080) made up of some member states and official candidate countries for membership in the European

Union (EU). The key concern of the SEE countries encompasses the imperative for managing environmental quality, as well as the promotion of the idea about sustainable development (United Nations Development Programme, 2007). In this regard, it is necessary to specify and monitor the state of sustainable development in these countries, as one of the prerequisites for EU membership, and in order to gain a clearer insight into the sustainability indicators of the region itself. This analysis traces some indicators of sustainable development in the Western Balkans countries (Albania, Bosnia and Herzegovina, North Macedonia and Serbia), but also more widely in Bulgaria, Croatia, Greece and Romania with the aim of obtaining a more comprehensive picture of this research problem.

The concept of sustainable development is incorporated into legislation and common EU policies, while the Sustainable Development Goals (SDGs) are included in the South East Europe 2030 Strategy itself, which was adopted at the Summit in Antalya in June 2021. The Strategy places an emphasis on improving the implementation of the SDGs, calling for stronger intra-regional cooperation of the SEE countries, but also for the adoption of comprehensive and consistent regional policies that would encourage their sustainable economic growth. At the same time, this strategic document in the form of particularly challenging problems in the region emphasizes youth unemployment, brain drain and depopulation, population aging, income inequalities, poverty, migration, climate change, pollution, sustainable energy supply, and limited financial resources (Ergezer et al., 2021, pp. 9-23). To put it in another way, these countries face similar economic, environmental and social constrains, while one of the possible solutions is the initiation of a green and digital transition that would accelerate their economic transformation (Österreichische Gesellschaft für Europapolitik, 2023). However, the main challenge of implementing this and similar global environmental documents is reflected in the maintenance of this vision, which would be closely connected to reality, and within which every action should lead to the creation of more sustainable and resilient societies (Filipović, 2024b, p. 54). In addition, the Western Balkans (WB) countries still base their economic activities on the prevailing brown industries, supported by sticky brown knowledge and skills, while the World Bank estimates that their path to green growth will not be easy at all (World Bank Group, 2021, p. 4). All of the mentioned above represents a good argument for paying more attention to the burning issues of sustainability in the SEE region.

Bearing in mind the stated importance of sustainable development, the purpose of this article is to examine the validity of the hypothesis about unsustainable development, as well as to assess the impact of certain infrastructural and environmental factors on sustainable development in selected SEE countries in the period from 2001 to 2020. Using the panel data Fixed Effects Model (FEM), the article assesses the sustainability of economic development on the example of the following eight analysed SEE countries: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, North Macedonia, Romania and Serbia. The article begins with the null hypothesis that economic development in these countries is not sustainable enough. The next section of this article provides a brief overview of relevant literature sources on the assessment of sustainable development in SEE countries, while the third one describes the sample and explains the materials and methods used in the research. The fourth section discusses the obtained results in detail, while the last one concludes the paper, giving some useful insights into the possible

reasons for the perceived unsustainable development in the observed SEE countries and achieving the main goal of this research.

Literature review

Despite the vital importance of sustainable development for Southeast European countries, it is possible to observe a limited number of empirical researches devoted to the study of this important thematic field. The scientific contribution of this article stems from this fact, while it sheds light on certain infrastructural and environmental determinants of sustainable development in selected SEE countries. From the aspect of analysing environmental indicators and sustainable development in target countries, on a sample of 11 former Yugoslav and SEE countries, Muntilak Ivanović et al. (2009, p. 2079) compared their 38 relevant indicators from the social, economic, ecological and institutional subsystems with the same parameters for Germany, France and Greece as reference countries. They drew the inference that SEE countries, unlike developed EU countries, still have a fragile relationship between the sets of economic and environmental measures. This empirical research revealed high positive values of environmental indicators that point to potentially economically less developed SEE countries, concluding that they should make great efforts in directing their economic development, but without endangering their own valuable ecological potentials. Çelebioğlu (2012, pp. 477-485) applied Explanatory Spatial Data Analysis (ESDA), geovisualization, spatial autocorrelation and spatial modelling on a sample of 21 countries in Eastern and South-Eastern Europe in the period from 2000 to 2010. The author analysed the dynamics of the GDP per capita average growth rate for this period, as well as the values of the Human Development Index (HDI) and Sustainable HDI for 2010. He noticed that there was a significant gap in the level of development among the considered European countries, as well as that their location largely determined the level of these indicators, and thus of their economic and social development. The Local Indicators of Spatial Association (LISA) statistics also indicated the presence of significant local spatial autocorrelation, pointing to remarkable spatial heterogeneity that occurred in the form of two different spatial clusters, the first one with high and the second one with low values of the observed indicators.

Petrov et al. (2018) use clusters created by the hierarchical method on a sample of 10 countries of Southeast Europe. They consider 15 indicators, 13 of which represent indicators of economic well-being, social equality and environmental quality, while the remaining two metrics refer to the poverty gap and the Gini index. The authors conclude that the analysed countries can be classified into three separate clusters, while they differ from each other according to their socio-economic environment. Finally, the economic development occurs either as an enabler or as an obstacle to their social and environmental progress. Raszkowski and Bartniczak (2019) use the Synthetic Measures of Development (SMD) method on the example of 11 countries of Central and Eastern Europe in the period from 2010 to 2016 with the aim of assessing the level of their sustainable development. The authors conduct a comprehensive analysis of 66 global SDGs, as well as of driving and disincentive indicators that cover general areas relevant to meeting these goals. This empirical article concludes that the situation regarding

sustainable development in the observed period has improved in the selected countries, although its condition is most favourable in the Czech Republic and Slovenia, moderate in Estonia, Hungary, Slovakia, Poland, Lithuania, Latvia and Croatia, while it is least conductive in Bulgaria and Romania.

In terms of the diagnosed relationship between environmental and economic development, Golušin et al. (2012, pp. 87-93) also analysed 20 different economic and environmental sustainable development indicators on an already mentioned repeated sample of 11 former Yugoslav and SEE countries. This research again pointed to a noticeable gap in the achieved degree of economic and environmental development among the SEE countries, on one hand, and Germany and France as the two most developed EU countries on the other hand. The article concludes that there is a clear direct connection between the degree of economic development and the threat to the environment, as well as that less developed SEE countries should invest large and wider efforts in their progress, but not at the expense of their own ecological prospects. Radovanović and Lior (2017) on the example of 10 SEE countries compare two basic scenarios: a) the traditional approach to assessing sustainable economic development, which is based on a high weighting of GDP-PPP variable with b) an alternative approach that assigns lower weights to GDP-PPP, but also higher weights to natural wealth and income equality (Gini coefficient). This research also included the consideration of Germany, France and Russia as the large non-EU country for the purpose of comparison. By using a set of 10 economic and 10 environmental indicators, they conclude that the SEE countries have the same, or even higher rankings of sustainability compared to the developed countries, as well as that developing countries that have relatively low greenhouse gas (GHG) emissions and energy use levels are in a more favourable position from the aspect of sustainable development.

Finally, from a policy approach point of view, Kutlača (2021) considers sustainable development in Albania, Bosnia and Herzegovina, North Macedonia, Montenegro and Serbia in the period from 2010 to 2019. The author emphasizes the achieved progress in energy efficiency, the use of renewable energy and the development of a smart specialization strategy in the selected countries. However, he also notes certain problems of WB countries, among which the brain drain, high youth unemployment rate, rampant corruption and underdeveloped financial systems stand out. In this sense, the author advocates for increased investment efforts in research and development, harmonization of their legal systems and institutional frameworks with those of the EU, commercialization of research systems, further encouragement of smart specialization strategies, as well as improvement of the scientific research work quality in scientific institutes and universities in adapting their national research systems to the needs and challenges of the new economy. On the other hand, the South East Europe (SEE) 2030 Strategy insists on the implementation of the 45 socio-economic UN Sustainable Development Goals in the SEE countries by fostering prosperity, empowering people and promoting peace and partnership (4Ps), all with the aim of eradicating poverty and reducing inequality, fostering social inclusion, strengthening marginalized groups, accelerating the green and digital transitions, preventing emigration flows and improving the overall quality of life of the population (Ergazer et. al, 2021, p. 27). These goals are particularly relevant in light of the accession of some of these countries to the EU and their Euro-Atlantic integration processes, as well as strengthening their resilience to global financial and economic crises, health challenges and other external shocks.

Sample description, materials and research methods

The aim of this article is to examine the hypothesis of unsustainable development on the example of the following eight selected countries of Southeast Europe: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, North Macedonia, Romania and Serbia, in the period from 2001 to 2020. The analysed sample initially consisted of 168 observations of a balanced panel, while the data used were derived from the UN SDGs and World Bank databases. With the aim of assessing the validity of the paradigm of unsustainable development in these countries, the paper examines the influence of relevant infrastructural, environmental and controlling economic predictors (Table 1) on the trend of real Gross domestic product (GDP) as one of the most frequently used indicators of sustainable growth in the scientific literature. The observed variables covered a number of different issues, especially in the domain of the United Nations goals SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), and SDG 9 (Industry, Innovation and Infrastructure).

Table 1 Variables used in research

Sustainable development goal	Variable name	Variable code	Variable description	Variable type
	Real GDP level	GDP	Annual GDP values (in billions of 2015 constant US$)	Regressand
SDG 6	Sanitation services	SAN	The share of population using safely managed sanitation services (in %)	Predictor
SDG 7	Renewable energy	RWNE	Renewable energy consumption in total final energy consumption (in %)	Predictor
SDG 8	Unemployment rate	UNEM	The share of unemployed in total labour force (in %)	Control variable
SDG 9	CO_2 emissions	CO_2	Carbon dioxide (CO_2) emissions per capita (in metric tons)	Predictor
SDG 9	Agri methane emissions	AGRIME	Agricultural methane emissions (in thousands of metric tons of CO_2 equivalent)	Predictor
SDG 9	Industrial value added	IND	The share of manufacturing value added in GDP (in %)	Control variable

Source: UN SDGs (2023) and the World Bank (2023)

At first glance, there appears to be a considerable heterogeneity among the analysed sample countries, especially due to the fact that some of them have been the EU members for a long time (Bulgaria, Croatia, Greece and Romania), while the rest of the countries are still on their way to their full EU membership (Albania, Bosnia and Herzegovina, North Macedonia and Serbia). When it comes to the response variable of interest, huge discrepancies in the level of real GDP are noticed among the countries considered, with Greece as the leading country, followed by Romania, Bulgaria, Croatia, Serbia, Bosnia and Herzegovina, Albania and North Macedonia in last place. Regarding the unemployment rate, the observed countries showed slightly less fluctuations, with the maximum achieved

value of this indicator in North Macedonia (37.3%), followed by Bosnia and Herzegovina (31.1%), Greece (27.5%) and Serbia (23%). On the other hand, in the period from 2000 to 2020, the lowest unemployment rates were obtained in Bulgaria (4.2%) and Romania (3.9%) as in the more developed countries from the sample. Finally, the perceived countries experienced smaller mutual differences in the share of industrial value added, with its maximum achieved value registered in Serbia (21.7%) and Romania (21.4%) and its lowest recorded value in Albania at the level of 4%.

In regard of the environmental variables of interest, the observed countries showed pronounced mutual discrepancies in access to safely managed sanitation services, with the highest value of this indicator in Greece at the level of 93%, Romania at 81.5% and Bulgaria at 70%. At the same time, Bosnia and Herzegovina and North Macedonia had the lowest share of the population with access to safely managed sanitary services, where these indicators amounted to around 19% and 13.6%, respectively. When it comes to CO_2 emissions, it is noted that the highest value of this indicator was achieved in Greece (9.4 mt per capita), followed by Serbia (7.7 mt per capita), Bulgaria (7 mt per capita) and Bosnia and Herzegovina (6.7 mt per capita). On the other hand, Albania, as a less developed sample country, had the lowest CO_2 emissions of only 1 metric ton per capita. Concerning the agricultural methane emissions, Romania and Serbia took the lead, while North Macedonia and Croatia experienced the lowest values of this indicator. Finally, it follows from the analysis that Albania (44.6%), Bosnia and Herzegovina (37.7%) and Croatia (33.6%) achieved the highest share of renewables in the total final energy consumption, while the surprising fact is that the opposite conclusion applies to Bulgaria (7.2%) and Greece (7.1%). The following Table 2 shows the summary results of the descriptive statistics of the indicators used in the analysis.

Table 2 Descriptive statistics of the used variables

Variables	Mean	Median	Maximum	Minimum	Stand. Dev.	Jarque-Bera	Prob.
Real GDP level	68.1893	39.6600	265.9700	6.0600	75.0560	44.6490*	0.0000
Sanitation services	45.2038	43.7350	93.3700	13.4700	23.2993	10.6185*	0.0049
Renewable energy	21.5108	20.0150	44.5800	7.1100	8.7128	10.1790	0.0062
Unemployment rate	16.4882	15.3300	37.2500	3.9000	8.4110	12.7916*	0.0017
CO_2 emissions	4.9375	4.7000	9.4000	1.0000	1.9253	0.2739	0.8720
Agri methane emissions	3195.619	2083.500	10225.000	769.000	2521.107	78.07948*	0.0000
Industrial value added	12.1474	12.2550	21.7300	4.0100	4.1592	1.8167	0.4032

**denotes statistical significance at the level of 5%*
Source: Authors' calculations

The article applies panel regression analysis with the aim of determining the relationship among the dependent variable Real GDP level and the observed explanatory variables. More precisely, the article uses the Fixed Effects Model (FEM) to identify the mentioned relations. The most general and simplest form of the Fixed Effects Model can be written as follows (Gujarati, 2012, pp. 293-298):

$$y_{it} = \alpha_i + \beta_i X_{it} + u_{it} \quad (1)$$

where y_{it} is the dependent variable estimated for each cross-sectional unit *i*, α_i is the intercept, X_{it} is the matrix of regression variables, β_i is the matrix of coefficients of explanatory variables, while u_{it} is the regression error term.

Taking into account Equation 1 and variable codes from Table 1, the considered research model can be written as follows:

$$\ln(GDP) = \alpha_i + \beta_1 SANit + \beta_2 RNWEit + \beta_3 UNEMit + \beta_4 CO_2 it + \beta_5 AGRIMEit + \beta_6 INDit + u_{it} \quad (2)$$

The statistical program used to analyse the panel data in the paper was the R programming language. The following software packages were used: plm, foreign, punitroots and lmtest.

Research results and discussion

The initial analysis included the calculation of the Variance Inflation Factor (VIF) for all observed independent variables in order to avoid the trap of multicollinearity between predictors. The values of the VIF indicator did not exceed the level of 2.85, indicating the absence of multicollinearity, as well as the possibility of continuing with the given research (Table 3).

Table 3 Collinearity statistics

Predictors	Tolerance	VIF
Sanitation services	0.438	2.285
Renewable energy	0.351	2.852
Unemployment rate	0.394	2.538
CO_2 emissions	0.358	2.790
Agri methane emissions	0.407	2.454
Industrial value added	0.398	2.512

Source: Authors' calculations

The article continued with the analysis of cross-sectional errors dependence across individually observed units *i*, that is, across analysed countries. For this purpose, the Pesaran CD cross-sectional dependence test was applied, which shows robust results even on small samples (Pesaran, 2004). The results of the applied Pesaran CD cross-sectional dependence test indicated the presence of cross-sectional dependence in all selected variables, with the exception of the Industrial value added indicator. The results of the cross-sectional dependence test are shown in the following Table 4.

Table 4 Pesaran CD cross-sectional dependence test results

Variables	Test statistic	Probability	Test diagnostics
Real GDP level	15.3471*	0.0000	Presence
Sanitation services	12.6231*	0.0000	Presence
Renewable energy	16.0950*	0.0000	Presence

Unemployment rate	10.4897*	0.0000	Presence
CO_2 emissions	5.0407*	0.0000	Presence
Agri methane emissions	16.9945*	0.0000	Presence
Industrial value added	1.5333	0.1252	Absence

** denotes statistical significance at the level of 5%*
Source: Authors' calculations

For this reason, the paper approached to the application of the second generation of panel data unit root tests, or more specifically to the use of the Covariate Augmented Dickey-Fuller (CADF) test, corrected for the effects of observed cross-correlational dependence, with the aim of determining the presence of stationarity of the observed variables. In this research, the CADF test was applied since it brings power gains, and it is appropriate for small size panels with macroeconomic data (Constantini and Lupi, 2011, pp. 1-41). The starting hypothesis of the CADF test is that all time series are stationary at the order of their first differences, while the alternative one is that at least one of them is not. After differentiating the variables and thus reducing the sample size from 168 to 160 observations, by using the CADF test, it was determined that all variables were stationary in their first differences at the level of statistical significance up to 5%. The only exception was the Real GDP level variable, which was stationary at the level of up to 10% (Table 5).

Table 5 Covariate Augmented Dickey-Fuller test results

Variables	**I(0)**			**I(1)**		
	None	**Drift**	**Trend**	**None**	**Drift**	**Trend**
Real GDP level	0.5165	0.9252	-2.2088*	-1.8044*	-2.8179*	-1.6063**
	(0.6973)	(0.8226)	(0.0136)	(0.0356)	(0.0024)	(0.0541)
Sanitation services	-6.2006*	2.6279	-1.1514	-5.3153*	-5.6287*	-4.5513*
	(2.81e-10)	(0.9957)	(0.1248)	(5.32e-08)	(9.07e-09)	(2.66e-06)
Renewable energy	-0.8470	-0.4754	1.9934	-4.9344*	-4.1438*	-4.6209*
	(0.1985)	(0.3172)	(0.9769)	(4.02e-07)	(1.70e-05)	(1.91e-06)
Unemployment rate	-2.9488*	3.6463	3.5108	-2.6686*	-2.4167*	-1.6562*
	(0.0016)	(0.9999)	(0.9998)	(0.0038)	(0.0078)	(0.0488)
CO_2 emissions	0.7553	-1.8642*	-2.3506*	-3.1993*	-5.1046*	-6.166*
	(0.775)	(0.0312)	(0.0094)	(0.0007)	(1.65e-07)	(3.50e-10)
Agri methane emissions	-1.2356	-4.481*	-4.5886*	-6.547*	-5.4972*	-4.2248*
	(0.1083)	(3.71e-06)	(2.23e-06)	(2.93e-11)	(1.92e-08)	(1.19e-05
Industrial value added	2.037	3.2131	-2.1298*	-2.2653*	-6.7979*	-3.373*
	(0.9792)	(0.9993)	(0.0166)	(0.0118)	(5.30e-12)	(0.0004)

**denotes statistical significance at the level of 5% and ** denotes statistical significance at the level of 10%*
Source: Authors' calculations

After this step, the article approached to the application of the F-test, the Lagrange multiplier test and the Hausman test with the aim of selecting the most appropriate panel data model (Table 6).

Table 6 The results of tests for selecting the most appropriate panel data model

Used tests	F-test	Breusch- Pagan Lagrange multiplier test	Hausman test
Test statistics	F = 3.7031*	Chisq = 7.7875*	Chisq = 24.9942*
Degrees of freedom	df1 = 7, df2 = 146	1	6
P-value	0.0010	0.0053	0.0003

** denotes statistical significance at the level of 1%*
Source: Authors' calculations

Diagnostics of the conducted tests from the previous Table 6 indicated that the Fixed Effects Model (FEM) appeared as the best choice. The following Table 7 represents the results of post hoc tests for the evaluation of serial correlation, cross-sectional dependence and heteroskedasticity of the selected FEM model.

Table 7 The results of post hoc tests of the chosen Fixed Effects Model

Used tests	Breusch- Godfrey/ Wooldridge test	Pesaran CD test	Modified Wald test for groupwise heteroskedasticity
Test statistics	Chisq = 45.456*	z = 9.7212*	Chisq = 37.75*
Degrees of freedom	20	-	8
P-value	0.0009	0.0000	0.0000

** denotes statistical significance at the level of 1%*
Source: Authors' calculations

The results of the Breusch-Godfrey/Wooldridge test for serial correlation showed that there was serial correlation in the model. The results of the Pesaran CD test for cross-sectional dependence confirmed the presence of cross-sectional dependence in the model. Finally, the results of the conducted Modified Wald test for groupwise heteroskedasticity indicated the presence of the heteroskedasticity problem in the selected model.

The following Table 8 presents the comparative results of the conducted panel regression analysis. The authors opted for conducting the panel regression analysis on the variables that were transformed by their first differentiation, bearing in mind the previously mentioned results of the panel unit root test from Table 5. Although the results of the conducted Hausman test clearly favoured the application of the Fixed Effects Model, the succeeding Table 7 provides a comparative overview of the following three competitive models` results: a) the Pooled model, b) the Feasible Generalized Least Squares (FGLS) model and of the most appropriate c) the Least Squares Dummy Variable (LSDV) model outcomes. In addition, it is important to note that the standard errors of the chosen and presented LSDV Fixed Effects Model were corrected for the effects of the observed autocorrelation, cross-sectional dependence and heteroskedasticity.

Table 8 The results of the Polled, FGLS and LSDV panel data regression models

Variables and test diagnostics	Pooled model	FGLS model	LSDV model
Constant	0.0236*	0.0253*	0.0296*
	(0.0011)	(0.0033)	(0.0055)
Sanitation services	-0.0033**	-0.0072**	-0.0151**
	(0.0013)	(0.0035)	(0.0062)
Renewable energy	-0.0003	-0.0001	-0.0005
	(0.0004)	(0.0006)	(0.0013)
Unemployment rate	-0.0065*	-0.0051*	-0.0064*
	(0.0005)	(0.0008)	(0.0018)
CO_2 emissions	0.0440*	0.0275*	0.0382*
	(0.0030)	(0.0047)	(0.0084)
Agri methane emissions	-1.52E-05**	-1.85E-05	-8.97E-07
	(6.29E-06)	(1.18E-05)	(2.13E-05)
Industrial value added	-0.0076*	-0.0047***	-0.0085**
	(0.0014)	(0.0024)	(0.0041)
Standard error of regression	0.0300	0.9861	0.0288
Residual sum of squares	0.9990	141.9712	0.1212
R-squared	0.3438	0.6048	0.4427
Adj. R-squared	0.3402	0.5697	0.3931
F-statistic	97.1737*	17.1905*	8.9217*
P-value of F-statistic	0.0000	0.0000	0.0000
Durbin-Watson statistic	1.4445	1.5155	1.5249

** denotes statistical significance at the level of 1%, ** denotes statistical significance at the level of 5%, while *** denotes statistical significance at the level of 10%, standard errors in parentheses*
Source: Authors' calculations

The results of the selected LSDV model indicated a statistically significant relationship among the response variable ln(GDP) and the following explanatory variables: Sanitation services, Unemployment rate, CO_2 emissions (in mt pc), and Industrial value added. The only exceptions were the Renewable energy and the Agricultural methane emissions variables, which did not generate statistically significant results. Furthermore, a negative relationship was observed among the variables ln(GDP) and Sanitation services, Renewable energy, Unemployment rate, Agri methane emissions, and Industrial value added, while there was a positive relationship between the dependent variable ln(GDP) and CO_2 emissions (in mt pc). Expressed in relation to the dependent variable ln(GDP), the obtained value of the CO_2 emissions β coefficient amounted to 0.0382. The Adjusted coefficient of determination (Adjusted R-squared) of the proposed model was about 0.39, which means that the model explained about 39% of the variations of the dependent variable ln(GDP) for the observed countries. In addition, the F-statistic value of 8.9217 was statistically significant at the level of $p=0.0000<0.001$, implying that all predictors jointly contributed to the real GDP and that it was a well-fitted model. Finally, a correct value of the Durbin-Watson statistic of 1.5249 showed the

absence of autocorrelation from the selected model (Doryab and Salehi, 2018, p. 103), also suggesting that it was a valid model.

First of all, these results indicate that the infrastructure in the observed countries expressed by access to safely managed sanitary services probably does not follow the needs of their real GDP increase, which is why one can conclude that from this aspect the economic development of the observed SEE countries is not sustainable enough. At the same time, sustainable and high-quality infrastructure is of key importance for economic development since it brings numerous economic, social and environmental benefits and supports economic growth by enabling the availability of fundamental services and improving economic opportunities for all economic subjects (OECD, 2023). The development of such infrastructure is of vital importance for every economy since it is more protected from climate risks and it contributes to a better quality of life, superior production processes, and higher returns on investments (Beksultanova et al., 2021). Among other things, sustainable infrastructure contributes to greater employment opportunities, migratory movements of workers and companies' decisions about their investment locations (Ahmad, 2021). Although upgrading and improving existing infrastructural solutions can be a challenge for the development of any contemporary society and the well-being of its citizens, better management of infrastructural systems, greater investments and the establishment of smart and digital infrastructure represent key steps in their direction towards sustainable development (Mouratidis, 2021). All of the above leads to the conclusion that SEE countries will have to work more decisively on developing their sustainable infrastructure in order to be able to catch up with the more developed part of the world.

Furthermore, the negative relationship between the use of renewables and the level of real GDP also indicates the unsustainability of their development, since their economic development is accompanied by decreasing use of renewable energy sources. The results of the conducted analysis also indicated that parallel to their real GDP increase, harmful CO_2 emissions also rise, based on which it can be concluded that in the sample countries economic development is not sustainable even from this aspect. In contrast to the expected effects of the Unemployment rate variable, the Industrial value added also quite unexpectedly showed a negative statistical relationship with the level of real GDP. These findings probably arose as a result of the fact that this article analyzes relatively underdeveloped SEE countries in relation to the EU average. At the same time, the other part of the analysed countries bases their development to the greatest extent on services, tourism and trade, while some of them also base it on agriculture. Finally, of all observed environmental predictors, only agricultural methane emissions yielded the expected negative relationship with the dependent variable real GDP. It should also be noted that the observed environmental variable (CO_2 emissions) is treated as an expression of consumption, i.e. the demand side factor. In other words, this indicator is perceived in the light of the production factors consumption influence on the production process itself and on energy production (thermal power plants and population consumption for everyday needs using wood and coal). In this way, the results of this conducted research fit quite well with the findings of other considered authors (Muntilak Ivanović et al., 2009; Golušin et al., 2012; Çelebioğlu, 2012; Radovanović and Lior, 2017; Petrov et al., 2018) on the negative relationship between economic growth and environmental protection expressed by environmental indicators trend, and therefore on the unsustainability of economic development in SEE countries.

Conclusion

The purpose of this article was to examine the validity of the sustainable development hypothesis, as well as to assess the impact of selected infrastructural and environmental indicators on the sustainable development in the observed SEE countries in the period from 2001 to 2020. More precisely, the analysis included an assessment of the feasibility of the sustainable development paradigm on the example of Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, North Macedonia, Romania and Serbia. Using the LSDV approach in evaluating the panel data, the article concluded that in these SEE countries, from the aspect of access to safely managed sanitary services, the use of renewable energy sources and harmful CO_2 emissions, their economic development was unsustainable. On the other hand, only the variable related to agricultural methane emissions showed the expected and therefore negative relationship with real GDP increase, indicating that they decreased along with the increase in the real GDP level. These findings confirmed the initial paper's hypothesis on the unsustainability of economic development in the given countries, with the exception of observed emissions of agricultural methane.

The obtained results are very significant since they indicate that the analysed countries clearly lag behind the developed ones in the context of sustainable development parameters. The findings also indicate that these SEE countries should invest much more effort in the future to promote their sustainable developmental paths, especially taking into account the fact that unsustainable development can lead to a series of negative externalities. In this sense, this article is especially instructive to public policy and decision makers, but also to researchers, scientists and a wider readership interested in encouraging sustainable development in the region of Southeast Europe. The objective limitation of this article relates to the availability of data used for the observed SEE countries, as well as to the fact that the analysis considered eight countries, a larger number of which could somewhat change the results obtained. In addition, this research is also limited by the impact of infrastructural, environmental and economic factors on the sustainable economic development of the countries considered. Therefore, possible future research directions of these important issues could focus on the investigating the influence of social factors and soft infrastructure such as health care, education, institutional development, rule of law, political instability, quality of financial institutions and prevailing inequalities on the sustainable development of the observed SEE countries.

The wider implications of this research are related to the fact that it contributes to the expansion of the stock of theoretical and empirical knowledge of this area, which makes the obtained results significant for decision and policy makers, researchers and the concerned wider public. The obtained findings indicate that in the future, decision and policy makers should more seriously consider the principles and recommendations from the SEE 2030 strategy in order to encourage intra-regional cooperation, develop sustainable infrastructure and thus finally guide their countries towards pathways of sustainable growth and development. This particularly applies to the improvements of elementary sanitary infrastructure, transport networks that prevent access to markets, increasing the resilience of educational systems and health infrastructure to disasters, better use of existing financial facilities, encouraging further investments in research, development and innovation, developing ICT and digital broadband infrastructure,

strengthening local infrastructure for the use of renewables, encouraging social protection policies, etc.

On a more concrete level, in terms of improved management of sanitation service supply, these countries need to educate and raise awareness among the population, implement strong sanitation management systems, improve water purification systems, work on the introduction, improvement and development of sustainable sanitation infrastructure, promote clean water practices, mobilize drivers for maintaining of public spaces and improve cooperation with local communities, all in accordance with Integrated Water Resource Management approach. This holistic approach promotes the safe use of water resources, the careful use of wastewater and the savings in water use for household and agricultural needs (Thevenon, 2020, p. 2). On the other hand, in terms of using renewables and reducing harmful CO_2 emissions, these countries need to work more seriously on promoting and developing stable and predictable policies for sustainable development, energy independence, energy security and a green transition through focusing on more intensive use of renewables. In this regard, investments in the construction of new clean energy capacities, the modernization of existing energy infrastructure and the introduction of innovative technologies should be intensified with the aim of increasing the potential of renewable energy resources and minimizing harmful CO_2 emissions. The aforementioned efforts could be supplemented by the increased use of pellets and biomass, as well as by encouraging the production of electricity and heat from environmentally friendly and renewable sources (Mykoliuk and Bobrovnyk, 2019, p. 69), with reduced pollution, and therefore by enhancing more sustainable development of the observed countries.

Acknowledgements

This paper is a part of the research results on project U Sustainable development and environmental protection in the business economy, realized by Faculty of Finance, Banking and Auditing of Alfa BK University from Belgrade, Serbia.

References

Ahmad, E. (2021). Multilevel financing of sustainable infrastructure in China— Policy options for inclusive, resilient and green growth. Journal of Infrastructure, Policy and Development, 5(1), 1-24. DOI: 10.24294/jipd.v5i1.1251

Beksultanova A.I., Gaisumova L.J., & Sadueva, M.A. (2021). The role of infrastructure in sustainable development. *SHS Web of Conferences 128, XVII International Scientific and Practical Conference on Sustainable Development of Regions* (pp. 1-7). Yekaterinburg, Russia: IFSDR 2021. https://doi.org/10.1051/shsconf/202112801008

Çelebioğlu, F. (2012, May-June). The Analysis of Sustainability Development of Eastern and South Eastern Europe in the Post Socialist Period. *Proceedings of the Third International Symposium On Sustainable Development* (pp. 477-486), May 31, 2012-June 1, 2012. Sarajevo, Bosnia and Herzegovina.

Constantini, M., & Lupi, C. (2011). A simple panel-CADF test for unit roots. Reihe Ökonomie/ Economics Series, No. 261. Vienna: Institute for Advanced Studies (IHS).

Doryab, B., & Salehi, M. (2018). Modeling and forecasting abnormal stock returns using the nonlinear Grey Bernoulli model. Journal of Economics, Finance and Administrative Science, 23(44), 95-112. http://dx.doi.org/10.1108/JEFAS-06-2017-0075

Ergazer, A., Balažić, P., & Kopliku, E. (2021). SEE 2030 Strategy. Sarajevo, Bosnia and Herzegovina: Regional Cooperation Council.

Filipović, M., Radukić, S., & Bačanek, V. (2024a). The Importance of the EU Strategic Approach for Progress Towards the Sustainable Development Goals. Economics of Sustainable Development, 8(1), 25-39. DOI: 10.5937/ESD2401025F

Filipović, M. (2024b). Trends in Sustainable Development and Environmental Protection in Serbia and the Western Balkans. Economics of Sustainable Development, 8(2), 53-65. DOI: 10.5937/ESD2402053F

Golušin, M., Muntilak Ivanović, O., Jovanović, L., & Domazet, S. (2012). Determination of the Ecological-Economic Degree of Development in Countries of SE Europe – Weight Coefficients Technique. Problems of Sustainable Development, 7(1), 87-93.

Gujarati, D. (2012). Econometrics by Example. New York: Palgrave Macmillan.

Kutlača, Đ. (2021). UNESCO Science Report: The race against time for smarter development. Chapter 10: Southeast Europe (pp. 291-307). Paris, France: UNESCO.

Madžar, L. (2023, June). Sustainable Development in the Western Balkans Countries: the Panel Analysis. Book of Proceedings, *Second International Conference Business, Economy, Law, Education – BELECON 2023* (pp. 283-290). Belgrade, Serbia: Belgrade Academy of Business and Art Vocational Studies, Belgrade.

Mensah, J., & Ricart Casadevall, S. (2019). Sustainable development: Meaning, history, principles, pillars, and implications for human action: Literature review. Cogent Social Sciences, 5(1), 1-21. https://doi.org/10.1080/23311886.2019.1653531

Mouratidis, A. (2021). Smooth integration of transport infrastructure into urban space. Journal of Infrastructure, Policy and Development, 5(2), 1-10. DOI: 10.24294/jipd.v5i2.1379

Muntilak Ivanović, O., Golušin, M.T., Dodić, S.N., & Dodić, J.M. (2009). Perspectives of sustainable development in countries of Southeastern Europe. Renewable and Sustainable Energy Reviews, 13(8), 2079-2087. https://doi.org/10.1016/j.rser.2009.03.004

Mykoliuk, O. A., & Bobrovnyk, V. M. (2019). Strategic guidelines on the development of renewable energy sources. Global Journal of Environmental Science and Management (GJESM), 5(2019), 61-71. DOI: 10.22034/gjesm.2019.SI.07

Organization for Economic Cooperation and Development. (2023). Improving the Landscape for Sustainable Infrastructure Financing. Paris, France: OECD.

Österreichische Gesellschaft für Europapolitik. (2023). Bringing sustainability to the Western Balkan region, March 15, 2023. Retrieved on October 22, 2023 from: https://www.oegfe.at/policy-briefs/bringing-sustainability-to-the-western-balkan-region/?lang=en

Pesaran, H.M. (2004). General Diagnostic Tests for Cross Section Dependence in Panels. IZA Discussion Paper Series, No. 1240. Bonn, Germany: IZA.

Petrov, V., Trivić, N., & Ćelić, Đ. (2018). Assessing Sustainability of the Southeast European Economies. Economics of Agriculture, 65(2), 519-529. https://doi.org/10.5937/ekoPolj1802519P

Popović, S., Cvetković, M., & Avramović, M. (2023). Green marketing in the function of sustainable development. *Ekonomika*, *69*(2), 61-73. https://doi.org/10.5937/ekonomika2302061P

Radovanović, M., & Lior, N. (2017). Sustainable economic–environmental planning in Southeast Europe – beyond-GDP and climate change emphases. Sustainable Development, 25(6), 580-594. https://doi.org/10.1002/sd.1679

Raszkowski, A., & Bartniczak, B. (2019). Sustainable Development in the Central and Eastern European Countries (CEECs): Challenges and Opportunities. Sustainability, 11(4), 1-18. https://doi.org/10.3390/su11041180

The World Bank. (2023). World Bank Open Data. Retrieved on August 6, 2023 from: https://data.worldbank.org/

Thevenon, F. (2020). Sustainable Sanitation Systems: Health, Environment and Governance Challenges: The Case of Human Rights-Based Policy Reform in Alternative Wastewater Management Strategies. Geneva: UN environment and Water Lex.

Tufaner, M.B., & Türker, T. (2016). The Importance of the Sustainable Development in Terms of Quality of Life of Future Generation. Journal of Social and Administrative Sciences, 3(4), 300-310.

United Nations. (1987). Report of the World Commission on Environment and Development: Our Common Future. New York, USA: United Nations.

United Nations. (2015). Global Sustainable Development Report, 2015 Edition. New York, USA: United Nations.

United Nations Development Programme. (2007). Environmental Policy in South-Eastern Europe. Belgrade, Serbia: UNDP.

United Nations Sustainable Development Goals. (2023). Country Profiles. Retrieved on August 5, 2023 from: https://dashboards.sdgindex.org/profiles

World Bank Group. (2021). Western Balkans Regular Economic Report, No. 20. Washington D.C., USA: International Bank for Reconstruction and Development and The World Bank.

ЕКОНОМИКА
ISSN 0350-137X, EISSN 2334-9190, UDK 338 (497,1)
Vol. 71, april-june 2025, № 1
P. 89-101

Bojan Stoiljković[1]
Marijana Joksimović[2]
Suzana Balaban[3]
Alfa BK University, Faculty of Finances, Banking and Auditing , Belgrade, Serbia

ORIGINAL SCIENTIFIC ARTICLE
DOI: 10.5937/ekonomika2502089S
Received: January 30, 2025
Accepted: April 10, 2025

ANALYSIS OF PROFITABILITY OF SERBIAN MANUFACTURING COMPANIES BEFORE AND DURING COVID-19 PANDEMIC

Abstract

The authors analysed the profitability of the Serbian manufacturing companies before and during the Covid-19 pandemic. The sample consists of fifty largest manufacturing companies by operating income in 2022. Observation time includes the period from 2017 to 2022. The financial statements of the selected companies had been used in the analysis covering the period before and during the Covid-19 pandemic in order to make a comparison between two periods. The authors use the IBM SPSS software for the statistical analysis of the data. The main aim of this paper is to determine whether the profitability of the observed companies differed significantly before and during the pandemic. For this purpose paired samples t-test is used. According to the obtain results there were no significant differences in profitability of Serbian manufacturing companies before and during the Covid-19 pandemic. This research may highlight potential areas for improvement in crisis management and government support for the manufacturing sector.

Key words: *Profitability, Financial statements, ROA, Covid-19 pandemic and Serbia*

JEL classification: *G30, G32, G40*

АНАЛИЗА ПРОФИТАБИЛНОСТИ ПРЕДУЗЕЋА ПРЕРАЂИВАЧКЕ ИНДУСТРИЈЕ У СРБИЈИ ПРЕ И ТОКОМ ПАНДЕМИЈЕ ЦОВИД-19

Апстракт

Аутори су анализирали профитабилност предузећа прерађивачког сектора Србије пре и током пандемије Цовид-19. Узорак чини педесет предузећа прерађивачких предузећа, чија је профитабилност анализирана за период од 2017. године до 2022. године. Селекција предузећа извршена је на основу критеријума опадајућих пословних прихода исказаних у билансу успеха 2022. године. Финан-

[1] bojan.stoiljkovic@alfa.edu.rs, ORCID ID 0000-0003-2796-8663

[2] joksimovicmarijana80@gmail.com, ORCID ID 0000-0002-5939-5137

[3] suzana.kolar@yahoo.com, ORCID ID 0000-0001-8132-9120

сијски извештаји одабраних компанија коришћени су у анализи која покрива период пре и током пандемије како би се направило поређење између два периода. За статистичку анализу података аутори су користили софтвер ИБМ СПСС. Основни циљ овог рада је да се утврди да ли се профитабилност посматраних компанија значајно разликовала пре и током пандемије. У ту сврху коришћен је паиред самплес т-тест. Према добијеним резултатима, није било значајнијих разлика у профитабилности српских прерађивачких предузећа пре и током пандемије. Ово истраживање може указати на потенцијалне области за унапређење менаџмента у кризним ситуацијама и државној подршци прерађивачком сектору.

Кључне речи: *прерађивачка индустрија, профитабилност, РОА, Цовид-19 пандемија, Србија*

Introduction

The Covid-19 pandemic led to a global crisis that affected nearly all aspects of life. The goal of this research is to examine the differences in profitability of Serbian manufacturing companies before and during the COVID-19 pandemic. By analyzing financial data from both periods, this study aims to identify the extent to which the pandemic influenced the performance of manufacturing firms in Serbia. The research will also explore the factors contributing to the changes in profitability, such as government interventions, changes in consumer behavior, and disruptions in supply chains. While it can be asserted that the pandemic did not undermine the stability of major world currencies or financial markets in the long term (Balaban et al., 2023), Zečević et al. (2022) noted that it caused significant disruptions of global supply chains, highlighting the necessity of explore the alternatives. It had a significant impact on the airline industry (Radić et al., 2021). Njegomir (2021) concludes that the Covid-19 pandemic resulted in a record decline in retail sales accelerating the development of the digital economy. According to the World Bank report (2020), Serbia faced a recession caused by the Covid-19 pandemic, which led to a decrease in GDP, an increase in the fiscal deficit, and rising public debt, while Paunović and Blagojević (2021)emphasized that Covid-19 does not impact all companies in the same way.

Research Questions: How did the profitability of Serbian manufacturing companies change before and during the COVID-19 pandemic? What were the key factors that contributed to the changes in profitability of Serbian manufacturing companies during the pandemic?

To what extent did government measures (such as financial aid, tax relief, or lockdowns) impact the profitability of Serbian manufacturing firms? Are there differences in the impact of the pandemic on small, medium, and large manufacturing companies in Serbia? What lessons can be learned from the profitability trends of Serbian manufacturing companies that can be applied to future economic crises?

The profitability of the companies across different sectors is a frequently analyzed concept in numerous scientific studies, considering that a high rate of profitability

significantly contributes to the well-being of individuals, economic entities, the state, and the broader community (Mirjanić and Karić, 2022; Lukić and Vojteški Kljenak, 2023). The following sections will provide a detailed examination of recent empirical studies aimed at analysing the profitability of different companies in the Republic of Serbia.

Literature review

Joksimović and Beke-Trivunac (2021) conclude that the largest global banks were well-capitalized and therefore prepared for the shock caused by the pandemic, thanks to the implementation of stricter regulatory rules during the outbreak of the Covid-19 pandemic. On the other hand, Lukić (2023) concludes that the profitability of the banking sector in the Republic of Serbia was significantly undermined by the pandemic. Knežević et al. (2022) show that the profitability of hospitality companies in the Republic of Serbia experienced a dramatic decline during the pandemic. Small and medium-sized companies in the Republic of Serbia were also significantly affected by the Covid-19 pandemic, which is reflected in the fact that their profitability significantly decreased during the pandemic. (Todić and Milić, 2021). Tica et al. (2023) show that Covid-19 pandemic has negative impact on construction companies in Bosnia and Herzegovina.

Table 1: The impact of COVID-19 on profitability – Results of previous studies

Author's	Sample	Period	Methodology	Results
Bangun et al. (2023)	30 banks listed on ISE	2017-2022	Wilcoxon rank and paired samples t-test	There is diference
Vojtekova and Kliestik (2024)	321 companies from SK NACE I	2016-2021	Nonparametric test	There is diference
Putri et al. (2023)	4 state-owned banks in Indonesia	2019-2020	Comparative quantitative analysis	There is diference
Qadri et al. (2023)	34 banks from the South Asian region	2016-2020	Wilcoxon rank test	There is diference
Surya and Suhendah (2023)	105 companies from food and beverages listed in Indonesia Stock Exchange	2019-2020	Wilcoxon rank and paired samples t-test	There is diference
Purwaningsih and Pernamasari (2023)	44 manufacturing companies listed on IDX	2018-2021	Paired samples t-test	Mixed results
Rathnayaka, R. M. U. R. and Gunasekara, A. L. (2023)	18 material sector companies in Sri Lanka	2018-2021	Nonparametric test	There is diference
Hamzah et al. (2022)	PT United Tractors Tbk	2019-2020	Comparative quantitative analysis	There is diference
Darma et al. (2022)	18 companies incorporated in IDX30	2019-2020	Quantitative descriptive approach	Mixed results
Knežević et al. (2022)	100 hotel companies in Serbia	2019-2020	Wilcoxon rank and paired samples t-test	There is diference
Daryanto et al. (2021)	PT Japfa Comfeed Indonesia	2019-2020	Paired samples t-test	There is no diference

Source: Authors' based on results of previous studies

Considering the results of the previous studies (Table 1), the authors formulated an initial hypothesis positing that there is a significant difference in profitability of the manufacturing companies in the Republic of Serbia before and during COVID-19 pandemic. According to official data from the World Health Organization, the official start of the Covid-19 pandemic is considered to be January 30, 2020, while May 5, 2023, was declared the end of the Covid-19 pandemic. In accordance with the main hypothesis, following auxiliary hypotheses have been formulated.

H_1: There is significant difference in ROE before and during the Covid-19 pandemic in manufacturing companies in Serbia.

H_2: There is significant difference in EBITDA before and during the Covid-19 pandemic in manufacturing companies in Serbia.

H_3: There is significant difference in ROA before and during the Covid-19 pandemic in manufacturing companies in Serbia.

In accordance with the stated hypotheses, the following research tasks have been defined: collecting financial data on ROE, EBITDA, and ROA before and during the Covid-19 pandemic, analyzing descriptive statistics, testing for significant differences, and identifying key factors influencing profitability changes. In accordance with the results of previous studies, the authors expect a significant difference in the profitability of manufacturing sector companies before and during the pandemic.

Research Design, Methodology, Research Tasks and Hypothesis

Financial analysis enables the identification of the relevant profitability indicators by examining the financial statements of enterprises. The authors used the SPSS 20 software program in order to analyse the profitability of manufacturing companies in the period before and during the Covid-19 pandemic. The research methods employed in the study include descriptive and comparative analysis, methods of induction and deduction, as well as content analysis of available literature.

The sample consists of 50 manufacturing companies in the Republic of Serbia. The companies were selected based on the criterion of declining business revenues observed in 2022. Companies for which there were no data for any of the observed years used in the analysis, during the period from 2017 to 2022, were excluded from the sample. The assumption is that financial statements of the observed companies from 2020, 2021, and 2022 were influenced by specific factors arising from the Covid-19 pandemic, while the financial statements from 2017, 2018, and 2019 were not affected by the specific factors arising from the Covid-19 pandemic.

$$ROE = \frac{Net\ Income}{Total\ Equity}$$

$$EBITDA\ margina = \frac{EBITDA}{Business\ Revenue}$$

$$ROA = \frac{Net\ Income}{Total\ Assets}$$

According to data from the Statistical Office of the Republic of Serbia, the manufacturing sector contributed to the GDP of the Republic of Serbia 15.1% in 2017, 14.5% in 2018, 13.7% in 2019, 13.3% in 2020, 13% in 2021, and 13.5% in 2022. In order to adequately analyse the profitability of the manufacturing companies in the Republic of Serbia before and during the Covid-19 pandemic, the authors analysed the following indicators: ROE (Return on Equity), EBITDA margin, and ROA (Return on Assets). ROA is the most commonly used profitability indicator in research papers (Stoiljković, 2024; Milošev, 2021; Vržina and Dimitrijević, 2020; Vuković and Jakšić, 2019). The indicators used in the study were calculated based on data available on the official website of the Serbian Business Registers Agency. Below is presented an overview of the formulas used to calculate the profitability indicators used in this study.

Research results

The means, standard deviations, minimum, and maximum values of the ROE for the observed manufacturing companies on an annual basis, covering the period from 2017 to 2022, are presented in Table 2.

Table 2. Descriptive statistics of ROE in the period from 2017 to 2022

Profitability indicator	N	Minimum	Maximum	Mean	Std. Deviation
ROE2017	50	-,7928	,8681	,232202	,2632365
ROE2018	50	-,7603	,6527	,179084	,2154522
ROE2019	50	-,0655	,6802	,176706	,1514930
ROE2020	50	-,5223	,7423	,141740	,1931576
ROE2021	50	-,2827	,7358	,184938	,1652532
ROE2022	50	-,3515	,9185	,212304	,2324542
Valid N (listwise)	50				

Source: Authors' calculation based on financial sheets from APR using SPSS

The means, standard deviations, minimum, and maximum values of the EBITDA margin for the observed manufacturing companies on an annual basis, covering the period from 2017 to 2022, are presented in Table 3.

Table 3. Descriptive statistics of EBITDA margin in the period from 2017 to 2022

Profitability indicator	N	Minimum	Maximum	Mean	Std. Deviation
EBITDAmargina2017	50	,0214	,3532	,139860	,0890113
EBITDAmargina2018	50	-,0091	,3739	,138320	,0956265
EBITDAmargina2019	50	-,0052	,4193	,135030	,0978576
EBITDAmargina2020	50	-,1154	,4614	,141166	,1118562
EBITDAmargina2021	50	-,0705	,4033	,143526	,1013625
EBITDAmargina2022	50	-,0905	,3943	,138794	,1008692
Valid N (listwise)	50				

Source: Authors' calculation based on financial sheets from APR using SPSS

The means, standard deviations, minimum, and maximum values of the ROA margin for the observed manufacturing companies on an annual basis, covering the period from 2017 to 2022, are presented in Table 4.

Table 4. Descriptive statistics of ROA in the period from 2017 to 2022

Profitability indicator	N	Minimum	Maximum	Mean	Std. Deviation
ROA2017	50	-,3269	,4041	,094312	,1012558
ROA2018	50	-,1734	,3419	,082432	,0892720
ROA2019	50	-,0487	,3444	,083800	,0744266
ROA2020	50	-,2620	,4301	,075804	,0969997
ROA2021	50	-,1922	,4500	,096416	,0927838
ROA2022	50	-,2406	,3936	,103322	,1070317
Valid N (listwise)	50				

Source: Authors' calculation based on financial sheets from APR using SPSS

Based on the results from Tables 1-3, it can be concluded that the profitability of the 50 analyzed manufacturing companies during the period from 2017 to 2022 were similar before and during the Covid-19 pandemic. It is assumed that the increase in the prices of raw materials was accompanied by a rise in sales prices, and consequently, business revenues. As a result, profitability indicators remained stable, suggesting that Covid-19 did not negatively impact the profitability of the observed companies.

In order to obtain adequate results, the authors employed a paired-samples t-test to assess the statistical significance of the differences between the means for the ROE, EBITDA margin, and ROA obtained in 2017, 2018, 2019, 2020, 2021, and 2022. The same test for this purpose was also applied by Surya and Suhendah (2023), Purwaningsih and Pernamasari (2023), Knežević et al. (2022) and Daryanto et al. (2021). In Table 4 are presented the results of the T-test for the differences between the means for the ROE. The statistical significance of the differences between the means was examined using the paired-samples T-test, for the following comparisons: ROE in 2017 and 2020, ROE in 2017 and 2021, ROE in 2017 and 2022, ROE in 2018 and 2020, ROE in 2018 and 2021, ROE in 2018 and 2022, ROE in 2019 and 2020, ROE in 2019 and 2021, and ROE in 2019 and 2022.

The research was conducted at a significance level of 0.05, corresponding to a 95% confidence interval. Since the p-value of the test (0.035) is less than the significance level of 0.05, the null hypothesis of equality between the means is rejected, leading to the conclusion that there is a statistically significant difference between the average ROE in 2017 and the average ROE in 2020. Conversely, the null hypothesis of equality between the means is accepted, concluding that there is no statistically significant difference between the means: of the ROE in 2017 and 2021, given that the p-value of the test (0.202) is greater than the significance level of 0.05; of the ROE in 2017 and 2022, given that the p-value of the test (0.680) is greater than the significance level of 0.05; of the ROE in 2018 and 2020, given that the p-value of the test (0.320) is greater than the significance level of 0.05; of the ROE in 2018 and 2021, given that the p-value of the test (0.865) is greater than the significance level of 0.05; of the ROE in 2018 and 2022, given that the p-value of the test (0.501) is greater than the significance level of 0.05; of

the ROE in 2019 and 2020, given that the p-value of the test (0.082) is greater than the significance level of 0.05; of the ROE in 2019 and 2021, given that the p-value of the test (0.668) is greater than the significance level of 0.05; of the ROE in 2019 and 2022, given that the p-value of the test (0.291) is greater than the significance level of 0.05.

Table 5. T-test of differences between arithmetic means of ROE

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	ROE2017 - ROE2020	,0904620	,2956800	,0418155	,0064307	,1744933	2,163	49	,035
Pair 2	ROE2017 - ROE2021	,0472640	,2586402	,0365773	-,0262407	,1207687	1,292	49	,202
Pair 3	ROE2017 - ROE2022	,0198980	,3389754	,0479384	-,0764377	,1162337	,415	49	,680
Pair 4	ROE2018 - ROE2020	,0373440	,2627007	,0371515	-,0373147	,1120027	1,005	49	,320
Pair 5	ROE2018 - ROE2021	-,0058540	,2429008	,0343514	-,0748856	,0631776	-,170	49	,865
Pair 6	ROE2018 - ROE2022	-,0332200	,3468905	,0490577	-,1318052	,0653652	-,677	49	,501
Pair 7	ROE2019 - ROE2020	,0349660	,1392054	,0196866	-,0045957	,0745277	1,776	49	,082
Pair 8	ROE2019 - ROE2021	-,0082320	,1350573	,0191000	-,0466149	,0301509	-,431	49	,668
Pair 9	ROE2019 - ROE2022	-,0355980	,2358397	,0333528	-,1026229	,0314269	-1,067	49	,291

Source: Authors' calculation based on financial sheets from APR using SPSS

In Table 6 are presented the results of the T-test for the differences between the means of the EBITDA margin. Using the paired-samples T-test, the statistical significance of the differences between the means was examined for the following comparisons: EBITDA margin in 2017 and 2020, EBITDA margin in 2017 and 2021, EBITDA margin in 2017 and 2022, EBITDA margin in 2018 and 2020, EBITDA margin in 2018 and 2021, EBITDA margin in 2018 and 2022, EBITDA margin in 2019 and 2020, EBITDA margin in 2019 and 2021, and EBITDA margin in 2019 and 2022.

The research was conducted at a significance level of 0.05, corresponding to a 95% confidence interval. The null hypothesis of equality between the means is accepted, concluding that there is no statistically significant difference between the means: of the EBITDA margin in 2017 and 2020, given that the p-value of the test (0.883) is greater than the significance level of 0.05; of the EBITDA margin in 2017 and 2021, given that the p-value of the test (0.640) is greater than the significance level of 0.05; of the EBITDA

margin in 2017 and 2022, given that the p-value of the test (0.910) is greater than the significance level of 0.05; of the EBITDA margin in 2018 and 2020, given that the p-value of the test (0.682) is greater than the significance level of 0.05; of the EBITDA margin in 2018 and 2021, given that the p-value of the test (0.400) is greater than the significance level of 0.05; of the EBITDA margin in 2018 and 2022, given that the p-value of the test (0.963) is greater than the significance level of 0.05; of the EBITDA margin in 2019 and 2020, given that the p-value of the test (0.266) is greater than the significance level of 0.05; of the EBITDA margin in 2019 and 2021, given that the p-value of the test (0.126) is greater than the significance level of 0.05; of the EBITDA margin in 2019 and 2022, given that the p-value of the test (0.695) is greater than the significance level of 0.05.

Table 6. T-test of differences between arithmetic means of EBITDA margin

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	EBITDAmargina 2017 – EBITDAmargina 2020	-,0013060	,0625344	,0088437	-,0190781	,0164661	-,148	49	,883
Pair 2	EBITDAmargina 2017 – EBITDAmargina 2021	-,0036660	,0550531	,0077857	-,0193119	,0119799	-,471	49	,640
Pair 3	EBITDAmargina 2017 – EBITDAmargina 2022	,0010660	,0662609	,0093707	-,0177651	,0198971	,114	49	,910
Pair 4	EBITDAmargina 2018 – EBITDAmargina 2020	-,0028460	,0488888	,0069139	-,0167401	,0110481	-,412	49	,682
Pair 5	EBITDAmargina 2018 – EBITDAmargina 2021	-,0052060	,0433694	,0061334	-,0175314	,0071194	-,849	49	,400
Pair 6	EBITDAmargina 2018 – EBITDAmargina 2022	-,0004740	,0714101	,0100989	-,0207685	,0198205	-,047	49	,963

Pair 7	EBITDAmargina 2019 – EBITDAmargina 2020	-,0061360	,0385477	,0054515	-,0170911	,0048191	-1,126	49	,266
Pair 8	EBITDAmargina 2019 – EBITDAmargina 2021	-,0084960	,0385956	,0054582	-,0194647	,0024727	-1,557	49	,126
Pair 9	EBITDAmargina 2019 – EBITDAmargina 2022	-,0037640	,0674513	,0095390	-,0229334	,0154054	-,395	49	,695

Source: Authors' calculation based on financial sheets from APR using SPSS

Table 7. T-test of the differences between arithmetic means of ROA

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	ROA2017 - ROA2020	,0185080	,1131062	,0159956	-,0136364	,0506524	1,157	49	,253
Pair 2	ROA2017 - ROA2021	-,0021040	,1058078	,0149635	-,0321742	,0279662	-,141	49	,889
Pair 3	ROA2017 - ROA2022	-,0090100	,1300159	,0183870	-,0459601	,0279401	-,490	49	,626
Pair 4	ROA2018 - ROA2020	,0066280	,0962954	,0136182	-,0207388	,0339948	,487	49	,629
Pair 5	ROA2018 - ROA2021	-,0139840	,0881504	,0124663	-,0390361	,0110681	-1,122	49	,267
Pair 6	ROA2018 - ROA2022	-,0208900	,1301843	,0184108	-,0578880	,0161080	-1,135	49	,262
Pair 7	ROA2019 - ROA2020	,0079960	,0562421	,0079538	-,0079878	,0239798	1,005	49	,320
Pair 8	ROA2019 - ROA2021	-,0126160	,0609292	,0086167	-,0299319	,0046999	-1,464	49	,150
Pair 9	ROA2019 - ROA2022	-,0195220	,0926834	,0131074	-,0458623	,0068183	-1,489	49	,143

Source: Authors' calculation based on financial sheets from APR using SPSS

In Table 7 are presented the results of the T-test for the differences between the means of the ROA. Using the paired-samples T-test, the statistical significance of the differences between the means was examined for the following comparisons: ROA in 2017 and 2020, ROA in 2017 and 2021, ROA in 2017 and 2022, ROA in 2018 and 2020, ROA in 2018 and 2021, ROA in 2018 and 2022, ROA in 2019 and 2020, ROA in 2019 and 2021, and ROA in 2019 and 2022.

The research was conducted at a significance level of 0.05, corresponding to a 95% confidence interval. The null hypothesis of equality between the means is accepted, concluding that there is no statistically significant difference between the means: of the ROA in 2017 and 2020, given that the p-value of the test (0.253) is greater than the significance level of 0.05; of the ROA in 2017 and 2021, given that the p-value of the test (0.889) is greater than the significance level of 0.05; of the ROA in 2017 and 2022, given that the p-value of the test (0.626) is greater than the significance level of 0.05; of the ROA in 2018 and 2020, given that the p-value of the test (0.629) is greater than the significance level of 0.05; of the ROA in 2018 and 2021, given that the p-value of the test (0.267) is greater than the significance level of 0.05; of the ROA in 2018 and 2022, given that the p-value of the test (0.262) is greater than the significance level of 0.05; of the ROA in 2019 and 2020, given that the p-value of the test (0.320) is greater than the significance level of 0.05; of the ROA in 2019 and 2021, given that the p-value of the test (0.150) is greater than the significance level of 0.05; of the ROA in 2019 and 2022, given that the p-value of the test (0.143) is greater than the significance level of 0.05. The results obtained do not confirm the hypotheses that were formed based on previous empirical research. However, the previous studies had a completely different research sample. Additionally, the results of the research may indicate that the management of manufacturing companies effectively managed costs during the pandemic period and adjusted sales prices in a way that the pandemic did not affect the profitability of the analyzed companies. Additionally, the research findings may also lead to the conclusion that the government's measures to mitigate the negative effects of the pandemic contributed to the reduction of costs for manufacturing companies.

Conclusion

Based on the results presented in Tables 1-6, the authors conclude that the profitability of the observed manufacturing companies had remained stable during the period from 2017 to 2022. Despite the negative impact of the Covid-19 pandemic on almost all areas of life, it appears that the increase in the prices of raw materials was accompanied by a rise in sales prices, and consequently, business revenues in manufacturing companies. As a result, profitability indicators remained stable, suggesting that Covid-19 did not negatively affect the profitability of the observed companies in the Republic of Serbia.

The authors utilized the paired-samples T-test to test the statistical significance of the difference between the means for indicators such as ROE, EBITDA margin, and ROA in 2017, 2018, 2019, 2020, 2021, and 2022. The research was conducted at a significance level of 0.05, corresponding to a confidence interval of 95%. Considering that the corresponding p-values of the applied test exceed the significance level of 0.05, the null hypotheses regarding the equality of the ROE means in the period before (2018 and 2019) and during the pandemic

(2020, 2021, and 2022) cannot be rejected. The statistically significant difference between the ROE means in 2017 and 2020 were exceptions. Since the corresponding p-values of the test exceeded the significance level of 0.05, the null hypotheses regarding the equality of the EBITDA margin means in the period before (2017, 2018, and 2019) and during the Covid19 pandemic (2020, 2021, and 2022) cannot be rejected. The null hypotheses regarding the equality of the ROA means in the period before (2017, 2018, and 2019) and during the Covid-19 pandemic (2020, 2021, and 2022) also cannot be rejected taking into account that the corresponding p-values of the applied test exceeded the significance level of 0.05.

This study provides practical implications for corporate management informing investors about the stability of manufacturing companies. Its scientific contribution lies in advancing the understanding of financial performance during economic disruptions. However, certain limitations must be acknowledged, including the relatively short time frame of analysis. Future research should extend the analysis to long-term financial effects, and compare different industries within Serbia.

Acknowledgements: This paper is part of the project II U-001/20 Evaluation of the Impact of Covid-19 on Social and Economic Development and project U 01/2023 Green Economy in the Era of Digitalization, at the Faculty of Finance, Banking, and Auditing, Alfa BK University

References

Agencija za privredne registre https://www.apr.gov.rs

Altin, M. and Özgun Atalay, M. (2024) The Covid-19 Pandemic's Impact on the Performance of Firms on the BIST 100 index companies, *Istanbul Business Research, 53*(1), 119-136. http://dx.doi.org/10.26650/ibr.2024.53.1138732

Balaban, S., Joksimović, M., Milenković, I. (2023) The euro exchange rate's resistance to the exogenous shock caused by COVID-19, *Strategic Management* https://doi.org/10.5937/StraMan2300059B

Bangun, A. P., Ediningsih, S. I., & Haryono, M. T. (2023). Comparison of banking profitability before and during COVID-19 at banks registered on the IDX in 2017–2022. **Journal of Business and Organization Management, 2**(1), 83–94.

Darma, P. E., Bailusy, M. N., & Buamonabot, I. (2022). The impact of the Covid-19 pandemic on the profitability ofcompanies incorporated in IDX30(Studies before and during the pandemic). *International Journal of Applied Businessand International Management, 7*(2), 116-125. http://dx.doi.org/10.32535/ijabim.v7i2.1663

Daryanto, W. M., Maharani, A. P., & Wiradjaja, N. (2021). Profitability ratio analysis before and during COVID-19: Case study in PT Japfa Comfeed Indonesia. **South East Asia Journal of Contemporary Business, Economics and Law, 24**(4), 52–59.

Ekonomski i socijalni uticaj Covid-19 (2020) beleške o zemljama, Zapadni Balkan, Redovni ekonomski izveštaj br. 17, World Bank Group, International Bank for Reconstruction and Development/ The World Bank, Washington

Hamzah, Z. Z., Muhlis, M., Rukmana, H. S., & Nugraha, G. D. (Year). Comparison analysis of financial performance before and during the COVID-19 pandemic at PT United Tractors Tbk in 2019 and 2020. **International Journal of Progressive Sciences and Technologies, 36**(1). https://doi.org/10.52155

Joksimović, M. and Beke-Trivunac, J. (2021) Uticaj Covid-19 na bankarsko poslovanje, *Megatrend revija 18*(1): 79-90. https://doi.org/10.5937/MegRev2101079J

Knežević, S., Milašinović, M., Džafić, G., Obradović, T. (2022) Covid-19 and profitability of hotel companies in the Republic of Serbia, *Bizinfo, 13*(2): 65-71. https://doi.org/10.5937/bizinfo2202065K

Lukić, R. (2023) Merenje i analiza dinamike profitabilnosti bankarskog sektora u Srbiji na bazi FLMAW-MARCOS metoda, *Bankarstvo* https://doi.org/10.5937/bankarstvo2301028L

Lukić, R., Vojteški Kljenak, D. (2023) Application of WASPAS method in the performance analysis of companies in Serbia listed on the Belgrade Stock Exchange, *Glasnik za društvene nauke, 15*, 23-38. https://www.gdn.rs/index.php/GDN/article/view/83/52

Mijić, K., Jakšić, D. (2017) Indebtness of Enterprises and Profitability Improvement, *Strategic Management, 22*(2): 36-40.

Milošev, I. (2021) The Imapct of Working Capital Management on Profitability of Large Firms in Serbia, *Business Economics, 2*: 1-18. https://doi.org/10.5937/poseko20-34263

Mirjanić B., Karić, D. (2022) Analiza performansi kompanije Aerodrom Nikola Tesla A. D. – investicioni pristup, *Glasnik za društvene nauke, 14*, 145-160. https://www.gdn.rs/index.php/GDN/article/view/74/44

Njegomir, V. (2021) Uticaj pandemije Covid-19 na ekonomiju, *Civitas, 11*(2): 78-97.

Paunović, B. & Aničić, Z. (2021) Uticaj kovid19 krize na MSP i mogući inovativni odgovori, *Ekonomika preduzeća, 69*(3-4), 169-184. https://doi.org/10.5937/EKOPRE2103169P

Purwaningsih, S., & Pernamasari, R. (2023). Differences in financial performance and earning persistence before and during the COVID-19 pandemic. **JAK (Jurnal Akuntansi): Kajian Ilmiah Akuntansi, 10**(2), 273–282. https://doi.org/10.30656/jak.v10i2.5643

Putri, N. N., Dwiputri, M., Wulan, N., & Hermawan, I. (2023). Analysis before and after the COVID-19 pandemic on profitability in bank. **West Science Business and Management, 1**(1), 1–6.

Qadri, S. U., Ma, Z., Raza, M., Li, M., Qadri, S., Ye, C., & Xie, H. (2023). COVID-19 and financial performance: Pre and post effect of COVID-19 on organization performance; A study based on South Asian economy. **Frontiers in Public Health, 10**, 1055406. https://doi.org/10.3389/fpubh.2022.1055406

Radić, N., Radić, V. & Grujić, B. (2021) Economic impact of the coronavirus pandemic on air traffic, *Ekonomika, 67*(2), 59-68. https://doi.org/10.5937/ekonomika2102059R

Rathnayaka, R. M. U. R. and Gunasekara, A. L. (2023) The impact of Covid-19 Global Crisis on the Firm's Performance: Evidence from Listed Materijal Sector Companies

in Sri Lanka, Journal of Business and Technology, 7(2), 1-15. http://dx.doi.org/10.4038/jbt.v7i2.93

Republički zavod za statistiku, zvanični sajt https://www.stat.gov.rs/sr-Latn/

Stoiljković, B., Balaban, S., & Simić, M. (2023) Uticaj likvidnosti na profitabilnost preduzeća prerađivačkog sektora u R. Srbiji, *Oditor, 9*(2), pp. 155-177. https://doi.org/10.5937/Oditor2302155S

Surya, K., & Suhendah, R. (2023). Comparative analysis of financial performance before and during COVID-19 pandemic. **International Journal of Application on Economics and Business, 1**(2), 337–348. https://doi.org/10.24912/ijaeb.v1i2.337-348

Tica, T., Đorđević, D., & Saković, D. (2023). Effect of the Covid-19 pandemic on the profitability of construction companies: evidence from Bosnia and Herzegovina. *Anali Ekonomskog Fakulteta U Subotici*, *59*(49), 147-161. https://doi.org/10.5937/AnEkSub2200013TK

Tica, T., Vuković, B., Saković, D. and Jakšić, D. (2023b) Specific impact of the Covid-19 pandemic on the profitability of logistics companies based in the Western Balkan countries. *Ekonomika preduzeća, 71*(5-6), 313-324. http://dx.doi.org/10.5937/EKOPRE2306313T

Todić, M, Milić. N. (2021) Mala i srednja preduzeća na udaru COVID cunamija, Ecologica, 28(104): 557-564. https://doi.org/10.18485/ecologica.2021.28.104.10

Vojtekova, S., & Kliestik, T. (2024). The Impact of the COVID-19 Pandemic on Profitability Indicators in the Hospitality Sector. *Management Dynamics in the Knowledge Economy, 12*(1), 39-53. DOI 10.2478/mdke-2024-0003

Vržina, S. i Dimitrijević, M. (2020) Determinants of profitability of the agricultural sector of Vojvodina: the role of corporate income tax, *The European Journal of Applied Economics 17*(1): 1-19. https://doi.org/10.5937/EJAE17-21368

Vuković, B. and Jakšić, D. (2019) The effect of working capital management on profitability evidence from Southern Europe, *Economics of Agriculture, 66*(1): 159-172. https://doi.org/10.5937/ekoPolj1901159V

Zečević, M., Joksimović, M., Balaban, S. (2022) The impact of Covid-19 pandemic on international commodity flows, Ecologica, 29(107), pp. 440-448. https://doi.org/10.18485/ecologica.2022.29.107.19

ШАБЛОН / ТЕМПЛАТЕ ЗА ПИСАЊЕ РАДОВА

Име аутора (Font size 10 Normal) Times New Roman (SR-Cyrilic)
Факултет или институција и Град (Font size 10 Italic)

НАСЛОВ СРПСКИ (Font size 11 Bold)

Апстракт

Текст апстракта на српском ...

***Кључне речи**:*

NASLOV ENGLESKI ili neki drugi jezik (Font size 11 Bold)

Abstract

Tekst apstrakta na engleskom ili na nekom drugom jeziku…

Key words:

НАСЛОВ (Font size 11 Bold)

Текст (Font size 10)……...

Литература

1. Списиак литературе

Veličina strane 170mm x 240mm
Margine: Top 30mm Bottom 20mm
Left 22mm Right 22mm

CIP – Каталогизација у публикацији
Народна библиотека Србије, Београд

33+657
ЕКОНОМИКА : међународни часопис за економску теорију и праксу и друштвена питања = international journal for economic theory and practice and social issues / главни и одговорни уредник Зоран Симоновић. - Год. 20, бр. 1/2 (1973)- . - Ниш : Друштво економиста"Економика", 1973- (Ниш : Medivest). - 24 cm
Тромесечно. - Текст на енгл. језику. - Је наставак: Наука и пракса = ISSN 0558-3063. - Друго издање на другом медијуму: Економика (Online) = ISSN 2334-9190
ISSN 0350-137X = Економика (Ниш)
COBISS.SR-ID 26903