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DVOSMERNNA VEZA INFLACIJE I INFLACIONE NEIZVESNOSTI: SLUČAJ SRBIJE

Siniša Miletić¹ Jovanka Popović²

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Apstakt

Cilj ovog istraživanja jeste analiza odnosa između inflacije i inflacione neizvesnosti na primer Srbije. Primenom GARCH modela ocenjena je inflaciona neizvesnost pri čemu se kao najbolji model pokazao EGARCH model. Rezultati Granger-ovog testa kauzalnosti između inflacije i inflacione neizvesnosti su pokazala da inflacija utiče na rast inflacione neizvesnosti i da rast inflacije dovodi do rasta neizvesnosti, čime je potvrđena hipoteza Friedman-Ball-a. S druge strane, rezultati su pokazali da inflaciona neizvesnost utiče na rast inflacije i da rast inflacione neizvesnosti utiče na porast inflacije što je u skladu sa Cukierman i Meltzer-ovom hipotezom.

Ključne reči: inflacija, inflaciona neizvesnost, GARCH modeli, Friedman-Ball hipoteza, Cukierman-Meltzer hipoteza

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Uvod

Koncept inflacije je jedan od najvažnijih ekonomskih fenomena i predmet interesovanja brojnih teorijskih i empirijskih istraživanja. U današnje vreme teško je naći zemlju koja se u prošlosti nije suočila sa problemom visoke stope inflacije. Imajući u vidu činjenicu da je očekivana stopa inflacija značajan faktor prilikom donošenja odluka, ekonomisti treba da se fokusiraju na odnos između inflacije i inflacione neizvesnosti. U ekonomskoj literaturi postoje različiti pogledi na odnos inflacije i njene neizvesnosti, iako je široko prihvaćeno da je visok nivo inflacije štetan za sve ekonomske subjekte (Karahana 2012).

Cilj ovog istraživanja jeste analiza odnosa između inflacije i inflacione neizvesnosti na primeru Srbije. Neizvesnost u pogledu kretanja inflacije smo ocenili primenom simetričnog GARCH modela, kao i tri asimetrična modela – EGARCH, TGARCH i APARCH.

U radu testirali smo hipotezu Friedman-Ball-a o postojanju pozitivnog odnosa između inflacije i inflacione neizvesnosti, Cukierman-Meltzer-ovu hipotezu koja

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ukazuje da rast inflacione neizvesnosti rezultira rastu stope inflacije, Pourgerami-Markus-ova hipoteza koja pretpostavlja postojanje negativnog efekta inflacije na inflacionu neizvesnost i Holland-ove hipoteze koja sugerise postojanje negativnog odnosa između inflacione neizvesnosti i prosečne stope inflacije.

Radni papir je strukturiran na sledeći način. U drugom poglavlju dat je pregled empirijske literature na ovu temu. Primenjena metodologija ukratko prezentovana je u trećem poglavlju. U četvrtom poglavlju predstavljani su rezultati empirijske analize. Konačno, zaključna razmatranja data su u poslednjom poglavlju.

Pregled literature

Inflaciona neizvesnost i njena veza sa inflacijom predmet je istraživanja brojnih radova. Ball (1992) je razvio model u kojem viša stopa inflacije vodi ka većoj inflacionoj neizvesnosti. Njegova ideja zasnovana je na radu Friedman-a (1977) koji je prvi sugerisao da veća inflacija može rezultirati većem stepenu inflacione neizvesnosti. Uzimajući u obzir obrnutu vezu, Cukierman i Meltzer (1986) su postavili hipotezu da rast inflacione neizvesnosti rezultira rastu stope inflacije. Pourgerami i Maskus (1987) razmatrali su mogućnost postojanja negativnog efekta inflacije na inflacionu neizvesnost. Autori su istakli da će u uslovima ubrzanja inflacije ekonomski agenti nastojati da predvide kretanje inflacije i stoga smanje inflacionu neizvesnost (videti i Ungar i Zilberfarb, 1993). Holland (1995) sugerise da viša inflaciona neizvesnost dovodi do niže prosečne stope inflacije, stoga se postojanje negativnog odnosa između inflacione neizvesnosti i prosečne stope inflacije naziva Holland-ova hipoteza.

Sa empirijske strane, brojne studije su istraživale odnos inflacije i inflacione neizvesnosti primenom različitih GARCH modela. Mladenović (2009) istraživala je odnos inflacije i inflacione neizvesnosti u Srbiji tokom perioda tranzicije 2000-2007 primenom različitih GARCH specifikacija. Izvedene varijable su bile uključene u VAR model kako bi se testirao Granger-ov test kauzalnosti između inflacije i inflacione neizvesnosti. Rezultati istraživanja su pokazali da viša stopa inflacije izaziva veću inflacionu neizvesnost, dok viši stepen inflacione neizvesnosti ima negativan uticaj na nivo inflacije u dugom roku, što govori u prilog efikasnosti monetarne politike Narodne banke Srbije.

Nor, Ling i Maarof (2007) su analizirali odnos inflacije i inflacione neizvesnosti u Maleziji. Koristeći različite GARCH modele: GARCH, GARCH-Mean, EGARCH i EGARCH-Mean autori su ocenili inflacionu neizvesnost pri čemu se kao najbolji model pokazao EGARCH model. Rezultati Grangerovog testa kauzalnosti pokazao je da viši nivo inflacije dovodi do veće buduće neizvesnosti i da veći stepen inflacione neizvesnosti dovodi do niže buduće stope inflacije.

Karahan (2012) je istraživao odnos između inflacije i inflacione neizvesnosti u Turskoj u periodu 2002 do 2011. Koristeći ARMA-GARCH model autor je

ocenio inflacionu neizvesnost a Granger-ov model kako bi testirao kauzalnost između inflacije i inflacione neizvesnosti. Rezultati empirijske studije podržale su Fridman-Ball-ovu hipotezu hipoteza da rast inflacije dovodi do rasta inflacione neizvesnosti.

Živkov, Njegić i Pećanac (2014) su istraživali dvosmernu vezi između inflacije i inflacione neizvesnosti na primeru 11 zemalja istočne Evrope. Autori su koristili GARCH modele u oceni optimalnog modela inflacione neizvesnosti a Granger-ov model kako bi testirali kauzalnost između inflacije i inflacione neizvesnosti. Rezultati empirijske analize podržale su i Fridmanovu i Cukierman-Meltzerova hipotezu prvenstveno u većim zemljama sa fleksibilnim deviznim kursom, dok u slučaju manjih, otvorenih ekonomija sa režimom fiksong deviznog kursa nisu potvrđene obe hipoteze.

Jiranyakul i Opiela (2010) su istraživali vezu između inflacije i inflacione neizvesnosti u zemljama ASEAN-5 u periodu 1970–2007. Autori su primenili EGARCH model za ocenu inflacione neizvesnosti, i Granger-ov model kako bi testirali kauzalnost između inflacije i inflacione neizvesnosti. Rezultati empirijskog istraživanja su pokazala da rast inflacije dovodi do rasta inflacione neizvesnosti i da rast inflacione neizvesnosti dovodi do rasta inflacije u svim posmatranim zemljama. Autori naglašavaju da iako su zemlje ASEAN-5 grupe u posmatranom periodu imale niže stope inflacije u poređenju sa drugim zemljama u razvoju rast inflacije dovodi do veće inflacione neizvesnosti, i da inflaciona neizvesnost dovodi do veće inflacije.

Asghar, Ahmad, Ullah, Zaman i Rashid (2011) su istraživali vezu između inflacije i inflacione neizvesnosti u zemljama SAARC regiona (Pakistan, Indija i Šri Lanka) tokom perioda 1980-2009. Autori su primenili EGARCH model za ocenu inflacione neizvesnosti, i Granger-ov model kako bi testirali kauzalnost između inflacije i inflacione neizvesnosti. Rezultati istraživanja pokazala su postojanje dvosmerne kauzalnost između inflacije i inflacione neizvesnosti u svim posmatranim zemljama SAARC regiona.

Ananzeh (2015) je analizirao odnos između inflacije i inflacione neizvesnosti u Jordanu za period 1976-2013. Autor je primenio različite GARCH modele za ocenu inflacione neizvesnosti, i Granger-ov model kako bi testirao kauzalnost između inflacije i inflacione neizvesnosti. Autor je našao jake dokaze koje podržavaju Friedman-Ball-ovu hipotezu i različite dokaze koji idu u prilog Cukerman-Meltzer-ove hipoteze.

Khatir, Guvenek i Mangir (2020) su istraživali vezu između inflacije i inflacione neizvesnosti u Turskoj za period 2005-2020 korišćenjem ARMA-GARCH modela. Rezultati empiriske studije pokazala su da rast inflacije dovodi do rasta neizvesnosti čime je potvrđena hipoteza Friedman-Ball-a. S druge strane autori

nisu našli dokaze koji idu u prilog Cukerman-Meltzer-ove hipoteze, odnosno rezultati su pokazali da inflaciona neizvesnost ne dovodi do rasta inflacije.

Metodologija

Empirijska analiza korišćena u ovom radu sastojala se iz nekoliko koraka. Na samom početku testirali smo stacionarnost vremeskih serija mesečnih stopa inflacije π_t kod svih posmatranih zemalja.

U radu smo primenili nekoliko testova jediničnog korena: ADF (Augmented Dickey –Fuller) i PP (Phillips and Perron), kojima se nultom hipotezom pretpostavlja postojanje jediničnog korena, a alternativnom stacionarnost serija.

Nakon toga, kreiran je autoregresioni model AR(p) reda. U modelu su uzete vrednosti reda od 1 do 12, s obzirom na mesečnu frekvenciju dostupnih podataka. AR(p) model za inflaciju dat je u sledećoj formi:

$$\pi_t = \alpha_0 + \alpha_1 \pi_{t-1} + \alpha_2 \pi_{t-2} + \dots + \alpha_p \pi_{t-p} + \varepsilon_t$$

Nakon izbora AR specifikacije jednačine inflacije, inflatornu neizvesnost smo ocenili primenom različitih modela uslovne heteroskedastičnosti. U radu smo testirali simetrični GARH model i tri asimetrična modela EGARCH, TGARCH i APARCH.

GARCH (p,q) model predstavljen od strane Bolersleva opisuje kretanje vremenske serije čija je bezuslovna varijansa stabilna, dok se uslovna varijansa (σ_t^2) menja tokom vremena. GARCH (p,q) model može se prikazati u sledećoj formi: (Bolerselev, 1986)

$$\sigma_t^2 = \alpha_0 + \sum_{j=1}^q \alpha_j \varepsilon_{t-j}^2 + \sum_{i=1}^p \beta_i \sigma_{t-i}^2$$

Veličina parametara α i β u prethodnoj jednačini određuje dinamiku kratkoročne volatilnosti posmatrane serije. Visoka vrednost koeficijenta β pokazuje da je šokovima na uslovnoj varijansi potrebno duže vremena da nestanu, što znači da je volatilnost visoka. Visoka vrednost koeficijenta α znači da volatilnost reaguje intenzivno na promene šokova (ε_t^2).

Nelson je predstavio eksponencijalni GARCH process ili EGARCH model za uslovnu varijansu, koji uzima u obzir efekat asimetrije. Nelsonov model inflatorne neizvesnosti može se predstaviti na sledeći način: (Nelson, 1991)

$$\ln \sigma_t^2 = \alpha_0 + \beta_1 \ln \sigma_{t-1}^2 + \theta_1 \frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \gamma_1 \left| \frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} \right|$$

Uslovna varijansa ovog modela je pozitivna bez obzira kakvog su znaka koeficijenti θ_1 i γ_1 , što omogućava njegovu široku primenu u empirijskim analizama.

Zakoian je predstavio TGARCH (p,q) model kao alternativu EGARCH procesu, gde je asimetrija pozitivnih i negativnih inovacija inkorporirana u model korišćenjem indikatora funkcije (Zakoian, 1994):

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^q (\alpha_i \varepsilon_{t-i}^2) + \sum_{i=1}^q (\gamma_i d(\varepsilon_{t-i} < 0) \varepsilon_{t-i}^2) + \sum_{j=1}^p (\beta_j \sigma_{t-j}^2)$$

gde su γ_i parametri koje treba oceniti, $d(\cdot)$ označava indikator funkcije definisan kao:

$$d(\varepsilon_{t-i} < 0) = \begin{cases} 1, & \varepsilon_{t-i} < 0 \\ 0 & \varepsilon_{t-i} \geq 0 \end{cases}$$

TGARCH model pretpostavlja da $(\varepsilon_{t-1} > 0)$ i $(\varepsilon_{t-1} < 0)$ imaju različite efekte na uslovnu varijansu.

APARCH (p, q) proces, predstavljen od strane od strane Ding, Granger i Engle, uključuje sedam različitih GARCH modela (ARCH, GARCH, AGARCH, TGARCH, TARCH NGARCH and Log-GARCH) (Ding, Granger i Engle 1993):

$$\sigma_t^\delta = \alpha_0 + \sum_{i=1}^q \alpha_i (|\varepsilon_{t-i}| - \gamma_i \varepsilon_{t-i})^\delta + \sum_{j=1}^p (\beta_j \sigma_{t-j}^\delta)$$

gde je $\alpha_0 > 0, \delta \geq 0, \beta_j \geq 0, j = 1, \dots, p, \alpha_i \geq 0, -1 < \gamma_i < 1, i = 1, \dots, q$.

Parametar δ označava eksponent uslovne standardne devijacije, dok parameter γ opisuje efekat asimetrije na uslovnu varijansu.

Utvrđivanje veze inflacije i inflatorne neizvesnosti izvršeno je korišćenjem Grager-ovog testa kauzalnosti kako bi se objasnilo da li jedna varijabla objašnjava vrednost druge varijable. (Viorica, Jemna, Pintilescu i Asandului 2014)

Kako bi testirali hipotezu da inflacija utiče na neizvesnost, ocenjen je VAR model:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \sigma_{t-1}^2 + \dots + \alpha_k \sigma_{t-k}^2 + \beta_1 \pi_{t-1} + \dots + \beta_k \pi_{t-k} + u_t$$

$$\pi_t = \alpha_0 + \alpha_1 \pi_{t-1} + \dots + \alpha_m \pi_{t-m} + \beta_1 \sigma_{t-1}^2 + \dots + \beta_m \sigma_{t-m}^2 + v_t$$

Za ovaj model testirana je nulta hipoteza primenom Granger-ovog testa kauzalnosti, $H_0: \beta_1 = \beta_2 = \dots = \beta_k = 0$, koja pretpostavlja da inflacija ne utiče na neizvesnost. Odbacivanje ove hipoteze znači prihvatanje Friedman-Ball-ove hipoteze. Testiranje primenom Granger-ovog testa je izvršeno za 4, 8 i 12 docnju.

U poslednjem delu empirijske analize, ispitali smo znak ovih odnosa. Smer korelacije dobijen je kao suma koeficijenata za varijable inflacije u prvoj hipotezi kojom se ispituje uticaj inflacije na neizvesnost.

Slično, za drugu hipotezu, kojom se ispituje uticaj inflacione neizvesnosti na inflaciju, $H_0: \beta_1 = \beta_2 = \dots = \beta_m = 0$, smer korelacije utvrđuje se na bazi sume koeficijenata uz inflacionu neizvesnost.

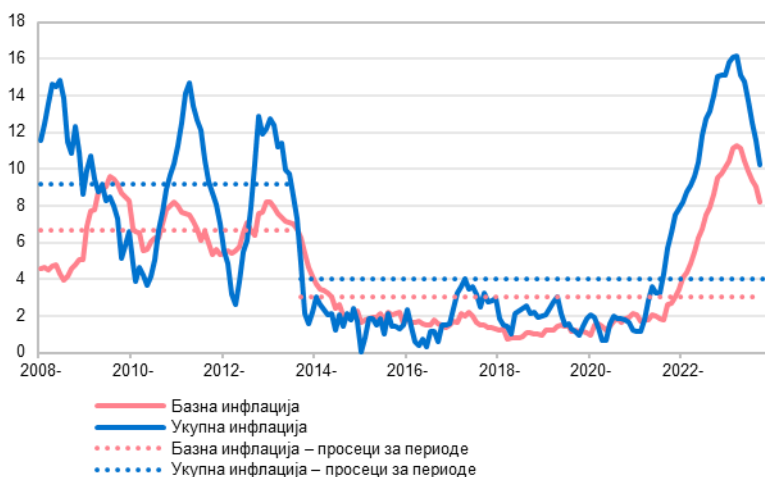
Rezultati empirijske analize

U empirijskoj analizi koristili smo mesečne podatke o harmonizovanom indeksu potrošačkih cena (HICP) dobijene sa veb sajta zavoda za statistiku Srbije. Empirijska analiza je sprovedena za period januar 2007–oktobar 2023. godine.

Vrednost mesečne inflacije izračunata je kao: $\pi_t = \ln \frac{CPI_t}{CPI_{t-1}} * 1200$, a množenje sa 1200 je izvršeno da bi se odredio njihov rast na godišnjem nivou.

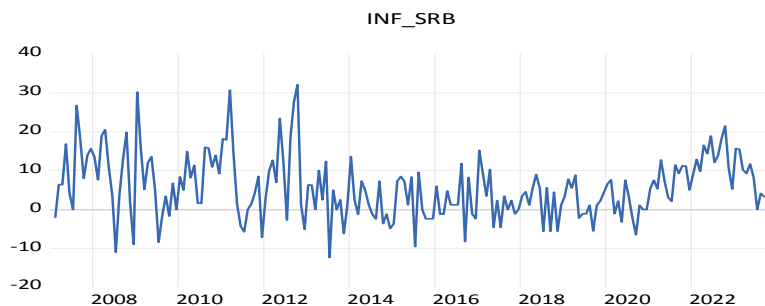
Inflacija u Srbiji je bila volatilna u periodu 2008-2013. godine, na šta su uticali šokovi iz međunarodnog okruženja (rast svetskih cena nafte i primarnih poljoprivrednih proizvoda) tokom 2010. i 2012. godine, kao i efekti deprecijacije dinara u uslovima ekspanzivne fiskalne politike naročito tokom 2012. godine. Od kraja 2013. sve do sredine 2021. godine inflacija u Srbiji je bila niska i stabilna i u proseku je iznosila oko 2%. Na to su uticali i niski inflatorni pritisci iz međunarodnog okruženja, ali i obezbeđena relativna stabilnost deviznog kursa, koordinacija monetarne i fiskalne politike i efekti fiskalne konsolidacije koji su uticali na nižu domaću tražnju. Od septembra 2021. inflacija ubrzava kao posledica brojnih šokova iz međunarodnog okruženja – naglog rasta tražnje u uslovima ograničene ponude nakon otvaranja brojnih ekonomija nakon prve faze pandemije, što je za posledicu imalo zastoje u globalnim lancima snabdevanja i poskupljenje transporta, zatim znatan rast svetskih cena primarnih proizvoda i industrijskih sirovina, naročito nakon izbijanja rata u Ukrajini, pojava energetske krize i dr. To je dovelo do znatnog rasta cena hrane i energenata i na domaćem tržištu, a rast uvozne inflacije se odrazio i na rast bazne inflacije, koja se ipak sve vreme kretala ispod ukupne inflacije. Od aprila 2023, zahvaljući restriktivnim merama monetarne politike i popuštanju globalnih troškovinih pritisaka inflacija u Srbiji se nalazi u padu i krajem 2023. bila je dvostruko niža (7,6% međugodišnje) nego krajem 2022.

Grafikon 1. Kretanje ukupne i bazne stope inflacije u Srbiji



Izvor: Narodna banka Srbije

Grafikon 2. Mesečne stope inflacije u Srbiji na godišnjem nivou



Rezultati deskriptivne statistike prikazani u tabeli (1.) pokazuju da stopa mesečne inflacije raste 0.5 procenata mesečno. Raspon između maksimalne i minimalne prosečne stope inflacije iznosi oko 4 procenata što uz standardnu devijaciju od 0.6 procenata ukazuje na visoku volatilnost zabeleženu u posmatranom periodu.

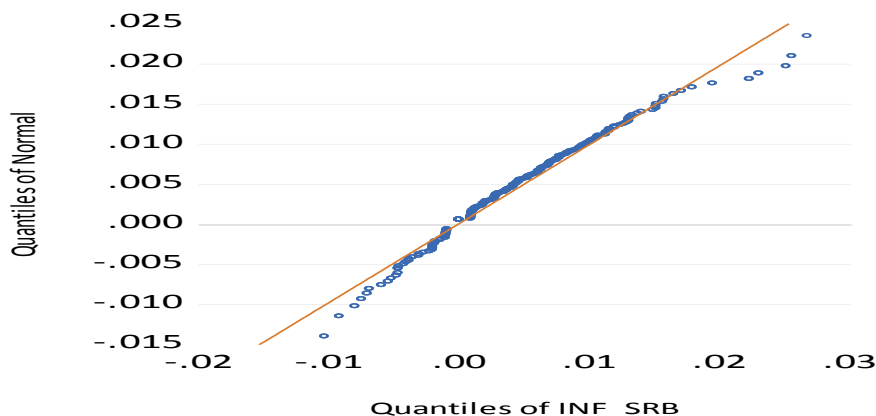
Tabela 1. Deskriptivna statistika

Srednja vrednost	Medijana	Maksimum	Minimum	Standardna devijacija
0.477	0.417	2.67	-1.032	0.667

Izvor: Kalkulacije autora

Q-Q dijagram prikazan u grafikonu (3.) pokazuje da distribucija potrošačkih cena odstupa od normalne.

Grafikon 3. Q-Q dijagram mesečne stope inflacije u Srbiji



Vrednosti ADF i PP testova jediničnog korena ukazuju da je serija mesečne stope inflacije stacionarna jer se prihvataju alternativne hipoteze.

Tabela 2. Test jediničnog korena

	Augmented Dickey-Fuller test	Phillips-Peron test
Srbija	-10.400***	-9.580***

Izvor: Kalkulacije autora.

Napomena: Kritične vrednosti ADF test za novo značajnosti: 1%, 5%, 10% iznose -3.436, -2.86, -2.567. Kritične vrednosti PP testa za nivo značajnosti : 1%, 5%, 10% iznose -3.436, -2.867, -2.567. *** označava statističku značajnost na nivou od 1%.

U sledećem koraku primenom GARCH modela ocenjena je inflaciona neizvesnost pri čemu su kao kriterijum izbora odgovarajućeg modela korišćeni Akaike i Schwarz informacioni kriterijumi, a vodilo se računa i da ocenjeni koeficijenti odgovarajuće specifikacije budu statistički značajni i ispravnog znaka. Tabela sa specifikacijama modela prikazana je u sledećoj tabeli, a u nastavku su prikazani detaljniji rezultati ocenjivanja. Kao najbolji model se pokazao EGARCH model, dok ostali modeli (GARCH, TGARCH i APARCH) koji su takođe testirani ili nisu imali statistički značajne koeficijente ili su imali veće vrednosti Akaike i Schwarz informacionog kriterijuma od EGARCH modela.

$$\ln \sigma_t^2 = 0.25(0.30) + 0.24(0.04) \ln \sigma_{t-1}^2 + 0.19(0.03) \frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} + 0.88(0.00) \left| \frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} \right|$$

Tabela 3. Ocena parametara stope inflacije u Srbiji primenom GARCH modela

	GARCH (1,1)	EGARCH(1,1)	TGARCH(1,1)	APARCH (1,1)
Jednačina sredine				
Konstanta	5.089(0.09)	4.787(0.00)	4.820(0.00)	4.913(0.00)
AR(1)	0.332(0.00)	0.254(0.00)	0.304(0.00)	0.260(0.00)
AR(3)	0.118(0.28)	0.167(0.00)	0.103(0.11)	0.168(0.01)
AR(12)	0.217(0.08)	0.155(0.00)	0.201(0.00)	0.156(0.01)
Jednačina uslovne varijanse				
c	40.31(0.82)	0.255(0.30)	0.504 (0.29)	0.781(0.53)
α	0.025(0.70)		-0.004 (0.68)	0.135(0.03)
β	0.496(0.82)	0.244(0.04)	1.027 (0.00)	1.00 (0.16)
θ		0.193(0.03)		
γ		0.880 (0.00)	-0.074 (0.01)	-0.726(0.07)
δ				0.778(0.00)
Svojstva ocenjenog modela				
Akaiki	6.927644	6.724878	6.663900	6.737421
Schwartz	7.047709	6.862095	6.801117	6.891790
ARCH-LM (1) TEST	7.21 (0.00)	0.24(0.62)	1.04(0.30)	0.13(0.71)
ARCH-LM (4) TEST	2.46 (0.04)	0.07(0.07)	0.34 (0.84)	0.05 (0.99)
DW	2.014921	1.889325	1.954287	1.902815

Izvor: Kalkulacije autora

Rezultati Granger-ovog testa kauzalnosti između inflacije i inflacione neizvesnosti prikazani su u tabeli (4.). Rezultati empirijskog istraživanja su pokazali da inflacija utiče na rast inflacione neizvesnosti čime je potvrđena hipoteza Friedman-Ball-a. Rezultati pokazuju i da inflaciona neizvesnost utiče na rast inflacije što je u skladu sa Cukierman i Meltzer-ovom hipotezom.

Tabela 4. VAR Granger-ov test kauzalnosti

Zemlja	Hipoteza	Docnja 4	Docnja 8	Docnja 12
Srbija	Inflacija ne utiče na rast inflacione neizvesnosti	55.08(0.00)	27.79(0.00)	22.84(0.00)
	Inflaciona neizvesnost ne utiče na rast inflacije	2.18(0.00)	2.06(0.00)	2.264(0.00)

Izvor: Kalkulacije autora

Rezultati prikazani u tabeli (5.) pokazuju da porast inflacije utiče na rast inflacione neizvesnosti. Pored toga rezultati pokazuju da rast inflacione neizvesnosti utiče na porast inflacije.

Tabela 5. Smer uticaja ocenjen na bazi VAR modela

Zemlja	Hipoteza	Docnja 4	Docnja 8	Docnja 12
Srbija	Inflacija ne utiče na rast inflacione neizvesnosti	+	+	-
	Inflaciona neizvesnost ne utiče na rast inflacije	+	+	+

Izvor: Kalkulacije autora

Zaključak

Cilj ovog istraživanja jeste analiza odnosa između inflacije i inflacione neizvesnosti u Srbiji. Empirijska analiza je sprovedena za period januar 2007–oktobar 2023. godine. Analiza se sastojala iz dva koraka, u prvom koraku smo ocenili parameter stope inflacije da bi nakon toga testirali kauzalnost inflacije i inflacione neivesnosti.

Neizvesnost u pogledu kretanja inflacije smo ocenili primenom GARCH metodologije pri čemu se kao najbolji model pokazao asimetrični EGARCH model. Zatim smo testirali hipoteze Friedman-Ball-a i Cukierman-Meltzer-a primenom Granger-ovog testa kauzalnosti inflacije i inflacione neizvesnosti.

Rezultati Granger-ovog testa kauzalnosti između inflacije i inflacione neizvesnosti su pokazala da inflacija utiče na rast inflacione neizvesnosti i da rast inflacije dovodi do rasta neizvesnosti, čime je potvrđena hipoteza Friedman-Ball-a. S druge strane, rezultati su pokazali da inflaciona neizvesnost utiče na rast inflacije i da rast inflacione neizvesnosti utiče na porast inflacije što je u skladu sa Cukierman i Meltzer-ovom hipotezom.

Imajući u vidu rezultate dobije empirijskom analizom, smatramo da je u cilju daljeg smanjenja stope inflacije u narednom period neophodno sprovođenje restriktivne monetarne politike.

Literatura

1. Ananzeh, I, E. 2015. „The Realationship between Inflation and its Uncertainty: Evidence from Jordan.“ *International Journal of Economics and Financial Issues*, 5(4) 929-932.
2. Asghar, A, K Ahmad, S Ullah, B Zaman, i M, T Rashid. 2011. „The Relationship between Inflation and Inflation Uncertainty: A Case Study for Saarc Countries.“ *International Research Journal of Finance and Economics*, Issue 66.
3. Ball, L. 1992. „Why Does High Inflation Raise Uncertainty?“ *Journal of Monetary Economics* 29(3) 371-388.
4. Bollerslev, T, R Engle, i D Nelson. 1994. "ARCH Models", *Handbook of Econometrics, Volume IV*. Amsterdam: North Holland: ed. Engle, R; McFadden, D.
5. Ding, Z, C, W, J, Granger, i R Engle. 1993. „A long memory property of stock market returnes and a new model.“ *Journal of Empirical Finance* 1 83-106.
6. Friedman, M. 1977. „Inflation and Unemployment.“ *Journal of Political Economy* 85(3) 451-472.
7. Holland, A, S. 1995. „Inflation and Uncertainty: Test for Temporal Ordering.“ *Journal of Money, Credit and Banking*, 27 827-837.

8. Jiranyakul, K, i T Opiela. 2010. „Inflation and inflation uncertainty in the ASEAN-5 economies.“ *Journal of Asian Economics*, Volume 21, Issue 2 105-112.
9. Karahan, O. 2012. „The Relationship between inflation and Inflation Uncertainty: Evidence from the Turkish Economy.“ *Procedia Economics and Finance* 1 219-228.
10. Khatir, A, Q, B Guvenek, i F Mangir. 2020. „The Relationship between Inflation and Inflation Uncertainty: Empirical Evidence from Turkey.“ *Journal of Academic Value studies*, 6(4) 331-340.
11. Mladenović, Z. 2009. „Relationship between inflation and inflation uncertainty: The case of Serbia.“ *Yugoslav Journal of Operations Research* 19(1) 171-183.
12. Nelson, D, B. 1991. „Conditional Heteroscedasticity in Asset Return: A New Approach.“ *Econometrica*, 52(2) 347-370.
13. Nor, A, H, S,M, T,Y Ling, i F Maarof. 2007. „On the Relationship between Inflation Rate and Inflation Uncertainty: An Application of the GARCH Family Models.“ *Sains Malaysiana* 36(2) 225-232.
14. Potgerami, A, i K, E Maskus. 1987. „The effects of inflation on the predictability of price changes in Latin America: Some estimates and policy implications.“ *World Development* 15(2) 287-290.
15. Ungar, M, i B Zilberfarb. 1993. „Inflation and its unpredictability: theory and empirical evidence.“ *Journal of Money, Credit and Banking* 25 709-720.
16. Viorica, D, D Jemna, C Pintilescu, i M Asandalui. 2014. „The Relationship between Inflation and Inflation Uncertainty: Empirical Evidence for the Newest EU Countries.“ *PLOS ONE*.
17. Zakoian, J, M. 1994. „Treshold Heteroskedastic Models.“ *Journal of Economic Dynamics and Control* 18 931-955.
18. Živkov, D, J Njegić, i Pećanac M. 2014. „Bodirectional linkage between inflation and inflation uncertainty.the case of Eastern European countries.“ *Baltic Journal of Economics* Vol.14, No. 1-2 124-139.
19. Narodna banka Srbije. 2023 Novembar. „Izveštaj o inflaciji“

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BIDIRECTIONAL LINKAGE between inflation and inflation uncertainty: case of serbia

Siniša Miletić³ Jovanka Popović⁴

Abstract

The aim of this study is to analyze the relationship between inflation and inflation uncertainty in Serbia. Using the GARCH model, inflation uncertainty was assessed with the EGARCH model proving to be the best model. The results of the Granger causality test between inflation and inflation uncertainty showed that inflation affects the growth of inflation uncertainty in the case of Serbia and that the growth of inflation leads to the growth of uncertainty, thus confirming the Friedman-Ball hypothesis. On the other hand, the results showed that inflation uncertainty affects the growth of inflation and that the growth of inflation uncertainty affects the growth of inflation in the case of Serbia which is in accordance with Cukierman and Meltzer's hypothesis.

Key words: *inflation, inflation uncertainty, GARCH models, Friedman-Ball hypothesis, Cukierman-Meltzer hypothesis*

JEL: *E31, E52, C22, C52*

Introduction

The concept of inflation is one of the most important economic phenomena and the subject of interest for numerous theoretical and empirical studies. Nowadays, it is difficult to find a country that has not faced the problem of high inflation rates in the past. Given the fact that the expected inflation rate is an important factor in decision-making, economists should focus on the relationship between inflation and inflation uncertainty. In the economic literature, there are different views on the relationship between inflation and its uncertainty, although it is widely accepted that high inflation is harmful to all economic entities (Karahan 2012).

The aim of this research is to analyze the relationship between inflation and inflation uncertainty using the example of Serbia. We assessed the uncertainty regarding inflation trends using the symmetric GARCH model, as well as three asymmetric models – EGARCH, TGARCH and APARCH.

In this paper, we tested the Friedman-Ball hypothesis of a positive relationship between inflation and inflation uncertainty, the Cukierman-Meltzer hypothesis indicating that an increase in inflation uncertainty results in an increase in the inflation rate, the Pourgerami-Markus hypothesis assuming a negative effect of

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inflation on inflation uncertainty, and the Holland hypothesis suggesting a negative relationship between inflation uncertainty and the average inflation rate.

The working paper is structured as follows. The second chapter provides an overview of the empirical literature on this topic. The applied methodology is briefly presented in the third chapter. The fourth chapter presents the results of the empirical analysis. Finally, concluding remarks are given in the last chapter.

Literature Review

Inflation uncertainty and its relationship with inflation have been the subject of numerous studies. Ball (1992) developed a model in which higher inflation rates lead to higher inflation uncertainty. His idea is based on the work of Friedman (1977), who first suggested that higher inflation can result in higher inflation uncertainty. Considering the reverse relationship, Cukierman and Meltzer (1986) hypothesized that an increase in inflation uncertainty results in an increase in the inflation rate. Pourgerami and Maskus (1987) considered the possibility of a negative effect of inflation on inflation uncertainty. The authors pointed out that in conditions of accelerating inflation, economic agents will try to predict the movement of inflation and therefore reduce inflation uncertainty (see also Ungar and Zilberfarb, 1993). Holland (1995) suggests that higher inflation uncertainty leads to lower average inflation rates, therefore the existence of a negative relationship between inflation uncertainty and average inflation rates is called Holland's hypothesis.

On the empirical side, numerous studies have investigated the relationship between inflation and inflation uncertainty using different GARCH models. Mladenović (2009) investigated the relationship between inflation and inflation uncertainty in Serbia during the transition period 2000-2007 using different GARCH specifications. The derived variables were included in the VAR model in order to test the Granger causality test between inflation and inflation uncertainty. The research results showed that higher inflation rates cause higher inflation uncertainty, while higher inflation uncertainty has a negative impact on the level of inflation in the long run, which speaks in favor of the effectiveness of the monetary policy of the National Bank of Serbia.

Nor, Ling and Maarof (2007) analyzed the relationship between inflation and inflation uncertainty in Malaysia. Using different GARCH models: GARCH, GARCH-Mean, EGARCH and EGARCH-Mean, the authors estimated inflation uncertainty, with the EGARCH model proving to be the best model. The results of the Granger causality test showed that higher inflation leads to higher future uncertainty and that higher inflation uncertainty leads to lower future inflation rates.

Karahan (2012) investigated the relationship between inflation and inflation uncertainty in Turkey in the period 2002 to 2011. Using the ARMA-GARCH model, the author estimated inflation uncertainty and the Granger model to test the causality between inflation and inflation uncertainty. The results of the empirical study supported the Friedman-Ball hypothesis that rising inflation leads to rising inflation uncertainty.

Živkov, Njegić and Pećanac (2014) investigated the bidirectional relationship between inflation and inflation uncertainty using the example of 11 Eastern European countries. The authors used GARCH models to estimate the optimal inflation uncertainty model and the Granger model to test the causality between inflation and inflation uncertainty. The results of the empirical analysis supported both the Friedman and Cukierman-Meltzer hypotheses primarily in larger countries with flexible exchange rates, while in the case of smaller, open economies with fixed exchange rate regimes, both hypotheses were not confirmed.

Jiranyakul and Opiela (2010) investigated the relationship between inflation and inflation uncertainty in ASEAN-5 countries in the period 1970–2007. The authors applied the EGARCH model to estimate inflation uncertainty, and the Granger model to test the causality between inflation and inflation uncertainty. The results of the empirical research showed that the increase in inflation leads to the increase in inflation uncertainty and that the increase in inflation uncertainty leads to the increase in inflation in all the observed countries. The authors emphasize that although the ASEAN-5 countries had lower inflation rates in the observed period compared to other developing countries, the increase in inflation leads to higher inflation uncertainty, and that inflation uncertainty leads to higher inflation.

Asghar, Ahmad, Ullah, Zaman and Rashid (2011) investigated the relationship between inflation and inflation uncertainty in the countries of the SAARC region (Pakistan, India and Sri Lanka) during the period 1980-2009. The authors applied the EGARCH model to estimate inflation uncertainty, and the Granger model to test the causality between inflation and inflation uncertainty. The results of the research showed the existence of a two-way causality between inflation and inflation uncertainty in all the observed countries of the SAARC region.

Ananzeh (2015) analyzed the relationship between inflation and inflation uncertainty in Jordan for the period 1976-2013. The author applied different GARCH models to estimate inflation uncertainty, and the Granger model to test the causality between inflation and inflation uncertainty. The author found strong evidence supporting the Friedman-Ball hypothesis and mixed evidence supporting the Cuckerman-Meltzer hypothesis.

Khatir, Guvenek, and Mangir (2020) investigated the relationship between inflation and inflation uncertainty in Turkey for the period 2005-2020 using the

ARMA-GARCH model. The results of the empirical study showed that the increase in inflation leads to the increase in uncertainty, which confirmed the Friedman-Ball hypothesis. On the other hand, the authors did not find evidence supporting the Cuckerman-Meltzer hypothesis, i.e. the results showed that inflation uncertainty does not lead to the increase in inflation.

Methodology

The empirical analysis used in this paper consisted of several steps. At the very beginning, we tested the stationarity of the time series of monthly inflation rates π_t for all observed countries.

In the paper, we applied several unit root tests: ADF (Augmented Dickey –Fuller) and PP (Phillips and Perron), which assume the existence of a unit root as the null hypothesis, and the stationarity of the series as the alternative.

After that, an autoregressive model of the AR(p) order was created. The model took order values from 1 to 12, considering the monthly frequency of the available data. The AR(p) model for inflation is given in the following form:

$$\pi_t = \alpha_0 + \alpha_1\pi_{t-1} + \alpha_2\pi_{t-2} + \dots + \alpha_p\pi_{t-p} + \varepsilon_t$$

After choosing the AR specification of the inflation equation, we estimated inflation uncertainty using different conditional heteroskedasticity models. In this paper, we tested the symmetric GARCH model and three asymmetric models EGARCH, TGARCH and APARCH.

The GARCH (p,q) model presented by Bolerslev describes the movement of a time series whose unconditional variance is stable, while the conditional variance (σ_t^2) changes over time. The GARCH (p,q) model can be represented in the following form: (Bolereslev, 1986)

$$\sigma_t^2 = \alpha_0 + \sum_{j=1}^q \alpha_j \varepsilon_{t-j}^2 + \sum_{i=1}^p \beta_i \sigma_{t-i}^2$$

The size of the parameters α and β in the previous equation determines the dynamics of the short-term volatility of the observed series. A high value of the coefficient β indicates that shocks to the conditional variance take a long time to dissipate, which means that volatility is high. A high value of the coefficient α means that volatility reacts intensively to changes in shocks (ε_t^2).

Nelson introduced the exponential GARCH process or EGARCH model for the conditional variance, which takes into account the effect of asymmetry. Nelson's model of inflationary uncertainty can be represented as follows: (Nelson, 1991)

$$\ln \sigma_t^2 = \alpha_0 + \beta_1 \ln \sigma_{t-1}^2 + \theta_1 \frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \gamma_1 \left| \frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} \right|$$

The conditional variance of this model is positive regardless of the sign of the coefficients θ_1 and γ_1 , which allows its wide application in empirical analyses.

Zakoian presented the TGARCH (p,q) model as an alternative to the EGARCH process, where the asymmetry of positive and negative innovations is incorporated into the model using the indicator function (Zakoian, 1994):

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^q (\alpha_i \varepsilon_{t-i}^2) + \sum_{i=1}^q (\gamma_i d(\varepsilon_{t-i} < 0) \varepsilon_{t-i}^2) + \sum_{j=1}^p (\beta_j \sigma_{t-j}^2)$$

where γ_i are the parameters to be estimated, $d(\cdot)$ denotes the function indicator defined as:

$$d(\varepsilon_{t-i} < 0) = \begin{cases} 1, & \varepsilon_{t-i} < 0 \\ 0 & \varepsilon_{t-i} \geq 0 \end{cases}$$

The TGARCH model assumes that $(\varepsilon_{t-1} > 0)$ and $(\varepsilon_{t-1} < 0)$ have different effects on the conditional variance.

The APARCH (p, q) process, introduced by Ding, Granger and Engle, includes seven different GARCH models (ARCH, GARCH, AGARCH, TGARCH, TARCH, NGARCH and Log-GARCH) (Ding, Granger and Engle 1993):

$$\sigma_t^\delta = \alpha_0 + \sum_{i=1}^q \alpha_i (|\varepsilon_{t-i}| - \gamma_i \varepsilon_{t-i})^\delta + \sum_{j=1}^p (\beta_j \sigma_{t-j}^\delta)$$

where $\alpha_0 > 0, \delta \geq 0, \beta_j \geq 0, j = 1, \dots, p, \alpha_i \geq 0, -1 < \gamma_i < 1, i = 1, \dots, q$.

The parameter δ denotes the exponent of the conditional standard deviation, while the parameter γ describes the effect of asymmetry on the conditional variance.

The relationship between inflation and inflationary uncertainty was determined using the Granger causality test to determine whether one variable explains the value of the other variable. (Viorica, Jemna, Pintilescu, and Asandului 2014)

To test the hypothesis that inflation affects uncertainty, a VAR model was estimated:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \sigma_{t-1}^2 + \dots + \alpha_k \sigma_{t-k}^2 + \beta_1 \pi_{t-1} + \dots + \beta_k \pi_{t-k} + u_t$$

$$\pi_t = \alpha_0 + \alpha_1 \pi_{t-1} + \dots + \alpha_m \pi_{t-m} + \beta_1 \sigma_{t-1}^2 + \dots + \beta_m \sigma_{t-m}^2 + v_t$$

For this model, the null hypothesis was tested using the Granger causality test, $H_0: \beta_1 = \beta_2 = \dots = \beta_k = 0$, which assumes that inflation does not affect uncertainty. Rejection of this hypothesis means acceptance of the Friedman-Ball hypothesis. Testing using the Granger test was performed for 4, 8 and 12 lags.

In the last part of the empirical analysis, we examined the sign of these relationships. The direction of the correlation was obtained as the sum of the coefficients for the inflation variables in the first hypothesis examining the impact of inflation on uncertainty.

Similarly, for the second hypothesis examining the impact of inflation uncertainty on inflation, $H_0: \beta_1 = \beta_2 = \dots = \beta_m = 0$, the direction of the correlation is determined based on the sum of the coefficients with inflation uncertainty.

Results of the empirical analysis

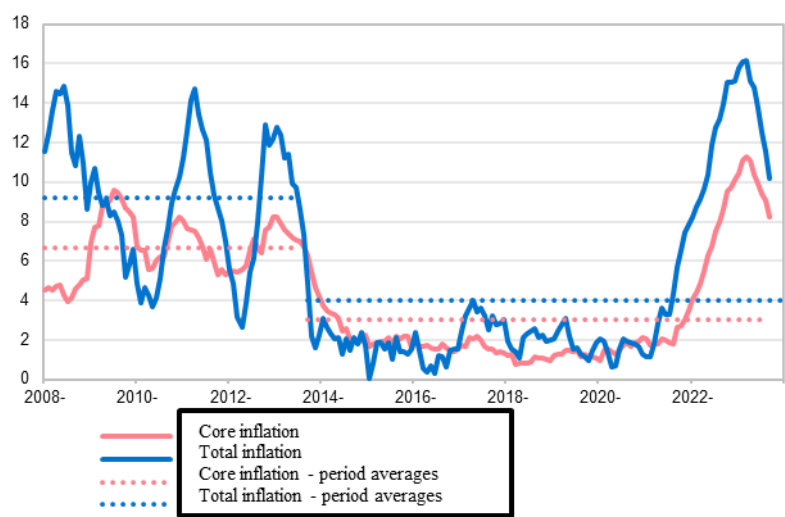
In the empirical analysis, we used monthly data on the Harmonized Index of Consumer Prices (HICP) obtained from the website of the Statistical Office of Serbia. The empirical analysis was conducted for the period January 2007–October 2023. The value of monthly inflation was calculated as:

$\pi_t = \ln \frac{CPI_t}{CPI_{t-1}} * 1200$, and multiplication by 1200 was performed to determine their growth on an annual basis.

Inflation in Serbia was volatile in the period 2008-2013., which was influenced by shocks from the international environment (growth in world prices of oil and primary agricultural products) during 2010 and 2012, as well as the effects of the depreciation of the dinar in conditions of expansive fiscal policy, especially during 2012. From the end of 2013 until mid-2021, inflation in Serbia was low and stable, averaging around 2%. This was also influenced by low inflationary pressures from the international environment, but also by the relative stability of the exchange rate, the coordination of monetary and fiscal policy, and the effects of fiscal consolidation, which influenced lower domestic demand. Since September 2021, inflation has been accelerating as a result of numerous shocks from the international environment - a sudden increase in demand in conditions of limited supply after the opening of numerous economies after the first phase of the pandemic, which resulted in disruptions in global supply chains and an increase in the cost of transport, then a significant increase in world prices of primary products and industrial raw materials, especially after the outbreak of the war in Ukraine, the emergence of an energy crisis, etc. This led to a significant increase in food and energy prices on the domestic market as well, and the growth in import inflation was also reflected in the growth in core inflation, which nevertheless remained below overall inflation throughout. Since April 2023, thanks to restrictive monetary policy measures and easing of global cost pressures,

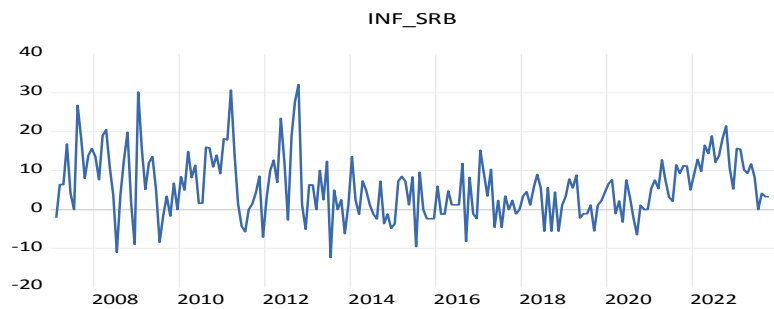
inflation in Serbia has been on the decline, and at the end of 2023 it was twice as low (7,6% year-on-year) as at the end of 2022.

Chart 1. Trends in overall and core inflation rates in Serbia



Source: National Bank of Serbia

Chart 2. Monthly inflation rates in Serbia on an annual basis



The results of descriptive statistics presented in Table (1) show that the monthly inflation rate is growing by 0.5 percent per month. The range between the maximum and minimum average inflation rate is around 4 percent, which with a standard deviation of 0.6 percent indicates high volatility recorded in the observed period.

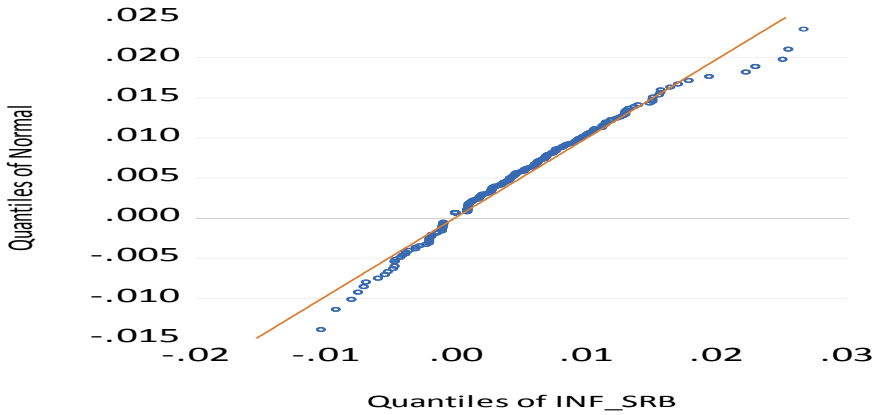
Table 1. Descriptive statistics

Mean	Median	Maximum	Minimum	Standard deviation
0.477	0.417	2.67	-1.032	0.667

Source: Author's calculations

The Q-Q diagram shown in graph (3) shows that the distribution of consumer prices deviates from normal.

Graph 3. Q-Q diagram of the monthly inflation rate in Serbia



The values of the ADF and PP unit root tests indicate that the monthly inflation rate series is stationary because the alternative hypotheses are accepted.

Table 2. Unit root test

	Augmented Dickey-Fuller test	Phillips-Peron test
Serbia	-10.400***	-9.580***

Source: Author's calculations

Note: Critical values of the ADF test for new significance: 1%, 5%, 10% are -3.436, -2.86, -2.567. Critical values of the PP test for significance level: 1%, 5%, 10% are -3.436, -2.867, -2.567. *** indicates statistical significance at the 1% level.

In the next step, inflation uncertainty was assessed using the GARCH model, with the Akaike and Schwarz information criteria used as criteria for selecting the appropriate model, and care was taken to ensure that the estimated coefficients of the appropriate specification were statistically significant and of the correct sign. The table with the model specifications is shown in the following table, and more detailed evaluation results are presented below. The EGARCH model turned out to be the best model, while the other models (GARCH, TGARCH and APARCH) that were also tested either did not have statistically significant coefficients or had higher values of the Akaike and Schwarz information criteria than the EGARCH model.

$$\ln \sigma_t^2 = 0.25(0.30) + 0.24(0.04) \ln \sigma_{t-1}^2 + 0.19(0.03) \frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} + 0.88(0.00) \left| \frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} \right|$$

Table 3. Estimation of inflation rate parameters in Serbia using the GARCH model

	GARCH (1,1)	EGARCH(1,1)	TGARCH(1,1)	APARCH (1,1)
Mean equation				
Constant	5.089(0.09)	4.787(0.00)	4.820(0.00)	4.913(0.00)
AR(1)	0.332(0.00)	0.254(0.00)	0.304(0.00)	0.260(0.00)
AR(3)	0.118(0.28)	0.167(0.00)	0.103(0.11)	0.168(0.01)
AR(12)	0.217(0.08)	0.155(0.00)	0.201(0.00)	0.156(0.01)
Conditional variance equation				
c	40.31(0.82)	0.255(0.30)	0.504 (0.29)	0.781(0.53)
α	0.025(0.70)		-0.004 (0.68)	0.135(0.03)
β	0.496(0.82)	0.244(0.04)	1.027 (0.00)	1.00 (0.16)
θ		0.193(0.03)		
γ		0.880 (0.00)	-0.074 (0.01)	-0.726(0.07)
δ				0.778(0.00)
Estimated model properties				
Akaiki	6.927644	6.724878	6.663900	6.737421
Schwartz	7.047709	6.862095	6.801117	6.891790
ARCH-LM (1) TEST	7.21 (0.00)	0.24(0.62)	1.04(0.30)	0.13(0.71)
ARCH-LM (4) TEST	2.46 (0.04)	0.07(0.07)	0.34 (0.84)	0.05 (0.99)
DW	2.014921	1.889325	1.954287	1.902815

Source: Author's calculations

The results of the Granger causality test between inflation and inflation uncertainty are shown in Table (4). The results of the empirical research showed that inflation affects the growth of inflation uncertainty, which confirms the Friedman-Ball hypothesis. The results also show that inflation uncertainty affects the growth of inflation, which is in line with the Cukierman and Meltzer hypothesis.

Table 4. VAR Granger causality test

Country	Hypothesis	Late 4	Late 8	Late 12
Serbia	Inflation does not affect the growth of inflation uncertainty	55.08(0.00)	27.79(0.00)	22.84(0.00)
	Inflation uncertainty does not affect the growth of inflation	2.18(0.00)	2.06(0.00)	2.264(0.00)

Source: Author's calculations

The results presented in Table (5) show that an increase in inflation affects an increase in inflation uncertainty. In addition, the results show that an increase in inflation uncertainty affects an increase in inflation.

Table 5. Direction of impact estimated based on VAR model

Country	Hypothesis	Late 4	Late 8	Late 12
Serbia	Inflation does not affect the growth of inflation uncertainty	+	+	-)
	Inflation uncertainty does not affect the growth of inflation	+	+	+

Source: Author's calculations

Conclusion

The aim of this research is to analyze the relationship between inflation and inflation uncertainty in Serbia. The empirical analysis was conducted for the period January 2007–October 2023. The analysis consisted of two steps, in the first step we estimated the inflation rate parameter and then tested the causality of inflation and inflation uncertainty.

We estimated the uncertainty regarding inflation trends using the GARCH methodology, with the asymmetric EGARCH model proving to be the best model. Then, we tested the Friedman-Ball and Cukierman-Meltzer hypotheses using the Granger test of causality of inflation and inflation uncertainty.

The results of the Granger test of causality between inflation and inflation uncertainty showed that inflation affects the growth of inflation uncertainty and that the growth of inflation leads to the growth of uncertainty, which confirmed the Friedman-Ball hypothesis. On the other hand, the results showed that inflation uncertainty affects inflation growth and that growth in inflation uncertainty affects inflation growth, which is in line with the Cukierman and Meltzer hypothesis.

Considering the results obtained through empirical analysis, we believe that in order to further reduce the inflation rate in the coming period, it is necessary to implement a restrictive monetary policy.

References

1. Ananzeh, I, E. 2015. „The Realationship between Inflation and its Uncertainty: Evidence from Jordan.“ *International Journal of Economics and Financial Issues*, 5(4) 929-932.
2. Asghar, A, K Ahmad, S Ullah, B Zaman, i M, T Rashid. 2011. „The Relationship between Inflation and Inflation Uncertainty: A Case Study for Saarc Countries.“ *International Research Journal of Finance and Economics*, Issue 66.
3. Ball, L. 1992. „Why Does High Inflation Raise Uncertainty?“ *Journal of Monetary Economics* 29(3) 371-388.
4. Bollerslev, T, R Engle, i D Nelson. 1994. "ARCH Models", *Handbook of Econometrics, Volume IV*. Amsterdam: North Holland: ed. Engle, R; McFadden, D.

5. Ding, Z, C, W, J, Granger, i R Engle. 1993. „A long memory property of stock market returns and a new model.“ *Journal of Empirical Finance* 1 83-106.
6. Friedman, M. 1977. „Inflation and Unemployment.“ *Journal of Political Economy* 85(3) 451-472.
7. Holland, A, S. 1995. „Inflation and Uncertainty: Test for Temporal Ordering.“ *Journal of Money, Credit and Banking*, 27 827-837.
8. Jiranyakul, K, i T Opiela. 2010. „Inflation and inflation uncertainty in the ASEAN-5 economies.“ *Journal of Asian Economics*, Volume 21, Issue 2 105-112.
9. Karahan, O. 2012. „The Relationship between inflation and Inflation Uncertainty: Evidence from the Turkish Economy.“ *Procedia Economics and Finance* 1 219-228.
10. Khatir, A, Q, B Guvenek, i F Mangir. 2020. „The Relationship between Inflation and Inflation Uncertainty: Empirical Evidence from Turkey.“ *Journal of Academic Value studies*, 6(4) 331-340.
11. Mladenović, Z. 2009. „Relationship between inflation and inflation uncertainty: The case of Serbia.“ *Yugoslav Journal of Operations Research* 19(1) 171-183.
12. Nelson, D, B. 1991. „Conditional Heteroscedasticity in Asset Return: A New Approach.“ *Econometrica*, 52(2) 347-370.
13. Nor, A, H, S,M, T,Y Ling, i F Maarof. 2007. „On the Relationship between Inflation Rate and Inflation Uncertainty: An Application of the GARCH Family Models.“ *Sains Malaysiana* 36(2) 225-232.
14. Potgerami, A, i K, E Maskus. 1987. „The effects of inflation on the predictability of price changes in Latin America: Some estimates and policy implications.“ *World Development* 15(2) 287-290.
15. Ungar, M, i B Zilberfarb. 1993. „Inflation and its unpredictability: theory and empirical evidence.“ *Journal of Money, Credit and Banking* 25 709-720.
16. Viorica, D, D Jemna, C Pintilescu, i M Asandalui. 2014. „The Relationship between Inflation and Inflation Uncertainty: Empirical Evidence for the Newest EU Countries.“ *PLOS ONE*.
17. Zakoian, J, M. 1994. „Treshold Heteroskedastic Models.“ *Journal of Economic Dynamics and Control* 18 931-955.
18. Živkov, D, J Njegić, i Pećanac M. 2014. „Boderectional linkage between inflation and inflation uncertainty.the case of Eastern European countries.“ *Baltic Journal of Economics* Vol.14, No. 1-2 124-139.
19. Narodna banka Srbije. 2023 Novembar. „Izveštaj o inflaciji“

POSREDNIČKA ULOGA VEŠTAČKE INTELIGENCIJE U MOTIVACIJI I UČINKU ZAPOSLENIH

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Apstrakt

Cilj istraživanja bio je da se ispituju relacije između motivacije i učinka zaposlenih, kao i posredni efekat veštačke inteligencije između sistema motivacije i učinka zaposlenih u turizmu. Glavno istraživačko pitanje odnosi se na utvrđivanje relacija koje motivacija ima na učinak zaposlenih u turizmu i uloge koje veštačka inteligencija ima u ovom odnosu. Empirijsko istraživanje je sprovedeno na uzorku od 202 zaposlena u turizmu i ugostiteljstvu u Republici Srbiji u periodu od maja do avgusta 2023. godine putem elektronskog upitnika. Predloženi odnosi su testirani PLS-SEM metodom primenom SmartPLS softvera. Istraživanja su ukazala da postoji direktan pozitivan efekat motivacije na primenu veštačke inteligencije i učinak zaposlenih. Primena veštačke inteligencije ima indirektan uticaj na odnos motivacije i učinka zaposlenih u organizacijama u turizmu i ugostiteljstvu. Adekvatan pristup motivaciji od strane organizacije i jačanje sposobnosti u pogledu AI rezultiraće većim učinkom zaposlenih.

Ključne reči: motivacija, učinak, veštačka inteligencija, turizam, ugostiteljstvo

JEL: M12, O33, Z3

Uvod

Kako ističe Öztirak (2023) veštačka inteligencija (AI) je na čelu digitalne transformacije i utiče na globalnu ekonomiju, poslovanje i društvo. Pojava ove vrste napredne tehnologije stvorila je nove mogućnosti organizacijama u sektorima turizma i hotelijerstva. U savremenim uslovima, sistemi za automatizaciju usluga su ubrzali zadatke koje tradicionalno sprovode zaposleni na prvoj liniji, kao što su registracija gostiju (prijava/odjava), posluga u sobu,

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barmen, chat botovi i virtuelna glasovna pomoć (Ivanov, Webster, 2017). Pojava ove vrste napredne tehnologije omogućila je zaposlenima u turizmu i ugostiteljstvu da koriste veštačku inteligenciju i rešenja za automatizaciju za stvaranje personalizovanijeg i nezaboravnog iskustva za smeštaj gostiju, a istovremeno redukuju troškove. Tekući tehnološki razvoj, veštačka inteligencija, automatizacija i robotika prema autorima Li, Bonn i Ye (2019) imaju značajan uticaj na profile radnih mesta, sate rada, odnose zaposlenih i menadžera, učinke i modele motivacije i nagrađivanja. Prema Ganta (2014) učinak predstavlja kombinaciju sposobnosti i motivacije zaposlenih u turizmu i ugostiteljstvu. Organizacije u ovom dinamičnom okruženju konstantno pokušavaju da motivišu svoje zaposlene kako bi postigli što bolje performanse. Cilj ovog istraživanja je ispitivanje relacija između motivacije i učinka zaposlenih, kao i posrednog efekta veštačke inteligencije u odnosu između motivacije i učinka zaposlenih u turizmu i ugostiteljstvu. Predmet istraživanja je utvrđivanje efekta koji motivacija prouzrokuje na učinak zaposlenih i uloge veštačke inteligencije u pomenutoj relaciji.

Pregled literature

Motivacija je složen proces heterogene prirode u kom organizacije podstiču zaposlene da deluju u pravcu postizanja poslovnih ciljeva. Autori Shahzadi i ostali (2014) navode da se motivacija zaposlenih tumačiti kao odraz nivoa energije, posvećenosti i kreativnosti koja je potrebna zaposlenima u obavljanju radnih zadataka. Prema Prahin i Katavić (2021) i Jain, Gupta i Bindal (2019) motivacija je proces u kome organizacija inspiriše na rad zaposlenog kroz nagrade u skladu sa ciljevima koje želi postići. Roslon (2020) ističe da dobro organizovan motivacioni sistem i adekvatan izbor motivatora izazivaju poželjno ponašanje kod zaposlenih sa stanovišta poslodavca i na taj način ostvaruju odlučujuću ulogu u uspehu organizacije.

Sektor turizma i hotelijerstva je radno intenzivan i ljudski resursi su značajan i odlučujući faktor za njegovu stabilnost. Kompanije nastoje pridobiti i zadržati što kvalitetnije ljudske resurse (Prahin, Katavić, 2021). Oslanjanje na ljudske resurse za pravilno funkcionisanje i rast uslužnih delatnosti, zahteva efikasnu praksu radne snage kako bi zaposleni obavljali posao na optimalnom nivou, čime se omogućava da sektor ostane održiv u globalnom okruženju koje se brzo menja (Zopiatitis et al., 2014). Krajnji cilj upravljanja organizacijom jesu zadovoljni zaposleni koji ostvaruju najbolji učinak. Konkretno, ostvarivanje što veće produktivnosti zaposlenih kao i smanjenje fluktuacije kreativnih i kvalitetnih ljudi je najbolji učinak (Sekeruš et al., 2019). Autori Ramos-Villagrasa et al. (2019) ističu da radni učinak predstavlja krajnji kriterijum za menadžment ljudskih resursa. Radni učinak se procenjuje na osnovu rezultata rada koji su određeni standardima u poslovanju (Sekeruš et al., 2019). Autori Shahzadi et al. (2014) u svom istraživanju zaključuju da motivacija zaposlenih ima značajan i pozitivan

odnos sa učinkom zaposlenih. U istraživanju autora Shahzadi i ostali (2014) otkrivaju da na učinak zaposlenih direktno utiču unutrašnje nagrade. Iako su istraživanja pokazala da postoji pozitivna korelacija između motivacije zaposlenih i radnog učinka, još uvek nije dovoljno jasno koji faktori motivacije u kolikoj meri doprinose uspešnosti jedne organizacije (Prahin, Katavić, 2021). Na osnovu pregleda literature iz oblasti motivacije i učinka zaposlenih u turizmu i ugostiteljstvu postavlja se sledeća hipoteza:

H1: Motivacija pozitivno i statistički značajno utiče na učinak zaposlenih u organizacijama u turizmu i ugostiteljstvu

Veštačka inteligencija se u literaturi poistovećuje sa mašinama koje pokazuju aspekte ljudskog uma (Huang, Rust, 2018; Longoni et al., 2020; Enholm et al., 2022; Haleem et al., 2022). Za razliku od ranijih proizvodnih ili informacionih tehnologija AI može da uči iz podataka i ažurira ih bez dodatne ljudske intervencije (Huang, Rust, 2018). Prema Nuseir i El Refae (2022) veštačka inteligencija (AI) je postala značajan faktor za unapređenje poslovnih sposobnosti koje dovode do poboljšanja poslovnih performansi. AI ima sposobnost da poboljša poslovne procese, performanse uslužnih zadataka koji vode ka visokom organizacionom učinku (Collins et al., 2021; Vlačić et al., 2021). Simulira ljudsku inteligenciju u mašinama, štedeći vreme i novac u poslovnim transakcijama (Haleem et al., 2022).

Prema Verma et al. (2021) automatizacija procesa usluga sa veštačkom inteligencijom (AI) nudi dodatnu mogućnost za poboljšanje organizacionih performansi i produktivnosti. Po Velojić et al. (2021) ugradnjom veštačke inteligencije (AI) u sistem dolazi do poboljšavanja kvaliteta samog sistema i uštede vremena i troškova. Na osnovama ovih navoda formirana je druga hipoteza:

H2: Motivacija pozitivno i statistički značajno utiče na učinak zaposlenih posredstvom veštačke inteligencije (AI) u organizacijama u turizmu i ugostiteljstvu.

Metodologija

2.1 Upitnik

Tokom procesa istraživanja relacija između motivacije zaposlenih, veštačke inteligencije i učinka zaposlenih, odnosno indirektnog uticaja motivacije na učinak, korišćen je elektronski upitnik „Google Forms“ koji se sastoji iz dva dela. Prvi deo upitnika odnosi se na kontrolna pitanja kao što su pol, godine starosti, nivo obrazovanja, tip sektora u kome su ispitanici zaposleni i hijerarhijski nivo na kome rade u organizaciji. Drugi deo upitnika bio je vezan isključivo za procenu motivacije zaposlenih kao nezavisne varijable, za učinak zaposlenih kao zavisne

varijable i veštačke inteligencije kao posredne varijable ili medijatora. Za istraživanje i merenje korišćena je Likertova skala, u rasponu od 1 do 5, pri čemu 1 predstavlja tvrdnju „izrazito se ne slažem“, 2 „ne slažem se“, 3 „neodlučno“, 4 „slažem se“ i 5 „izrazito se slažem“ (Joshi et al., 2015). Link upitnika je podeljen zaposlenima koji pripadaju turističkom i ugostiteljskom sektoru.

2.2 Karakteristike uzorka

Upitnik je bio namenjen isključivo zaposlenim licima na različitim pozicijama u turističkom i ugostiteljskom sektoru. Upitnik koji se odnosi na relacije između motivacije, učinka zaposlenih i veštačke inteligencije popunilo je 202 zaposlenih lica na teritoriji Republike Srbije. Prikupljanje podataka je izvršeno počev od maja do avgusta 2023. godine. U **tabeli 1** prikazana je struktura uzorka prema polu, godinama starosti, obrazovanju, tipu sektora u kome su ispitanici zaposleni i hijerarhijskom nivu na kome rade u organizaciji. Uzorak su činili uglavnom ispitanici ženskog pola (64,40%), zaposleni od 35 do 44 godine (52,50%), sa završenim četvorogodišnjim akademskim studijama (50,50%) u uslužnom sektoru (59,40%).

Tabela 1. Karakteristike uzorka

Karakteristike uzorka		N	Struktura uzorka
Pol		202	100
1.	Muški	72	35,60
2.	Ženski	130	64,40
Godine starosti		202	100
1.	Ispod 25	2	1,00
2.	25-34	50	24,80
3.	35-44	106	52,50
4.	45-55	39	19,30
5.	Iznad 55	5	2,50
Nivo obrazovanja		202	100
1.	Srednja škola	3	1,50
2.	Osnovne strukovne studije	24	11,90
3.	Master strukovne studije	23	11,40
4.	Osnovne akademske studije	102	50,50
5.	Master akademske studije	38	18,80
6.	Doktorske akademske studije	12	5,90
Tip sektora		202	100
1.	Turistički sektor	82	40,60
2.	Uslužni sektor	120	59,40

Izvor: Autor na bazi sopstvenog istraživanja

Rezultati istraživanja

Za predstavljanje rezultata istraživanja o postojanju relacija između motivacije i učinka zaposlenih, korišćeni su statistički softveri „SPSS“ i „Smart PLS“. Kako bi se na adekvatan način utvrdili odnosi između posmatranih varijabli, izvršena je

PLS-SEM analiza. Dakle, istraživanje je sprovedeno kako bi se utvrdio direktan uticaj motivacije na učinak zaposlenih u turizmu i ugostiteljstvu, kao i posredan efekat veštačke inteligencije (AI). U **tabeli 2** prikazana je deskriptivna statistika za svaku od posmatranih varijabli.

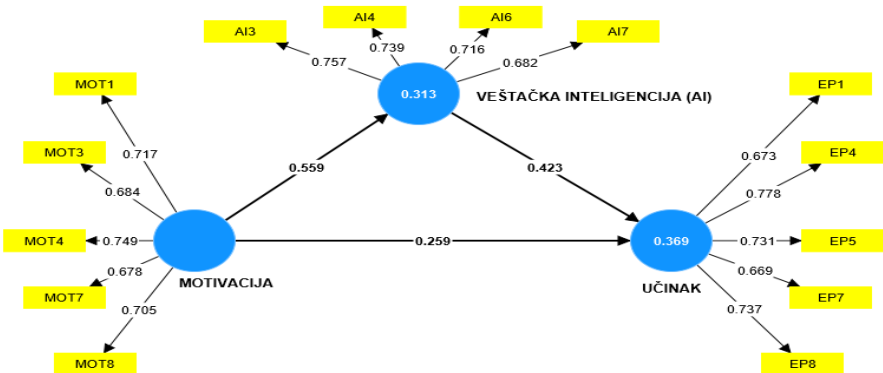
Tabela 2. Deskriptivna statistika za posmatrane varijable

	N	Minimum	Maximum	Mean	Std. Deviation
MOTIVACIJA	202	2,75	5,00	4,3370	0,38919
UČINAK	202	2,00	5,00	4,3000	0,42679
VEŠTAČKA INTELIGENCIJA (AI)	202	2,50	5,00	4,2690	0,44120

Izvor: Autor na bazi sopstvenog istraživanja

U okviru prvog dela analize prikazani su rezultati merenja reflektivnih konstrukata u okviru postavljenog modela, pri čemu je neophodno analizirati spoljno opterećenje indikatora za svaku promenljivu u okviru modela, ali i pouzdanost, konvergentnu validnost i diskriminatornu validnost. U **tabeli 3**, prikazano je spoljno opterećenje indikatora za svaku promenljivu u postavljenom modelu. Kako navode Grubor i ostali (2020) i Berber i ostali (2020) opterećenja ispod 0,708 treba da budu isključena iz dalje analize. Prema Berber i ostali (2022) opterećenja između 0,4 i 0,7 treba zadržati u modelu, samo ukoliko se ne remete ostali pokazatelji. Kako su opterećenja remetila ostale pokazatelje, u okviru prvog koraka analize dobijenih rezultata, isključeni su indikatori MOT2, MOT5, MOT6, EP2, EP3, EP6, AI1, AI2 I AI5. Nakon isključivanja indikatora koji nisu prošli test, u drugom koraku su svi indikatori imali opterećenja iznad 0,6, što je prihvatljivo prema Jevtić i Gašić (2023).

Slika 1. Prikaz istraživačkog modela



Izvor: Autor na bazi sopstvenog istraživanja

Tabela 3. Spoljno opterećenje svih indikatora iz postavljenog modela

	MOTIVACIJA	UČINAK	VEŠTAČKA INTELIGENCIJA (AI)
MOT1	0,717		
MOT3	0,684		
MOT4	0,749		
MOT7	0,678		
MOT8	0,705		
EP1		0,673	
EP4		0,778	
EP5		0,731	
EP7		0,669	
EP8		0,737	
AI3			0,757
AI4			0,739
AI6			0,716
AI7			0,682

Izvor: Autor na bazi sopstvenog istraživanja

U **tabeli 4** prikazana je pouzdanost i konvergentna validnost koja je merena Cronbach's alpha, kompozitna pouzdanost i ekstrahovana prosečna varijansa (AVE). Prema Gašić i Berber (2021), granična vrednost za Cronbach's alpha je 0,6. Konvergentna validnost se postiže za sve konstrukte iz modela, jer su vrednosti Cronbach's alpha veće od 0,60. Prema Gašić i Berber (2023) preporučeni „prag“ vrednosti za kompozitnu pouzdanost je 0,70. Kompozitna pouzdanost je preko 0,80 za svaki konstrukt iz modela, dok je ekstrahovana prosečna varijansa (AVE) veća od 0,50, kako i navode Berber et al. (2020) i Salisu et al. (2015).

Tabela 4. Pouzdanost i konvergentna validnost

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
MOTIVACIJA	0,749	0,751	0,833	0,50
UČINAK	0,766	0,773	0,842	0,53
VEŠTAČKA INTELIGENCIJA (AI)	0,697	0,697	0,815	0,52

Izvor: Autor na bazi sopstvenog istraživanja

Prema Berber et al. (2022) diskriminantna validnost se može utvrditi na osnovu analize unakrsnih opterećenja (Cross-Loadings), Fornell-Larcker kriterijuma i HTMT. U **tabeli 5** prikazana je analiza unakrsnih opterećenja koja predstavlja

procenu diskriminantne validnosti na nivou indikatora. Posmatrani model ima odgovarajuću diskriminantnu validnost ukoliko je svaki indikator određenog konstrukta slabo korelisan sa drugim konstruktima, odnosno ukoliko je opterećenje indikatora veće od bilo kog unakrsnog opterećenja (Grubor et al., 2021). U prikazanoj **tabeli 5** je evidentno da je opterećenje svakog indikatora veće od bilo kog drugog konstrukta u istoj koloni ili redu.

Tabela 5. Diskriminantna validnost - analiza unakrsnih opterećenja (Cross-loadings)

	MOTIVACIJA	UČINAK	VEŠTAČKA INTELIGENCIJA (AI)
MOT1	0,717	0,361	0,344
MOT3	0,684	0,377	0,370
MOT4	0,749	0,37	0,435
MOT7	0,678	0,357	0,404
MOT8	0,705	0,283	0,418
EP1	0,347	0,673	0,347
EP4	0,360	0,778	0,437
EP5	0,368	0,731	0,44
EP7	0,269	0,669	0,341
EP8	0,418	0,737	0,455
AI3	0,383	0,422	0,757
AI4	0,428	0,407	0,739
AI6	0,426	0,36	0,716
AI7	0,381	0,452	0,682

Izvor: Autor na bazi sopstvenog istraživanja

Na nivou indikatora, diskriminantna validnost je uspostavljena ukoliko je estrahovana prosečna varijansa (AVE) za svaki konstrukt veća od njegovih kvadratnih korelacija sa drugim konstruktima (Grubor et al., 2021). Fornell-Larcker kriterijum je ispunjen ukoliko je prvi konstrukt veći od drugog konstrukta. Na osnovu **tabele 6** može se zaključiti da je diskriminantna validnost preko Fornell- Larckerovog kriterijum postignuta.

Tabela 6. Diskriminantna validnost – Fornell – Larcker kriterijum

	MOTIVACIJA	UČINAK	VEŠTAČKA INTELIGENCIJA (AI)
MOTIVACIJA	0,707		
UČINAK	0,496	0,719	
VEŠTAČKA INTELIGENCIJA (AI)	0,559	0,568	0,724

Izvor: Autor na bazi sopstvenog istraživanja

U **tabeli 7** prikazan je HTMT pristup kojim se mogu prevazići potencijalna odstupanja po pitanju diskriminantne validnosti i zato predstavlja najprecizniji pokazatelj diskriminantne validnosti. Granična vrednost je 0,90 (Franke, Sarstedt, 2019). Kako su u tabeli sve prikazane vrednosti ispod 0,9 to ukazuje da je postignuta diskriminantna validnost po pitanju ovog kriterijuma.

Tabela 7. Diskriminantna validnost – HTMT

	MOTIVACIJA	UČINAK	VEŠTAČKA INTELIGENCIJA (AI)
MOTIVACIJA			
UČINAK	0,645		
VEŠTAČKA INTELIGENCIJA (AI)	0,772	0,768	

Izvor: Autor na bazi sopstvenog istraživanja

Rezultati koji su prikazani u **tabeli 8** predstavljaju analizu multikolinearnosti, pri čemu su vrednosti za VIF u većini slučajeva ispod 3. Granična vrednost za VIF je 3 (Hair et al., 2014). Prema Shams et al. (2020) granična vrednost je 5, dok se prema Hair et al. (2019) prihvataju i vrednosti manje od 10. U postmatranom modelu sve vrednosti su ispod 3.

Tabela 8. Testiranje multikolineranosti indikatora

	VIF
MOT1	1,467
MOT3	1,353
MOT4	1,56
MOT7	1,285
MOT8	1,461
EP1	1,347
EP4	1,594
EP5	1,411
EP7	1,367
EP8	1,399
AI3	1,419
AI4	1,355
AI6	1,372
AI7	1,248

Izvor: Autor na bazi sopstvenog istraživanja

R Squared pokazuje da su promene u ostvarenom učinku zaposlenih 36,9% izazvane veštačkom inteligencijom, dok ostali neistraženi faktori čine 63,1%.

Tabela 9. Koeficijenti determinacije konstrukta (R Square)

	R-square	R-square adjusted
UČINAK	0,369	0,362
VEŠTAČKA INTELIGENCIJA (AI)	0,313	0,309

Izvor: Autor na bazi sopstvenog istraživanja

Poslednji korak odnosi se na analizu odnosa između nezavisne varijable i zavisnih varijabli, odnosno motivacije zaposlenih i učinka zaposlenih, kao i posredničkom ulogom veštačke inteligencije u relaciji između motivacije i učinka zaposlenih.

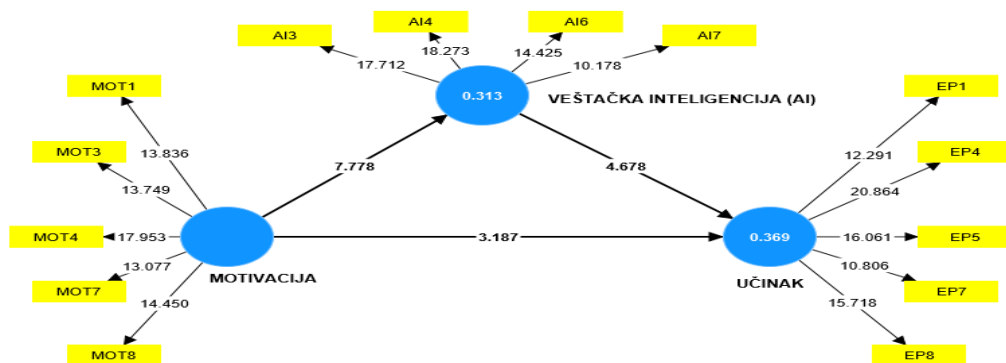
Tabela 10. Testiranje statističke značajnosti - direktni i specifičan (medijatorski) indirektni efekat

	Original sample	Sample mean	Standard deviation	T statistics	P values
MOTIVACIJA→UČINAK	0,259	0,263	0,081	3,187	0,001
MOTIVACIJA →VEŠTAČKA INTELIGENCIJA (AI)	0,559	0,565	0,072	7,778	0,000
VEŠTAČKA INTELIGENCIJA (AI)→UČINAK	0,423	0,425	0,09	4,678	0,000
MOTIVACIJA→VEŠTAČKA INTELIGENCIJA (AI) →UČINAK	0,237	0,241	0,063	3,751	0,000

Izvor: Autor na bazi sopstvenog istraživanja

Tabela 10 obuhvata srednju vrednost, standardnu devijaciju, t – statistiku i p – vrednost. Na osnovu dobijenih rezultata može se zaključiti da postoji pozitivna i statistički značajna veza između motivacije i učinka zaposlenih ($\beta=0,259$, $T=3,187$, $p=0,001$) pozitivna i statistički značajna veza između motivacije zaposlenih i veštačke inteligencije ($\beta=0,559$, $T=7,778$, $p=0,000$), pozitivna i statistički značajna veza između veštačke inteligencije i učinka zaposlenih ($\beta=0,423$, $T=4,678$, $p=0,000$). Kada je reč o posredničkoj ulozi veštačke inteligencije u relaciji između motivacije i učinka zaposlenih, odnosno indirektnom uticaju motivacije na učinak zaposlenih, putem medijacije utvrđuje se pozitivna i statistički značajna veza, indirektna uticaj motivacije na učinak zaposlenih ($\beta=0,237$, $T=3,187$, $p=0,000$).

Slika 2. Prikaz istraživačkog modela sa bootstrabing rezultatima



Izvor: Autor na bazi sopstvenog istraživanja

Diskusija o rezultatima istraživanja

Rezultati istraživanja ukazuju da motivacija ima pozitivan efekat na primenu veštačke inteligencije. Kako primena veštačke inteligencije posreduje u relaciji između motivacije i učinka zaposlenih, postoji indirektan efekat motivacije na učinak zaposlenih. Dakle, na osnovu sprovedenog istraživanja može se zaključiti da postoji direktan, pozitivan i statistički značajan uticaj motivacije na primenu veštačke inteligencije, direktan, pozitivan i statistički značajan uticaj motivacije na učinak zaposlenih i pozitivan statistički značajan uticaj između primene veštačke inteligencije i učinka zaposlenih. Na taj način mogu se potvrditi postavljene hipoteze H1 i H2. Kada je reč o indirektnom uticaju motivacije na učinak zaposlenih preko primene veštačke inteligencije, utvrđen je pozitivan i statistički značajan uticaj. Medijatorska analiza je sprovedena kako bi se utvrdilo da li postoji posrednička uloga primene veštačke inteligencije u odnosu na motivaciju i učinak zaposlenih u turizmu i ugostiteljstvu. Obzirom na to da postoje direktne veze između motivacije, primene veštačke inteligencije i učinka zaposlenih kao i indirektna veza između motivacije i učinka zaposlenih posredstvom primene veštačke inteligencije može se zaključiti da je formirana delimična medijacija.

Zaključna razmatranja

Ljudski resursi su najkonkurentnija imovina svake organizacije koja ima bitnu ulogu u postizanju ciljeva i uspešnosti u celini. U tom kontekstu su motivacija, zadovoljstvo poslom i radni učinak prepoznati kao ključni pojmovi vezani za ljudske resurse. Na osnovu pregleda literature i sprovedenog istraživanja zaključuje se da dobro organizovan motivacioni sistem i adekvatan izbor motivatora usmeren ka zaposlenima sa stanovišta poslodavca igra odlučujuću ulogu u uspehu organizacije. Dakle, postoji direktan, pozitivan i statistički značajan uticaj motivacije na primenu veštačke inteligencije, direktan, pozitivan i

statistički značajan uticaj motivacije na učinak zaposlenih i pozitivan statistički značajan uticaj između primene veštačke inteligencije i učinka zaposlenih. Adekvatan pristup motivaciji od strane organizacije usmeren ka zaposlenim u turizmu i ugostiteljstvu, jačanje sposobnosti u pogledu AI rezultiraće većim učinkom zaposlenih.

Ograničenje sprovedenog istraživanja odnosi se na relativno mali uzorak. Neki od predloga za buduća istraživanja je da se poveća broj ispitanika u organizacijama koje razvijaju različite modele i sisteme motivacije zaposlenih i primene veštačke inteligencije. Suština je da primena savremene tehnike i tehnologije postane ključno pitanje savremene radne organizacije. Organizacije na osnovu sistema merenja motivacije zaposlenih treba da teže da različitim materijalnim i nematerijalnim podsticajima podstaknu zaposlene na primenu savremene tehnike i tehnologije i time doprinesu povećanju učinka.

Literatura

1. Berber N., D. Gašić, I. Katić, & J. Borocki. 2022. The Mediating Role of Job Satisfaction in the Relationship between FWAs and Turnover Intentions. *Sustainability* 14, (8): 4502.
2. Berber, N., A. Slavić, & M. Aleksić. 2020. Relationship between perceived teamwork effectiveness and team performance in banking sector of Serbia. *Sustainability* 12, (20): 8753.
3. Collins, C., D. Dennehy, K. Conboy, & P. Mikalef. 2021. Artificial intelligence in information systems research: A systematic literature review and research agenda. *International Journal of Information Management*, 60: 102383.
4. Enholm, I. M., E. Papagiannidis, P. Mikalef, & J. Krogstie. 2022. Artificial intelligence and business value: A literature review. *Information Systems Frontiers*, 24, (5): 1709-1734.
5. Franke, G., & M. Sarstedt. 2019. Heuristics versus statistics in discriminant validity testing: a comparison of four procedures. *Internet Research* 29, (3): 430-447.
6. Ganta, V. C. 2014. Motivation in the workplace to improve the employee performance. *International Journal of Engineering Technology, Management and Applied Sciences* 2, (6): 221-230.
7. Gašić, D., & N. Berber. 2021. The influence of flexible work arrangement on employee behavior during the COVID-19 pandemic in the Republic of Serbia. *Management: Journal Of Sustainable Business And Management Solutions In Emerging Economies* 26, (3): 73-88.
8. Gašić, D., & N. Berber. 2023. The Mediating Role of Employee Engagement in the Relationship between Flexible Work Arrangements and Turnover

- Intentions among Highly Educated Employees in the Republic of Serbia. *Behavioral Sciences* 13, (2): 131.
9. Grubor, A., N. Berber, M. Aleksić, & R. Bjekić. 2020. The influence of corporate social responsibility on organizational performance: A research in AP Vojvodina. *Anali Ekonomskog fakulteta u Subotici*, (43): 3-13.
 10. Grubor, A., N. Đokić, N. Milićević, & I. Đokić. 2021. Marketing istraživanje. Subotica: Ekonomski fakultet.
 11. Hair Jr, J. F., M. Sarstedt, L. Hopkins, & V. G. Kuppelwieser. 2014. Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research. *European business review* 26, (2): 106-121.
 12. Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. 2019. When to use and how to report the results of PLS-SEM. *European business review*, 31, (1): 2-24.
 13. Haleem, A., M. Javaid, M. A. Qadri, & R. Suman. 2022. Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers* 3: 275-285.
 14. Huang, M. H., & R. T. Rust. 2018. Artificial intelligence in service. *Journal of service research*, 21(2): 155-172.
 15. Ivanov, S. H. & C. Webster. 2017. Adoption of robots, artificial intelligence and service automation by travel, tourism and hospitality companies—a cost-benefit analysis.
 16. Jain, A., B. Gupta, & M. Bindal. 2019. A study of employee motivation in organization. *International Journal of Engineering and Management Research (IJEMR)* 9, (6): 65-68.
 17. Jevtić, T., & D. Gašić. 2023. The effects of the compensation system on job satisfaction and turnover intentions of employees in the Republic of Serbia, 20, (10).
 18. Joshi, A., S. Kale., S. Chandel, & D. K. Pal. 2015. Likert scale: Explored and explained. *British Journal of Applied Science & Technology* 7, (4): 396-403.
 19. Li, J. J., M. A. Bonn, & B. H. Ye. 2019. Hotel Employee's Artificial Intelligence and Robotics Awareness and Its Impact on Turnover Intention: The Moderating Roles of Perceived Organizational Support and Competitive Psychological Climate. *Tourism Management* (73):172-181.
 20. Longoni, C., A. Bonezzi, & C. K. Morewedge. 2020. Resistance to medical artificial intelligence is an attribute in a compensatory decision process: response to Pezzo and Beckstead. *Judgment and Decision Making*, 15(3): 446-448.
 21. Nuseir, M. T., & G. A. El Refae. 2022. Factors influencing the choice of studying at UAE universities: an empirical research on the adoption of educational marketing strategies. *Journal of Marketing for Higher Education* 32, (2): 215-237.

22. Öztirak, M. 2023. A study on the impact of artificial intelligence anxiety on the innovation-oriented behaviours of employees. *Optimum Ekonomi ve Yönetim Bilimleri Dergisi* 10, (2): 267-286.
23. Prahin, D., & I. Katavić. 2021. Analiza motivacije, zadovoljstva poslom i radnog učinka zaposlenika na primjeru odabranog poduzeća. *Obrazovanje za poduzetništvo-E4E: znanstveno stručni časopis o obrazovanju za poduzetništvo* 11, (2): 7-23.
24. Ramos-Villagrasa, P. J., J. R. Barrada, E. Fernández-del-Río, i L. Koopmans. 2019. Assessing Job Performance Using Brief Self-Report Scales: The Case of the Individual Work Performance Questionnaire. *Journal of Work and Organizational Psychology* 35: 195-205
25. Rosłon, J. 2020. Motivators and Demotivators for Employees. *Olsztyn Economic Journal* 15, (4): 327-338.
26. Salisu, J. B., E. Chinyio, i S. Suresh. 2015. The Impact of Compensation on the Job Satisfaction of Public Sector Construction Workers of Jigawa State of Nigeria. *The Business & Management Review* 6, (4): 282.
27. Sekeruš J., S. Vasić, V. Mirčetić. 2019. The Impact od Leadership on organizational performance. *Vitez, Bosnia and Herzegovina*.
28. Shahzadi, I., A. Javed, S., S. Pirzada, S. Nasreen, & F. Khanam. 2014. Impact of Employee Motivation on Employee Performance. *European Journal of Business and Management* 6, (23): 159-166.
29. Shams, M. S., M. M. Niazi, i F. Asim. 2020. The Relationship Between Perceived Organizational Support, Employee Engagement, and Organizational Citizenship Behavior: Application of PLS-SEM Approach. *Kardan Journal of Economics and Management Sciences* 3, (1): 35-55.
30. Velojić, M., P. Atlagić, i M. Đurić. 2021. Odnos veštačke inteligencije i menadžmenta kvaliteta i standardizacije. *Zbornik Međunarodnog kongresa o procesnoj industriji–Procesing* 34, (1): 183-192.
31. Verma, S., R. Sharma, S. Deb, & D. Maitra. 2021. Artificial intelligence in marketing: Systematic review and future research direction. *International Journal of Information Management Data Insights* 1, (1): 100002.
32. Vlačić, B., L. Corbo, S. C. e Silva, & M. Dabić. 2021. The evolving role of artificial intelligence in marketing: A review and research agenda. *Journal of Business Research*, 128: 187-203.
33. Zopiatis, A., P. Constanti, i A. L. Theocharous. 2014. Job Involvement, Commitment, Satisfaction and Turnover: Evidence from Hotel Employees in Cyprus. *Tourism Management* 41: 129-140.

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THE MEDIATING ROLE OF ARTIFICIAL INTELLIGENCE IN MOTIVATION AND PERFORMANCE OF EMPLOYEES

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Abstract

The aim of the research was to examine the relationships between motivation and employee performance, as well as the mediating effect of artificial intelligence between the motivation system and employee performance in tourism. The main research question relates to determining the relationships that motivation has on employee performance in tourism and the roles that artificial intelligence plays in this relationship. The empirical research was conducted on a sample of 202 employees in tourism and hospitality in the Republic of Serbia from May to August 2023 using an electronic questionnaire. The proposed relationships were tested using the PLS-SEM method with SmartPLS software. The research indicated that there is a direct positive effect of motivation on the implementation of artificial intelligence and employee performance. The implementation of artificial intelligence has an indirect impact on the relationship between motivation and employee performance in tourism and hospitality organizations. An adequate approach to motivation by the organization and strengthening capabilities regarding AI will result in higher employee performance.

Key words: Motivation, Performance, Artificial Intelligence, Tourism, Hospitality

JEL: M12, O33, Z3

Introduction

As Öztirak (2023) points out, artificial intelligence (AI) is at the forefront of digital transformation and is affecting the global economy, business and society. The emergence of this type of advanced technology has created new opportunities for organizations in the tourism and hospitality sectors. In modern conditions, service automation systems have accelerated tasks traditionally performed by front-line employees, such as guest registration (check-in/check-out), room service, bartending, chat bots and virtual voice assistance (Ivanov, Webster,

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2017). The emergence of this type of advanced technology has enabled tourism and hospitality employees to use artificial intelligence and automation solutions to create a more personalized and memorable guest experience, while reducing costs. According to Li, Bonn and Ye (2019), ongoing technological developments, artificial intelligence, automation and robotics have a significant impact on job profiles, working hours, employee-manager relations, performance and motivation and reward models. According to Gant (2014), performance is a combination of employees' abilities and motivation in the tourism and hospitality industry. Organizations in this dynamic environment are constantly trying to motivate their employees in order to achieve the best possible performance. The aim of this research is to examine the relationship between employee motivation and performance, as well as the indirect effect of artificial intelligence on the relationship between employee motivation and performance in the tourism and hospitality industry. The subject of the research is to determine the effect that motivation has on employee performance and the role of artificial intelligence in the aforementioned relationship.

Literature review

Motivation is a complex process of heterogeneous nature in which organizations encourage employees to act towards achieving business goals. Authors Shahzadi et al. (2014) state that employee motivation should be interpreted as a reflection of the level of energy, commitment and creativity that employees need to perform work tasks. According to Prahin and Katavić (2021) and Jain, Gupta and Bindal (2019), motivation is a process in which an organization inspires an employee to work through rewards in accordance with the goals it wants to achieve. Roslon (2020) points out that a well-organized motivational system and an adequate selection of motivators cause desirable behavior in employees from the employer's point of view and thus play a decisive role in the success of the organization.

The tourism and hospitality sector is labor-intensive and human resources are a significant and decisive factor for its stability. Companies strive to attract and retain the highest quality human resources (Prahin, Katavić, 2021). Relying on human resources for the proper functioning and growth of service industries requires effective workforce practices to ensure that employees perform at an optimal level, thus enabling the sector to remain sustainable in a rapidly changing global environment (Zopiatis et al., 2014). The ultimate goal of organizational management is to have satisfied employees who perform at their best. Specifically, achieving the highest possible employee productivity and reducing the turnover of creative and quality people is the best performance (Sekeruš et al., 2019). The authors Ramos-Villagrasa et al. (2019) emphasize that performance is the ultimate criterion for human resource management. Performance is assessed based on work results that are determined by business standards (Sekeruš et al., 2019). The authors Shahzadi et al. (2014) conclude in their research that employee

motivation has a significant and positive relationship with employee performance. In their research, the authors Shahzadi et al. (2014) reveal that employee performance is directly affected by intrinsic rewards. Although research has shown that there is a positive correlation between employee motivation and work performance, it is still not clear which motivation factors contribute to the success of an organization (Prahin, Katavić, 2021). Based on a review of the literature in the field of employee motivation and performance in tourism and hospitality, the following hypothesis is put forward:

H1: Motivation has a positive and statistically significant effect on the performance of employees in tourism and hospitality organizations.

Artificial intelligence is identified in the literature with machines that exhibit aspects of the human mind (Huang, Rust, 2018; Longoni et al., 2020; Enholm et al., 2022; Haleem et al., 2022). Unlike earlier manufacturing or information technologies, AI can learn from data and update it without additional human intervention (Huang, Rust, 2018). According to Nuseir and El Refae (2022), artificial intelligence (AI) has become a significant factor in improving business capabilities that lead to improved business performance. AI has the ability to improve business processes, service task performance that leads to high organizational performance (Collins et al., 2021; Vlačić et al., 2021). It simulates human intelligence in machines, saving time and money in business transactions (Haleem et al., 2022). According to Verma et al. (2021) automation of service processes with artificial intelligence (AI) offers an additional opportunity to improve organizational performance and productivity. According to Velojić et al. (2021), incorporating artificial intelligence (AI) into the system improves the quality of the system itself and saves time and costs. Based on these statements, a second hypothesis was formed:

H2: Motivation has a positive and statistically significant impact on employee performance through artificial intelligence (AI) in tourism and hospitality organizations.

Methodology

2.1 Questionnaire

During the process of researching the relationship between employee motivation, artificial intelligence and employee performance, i.e. the indirect impact of motivation on performance, an electronic questionnaire "Google Forms" was used, which consists of two parts. The first part of the questionnaire refers to control questions such as gender, age, level of education, type of sector in which the respondents are employed and hierarchical level at which they work in the organization. The second part of the questionnaire was related exclusively to the

assessment of employee motivation as an independent variable, employee performance as a dependent variable and artificial intelligence as an indirect variable or mediator. A Likert scale was used for research and measurement, ranging from 1 to 5, where 1 represents the statement "strongly disagree", 2 "disagree", 3 "undecided"; 4 "agree" and 5 "strongly agree" (Joshi et al., 2015). The questionnaire link was distributed to employees belonging to the tourism and hospitality sector.

2.2 Sample characteristics

The questionnaire was intended exclusively for employees in various positions in the tourism and hospitality sector. The questionnaire, which relates to the relationship between motivation, employee performance and artificial intelligence, was completed by 202 employees in the territory of the Republic of Serbia. Data collection was carried out from May to August 2023. Table 1 shows the structure of the sample according to gender, age, education, type of sector in which the respondents are employed and hierarchical level at which they work in the organization. The sample consisted mainly of female respondents (64.40%), employees aged 35 to 44 (52.50%), with completed four-year academic studies (50.50%) in the service sector (59.40%).

Table 1. Sample characteristics

Sample Characteristics		N	Sample Structure
Gender		202	100
1.	Male	72	35,60
2.	Female	130	64,40
Age		202	100
1.	Under 25	2	1,00
2.	25-34	50	24,80
3.	35-44	106	52,50
4.	45-55	39	19,30
5.	Above 55	5	2,50
Education Level		202	100
1.	High School	3	1,50
2.	Basic Vocational Studies	24	11,90
3.	Master Vocational Studies	23	11,40
4.	Basic Academic Studies	102	50,50
5.	Master Academic Studies	38	18,80
6.	Doctoral Academic Studies	12	5,90
Sector Type		202	100
1.	Tourism Sector	82	40,60
2.	Service Sector	120	59,40

Source: Author based on own research

Research Results

To present the results of the research on the existence of relationships between employee motivation and performance, the statistical software "SPSS" and "Smart PLS" were used. In order to adequately determine the relationships between the observed variables, a PLS-SEM analysis was performed. Therefore, the research was conducted to determine the direct impact of motivation on the performance of employees in tourism and hospitality, as well as the indirect effect of artificial intelligence (AI). Table 2 shows descriptive statistics for each of the observed variables.

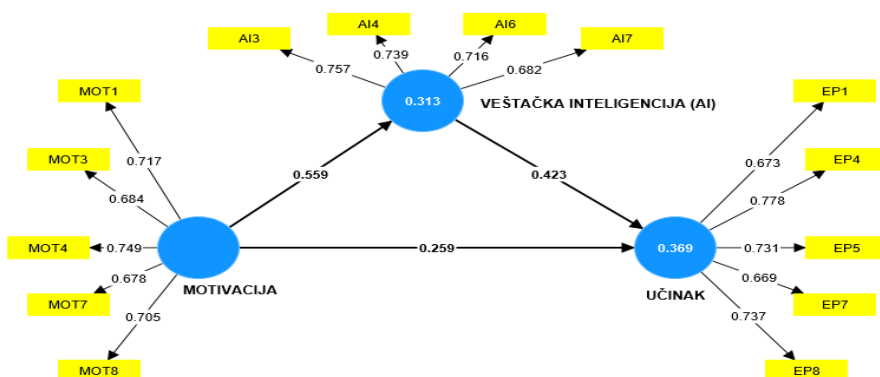
Table 2. Descriptive statistics for the observed variables

	N	Minimum	Maximum	Mean	Std. Deviation
MOTIVATION	202	2,75	5,00	4,3370	0,38919
PERFORMANCE	202	2,00	5,00	4,3000	0,42679
ARTIFICIAL INTELLIGENCE (AI)	202	2,50	5,00	4,2690	0,44120

Source: Author based on own research

The first part of the analysis presents the results of measuring reflective constructs within the established model, whereby it is necessary to analyze the external loading of indicators for each variable within the model, as well as reliability, convergent validity and discriminant validity. Table 3 shows the external loading of indicators for each variable in the established model. As stated by Grubor et al. (2020) and Berber et al. (2020), loadings below 0,708 should be excluded from further analysis. According to Berber et al. (2022), loadings between 0,4 and 0,7 should be retained in the model, only if other indicators are not disturbed. Since the loadings disturbed other indicators, in the first step of the analysis of the obtained results, indicators MOT2, MOT5, MOT6, EP2, EP3, EP6, AI1, AI2 and AI5 were excluded. After excluding indicators that did not pass the test, in the second step all indicators had loadings above 0,6, which is acceptable according to Jevtić and Gašić (2023).

Figure 1. Overview of the research model



Source: Author based on own research

Table 3. External loading of all indicators from the fitted model

	MOTIVATION	PERFORMANCE	ARTIFICIAL INTELLIGENCE (AI)
MOT1	0,717		
MOT3	0,684		
MOT4	0,749		
MOT7	0,678		
MOT8	0,705		
EP1		0,673	
EP4		0,778	
EP5		0,731	
EP7		0,669	
EP8		0,737	
AI3			0,757
AI4			0,739
AI6			0,716
AI7			0,682

Source: Author based on own research

Table 4 shows the reliability and convergent validity measured by Cronbach's alpha, composite reliability and average variance extracted (AVE). According to Gašić and Berber (2021), the threshold value for Cronbach's alpha is 0.6. Convergent validity is achieved for all constructs in the model, as Cronbach's alpha values are greater than 0,60. According to Gašić and Berber (2023), the recommended "threshold" value for composite reliability is 0,70. Composite

reliability is over 0,80 for each construct in the model, while the average variance extracted (AVE) is greater than 0,50, as reported by Berber et al. (2020) and Salisu et al. (2015).

Tabela 4. Pouzdanost i konvergentna validnost

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
MOTIVATION	0,749	0,751	0,833	0,50
PERFORMANCE	0,766	0,773	0,842	0,53
ARTIFICIAL INTELLIGENCE (AI)	0,697	0,697	0,815	0,52

Source: Author based on own research

According to Berber et al. (2022), discriminant validity can be determined based on the analysis of cross-loadings, the Fornell-Larcker criterion and the HTMT. Table 5 shows the cross-loading analysis, which represents an assessment of discriminant validity at the indicator level. The observed model has adequate discriminant validity if each indicator of a particular construct is weakly correlated with other constructs, i.e. if the loading of the indicator is greater than any cross-loading (Grubor et al., 2021). In the presented table 5, it is evident that the loading of each indicator is greater than any other construct in the same column or row.

Table 5. Discriminant validity - cross-loadings analysis

	MOTIVATION	PERFORMANCE	ARTIFICIAL INTELLIGENCE (AI)
MOT1	0,717	0,361	0,344
MOT3	0,684	0,377	0,370
MOT4	0,749	0,37	0,435
MOT7	0,678	0,357	0,404
MOT8	0,705	0,283	0,418
EP1	0,347	0,673	0,347
EP4	0,360	0,778	0,437
EP5	0,368	0,731	0,44
EP7	0,269	0,669	0,341
EP8	0,418	0,737	0,455
AI3	0,383	0,422	0,757
AI4	0,428	0,407	0,739
AI6	0,426	0,36	0,716
AI7	0,381	0,452	0,682

Source: Author based on own research

At the indicator level, discriminant validity is established if the average variance extracted (AVE) for each construct is greater than its squared correlations with other constructs (Grubor et al., 2021). The Fornell-Larcker criterion is met if the first construct is greater than the second construct. Based on Table 6, it can be concluded that discriminant validity via the Fornell-Larcker criterion is achieved.

Table 6. Discriminant validity – Fornell – Larcker criterion

	MOTIVATION	PERFORMANCE	ARTIFICIAL INTELLIGENCE (AI)
MOTIVATION	0,707		
PERFORMANCE	0,496	0,719	
ARTIFICIAL INTELLIGENCE (AI)	0,559	0,568	0,724

Source: Author based on own research

U **tabeli 7** prikazan je HTMT pristup kojim se mogu prevazići potencijalna odstupanja po pitanju diskriminantne validnosti i zato predstavlja najprecizniji pokazatelj diskriminantne validnosti. Granična vrednost je 0,90 (Franke, Sarstedt, 2019). Kako su u tabeli sve prikazane vrednosti ispod 0,9 to ukazuje da je postignuta diskriminantna validnost po pitanju ovog kriterijuma.

Table 7. Discriminant validity – HTML

	MOTIVATION	PERFORMANCE	ARTIFICIAL INTELLIGENCE (AI)
MOTIVATION			
PERFORMANCE	0,645		
ARTIFICIAL INTELLIGENCE (AI)	0,772	0,768	

Source: Author based on own research

The results shown in Table 8 represent a multicollinearity analysis, with VIF values in most cases below 3. The cut-off value for VIF is 3 (Hair et al., 2014). According to Shams et al. (2020), the cut-off value is 5, while according to Hair et al. (2019), values less than 10 are also accepted. In the post-observed model, all values are below 3.

Table 8. Testing for multicollinearity of the indicator

	VIF
MOT1	1,467
MOT3	1,353
MOT4	1,56
MOT7	1,285
MOT8	1,461
EP1	1,347

EP4	1,594
EP5	1,411
EP7	1,367
EP8	1,399
AI3	1,419
AI4	1,355
AI6	1,372
AI7	1,248

Source: Author based on own research

R Squared shows that 36.9% of changes in employee performance are caused by artificial intelligence, while other unexplored factors account for 63.1%.

Table 9. Coefficients of determination of the construct (R Square)

	R-square	R-square adjusted
PERFORMANCE	0,369	0,362
ARTIFICIAL INTELLIGENCE (AI)	0,313	0,309

Source: Author based on own research

The last step refers to the analysis of the relationship between the independent variable and the dependent variables, namely employee motivation and employee performance, as well as the mediating role of artificial intelligence in the relationship between employee motivation and performance.

Table 10. Statistical significance testing - direct and specific (mediator) indirect effect

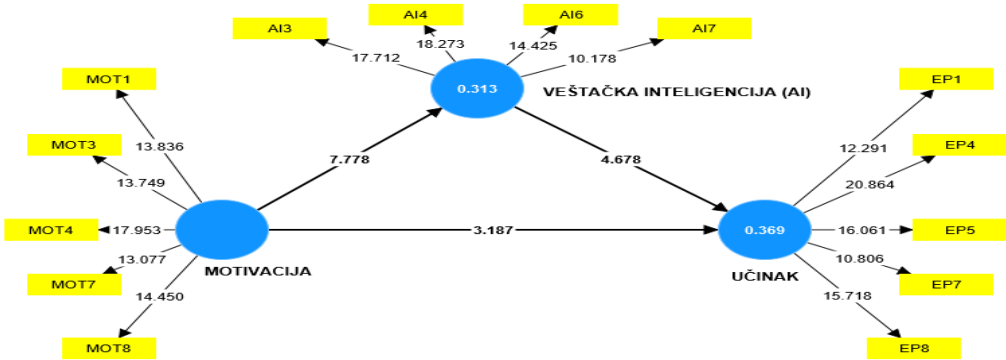
	Original sample	Sample mean	Standard deviation	T statistics	P values
MOTIVATION → PERFORMANCE	0,259	0,263	0,081	3,187	0,001
MOTIVATION → ARTIFICIAL INTELLIGENCE (AI)	0,559	0,565	0,072	7,778	0,000
ARTIFICIAL INTELLIGENCE (AI) → PERFORMANCE	0,423	0,425	0,09	4,678	0,000
MOTIVATION → ARTIFICIAL INTELLIGENCE (AI) → PERFORMANCE	0,237	0,241	0,063	3,751	0,000

Source: Author based on own research

Table 10 includes the mean, standard deviation, t-statistics and p-value. Based on the results obtained, it can be concluded that there is a positive and statistically significant relationship between employee motivation and performance ($\beta=0.259$, $T=3.187$, $p=0.001$) a positive and statistically significant relationship between employee motivation and artificial intelligence ($\beta=0.559$, $T=7.778$, $p=0.000$), a positive and statistically significant relationship between artificial intelligence and employee performance ($\beta=0.423$, $T=4.678$, $p=0.000$). When it comes to the

mediating role of artificial intelligence in the relationship between employee motivation and performance, i.e. the indirect impact of motivation on employee performance, a positive and statistically significant relationship is determined through mediation, the indirect impact of motivation on employee performance (β =0.237, T=3.187, p=0.000).

Figure 2. Presentation of the research model with bootstrapping results



Source: Author based on own research

Discussion of research results

The research results indicate that motivation has a positive effect on the application of artificial intelligence. As the application of artificial intelligence mediates the relationship between motivation and employee performance, there is an indirect effect of motivation on employee performance. Therefore, based on the research conducted, it can be concluded that there is a direct, positive and statistically significant effect of motivation on the application of artificial intelligence, a direct, positive and statistically significant effect of motivation on employee performance and a positive statistically significant effect between the application of artificial intelligence and employee performance. In this way, the hypotheses H1 and H2 can be confirmed. When it comes to the indirect effect of motivation on employee performance through the application of artificial intelligence, a positive and statistically significant effect was determined. Mediation analysis was conducted to determine whether there is a mediating role of the application of artificial intelligence in relation to the motivation and performance of employees in tourism and hospitality. Given that there are direct links between motivation, the application of artificial intelligence, and employee performance, as well as an indirect link between motivation and employee performance through the application of artificial intelligence, it can be concluded that partial mediation has been formed.

Concluding remarks

Human resources are the most competitive asset of any organization that plays an important role in achieving goals and overall success. In this context, motivation, job satisfaction and performance are recognized as key concepts related to human resources. Based on the literature review and the conducted research, it is concluded that a well-organized motivational system and an adequate selection of motivators directed towards employees from the employer's point of view play a decisive role in the success of the organization. Therefore, there is a direct, positive and statistically significant impact of motivation on the application of artificial intelligence, a direct, positive and statistically significant impact of motivation on employee performance and a positive statistically significant impact between the application of artificial intelligence and employee performance. An adequate approach to motivation by the organization directed towards employees in tourism and hospitality, strengthening capabilities in terms of AI will result in higher employee performance.

The limitation of the conducted research relates to a relatively small sample. Some of the suggestions for future research are to increase the number of respondents in organizations that develop different models and systems of employee motivation and the application of artificial intelligence. The essence is that the application of modern techniques and technology becomes a key issue of modern work organization. Organizations, based on the employee motivation measurement system, should strive to encourage employees to apply modern techniques and technology through various material and non-material incentives and thus contribute to increasing performance.

References

1. Berber N., D. Gašić, I. Katić, & J. Borocki. 2022. The Mediating Role of Job Satisfaction in the Relationship between FWAs and Turnover Intentions. *Sustainability* 14, (8): 4502.
2. Berber, N., A. Slavić, & M. Aleksić. 2020. Relationship between perceived teamwork effectiveness and team performance in banking sector of Serbia. *Sustainability* 12, (20): 8753.
3. Collins, C., D. Dennehy, K. Conboy, & P. Mikalef. 2021. Artificial intelligence in information systems research: A systematic literature review and research agenda. *International Journal of Information Management*, 60: 102383.
4. Enholm, I. M., E. Papagiannidis, P. Mikalef, & J. Krogstie. 2022. Artificial intelligence and business value: A literature review. *Information Systems Frontiers*, 24, (5): 1709-1734.

5. Franke, G., & M. Sarstedt. 2019. Heuristics versus statistics in discriminant validity testing: a comparison of four procedures. *Internet Research* 29, (3): 430-447.
6. Ganta, V. C. 2014. Motivation in the workplace to improve the employee performance. *International Journal of Engineering Technology, Management and Applied Sciences* 2, (6): 221-230.
7. Gašić, D., & N. Berber. 2021. The influence of flexible work arrangement on employee behavior during the COVID-19 pandemic in the Republic of Serbia. *Management: Journal Of Sustainable Business And Management Solutions In Emerging Economies* 26, (3): 73-88.
8. Gašić, D., & N. Berber. 2023. The Mediating Role of Employee Engagement in the Relationship between Flexible Work Arrangements and Turnover Intentions among Highly Educated Employees in the Republic of Serbia. *Behavioral Sciences* 13, (2): 131.
9. Grubor, A., N. Berber, M. Aleksić, & R. Bjekić. 2020. The influence of corporate social responsibility on organizational performance: A research in AP Vojvodina. *Anali Ekonomskog fakulteta u Subotici*, (43): 3-13.
10. Grubor, A., N. Đokić, N. Milićević, & I. Đokić. 2021. Marketing istraživanje. Subotica: Ekonomski fakultet.
11. Hair Jr, J. F., M. Sarstedt, L. Hopkins, & V. G. Kuppelwieser. 2014. Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research. *European business review* 26, (2): 106-121.
12. Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. 2019. When to use and how to report the results of PLS-SEM. *European business review*, 31, (1): 2-24.
13. Haleem, A., M. Javaid, M. A. Qadri, & R. Suman. 2022. Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers* 3: 275-285.
14. Huang, M. H., & R. T. Rust. 2018. Artificial intelligence in service. *Journal of service research*, 21(2): 155-172.
15. Ivanov, S. H. & C. Webster. 2017. Adoption of robots, artificial intelligence and service automation by travel, tourism and hospitality companies—a cost-benefit analysis.
16. Jain, A., B. Gupta, & M. Bindal. 2019. A study of employee motivation in organization. *International Journal of Engineering and Management Research (IJEMR)* 9, (6): 65-68.
17. Jevtić, T., & D. Gašić. 2023. The effects of the compensation system on job satisfaction and turnover intentions of employees in the Republic of Serbia, 20, (10).
18. Joshi, A., S. Kale., S. Chandel, & D. K. Pal. 2015. Likert scale: Explored and explained. *British Journal of Applied Science & Technology* 7, (4): 396-403.
19. Li, J. J., M. A. Bonn, & B. H. Ye. 2019. Hotel Employee's Artificial Intelligence and Robotics Awareness and Its Impact on Turnover Intention:

- The Moderating Roles of Perceived Organizational Support and Competitive Psychological Climate. *Tourism Management* (73):172-181.
20. Longoni, C., A. Bonezzi, & C. K. Morewedge. 2020. Resistance to medical artificial intelligence is an attribute in a compensatory decision process: response to Pezzo and Beckstead. *Judgment and Decision Making*, 15(3): 446-448.
 21. Nuseir, M. T., & G. A. El Refae. 2022. Factors influencing the choice of studying at UAE universities: an empirical research on the adoption of educational marketing strategies. *Journal of Marketing for Higher Education* 32, (2): 215-237.
 22. Öztirak, M. 2023. A study on the impact of artificial intelligence anxiety on the innovation-oriented behaviours of employees. *Optimum Ekonomi ve Yönetim Bilimleri Dergisi* 10, (2): 267-286.
 23. Prahin, D., & I. Katavić. 2021. Analiza motivacije, zadovoljstva poslom i radnog učinka zaposlenika na primjeru odabranog poduzeća. *Obrazovanje za poduzetništvo-E4E: znanstveno stručni časopis o obrazovanju za poduzetništvo* 11, (2): 7-23.
 24. Ramos-Villagrasa, P. J., J. R. Barrada, E. Fernández-del-Río, i L. Koopmans. 2019. Assessing Job Performance Using Brief Self-Report Scales: The Case of the Individual Work Performance Questionnaire. *Journal of Work and Organizational Psychology* 35: 195-205
 25. Rosłon, J. 2020. Motivators and Demotivators for Employees. *Olsztyn Economic Journal* 15, (4): 327-338.
 26. Salisu, J. B., E. Chinyio, i S. Suresh. 2015. The Impact of Compensation on the Job Satisfaction of Public Sector Construction Workers of Jigawa State of Nigeria. *The Business & Management Review* 6, (4): 282.
 27. Sekeruš J., S. Vasić, V. Mirčetić. 2019. The Impact od Leadership on organizational performance. *Vitez, Bosnia and Herzegovina*.
 28. Shahzadi, I., A. Javed, S., S. Pirzada, S. Nasreen, & F. Khanam. 2014. Impact of Employee Motivation on Employee Performance. *European Journal of Business and Management* 6, (23): 159-166.
 29. Shams, M. S., M. M. Niazi, i F. Asim. 2020. The Relationship Between Perceived Organizational Support, Employee Engagement, and Organizational Citizenship Behavior: Application of PLS-SEM Approach. *Kardan Journal of Economics and Management Sciences* 3, (1): 35-55.
 30. Velojić, M., P. Atlagić, i M. Đurić. 2021. Odnos veštačke inteligencije i menadžmenta kvaliteta i standardizacije. *Zbornik Međunarodnog kongresa o procesnoj industriji-Procesing* 34, (1): 183-192.
 31. Verma, S., R. Sharma, S. Deb, & D. Maitra. 2021. Artificial intelligence in marketing: Systematic review and future research direction. *International Journal of Information Management Data Insights* 1, (1): 100002.

32. Vlačić, B., L. Corbo, S. C. e Silva, & M. Dabić. 2021. The evolving role of artificial intelligence in marketing: A review and research agenda. *Journal of Business Research*, 128: 187-203.
33. Zopiatis, A., P. Constanti, i A. L. Theocharous. 2014. Job Involvement, Commitment, Satisfaction and Turnover: Evidence from Hotel Employees in Cyprus. *Tourism Management* 41: 129-140.

PREDICTION OF ACADEMIC SUCCESS BASED ON PERSONALITY CHARACTERISTICS, SELF-EFFICACY AND ACHIEVEMENT MOTIVATION AMONG STUDENTS IN SERBIA

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Abstract

The subject of research in this paper is the connection between personality characteristic according to the HEXACO model, self-efficacy and dimensions of achievement motives on the one hand and academic success on the other hand among students in Serbia. The aim is to determine to what extent personality traits, achievement motive and self-efficacy influence academic success. The average in the last year of study, the overall average at the faculty and satisfaction with academic achievement were determined as indicators of the student's academic success. The research sample consisted of 269 respondents; statistical data processing was carried out using the IBM SPSS Statistics 21 program. Descriptive statistics (AS, SD), Pearson's correlation coefficient and multiple linear regression analysis were used in data processing. The results showed statistically significant correlations of honesty, conscientiousness, self-efficacy, all dimensions as well as overall achievement motive on the one hand and indicators of academic achievement on the other hand. This study provides a better understanding of the personality traits, beliefs, and motivations of students that contribute to academic achievement.

Key words: HEXACO model, academic success, achievement motive, self-efficacy, Serbia

Introduction

Individual variation exists in every aspect of thinking, feeling, and behaving. Modeling the fundamental components of personality structure represented a revolutionary discovery in the study and understanding of individual variation. These theories explain what individual differences are in terms of

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personality traits and how these differences can be succinctly but thoroughly summarized in terms of basic personality dimensions. In general, personality traits are relatively stable patterns of thinking, mood, and behavior that indicate a tendency to act in a certain way when faced with certain situations (Zettler, et al., 2020).

Predicting students' performance can help identify the students who are at risk of failure and thus management can provide timely help and take essential steps to coach the student to improve his performance. Today academic success of students of any professional Institution has become the major issue for the management. An early prediction of students at risk of poor performance helps the management take timely action to improve their performance through extra coaching and counseling (Mishra, et al., 2014). Predictive modeling, profiling and segmentation, which are tools used for portfolio risk management and targeted marketing in the financial industry, are now utilized to monitor student's academic progress and to customize programs for student academic engagement (Ornelas, Ordenez, 2017).

The general field of educational data mining for predicting student success has drawn considerable attention from the research community. Education's primary aim has always been to boost student academic performance (Gundogan, Radulović: 2023). Many studies have been performed over the years by researchers and educators to assess the factors that affect (positively or negatively) student achievement in their academic track. Early prediction of student success in the correct manner would enhance both student retention and the assessment methods used by the students. This approach would also support educators and education officials by providing them with more knowledge about their students' learning abilities as well as how to better assist students who are falling behind in a given set (Viswanathan, Vengatesh, 2021).

Models of basic personality structure are among the most widely used frameworks in psychology and beyond, and have significantly advanced the understanding of individual differences in a host of consequential outcomes. Over the past decades, two such models have become most widely used: the Five Factor Model (FFM) or Big Five, respectively, and the HEXACO Model of Personality (Thielmann, et al., 2021). Since 2004, when the first version of the HEXACO model was published (Lee & Ashton, 2004), the number of studies using the HEXACO model has grown rapidly (de Vries, et al., 2019).

Literature review

In the last two decades of the 20th century, the Big Five model developed into a dominant theoretical and research paradigm when it comes to the structure of basic personality traits (Goldberg, 1990; John, Naumann, Soto, 2008; Costa,

McCrae, 2008, Mata et al., 2021). According to this model, personality is structured from five basic, mutually orthogonal traits: neuroticism, extraversion, openness, cooperation and conscientiousness. However, studies conducted in the late 1990s provided indications that a six-factor structure of latent dimensions should be examined. Probably the best-known operationalization of the revised lexical model of personality is the HEXACO structure (Ashton, Lee, 2007; Lee, Ashton, 2008; Ashton, Lee, De Vries, 2014; De Raad, et., al 2014; Anglim, et al., 2018), whose name is an acronym for the dimensions represented in it: H – Honesty/Humility, E – Emotionality, X – eXtraversion, A – Agreeableness, C – Conscientiousness and O – Openness.

The trait of honesty is characterized by qualities such as honesty, modesty and avoidance of greed as opposed to conceit and greed. People with a high level of this dimension are not prone to cheating and manipulation, nor are they motivated by material gain or social status. Conversely, individuals who are low on the honesty dimension tend to break the rules, are motivated by material gain, and have a strong sense of self-confidence (Camps, et al., 2016). Timidity, anxiety, dependence on others, and sentimentality versus fearlessness, independence, and unemotionality are the basic descriptions of the dimension of emotionality. Highly emotional people are more likely to experience fear and anxiety, and have a need for close relationships and for receiving emotional support. On the other hand, people with low emotionality have no worries or fears, even in stressful or dangerous situations, and they do not share their emotions with others (Pilch, 2023). The extraversion characteristics of this dimension are sociability, liveliness, social boldness and self-esteem as opposed to shyness and passivity. People with high extraversion feel positive in their own skin, enjoy company and interactions with people, and experience positive feelings of enthusiasm and energy. Conversely, people on the opposite side of the dimension feel uncomfortable in social situations, that is, they are more shy and passive in their relationships with others and are indifferent to social activities and feel less optimistic (Li, et al., 2022). Patience, gentleness, flexibility and forgiveness are associated with agreeableness. Gentle nature and tolerance is specific for individuals who have a high expression of agreeableness, as well as willingness to compromise and cooperate with others, and temper control. The opposite sex is characterized by a sudden temperament, irritability, criticality and a tendency to argue. The traits that define conscientiousness are diligence, organization, prudence, and perfectionism versus sloppiness, carelessness, irresponsibility, and laziness. Dedication to work, striving for perfection and caution when making decisions are characteristics of a person with a high degree of conscientiousness (Shu, et al., 2017; Anglim, O'conno, 2019). On the other hand, people with a low level of conscientiousness avoid difficult and demanding tasks, and make decisions impulsively or with little thought. The dimension of openness to experiences consists of curiosity, appreciation of aesthetics, creativity

and unconventionality as opposed to unimaginativeness and conventionality. Creativity, imagination, originality and intellectual curiosity and interest in unusual people and ideas are specific to people who have a high degree of openness to experiences. People with a low expression of this dimension are not intellectually curious, so they are not attracted to unconventional ideas (Hakimi, et al., 2011).

The concept of self-efficacy was constructed by Albert Bandura in the seventies of the 20th century. Bandura (1977) defined self-efficacy as an individual's belief about his own abilities to organize and perform certain activities that are essential in order to realize a set goal. Self-efficacy represents the subjective experience of personal competencies related to the achievement of various tasks (Miletić, 2022). According to this theory, self-efficacy increases with success, vicarious experience, verbal persuasion, and emotional arousal. It is important to emphasize that success is the most important of the mentioned factors. Success raises expectations of future success, and failure lowers those expectations. When a strong sense of self-efficacy is developed after repeated successes, occasional failures will have no significant impact (Kpolovie, et al., 2014; Sokić, et al., 2021).

The achievement motive is reflected in a person's need to achieve significant success in an activity and to excel in relation to other people. Murray (1938) defines the achievement motive as a complex need that manifests itself in the desire to achieve something that is difficult to achieve; to master things, people and ideas; to overcome obstacles and achieve something that is highly valued; to compete with others, to excel in front of others and to surpass others; to make a great effort to achieve something that is difficult. Therefore, the motive for achievement represents a complex motive consisting of several simple ones, among which the motive for fighting, the motive for dominance, the motive for prestige, self-actualization, the level of aspiration, etc. stand out. The achievement motive represents a person's constant attempts to compete with "standards of excellence" such as success, victory, overcoming existing results (other people's results, own, imagined).

Material and Method

Sample and research instruments

The research sample consisted of 269 respondents, of which 89 were male students and 180 female students, with an average age of 21.38 years (SD=2.17). Students from the Faculty of Sport, Faculty of Law, Security and Management in Niš, University of "UNION-Nikola Tesla", Faculty of Political Sciences of the University of Belgrade (majoring in communication), Faculty of Philosophy, University of Belgrade, and Faculty of Hotel Management and Tourism in

Vrnjačka Banja, University of Kragujevac were interviewed. The sample consisted of students attending the second (109 respondents), third (58) and fourth (102) years of study. Most of the respondents come from complete families (233), while 30 respondents live only with their mother (30), and 6 only with their father.

HEXACO basic personality traits were measured with the HEXACO-60 instrument (Ashton & Lee, 2009). That instrument, which is an operationalization of the HECACO model of personality structure, measures six broad personality domains: honesty, extraversion, emotionality, agreeableness, conscientiousness, and openness to experience. The HEXACO-60 questionnaire contains a total of 60 statements that measure those 6 domains (10 for each factor). Respondents on a scale of 1 to 5 (from do not agree at all to completely agree) express their degree of agreement with each of the 60 statements. Examples of items of measured dimensions are: for the dimension of honesty "I would never accept a bribe, even a very large one", for emotionality "Sometimes I can't help but worry about little things", for the dimension of extraversion "I prefer jobs that involve contact with people rather jobs where I would work alone", for pleasantness "I usually don't get angry with people, even those who hurt me badly", for the dimension of conscientiousness "I plan in advance and organize myself in order to avoid finishing something at the last minute" and end for openness "I like people who have unconventional views." The calculated reliabilities (Krombach's alpha coefficient) on the scale of this instrument are high (honesty $\alpha=0.81$; emotionality $\alpha=0.76$; extraversion $\alpha=0.80$; agreeableness $\alpha=0.64$; conscientiousness $\alpha=0.81$; openness $\alpha=0.73$).

The General Self-Efficacy Scale (GSE, Schwarzer, Jerusalem, 1995) questionnaire was used to examine self-efficacy. The questionnaire contains 10 items ("Even when I'm in trouble, I can usually think of a solution"). Respondents indicate their agreement with a certain statement on a four-point Likert-type scale. The coefficient of internal consistency is 86.

MOP 2002 (Franceško, Mihić and Bala, 2002) is intended to measure achievement motives. The instrument consists of 55 statements with five-point Likert-type answering scales. This instrument consists of four subscales that measure general achievement motive factors. These are, first of all, competition with others, a factor that is determined by statements that point to a person's tendency to stand out in front of others and be more successful than others (an example of the statement is: "Competition with others is the biggest incentive for me"). The second subscale is persistence in achieving goals, i.e. a factor determined by statements describing persistence (an example of a statement is: "At any cost, I must achieve success in the activities I am engaged in"). The third subscale is the achievement of goals as a source of satisfaction, which consists of statements related to the tendency to achieve goals, the fulfillment of which is perceived as a reward (an example of the statement is: "A successfully completed

job is the greatest reward for me"). The fourth subscale is orientation towards planning, and it is determined by statements that describe a person's tendency to plan activities in order to fulfill set goals (an example statement is: "I plan everything in advance in order to achieve better results"). In this paper, the internal consistency reliability for the scale as a whole is $\alpha=0.95$. The reliability of the subscale competition with others is $\alpha=0.92$, the subscale persistence in achieving goals $\alpha=0.89$, the subscale achievement of goals as a source of satisfaction $\alpha=0.87$ and the subscale orientation towards planning $\alpha=0.87$.

For the purposes of this research, a questionnaire was created that contained the following variables: gender, age, year of study, faculty the student attends, parents' education, work status (employed or unemployed) of the parents, completeness of the family in which the student grows up (whether the respondent lives only with one or both parents), satisfaction with academic achievement, the average in the last year of study as well as the overall average at the university. The research was conducted in November and December 2023. Respondents were informed about the purpose of the research, anonymity and the method of data use. Filling out the questionnaire took an average of 25 minutes. Statistical data processing was carried out using the IBM SPSS Statistics 21 program. Descriptive statistics (AS, SD), Pearson's correlation coefficient and multiple linear regression analysis were used in data processing.

Objectives of the Study

- 1) Examine the connection between HEXACO personality traits, self-efficacy and dimensions and the overall achievement motive on the one hand and the average in the last year of studies on the other hand
- 2) Examine the connection between HEXACO personality traits, self-efficacy and dimensions and the overall achievement motive on the one hand and the overall average at the university on the other hand
- 3) Examine the connection between HEXACO personality traits, self-efficacy and dimensions and the overall achievement motive on the one hand and satisfaction with academic achievement on the other hand
- 4) Examine the prediction of the average prediction in the last year of studies based on HEXACO personality traits, self-efficacy and achievement motive dimensions
- 5) Examine the prediction of the overall average at the university based on HEXACO personality traits, self-efficacy and achievement motive dimensions
- 6) Examine the prediction of academic achievement satisfaction based on HEXACO personality traits, self-efficacy and achievement motive dimensions.

Result and discussion

The paper first presents the results of descriptive statistics, then the correlations of the basic research variables (HEXACO personality traits, self-efficacy and dimensions and overall achievement motive) on the one hand and the average in the last year of study on the other hand for the entire sample. The established correlations of the basic research variables (HEXACO personality traits, self-efficacy and dimensions and overall achievement motive) on the one hand and the overall average at the faculty on the other hand are also shown. It is important to note that the mentioned correlations were obtained on a sample of third and fourth year students. Therefore, these correlations were not obtained in the sample of second-year students because they only have the average in the last year of study as an indicator of academic achievement. Then the correlations of basic variables and satisfaction with academic achievement are presented. The results of a linear regression analysis, which was carried out with the aim of predicting the average in the last year of studies based on HEXACO personality traits, self-efficacy and achievement motive dimensions, are presented for the entire sample. Then the results of the regression analysis are presented, in which the criterion is the overall average at the university and the HEXACO predictors are personality traits, self-efficacy and the dimensions of the achievement motive on a sample of third- and fourth-year students. Finally, the results of a linear regression analysis were presented, which was conducted with the aim of predicting satisfaction with academic achievement based on HEXACO personality traits, self-efficacy and achievement motive dimensions on the entire sample.

Table 1. Descriptive statistics of basic variables

	AS	SD
Honesty	3.64	.73
Extraversion	3.31	.77
Emotionality	3.23	.73
Pleasantness	3.11	.62
Conscientiousness	3.68	.73
Openness to experiences	3.65	.69
Self-efficacy	3.20	.55
Perseverance in achieving goals	3.83	.70
Competing with others	3.10	.82
Achieving goals as a source of satisfaction	4.17	.62
Orientation towards planning	3.45	.92

Overall achievement motive	3.60	.62
Satisfaction with academic achievement	3.97	.96
Average grade in the last year of study	8.30	.80
Overall average grade for previous studies	8.25	.75

Table 1 presents the determined correlations of the basic research variables (HEXACO personality traits, self-efficacy and dimensions and overall achievement motive) on the one hand and the average in the last year of studies on the other hand.

Table 2. Correlations of the basic research variables on the one hand and the average in the last year of studies on the other hand

	Average in the last year of study	
		P
Honesty	.201**	.001
Extraversion	.099	.104
Emotionality	-.009	.878
Pleasantness	.091	.135
Conscientiousness	.392**	.000
Openness to experiences	.112	.068
Self-efficacy	.249**	.000
Perseverance in achieving goals	.277**	.000
Competing with others	.126*	.040
Achieving goals as a source of satisfaction	.224**	.000
Orientation towards planning	.225**	.000
Overall achievement motive	.242**	.000

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Based on the results in Table 2, we observe statistically significant positive correlations of the traits of honesty and conscientiousness on the one hand and the average in the last year of studies on the other hand. The traits of extraversion, emotionality, agreeableness and openness to new experiences are not related to the average in the last year of study. Furthermore, there is a statistically significant positive correlation of self-efficacy and average in the last year of studies. Statistically significant positive correlations of all dimensions as well as

the overall motive of achievement on the one hand and the average in the last year of studies on the other hand were established.

Table 3. Correlations of the basic variables of the research on the one hand and the overall average on the studies on the other hand

	Total average during studying	P
Honesty	.187 ^{***}	.009
Extraversion	.047	.512
Emotionality	-.050	.487
Pleasantness	.075	.296
Conscientiousness	.410 ^{**}	.000
Openness to experiences	.005	.947
Self-efficacy	.289 ^{***}	.000
Perseverance in achieving goals	.276 ^{**}	.000
Competing with others	.201 ^{**}	.005
Achieving goals as a source of satisfaction	.218 ^{**}	.002
Orientation towards planning	.142 [*]	.049
Overall achievement motive	.256 ^{**}	.000

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Note: the correlations in Table 3 were obtained on a sample of third- and fourth-year students, given that the average in the last year of second-year students is the same as the total average in the studies.

The data in Table 3 indicate that statistically significant positive correlations were found between the traits of honesty and conscientiousness on the one hand and the overall average across the studies on the other hand. Furthermore, the traits of extraversion, emotionality, agreeableness and openness to new experiences are not related to the overall average in the studies. The results showed a statistically significant positive correlation of self-efficacy and the overall average in studies. Statistically significant positive correlations of all dimensions as well as the overall motive of achievement on the one hand and the overall average on the studies on the other hand were also determined.

Table 4. Correlations of basic research variables and satisfaction with academic achievement

	Satisfaction with academic achievement	
		P
Honesty	.345**	.000
Extraversion	.291**	.000
Emotionality	-.007	.904
Pleasantness	.066	.279
Conscientiousness	.369**	.000
Openness to experiences	.043	.480
Self-efficacy	.362**	.000
Perseverance in achieving goals	.413**	.000
Competing with others	.118*	.050
Achieving goals as a source of satisfaction	.377**	.000
Orientation towards planning	.227**	.000
Overall achievement motive	.317**	.000

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

The results showed statistically significant positive correlations of the traits of honesty, extraversion and conscientiousness on the one hand and satisfaction with academic achievement on the other. The traits of emotionality, agreeableness, and openness to new experiences are not related to satisfaction with academic achievement. Furthermore, there is a statistically significant positive correlation of self-efficacy and satisfaction with academic achievement. Statistically significant positive correlations of all dimensions as well as the overall motive of achievement on the one hand and satisfaction with academic achievement on the other hand were established.

In the continuation of this paper, the results of three regression analyzes are presented. First, a multiple regression analysis was presented, which was carried out with the aim of predicting the average in the last year of studies based on a set of predictors of personality traits, self-efficacy and achievement motive dimensions on the entire sample. Then the results of the prediction of the overall average at the university based on a set of predictors (HEXACO personality traits, self-efficacy and achievement motive dimensions) were presented. It is important to note that the second regression analysis was performed on a sample of third- and fourth-year students. This analysis did not include second-year students because they only had the average in the last year of study as an indicator of academic achievement. And finally, the results of the third linear regression analysis, which was carried out with the aim of predicting satisfaction with academic achievement based on HEXACO personality traits, self-efficacy and dimensions of achievement motives on the entire sample, are presented.

Table 5. Prediction of the average in the last year of studies based on a set of predictors of personality traits, self-efficacy and achievement motive dimensions

Prediction of the average in the last year of study	B	T	Sig.
Honesty	.087	1.199	.231
Extraversion	-.112	-1.517	.131
Emotionality	.036	.570	.569
Pleasantness	.116	1.885	.061
Conscientiousness	.342	3.688	.000
Openness to experiences	.078	1.339	.182
Self-efficacy	.168	1.865	.063
Perseverance in achieving goals	.010	.077	.938
Competing with others	.081	1.007	.315
Achieving goals as a source of satisfaction	-.093	-.862	.390
Orientation towards planning	.006	.076	.940

The multiple correlation coefficient ($R = 0.445$) is statistically significant ($F(11) = 5.713$; $Sig = .000$). It was found that 19% of the variability ($R^2 = 0.198$) of the average in the last year of studies can be explained on the basis of a set of predictors of personality traits, self-efficacy and achievement motive dimensions. The results showed that the only statistically significant predictor of the average in the last year of studies is conscientiousness. Other predictors are not statistically significant.

Table 6. Prediction of the overall average in the studies based on a set of predictors of personality traits, self-efficacy and achievement motive dimensions

Prediction of the overall average in the studies	B	T	Sig.
Honesty	.052	.616	.539
Extraversion	-.225	-2.541	.012
Emotionality	.059	.813	.417
Pleasantness	.164	2.331	.021
Conscientiousness	.483	4.408	.000
Openness to experiences	-.038	-.575	.566
Self-efficacy	.250	2.296	.023
Perseverance in achieving goals	.048	.320	.749
Competing with others	.196	2.058	.041
Achieving goals as a source of satisfaction.	-.191	-1.460	.146
Orientation towards planning	-.179	-1.827	.069

Note: the correlations in Table 3 were obtained on a sample of third- and fourth-year students, given that the average in the last year of second-year students is the same as the overall average in the studies

The results showed that the coefficient of multiple correlation ($R = .514$) is statistically significant ($F(11) = 5.910$; $Sig = 0.000$). Of the total variability of the criteria, 26% of the variability ($R^2 = 0.26$) can be explained on the basis of a set of predictors of personality traits, self-efficacy and achievement motive dimensions. By looking at the partial standardized regression coefficients, it is concluded that extraversion, agreeableness, conscientiousness, self-efficacy and competition with others have a statistically significant partial contribution to the explanation of individual differences in the overall average of the studies. Other predictors are not statistically significant.

Table 7. Prediction of satisfaction with academic success based on a set of predictors of personality traits, self-efficacy and achievement motive dimensions

Prediction of satisfaction with academic success	B	T	Sig.
Honesty	.297	4.382	.000
Extraversion	.120	1.725	.086
Emotionality	.044	.734	.464
Pleasantness	.008	.145	.885
Conscientiousness	.072	.828	.408
Openness to experiences	-.048	-.864	.389
Self-efficacy	.208	2.455	.015
Perseverance in achieving goals	-.004	-.034	.973
Competing with others	-.040	-.535	.593
Achieving goals as a source of satisfaction	.175	1.736	.084
Orientation towards planning	-.026	-.325	.746

The multiple correlation coefficient ($R = 0.541$) is statistically significant ($F(11) = 9.617$; $Sig = .000$). It was found that 26% of the variability ($R^2 = 0.263$) of satisfaction with academic success can be explained based on a set of predictors of personality traits, self-efficacy and achievement motive dimensions. The results showed that honesty and self-efficacy are statistically significant predictors of satisfaction with academic success. Other predictors are not statistically significant.

The obtained findings are significant, not only for researchers in order to better understand the academic achievement of students, but also for psychologists, pedagogues, professors, and students themselves. The research

results show that personality traits, achievement motive and self-efficacy are significant predictors of academic achievement, which suggests that they must be taken into account when creating interventions to increase academic success. It is important that psychologists, pedagogues and professors in their work with students get to know their characteristics, beliefs and motives and based on that develop ways and strategies to increase academic achievement. This study provided a better understanding of the personality traits, beliefs, and motives of students that contribute to academic achievement.

Conclusion

In this paper, statistically significant positive correlations of the traits of honesty and conscientiousness on the one hand and indicators of academic success on the other hand were established. The correlation between the trait of conscientiousness and academic success has been consistently shown in numerous studies (Conard, 2006, Wan, Liu, Wang, Wang, 2023; John, John, Zia-ur-Rehman Rao, 2020). Students who have a pronounced trait of conscientiousness are characterized by self-control, discipline, and effort in achieving goals. Such students put a lot of effort into learning, which results in greater confidence in their own abilities and greater success. On the other hand, students with lower conscientiousness are to a greater extent irresponsible, unscrupulous, lazy and do not invest continuous effort in their development, do not believe in their competence and do not have high self-confidence and achieve lower academic success. Furthermore, the results showed statistically significant correlations between honesty and indicators of academic performance. Students with a more pronounced dimension of honesty are fairer and more virtuous as well as more academically successful. In contrast, students who tend to break the rules, are greedy, and are motivated solely by material gain have less achievement in college. Furthermore, the traits of extraversion, emotionality, agreeableness, and openness to new experiences are not related to indicators of academic success.

There is a statistically significant positive correlation of self-efficacy and indicators of academic success. Students with higher self-efficacy are more persistent in learning and achieving goals, invest more effort and work in fulfilling their obligations, and also have less violent emotional reactions when faced with difficulties. On the other hand, students who do not believe in their competence and efficiency may avoid putting in effort or experiencing discomfort in case of failure. Therefore, students with lower self-efficacy, in situations where they face difficulties, reduce their efforts and give up quickly, which reflects on their success. These results are consistent with previous research (Honicke, Broadbent, Fuller-Tyszkiewicz, 2023; Hayat, Shateri, Amini, Shokrpour, 2020).

Statistically significant positive correlations of all dimensions as well as the overall achievement motive on the one hand and academic success indicators on the other were established. Students who are persistent in achieving their goals and want to stand out in front of others have higher academic success. Also, students who plan their activities to achieve goals and feel satisfaction when they achieve them have higher academic achievement. On the other hand, students with a low achievement motive, are not persistent in achieving their goals, do not find satisfaction in their fulfillment, and have little academic achievement. It is the same with students who do not plan to fulfill their obligations at the university and do not try to stand out in front of others; they have lower academic performance.

This research also determined the correlations of basic variables and satisfaction with academic achievement. The results showed statistically significant positive correlations of the traits of honesty, extraversion and conscientiousness on the one hand and satisfaction with academic achievement on the other. Research (Lievens, Ones, Dilchert, 2009) established the connection between extraversion and conscientiousness on the one hand and academic achievement on the other. Students who are more social, optimistic and have higher self-esteem achieve higher academic success. Conversely, students who are more pessimistic, shy and passive in their relationships with others have lower academic achievement. Furthermore, the traits of emotionality, agreeableness, and openness to new experiences were not related to satisfaction with academic achievement. Also, there is a statistically significant positive correlation of self-efficacy and satisfaction with academic achievement. Statistically significant positive correlations of all dimensions as well as the overall motive of achievement on the one hand and satisfaction with academic achievement on the other hand were established.

Three regression analyzes were conducted with the aim of predicting academic success based on HEXACO personality traits, self-efficacy and achievement motive dimensions. In the first, the results showed that 19% of the variability of the average in the last year of studies can be explained on the basis of a set of predictors of personality traits, self-efficacy and achievement motive dimensions. Conscientiousness is the only statistically significant predictor of average in the last year of study. Other predictors are not statistically significant. In the second, an insight into the partial standardized regression coefficients concludes that extraversion, agreeableness, conscientiousness, self-efficacy and competition with others have a statistically significant partial contribution to the explanation of individual differences in the overall average of the studies. Other predictors are not statistically significant. And finally, the third linear regression analysis showed that 26% of the variability of satisfaction with academic success can be explained based on a set of predictors of personality traits, self-efficacy and achievement motive dimensions. Honesty and self-efficacy were found to be statistically significant predictors of satisfaction with academic success.

Recommendations and limitations of this study

One of the shortcomings in the interpretation of research results is the number of respondents. Next, the study sample was convenient because it consisted of students who attend lectures consistently, who are assumed to have more significant academic achievement than those who do not attend classes regularly. Further limitations arise from the sole reliance on self-report. More reliable data on academic performance would be obtained from student services. Analysis of the results of this study allows suggesting future directions of similar research. For example, future research should include a larger number of students from multiple faculties. In the context of predicting academic success, it would be more adequate to use the academic self-efficacy questionnaire, which is intended exclusively for students. Further research in this area could include variables such as intelligence, self-confidence, resilience, academic motivation, anxiety, stress coping strategies, etc. as predictors

References

1. Ashton, M. C. & Lee, K. (2007). Empirical, theoretical, and practical advantages of the HEXACO model of personality structure. *Personality and Social Psychology Review*, 11 (2), 150–166. <https://doi.org/10.1177/1088868306294907>
2. Ashton, M., & Lee, K. (2009). The HEXACO – 60: A Short Measure of the Major Dimensions of Personality. *Journal of Personality Assessment*, 91(4), 340–345. DOI: [10.1080/00223890902935878](https://doi.org/10.1080/00223890902935878)
3. Ashton, M., Lee, K., & De Vries, R. (2014). The HEXACO Honesty-Humility, Agreeableness, and Emotionality Factors: A Review of Research and Theory, *Personality and Social Psychology Review*, 18(2) 139–152. DOI: [10.1177/1088868314523838](https://doi.org/10.1177/1088868314523838)
4. Anglim, J., Lievens, F., Everton, L., Grant, S. L., & Marty, A. (2018). HEXACO personality predicts counterproductive work behavior and organizational citizenship behavior in low- stakes and job applicant contexts. *Journal of Research in Personality*, 77, 11–20. <https://doi.org/10.1016/j.jrp.2018.09.003>
5. Anglim, J. & O’conno, P. (2019) Measurement and research using the Big Five, HEXACO, and narrow traits: A primer for researchers and practitioners. *Australian Journal of Psychology*, Volume 71, - Issue 1. <https://doi.org/10.1111/ajpy.12202>
6. Bandura, A. (1977). Self – efficacy; Toward a unifying theory of behavioral change. *Psychological Review*, 84, 191-215.
7. Bandura, A. (1997). *Self-Efficacy: The Exercise of Control*. New York: Freeman.

8. Costa, P. T. & McCrae, R. R. (2008). *The revised neo personality inventory (NEOPI- R)*. In: G. J. Boyle., G. Matthews, D. H. Saklofske (Eds.), *The SAGE handbook of personality theory and assessment. Personality measurement and testing* (179– 198). Thousand Oaks, CA: Sage.
9. Camps, J., Stouten, J., & Euwema, M. (2016). The relation between supervisors' big five personality traits and employees' experiences of abusive supervision. *Front. Psychol.* 7:112. doi: [10.3389/fpsyg.2016.00112](https://doi.org/10.3389/fpsyg.2016.00112)
10. de Vries, R. E., Ashton, M. C. & Lee, K. (2019) New Developments in HEXACO Personality Research. *Zeitschrift für Psychologie*, 227(3), 163–165. <https://doi.org/10.1027/2151-2604/a000374>
11. de Raad, B., Barelds, D., Timmerman, M. E., De Roover, K., Mlačić, B., & Church, A.T. (2014) Towards A Pan–Cultural Personality Structure: Input from 11 Psycholexical Studies. *European Journal of Personality*. Volume 28, Issue 5. <https://doi.org/10.1002/per.1953>
12. Franceško, M., Mihić, V. & Bala, G. (2002). Struktura motiva postignuća merena skalom MOP2002. Novi Sad: Zbornik Odseka za psihologiju Filozofskog fakulteta u Novom Sadu, str. 134–143.
13. Goldberg, A. (2005). *Sports slump busting: 10 steps to mental toughness and peak performance*. Coral Springs, FL: Llumina Press.
14. Gundogan, D., Radulović, M. (2023) A relation between high-school students' achievement and their socio-economic status in post-yugoslav countries and western europe. *Sociologija*, Vol. LXV, N° 4, 610-624, DOI: <https://doi.org/10.2298/SOC2304610G>
15. Hakimi, S., Hejazi, E., & Lavasani, M. G. (2011). The relationships between personality traits and students' academic achievement. *Procedia Soc. Behav. Sci.* 29, 836–845. doi: [10.1016/j.sbspro.2011.11.312](https://doi.org/10.1016/j.sbspro.2011.11.312)
16. John, O. P., Naumann, L. P., & Soto, C. J. (2008). Paradigm shift to the integrative Big Five trait taxonomy: History, measurement, and conceptual issues. In: O. P. John, R. W. Robins, L. A. Pervin (Eds.), *Handbook of personality: Theory and research* (114–158). New York City: The Guilford Press.
17. Kpolovie, P.J., Joe, A.I., & Okoto T. (2014) Academic Achievement Prediction: Role of Interest in Learning and Attitude towards School. *International Journal of Humanities Social Sciences and Education (IJHSSE)* Volume 1, Issue 11, 73-100. <https://www.arcjournals.org/pdfs/ijhsse/v1-i11/10.pdf>
18. Lee, K. & Ashton, M. C. (2008). The HEXACO personality factors in the indigenous personality lexicons of English and 11 other languages. *Journal of Personality*, 76 (5), 1001–1054. DOI: [10.1111/j.1467-6494.2008.00512.x](https://doi.org/10.1111/j.1467-6494.2008.00512.x)
19. Li G, Wu Y, Wen H, Zhang F, Yan D., (2022) Influence of Intellectual-cultural Orientation as Family Culture on Chinese College Students' Subjective Well-being: A Moderation Model. *INQUIRY: The Journal of*

- Health Care Organization, Provision, and Financing* Volume 59: 1–9. doi:[10.1177/00469580221103924](https://doi.org/10.1177/00469580221103924)
20. Mishra, T., Kumar, D. and Gupta, S. (2014) Mining Students' Data for Prediction Performance, *2014 Fourth International Conference on Advanced Computing & Communication Technologies*, Rohtak, India, pp. 255-262, doi: [10.1109/ACCT.2014.105](https://doi.org/10.1109/ACCT.2014.105).
 21. Murray, H.A. (1938). *Explorations in personality*. New York: Oxford Univ. Press.
 22. Miletić, S., & Radić, S. (2022). Evolucija prakse upravljanja dobitkom - nova pretnja kvalitetu finansijskih izveštaja. *Oditor*, 8(3), 117-142. <https://doi.org/10.5937/Oditor2203117M>
 23. Mata, M. N., Anees, S. S. T., Martins, J. M., Haider, S. A., Jabeen, S., Correia, A. B., et al. (2021). Impact of non-monetary factors on retention of higher education institutes teachers through mediating role of motivation. *Acad. Strateg. Manag. J.* 20, 1–17.
 24. Ornelas, F., & Ordonez, C. (2017) Predicting Student Success: A Naïve Bayesian Application to Community College Data. *Tech Know Learn* 22, 299–315. DOI: [10.1007/s10758-017-9334-z](https://doi.org/10.1007/s10758-017-9334-z)
 25. Pilch, I. (2023) Comparison of the Big Five and the HEXACO Models of Personality in the Prediction of Emotional Wellbeing: an Experience Sampling Study. *Trends in Psychology*, Springer, <https://doi.org/10.1007/s43076-023-00311-w>
 26. Schwarzer, R., & Jerusalem, M. (1995). *General Self-Efficacy Scale (GSE)*, APA PsycTests. <https://doi.org/10.1037/t00393-000>
 27. Sokić, K., Qureshi, F. H. & Khawaja, S. (2021) Predicting Academic Procrastination and Academic Achievement in Private Higher Education With the HEXACO Model of Personality and Psychological Distress. *International Research in Higher Education* Vol. 6, No. 4. , 29-39. <https://doi.org/10.5430/irhe.v6n4p29>
 28. Shu, F., McAbee, S.T., & Ayman, A. (2017) The HEXACO personality traits, cultural intelligence, and international student adjustment. *Personality and Individual Differences*. Volume 106, Pages 21-25. <https://doi.org/10.1016/j.paid.2016.10.024>
 29. Thielmann, I., Moshagen, M., Hilbig, B.E. & Zettler, I. (2021) On the Comparability of Basic Personality Models: Meta-Analytic Correspondence, Scope, and Orthogonality of the Big Five and HEXACO Dimensions. *European Journal of Personality*. DOI: [10.1177/08902070211026793](https://doi.org/10.1177/08902070211026793)
 30. Viswanathan, S., & Vengatesh K. S. (2021) Study Of Students' Performance Prediction Models Using Machine Learning *Turkish Journal of Computer and Mathematics Education* Vol.12 No.2 (2021), 3085 – 3091.

<https://www.proquest.com/docview/2624698995?sourcetype=Scholarly%20Journals>

31. Zettler, I., Thielmann, I., Hilbig, B.E., & Moshagen, M. (2020) The Nomological Net of the HEXACO Model of Personality: A Large-Scale Meta-Analytic Investigation. *Perspectives on Psychological Science*, Vol. 15(3) 723–760. DOI: [10.1177/1745691619895036](https://doi.org/10.1177/1745691619895036)
32. Conard, M. (2006). Aptitude is not enough: how personality and behavior predict academic performance. *Journal of research in personality*, 40, 339-346. <https://doi.org/10.1016/j.jrp.2004.10.003>
33. Honicke, T., Broadbent, J., & Fuller-Tyszkiewicz, M. (2023). The self-efficacy and academic performance reciprocal relationship: the influence of task difficulty and baseline achievement on learner trajectory, *Higher Education Research & Development*, 42:8, 1936-1953, DOI: [10.1080/07294360.2023.2197194](https://doi.org/10.1080/07294360.2023.2197194)
34. Hayat, A., Shateri, K., Amini, M., & Shokrpour, N. (2020). Relationships between academic self-efficacy, learning-related emotions, and metacognitive learning strategies with academic performance in medical students: a structural equation model, *BMC Medical Education*, 20, <https://doi.org/10.1186/s12909-020-01995-9>
35. Wang H, Liu Y, Wang Z, & Wang T. (2023). The influences of the Big Five personality traits on academic achievements: Chain mediating effect based on major identity and self-efficacy. *Front Psychol.*, doi: [10.3389/fpsyg.2023.1065554](https://doi.org/10.3389/fpsyg.2023.1065554).
36. John, R., John, R., & Zia-ur-Rehman Rao, Z. (2020). The Big Five Personality Traits And Academic Performance, *Journal of Law & Social Studies*. 2 (1), 10-19, [Doi.org/10.52279/jlss.02.01.1019](https://doi.org/10.52279/jlss.02.01.1019)

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REVIZIJA FINANSIJSKIH IZVEŠTAJA U SRBIJI: DA LI POSTOJI RODNA RAVNOPRAVNOST U PROFESIJI?

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Apstrakt

Cilj ovog rada je da se ispita položaj žena u revizorskoj profesiji u Srbiji. Uzorak istraživanja obuhvata 2.116 revizorskih izveštaja koji je analiziran sa stanovišta angažovanog revizorskog društva i roda potpisnika revizorskog izveštaja. Rezultati pokazuju da je broj revizorskih izveštaja koje izdaju revizori muškog i ženskog roda skoro jednak, sa primetnim trendovima u korist angažovanja ženskih revizora u revizorskim društvima koje pripadaju Velikoj četvorci. Takođe, rezultati ukazuju da postoji skoro ista verovatnoća za sticanje novih klijenata kod revizora muškog i ženskog roda, sa naglaskom da revizori muškog roda imaju blagu prednost u celini, uključujući i domaća revizorska društva. Međutim, ova prednost se pomera na revizore ženskog roda kada su u pitanju društva iz grupe Velike četvorke (Big 4). Rezultati Pearson-ove korelacije pokazuju slabu, ali statistički značajnu i pozitivnu vezu između roda revizora i viših prosečnih naknada za reviziju, što ukazuje na potencijalnu percepciju povećane vrednosti povezane sa revizorima ženskog roda.

Ključne reči: revizorski izveštaj, rodna ravnopravnost, revizija, revizori ženskog pola.

JEL: M40, M42

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Uvod

Industrijska revolucija, urbanizacija gradova, razvoj potrošačkog društva, ubrzani ekonomski rast i pojava globalizacije samo su neke od promena koje karakterišu savremeno društvo. Dakle, modernizacija postavlja pitanje transformacije društvenih odnosa (rodne razlike, stvaranje novih društvenih klasa, saradnja itd.). U slučaju tranzicionih društava, gde dolazi do prelaska iz jednog društvenog sistema u drugi, takve promene dovode do stvaranja mogućnosti za razvoj odgovornih i slobodnih pojedinaca koji teže da se prilagode savremenim trendovima (Antonijevic et al., 2022; Pavicevic, 2012). Dok su ranija verovanja osobe ženskog roda povezivala isključivo sa brigom o domaćinstvu i porodici, vremenom su se njihov položaj i uloga značajno promenili (Pruett, 2023). Postepeno uključivanje osoba ženskog roda u društvene, ekonomske i političke sfere vodi unapređenju, podsticanju i postizanju rodne ravnopravnosti, kao i širenju uticaja i njihove aktivnosti van granica porodičnog doma (Curakovic 2023; Dobrijevic, 2014). *Harvard Business Review* naglašava da privredna društva sa rodnom raznolikošću imaju tendenciju da budu produktivnija od ostalih društava, na šta ukazuju tržišna vrednost i prihod (Turban et al., 2019). Takva radna snaga prihvata raznolikost i ističe se u privlačenju vrhunskih talenata, podsticanju inovacija i ulivanju poverenja investitorima.

Kada je reč o računovodstvu i reviziji kao profesiji, prema izveštaju koji je sačinila Međunarodna federacija računovođa (*International Federation of Accountants* - IFAC) 2020. godine, osobe ženskog roda su bile zastupljene sa 46% na globalnom nivou. U istoj godini, po prvi put od osnivanja IFAC-a, federacija je imala odbor u kojem su osobe ženskog roda bile u većini, sa 52% (Churikova, 2020). Prema izveštaju „*Trends in the Supply of Accounting Graduates and Demand for Public Accounting Recruits*“ Američkog instituta ovlašćenih javnih računovođa (engl. *American Institute of Certified Public Accountants* – AICPA) iz 2021. godine, oko 55% od ukupnog broja novih diplomiranih računovođa je bilo ženskog roda u periodu 2019-2020. godine (AICPA, 2022). Kada je reč o Sjedinjenim Američkim Državama, broj revizora ženskog roda konstantno raste, pri čemu je procenat porastao sa 23.5% u 1993. godini na 58.8% u 2022. godini.

Brasnjić & Sevo (2019) navode da u regionu Balkana i dalje postoji dominantna uloga osoba muškog roda, ali se pod uticajem evropskih i svetskih trendova i dalje može uočiti napredak u domenu učešća osoba ženskog roda u različitim oblastima (posebno u smislu povećanja njihovog učešća na najvišim političkim pozicijama). Kada je reč o Republici Srbiji, primetno je da su uloženi određeni naponi da se razvije pravni i institucionalni okvir koji ima za cilj unapređenje položaja osoba ženskog roda u društvu i unapređenje rodne ravnopravnosti uopšte. Navedeno potvrđuje i usvajanje Zakona o zabrani diskriminacije, Zakona o rodnoj ravnopravnosti, Nacionalne strategije za rodnu ravnopravnost za period 2021-

2030 (Official Gazette of RS No. 12, 2022), zajedno sa pratećim akcionim planovima i drugo.

Ostaje pitanje koliko su ovi mehanizmi doprineli podizanju svesti i edukaciji o ekonomskoj i rodnoj ravnopravnosti. Ovo potkrepljuje istraživanje koje je sproveo Hughson & Bacanovic (2014), upravo u oblasti ekonomije uočavaju se najznačajnije razlike između rodova u pogledu njihovih pozicija. Isti autori ističu značaj preduzimanja akcija ka ekonomskom osnaživanju osoba ženskog roda, posebno u smislu promovisanja ženskog preduzetništva, povećanja stope zaposlenosti, smanjenja stope siromaštva među osobama ženskog roda i sličnih napora.

Doprinos ovog rada ogleda se u pružanju odgovora na nekoliko istraživačkih pitanja:

- Da li isti broj revizorskih izveštaja potpisuju revizori muškog i ženskog roda?
- Da li postoje razlike u prosečnim naknadama za pružene usluge na nivou revizorskog društva kada je reč o potpisnicima izveštaja na osnovu roda?
- Da li postoji korelacija između roda potpisnika revizorskih izveštaja i udela vlasnika ženskog roda u revizorskim društvima?
- Da li je pol potpisnika revizorskog izveštaja povezan sa tipom revizorskog društva (Velika četvorka, međunarodna i domaća revizorska društva)?

Strukturu preostalog dela rada čine tri dela. Naredni deo obuhvata pregled literature, koji će predstaviti aktuelne trendove u ovoj oblasti i istaći dosadašnja dostignuća autora na ovu temu. Nakon pregleda literature, uslediće objašnjenje korišćene metodologije istraživanja, opis uzorka istraživanja i prezentacija dobijenih rezultata sa propratnom diskusijom. Na kraju, poslednji deo rada posvećen je završnim napomenama i preporukama za dalja istraživanja.

Pregled literature

Iako se razlika u zaradama između rodova smanjila poslednjih decenija, to i dalje predstavlja problem. U svim oblastima rada i u većini delatnosti, osobe ženskog roda su znatno manje plaćene od osoba muškog roda (Garcia-Blandon i ostali, 2020). Prema istraživanju Blau & Kahna (2017), prosečna sedmična zarada osoba ženskog roda iznosila je 82% prosečne sedmične zarade osoba muškog roda u 2014. godini, što je manje u poređenju sa 61% koliko je iznosila 1965. godine. Kada je reč o Srbiji, Reva (2012) ističe da postoje značajne rodne razlike u prosečnim zaradama kada se izvrši poređenje prema različitim poslovnim karijerama i industrijama.

Naročito na nivou revizorskih partnera, osobe ženskog roda su i dalje nedovoljno zastupljene u poslovima revizije finansijskih izveštaja (Hardies et al., 2013). Prethodno istraživanje je pokazalo da su od 1.039 registrovanih revizora u 2008. godini, samo 21,4% bili revizori ženskog roda. Takođe, od ukupnog broja

posmatranih revizora, 646 revizora je bilo angažovano na najmanje jednom revizorskom angažmanu, pri čemu su samo 81 revizorski angažman obavljali revizori ženskog roda (12,5%). Dodatno, u poređenju sa revizorskim društvima drugog reda (22%) i malim revizorskim društvima (19,6%), Velika četvorka je angažovala relativno više registrovanih revizora ženskog roda (23,5%).

Abdelfattah et al. (2019) ističu razlike u ponašanju između rodova revizorskih partnera. Rezultati istraživanja ukazuju da će zapošljavanje revizora ženskog roda verovatno povećati količinu informacija u pasusima vezano za skretanje pažnje ili osnovama formiranog revizorskog mišljenja (engl. *KAM - Key Audit Matters*). Rezultati su zasnovani na uzorku britanskih društava između 2013. i 2017. godine. Ipak, autori tvrde da su osobe ženskog roda nedovoljno zastupljene na rukovodećim pozicijama, budući da je prosečan procenat partnera ženskog roda u revizorskim društvima bio oko 20% od 2013. do 2022. godine (Statista, 2023).

Prema Ittonen & Peni (2012), rod revizora angažovanog na reviziji može imati uticaj na visinu revizorskih naknada za izvršene usluge. Istraživanje je obuhvatilo izveštajni period 2005-2006. godine, sa podacima društava koje su navedene na NASDAK OMX berzi u Švedskoj, Finskoj i Danskoj. Raspodela rodova među revizorskim partnerima otkriva neke zanimljive rezultate. Od ukupno 715 posmatranih društava tokom dve godine, angažmani sa revizorima ženskog roda iznosili su samo 16 (4,80%) u 2005. godini i 18 (4,71%) u 2006. godini. Istraživanje je dodatno otkrilo da veća revizorska društva pokazuju izraženiji uticaj roda na visinu naknade za pružene usluge revizije. Konačno, pokazalo se da uslugu revizije koje su obavile osobe ženskog roda, imaju znatno veće naknade za izvršene usluge. Sličan zaključak dali su autori Miglani & Ahmed (2019), u istraživanju sprovedenom na 200 indijskih društava koje je obuhvatilo period 2011-2014. godine.

U studiji koje su sproveli Hardies et al. (2015), istraženo je da li revizori ženskog roda primaju veće naknade za izvršene revizorske usluge. Prethodno pomenuti autori sproveli su istraživanje na uzorku od 57.723 opservacija belgijskih društava koja su revidirala 93 revizora ženskog i 599 revizora muškog pola u periodu od 2008. do 2011. godine. Rezultati ukazuju da klijenti revizije plaćaju za približno 7% veću naknadu za pružene usluge revizorima ženskog roda. Nasuprot tome, Ting-Chiao Huang et al. (2015) bavili su se istraživanjem da li revizori ženskog roda primaju niže naknade za usluge revizije na uzorku tajvanskih javnih društava. Rezultati istraživanja su pokazali da, tokom posmatranog perioda, postoji diskriminacija revizora ženskog roda na Tajvanu kao i statistički značajna korelacija između revizora ženskog roda i naknade za usluge revizije.

Koristeći revizorske izveštaje 624 australijska društva u 2011. godini, Aldamen et al. (2016) su testirali korelaciju između prisustva osoba ženskog roda u odboru za reviziju i naknada za uslugu revizije. Rezultati istraživanja su pokazala da 96 (15,4%) od 624 uzrokovanih društava ima barem jednog revizora ženskog roda.

Takođe, njihovo istraživanje je pokazalo da su društva sa osobama ženskog roda u odboru za reviziju bile veće, imale su revizora iz Velike četvorke i bile su uspešnije od društava sa isključivo članovima muškog roda. Kao što je primećeno, naknade za uslugu revizije su bile značajno više za veća društva, a pored toga, procenat revizora ženskog roda je bio povezan sa veličinom društva i prisustvom revizora iz Velike četvorke.

U sličnom istraživanju, Sellami & Cherif (2020) ističu pozitivan odnos između zastupljenosti ženskog roda u revizorskom odboru i naknada za reviziju. Istraživanje je bilo usmereno na period od 2013. do 2017. godine, obuhvatajući 790 švedskih javnih društava. Rezultati istraživanja su pokazali da više naknade za reviziju nisu u potpunosti uzrokovane prisustvom direktora ženskog roda, kada se u obzir uzmu demografske karakteristike žena. Rezultati istraživanja ističu značaj stručnosti direktora ženskog roda u revizorskom odboru, što posledično dovodi do povećanja naknada za reviziju. Autori ističu da izbor direktora ženskog roda u odborima privrednih društava trebalo bi da se zasniva na kvalifikacijama koje su potrebne za dati posao.

Ukratko, pregled literature naglašava postojanje jaza u zaradama i nedovoljnu zastupljenost ženskog roda na rukovodećim pozicijama u revizorskim društvima. Posmatrana istraživanja, obuhvatajući različite države i vremenske periode, dosledno ističu niži procenat revizora i partnera ženskog roda, sa posebnim osvrtom na velika revizorska društva (uključujući Veliku četvorku). Takođe, autori potvrđuju uticaj roda na naknade za reviziju, otkrivajući mešovite rezultate u vezi sa tim da li revizori ženskog roda dobijaju više ili niže naknade, pri čemu neka istraživanja sugerisu na diskriminaciju revizora ženskog roda u određenim regionima, što može biti posledica razlika u kulturi.

Metodologija istraživanja

U cilju davanja odgovora na postavljena istraživačka pitanja, sprovedeno je istraživanje. Uzorak istraživanja obuhvata 2.116 revizorskih izveštaja srednjih i velikih nasumično odabranih privrednih subjekata registrovanih u Republici Srbiji. Period istraživanja obuhvata izveštajni period 2020. godine. Svi revizorski izveštaji preuzeti su sa zvaničnog sajta Agencije za privredne registre (APR) Republike Srbije. Rodna struktura zaposlenih licenciranih ovlašćenih revizora, kao i svi ostali pojedinačni podaci prikupljeni su sa zvaničnog sajta Komore ovlašćenih revizora (KOR) zaključno sa 31.12.2020. godine. Prosečna naknada za pružene usluge po revizorskom društvu izračunata je na osnovu informacija obelodanjenih u Izveštajima o transparentnosti za 2020. godinu, koja su javno objavila revizorska društva koja su izvršila reviziju finansijskih izveštaja javnih subjekata. Neki od izveštaja su prikupljeni sa sajta KOR-a, dok su drugi pronađeni na zvaničnim internet stranicama revizorskih društava (prema Zakonu o reviziji, revizorska društva imaju obavezu da objave izveštaje o transparentnosti u roku od

4 meseca nakon posmatranog perioda, bilo na sajtu KOR-a ili sopstvenom). U istraživanju su posmatrane sledeće varijable:

- Rod revizora – spisak svih licenciranih ovlašćenih revizora preuzet je sa zvanične internet stranice KOR-a, kao i informacije o njihovom rodu i revizorskom društvu u kom su angažovani.
- Angažovan revizor – broj angažovanja revizora ženskog roda (prema potpisu iz revizorskog izveštaja).
- Vrsta revizorskog društva – spisak svih registrovanih revizorskih društava preuzet sa zvanične internet stranice KOR-a i podeljen na tri grupe: Velika četvorka (engl. *Big 4*), međunarodna (ukoliko pripadaju međunarodnoj mreži) i domaća (ukoliko ne pripadaju).
- Vlasnik revizorskog društva – posmatrano po revizorskom društvu i označeno sa 0 ako je vlasnik fizičko lice (ženskog ili muškog roda) ili 1 ukoliko je vlasnik pravno lice (uglavnom drugo revizorsko društvo, međunarodno ili domaće). Podaci su preuzeti sa zvanične internet stranice KOR-a za svako revizorsko društvo pojedinačno.
- Učešće vlasnika ženskog roda – učešće osoba ženskog roda u vlasništvu revizorskog društva (vlasnici revizorskih društava podeljeni su u tri grupe: osobe muškog roda, osobe ženskog roda i pravna lica). Podaci su preuzeti sa zvanične internet stranice KOR-a za svako revizorsko društvo pojedinačno.
- Učešće revizora ženskog roda – broj revizora ženskog roda i njihovo učešće u ukupnom broju zaposlenih revizora za sva registrovana revizorska društva.
- Prosečna naknada – određuje se deljenjem ukupnog prihoda od revizije finansijskih izveštaja sa brojem klijenata, za svako revizorsko društvo pojedinačno. Ako prosečna naknada revizorskog društva prelazi 300.000 dinara (medijana za sva revizorska društva), revizorsko društvo je označeno brojem 1, odnosno brojem 0 ukoliko je ista niža.

Za obradu podataka i sprovođenje istraživanja korišćen je statistički softverski paket SPSS (engl. *Statistical Package for the Social Sciences*).

Rezultati istraživanja sa diskusijom

Ovaj deo rada predstavlja rezultate sprovedenog istraživanja u skladu sa prethodno definisanim istraživačkim pitanjima. Istraživački uzorak obuhvata 2.116 revizorskih izveštaja, analiziranih prema vrsti angažovanog revizorskog društva i roda potpisnika revizorskog izveštaja. U tabeli u nastavku prikazano je da je gotovo jednak broj revizorskih izveštaja potpisan od strane revizora muškog i ženskog roda. Kada je reč o međunarodnim i domaćim revizorskim društvima, zanimljivo je to da su dobijene vrednosti gotovo jednake, pri čemu je primećeno da revizorska društva koja pripadaju Velikoj četvorci (*Big 4*) imaju veći broj revizorskih izveštaja potpisanih od strane revizora ženskog roda (oko 70%). Ukupno posmatrano, razlika je gotovo neprimetna, s obzirom na to da 85%

ukupnih revizorskih izveštaja potiče od međunarodnih i domaćih revizorskih društava.

Tabela 1. Broj revizorskih izveštaja po vrsti angažovanog revizorskog društva i roda revizora

Rod	Ukupno		Big 4		Međunarodna		Domaća	
Ženski	1.092	51,61%	227	69,21%	337	46,61%	529	49,62%
Muški	1.024	48,39%	101	30,79%	386	53,39%	537	50,38%
Ukupno:	2.116	100%	328	100%	723	100%	1,066	100%

Izvor: Rezultati autora.

Međutim, prethodni rezultati ne pružaju dokaz o rodnoj jednakosti prilikom angažovanja revizora. Naime, postoji mogućnost da su neki revizori češće dodeljivani novim klijentima od drugih. Stoga, u zavisnosti od situacije, određenom revizoru može biti uskraćeno dodeljivanje zadataka, dok se drugi revizor angažuje za obavljanje revizija za više klijenata. Za izračunavanje prosečnog broja angažovanja koje obavljaju revizori muškog ili ženskog roda, potrebno je prikupiti podatke o ukupnom broju revizora i njihovoj strukturi prema rodu i vrsti revizorskog društva. Tabela 2 prikazuje te rezultate.

Table 2. Broj licenciranih ovlašćenih revizora po rodu i vrsti revizorskog društva

Rod	Ukupno		Big 4		Međunarodna		Domaća	
Ženski	170	56,48%	25	60,98%	71	57,72%	74	54,01%
Muški	131	43,52%	16	39,02%	52	42,28%	63	45,99%
Ukupno:	301	100%	41	100%	123	100%	137	100%

Izvor: Rezultati autora.

Rezultati istraživanja pokazuju da postoji prilično jednak broj angažovanih revizora oba roda, ali je ipak prednost na strani revizora ženskog roda. Kao što se očekivalo, domaća revizorska društva imaju najveći udeo u ukupnom broju angažovanih revizora (oko 46%), što je u skladu sa njihovim udelom u ukupnom broju obavljenih revizija (oko 50%). Velika i međunarodna revizorska društva imaju veći udeo revizora ženskog roda, dok je taj udeo približniji u domaćim revizorskim društvima. Na osnovu dobijenih rezultata, može se očekivati da su revizori ženskog roda češće angažovani za obavljanje revizija u posmatranim društvima. Međutim, kako bi se pomenuto potvrdilo, potrebno je izračunati odnos prosečnog broja angažovanja koje obavljaju revizori ženskog roda i ukupnog broja angažovanja po revizoru za svako revizorsko društvo u uzorku:

$$GPER = \frac{\bar{x}_f}{\bar{x}_t} \quad (1)$$

gde je: *GPER* – odnos angažovanja u cilju postizanja rodne jednakosti (engl. *gender parity engagement ratio*); $\bar{x}_f$ – prosečan broj angažovanja koje obavljaju revizori ženskog roda (engl. *average number of engagements performed by female auditors*); $\bar{x}_t$ – prosečan broj angažovanja po revizoru (oba roda) (engl. *average number of engagements performed per auditor (both genders)*).

Ovaj racio se izračunava pojedinačno, za svako revizorsko društvo obuhvaćeno istraživanjem. U prethodno prikazanoj formuli, $\bar{x}_f$ se određuje kada se broj revizorskih izveštaja potpisanih od strane revizora ženskog roda podeli sa ukupnim brojem ovlašćenih licenciranih revizora ženskog roda zaposlenih u posmatranom revizorskom društvu. Sa druge strane, $\bar{x}_t$ se određuje kada se ukupan broj revizorskog izveštaja koje je izdalo posmatrano društvo podeli sa ukupnim brojem ovlašćenih licenciranih revizora. Očekuje se da bi posmatrani odnos trebalo biti jednak 1, što bi ukazivalo da oba roda imaju jednaku verovatnoću da budu angažovana u procesu sprovođenja revizije finansijskih izveštaja. Revizori muškog roda imaju veću verovatnoću da budu angažovani ako je odnos manji od 1, dok će revizori ženskog roda biti verovatnije angažovani ukoliko je odnos veći od 1. Tabela koja sledi prikazuje prosečne vrednosti odnosa za sva društva i dodatno ih deli prema vrsti revizorskog društva.

Tabela 3. Prosečan udeo angažovanja po rodu i vrsti revizorskog društva

Vrsta revizorskog društva	Ukupno	Big 4	Međunarodno	Domaće
Prosečan broj angažovanja po revizoru ženskog roda	7,00	10,13	5,15	7,67
Prosečan broj angažovanja po revizoru	7,06	8,49	5,96	7,41
Prosečan odnos angažovanja u cilju postizanja rodne jednakosti	0,96	1,17	0,87	0,98

Izvor: Rezultati autora.

U cilju pružanja odgovora na preostala istraživačka pitanja, izračunati su Pearsonovi koeficijenti korelacije (engl. *Pearson correlation coefficient*). Rezultati istraživanja su prikazani na grafikonu koji sledi.

Grafikon 1. Rezultati Pearsonove korelacije za odabrane varijable

Rod revizora	1	-0,14	0,349	0,092	0,096	0,152	1
Vrsta revizorskog društva	-0,14	1	0,018	0,317	-0,676	-0,373	0.8
% revizora ženskog roda	0,349	0,018	1	0,357	-0,158	0,19	0.4
% vlasnika ženskog roda	0,092	0,317	0,357	1	-0,49	-0,448	0
Vlasnik revizorskog društva	0,096	-0,676	-0,158	-0,49	1	0,305	-0.4
Prosečna naknada za pruženu uslugu	0,152	-0,373	0,19	-0,448	0,305	1	-0.8
	Rod revizora	Vrsta revizorskog društva	% revizora ženskog roda	% vlasnika ženskog roda	Vlasnik revizorskog društva	Prosečna naknada za pruženu uslugu	-1

Izvor: Rezultati autora.

Takođe, rezultati iz prethodne tabele pokazuju da su sve korelacije između roda revizora i ostalih varijabli statistički značajne, sa vrednostima ispod 0,01. Kada je u pitanju drugo istraživačko pitanje, rezultati pokazuju da postoji slaba, ali pozitivna korelacija između roda revizora i prosečne naknade za pruženu uslugu. Dakle, može se zaključiti da su izveštaji koje potpisuju revizori ženskog roda dolazili od revizorskih društava sa višim prosečnim naknadama za reviziju.

Treće istraživačko pitanje ima za cilj da istraži korelaciju između vlasnika revizorskog društva i roda revizora. Može se pretpostaviti da bi pravna lica, kao vlasnici revizorskih društava, mogla imati neutralniju politiku u pogledu angažovanja revizora. Rezultati pokazuju da revizorska društva u vlasništvu drugih pravnih lica (ili fizičkih lica ženskog roda) imaju veći broj revizija koje obavljaju revizori ženskog roda. U poređenju sa drugim privredama, udeo fizičkih lica ženskog roda u ukupnom broju vlasnika je veći, približno 44% (ili oko 48% kada se izuzmu pravna lica kao vlasnici). Rezultati poslednjeg istraživačkog pitanja su u skladu sa prethodnim zapažanjima u vezi sa tipom revizorskog društva i rodom revizora koji potpisuju izveštaje. Konkretno, postoji slaba i negativna korelacija između roda revizora i tipa revizorskog društva, što ukazuje da društva koja pripadaju Velikoj četvorci (*Big 4*) imaju veći udeo revizora ženskog roda.

Zaključak

Iako je primetno povećanje učešća osoba ženskog roda u poslovnom svetu, kada je Balkan u pitanju, često se pominje da u ovom delu sveta i dalje postoji dominantna uloga osoba muškog roda. Pod uticajem evropskih i svetskih trendova primetno je povećanje učešća osoba ženskog roda u različitim oblastima. Ovo istraživanje pruža značajan uvid u rodnu strukturu revizorske profesije u Republici Srbiji, ističući oblasti u kojima je postignut napredak i one koje zahtevaju kontinuiranu pažnju. Rezultati ukazuju na povoljan trend: skoro jednak broj revizorskih izveštaja potpisuju revizori muškog i ženskog roda. Distribucija domaćih i međunarodnih revizorskih društava je uravnotežena; ipak, revizorska društva koja pripadaju Velikoj četvorci imaju veći procenat izveštaja (oko 70%) potpisanih od strane revizora ženskog roda. Prethodno navedeno ukazuje da revizorska društva koja pripadaju Velikoj četvorci imaju veći udeo angažovanih revizora ženskog roda. Rezultati pokazuju napredak u rodnoj ravnopravnosti u pogledu angažovanja revizora, posebno u većim revizorskim društvima. Prema Pirsonovoj korelacionoj analizi postoji slaba, ali pozitivna korelacija između roda revizora i prosečne naknade po revizorskom društvu. Interesantno je da su revizorska društva sa višim prosečnim naknadama povezane sa izveštajima koje su potpisali revizori ženskog roda. Ova korelacija može odražavati potencijalne trendove u percipiranoj vrednosti ili stručnosti koja se pripisuje revizorima ženskog roda posmatrajući iz ugla klijenata što je potvrđeno sličnim istraživanjima u drugim privredama. Rezultati pokazuju da revizorska društva sa neutralnijom vlasničkom strukturom ili ako su vlasnici fizička lica ženskog roda mogu biti inkluzivnije u angažovanju revizora ženskog roda. Prethodno pomenuto je u skladu sa širim trendom povećanja učešća osoba ženskog roda u različitim oblastima pod uticajem globalnih i evropskih trendova. Svi ovi rezultati naglašavaju potrebu za stalnim naporima na promovisanju rodne ravnopravnosti na vodećim pozicijama u revizorskoj profesiji. Iako je napredak evidentan i moglo bi se zaključiti da osobe ženskog roda u posmatranoj profesiji uživaju mnogo bolji položaj u poređenju sa drugim profesijama, postoji poziv na kontinuiranu podršku za prevazilaženje sistemskih barijera i predrasuda koje mogu uticati na potpuno uključivanje osoba ženskog roda u ključne rukovodeće uloge. Buduća istraživanja treba da budu posebno usmerena na ove izazove kako bi doprinela sveobuhvatnijem razumevanju dinamike u ovoj grani.

Literatura

1. Abdelfattah, T., Elmahgoub, M., and Elamer, A. 2019. "Female Audit Partners and Extended Audit Reporting: UK Evidence." *Journal of Business Ethics* 174 (1): 177–197.

2. AICPA. 2022. "2021 Trends report." Available at: <https://www.aicpa-cima.com/professional-insights/download/2021-trends-report>
3. Aldamen, H., Hollindale, J., and Ziegelmayer, J. 2016. "Female audit committee members and their influence on audit fees." *Accounting & Finance* 58(1): 57-89.
4. Antonijevic, M., Ljumovic, I., and Ivanovic, Đ. 2022. "Is there a Gender Gap in Financial Inclusion across Countries?" *Journal of Women's Entrepreneurship and Education* 1-2: 79-96.
5. Blau, F., and Kahn, L. 2017. "The Gender Wage Gap: Extent, Trends, and Explanations." *Journal of Economic Literature* 55(3): 789-865.
6. Brasnjic, F. F., and Sevo, B. N. 2019. "Položaj žene u društvu kroz historiju." *Baština* 47: 221-232.
7. Churikova, E. 2020. "Toward Gender Equality: Accounting for Change." Available at: <https://www.ifac.org/knowledge-gateway/preparing-future-ready-professionals/discussion/toward-gender-equality-accounting-change>
8. Curakovic, D. 2023. "Tržište rada u sektoru turizma kroz prizmu rodne ravnopravnosti." *Oditor* 9 (3): 1-38.
9. Dobrijevic, G. 2014. "The Effect of Gender on Negotiation Behaviour." *The European Journal of Applied Economics* 11(1): 43-52.
10. Garcia-Blandon, J., Argilés, J., and Ravenda, D. 2020. "Audit firm tenure and audit quality: A cross- European study." *Journal of International Financial Management & Accounting* 31(1): 35-64.
11. Gender Equality Directorate of Republic of Serbia. 2021. "Gender Equality Strategy 2021-2030." Available at: <https://www.srbija.gov.rs/vest/en/179692/2021-2030-gender-equality-strategy-adopted.php>
12. Hardies, K., Breesch, D., and Branson, J. 2013. "Gender Inequality in Small and Large Audit Firms." Available at: <https://dx.doi.org/10.2139/ssrn.2254268>
13. Hardies, K., Breesch, D., and Branson, J. 2015. "The Female Audit Fee Premium." *Auditing: A Journal of Practice & Theory* 34(4): 171–195.
14. Hughson, M., and Bacanovic, V. 2014. "Rodna ravnopravnost u Srbiji 2014: Analiza stanja u oblasti ekonomije." *Zbornik Instituta za kriminološka i sociološka istraživanja (IKSI)* 1 (2): 7-24.
15. Ittonen, K., and Peni, E. 2012. "Auditor's Gender and Audit Fees." *International Journal of Auditing* 16(1): 1-18.
16. Miglani, S., and Ahmed, K. 2019. "Gender diversity on audit committees and its impact on audit fees: Evidence from India." *Accounting Research Journal* 32(4): 568-586.
17. Official Gazette of RS No. 12. 2022. "National Strategy for Prevention and Protection Against Discrimination for the period from 2022 to 2030."

Available at: <https://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/eli/rep/sgrs/vlada/strategija/2022/12/2>

18. Pavicevic, O. 2012. "Individua u perspektivi globalne modernizacije." *Teme* 36(1): 11-26.
19. Pruett, M. 2023. "Confidence and Character: The Future of Women's Entrepreneurship Education?" *Journal of Women's Entrepreneurship and Education* (1-15): 1-15.
20. Reva, A. 2012. "Gender Inequality in the Labor Market in Serbia." World Bank Policy Research Working Paper No. 6008. Available at: <https://ssrn.com/abstract=2027301>.
21. Sellami, M. Y., and Cherif, I. 2020. "Female audit committee directorship and audit fees." *Managerial Auditing Journal* 35(3): 398-428.
22. Statista. 2023. "Share of accountants and auditors in the United States in from 2020 to 2022 by gender." Available at: <https://www.statista.com/statistics/1086831/share-accountants-auditors-united-states-gender/>
23. Ting-Chiao Huang, X., Chiou, J.R., Huang, H.W., and Chen, J.F. 2015. "Lower audit fees for women audit partners in Taiwan and why." *Asia Pacific Management Review* 20(4): 219-233.
24. Turban, S., Wu, D., and Zhang, L. 2019. "Research: When Gender Diversity Makes Firms More Productive." *Harvard business review*. Available at: <https://hbr.org/2019/02/research-when-gender-diversity-makes-firms-more-productive>

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FINANCIAL STATEMENTS AUDIT PROFESSION IN SERBIA: IS THERE A GENDER EFFECT?

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Abstract

The aim of this paper is to examine the position of women in the audit profession in Serbia. The research sample of 2,116 audit reports has been analysed from the point of hired audit firms and gender of the auditor that signed the report. The results show that the number of reports produced by male and female auditors is almost equal, with noticeable trends in Big 4 firms favouring female auditor engagements. In addition, the results show that both male and female auditors have almost the same probability of acquiring new clients, with males having a slight advantage overall, and in domestic audit firms. However, this advantage shifts to females in Big 4 firms. Pearson's correlation results show a weak but statistically significant and positive relationship between auditor gender and higher average audit fees, indicating potential perceptions of increased value associated with female auditors.

Key words: audit report, gender equality, auditing, female auditors

JEL: M40, M42

Introduction

The Industrial Revolution, urbanization of cities, development of consumer society, accelerated economic growth, and the emergence of globalization are just some of the changes that characterize modern society. Thus, modernization raises the question of transforming social relations (gender differences, the creation of new social classes, cooperation, etc.). In case of transitional societies, where there is a transition from one social system to another, such changes lead to the creation of opportunities for the development of responsible and free individuals who strive to adapt to contemporary trends trends (Antonijevic et al., 2022; Pavicevic, 2012). While earlier beliefs solely associated women with household and family

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care, over time, their position and role have significantly changed (Pruett, 2023). The gradual inclusion of women in social, economic, and political spheres leads to the promotion, encouragement, and achievement of gender equality, as well as the expansion of women's influence and activities beyond the confines of the family home (Curakovic 2023; Dobrijevic, 2014). The Harvard Business Review highlights that companies with gender diversity tend to exhibit higher productivity, as indicated by market value and revenue (Turban et al., 2019). Such workforce embraces diversity and excels in attracting top talent, fostering innovation, and instilling confidence in investors.

When it comes to accounting and auditing as a profession, according to the report made by the International Federation of Accountants (IFAC) in 2020, women professionals were represented by 46% globally. Likewise, in the same year, for the first time since the establishment of IFAC, it had a majority-female Board, with females constituting 52% (Churikova, 2020). Regarding future workforce, report Trends in the Supply of Accounting Graduates and Demand for Public Accounting Recruits published by AICPA in 2021, show that 55% of all new accounting graduates in 2019–2020 were female (AICPA, 2022). When it comes to the United States, figures show that there is a constant rise of the number of female auditors, where percentage increased from 23.5% in 1993 to 58.8% in 2022.

Brasnjić & Sevo (2019) state that the dominant role of men still exists in the Balkan region, but under the influence of European and global trends, improvement in the involvement of women in various fields can still be observed (especially in terms of increasing their participation in top political positions). When it comes to the Republic of Serbia, it is noticeable that certain efforts have been made to develop a legal and institutional framework aimed at improving the position of women in society and advancing gender equality in general. The aforementioned is confirmed by the adoption of the Law on Prohibition of Discrimination, Law on Gender Equality, National Strategy for Gender Equality for the period 2021-2030 (Gender Equality Directorate of Republic of Serbia, 2021), National Strategy for Prevention and Protection against Discrimination for the period 2022-2030 (Official Gazette of RS No. 12, 2022), along with accompanying action plans, and more.

The question remains as to how much these mechanisms have contributed to raising awareness and education about economic equality. This is supported by the research conducted by Hughson & Bacanovic (2014), it is precisely in the field of economics that the most significant differences between men and women in terms of their positions are observed. The same authors emphasize the importance of taking actions towards the economic empowerment of women, particularly in terms of promoting female entrepreneurship, increasing women's employment rates, reducing the poverty rate among women, and similar efforts.

The main contribution of this paper lies in providing answers to several research questions:

- Is the same number of reports signed by male and female auditors?
- Are there gender-based differences in average fees at the level of auditing firm when it comes to report signatories?
- Is there a correlation between the gender of report signatories and the share of female owners in auditing firms?
- Is the gender of the report signatories correlated with the type of auditor (Big 4, international, and domestic)?

The structure of this paper consists of remaining three sections. The second section of comprises of a literature review, which will present current trends in this field and highlight the authors' previous achievements on the topic. After the literature review, an explanation of the research methodology used, a description of the research sample, and the presentation of the obtained results with accompanying discussion will follow. Lastly, the final part of the paper is dedicated to concluding remarks and recommendations for further research.

Literature review

Although wages disparity between genders decreased in recent decades, it remains a problem. In all areas of work and most industries, women are paid considerably less than men (Garcia-Blandon et al., 2020). According to the research of Blau and Kahn (2017), average women's weekly wages were 82% of men's in 2014, down from 61% in 1965. When it comes to Serbia, Reva (2012) claims there are significant gender differences in average earnings when compared across career or industry groups.

Particularly at the partner level, women continue to be underrepresented in financial statements audit (Hardies et al., 2013). Research showed that out of 1,039 registered auditors in 2008, only 21.4% of them were female auditors. Furthermore, out of total number of observed auditors, 646 auditors of them were engaged in at least one audit assignment, with only 81 of them being performed by female auditors (12.5%). Furthermore, in comparison to the second-tier (22%) and small audit companies (19.6%), the Big 4 hired relatively more female registered auditors (23.5%).

Abdelfattah et al. (2019) highlight the differences in behaviour between the genders of the audit partners. The results indicate that hiring female auditors is likely to raise the number of details on KAMs (Key Audit Matters). The results are based on a sample of UK firms between 2013 and 2017. Still, authors claim that women are underrepresented in leadership positions, as the average percentage of female partners in audit firms was app. 20% since 2013 till 2022 (Statista, 2023).

According to Ittonen and Peni (2012), the gender of the audit engagement partner could have an impact on the audit fees. Research covered 2005-2006 reporting period, with data from companies listed on the NASDAQ OMX exchanges in Sweden, Finland, and Denmark. Gender distribution among audit partners reveals some interesting findings. Out of a total 715 observed firms over two years, engagements with female auditors is just 16 (4.80%) in 2005, and 18 (4.71%) in 2006. The study additionally revealed that larger auditing firms exhibit a more noticeable gender effect on audit prices. Finally, female audits were shown to have considerably higher fees. Similar conclusion was given by Miglani and Ahmed (2019), in a research conducted on 200 Indian companies that covered 2011-2014 period.

The question of whether female audit partners receive higher audit fees was also explored in a study by Hardies et al. (2015). The aforementioned authors explored 57,723 firm-year observations from Belgian companies that were audited by 599 male and 93 female audit partners between 2008 and 2011. Results suggest that clients afford app. 7% higher audit fees for female auditors. Conversely, Ting-Chiao Huang et al. (2015) used a sample of Taiwanese public corporations to investigate whether female audit partners earn reduced audit fees. The findings indicated that there was prejudice against female audit partners in Taiwan over the examined period, and that there was a statistically significant link between female audit partners and audit fees.

In summary, literature review emphasizes the persistent wage gap and underrepresentation of women in leadership roles in audit companies. Observed studies, spanning different countries and time periods, consistently highlight the lower proportion of female auditors and partners, with specific attention to the Big 4 firms. Additionally, authors confirm impact of gender on audit fees, revealing mixed findings on whether female auditors receive higher or lower fees, with some studies suggesting discrimination against female auditors in certain regions, which may be a consequence of national culture differences.

Research methodology

In order to provide answers to defined research questions, a study has been conducted. Research sample included 2,116 audit reports of medium and large business entities selected by random. Research period covered 2020 reporting period, and all business entities were registered in the Republic of Serbia at the time being. Audit reports have been collected from the official web-site of Business Register Agency (BRA) of the Republic of Serbia. Gender structure of employed licenced authorised auditors, as well as all other individual data have been collected from the official web-site of Chamber of Authorized Auditors (CAA) as of December 31st, 2020. Average fee per audit firm has been calculated based on the information disclosed in Transparency reports for 2020, publically

disclosed by audit firms that have conducted financial statements audit of public entities. Some of reports have been collected from the CAA website, while others have been found on official website presentations of audit firms (as per Law on Auditing, audit firms have an obligation to disclose transparency reports within 4 months after the observed period, either on CAA website, or their own). Following variables have been observed:

- Auditor gender – list of all licenced authorised auditors has been collected from CAA website, along with information on their gender, and audit firm of employment.
- Assigned auditor – number of engagements performed by female auditors (according to signature from audit report).
- Auditor firm type – list of all registered audit firms has been taken from CAA website, and afterwards they were divided in three groups Big 4, international (if they belong to international network), and domestic (if they do not).
- Audit firm owner – observed per audit firm and assigned 0 if the owner is a person (female or male) and 1 if the owner is a business entity (usually other audit firm, global or domestic). Data has been taken from CAA website for each audit firm individually.
- Share of female owners – involvement of female persons in owning audit firms (owners have been divided in three groups: male persons, female persons, and business entities). Data has been taken from CAA website for each audit firm individually.
- Share of female auditors – number of female auditors and its share in total employed auditors for all registered audit firms.
- Average fee - determined by dividing the total revenue from financial statement audits by the number of audit clients, for each audit firm. If an audit firm's average fee exceeds RSD 300,000 (the median fee for all audit companies) it is given a value of 1, and 0 if it is less than that.

Finally, research has been done by using statistical software platform SPSS.

Research results with discussion

This section presents research results in accordance to previously defined research questions. Research sample consists of 2,116 audit reports, analysed from the point of hired audit firm and gender of report signatory. Following table reveals that surprisingly almost equal number of audit reports have been signed by male and female auditors. It's interesting to note that figures almost match when it comes to international and domestic audit firms, with the Big 4 audit firms having a larger percentage of audit reports (about 70%) signed by female auditors. The difference is not significant overall, given that 85% of all reports are issued by international and domestic audit firms.

Table 1. Number of audit reports per audit firm type and auditor gender

Gender	Total		Big 4		International		Domestic	
Female	1,092	51.61%	227	69.21%	337	46.61%	529	49.62%
Male	1,024	48.39%	101	30.79%	386	53.39%	537	50.38%
Total:	2,116	100%	328	100%	723	100%	1,066	100%

Source: Authors' calculation.

However, previous results do not provide a proof that there is a gender equality in assigning auditors. Namely, there is a possibility that some auditors were assigned with new clients more often than others. Therefore, depending on the situation, a certain auditor may be left out of assignments, while another auditor may be engaged to perform audits for multiple clients. To calculate what is the average number of engagements performed by male or female auditors, it is needed to collect data on total number of auditors and its structure per gender and audit firm type. Table 2 shows those results.

Table 2. Number of licenced authorised auditors per gender and audit firm type

Gender	Total		Big 4		International		Domestic	
Female	170	56.48%	25	60.98%	71	57.72%	74	54.01%
Male	131	43.52%	16	39.02%	52	42.28%	63	45.99%
Total:	301	100%	41	100%	123	100%	137	100%

Source: Authors' calculation.

Results show that there is a fairly equal number of employed auditors of both sexes, but advantage is on the female auditors' side. As expected, domestic firms have the highest share in the total number of employed auditors (app. 46%), which is in line with their share in the total number of performed audits (app. 50%). Big 4 and international firms have higher share of female auditors, while that share is more balanced in domestic firms. Based on these results, it can be expected that female auditors are more hired to perform audits within observed firms. However, to do so, it is needed to calculate a ratio of average number of engagements performed by female auditors and total number of engagements per auditor for each audit firm in the sample:

$$GPER = \frac{\bar{x}_f}{\bar{x}_t} \quad (1)$$

where: $GPER$ – gender parity engagement ratio; $\bar{x}_f$ – average number of engagements performed by female auditors; $\bar{x}_t$ – average number of engagements performed per auditor (both genders).

Ratio is computed individually for each audit firm. In the above formula, $\bar{x}_f$ is determined when the number of audit reports signed by female auditors is divided by the total number of authorized licensed female auditors employed in observed firm. On the other hand, $\bar{x}_t$ is calculated when the total number of audit reports issued by observed firm is divided by total number of authorized licensed auditors. One would anticipate the ratio to equal 1, indicating an equal likelihood for male and female auditors to be involved in conducting audits of financial statements. Male auditors may be more likely to be chosen if the ratio is less than 1, whereas female auditors may be more likely to be chosen if the ratio is greater than 1. The following table shows the average ratio values for each firm and further breaks them down by type of auditing firm.

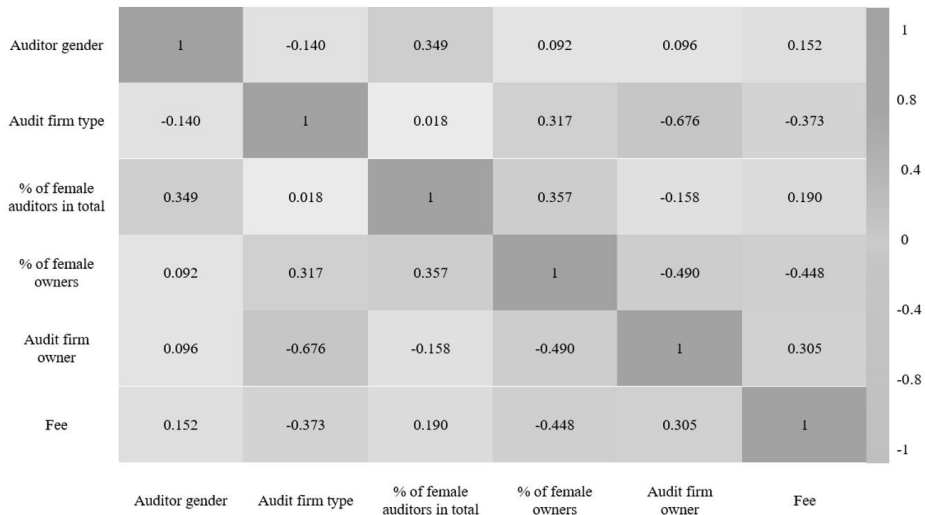
Table 3. Average share of engagements per gender and audit firm type

Auditor firm type	Total	Big 4	International	Domestic
Average number of engagements per female auditor	7.00	10.13	5.15	7.67
Average number of engagements per auditor	7.06	8.49	5.96	7.41
Average gender parity engagement ratio	0.96	1.17	0.87	0.98

Source: Authors' calculation.

In order to provide answers to remaining research questions, Pearson correlation coefficients have been calculated. Results are presented on figure 1.

Figure 1. Pearson correlation results for selected variables



Source: Authors' calculation.

Additional information regarding previous table is that all correlations between audit gender and other variables are statistically significant, with values below 0.01. Regarding the second research question, results show that there is a weak but positive correlation between auditor gender and average fee per audit firm. Therefore, it can be concluded that reports signed by female auditors came from audit firms with higher average audit fees.

The third research question aims to explore correlation between audit firm owners and auditor gender. It can be presumed that business firms, as owners of audit firms, might have a more neutral policy regarding auditor engagement. The results reveal that audit firms owned by other business entities (or female owners) have higher number of audits performed by female auditors. When compared to other economies, share of female owners in total number of owners is higher, app. 44% (or app. 48% when business entities as owners are excluded). Lastly, the findings of the last research question align with the previous observations regarding audit firm type and the gender of auditors who sign the reports. Specifically, there is a weak and negative correlation between auditor gender and auditor firm type, indicating that Big 4 firms have a higher proportion of female auditors.

Conclusions

Although there is a noticeable increase in the participation of women in business worldwide, when it comes to the Balkans, it is often mentioned that the dominant role of men still exists in this part of the world. Increasing participations of woman in various fields is noticeable under the influence of European and global trend. This study sheds light on areas of progress and areas that need ongoing attention, providing insightful information about the gender dynamics of the audit profession in the Republic of Serbia. Findings indicate a favourable trend: about equal number of audit reports have been produced by male and female auditors. The distribution of domestic and international audit firms is balanced; nevertheless, the Big 4 firms have a greater percentage of reports (about 70%) signed by female auditors. Furthermore, previous implies that Big 4 firms have a higher proportion of hired female auditors. Results show progress in gender parity in terms of auditor engagement, especially in larger audit firms. According to Pearson's correlation analysis there is a weak but positive correlation between auditor gender and the average fee per audit firm. Interestingly, audit firms with higher average fees are associated to audit reports signed by female auditors.

This correlation may reflect potential trends in the perceived value or expertise attributed to female auditors in the eyes of clients, which has been confirmed by

similar research in other economies. Furthermore, results suggest that audit firms with more neutral ownership structures or female owners may be more inclusive in engaging female auditors. The findings align with the broader trend of increasing female participation in various fields under the influence of global and European trends. All of these findings highlight the need for on-going efforts to promote gender equality in leadership positions within the audit profession. While progress is evident, and one might conclude that females in observed profession enjoy much better position compared to other professions, there is a call for sustained support to overcome systemic barriers and biases that may hinder the full inclusion of women in key leadership roles. Future research endeavours should specifically target these challenges to contribute to a more comprehensive understanding of the dynamics at play.

References

1. Abdelfattah, T., Elmahgoub, M., and Elamer, A. 2019. "Female Audit Partners and Extended Audit Reporting: UK Evidence." *Journal of Business Ethics* 174 (1): 177–197.
2. AICPA. 2022. "2021 Trends report." Available at: <https://www.aicpa-cima.com/professional-insights/download/2021-trends-report>
3. Antonijevic, M., Ljumovic, I., and Ivanovic, Đ. 2022. "Is there a Gender Gap in Financial Inclusion across Countries?" *Journal of Women's Entrepreneurship and Education* 1-2: 79-96.
4. Blau, F., and Kahn, L. 2017. "The Gender Wage Gap: Extent, Trends, and Explanations." *Journal of Economic Literature* 55(3): 789-865.
5. Brasnjic, F. F., and Sevo, B. N. 2019. "Položaj žene u društvu kroz historiju." *Baština* 47: 221-232.
6. Churikova, E. 2020. "Toward Gender Equality: Accounting for Change." Available at: <https://www.ifac.org/knowledge-gateway/preparing-future-ready-professionals/discussion/toward-gender-equality-accounting-change>
7. Curakovic, D. 2023. "Tržište rada u sektoru turizma kroz prizmu rodne ravnopravnosti." *Oditor* 9 (3): 1-38.
8. Dobrijevic, G. 2014. "The Effect of Gender on Negotiation Behaviour." *The European Journal of Applied Economics* 11(1): 43-52.
9. Garcia-Blandon, J., Argilés, J., and Ravenda, D. 2020. "Audit firm tenure and audit quality: A cross- European study." *Journal of International Financial Management & Accounting* 31(1): 35-64.
10. Gender Equality Directorate of Republic of Serbia. 2021. "Gender Equality Strategy 2021-2030." Available at: <https://www.srbija.gov.rs/vest/en/179692/2021-2030-gender-equality-strategy-adopted.php>

11. Hardies, K., Breesch, D., and Branson, J. 2013. "Gender Inequality in Small and Large Audit Firms." Available at: <https://dx.doi.org/10.2139/ssrn.2254268>
12. Hardies, K., Breesch, D., and Branson, J. 2015. "The Female Audit Fee Premium." *Auditing: A Journal of Practice & Theory* 34(4): 171–195.
13. Hughson, M., and Bacanovic, V. 2014. "Rodna ravnopravnost u Srbiji 2014: Analiza stanja u oblasti ekonomije." *Zbornik Instituta za kriminološka i sociološka istraživanja (IKSI)* 1 (2): 7-24.
14. Ittonen, K., and Peni, E. 2012. "Auditor's Gender and Audit Fees." *International Journal of Auditing* 16(1): 1-18.
15. Miglani, S., and Ahmed, K. 2019. "Gender diversity on audit committees and its impact on audit fees: Evidence from India." *Accounting Research Journal* 32(4): 568-586.
16. Official Gazette of RS No. 12. 2022. "National Strategy for Prevention and Protection Against Discrimination for the period from 2022 to 2030." Available at: <https://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/eli/rep/sgrs/vlada/strategija/2022/12/2>
17. Pavicevic, O. 2012. "Individua u perspektivi globalne modernizacije." *Teme* 36(1): 11-26.
18. Pruett, M. 2023. "Confidence and Character: The Future of Women's Entrepreneurship Education?" *Journal of Women's Entrepreneurship and Education* (1-15): 1-15.
19. Reva, A. 2012. "Gender Inequality in the Labor Market in Serbia." World Bank Policy Research Working Paper No. 6008. Available at: <https://ssrn.com/abstract=2027301>.
20. Statista. 2023. "Share of accountants and auditors in the United States in from 2020 to 2022 by gender." Available at: <https://www.statista.com/statistics/1086831/share-accountants-auditors-united-states-gender/>
21. Ting-Chiao Huang, X., Chiou, J.R., Huang, H.W., and Chen, J.F. 2015. "Lower audit fees for women audit partners in Taiwan and why." *Asia Pacific Management Review* 20(4): 219-233.
22. Turban, S., Wu, D., and Zhang, L. 2019. "Research: When Gender Diversity Makes Firms More Productive." *Harvard business review*. Available at: <https://hbr.org/2019/02/research-when-gender-diversity-makes-firms-more-productive>

ECONOMIC DEVELOPMENT OF SERBIA AFTER 2000 – RESULTS AND PERSPECTIVES FOR DEVELOPMENT

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Abstract

The economic development of Serbia is largely based on traditional sectors (food industry, agriculture, construction, metal industry) characterized by low productivity and limited added value, employing over 50% of the total workforce. Consequently, Serbia has failed to reduce its development gap relative to the Central and Eastern European (CEE) countries over the past 20 years and remains at 60% of their average level. Achieved growth rates have primarily relied on increased investments and employment, with minimal contributions from technical progress and new technologies. Therefore, a shift in economic policy is necessary, emphasizing the application of knowledge and new technologies, along with significantly higher investment participation in the gross domestic product (GDP) from the domestic private sector. Only growth based on these assumptions will be sustainable in the long term and lead to increased competitiveness of the economy in the global market.

Keywords: economic development, GDP, CEE, Serbia, competitiveness

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Introduction

At the beginning of the 2000s, Serbia faced a significant economic lag compared to the countries of Central and Eastern Europe (CEE), particularly when measured against developed nations of the European Union. This economic underdevelopment was primarily the result of hyperinflation during the 1990s, international sanctions imposed by the global community and the 1999 NATO

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bombing. Following political changes in 2000, Serbia reopened to international cooperation and initiated a privatization process, which further weakened its economic structure, particularly through the dismantling of its industrial sector as the backbone of the economy. The country's economic policy largely relied on foreign direct investments (FDIs) and public infrastructure development, while neglecting domestic private investments, resulting in a persistent gap in development compared to the developed world.

In recent years, Serbia has achieved a moderate level of economic development, with growth and development primarily driven by increases in capital and employment, particularly in traditional sectors. The immediate determinants of economic growth include investments, employment and technological progress, supplemented by the broader economic environment characterized by macroeconomic stability (exchange rate stability, inflation control, tax policy, interest rates and infrastructure). Serbia's economy remains dominated by traditional sectors (construction, food processing, rubber manufacturing, metallurgy, agriculture and mining), which exhibit low productivity and limited added value, employing more than 50% of the workforce. Consequently, Serbia has failed to reduce the development gap with CEE countries over the past two decades and currently stands at 60% of their average development level.

This paper analyzes the growth of Serbia's gross domestic product (GDP) and investments in the period following 2000, as well as the growth trends of these indicators in CEE countries and the global average. Primary aim is to determine, through comparative analysis, whether Serbia has managed to reduce its developmental lag relative to CEE countries, considering that in the 1980s, Serbia outperformed this group of countries in several economic development indicators. Based on the findings, recommendations can be provided to economic policymakers to address and rectify policy missteps that have occurred since 2000.

Methodology

The defined subject and objectives of the research have determined the application of both qualitative and quantitative methodologies. Qualitative research has enabled an overview of scientific achievements related to the observed issue and facilitated necessary comparisons. The empirical research was conducted based on secondary data from relevant domestic and international sources, including textbooks from economics and related faculties, scientific journals, and statistical data published by domestic and foreign institutions related to economic development.

The analytical method was used to identify the fundamental indicators and factors of economic development, as well as to provide their theoretical and empirical coverage and measurement. The synthetic method was applied to integrate key elements of economic development into a unified whole, allowing for the derivation of relevant conclusions. This method was also employed to connect individual indicators of GDP growth and other macroeconomic variables into a comprehensive system from which aggregated indicators and conclusions could be drawn.

A comparative method was used to analyze Serbia's GDP growth rates relative to Central and Eastern European (CEE) countries and the global average over two separate periods: 2001–2011 and 2012–2023. Additionally, gross investment rates in Serbia, CEE countries, and the global average were compared for the same periods. The comparative analysis led to the conclusion that Serbia's economic development is still predominantly based on traditional sectors with low productivity and limited added value, in contrast to CEE countries, where innovation-driven and high-tech sectors are more prevalent.

The historical method was applied to chronologically present Serbia's economic development alongside CEE countries from 2000 to the present, using data from relevant databases such as the World Bank. Furthermore, historical data on Serbia's and CEE countries' economic development before and after 2000 were analyzed. The findings indicate that Serbia currently stands at 60% of the development level of CEE countries, whereas before the 1990s, it was more developed than them.

The descriptive method was utilized to present relevant indicators of economic growth and development, along with factors influencing economic policy. The compilation method was employed to integrate the findings of empirical research and scientific studies conducted by other authors who have examined similar topics.

Literature Review

Economic growth is a measurable, numerically expressed component of development that represents the aggregate economic value of goods and services produced within a given time period (Madžar, 2002). In addition to economic growth, economic development encompasses structural changes in the economy and, accordingly, represents a process of overcoming economic backwardness (Djurić-Kuzmanović, 2001). Economic development involves an increase in national economic output while also explaining complex transformations in the

composition and structure of the economy, as well as changes in the significance and contribution of various inputs to overall output growth (Rosić, 2002).

The significance of economic growth is reflected in its contribution to the overall prosperity of society. Growth enables an increase in the consumption of goods and services, as well as improvements in the quantity and quality of public goods and services, thereby raising the standard of living within a society. Therefore, increasing the rate of economic growth and development remains one of the primary objectives of macroeconomic policy (Kitanović et al., 2008).

Economic development is not merely an economic phenomenon. Ultimately, it must encompass more than the material and financial aspects of human life. It should be understood as a multidimensional process that, in addition to increasing material production, entails a reorganization of the entire economic and social system (Cvetanović, 2004).

Economic development should not be perceived as a linear, historically determined, and constantly recurring trend. Instead, it should be regarded as a process characterized by continuous positive and negative deviations around a certain equilibrium growth trend. Development is considered sustainable if it meets the needs of the present generation without compromising the ability of future generations to meet their own needs (Pokrajac, 2002). Sustainable development, beyond its economic and environmental dimensions, must also be socially, culturally, and politically viable. Global markets and global technologies have the potential to enrich human lives in every corner of the world and significantly expand the range of choices available to individuals (Jovanović Gavrilović, 2005).

New Information and Communication Technologies (ICTs) create opportunities for economic growth, development, improved healthcare, better services, and overall social and cultural advancement (Ilić, 2005). Increases in production and services, and consequently GDP growth, can occur even without additional investments, thanks to technological progress and better utilization of existing resources (Bajec & Joksimović, 2004).

The most significant sources of economic growth include the size and quality of the labor force, the quality of capital (research and development, technology transfer, innovation), and improvements in the efficiency of combining labor and capital in production (Vukotić, 2001). The importance of natural resources for a country's economy is determined by its level of economic and technological development, the characteristics of its economic structure, the position of the national economy within the international division of labor, and a range of

strategic and political factors that shape the country's development orientation (Arandelović, 2004).

Globalization is often presented as a qualitatively new stage in the development of the world economy, characterized by the dominance of transnational corporations, financial capital, and the consequent redistribution of economic and political functions between nation-states, transnational corporations, and international organizations (Leković, 2008). Without delving into the political aspects of globalization, it can be concluded that it is a long-term economic trend that should not be resisted, as modern society is inherently characterized by processes of interconnection, internationalism, and global integration (Veselinović, 2006).

Beck (2003) defines globalization as a process through which transnational actors with different power prospects, orientations, identities, and networks intersect sovereign nation-states. Globalization represents an unstoppable process, and any state that opposes its manifestation would be condemned to political isolation and economic stagnation (Mesarić, 2002). In the globalization process, the rules of the game are dictated by the large and powerful, making autocracy appear as the only alternative to globalization. Regardless of whether globalization is beneficial for some and detrimental for others, isolation is undoubtedly the worst possible outcome, meaning it should never be considered an alternative to globalization (Drašković, 2003).

Serbia's transition began with a decade-long delay, during which the initial advantages the country had over other post-socialist economies were lost. The advantage of entering the transition later and learning from the experiences of others was squandered, ultimately affecting the balance of achieved results (Jovanović Gavrilović, 2010). Serbia's industry lags significantly behind other transition economies. The technological structure of the industry has not substantially changed, and it remains dominated by low-tech and medium-low-tech subsectors. The services sector has a disproportionately large share in GDP creation and contributes the most to its growth (Ministry of Finance, 2011).

Serbia is too poor relative to its production potential. Consequently, the country should focus on developing industrial production—particularly in the machinery and automotive industries, as well as the broader chemical industry—to achieve competitiveness in foreign markets (Hausmann et al., 2009).

Economic policy can have both positive and negative effects on structural changes in the economy, either bringing it closer to or pushing it further away from its optimal state (Marjanović, 2015). Therefore, a state's ability to shape and influence the structure of the economy and individual sectors through appropriate

economic policies is crucial. It must efficiently, continuously, and actively implement structural changes in accordance with the available development factors (Mičić, 2016).

In developing countries, structural changes are essential to ensure faster progress toward higher levels of development (Lin, 2012) and to reach countries with a higher GDP per capita. Today, in addition to the main drivers of structural change—innovation and new technologies—factors such as knowledge, investment, externalities, skills, resource utilization, supply and demand, international trade, connectivity and agglomerations, institutional frameworks, and globalization play a significant role (UNIDO, 2013).

Deindustrialization leads to the tertiarization of the economic structure due to the strong development of the service sector. This is a long-term process that varies to some extent between countries (Timmer, Akkus, 2008). A common characteristic of this process is the correlation between GDP per capita, sectoral contributions to GDP, value added, employment distribution, and labor productivity.

In endogenous growth theories, technology plays a central role in explaining economic development and structural change (Baldwin, Braconier & Forslid, 2005). These theories also examine the role of research and development, infrastructure, government, institutional factors, and organizations. Furthermore, they incorporate intangible factors such as organizational structure, managerial capabilities, and culture in explaining development and structural transformations.

GDP Growth in CEE Countries and Serbia from 2000 to 2024

Serbia has achieved a moderate level of economic development, with growth driven primarily by increased capital and employment in traditional sectors. However, to achieve further growth and join the ranks of high-income developed countries, a shift toward high-tech industries is essential. These are sectors with high added value, capable of attracting young, highly skilled labor to remain in the country and contribute to its development.

Immediate determinants of economic growth include investment rate, employment and technological progress, while additional factors encompass economic environment, such as macroeconomic stability (exchange rate stability, inflation control, tax policy, interest rates, and infrastructure). Fundamental growth factors include geographic attributes, historical heritage, culture and institutions (Arsić, 2024).

Serbia's economy is dominated by traditional sectors, such as construction, food processing, rubber manufacturing, metallurgy, agriculture and mining, which

exhibit low productivity and limited added value, employing over 50% of the workforce. As a result, Serbia has failed to narrow the development gap with CEE countries over the past two decades, remaining at 60% of their average development level (Petrović, 2024). In contrast, countries like Croatia, Romania and Bulgaria have reached approximately 90% of the CEE average.

Serbia's GDP growth has been driven by increased employment, capital accumulation and some technological progress. High growth rate has primarily been the result of increased investments and employment, with minimal contributions from technological advancements, contrary to the CEE growth model, where technological progress serves as the primary driver. Investment and employment-based growth model is gradually becoming unsustainable due to unfavorable demographic trends.

Economic growth in Serbia has predominantly been fueled by investments, which in recent years have exceeded 20% of GDP. However, two-thirds of these investments have been initiated by the state through public institutions and enterprises, while foreign investors accounted for one-third. Domestic private enterprises have not contributed to this investment growth; their investments have declined, highlighting a significant structural imbalance. This raises the question of whether Serbia can sustain its current growth trajectory (Petrović, 2024). Domestic investments are largely concentrated in traditional sectors, reflecting a reluctance among investors to engage in riskier, high-tech projects that are prevalent in technologically advanced economies. Future growth must be based on the adoption of new technologies by domestic private sector, which requires an appropriate environment, including strong institutions, the rule of law and focus on education.

Investments represent a crucial immediate factor in economic growth, as their level and efficiency reflect the quality of economic policy and institutional frameworks. Investments also influence other drivers of economic growth, such as technological progress and employment. The impact of investments on economic growth depends on numerous factors, including macroeconomic and institutional environment, the openness of the economy, the intensity of competition and others. According to Levin and Renelt (1992), investments and economic openness are the most significant drivers of economic growth, while Mankiw et al. (1992) estimate that investments in physical capital account for approximately one-third of economic growth.

Three groups of factors determine differences in investment efficiency across countries. Institutions: these include the protection of property rights and equal

treatment of market participants. Structural Characteristics of the Economy: this encompasses the development of financial system, the openness of economic system, demographic characteristics of the population and similar factors. Economic Policy: this includes tax policy, inflation levels, public debt, wage dynamics, productivity and other related elements (Besley, 1995; Lim, 2014).

The most successful episodes of high GDP growth rates and economic convergence with developed countries in recent decades—such as Italy (1960–1980), Spain (1980–2009), Japan (1966–1997), South Korea (1988–2010) and Taiwan (1968–2008)—were primarily based on several common characteristics (Šoškić, 2024):

- Ambitious initial reform packages,
- Productivity growth,
- A significant increase in the share of investments in GDP and
- Development of financial system.

Economic development consists of two primary components: 1) Economic Growth and 2) Structural Changes in the Economy (Devetaković et al., 2010). Factors influencing economic development can be categorized into: 1. Basic or Primary Factors - these include population and its structure, the level and availability of natural resources and the size of the country; 2. Systemic Factors - these refer to the dominant forms of ownership, decision-making systems and coordination and management mechanisms; 3. Effects of Economic and Development Policies - these include policy interventions that shape economic performance and long-term development trajectories (Dragutinović et al., 2012).

One of the most critical missing factors explaining the poor performance of underdeveloped countries is social infrastructure. Social infrastructure includes "soft" factors that facilitate economic interactions, thereby enhancing the efficiency of all other factors. These factors encompass property rights, human rights and the rule of law. Additionally, public infrastructure serves as a key determinant that raises the production function, *ceteris paribus* (Burda & Wyplosz, 2012).

The most commonly used indicator of a country's economic performance is economic growth, measured by the increase in real GDP or real GDP per capita over a specific period. A growing economy signifies an increasing number of jobs, greater capacity to finance the public sector and improved population welfare. Economic efficiency refers to the effectiveness with which an economic system utilizes available resources (including knowledge) either in a specific

period (static efficiency) or over time (dynamic efficiency) (Gregory & Stuart, 2015).

Structural changes significantly influence the design and implementation of economic policy, which represents the deliberate effort by the state to achieve specific development objectives. Economic policy can either positively or negatively impact changes in the economic structure, steering it closer to or further away from its optimal configuration (Marjanović, 2015, p. 67). Therefore, it is crucial for the state to possess the capacity to shape and influence the economy's structure and the composition of individual sectors through appropriate economic policies. This requires effectively, continuously and proactively implementing structural changes in alignment with the available development factors (Mičić, 2016, pp. 153–161).

Data from Table 1 indicate that Serbia has achieved a higher average GDP growth rate compared to the average of CEE countries and the global average. However, it is important to consider that Serbia started from a very low baseline at the beginning of the 2000s. This low baseline was a direct consequence of the events during the 1990s, including international sanctions imposed by the UN Security Council, hyperinflation in 1992/93 and the 1999 NATO bombing. These factors left the Serbian economy severely devastated and disconnected from global economic flows.

Table 1: GDP in Serbia, CEE and World from 2001 to 2011, annual growth rates in %

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg.
Serbia	6,9	6,4	4,4	9,0	5,5	5,1	6,4	5,7	-2,7	0,7	2,0	4,44
CEE	3,1	3,6	4,1	5,8	5,0	6,6	6,4	1,9	-3,9	1,7	3,1	3,58
World	2,0	2,3	3,2	4,5	4,0	4,5	4,5	2,1	-1,3	4,5	3,3	3,04

Source: World Bank, database, <https://data.worldbank.org>, Statistical Office of the Republic of Serbia

Since 2012, Serbia's average GDP growth rate has fallen below the average of Central and Eastern European (CEE) countries and the global average (Table 2). This period was marked by two major global events that significantly impacted the economies of all nations: the 2008 global economic and financial crisis and the COVID-19 pandemic in 2020. Both events resulted in substantial reductions in economic activity worldwide. However, some countries suffered less due to the resilience and adaptability of their economies to external shocks.

For Serbia, the economic trajectory post-2000 was notably shaped by the privatization of state-owned enterprises. This process had significant effects on the country's development path. Privatization effectively became a process of deindustrialization, as buyers of production enterprises were not obligated to continue operations. A considerable portion of enterprise acquisitions was motivated by the favorable locations of these properties, with plans to repurpose them for commercial and residential real estate development in the future. This led to numerous negative consequences, including: a decline in GDP, increased unemployment and a decrease in the population's standard of living. Additionally, Serbia consistently faced a negative trade balance, characterized by higher imports than exports. The country's external debt has also shown a continuous upward trend over the years.

Table 2: GDP in Serbia, CEE and World from 2012 to 2023, annual growth rates in %

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Avg.
Ser.	-0,7	2,9	-1,6	1,8	3,3	2,1	4,5	4,3	-0,9	7,7	2,5	2,5	2,37
CEE	0,8	0,7	3,2	4,0	2,7	5,1	4,9	3,9	-3,4	6,5	4,1	0,5	2,72
Wor	2,7	2,8	3,1	3,1	2,8	3,4	3,3	2,6	-3,1	6,2	3,1	2,7	2,71

Source: World Bank, database, <https://data.worldbank.org>, Statistical Office of the Republic of Serbia

Investment Policy as a Driver of Economic Development

Investments are one of the key drivers of economic growth, with their efficiency reflecting the quality of a country's economic policies and institutions. Investments also impact other factors of economic growth, such as technological progress and employment. Differences in investment efficiency play a crucial role in determining the level of economic development among countries. The challenges of rational investment—efficient planning and execution of appropriate investment projects—are among the critical issues in economic development, as investment failures can have significant negative macroeconomic consequences. Macroeconomic policy must create a favorable investment climate to encourage domestic and foreign investments, thereby promoting overall economic and social development.

The efficiency of investments varies between countries depending on the quality of institutions, the structure of the economy and the policies implemented. In addition to foreign investments, domestic public and private investments play a

crucial role in economic development, as demonstrated empirically in many developed countries. Foreign direct investments (FDIs) can have numerous positive effects on the host country but may also bring negative consequences, particularly for economies overly reliant on them. This is especially true for FDIs that are primarily attracted by cheap labor and significant tax incentives or subsidies.

Beyond domestic savings, other factors influence the level of investments, including macroeconomic policies, institutional quality and economic structure. Economic policy positively affects private investments if it maintains macroeconomic stability, characterized by low inflation, stable exchange rates, low and relatively stable interest rates and the absence of risks related to public or private debt crises (Aizenman & Nancy, 1993). Fatas & Mihov (2013) argue that investment policy benefits more from consistent economic rules rather than discretionary government decisions. A stable and predictable policy framework enhances investor confidence, reduces uncertainty and fosters sustained economic growth.

Empirical studies have demonstrated that countries with higher domestic savings achieve greater investment levels and faster economic growth. Feldstein & Horioka (1981) established that differences in investment rates among countries closely correlate with differences in domestic savings rates. Similarly, Aizenman et al. (2007) found that developing countries finance approximately 90% of their capital investments through domestic savings. These studies also highlight that economies relying more on domestic savings for investment financing experience higher economic growth. High levels of domestic savings reflect strong institutions, a favorable business environment and sound economic policies. Aghion et al. (2006) underscore the importance of domestic savings in developing countries, emphasizing that it facilitates the adoption of advanced technologies critical for economic modernization.

Developing economies often base their growth strategies on foreign direct investments (FDIs), which provide various advantages: access to advanced technologies unavailable domestically, integration into international markets (particularly through global multinational corporations), and improvements in managerial practices and workplace discipline (Filipović & Nikolić, 2017).

However, insufficient total investments negatively impact labor productivity, employment and future real wages, fostering emigration trends. To boost total investments, it is essential to increase productive public investments and use economic policy to create systemic incentives for both savings and investments.

In Serbia's transition period, FDIs were predominantly realized through privatization rather than greenfield investments, leading to less transformative effects on the economy (Maksimović & Kostić, 2019).

Data from Table 3 reveal that investment rates in Serbia from 2001 to 2011 were significantly lower than the average for Central and Eastern European (CEE) countries and the global average. This disparity has substantially influenced Serbia's GDP trends compared to peer economies.

Table 3: Gross investments in Serbia, CEE and World from 2001 to 2011, as a part of GDP in %

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg.
Ser.	12,2	15,1	17,1	19,5	19,4	21,2	23,8	23,7	18,7	17,7	17,5	18,72
CEE	23,5	22,7	27,8	22,9	23,5	24,7	27,1	27,4	23,6	22,2	22,6	24,36
Wor.	23,3	22,6	22,7	23,1	23,6	24,0	24,2	23,5	23,5	23,4	23,9	23,5

Source: World Bank, database, <https://data.worldbank.org>

In Serbia, there are frequent changes in economic policy, with a large number of laws being passed through expedited procedures, often without necessary public consultations. This creates uncertainty in business operations and increases risks, which negatively affects investment decisions. Furthermore, an important cause of low domestic investments in Serbia is weak institutions. These institutions create so-called non-commercial risks, such as weak protection of property rights, frequent changes in regulations and similar factors. Characteristics of weak institutions include complicated bureaucratic procedures, high levels of corruption, a large informal economy and unequal treatment of investors, all of which contribute to increased investment costs and, consequently, a lower volume of investments. In such an environment, investors are forced to spend a significant portion of their time and resources on non-productive activities, such as lobbying, which results in a reduction of resources available for investment.

After 2011, Serbia saw a gradual increase in the investment-to-GDP ratio, which for the period 2012-2023 was 19.54%, approaching the CEE average of 21.34%, but still significantly lower than the global average of 25.27%. Since 2019, Serbia's investment rate has been higher than the CEE countries, but it is still insufficient to significantly reduce the development gap. Economic literature suggests that Serbia would need an investment rate of at least 25% of GDP to catch up with the developed world. A key factor in achieving sustainable growth is the sectoral structure of investments, particularly a higher share of domestic private investments in total investments. A greater role for domestic investment

would significantly increase the competitiveness of the domestic economy and create the basis for long-term sustainable development in the global market.

Table 4: Gross investments in Serbia, CEE and World from 2012 to 2023, as a part of GDP in %

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Avg.
Serb.	20,2	16,5	15,9	17,0	17,1	17,7	20,0	22,5	21,4	22,5	24,2	19,54
CEE	22,0	21,3	21,6	22,2	20,4	20,5	21,1	21,8	21,2	21,1	21,5	21,34
Wor.	24,4	24,5	24,8	25,0	24,8	25,0	25,4	25,7	25,8	26,4	26,2	25,27

Source: World Bank, database, <https://data.worldbank.org>

Conclusion

Frequent changes in economic policy are characteristic of Serbia, creating uncertainty in business operations, increasing business risks and negatively impacting investment decisions. A major cause of low domestic investment in Serbia is weak institutions, which create so-called non-commercial risks, such as weak protection of property and contract rights, frequent changes in regulations and similar issues. Economic literature suggests that Serbia needs to achieve an investment rate of at least 25% to catch up with the developed world. The sectoral structure of investments is also crucial, particularly the increased participation of domestic private investments in total investments. This would significantly enhance the competitiveness of domestic economy and create the conditions for long-term sustainable development in the global market.

Investments represent one of the key elements of economic policy, as their implementation creates the conditions not only for economic development but also for the stability of economic and social flows. Less developed countries, such as Serbia, should base their economic development, among other things, on structural adjustment through increased investments. The economic structure of investments determines the productive structure of the national economy, imports, exports, employment and other key macroeconomic indicators. Therefore, ensuring a favorable investment climate is an important part of developmental economic policy, which includes a sound legislative framework, an efficient and non-corrupt judiciary, minimal bureaucratic obstacles to investments, good physical infrastructure, skilled and qualified workforce.

References

1. Aghion, P., Diego, C., Howit, P., (2006), „When Does Domestic Saving matter for Economic Growth?“, Working Paper 12275 NBER

2. Aizenman, J., Nancy, M., (1993) Policy Uncertainty, Persistence and Growth, *Review of International Economics* 1:145-63.
3. Arandelović, Z. (2004). Nacionalna ekonomija, Ekonomski fakultet, Niš
4. Arsić, M., Gligorić, M. M., (2024) Uticaj fundamentalnih faktora na rast privrede Srbije, Naučni skup: Ekonomija: privredni razvoj Srbije i njegove determinante, SANU, Beograd
5. Bajec, J., Joksimović, L. (2004). Savremeni privredni sistemi, Ekonomski fakultet, Beograd
6. Baldwin, R., Braconier, H., & Forslid, R. (2005). Multinationals, endogenous growth and technological spillovers: Theory and evidence. *Review of International Economics*, 13(5), 945- 963. doi: 10.1111/j.1467-9396.2005.00546.
7. Bek, U. (2003). Virtuelni poreski obveznici, u: Globalizacija–Mit ili stvarnost, Sociološka hrestomatija (priredio Vuletić Vladimir), Beograd, Zavod za udžbenike i nastavna sredstva
8. Besley, T., (1995) „Property Rights and Investment Incentives: Theory and Evidence from Ghana“, *Journal of Political Economy*, Vol. 10, No 5.
9. Burda, M., Viploš, Č., (2012) Makroekonomija, Evropski udžbenik, Ekonomski fakultet, Beograd
10. Cvetanović, S. (2004). Teorija privrednog razvoja, Ekonomski fakultet, Niš
11. Devetaković S., Jovanović Gavrilović B., Rikalović G. , (2010), Nacionalna ekonomija, Ekonomski fakultet, Beograd
12. Dragutinović, D., Filipović, M., Cvetanović, S., (2012) Taorija privrednog rasta i razvoja, Ekonomski fakultet, Beograd
13. Drašković, V. (2003). Kontrasti globalizacije, Beograd, Kotor; Ekonomika, Fakultet za pomorstvo.
14. Đurić-Kuzmanović, T. (2001). Ekonomika Jugoslavije: ekonomika razvoja i tranzicije, Alef, Novi Sad
15. Fatas, A., Mihov, I., (2013), „Policy Volatility, Institutions, and Economic Growth“, *The Review of Economics and Statistics* 95(2): 362-376.
16. Feldstein, M., Hariooka, C., (1981), „Domestic Saving and International Capital Flows“, *the Economic journal* 90(358), pp. 314-329.
17. Filipović, M., Nikolić, M.,(2017), Razvojna politika Srbije u 2017.- predlozi za promenu postojeće politike podsticaja, Zbornik radova: Ekonomska politika Srbije u 2017. godini, Naučno društvo ekonomista Srbije i Ekonomski fakultet Beograd, str. 157-177.
18. Gregori, R. P., Stjuart, C. R., (2015) Globalna ekonomija i njeni ekonomski sistemi, Ekonomski fakultet, Beograd
19. Hausmann, R., Hidalgo, C. A., Bustos, S., Coscia, M., & Simoes, A. (2014). *The Atlas of Economic Complexity: Mapping Paths to Prosperity*, Mit Press.

20. <https://data.worldbank.org>, pristup: decembar 2024.
21. Ilić, B. (2005). Razvojne šanse zemalja u tranziciji u uslovima „nove ekonomije”, Institucionalne promene kao determinanta privrednog razvoja Srbije, Ekonomski fakultet, Kragujevac
22. Jovanović Gavrilović, B. (2010). Serbia Economic Growth Quality–Critical Analysis, ECONOMIC GROWTH AND DEVELOPMENT OF SERBIA NEW MODEL
23. Kitanović, D., Golubović, N., Petrović, D. (2008). Osnovi ekonomije, Ekonomski fakultet, Niš
24. Leković, V. (2008). Komparativni ekonomski sistemi, Ekonomski fakultet, Kragujevac
25. Levine, R., Renelt, D., (1992), „ A Sensitivity Analysis of Cross-Country Growth Regressions,” American Economic review, American Economic Association, vol. 82(4) p. 942-963, September.
26. Lim, J. J., (2014), „ International and Structural Determinants of Investment Worldwide“, Journal of Macroeconomics, vol. 41(C), p 160-167.
27. Madžar, Lj. (2002). Teorija proizvodnje i privrednog rasta, I tom, Savezni sekretarijat za razvoj i nauku, Beograd
28. Maksimović, Lj., Kostić, M., (2019), „Dinamika i implikacije odnosa stranih direktnih investicija i tekućeg bilansa odabranih zemalja Balkana“, Zbornik radova Ekonomska politika Srbije u 2019. godini, Naučno društvo ekonomista Srbije, SANU i Ekonomski fakultet Beograd, str. 61-74.
29. Mankiw, N. G., Romer, D., David, W., (1992), A Contribution to the Empirics of Economic Growth, Quarterly Journal of Economics, 107(2), 407-437.
30. Marjanović, V. (2015). Strukturne promene i strukturna transformacija u savremenoj razvojnoj ekonomiji. Ekonomske teme, 53(1), 65-84.
31. Mesarić, M. (2002). Uloga države u savremenim tržišnim privredama, Makroekonomsko planiranje i tranzicija, Beograd
32. Mičić, V. (2016). Strukturne promene i konkurentnost prerađivačke industrije Republike Srbije, U: V. Marinković, V. Janjić, i V. Mičić, (Red.). Unapređenje konkurentnosti privrede Republike Srbije (str. 153-161). Kragujevac, Republika Srbija: Ekonomski fakultet Univerziteta u Kragujevcu.
33. Ministarstvo finansija (2011) Izveštaj o razvoju Srbije 2010. Beograd.
34. Petrović, P., Berčerević, B., Minić, S., (2024) Privredni rast Srbije: determinante i budući izgledi, Naučni skup: Ekonomija: privredni razvoj Srbije i njegove determinante, SANU, Beograd
35. Pokrajac, S. (2002). Tehnologija, tranzicija i globalizacija, Beograd

36. Rosić, I. (2002). Rast, strukturne promene i funkcionisanje privrede, Komino trade, Kraljevo
37. Šoškić, D., (2024) Tržište kapitala kao faktor rasta investicija i privrednog razvoja u Srbiji, Naučni skup: Ekonomija: privredni razvoj Srbije i njegove determinante, SANU, Beograd
38. Timmer, C. P., & Akkus, S. (2008). The structural transformation as a pathway out of poverty: Analytics, empirics and politics. Working Paper, No. 150.
39. UNIDO. (2013). Industrial Development Report 2013, Sustaining Employment Growth: The Role of Manufacturing and Structural Change. United Nations Industrial Development Organization
40. Veselinović, P. (2006). Oživljavanje privredne aktivnosti u uslovima globalnih ekonomskih promena, Ekonomske teme, br. 1-2, Niš
41. Vukotić, V. (2001). Makroekonomski računi i modeli, CID, Podgorica

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ASSESSING PROGRESS OF RURAL TOURISM DEVELOPMENT: IMPACT OF THE COMPLEXITY OF SOCIAL SUSTAINABILITY INDICATORS

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Abstract

This scientific paper explores the intricate dynamics of rural tourism development, focusing on the social sustainability indicators that influence the progress of rural communities. Focusing on Western Serbia, this research delves into the social sustainability indicators influenced by rural tourism. This study relied on structured surveys conducted among residents of the popular ethno villages – Koštunići, Vraneša, Sunčana reka, and Sirogojno. Utilizing a Likert scale, participants rated their perceptions on social sustainability indicators and gender-related dynamics. Statistical analyses, including Chi-Square Tests, were utilized to explore associations between social indicators and the gender of the participants. Examining family conflicts, trust, generosity, personal appearance, information use, social responsibility, confidence, and women's health, the study uncovers positive shifts in community well-being. The study emphasizes the pivotal role of social sustainability in evaluating the impact of rural tourism on community well-being and underscores the need for a comprehensive understanding of social dynamics to ensure the success of sustainable rural tourism initiatives.

Keywords: rural tourism, sustainable tourism, social sustainability indicators, Western Serbia

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Introduction

The dynamism of contemporary societies has propelled rural tourism to the forefront of sustainable development discussions. As urban landscapes grapple with challenges such as congestion, environmental degradation, and the strain on

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resources, rural areas have become focal points for alternative and sustainable development strategies. As it becomes a more influential industry, Jasrotia & Gangotia (2018) highlight its significant importance within the economic and social realms of most destinations. Tourism, particularly in rural settings, is a multifaceted instrument capable of stimulating economic growth, preserving cultural heritage, and fostering community well-being. However, the success of rural tourism ventures depends not only on economic factors but also on the intricate web of social dynamics that shape the fabric of local communities.

Within the realm of tourism, rural tourism emerges as a pivotal contributor to the social progress of rural communities (Bouzarjomehri et al., 2022). As rural tourism development continues to gain momentum as a driver of sustainable development, understanding its impact on social sustainability becomes imperative. Social sustainability, which Hussain et al. (2023) clarify that it pertains to principles such as equal opportunities, elevated quality of life, and the advancement of sustainable human development. In other words, it can be seen as an indispensable dimension of the overall sustainability paradigm and encompasses a spectrum of factors that collectively contribute to the well-being of individuals and communities. According to Pérez et al. (2017), indicators for sustainable rural tourism development should encompass aspects of social sustainability, focusing on enhancing the quality of life for residents and communities. Examining social indicators, as suggested by Yuedi et al. (2023), provides insights into residents' sentiments toward tourism, facilitating the development of tourism in a way that prioritizes the safety of residents and avoids disrupting their everyday lives. Hwang et al. (2012) highlight that it is essential to address the issue of emigration and enhance the social sustainability of the community. The confirmation of this may be found in the findings of Soltani Moqadas & Taleshi (2020) who conclude that among the various aspects of social sustainability, maintaining a stable population is of utmost importance, especially considering the job opportunities emerging from the tourism sector. Campón-Cerro et al. (2017) emphasize that preserving and nurturing the local traditional culture is crucial, as rural tourism has the potential to harm it, and doing so promotes social sustainability. Understanding the intricacies of social sustainability is imperative for evaluating the progress and impact of rural tourism development initiatives. Yu et al. (2023) understand social factors as factors that comprise a range of human activities, encompassing aspects such as sanitation, the quality of living environments, educational settings, and overall living conditions. On the other hand, Bouzarjomehri et al. (2022) see social development as a possibility for enhancing the social well-being of rural women. Another dimension of social indicators is presented by Firza et al. (2023) who observe and introduce the indicators of social well-being of the destination encompassing the availability of a range of local services. Kang et al. (2012) add that indicators for sustainable rural tourism development should encompass

aspects of social sustainability, focusing on enhancing the quality of life for residents and communities, while Utami et al. (2023) see the benefits of cooperation of the local residents in creating entrepreneurship opportunities in rural area. Finally, social sustainability indicators serve as crucial metrics for evaluating the impact of rural tourism development on the well-being of individuals and communities and it would serve as a main motive of examination in this paper.

In this study, we delve into the complexities of social sustainability through an examination of specific indicators, namely family conflicts, trust in people, generosity, personal appearance, information use, social responsibility, confidence, and women's health. The main focus of the study will be the examination of relationships between gender and the abovementioned social sustainability indicators, unraveling the complexities that underlie the dynamics of rural tourism development.

This paper focuses on Western Serbia, an area renowned for its picturesque landscapes, traditional way of life, and rural scenery. Western Serbia presents a distinctive combination of natural beauty, cultural heritage, and the warm hospitality of rural communities. The region boasts geographical diversity, featuring rolling hills, fertile plains, and pristine rivers that serve as a vibrant backdrop for various rural tourism activities such as hiking, fishing, agrotourism, and cultural events. Additionally, its proximity to national parks and protected areas enhances its allure as a rural tourism destination. The study area encompasses four tourist villages: Koštunići, Vraneša, Sunčana reka, and Sirogojno. These villages have embraced tourism as a means to diversify their economies while safeguarding their cultural and natural heritage. Visitors to these villages can engage in authentic experiences, explore traditional craftsmanship, and immerse themselves in the local way of life. The study aims to analyze the dynamics of rural tourism in these villages and evaluate its impact on the quality of life for the local communities.

The research findings indicate that in the observed rural areas of Western Serbia, tourist activities have yielded positive social effects on the lives of the local population. Furthermore, the changes brought about by the development of tourism have significantly influenced social conditions, perspectives, and established practices among the residents.

Methodology

Study area

The research area comprises four tourist villages in western Serbia: Koštunići, Vraneša, Sunčana reka, and Sirogojno.

By observing the same area Panić et al. (2024) provided more insights about the

selected villages. Koštunići, positioned 32 kilometers northwest of Gornji Milanovac, is a rural settlement primarily dedicated to cattle breeding, with a dispersed layout. Situated on the southern inclines of Suvobor, a summit with an elevation of 866 meters, as documented by Čulić 2006). Notably, it stands out as the most extensive rural settlement in the Gornji Milanovac municipality in terms of land area Pavlović, 2016). The village is surrounded by four mountain rivers, providing habitats for diverse river fish and crab species Milošević, 2006). Known for its outstanding ecological and scenic attributes, Jovanović Tončev 2016) additionally points out features of valleys in Koštunići with well-defined agrarian, forest, and meadow ecosystems, making it the sole ecological village in Serbia.

Vraneša, located in the Zlatibor region near the town of Nova Varoš, is an ethno-eco village situated within a coniferous forest. The village with traditional bungalow-style accommodation, at an elevation of 943 meters, offers picturesque views of Zlatar Lake Svojić, 2015). Constructed in adherence to traditional Serbian village architecture, using environmentally friendly materials like black pine and stone, Vraneša is surrounded by lush greenery, rolling hills, and pristine rivers. According to Svojić 2015), it is a favored destination for outdoor enthusiasts seeking natural beauty, trekking, and immersion in local culture.

Sunčana Reka, situated on the banks of the Drina River near Loznica, offers a picturesque setting surrounded by natural beauties like Banja Koviljača and the historically significant Gučevo mountain. According to Stepanović 2015), the tourist complex comprises seven accommodation settlements with various facilities, including sports and recreational activities such as horseback riding, ball sports, and Drina-based recreational activities.

Sirogojno, located on Zlatibor, operates as an open-air museum named "Staro selo" Old Village). Showcasing the life of Serbian peasants and forgotten crafts and skills through its unique construction architecture and interior decoration, Sirogojno covers an area of 5 hectares and includes approximately 50 buildings relocated from surrounding Zlatibor villages Đenić, 2008). Positioned near one of the largest Serbian mountaineering centers, Ranko 1987) emphasizes the fact that Sirogojno offers a glimpse into the hilly and mountainous areas of the Dinaric region.

Sources of data

In this research, we relied on the perspectives of the local community to evaluate the sustainable social impacts of tourism on their quality of life. The choice to focus on the social aspect of the research is driven by the recognition that tourism, particularly in rural areas, has profound implications for local communities beyond economic considerations. Understanding and addressing the social dimensions are crucial for ensuring sustainable and responsible tourism development. Social sustainability encompasses factors such as

community well-being, cultural preservation, and the equitable distribution of benefits among residents.

We adapted our research methodology from Monterrubio et al. 2020), who sought insights from the local population regarding the primary effects of tourism development in rural areas. Our objective was to convey the local community's viewpoints on the repercussions of tourism development, specifically the transformation of ethnic villages and objects into tourist attractions, on the quality of life in the surrounding villages. With a specific emphasis on gender roles and their influence on overall quality of life, positive outcomes were anticipated. Spanning from May 2022 to May 2023, our study encompassed the local population of eco-ethno villages in Western Serbia—Koštunići, Vraneša, Sunčana reka, and Sirogojno. A total of 469 participants took part, providing ratings on a 1-5 ordinal scale, where 1 represented the most negative impact, 5 the most positive, and 3 indicated no change. A Likert scale was utilized to measure the gradation of attitudes.

The primary goal of the study was to evaluate the significance of specific attitudes within social dimensions, aiming to mitigate negative aspects and highlight positive elements in the development of rural destinations. Our focus centered on variables presumed to exert the most substantial influence on the quality of life for the local population. The examined dependent variable was economic impacts Family conflicts, trust in people, generosity, personal appearance, information used, confidence, social responsibility and women's health). Among the independent variables, "Gender" was integrated into the study. Chi-Square Tests were employed to explore potential associations between variables and the likelihood of connection. The initial assumption posited that there would be no disparity in responses based on the gender of the participants, and statistically significant differences were defined as those with p-values less than 0.05.

From this point, the following primary and supporting hypotheses can be formulated:

H1: The economic development of ethno villages in Western Serbia is significantly influenced by key social indicators, including family conflicts, trust in people, generosity, personal appearance, information used, confidence, social responsibility, and women's health

H2: Women's health has been significantly improved as a result of more women's involvement in the entrepreneurship life of rural tourism.

Results

The largest number of respondents noticed a decrease in the number of family conflicts Table 1). Constant stress caused by economic pressure ultimately

results in family conflicts, disorder, and unstable relationships Fine & Fincham, 2013). Nevertheless, these results indicate that with the increase in economic well-being that comes as a result of the creation of a direct or indirect tourist offer, the level of stress and family conflicts decreases.

Table 1. Family conflicts

			Gender		Total
			Male	Female	
Family conflicts	Greatly decreasing	Count	55	40	95
		% of Total	11,8%	8,5%	20,3%
	Decreasing	Count	136	110	246
		% of Total	29,1%	23,5%	52,6%
	No change	Count	65	62	127
		% of Total	13,9%	13,2%	27,1%
Total		Count	256	212	468
		% of Total	54,7%	45,3%	100,0%

Source: Authors’ research

The Chi-Square Test for family conflicts and gender produced a p-value of 0.589, indicating no significant relationship Table 2). This means that the results presented in the previous table are equally distributed according to gender, that is, that both genders react equally to changes related to the aspect of family conflicts.

Table 2. Pearson Chi-Square Test

	Value	df	Statistical significance p)
Pearson Chi-Square Test	1,060 ^a	2	,589

Source: Authors’ research

Both males and females reported an increase in trust in people 72.2% (Table 3), with a slightly higher representation of males. Rural tourism development has led to a notable increase in trust among people, fostering a stronger sense of community and cooperation within rural areas. In addition to the trust that is increasingly developing between the representatives of the tourist offer and tourists, the trust that these results can indicate is also related to tourism institutions. Having trust in individuals underscores the importance of tourism organizations in the advancement of tourist villages through the dissemination of comprehensive and transparent information to the entire community regarding the management of tourism (Prayitno et al., 2023).

Table 3. Trust in people

			Gender		Total
			Male	Female	
Trust in people	No change	Count	60	70	130
		% of Total	12,8%	15,0%	27,8%
	Increasing	Count	141	103	244
		% of Total	30,1%	22,0%	52,1%
	Greatly increasing	Count	55	39	94
		% of Total	11,8%	8,3%	20,1%
Total		Count	256	212	468
		% of Total	54,7%	45,3%	100,0%

Source: Authors' research

P-value of 0.070, indicating no significant relationship between gender and trust in people (Table 4). This means that both genders equally develop trust in people under the influence of tourist activities and experiences.

Table 4. Pearson Chi-Square Test

	Value	df	Statistical significance p)
Pearson Chi-Square Test	5,321 ^a	2	,070

Source: Authors' research

Both males and females reported an increase in generosity (74,8%), with a slightly higher representation of males. The income generated from tourism often gets reinvested in the community, supporting various local initiatives and community projects. That includes home renovations, emergencies, helping others, etc. (Passafaro et al., 2017). Rural tourism, therefore, not only revitalizes these areas but also brings about a cultural renaissance, instilling a greater sense of generosity and welcoming spirit among the local population.

Table 5. Generosity

			Gender		Total
			Male	Female	
Generosity	No change	Count	48	70	118
		% of Total	10,3%	15,0%	25,2%
	Increasing	Count	130	101	231
		% of Total	27,8%	21,6%	49,4%
	Greatly increasing	Count	78	41	119
		% of Total	16,7%	8,8%	25,4%
Total		Count	256	256	212
		% of Total	54,7%	54,7%	45,3%

Source: Authors' research

The results of the Chi-Square Test indicate that there is a statistically significant relationship between gender and the reported level of generosity (Table 6). This means that the level of generosity differs significantly between males and females in the sample. Based on the results of the Chi-Square Test, it appears that females tend to be more generous than males. A significantly larger number of women did not notice the difference in this aspect with the advent of rural tourism, unlike men.

Table 6. Pearson Chi-Square Test

	Value	df	Statistical significance p)
Pearson Chi-Square Test	15,245 ^a	2	,000

Source: Authors’ research

Despite similar opinions by both genders, a slightly higher proportion of males reported an increase in personal appearance perceptions compared to females (Table 7). Respondents commonly attribute the flourishing tourism industry to their enhanced sense of personal appearance, as they are eager to present the rich cultural heritage of their region to the world. In addition, local respondents frequently highlight the positive impact of rural tourism on their self-esteem and overall well-being. For example, some research highlights the emphasis for residents in an Eastern European setting lies more in the pride and self-esteem gained from psychological empowerment and the sense of improved community cohesion, rather than the economic promises presented by tourism (Strzelecka et al., 2017).

Table 7. Personal appearance

			Gender		Total
			Male	Female	
Personal appearance	No change	Count	51	51	102
		% of Total	10,9%	10,9%	21,8%
	Increasing	Count	124	103	227
		% of Total	26,5%	22,0%	48,5%
	Greatly increasing	Count	81	58	139
		% of Total	17,3%	12,4%	29,7%
Total		Count	256	212	468
		% of Total	54,7%	45,3%	100,0%

Source: Authors’ research

The Chi-Square Test (Table 8) for personal appearance and gender produced a value of 1.626 with a p-value of 0.444, indicating no significant relationship between gender and personal appearance perceptions.

Table 8. Pearson Chi-Square Test

	Value	df	Statistical significance p)
Pearson Chi-Square Test	1,626 ^a	2	,444

Source: Authors’ research

In the context of "other" social impacts, rural tourism has a significant impact, with a notable gender difference favoring males (Table 9). This data tells us that the development of rural tourism has contributed to a better experience of the local population in those sociological aspects that were not individually analyzed previously. Other social aspects may include linking stakeholders, safeguarding and passing on knowledge, protecting cultural heritage, reinforcing identity, promoting intergenerational communication, and more (Topole, et al., 2021).

Table 9. Information use

		Gender		Total
		Male	Female	
Information use	No change	9	3	12
	Better	19	4	23
	Much better	228	205	433
Total		256	212	468

Source: Authors’ research

The Chi-Square Test (Table 10) examining the relationship between gender and information use shows significance in this relationship. The low p-value of 0.007 suggests that the observed relationship is unlikely to have occurred by random chance alone, providing evidence of a significant association between gender and information used in the analyzed dataset. In today's digital age where the Internet plays a central role in information dissemination, it becomes important to explore the frequency of internet usage across different genders. Some research, as outlined by Wasserman & Richmond- Abbott (2005), indicates that women tend to visit fewer websites and use the Internet less frequently than men. This difference is believed to be even more emphasized in rural areas given the traditional roles between the genders.

Table 10. Pearson Chi-Square Test

	Value	df	Statistical significance p)
Pearson Chi-Square Test	9,956a	2	,007

Source: Authors’ research

In terms of social responsibility, results (Table 11) show much better conditions in this domain among both genders after the emergence of rural tourism activity in the observed destinations. This applies not only to individuals from the local environment but also to the way of relationships in the business environment, especially among local entrepreneurs. Those phenomena are noted also by Cheng & Fallon (2023), who highlighted that entrepreneurs can contribute through a variety of advantages, offering not just economic but also cultural, environmental, and social benefits to communities.

Table 11. Social responsibility

		Gender		Total
		Male	Female	
Social responsibility	No change	11	9	20
	Better	31	13	44
	Much better	214	190	404
Total		256	212	468

Source: Authors’ research

According to the results of the Chi-Square Test (Table 12), there is no statistical significance when it comes to the relationship between gender and social responsibility. It indicates that both genders equally perceive differences in the positive change of social responsibility among the local population due to the development of rural tourism.

Table 12. Pearson Chi-Square Test

	Value	df	Statistical significance p)
Pearson Chi-Square Test	4,896a	2	,086

Source: Authors’ research

The local population is more confident in its capabilities and potential after rural tourism is imposed in the observed areas (Table 13). According to Yan (2021), the core of regional characteristics forms the bedrock for the self-assurance of local culture, enhancing the cultural allure and cohesiveness of rural life landscapes. Moreover, the same author (Yan, 2021) adds that it plays a pivotal role in

bolstering the local culture's confidence and acts as a driving force, prompting young individuals to return to their hometowns for constructive engagement.

Table 13. Confidence

		Gender		Total
		Male	Female	
Confidence	No change	8	5	13
	Better	20	6	26
	Much better	228	201	429
Total		256	212	468

Source: Authors’ research

According to the results of Table 14, there is no statistically significant relationship between the increase in confidence and gender. The reason for that may be found in the fact that both men and women evaluate and perceive their level of confidence based on the success of their local businesses. Some authors, including Sofer et al. (2023) notice that smaller enterprises, including micro-businesses and small businesses, were less prone to express 'high confidence' in business survival when compared to their larger counterparts.

Table 14. Pearson Chi-Square Test

	Value	df	Statistical significance p)
Pearson Chi-Square Test	5,845a	2	,054

Source: Authors’ research

When talking about the issue of women's health among the local population, the research results (Table 15) indicate a significantly better state of women's health after rural tourism became an important factor in the local economy of the observed destinations. Jobs in the tourism sector, according to Alrwajfah et al. (2020) are appropriate for women and should not compromise their health or dignity. The issue of mental health is particularly important. Females exhibit a greater number of depressive symptoms than males (Nikpour et al., 2018), but having more opportunities for self-actualization while working in the tourism sector their level of stress and depression might decrease.

Table 15. Women's Health

		Gender		Total
		Male	Female	
Women's Health	No change	9	4	13
	Better	19	8	27
	Much better	228	200	428
Total		256	212	468

Source: Authors’ research

Although women experience a disproportionate impact on their health profiles, displaying lower overall health indicators compared to men, particularly in rural areas (Giri, 2023), the Chi-Square Test shows no statistical significance between gender and women’s health. It shows that not only women, but men as well understand the importance and realize the difference in women’s health conditions before and after rural tourism became established.

Table 16. Pearson Chi-Square Test

	Value	df	Statistical significance p)
Pearson Chi-Square Test	4,136a	2	,126

Source: Authors’ research

Discussion and Conclusion

In conclusion, the contemporary dynamism of societies has positioned rural tourism as a pivotal component in discussions surrounding sustainable development. As urban areas grapple with challenges such as congestion, environmental degradation, and resource strain, rural locales have emerged as focal points for alternative and sustainable development strategies. Rural tourism, especially in such settings, emerges as a versatile instrument capable of not only driving economic growth but also preserving cultural heritage and enhancing community well-being. Nevertheless, the success of rural tourism ventures is contingent not only upon economic factors but also on the intricate web of social dynamics shaping the fabric of local communities.

Social sustainability, an indispensable facet of the broader sustainability paradigm, encompasses a spectrum of factors contributing collectively to the well-being of individuals and communities. A nuanced understanding of social sustainability is imperative for evaluating the progress and impact of rural tourism development initiatives. This paper has delved into the intricate relationship between gender and various social sustainability indicators, unraveling the complexities underlying the dynamics of rural tourism development.

As rural tourism gains traction, it is essential to critically examine its impact on the social fabric of host communities. This requires an exploration of the intricate interplay between various social dimensions, including familial relations, interpersonal trust, individual attitudes, and health considerations. The lens through which these dimensions are assessed is not uniform but varies based on the social and cultural context of each community. Therefore, a comprehensive evaluation of rural tourism development necessitates a nuanced understanding of the diverse factors contributing to social sustainability.

Social sustainability indicators serve as crucial metrics for evaluating the impact of rural tourism development on the well-being of individuals and communities. These indicators encompass a broad spectrum of elements that capture the essence of social life, ranging from interpersonal relationships to personal well-being. In this study, we delved into the complexities of social sustainability through an examination of specific indicators, namely family conflicts, trust in people, generosity, personal appearance, information use, social responsibility, confidence, and women's health.

In the context of rural tourism development as a driver of sustainable progress, understanding its impact on social sustainability becomes imperative. By scrutinizing family conflicts, trust in people, generosity, personal appearance, information use, social responsibility, confidence, and women's health, we aim to provide a nuanced understanding of the intricate web of social dynamics influenced by tourism activities. The inclusion of gender as an independent variable adds a layer of complexity to our analysis, recognizing the diverse experiences and roles of men and women in rural communities.

Analyzing the results, a notable decrease in family conflicts was observed, underscoring the potential of rural tourism to alleviate economic stress and enhance family stability. Trust in people increased significantly, fostering a stronger sense of community and cooperation. Generosity also rose, indicating that income generated from tourism often reinvests in the community, supporting local initiatives. Personal appearance perceptions saw a slight increase, attributed to the positive impact of rural tourism on self-esteem and overall well-being.

The results underscore the positive impact of rural tourism on social responsibility, confidence, and women's health. Social responsibility conditions improved after the emergence of rural tourism, indicating a positive shift in individual and business relationships within the community. The local population exhibited increased confidence in its capabilities and potential, contributing to cultural allure and cohesiveness. Notably, women's health showed a significantly

better state after the integration of rural tourism, emphasizing the positive impact on mental health and well-being.

The findings of our study provide substantial evidence supporting Hypothesis 1. The economic development of ethno villages in Western Serbia is indeed significantly influenced by key social indicators. Family conflicts, as indicated by respondents, exhibited a notable decrease, aligning with the assumption that reduced conflict positively impacts economic development. Increased trust in people and generosity, particularly among males, suggests that the communal support fostered by these social indicators contributes positively to economic growth.

The slight increase in personal appearance perceptions among respondents further supports the hypothesis, emphasizing that a positive self-image can be linked to economic well-being. Additionally, the positive impact of rural tourism on social responsibility and confidence aligns with the notion that these factors contribute to the economic development of ethno villages. Women's health, a crucial aspect of social indicators, showed a significantly better state after the integration of rural tourism, indicating a positive correlation between women's health and economic development.

The outcomes of our study provide robust support for Hypothesis 2. Women's health exhibited a significantly better state after the integration of rural tourism as a vital factor in the local economy. The study indicates a positive association between women's increased involvement in the entrepreneurship aspects of rural tourism and improved health conditions. This aligns with existing literature emphasizing the appropriateness of jobs in the tourism sector for women, promoting their well-being and dignity.

While the results showcase positive outcomes, it is important to note that gender differences were observed in certain aspects. The level of generosity differed significantly between males and females, with women tending to be more generous. However, no significant relationship was found between gender and personal appearance perceptions, trust in people or social responsibility. Moreover, the study revealed that both genders equally perceived differences in positive changes related to family conflicts, confidence, and women's health.

In conclusion, rural tourism development holds promise as a catalyst for positive social change. The findings suggest that it not only contributes to economic growth but also fosters social sustainability by improving various indicators related to interpersonal relationships, community well-being, and individual health. However, the nuanced nature of these impacts, as influenced by gender

and other contextual factors, necessitates ongoing research and tailored strategies to ensure that rural tourism development is inclusive and beneficial for all members of the community. This study contributes to the growing body of knowledge on the intricate dynamics of rural tourism and its role in promoting sustainable development from a social perspective.

References

1. Bouzarjomehri, K., Akhlaghi, M., & Shayan, H. 2022. The Role of Tourism and Ecotourism Resorts in Empowering Rural Women Case Study: Razavi Khorasan Province. *Geography and Territorial Spatial Arrangement*, 1242: 147-170.
2. Campón-Cerro, A. M., Hernández-Mogollón, J. M., & Alves, H. 2017. Sustainable improvement of competitiveness in rural tourism destinations: The quest for tourist loyalty in Spain. *Journal of Destination Marketing & Management*, 63: 252-266.
3. Cheng, Y., & Fallon, J. 2023. Developing an Integrated Rural Tourism Model for Stakeholders in Yuanjia Village, China. *ABAC Journal*, 434: 205-222.
4. Čulić, L. 2006. Marketing strategija Suvoborske regije sa posebnim osvrtom na destinaciju Koštunići. Departman za geografiju, turizam I hotelijerstvo, Novi Sad. 181 (in Serbian).
5. Đenić, Z. 2008. Seoski turizam Zlatiborskog kraja. Departman za geografiju, turizam I hotelijerstvo, Novi Sad. 54. (in Serbian).
6. Fine, M. A., & Fincham, F. D. Eds.. 2013. *Handbook of family theories: A content-based approach*. Routledge.
7. Firza, N., Antonucci, L., Crocetta, C., d'Ovidio, F. D., & Monaco, A. 2023. Spatial Analysis to Investigate the Relationship Between Tourism and Wellbeing in Italy. *Social Indicators Research*, 1-17.
8. Giri, R. 2023. *ROLE OF MICRO FINANCE ON WOMEN'S EMPOWERMENT*. Doctoral dissertation, Department of Economics, TU Birendra Multiple Campus.
9. Hussain, S., Ahonen, V., Karasu, T., & Leviäkangas, P. 2023. Sustainability of smart rural mobility and tourism: A key performance indicators-based approach. *Technology in Society*. 102287.
10. Hwang, D., Stewart, W. P., & Ko, D. W. 2012. Community behavior and sustainable rural tourism development. *Journal of Travel research*. 513: 328-341.
11. Jasrotia, A., & Gangotia, A. 2018. Smart cities to smart tourism destinations: A review paper. *Journal of tourism intelligence and smartness*. 11: 47-56.
12. Jovanović Tončev, M. 2016. The importance of sustainable rural tourism development in Serbia. In *Sinteza 2016-International Scientific Conference*

- on ICT and E-Business Related Research. 575-581. Singidunum University.
13. Kang, S. K., Lee, C. K., Yoon, Y., & Long, P. T. 2008. Resident perception of the impact of limited-stakes community-based casino gaming in mature gaming communities. *Tourism management*. 29(4): 681-694.
 14. Milošević, S. 2006. Seoski turizam u selu Koštunići. Departman za geografiju, turizam i hotelijerstvo, Novi Sad. 55. (in Serbian).
 15. Nikpour, A., Rezghi, F., & Rineh, M. S. 2018. Spatial Analysis of Urban Form based on Building Density, Babol. *Geographical Urban Planning Research*. 62: 1-4
 16. Panić, A., Vujko, A. & Knežević, M. 2024 (Accepted for publishing in vol. 2, 2024). Rural tourism impact on the life quality of the local community: a case study of Western Serbia. *Economic of Agriculture*.
 17. Passafaro, P., Mura, M., Albanese, A., & Bocci, E. 2017. Potential preferences for alternative forms of sustainable tourism: The case of rural and intergenerational tourism. In *Ecotourism and Sustainable Tourism: Management, Opportunities and Challenges*. 29-84. Nova Science Publishers, Inc.
 18. Pavlović, S. 2016. Elements of tourist destinations: Example of Tourist-recreation centre in Koštunići. *Zbornik radova-Geografski fakultet Univerziteta u Beogradu*. 64: 453-480.
 19. Pérez, V. E., Santoyo, A. H., Guerrero, F., León, M. A., da Silva, C. L., & Caballero, R. 2017. Measuring the sustainability of Cuban tourism destinations considering stakeholders' perceptions. *International Journal of Tourism Research*. 19(3): 318-328.
 20. Prayitno, G., Dinanti, D., Wisnu Adrianto, D., Rahmawati, R., Auliah, A., & Eka Wardhani, L. 2023. The influence of social capital in improving the quality of life of the community in sidomulyo tourism village, Indonesia. *GeoJournal of Tourism and Geosites*. 46(1): 208-217.
 21. Ranko, F. 1987. Zlatiborska brvnara i muzej narodnog graditeljstva "Staro selo" u Sirogoinju. Beograd, Republički zavod za zaštitu spomenika kulture. 67. (in Serbian).
 22. Sofer, M., Shmuel, I., Amit-Cohen, I., Tchetchik, A., Shiff, S., & Michael, Y. 2023. COVID-19 and the impact on cultural tourism: The case of Beit She'an Valley, Israel. *Tourism Culture & Communication*.
 23. Stepanović, M. 2013. Turistička valorizacija opštine Loznica. Departman za geografiju, turizam i hotelijerstvo, Novi Sad, 33, in Serbian.
 24. Strzelecka, M., Boley, B. B., & Strzelecka, C. 2017. Empowerment and resident support for tourism in rural Central and Eastern Europe CEE: The case of Pomerania, Poland. *Journal of Sustainable Tourism*, 25(4): 554-572.
 25. Svojić, D. 2015. Analiza poslovanja etno eko sela Vraneša. Departman za

- geografiju, turizam I hotelijerstvo, Novi Sad. 100. (in Serbian).
26. Topole, M., Pipan, P., Gašperič, P., Geršič, M., & Kumer, P. 2021. Culinary events in the Slovenian countryside: Visitors' motives, satisfaction, and views on sustainability. *Acta geographica Slovenica*. 611: 107-125.
 27. Utami, D. D., Dhewanto, W., & Lestari, Y. D. 2023. Rural tourism entrepreneurship success factors for sustainable tourism village: Evidence from Indonesia. *Cogent Business & Management*. 101. 2180845.
 28. Wasserman, I. M., & Richmond- Abbott, M. 2005. Gender and the Internet: Causes of variation in access, level, and scope of use. *Social science quarterly*. 861: 252-270.
 29. Yan, W. 2021. Exploring the Traditional Farming Culture and Improving the Local Cultural Confidence: Solving the Problem of Rural Tourism Homogenization. In *E3S Web of Conferences*. 275: 02063. EDP Sciences.
 30. Yu, J., Yang, J., Li, J., Lin, L., & Ren, Y. 2023. The Role of Tourism in Promoting the Urbanization of Ethnic Border Areas: A Case Study of Xishuangbanna. *Sustainability*. 15 20: 15119.
 31. Yuedi, H., Sanagustín-Fons, V., Coronil, A. G., & Moseñe-Fierro, J. A. 2023. Analysis of tourism sustainability synthetic indicators. A case study of Aragon. *Heliyon*. 94.

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VEŠTAČKA INTELIGENCIJA U SLUŽBI SPROVOĐENJA ZAKONA U EVROPSKOJ UNIJI I REPUBLICI SRBIJI

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Apstrakt

Veštačka inteligencija od nedavno intenzivno pomera granice razvoja ljudske civilizacije i tehnološkog razvoja. Kao tehnološko dostignuće, ona se neprimetno „ušunjala“ u život svakog pojedinca i postala sastavni deo svih sfera društvenog života. U primeni veštačke inteligencije danas kao da ne možemo da se otmemo utusku da ono što je u jednom trenutku izgledalo moguće za sto godina, u stvari je postalo realnost u poslednjih desetak godina. Potreba za pravnom regulacijom i zakonskim uređenjem korišćenja veštačke inteligencije se nameće kao važno pitanje za njen budući razvoj u korist ljudske zajednice i celokupnog čovečanstva. Ovo istraživanje je deo šire slike o potencijalnoj upotrebi veštačke inteligencije u pojedinim granama prava, usmereno ka sagledavanju posebnog „interregnuma“ između uspostavljene prakse korišćenja veštačke inteligencije i njene pravne regulacije. U radu se posebno fokusiramo na analizu i istraživanje upotrebe sistema veštačke inteligencije u oblasti sprovođenja zakona. Tačnije, osvetličemo regulatorni proces vezan za veštačku inteligenciju u EU i ukazati na specifičnosti njene upotrebe u bezbednosne i policijske svrhe, pre svega uspostavljanjem ograničenja u korist javnosti i građana, kategorizacijom upotrebe pojedinih sistema veštačke inteligencije kao zabranjeni i visokorizični. Radi se o sistemima veštačke inteligencije koji koriste tehnike predviđanja, biometrijskog nadzora odnosno prepoznavanja lica i izvedenih biometrijskih podataka. Njihov uticaj na ljudska prava je predmet posebnog dubinskog istraživanja van ovog okvira, imajući u vidu da se nekontrolisana upotreba ovih tehnika kao deo sistema veštačke inteligencije danas može poistoveti sa posledicama bacanja „atomske bomba“ na čovekove slobode i prava. Osim regulatornog procesa unutar EU, ukazujemo i na potencijalnu upotrebu veštačke inteligenciju u Srbiji od strane službi za sprovođenje zakona kroz analizu pravnog okvira Republike Srbije.

Ključne reči: veštačka inteligencija, sprovođenje zakona, policijsko predviđanje, prepoznavanje lica, biometrijske tehnike

JEL: K33

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Uvod

Veštačka inteligencija je tehnološko dostignuće čija primena u svim oblastima ljudskog delovanja postaje neizbežna, kako globalno, tako regionalno i lokalno. Time na scenu stupa „trka“ za pravnu regulaciju i zakonsko uređenje korišćenja veštačke inteligencije kao ključno pitanje za njen budući razvoj u korist ljudske zajednice i celokupnog čovečanstva. Debate o potrebi, načinu i metodama pravne regulacije se odvijaju na raznim nivoima od međunarodnog, preko regionalnih organizacija i nacionalnog nivoa do privatnog sektora i tehnoloških giganta koji već čine dostupnim pojedine oblike veštačke inteligencije svim građanima na dnevnom nivou. Pravna regulacija se pre svega odnosi na razne aspekte primene veštačke inteligencije i može se posmatrati i kao uspostavljanje „pravne infrastrukture“ za njeno korišćenje, upotrebu, razvoj i monitoring u svim oblastima društvenog života.

Ovim radom autor istražuje pravnu regulaciju i potencijalnu upotrebu veštačke inteligencije u osetljivoj oblasti prava, usmeravajući se na sagledavanje već uspostavljene prakse za korišćenje veštačke inteligencije u sprovođenju zakona. Tačnije, osvetlićemo regulatorni proces vezan za veštačku inteligenciju u EU i fokusirati se na upotrebu veštačke inteligencije u bezbednosne i policijske svrhe, ukazujući na ograničenja uspostavljena u korist javnosti i građana koja se nameću službama za sprovođenje zakona kategorizacijom određenih postupanja kao zabranjena i visokorizična. Polazimo od pravne infrastrukture za veštačku inteligenciju koja se uspostavlja predloženom Uredbom EU o utvrđivanju usklađenih pravila o veštačkoj inteligenciji koja se često naziva i Zakon o veštačkoj inteligenciji ili Akt o veštačkoj inteligenciji.

Bezbednost i policijsko postupanje treba da obezbede ambijent, siguran i lišen bilo kog straha po svakog pojedinca, u kom su ljudska prava i osnovne slobode zaštićeni od maliciozne upotrebe veštačke inteligencije, imajući u vidu da službe za sprovođenje zakona poseduju systemska, diskreciona i javna ovlašćenja sa visokim stepenom rizika za potencijalnu zloupotrebu veštačke inteligencije. Veliki broj istraživanja na globalnom nivou ukazuje na opasnosti po ljudska prava i osnovne slobode u slučaju primene veštačke inteligencije u bezbednosne svrhe, posebno u slučajevima biometriskog prepoznavanja i otkrivanja nepoželjnog ponašanja pojedinaca. Osim regulatornog procesa unutar EU, sagledavamo i upotrebu veštačke inteligencije u ovoj oblasti u Srbiji kroz analizu pravnog okvira odnosno Strategije Republike Srbije i drugih nacionalnih akata mekog prava o veštačkoj inteligenciji (u daljem tekstu: VI).

Uspostavljanje pravne infrastrukture i definisanje zabranjenih i visokorizičnih sistema VI

Pravna infrastruktura je termin koji se koristi u novijim istraživanjima i označava uspostavljanje pravnog okvira i regulacija određene oblasti društvenog ponašanja

odnosno normiranje i donošenje pravnih akata kao osnova uređenja i stvaranja uslova za dalji razvoj te oblasti. Infrastrukture u običnom govoru se odnose na fizičke ili organizacione aspekte sveta koji su društvima potrebni da bi funkcionisala. Metafora prava kao infrastrukture nastaje u spajanju odnosno ozbiljnog shvatanja prava kao društveno-materijalni oblik, s jedne strane ostvaren kroz društveno delovanje, ali s druge značajno preoblikujući svet oko nas (Byrne, Gammeltoft-Hansen, 2023). Ovaj termin je odvojen i ne treba ga mešati sa stvarnom elektonskom, digitalnom i informatičkom infrastrukturom kao materijalnom bazom razvoja VI. Pravna infrastuktura u konkretnom slučaju naglašava značaj pravne regulacije i razumevanja neophodnosti za normativno uređenje korišćenja VI posebno ako potrebu, način i metode pravne regulacije shvatimo kao „uslov nad uslovima“ za funkcionisanje društva odnosno, kao infrastrukturnu pripremu i radove na definisanju ogromne oblasti koja organizacijski zahteva uspostavljanje savremenog pravnog „auto puta sa velikim dozvoljenim brzinama“. Bezbednost i sprečavanje rizika od ugrožavanja ljudskih života nameće i definisanje striktnih „ograničenja brzine i pojedinih obaveznih pravaca kretanja“ koji su istinski neophodni kako se razvoj i upotreba VI ne bi pretvorile u kaos, pretnju i ugrožavanju opstanka čovečanstva. Balans između mogućnosti daljeg brzog razvoja VI u korist svakog pojedinaca i maksimalnog smanjenja rizika od nekontrolisanog „kretanja ili iskakanja“, danas znači omogućiti, podstaći i usmeriti njen dalji budući razvoj u oblastima ekonomije, medicine, javnog zdravlja, ekologije, proizvodvodnje hrane, snabdevanja, energetike itd. Željom da veštačka inteligencija potpuno poboljša način na koji ljudi razmišljaju, stvaraju i kreću se u stvarnom svetu, govori i o izgradnja jednog budućeg „naučnog auto puta sa mnoštvom traka“(Prlja et al.,2021:96).

Uspostavljanje pravne infrasrukture za VI, odnosno pripremni radovi za njeno definisanje, se ubrzano odvijaju u međunarodnim organizacijama kao i unutar formalnih i neformalnih skupova i koalicija država. Na primer, preispitivanja etičkih dilema korišćenja VI i smernice Ujedinjenih nacija su dati u Uneskovom vodiču (UNESCO, 2022), dok su prve smernice za upotrebu VI u sprovođenju zakona predstavljene od strane Interpol i Međuregionalnog instituta za istraživanje kriminala i pravde UN (Interpol&UNICRI, 2019). Regionalne organizacije, pre svega Savet Evrope i Organinizacija za ekonomsku saradnju i razvoj - OECD su uvojile preporuke (OECD, 2022) oko modaliteta, načina i stepena obuhvata korišćenja VI i sa državama članicama pripremaju konvencije (Council of Europe, 2023) ili vodiče za upotrebu VI u različitim sferama društvenog života. Države su takođe uključene u nacionalno definisanje okvira za primenu VI u čemu prednjače SAD (White House Office of Science and Technology Policy, 2022) i Kina The China Academy of Information and Communications Technology, 2022), a u međunarodnim okvirima je otpočelo grupisanje i održavanje samita država koje podstiču inovacije u oblasti VI i zakonski ili kroz nacionalne strategije regulišu razvoj VI. U sve to je uključen

privatni sektor i tehnološki giganti od kojih većina nije oduševljena nametanjem međunarodnog i nacionalnog okvira regulacije, imajući u vidu da su već učinile dostupnim pojedine oblike veštačke inteligencije svim građanima na dnevnom nivou. Ne mali doprinosi kako razvoju VI tako i celokupnom postupku pravne regulacije daje i akademska zajednica u okviru koje postoje istraživački instituti kao što je Institut za VI usmerenu na čoveka Univerziteta Stanford koji vodi sveukupni godišnji globalni indeks razvoja, napredka i pravne regulacije VI (Maslej, et al., 2024).

U ovakvoj globalnoj konstelaciji, od svih pokušaja uspostavljanja pravne infrastrukture za korišćenje VI najdalje je otišla EU u okviru koje je u završnoj fazi zakonodavni postupak za usvajanje Uredbe o VI (COM/2021/ 206, u daljem tekstu: Uredba o VI ili Uredba). Naime, Evropski parlament je u okviru redovne zakonodavne procedure usvojio Zakonodavnu rezoluciju (Evropski Parlament, 2024) i čeka se potvrda i njeno usvajanje u Savetu EU. Dogovor institucija EU o ovom aktu je postignut krajem 2023 godine i u prvim reakcijama na vest o usvajanju regulative ističe se da interes građana ipak nije stavljen na prvo mesto i da su uvedeni dvostruki standardi za policiju i službe bezbednosti, sa dovoljno mogućnosti za kršenje ljudskih prava (Share Fondacija, 2024). Ipak, nisu beznačajne izmene izvršene u poslednjem trenutku uvođenjem obavezne procene uticaja na osnovna prava za visokorizične sisteme VI, obavezujući one koji ih koriste da procene i ublaže predvidive uticaje na osnovna prava onih koji su pogođeni, posebno marginalizovanih i ranjivih grupa. To se odnosi i na uvođenje prava pojedinaca da podnose žalbe nadležnim organima u vezi sa mogućim kršenjem Uredbe o VI (Friedl, Gasiola, 2024.).

Uredba daje definiciju samih sistema VI kao „mašinski sistem dizajniran za rad na različitim nivoima autonomije, koji nakon uvođenja može pokazati prilagodljivost i koji, za eksplicitne ili implicitne ciljeve, iz ulaznih vrednosti koje prima, zaključuje kako generisati izlazne vrednosti kao što su predviđanja, sadržaj, preporuke ili odluke koji mogu uticati na fizička ili virtualna okruženja“ (član 3, tačka 1 Uredbe). U Uredbi je istaknut pristup razvoja i upotrebe VI zasnovan na riziku a sami sistemi VI su kategorisani u različite klase i podležu različitim pravilima u skladu sa stepenom rizika koji se pretpostavlja da predstavlja po pojedince i društvo u celini. Uredba o VI postavlja različita ograničenja za sisteme VI koji bi mogli da se koriste u oblasti sprovođenja zakona. Sistemi za koje se smatra da predstavljaju „neprihvatljiv rizik“, kao što su takozvani sistemi „socijalnog bodovanja“ ili određene vrste biometrijskog nadzora, zabranjeni su u potpunosti (čl. 5 Uredbe). Najveći broj sistema VI koje se koriste od službi za sprovođenje zakona u bezbednosne i policijske svrhe je smešten u neprihvatljivu, odnosno zabranjenu ili strogo kontrolisanu, visokorizičnu praksu. Zabranjenu praksu korišćenja sistema VI čine: manipulativne ili obmanjujuće tehnike, iskorištavanje bilo koje slabosti pojedinaca ili određenih grupa, evaluacija ili klasifikacija fizičkih lica ili grupe lica u određenom periodu na osnovu njihovog

društvenog ponašanja, procena ili predviđanje verovatnoće da će fizičko lice počiniti krivično delo isključivo na osnovu izrade profila fizičkog lica ili procene negovih osobina i obeležja ličnosti, baze podataka za prepoznavanje lica neciljanim prikupljanjem fotografija lica s interneta ili snimaka CCTV-a, izvođenje zaključaka o emocijama fizičkog lica na radnom mestu i u obrazovnim ustanovama, biometrijska kategorizaciju u kojima se fizička lica pojedinačno kategorizuju na osnovu biometrijskih podataka o njihovoj rasi, političkim mišljenjima, članstvu u sindikatu, verskim ili filozofskim uverenjima, seksualnoj orijentaciji kao i biometrijska identifikacija pojedinaca u realnom vremenu. Daljinska biometrijska identifikacija u realnom vremenu može se koristiti samo ako je njena upotreba vremenski i geografski ograničena i ako je prethodno data posebna sudska ili administrativna dozvola. Uredbom su definisana tri izuzetka za daljinsku biometrijsku identifikaciju u svrhu krivičnog gonjenja za krivična dela koja sadrže visok stepen društvene opasnosti i to: 1) ciljane potrage za konkretnim žrtvama otmice, trgovine ljudima ili seksualnog iskorištavanja ljudi, kao i potrage za nestalim osobama; 2) sprečavanja konkretne, značajne i neposredne pretnje životu ili telesnoj bezbednosti fizičkih lica ili stvarne i prisutne ili stvarne i predvidljive pretnje od terorističkog napada; i 3) lociranja ili identifikacije lica osumnjičenog za izvršenje krivičnog dela u svrhu vođenja krivične istrage, progona ili izvršenja krivične sankcije za krivična dela nabrojana u Prilogu 2 a koja su državama članicama kažnjiva kaznom zatvora ili merom oduzimanja slobode u maksimalnom trajanju od najmanje četiri godine (član 5, stav 1, tačka h Uredbe).

Visokorizična praksa ili kategorizacija sistema VI na visokorizične obuhvata ispunjenje strogih zahteva za njihovu upotrebu uvođenjem dopunskih pravila regulacije i kontrole. Razlika između neprihvatljivih ili zabranjenih sistema VI i visokorizičnih je u tome što se drugi ne smatraju toliko opasnim, odnosno ne predstavljaju toliko visok stepen rizika po ljudska prava da ih je neophodno zabraniti. Tu se u najvećem broju nalaze sistemi VI koji se koriste u sprovođenju zakona odnosno, oblasti policije, sudstva i kritične infrastrukture (Prilogu 3 Uredbe).

Zabranjena i visokorizična praksa upotrebe VI u sprovođenju zakona oslanja se pre svega na razvoj i primenu određenih komponenata VI vezane za obradu velike količine podataka, algoritme i naprednu kompjutersku tehnologiju. Ove komponente su ranije podsticane radi promene, primene i preispitivanja tehnika pametnog nadzora, profilisanja, upotreba velikog broja podataka i što šire digitalizacije javnog sektora (Fuster, 2020:21). Generalno, VI se povezuje i klasifikuje po unapređenim grupisanjem algoritama koji se koriste za razvoj tehnologije, prema teorijskim konceptima koji stoje iza njih a koji su prvenstveno nastali u matematici, logici, filozofiji i teoriji informacija (Samoili, 2021:11). Postoje razne teorije koje ističu subjektivnost ljudske percepcije iz perspektive prava, za to šta je autonomno i inteligentno u računskim procedurama

ukazivanjem na jednostranost u upotrebi termina koji će se menjati u budućnosti. Naime, ono što je tokom 80 godina prošlog veka spadalo u te kategorije danas nije ni inteligentno ni autonomno. Zato se Kodagnoneu (Codagnone) VI kao pojam čini neprikladnim za regulaciju zakonskim i podzakonskim aktima, već bi legislativno trebalo urediti algoritme koji su u osnovi sistema VI. Shodno tome, pravni akti koji su već donešeni i uređuju algoritamske procese i donošenje odluka u različitim scenarijima i sa različitim svrhama su povezani sa izgradnjom i sastavni su deo regulatornog okvira za VI u EU (Codagnone et al., 2022:46). Algoritmi su naime, moćni artefakti koji deluju unutar našeg informacionog miljea, vršeći strukturiranje naših podataka, profilisanje, kategorizaciju, i predviđanje ko smo, šta smo, šta želimo, pa i više od toga (Hayes et al., 2020).

Izazovi upotrebe sistema VI u sprovođenju zakona sa aspekta predviđanja i upotrebe posebnih biometrijskih tehnika

Upotreba algoritama u oblasti policijskog postupanja i bezbednosti, je posebno osetljivo pitanje sa velikim potencijalom za unapređenje mera i postupaka u sprovođenju zakona, ali i sa ogromnim rizikom za nanošenje štete i kršenje ljudskih prava (Hayes et al., 2020:1). Jedna od prvih tehnika korišćenja algoritama u oblasti bezbednosti, tančije u policijskom postupanju a koja predhodi upotrebi sistema VI je policijsko predviđanje (inače zabranjeno članom 5, tačka d. Uredbe). Policijsko predviđanje je algoritamska obrada skupova podataka koja otkriva obrasce verovatnih budućih krivičnih dela i ugrožavanja radi njihovog sprečavanja pre samog izvršenja. Ono može da se podeli u četiri šire kategorije kao što su: 1) metodi za predviđanje krivičnih dela ili mesta i vremenski periodi u koje postoji povećani rizik od pojave kriminalnih aktivnosti; 2) metodi predviđanja i otkrivanje mogućih učinilaca krivičnih dela; 3) metodi predviđanja identiteta učinilaca ili kreiranje profila sličnim učiniocima krivičnih dela u prošlosti; i 4) predviđanje žrtava krivičnih dela odnosno identifikovanje grupa i individua za koje postoji verovatnoća da će postati žrtve krivičnog dela (Perry et al., 2013:xiv). Policijsko predviđanje kao nova tehnika za sprečavanje kriminala se pojavljuje u SAD krajem 20. veka, kada se u policijskim upravama pojedinih velikih gradova angažuju profesionalni analitičari kriminala koji eksperimentišu sa obradom velikog broja podataka i korišćenjem novih tehnologija, pokušavajući da predvide događaje, tačnije, vreme, mesto i sama krivična dela koja će biti učinjena kao i potencijalne učinioce. Kasnije je u Velikoj Britaniji razvijen poseban model policijskog predviđanja pod nazivom Matriks nasilja bandi (Gang Violence Matrix) koji je policija Londona počela da koristi 2012 godine. Ovaj model je služio za identifikovanje i procenu rizika članova bandi uključenih u nasilju kao i identifikaciju ranjivih grupa odnosno onih ka kojima je nasilje usmereno. U drugim državama članicama EU pojavljuje se u sprovođenju zakona u oblasti pranja novca i finansiranja terorizma, kada su na nivou EU bankama i drugim pravnim licima nametnute obaveze preduzimanja odgovarajućih korake za

identifikaciju faktora rizika za procenu izvršenja pomenutih krivičnih dela (Fuster, 2020:23).

Prepoznavanje lica je biometrijska tehnika u rapidnom razvoju, koja je u Uredbi uvršćena u dve kategorije, odnosno pominje se kao zabranjena odnosno visokorizična praksa korišćenja VI u oblasti sprovođenja zakona. Tehnologija prepoznavanja lica kao deo sistema VI omogućava automatsku identifikaciju ili potvrdu autentičnosti pojedinca putem upoređivanja i potvrđivanja crta lica sa dve ili više digitalnih slika (EU FRA, 2019:2). To je proces kojim AI softver može da identifikuje ili prepozna osobu koristeći njene biometrijske crte lica izvučene sa fotografije ili video snimka (Gikay, 2023:417). Iako je prepoznavanje lica tehnologija koja postoji već nekoliko decenija, tehnički napredak u poslednjih nekoliko godina je ogroman. Neki od današnjih algoritama za prepoznavanje lica sa najboljim performansama imaju skoro 100% uspeha na izazovnim skupovima podataka. Nacionalni institut za standarde i tehnologiju SAD (National Institute of Standards and Technology (NIST)) je napravio test za prepoznavanja lica (Face Recognition Vendor Test (FRVT)) mereći napredak u prepoznavanju lica i koliko dobro algoritmi izvršavaju različite zadatke vezane za bezbednost i sprovođenja zakona, a odnose se konkretno na prepoznavanje lica sa fotoreporterskih slika, u svrhu identifikacije žrtve trgovine decom, otkrivanja falsifikovanih pasoša i unakrsne provere slike izdate vize. Napredak algoritma u prepoznavanju lica se meri prema lažnoj stopi nepodudaranja ili stopi greške koja predstavlja učestalost sa kojom algoritam ne uspeva da uskladi sliku sa stvarnom osobom. U 2017. najuspešnija prepoznavanja lica su imali stope greške od preko 50,0% dok od 2021. nije registovana stopa greške veća od 3,0%. Model sa najboljim učinkom u svim skupovima podataka u 2021 (fotografije vize) registrovao je stopu greške od 0,1%, što znači da za svakih 1000 lica, model je tačno identifikovao 999. Posebno zabrinjavajuća je upotreba ove tehnologije putem sistema VI, odnosno prepoznavanje lica i detekcija pojedinaca uživo u realnom vremenu. Softver VI upoređuje, u realnom vremenu, biometrijske slike lica snimljene kamerom sa postojećim šablonima osumnjičenog lica u bazi podataka. Stepem rasprostranjenosti upotrebe sistema prepoznavanja lica je indikativan imajući u vidu da u SAD danas, 18 od 24 vladinih agencija za sprovođenje zakona već koriste neku vrstu tehnologije za prepoznavanje lica (Zhang et al., 2022:62). Izvestaji iz SAD još od 2016 ukazuju na rasprostranjenu upotrebu prepoznavanja lica uživo, upozoravajući da je tada nekoliko velikih policijskih uprava aktivno istraživalo prepoznavanje lica u realnom vremenu na video snimcima kamere za nadzor uživo. Od tada je sve češće izričito pozivanje na donošenje zakona koji bi regulisao upotrebu prepoznavanja lica od strane organa za sprovođenje zakona, upozorenjem da je „prepoznavanje lica previše moćno da bi ostalo tajno“ i pravno nedefinisano (Garvie et al., 2016).

Sa druge strane Vlada Velike Britanije pozvala je policiju da proširi upotrebu tehnologija baziranih na VI i pored činjenice da ovakvi sistemi ugrožavaju

građanske slobode. U jednoj britanskoj nacionalnoj anketi iz 2019., 70% ispitanika je istaklo da policiji treba dozvoliti da koristi prepoznavanje lica u krivičnim istragama, a 71% je podržalo njegovu upotrebu na javnim prostorima, ako pomaže u smanjenju kriminala. Ilustrativan je primer akcije sprečavanja krađa i nasilja u maloprodajnim objektima u Londonu 2023. godine, u kojoj je Metropolitena policija koristila prepoznavanje lica za identifikaciju 149 osumnjičenih za maloprodajne zločine upoređivanjem stotine CCTV fotografija (Gikay, 2023). Trenutno su dostupne samo ograničene informacije o mogućoj upotrebi tehnologija prepoznavanja lica u državama članicama EU. U Nemačkoj je Hamburška policija koristila tehnologije za prepoznavanje lica demonstranata koji su izazvali nered zbog Samita G20 u julu 2017. dok je 2018. sprovedeno testiranje mogućnosti upotrebe ovih sistema na železničkoj stanici u Berlinu (Engel, 2024). Policija u Nici (Francuska) sprovedla je test korišćenja tehnologije za prepoznavanje lica uživo na karnevalu 2018. Žandarmerija u Francuskoj koristi tehnologije za prepoznavanje lica za krivične istrage, ali ne koristi tehnologije prepoznavanja lica uživo, zbog nepostojanja pravnog osnova. Austrijske vlasti su kupile softver za prepoznavanje lica 2019. za pretraživanje baze podataka kako bi se identifikovali nepoznati počinioci krivičnih dela čije su slike dostupne sa CCTV-a kamera ili drugih izvora. U Holandiji su takođe počela testiranja za upotrebu tehnologije prepoznavanja lica (EU FRA, 2019:6). Neke studije ukazuju i na buduću upotrebu 3D tehnologije za prepoznavanje lica i to u oblasti kontrole spoljnih granica Unije od strane Fronteksa. Dok se trenutne tehnologije za prepoznavanje lica oslanjaju na „ravnu“ fotografiju lica pojedinca, 3D prepoznavanje lica koristi trodimenzionalne karakteristike ljudskog lica za automatsko prepoznavanje i uparivanje. Kada se stekne 3D geometrija ljudskog lica, onda se izdvajaju značajne karakteristike sa površine lica. To omogućava veću preciznost od klasičnog dvodimenzionalnog prepoznavanja lica (Statewatch, 2023:37).

Suštinski prepoznavanje lica predstavlja samo jedan mozaik šireg korišćenja biometrije u bezbednosne svrhe. Postoje biometrijske tehnike koje uključuju biometrijsku identifikaciju, biometrijsku kategorizaciju, detekciju ponašanja, prepoznavanje emocija, interfejsi mozga i računara i druge slične tehnike koje imaju širok spektar namena. Termin „biometrijske tehnike“ treba shvatiti tako da uključuju bilo koju tehnologiju ili operaciju koja se: 1) oslanja na specifičnu tehničku obradu podataka koji se odnose na fizičke, fiziološke aspekte ili aspekte ponašanja ljudskog tela (uključujući i kada je u pokretu); i 2) za svrhe kao što su autentifikacija ili identifikacija ljudskih individua, kategorizacija ljudskih individua prema trajnim ili dugoročnim karakteristikama (uključujući u cilju predviđanja budućeg ponašanja) ili otkrivanje privremenih ili trajnih stanja ljudske individue (kao što je strah, umor, ili bolest, ili određena namera). Napominje se međutim sve veća upotreba „slabe“ i „meke“ biometrije zajedno sa „jakom“ biometrijom, fokusirajući se na niz obrazaca različitih vrsta ponašanja, i

razvoj ka multimodalnoj biometriji. Zajedno sa poboljšanim senzorskim i računarskim mogućnostima, kao i poboljšanom vezom, ovo utire put za masovno uvođenje biometrijskih tehnologija u širok spektar sektora i za širok spektar namena, čak daleko izvan sprovođenja zakona i graničnih kontrola, pretvarajući biometrijske tehnologije u nešto poput univerzalnih tehnologija. (Wendehorst, Duler, 2021:1).

Druga istraživanja nalaze da se radi o mnoštvu tehnologija prepoznavanja lica kao specifičan tip biometrijskih tehnologija koje se koriste u različite svrhe, u rasponu od jednostavnog otkrivanja prisustva lica na slici, do složenijih verifikacija, identifikacija i kategorizacija ili klasifikacija pojedinaca. **Verifikacija** (poređenje jedan na jedan) omogućava poređenje dva biometrijska šablona, za koje se obično pretpostavlja da pripadaju istoj osobi. **Identifikacija** (poređenje jedan prema više) znači da se šablon slike lica osobe upoređuje sa drugim šablonima uskladištenim u bazi podataka kako bi se otkrilo da li je njihova slika tamo uskladištena. Prepoznavanje lica se takođe koristi za vršenje **kategorizacije** (ili klasifikacije) pojedinaca, na osnovu njihovih ličnih karakteristika. U tom smislu, razvijen je širok spektar softvera za procenu atributa osobe sa njenog lica, u svrhu „klasifikacije atributa lica“ (npr. pol, rasa ili etnička pripadnost) ili za „procenu atributa lica“ (npr. godine). Štaviše, prepoznavanja lica se može koristiti za klasifikaciju izraza lica (kao što je osmeh) ili emocionalnog stanja osobe kao što je srećan, tužan ili ljut (Madiega, Mildebrath, 2021:1).

Slika 1. Prepoznavanje emocija u realnom vremenu.

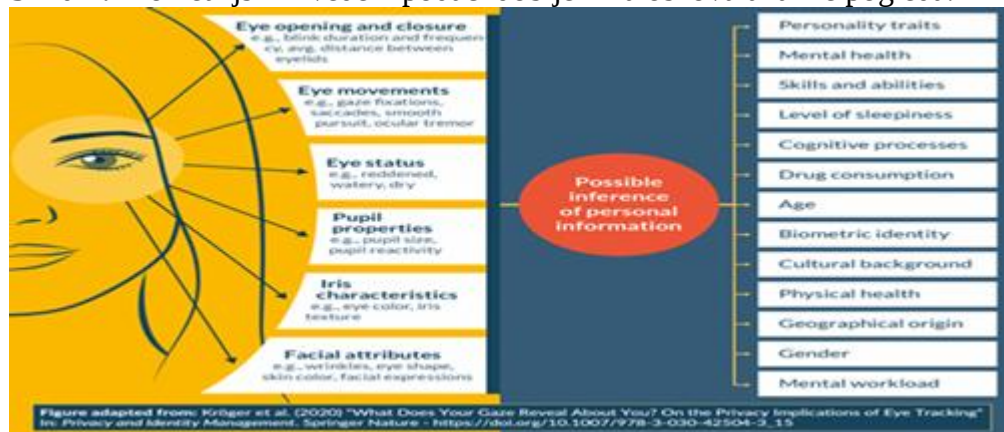


Izvor: Article 19. <https://www.article19.org/resources/eu-emotion-misrecognition/>

Ovo poslednje je istraživano na spoljnim granicama EU, tačnije na pojedinim graničnim prelazima Grčke, Mađarske i Letonije u okviru projekta Horizont 2020, pod nazivom Integrirani prenosni sistem kontrole (iBorderCtrl) koji integriše prepoznavanje lica i druge tehnologije za otkrivanje da li pojedinac govori istinu. Ispitivani su i identifikovani tzv. „biomarkeri prevare“, neverbalni mikroizrazi

povezivani sa laganjem kao što su treptanje levog oka, pojačano crvenilo lica, pravci kretanja glave itd. (Sánchez-Monedero, Dencik, 2022). Radi se u stvari o nepreglednom nizu varijacija u korišćenju biometrijskih tehnika, identifikatora i preko njih biometrijski izvedenih podataka. Biometrijski izvedeni podaci su zbir skupova podataka koji su rezultat informacija dobijenih iz biheviornalnih, fizičkih i psiholoških biometrijskih tehnika identifikacije i drugih neverbalnih metoda komunikacije.

Slika 2. Biometrijski izvedeni podaci dobijeni na osnovu analize pogleda.



Izvor XRSI: https://xrsi.org/wp-content/uploads/2020/09/illustrations_XRSI_privacy_framework_20200906_DEF-7-1-1536x1277.png

Ovi izvedeni podaci se dobijaju od glavnih biometrijskih tehnika identifikacije odnosno „jakih“ biometrijskih identifikatora kao što su: prepoznavanje lica, daktiloskopski podaci (provera otisaka prsta), skeniranje šarenice, analiza mrežnjače; prepoznavanje glasa i prepoznavanje oblika uha. Tu su uključeni i analiza tastera, analiza vlastitog potpisa, analiza hoda, analiza pogleda (praćenje očiju) (XRSI, 2024). Za jedinstvenu identifikaciju fizičkih lica, „jake“ biometrijske identifikatore treba uhvatiti, transformisati u digitalne podatke i na kraju u standardizovani u šablon (Wendehorst, Duler, 2021b). Na kraju moramo da pomenemo i „otisak ljudskog pokreta“ kao jedan od biometrijski jakih identifikatora. Otisak ljudskog pokreta može takođe biti idealan za predviđanje aktivnosti, kriminala i bolesti pa samim tim i deo policijskog predviđanja i bezbednosti. Prema pioniru VI Luisu Rozenbergu, postoje stvarne opasnosti „da će sistemi moći da vas identifikuju bez vašeg pristanka i učešća bez uopšte i da znate da ste bili meta identifikacije“. Otisak pokreta za razliku od tehnike prepoznavanja lica može omogućiti identifikaciju otpozadi, bez da se uopšte vidi lice osobe (Kremidas-Courtney, Linderstal, 2023).

Sve opisane biometrijske tehnike su moćan alat za službe bezbednosti što dramatično komplikuje već dovoljno polarizovane strane koje se zalažu za više bezbednosti ili više prava i sloboda građana. Tako, po zaštitnicima ljudskih prava

konačni tekst Uredbe o VI predstavlja propuštenu prilika za zaštitu građanskih sloboda. Usvajanje Uredbe o VI se shvata kao prihvatanje prakse koja je kroz istoriju bila povezana sa „eugenikom“ odnosno naukom o različitim načinima poboljšanja i kontrolisanja ljudske vrste. Konačna verzija Uredbe o VI ide na dušu Francuskoj koja se optužuje da je značajno uticala na njenu sadržinu sa namerom očuvanja i širenja ovlašćenja države da koristi netransparentne i nepouz dane sisteme VI iz bezbednosnih razloga i povećavanje efikasnosti rada policije na sprečavanju kriminala i nasilja na javnim okupljanjima i sve to uoči Olimpijskih i Paraolimpijskih igara u Parizu (Reclaim your face, 2024).

Pravni okvir za upotrebu sistema VI u sprovođenju zakona u Republici Srbiji

Značaj upotrebe VI i njenog prožimanja svih sfera društvenog života u Republici Srbiji je prepoznat sredinom druge decenije 20 veka. Sprovođenje digitalizacije i značajan razvoj IT sektora koji poslednjih godina ima priličan udeo u rastu BDP su bili direktan most ka istraživanjima, inovacijama i uobličavanju primene VI. To je dovelo do usvajanja prve Strategije za razvoj veštačke inteligencije 2019. godine, etabliajući Srbiju kao prvu zemlju u Jugoistočnoj Evropi i 26. u svetu koja ima ovakav dokument. Takođe, Srbija 2022. godine, postaje deo Globalnog partnerstva za veštačku inteligenciju (u daljem tekstu: GPAI) a 2023. i članica Alijanse za upravljanje veštačkom inteligencijom Svetskog ekonomskog foruma (Euroactiv, 2024).

GPAI je inicijativa koja teži da uspostavi globalne standarde i pravila za razvoj veštačke inteligencije, kao i da ubrza razvoj veštačke inteligencije globalno. Članstvom u GPAI Srbija je stekla brojne benefite na nekoliko različitih polja. Jedan od najznačajnijih je svakako pristup najsavremenijim tokovima u oblasti veštačke inteligencije. Srbija će u naredne tri godine biti predsedavajuća GPAI i to u prvoj i trećoj pomoćna, dok će u drugoj godini biti glavna. Kriterijumi za članstvo bili su napredak razvoja veštačke inteligencije, i posvećenost odgovornom razvoju veštačke inteligencije. Sekretarijat GPAI je pri Organizaciji za ekonomsku saradnju i razvoj (OECD), a ekspertske centri su u Montrealu i Parizu, dok će novi biti otvoren u Japanu (Euroactiv, 2024a).

Republika Srbija ima ukupno 21 politiku i oblasti saradnje i razvoja VI koje su registrovane na OECD-ovoj Observatoriji za VI (OECD AI, 2024). Jedna značajnijih je već pomenuta Strategija za razvoj veštačke inteligencije u Republici Srbiji za period 2020-2025. godine (u daljem tekstu: Strategija).

Strategija u uvodnom delu sadrži ciljeve i mere za razvoj veštačke inteligencije čija implementacija treba da rezultira ekonomskim rastom, unapređenjem javnih usluga, unapređenjem naučnog kadra i razvojem veština za poslove budućnosti (Strategija razvoja veštačke inteligencije u Republici Srbiji za period 2020-2025. godine, "Sl. glasnik RS", br. 96/2019). Usklađena je sa Evropskom inicijativom za VI koja je predhodila Strategiji i Predlogu Uredbe EU o VI kao jedna od obaveza

iz procesa pristupanja Republike Srbije EU i koja treba da omogući njenu potpunu integraciju u Evropski istraživački prostor. Od razloga za usvajanje se u Strategiji naglašava „da je VI tehnologija opšte namene poput parne mašine, železnice i električne struje koja dramatično doprinosi razvoju svih oblasti privrede i društva i u mnogim od njih unosi revolucionarne promene“. Takođe se ističe da VI može unaprediti i efikasnost rada javne uprave i kvalitet usluga koje država pruža građanima i privredi (naslov 2.1 Strategije).

Ukazuje se na prednosti njene upotrebe u raznim društvenim sferama sa mogućim rizicima koji proizlaze iz njene primene. U konkretnim rizicima po na primer lične podatke, unutar naslova „Pojedinaac i društvo“ ističe se da politika i zakonski okvir Republike Srbije u ovoj oblasti prati standarde EU tačnije Opštu uredbu EU o zaštiti podataka obezbeđujući time primenu visokih standarda zaštite podataka o ličnosti. U izazovima se sagledavajući uporednu praksu, naglašava potreba za prevenciju diskriminacije ukazujivanjem „da se može dogoditi da se uvede sistem koji analizom podataka utvrđuje stepen rizika pojedinaca da počine prekršaj ili zločin. Ukoliko se ne koriste adekvatno podaci, ovakav sistem može da reprodukuje diskriminativni obrazac” (naslov 4.4 Strategije). Deo koji se odnosi na konkretne ciljeve, posebno delovi koji se odnose na upotrebu VI u javnoj upravi ne sadrže nikakvo pozivanje niti spominje rizike od njene primene u policijske i bezbednosne svrhe.

Rizici i izazovi kao i kategorizacija ovih sistema su sadržani u Etickim smernicama za razvoj, primenu i upotrebu pouzdane i odgovorne VI iz 2023 ("Sl. glasnik RS", br. 23/2023, u daljem tekstu: Smernice). Smernice slede kategorizaciju sadržanu u predlogu Uredbe o VI Evropske komisije i u kategoriji visoko rizične nabroja sisteme VI:

- biometrijske identifikacije i kategorizacije pojedinca: naročito obuhvataju sisteme namenjene za daljinsku biometrijsku identifikaciju pojedinca u realnom vremenu kao i naknadnu daljinsku biometrijsku identifikaciju;
- krivičnog gonjenja: naročito obuhvata sisteme namenjene organima krivičnog gonjenja koji vrše procenu rizika pojedinaca za izvršenje ili ponovno izvršenje krivičnih dela na osnovu osobina, karakteristika ili prethodnog kriminalnog ponašanja; sisteme koji bi se koristili kao poligrafska sredstva ili sredstva za otkrivanje emocionalnog stanja pojedinca; sisteme koji bi se koristili za ocenu verodostojnosti dokaza tokom predistražnog, istražnog i sudskog postupka; sisteme koji bi se koristili za procenu pojedinca; sisteme namenjene za analitiku krivičnih dela koji se odnose na pojedince i koji omogućavaju pretraživanje složenih povezanih i nepovezanih velikih skupova podataka iz različitih izvora ili u različitim formatima s ciljem uočavanja nepoznatih uzoraka u podacima ili skrivenih veza među podacima;
- upravljanja migracijama ljudi, azilom i nadzora državne granice: naročito obuhvata sisteme koji bi se koristili kao poligrafska sredstva ili sredstva za otkrivanje emocionalnog stanja pojedinca; sisteme namenjene nadležnim

organima/institucijama za procenu rizika (uključujući rizik za sigurnost, rizik od nezakonitih imigracija ili rizik za zdravlje) koji predstavlja pojedinac koji namerava da uđe ili je ušao na teritoriju države Republike Srbije; sisteme namenjene nadležnim organima/institucijama za proveru verodostojnosti putnih isprava, naročito kroz proveru sigurnosnih obeležja tih isprava; sisteme namenjene za pomoć nadležnim organima/institucijama pri razmatranju zahteva za azil, vize, boravišne i radne dozvole i s njima povezanim procesima (povezani procesi obuhvataju proveru krivične i prekršajne osuđivanosti, postojanje i vrstu pritužbi datih u vezi s predmetnim zahtevima i sl.), a u cilju donošenja odluka u vezi sa predmetnim zahtevima (Naslov 2.3 Smernica).

Usvajanje Smernica je iskorak u oblikovanju pravnog okvira za upotrebu VI u Republici Srbiji s tim što Smernice nemaju obavezu snagu već predstavljaju instrument mekog prava kojim se načelno usmerava budući razvoj VI i njena primena od strane službi za sprovođenje zakona. One nisu u potpunosti usklađene sa Uredbom EU o VI jer ne sadrže listu zabranjene odnosno neprihvatljive prakse upotrebe sistema VI u bezbednosne svrhe. Smernice, u stvari, u visokorizične sisteme ubrajaju zabranjene sisteme u EU kao što je na primer, biometrijska identifikacija i kategorizacija pojedinaca odnosno sisteme namenjene za daljinsku biometrijsku identifikaciju pojedinca u realnom vremenu kao i naknadnu daljinsku biometrijsku identifikaciju.

Postavlja se pitanje da li je upotreba sistema VI u bezbednosne i policijske svrhe definisana Smernicama kao visokorizična, dovoljna za sprečavanje njene maliciozne upotrebe od strane službi za sprovođenje zakona u Republici Srbiji? Da li je Zaključak Vlade kao pravni akt koji definiše Smernice dovoljan da spreči službe u masovnom nadzoru putem sistema VI? Odgovor na ova pitanja je određen posebno imajući u vidu iskustva sa neuspešnim pokušajem donošenja Zakon o unutrašnjim poslovima u periodu 2020-2022. koji je *de facto* trebao da legalizacije upotrebu biometrijskog nadzora. Bilo je predviđeno korišćenje biometrijskog nadzora između ostalog u javnom prostoru odnosno na javnim okupljanjima visokog rizika na osnovu naređenja ministra (Vasilkov, 2023). Nevladine organizacije i civilno društvo su svojim aktivizmom, debatama i kritikama uspele da odlože legislativni proces legalizacije zabranjene i visokorizične prakse biometrijskog nadzora i pored obrazloženja predstavnika MUP-a kao predlagača, da ovi sistemi u mnogome doprinose povećanju bezbednosti građana, i da su već standardna praksa u EU. Naime, civilno društvo ističe da se Srbija se više puta našla na „procurelim“ spiskovima korisnika moćnih softvera za prepoznavanje lica poput *Clearview AI-a* i *Griffeye* kao i da su nabavljeni sistemi VI pomoću kojih je moguće vršiti obradu biometrijskih i drugih podataka, poput „pametnih“ kamera, softvera *Social Links*, *Maltego* i *Mozenga*, kao i programa za napredno prepoznavanje lica (European Western Balkans, 2023).

Zaključak

Bezbednost, policijsko postupanje i rad službi za sprovođenja zakona sa jedne strane i zaštita ljudskih prava i osnovnih sloboda sa druge, su oduvek suprotni polovi, nepomirljive suprotnosti, teme koje razdvajaju i polarizuju javnost posebno zaštitnike ljudskih prava i bezbednosne eksperte i profesionalce. Kada na ovaj većiti antagonizam i debate o tome ko je stariji, bezbednost ili ljudska prava, da li zaštita jedne od ovih vrednosti isključuje zaštitu i poštovanje druge, koliko je dovoljno bezbednosti a kolika je oblast zaštićene privatnosti i nivo poštovanja ljudskih prava, dodamo i primenu sistema VI u bezbednosne svrhe dobijamo veoma izazovnu, rizičnu i prilično tešku jednačinu sa tri nepoznate.

Biometrijski sistemi VI označeni kao zabranjeni i visokorizični u Uredbi o VI će prestati da se primenjuju odnosno početi da se primenjuju na način predviđen Uredbom, 6 meseci od njenog objavljivanja u Službenom glasniku EU sa obavezom potpune implementacije u narednih dve godine što označava uspostavljanje prvog zakonodavnog okvira kojim se uređuje primena sistema VI u oblasti sprovođenja zakona. Države članice će morati da nađu transparentan, odgovoran i proporcionalni način i oblik upotrebe sistema za predviđanje, upotrebe biometrije i drugih tehnika za nadzor granica, krivično gonjenje i borbu protiv terorizma a na čije korišćenje pretenduju službe za sprovođenje zakona.

Regulisanje pojedinih praksi primene VI u oblasti sprovođenja zakona u Republici Srbiji je definisano Strategijom o primeni veštačke inteligencije 2020 - 2025 i Etičkim smernicama iz 2023. Pokušaj zakonskog uvođenja biometrijskog nadzora kroz predloženi Zakon o unutrašnjim poslovima tokom 2022 je uznemirio javnost i razbesneo zastupnike ljudskih prava u Srbiji. Ono što predstoji u narednom periodu posebno do kraja 2024. godine za kada je predviđeno usvajanje Zakona o unutrašnjim poslovima je nastavak „borbe“ između pristalica više bezbednosti sa jedne i pristalca zaštite ljudskih prava, sa druge strane. Jedna vrsta mogućeg rešenja ovog društveno bezbednosnog fenomena kao i preporuka koja proizlazi iz ovog istraživanja može biti povezivanje postojećih politika u oblasti VI sa pojedinim zakonima odnosno parcijalno zakonsko normiranje putem izmene postojeće legislative. Tako, pojedini zakoni bi mogli da regulišu primenu sistema VI, posebno u oblasti sprovođenja zakona kao pomenuti Zakon o unutrašnjim poslovima i Zakon o graničnoj kontoli koji bi regulisao upotrebu sistema VI na graničnim prelazima i nadzoru i zaštiti državne granice. Zakon o organizaciji i nadležnosti državnih organa za borbu protiv visokotehnološkog kriminala bi sadržao odredbe o zabrani korišćenju sistema VI za radnje koje ugrožavaju visokotehnološku bezbednost. Krivični zakonik i Zakon o krivičnom postupku bi obezbedili dovoljan nivo zaštite ljudskih prava u primeni sistema VI u krivičnopravnoj materiji a Zakon o bezbednosno-informativnoj agenciji bi izmenama onemogućio samovoljnu i neseliktivnu upotrebu sistema VI i omogućio takođe veći stepen zaštite ljudskih prava i sloboda. Ovakav način izgradnje pravne infrastrukture i pravne regulacije bi doprineo ne samo izgradnji standarda i prakse

zakonite upotrebe biometričkih i drugih visokorizičnih sistema VI u nacionalnom pravnom poretku Republike Srbije već i unapređenju međunarodne bezbednosne saradnje sa službama EU za sprovođenje zakona kao što su Evropol i Fronteks, zatim Interpol a i na kraju na bilateralnoj osnovi kada se bezbednosna saradnja sa drugim državama upotrebom sistema VI pokaže kao neophodnost.

Literatura

1. Byrne W. H., T. Gammeltoft-Hansen. 2023. Untangling the Legal Infrastructure of Schengen. MOBILE Working Paper, No. 21. DOI: <https://doi.org/10.31235/osf.io/9h4e3>
2. Prlja D., G. Gasmi., i V. Korać. 2021. Veštačka inteligencija u pravnom sistemu EU. Institut za uporedno pravo. Beograd. ISBN 978-86-80186-73-3
3. UNESCO. 2022. Recommendation on the Ethics of Artificial Intelligence. (dostupno na web sajtu: <https://unesdoc.unesco.org/ark:/48223/pf0000381137>)
4. Interpol&UNICRI. 2019. Artificial Intelligence and Robotics for Law Enforcement. (dostupno na web sajtu: <https://unicri.it/artificial-intelligence-and-robotics-law-enforcement>)
5. OECD. 2022. Recommendation of the Council on Artificial Intelligence, OECD/LEGAL/0449. (dostupno na web sajtu: <https://legalinstruments.oecd.org/en/instruments/oecd-legal-0449>)
6. Council of Europe. 2023. Draft Framework Convention on artificial intelligence, human rights, democracy and the rule of law. (dostupno na web sajtu: <https://rm.coe.int/-1493-10-1b-committee-on-artificial-intelligence-cai-b-draft-framework/1680aee411>)
7. White House Office of Science and Technology Policy. 2022. The Blueprint for an AI Bill of Rights: Making Automated Systems Work for the American People. (dostupno na web sajtu: <https://www.whitehouse.gov/ostp/ai-bill-of-rights>)
8. The China Academy of Information and Communications Technology. 2022. Artificial Intelligence White Paper. (dostupno na web sajtu: https://cset.georgetown.edu/wpcontent/uploads/t0442_AIwhite_paper2022_EN.pdf)
9. Maslej N. et al., 2024. The AI Index 2024 Annual Report. AI Index Steering Committee, Institute for Human-Centered AI. Stanford University, Stanford, CA. (dostupno na web sajtu: <https://aiindex.stanford.edu/report/>)
10. European Commission. 2021. Proposal for a Regulation Of The European Parliament and of The Council Laying Down Harmonised Rules on Artificial Intelligence (Artificial Intelligence Act) and Amending Certain Union Legislative Acts. COM/2021/206 final.
11. Evropski Parlament. 2024. Akt o umjetnoj inteligenciji. Zakonodavna rezolucija Evropskog parlamenta od 13. ožujka 2024. o Prijedlogu uredbe Evropskog parlamenta i Vijeća o utvrđivanju usklađenih pravila o umjetnoj inteligenciji (Akt o umjetnoj inteligenciji) i izmjeni određenih zakonodavnih

- akata Unije (COM(2021)0206 – C9-0146/2021 – 2021/0106(COD)). P9_TA(2024)0138.
12. Share Fondacija. 2024. Usvojen AI Akt: Ljudska prava ostala u drugom planu. (dostupno na web sajtu: <https://www.sharefoundation.info/sr/usvojen-ai-akt-ljudska-prava-ostala-u-drugom-planu/>)
 13. Friedl P., G.G. Gasiola. 2024. Examining the EU's Artificial Intelligence Act. VerfBlog. DOI: 10.59704/789d6ad759d0a40b (dostupno na web sajtu: <https://verfassungsblog.de/examining-the-eus-artificial-intelligence-act/>)
 14. Fuster G.G. 2020. Artificial Intelligence and Law Enforcement - Impact on Fundamental Rights. Study requested by the LIBE committee. doi:10.2861/880024
 15. Samoili S. et al., 2021. AI Watch. Defining Artificial Intelligence 2.0. Towards an operational definition and taxonomy for the AI landscape. Publications Office of the European Union. European Parliament, Luxembourg, doi:10.2760/019901.
 16. Codagnone C. et al., 2022. Identification and assessment of existing and draft EU legislation in the digital field. Study for the special committee on Artificial Intelligence in a Digital Age (AIDA). Policy Department for Economic, Scientific and Quality of Life Policies. European Parliament, Luxembourg, doi: 10.2861/73141.
 17. Hayes P. et al., 2020. Algorithms and values in justice and security. AI & SOCIETY 35: 533–555. <https://doi.org/10.1007/s00146-019-00932-9>
 18. Perry L.W. et al., 2013. Predictive Policing: The Role of Crime Forecasting in Law Enforcement Operations. Rand Corporation. ISBN: 978-0-8330-8148-3. (dostupno na web sajtu: https://www.rand.org/pubs/research_reports/RR233.html)
 19. European Union Agency for Fundamental Rights (EU FRA). 2019. Facial recognition technology: fundamental rights considerations in the context of law enforcement. (dostupno na web sajtu: https://fra.europa.eu/sites/default/files/fra_uploads/fra-2019-facial-recognition-technology-focus-paper-1_en.pdf)
 20. Gikay A.A. 2023. REGULATING USE BY LAW ENFORCEMENT AUTHORITIES OF LIVE FACIAL RECOGNITION TECHNOLOGY IN PUBLIC SPACES: AN INCREMENTAL APPROACH.” The Cambridge Law Journal 82, no. 3 (2023): 414–49. <https://doi.org/10.1017/S0008197323000454>
 21. Zhang D. et al., 2022. The AI Index 2022 Annual Report. AI Index Steering Committee, Stanford Institute for Human-Centered AI, Stanford University. (dostupno na web sajtu: <https://aiindex.stanford.edu/ai-index-report-2022/>)
 22. Garvie C., et al., 2016. The Perpetual Line-Up. Unregulated Police Face Recognition, Georgetown Law Center on Privacy & Technology. (dostupno na web sajtu: <https://www.perpetuallineup.org/>)
 23. Engel A. 2024. Facial Recognition Technologies in the Public Sector: Observations from Germany. Chapter. In The Cambridge Handbook of Facial

Recognition in the Modern State, edited by Rita Matulionyte and Monika Zalnieriute, 186–97. Cambridge Law Handbooks. Cambridge: Cambridge University Press.

24. Gikay A.A. 2023. Live Facial Recognition for Law Enforcement: The European Union’s Regulatory Approach Should be Informed by UK Police’s Practice. (dostupno na web sajtu: <https://eulawanalysis.blogspot.com/2023/11/live-facial-recognition-for-law.html>)
25. Statewatch. 2023. Europe’s techno borders. EuroMed Rights & Statewatch. (dostupno na web sajtu: <https://www.statewatch.org/publications/reports-and-books/europe-s-techno-borders/>).
26. Wendehorst C., Y. Duler. 2021a. Biometric Recognition and Behavioural Detection Assessing the ethical aspects of biometric recognition and behavioural detection techniques with a focus on their current and future use in public spaces. BRIEFING Requested by the JURI AND PETI committees Policy Department for Citizens' Rights and Constitutional Affairs. Directorate-General for Internal Policies PE 697.131 (dostupno na web sajtu: [https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/697131/IPOL_BRI\(2021\)697131_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/697131/IPOL_BRI(2021)697131_EN.pdf))
27. Madiega T., H. Mildebrath. 2021. Regulating facial recognition in the EU. European Parliamentary Research Services (EPRS). Brussels. DOI:10.2861/140928. (dostupno na web sajtu: [https://www.europarl.europa.eu/RegData/etudes/IDAN/2021/698021/EPRS_IDA\(2021\)698021_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/IDAN/2021/698021/EPRS_IDA(2021)698021_EN.pdf))
28. Sánchez-Monedero J., L. Dencik. 2022. The politics of deceptive borders: ‘biomarkers of deceit’ and the case of iBorderCtrl. Information, Communication & Society. 25:3, 413-430. (dostupno na web sajtu: <https://www.tandfonline.com/doi/full/10.1080/1369118X.2020.1792530>)
29. XReality Safety Intelligence (XRSI).2024. Biometrically-Inferred Data (BID). (dostupno na web sajtu: <https://xrsi.org/definition/biometrically-inferred-data-bid>).
30. Wendehorst C., Y. Duler. 2021b. Biometric Recognition and Behavioural Detection Assessing the ethical aspects of biometric recognition and behavioural detection techniques with a focus on their current and future use in public spaces. European Parliament Study requested by the JURI AND PETI committees Policy Department for Citizens' Rights and Constitutional Affairs. Directorate-General for Internal Policies. doi: 10.2861/982599
31. Kremidas-Courtney C., H. Linderstal. 2023.The convergence of new technologies endangering human agency. Friends of Europe. (dostupno na web sajtu: <https://www.friendsofeurope.org/insights/the-convergence-of-new-technologies-endangering-human-agency/>)
32. Reclaim your face. 2024. EU AI Act will fail commitment to ban biometric mass surveillance (Deutsche Version unten). (dostupno na web sajtu: <https://reclaimyourface.eu/eu-ai-act-will-fail-commitment-to-ban-biometric-mass-surveillance/>)

33. Euroactiv. 2024. Da li smo spremni za Veštačku inteligenciju? Indeks pokazuje da smo na 57. mestu, Srbija će uložiti 100 miliona evra. (dostupno na web sajtu: <https://euractiv.mondo.rs/tehnologija/a6320/Da-li-je-Srbija-spremna-za-vestacku-inteligenciju.htm>)
34. Euroactiv. 2024a. ŠTA JE "ORGANIZACIJA GLOBALNO PARTNERSTVO ZA VEŠTAČKU INTELIGENCIJU"? Srbiji donosi brojne benefite i razvoj tehnologije (dostupno na web sajtu: <https://euractiv.mondo.rs/tehnologija/a6482/Sta-je-organizacija-Globalno-partnerstvo-za-vestacku-inteligenciju-i-sta-znaci-za-Srbiju.html>)
35. OECD 2024. OECD AI Policy Observatory. AI in Serbia (dostupno na web sajtu: <https://oecd.ai/en/dashboards/countries/Serbia>)
36. Strategija razvoja veštačke inteligencije u Republici Srbiji za period 2020-2025. godine. "Sl. glasnik RS", br. 96/2019.
37. Zaključak o usvajanju Etičkih smernica za razvoj, primenu i upotrebu pouzdane i odgovorne veštačke inteligencije. "Sl. glasnik RS", br. 23/2023.
38. Vasilkov Z. 2023. Unutrašnji poslovi i bezbednost u pravu Evropske unije nakon Lisabonskog ugovora. Zadužbina Andrejević: Beograd. ISBN 978-86-525-0429-9
39. European Western Balkans. 2023. Akt EU o veštačkoj inteligenciji će onemogućiti nekontrolisan biometrijski nadzor u Srbiji. (dostupno na web sajtu: <https://europeanwesternbalkans.rs/akt-eu-o-vestackoj-inteligenciji-ce-onemoguciti-nekontrolisan-biometrijski-nadzor-u-srbiji/>)

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ARTIFICIAL INTELLIGENCE IN SERVICE LAW ENFORCEMENT IN THE EUROPEAN UNION AND THE REPUBLIC OF SERBIA

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Abstract

Artificial intelligence has recently been intensively pushing the boundaries of human civilization and technological development. As a technological achievement, it imperceptibly "sneaked" into the life of every individual and became an integral part of all spheres of social life. In the application of artificial intelligence today, it seems that we cannot shake the impression that what at one point seemed possible in 100 years, has in fact become a reality in the last 10 or so years. The need for legal regulation and legal regulation of the use of artificial intelligence arises as an important issue for its future development for the benefit of the human community and the entire humanity. This research is part of a broader picture of the potential use of artificial intelligence in certain branches of law, aimed at looking at the special "interregnum" between the established practice of using artificial intelligence and its legal regulation. In the work, we focus in particular on the analysis and research of the use of artificial intelligence systems in the field of law enforcement. More precisely, we will shed light on the regulatory process related to artificial intelligence in the EU and point out the specifics of its use for security and police purposes, primarily by establishing restrictions for the benefit of the public and citizens, by categorizing the use of certain artificial intelligence systems as prohibited and high-risk. These are artificial intelligence systems that use prediction techniques, biometric surveillance, i.e. face recognition and derived biometric data. Their impact on human rights is the subject of special in-depth research outside this framework, bearing in mind that the uncontrolled use of these techniques as part of the artificial intelligence system today can be equated with the consequences of dropping an "atomic bomb" on human freedoms and rights. Apart from the regulatory process within the EU, we also point out the potential use of artificial intelligence in Serbia by law enforcement services through the analysis of the legal framework of the Republic of Serbia.

Keywords: artificial intelligence, law enforcement, police forecasting, facial recognition, biometric techniques

JEL: K33

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Introduction

Artificial intelligence is a technological achievement whose application in all areas of human activity is becoming inevitable, both globally, regionally and locally. Thus, the "race" for legal regulation and legal regulation of the use of artificial intelligence enters the scene as a key issue for its future development for the benefit of the human community and the entire humanity. Debates on the need, manner and methods of legal regulation take place at various levels, from international, through regional organizations and national level to the private sector and technological giants who already make certain forms of artificial intelligence available to all citizens on a daily basis. Legal regulation primarily refers to various aspects of the application of artificial intelligence and can be seen as the establishment of a "legal infrastructure" for its use, use, development and monitoring in all areas of social life.

With this work, the author investigates the legal regulation and potential use of artificial intelligence in the sensitive area of law, focusing on the review of already established practice for the use of artificial intelligence in law enforcement. More specifically, we will shed light on the regulatory process related to artificial intelligence in the EU and focus on the use of artificial intelligence for security and policing purposes, pointing out the limitations established for the benefit of the public and citizens that are imposed on law enforcement services by categorizing certain actions as prohibited and high risk. We start from the legal infrastructure for artificial intelligence that is established by the proposed EU Regulation establishing harmonized rules on artificial intelligence, often referred to as the Artificial Intelligence Law or the Artificial Intelligence Act.

Security and policing should provide an environment, safe and devoid of any fear for each individual, in which human rights and basic freedoms are protected from the malicious use of artificial intelligence, bearing in mind that law enforcement services possess systemic, discretionary and public powers with high degree of risk for potential abuse of artificial intelligence. A large number of studies at the global level point to the dangers to human rights and basic freedoms in the case of the application of artificial intelligence for security purposes, especially in cases of biometric recognition and detection of undesirable behavior of individuals. Apart from the regulatory process within the EU, we also look at the use of artificial intelligence in this area in Serbia through the analysis of the legal framework, i.e. the Strategy of the Republic of Serbia and other national soft law acts on artificial intelligence (hereinafter: AI).

Establishing legal infrastructure and defining prohibited and high-risk AI systems

Legal infrastructure is a term used in recent research and denotes the establishment of the right framework and regulation of a certain area of social behavior, that is, the standardization and adoption of legal acts as the basis of regulation and creation of conditions for the further development of that area. Infrastructures in common parlance refer to the physical or organizational aspects of the world that societies need to function. The metaphor of law as an infrastructure arises in the merging, that is, of a serious understanding of law as a socio-material form, on the one hand realized through social action, but on the other significantly reshaping the world around us (Byrne, Gammeltoft-Hansen, 2023). This term is separate and should not be confused with the actual electronic, digital and information infrastructure as the material base of AI development. The legal infrastructure in the specific case emphasizes the importance of legal regulation and understanding the necessity for normative regulation of the use of AI, especially if we understand the need, method and methods of legal regulation as a "condition above the conditions" for the functioning of society, that is, as infrastructural preparation and work on defining a huge area that organizationally requires the establishment of a modern legal "high speed highway". Security and prevention of the risk of endangering human lives also imposes the definition of strict "speed limits and certain mandatory directions of movement" which are truly necessary so that the development and use of AI does not turn into chaos, a threat and a threat to the survival of humanity. The balance between the possibility of further rapid development of AI for the benefit of each individual and the maximum reduction of the risk of uncontrolled "movement or popping" today means enabling, encouraging and directing its further future development in the fields of economy, medicine, public health, ecology, food production, supply, energy etc. The desire for AI to completely improve the way people think, create and move in the real world also speaks of the construction of a future "scientific highway with many lanes" (Prlja et al., 2021:96).

The establishment of the legal infrastructure for the AI, that is, the preparatory work for its definition, is rapidly taking place in international organizations as well as within formal and informal gatherings and coalitions of states. For example, reviews of the ethical dilemmas of the use of AI and United Nations guidelines are provided in a UNESCO guide (UNESCO, 2022), while the first guidelines for the use of AI in law enforcement were presented by Interpol and the UN Interregional Institute for Crime and Justice Research (Interpol&UNICRI, 2019). Regional organizations, primarily the Council of Europe and the Organization for Economic Co-operation and Development - OECD have introduced recommendations (OECD, 2022) regarding the modalities, ways and degree of coverage of the use of AI and are preparing conventions (Council of Europe, 2023) or guides for use with the member states AI in different spheres of

social life. States are also involved in the national definition of the framework for the implementation of AI, in which the USA is leading (White House Office of Science and Technology Policy, 2022) and China The China Academy of Information and Communications Technology, 2022), and in international frameworks grouping and holding summits have begun states that encourage innovation in the field of AI and regulate the development of AI by law or through national strategies. All this includes the private sector and technological giants, most of which are not enthusiastic about the imposition of an international and national regulatory framework, bearing in mind that they have already made certain forms of artificial intelligence available to all citizens on a daily basis. Not a small contribution to both the development of AI and the entire process of legal regulation is made by the academic community, within which there are research institutes such as the Institute for Human-Centered AI at Stanford University, which leads the overall annual global index of the development, progress and legal regulation of AI (Masley, et al., 2024).

In this global constellation, of all attempts to establish a legal infrastructure for the use of AI, the EU has gone the furthest, within which the legislative procedure for the adoption of the Regulation on AI (COM/2021/206, hereinafter: Regulation on AI or Regulation) is in the final stage. Namely, within the regular legislative procedure, the European Parliament adopted the Legislative Resolution (European Parliament, 2024) and its confirmation and adoption by the Council of the EU is awaited. The agreement of the EU institutions on this act was reached at the end of 2023, and in the first reactions to the news about the adoption of the regulation, it is emphasized that the interests of citizens were not put first and that double standards were introduced for the police and security services, with enough opportunities for human rights violations (Share Foundation, 2024). However, last-minute changes are not insignificant, introducing a mandatory fundamental rights impact assessment for high-risk AI systems, obliging those who use them to assess and mitigate foreseeable impacts on the fundamental rights of those affected, especially marginalized and vulnerable groups. This also refers to the introduction of the right of individuals to submit complaints to competent authorities regarding possible violations of the AI Regulation (Friedl, Gasiola, 2024).

The regulation defines the AI systems themselves as "a machine system designed to work at different levels of autonomy, which after introduction can show adaptability and which, for explicit or implicit goals, infers from the input values it receives how to generate output values such as predictions, content, recommendations or decisions that may affect physical or virtual environments" (Article 3, Point 1 of the Regulation). In the Regulation, a risk-based approach to the development and use of AI is highlighted, and the AI systems themselves are categorized into different classes and subject to different rules in accordance with the degree of risk assumed to represent individuals and society as a whole. The AI

Regulation places various restrictions on the AI systems that could be used in law enforcement. The majority of AI systems used by law enforcement agencies for security and policing purposes are placed in unacceptable, i.e. prohibited or strictly controlled, high-risk practices. The prohibited practice of using AI systems consists of: **manipulative** or misleading techniques, exploiting any weakness of individuals or certain groups, **evaluating or classifying natural persons** or a group of persons in a certain period based on their social behavior, **estimating or predicting** the probability that a natural person will commit a criminal offense exclusively based on the creation of a profile of a natural person or assessment of his characteristics and personality traits, **databases for facial recognition** by untargeted collection of face photos from the Internet or CCTV recordings, **drawing conclusions about the emotions** of a natural person in the workplace and in educational institutions, **biometric categorization** in which natural persons are individually categorized based on biometric data about their race, political opinions, union membership, religious or philosophical beliefs, sexual orientation, as well as **biometric identification** of individuals in real time.

Real-time remote biometric identification may only be used if its use is limited in time and geographically and if special judicial or administrative permission has been previously granted. The regulation defines three exceptions for remote biometric identification for the purpose of criminal prosecution for criminal offenses involving a high degree of social danger, namely: 1) targeted searches for specific victims of kidnapping, human trafficking or sexual exploitation of people, as well as searches for missing persons; 2) prevention of a concrete, significant and immediate threat to the life or physical safety of natural persons or a real and present or real and foreseeable threat of a terrorist attack; ; and 3) locating or identifying a person suspected of committing a criminal offense for the purpose of conducting a criminal investigation, prosecution or execution of a criminal sanction for the criminal offenses listed in Annex 2, which are punishable by imprisonment or deprivation of liberty for a maximum period of at least four years (Article 5, paragraph 1, point h of the Regulation).

High-risk practice or the categorization of AI systems as high-risk includes the fulfillment of strict requirements for their use by introducing additional rules of regulation and control. The difference between unacceptable or prohibited AI systems and high-risk ones is that others are not considered so dangerous, that is, they do not pose such a high degree of risk to human rights that it is necessary to ban them. This is where the largest number of AI systems are found, which are used in law enforcement, that is, in the areas of the police, the judiciary and critical infrastructure (Annex 3 of the Regulation).

The prohibited and high-risk practice of using AI in law enforcement relies primarily on the development and application of certain AI components related to the processing of large amounts of data, algorithms and advanced computer

technology. These components were previously encouraged in order to change, apply and review the technique of smart surveillance, profiling, the use of a large amount of data and, as widely as possible, the digitalization of the public sector (Fuster, 2020:21). In general, AI is linked and classified by the advanced grouping of algorithms used for technology development, according to the theoretical concepts behind them, which primarily originated in mathematics, logic, philosophy and information theory (Samoili, 2021:11).

There are various theories that emphasize the subjectivity of human perception from the perspective of law, for what is autonomous and intelligent in computational procedures by pointing to the one-sidedness in the use of terms that will change in the future. Namely, what fell into those categories during the 80s of the last century is neither intelligent nor autonomous today. That is why Kodagnone (Codagnone) AI as a term seems unsuitable for regulation by legal and by-laws, but the algorithms that are the basis of the AI system should be legislated. Accordingly, the legal acts that have already been adopted and regulate algorithmic processes and decision-making in different scenarios and with different purposes are related to the construction and are an integral part of the regulatory framework for AI in the EU (Codagnone et al., 2022:46). Namely, algorithms are powerful artifacts that operate within our information milieu, structuring our data, profiling, categorizing, and predicting who we are, what we are, what we want, and more (Hayes et al., 2020).

Challenges of using the AI system in law enforcement from the aspect of predicting and using special biometric techniques

The use of algorithms in the field of policing and security is a particularly sensitive issue with great potential for improving law enforcement measures and procedures, but also with a huge risk of causing harm and violating human rights (Hayes et al., 2020:1). One of the first techniques of using algorithms in the field of security, more specifically in police action, which precedes the use of the AI system, is police prediction (otherwise prohibited by Article 5, point d of the Regulation). Police predicting is the algorithmic processing of data sets that reveals patterns of likely future crimes and threats in order to prevent them before they actually occur. It can be divided into four broad categories such as: 1) methods for predicting criminal acts or places and time periods in which there is an increased risk of criminal activity; 2) methods of prediction and detection of possible perpetrators of criminal acts; 3) methods of predicting the identity of perpetrators or creating profiles similar to perpetrators of criminal acts in the past; and 4) predicting crime victims, that is, identifying groups and individuals who are likely to become victims of crime (Perry et al., 2013:xiv). Police predicting as a new technique for crime prevention appeared in the USA at the end of the 20th century, when the police departments of some large cities hired professional crime analysts who experimented with the processing of large amounts of data and the

use of new technologies, trying to predict events, more precisely, the time, the place and the criminal acts that will be committed as well as the potential perpetrators. Later, a special police prediction model called the Gang Violence Matrix was developed in Great Britain, which the London police began to use in 2012. This model was used to identify and assess the risk of gang members involved in violence, as well as to identify vulnerable groups, that is, those towards whom violence is directed. In other EU member states, it appears in the law enforcement in the area of money laundering and terrorist financing, when at the EU level, banks and other legal entities are required to take appropriate steps to identify risk factors for the assessment of the execution of the mentioned criminal acts (Fuster, 2020:23).

Facial recognition is a biometric technique in rapid development, which is included in two categories in the Regulation, that is, it is mentioned as a prohibited and high-risk practice of using AI in the field of law enforcement. Facial recognition technology as part of the AI system enables the automatic identification or authentication of an individual by comparing and confirming facial features with two or more digital images (EU FRA, 2019:2). It is the process by which AI software can identify or recognize a person using their biometric facial features extracted from a photo or video (Gikay, 2023:417). Although facial recognition is a technology that has been around for several decades, the technical advances in the last few years have been enormous. Some of today's best-performing face recognition algorithms have nearly 100% success on challenging datasets. The US National Institute of Standards and Technology (NIST) has created a Face Recognition Vendor Test (FRVT) measuring advances in facial recognition and how well algorithms perform various security and law enforcement tasks of the law, and refer specifically to the recognition of faces from photojournalist images, for the purpose of identifying victims of child trafficking, detecting forged passports and cross-checking the image of the issued visa. An algorithm's progress in facial recognition is measured by the false mismatch rate, or error rate, which represents the frequency with which the algorithm fails to match an image to a real person. In 2017, the most successful face recognitions had an error rate of over 50.0%, while as of 2021, no error rate higher than 3.0% was registered. The best-performing model across all datasets in 2021 (visa photos) registered an error rate of 0.1%, meaning that for every 1000 faces, the model correctly identified 999. Of particular concern is the use of this technology through system AI, i.e. recognition faces and detection of individuals live in real time. The AI software compares, in real time, the biometric facial images captured by the camera with the existing patterns of the suspect in the database. The extent of the use of facial recognition systems is indicative given that in the US today, 18 out of 24 government law enforcement agencies already use some form of facial recognition technology (Zhang et al., 2022:62). Reports from the US as far back as 2016 indicate widespread use of live facial recognition,

noting that at the time several major police departments were actively exploring real-time facial recognition on live surveillance camera footage. Since then, there have been increasingly explicit calls for legislation to regulate the use of facial recognition by law enforcement, warning that “facial recognition is too powerful to remain secret” and legally undefined (Garvie et al., 2016).

On the other hand, the UK government has called on the police to expand the use of AI-based technologies despite the fact that such systems threaten civil liberties. In a 2019 British national poll, 70% of respondents said the police should be allowed to use facial recognition in criminal investigations, and 71% supported its use in public spaces if it helped reduce crime. An illustrative example is the operation to prevent theft and violence in retail stores in London in 2023, in which the Metropolitan Police used facial recognition to identify 149 retail crime suspects by comparing hundreds of CCTV images (Gikay, 2023). Currently, only limited information is available on the possible use of facial recognition technologies in EU member states. In Germany, the Hamburg police used facial recognition technologies on protesters who caused riots over the G20 Summit in July 2017, while in 2018 the feasibility of using these systems was tested at a train station in Berlin (Engel, 2024). Police in Nice (France) conducted a test of the use of live facial recognition technology at Carnival 2018. The Gendarmerie in France uses facial recognition technologies for criminal investigations, but does not use live facial recognition technologies, due to the lack of a legal basis. Austrian authorities bought facial recognition software in 2019 to search a database to identify unknown criminals whose images are available from CCTV cameras or other sources. Testing for the use of facial recognition technology has also begun in the Netherlands (EU FRA, 2019:6). Some studies point to the future use of 3D facial recognition technology in the area of control of the Union's external borders by Frontex. While current facial recognition technologies rely on a "flat" photograph of an individual's face, 3D facial recognition uses three-dimensional features of the human face for automatic recognition and matching. Once the 3D geometry of the human face is acquired, significant features from the surface of the face are extracted. This enables greater precision than classic two-dimensional face recognition (Statewatch, 2023:37).

Essentially, facial recognition represents only one mosaic of the wider use of biometrics for security purposes. There are biometric techniques that include biometric identification, biometric categorization, behavior detection, emotion recognition, brain-computer interfaces, and other similar techniques that have a wide range of uses. The term "biometric techniques" should be understood to include any technology or operation that: 1) relies on the specific technical processing of data relating to the physical, physiological or behavioral aspects of the human body (including when it is in motion); and 2) for purposes such as authentication or identification of human individuals, categorization of human individuals according to permanent or long-term characteristics (including for the

purpose of predicting future behavior) or detection of temporary or permanent conditions of a human individual (such as fear, fatigue, or illness, or certain intention). However, the increasing use of "weak" and "soft" biometrics together with "strong" biometrics, focusing on a range of patterns of different types of behavior, and the development towards multimodal biometrics are noted. Together with improved sensing and computing capabilities, as well as improved connectivity, this paves the way for the mass adoption of biometric technologies in a wide range of sectors and for a wide range of purposes, even far beyond law enforcement and border controls, making biometric technologies something of a universal technology. (Wendehorst, Duler, 2021:1).

Other research finds that it is a multitude of facial recognition technologies that are used for different purposes, ranging from simple detection of the presence of a face in an image, to more complex verification, identification and categorization or classification of individuals. **Verification** (one-to-one comparison) allows the comparison of two biometric templates, which are usually assumed to belong to the same person. **Identification** (one-to-many comparison) means that a person's face image template is compared to other templates stored in the database to find out if their image is stored there. Facial recognition is also used to **categorize** (or classify) individuals, based on their personal characteristics. In this sense, a wide range of software has been developed to estimate a person's attributes from their face, for the purpose of "classifying facial attributes" (eg gender, race or ethnicity) or "estimating facial attributes" (eg age). Furthermore, facial recognition can be used to classify facial expressions (such as a smile) or a person's emotional state such as happy, sad or angry (Madiaga, Mildebrath, 2021:1).

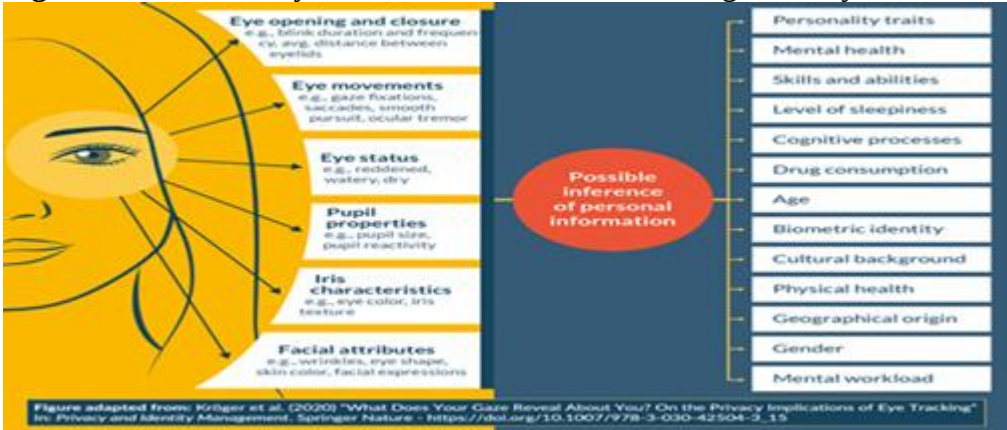
Figure 1. Real-time emotion recognition.



Source: Article 19. <https://www.article19.org/resources/eu-emotion-misrecognition/>

The latter was investigated at the external borders of the EU, more precisely at certain border crossings of Greece, Hungary and Latvia within the Horizon 2020 project, called the Integrated Transfer Control System (iBorderCtrl) which integrates facial recognition and other technologies to detect whether an individual is telling the truth. The so-called were examined and identified. "deception biomarkers", non-verbal micro-expressions associated with lying such as blinking of the left eye, increased redness of the face, directions of head movement, etc. (Sánchez-Monedero, Dencik, 2022). It is, in fact, an inexhaustible series of variations in the use of biometric techniques, identifiers and biometrically derived data through them. Biometrically derived data is a collection of data sets that are the result of information obtained from behavioral, physical and psychological biometric identification techniques and other non-verbal communication methods.

Figure 2. Biometrically derived data obtained based on gaze analysis.



Source XRSI: https://xrsi.org/wp-content/uploads/2020/09/illustrations_XRSI_privacy_framework_20200906_DEF-7-1-1536x1277.png

These derived data are obtained from the main biometric identification techniques, i.e., "strong" biometric identifiers such as: facial recognition, dactyloscopic data (fingerprint verification), iris scanning, retina analysis; voice recognition and ear shape recognition. Key analysis, signature analysis, gait analysis, gaze analysis (eye tracking) are also included (XRSI, 2024). For the unique identification of natural persons, "strong" biometric identifiers should be captured, transformed into digital data and finally standardized into a template (Wendehorst, Duler, 2021b). Finally, we have to mention the "print of human movement" as one of the biometrically strong identifiers. Human movement fingerprinting can also be ideal for predicting activity, crime and disease and therefore part of police prediction and security. According to AI pioneer Louis Rosenberg, there are real dangers "that systems will be able to identify you without your consent and participation without you even knowing that you have been targeted." Gesture printing, unlike

face recognition techniques, can enable identification from behind, without seeing the person's face at all (Kremidas-Courtney, Lindersthal, 2023).

All the described biometric techniques are a powerful tool for the security services, which dramatically complicates the already sufficiently polarized parties that advocate for more security or more rights and freedoms of citizens. Thus, according to defenders of human rights, the final text of Regulation AI represents a missed opportunity for the protection of civil liberties. The adoption of the AI Regulation is understood as the acceptance of a practice that throughout history has been associated with "eugenics", that is, the science of various ways of improving and controlling the human species. The final version of the AI Regulation goes to the soul of France, which is accused of significantly influencing its content with the intention of preserving and expanding the state's authority to use non-transparent and unreliable AI systems for security reasons and increasing the effectiveness of police work to prevent crime and violence in public gatherings and all this on the eve of the Olympic and Paralympic Games in Paris (Reclaim your face, 2024).

Legal framework for the use of the AI system in law enforcement in the Republic of Serbia

The importance of the use of AI and its permeation of all spheres of social life in the Republic of Serbia was recognized in the middle of the second decade of the 20th century. The implementation of digitalization and the significant development of the IT sector, which in recent years has had a considerable share in GDP growth, were a direct bridge to research, innovation and shaping the implementation of AI. This led to the adoption of the first Strategy for the Development of Artificial Intelligence in 2019, establishing Serbia as the first country in Southeast Europe and the 26th in the world to have such a document. Also, in 2022, Serbia will become part of the Global Partnership for Artificial Intelligence (hereinafter: GPAI) and in 2023, a member of the Alliance for Artificial Intelligence Management of the World Economic Forum (Euroactiv, 2024).

GPAI is an initiative that aims to establish global standards and rules for the development of artificial intelligence, as well as to accelerate the development of artificial intelligence globally. Membership in GPAI Serbia has gained numerous benefits in several different fields. One of the most important is certainly access to the most modern trends in the field of artificial intelligence. In the next three years, Serbia will be the chairman of the GPAI, and in the first and third years it will be the assistant chair, while in the second year it will be the main chair. The criteria for membership were progress in the development of artificial intelligence, and commitment to responsible development of artificial intelligence. The GPAI secretariat is at the Organization for Economic Cooperation and Development

(OECD), and the expert centers are in Montreal and Paris, while a new one will be opened in Japan (Euroactiv, 2024a). The Republic of Serbia has a total of 21 policies and areas of cooperation and development of AI that are registered on the OECD Observatory for AI (OECD AI, 2024). One of the more significant ones is the already mentioned Strategy for the Development of Artificial Intelligence in the Republic of Serbia for the period 2020-2025. (hereinafter: Strategy).

The Strategy in the introductory part contains goals and measures for the development of artificial intelligence, the implementation of which should result in economic growth, improvement of public services, improvement of scientific staff and development of skills for the jobs of the future (Strategy for the development of artificial intelligence in the Republic of Serbia for the period 2020-2025, "Official Gazette of RS", No. 96/2019). It is harmonized with the European Initiative for AI, which preceded the Strategy and Proposal of the EU Regulation on AI as one of the obligations from the accession process of the Republic of Serbia to the EU and which should enable its complete integration into the European Research Area. The reason for its adoption is emphasized in the Strategy, "that AI is a general-purpose technology such as the steam engine, railways and electricity, which dramatically contributes to the development of all areas of the economy and society and brings revolutionary changes in many of them". It is also emphasized that AI can improve the efficiency of public administration work and the quality of services provided by the state to citizens and the economy (heading 2.1 of the Strategy).

It points out the advantages of its use in various social spheres with the possible risks arising from its application. In specific risks for example personal data, under the title "Individual and society" it is emphasized that the policy and legal framework of the Republic of Serbia in this area follows EU standards, more precisely the EU General Data Protection Regulation, thereby ensuring the application of high standards of personal data protection. In the challenges, looking at the comparative practice, he emphasizes the need for the prevention of discrimination by pointing out that "it may happen to introduce a system that, through data analysis, determines the level of risk of individuals to commit a misdemeanor or crime." If the data is not used adequately, such a system can reproduce a discriminatory pattern" (heading 4.4 of the Strategy). The part that refers to specific objectives, especially the parts that refer to the use of AI in public administration, does not contain any reference or mention the risks of its application for police and security purposes.

The risks and challenges as well as the categorization of these systems are contained in the Ethical Guidelines for the Development, Implementation and Use of a Reliable and Responsible AI from 2023 ("Official Gazette of RS", No. 23/2023, hereinafter: Guidelines). The Guidelines follow the categorization contained in the proposal of the Regulation on AI of the European Commission and in the category of high risk lists AI systems:

- biometric identification and categorization of an individual: in particular, they include systems intended for remote biometric identification of an individual in real time as well as subsequent remote biometric identification;
- criminal prosecution: in particular, it includes systems intended for criminal prosecution bodies that assess the risk of individuals for committing or re-committing criminal acts based on characteristics, characteristics or previous criminal behavior; systems that would be used as polygraph devices or devices to detect an individual's emotional state; systems that would be used to assess the credibility of evidence during pre-investigation, investigation and court proceedings; systems that would be used to assess the individual; systems intended for the analysis of crimes related to individuals and which enable the search of complex linked and unlinked large data sets from different sources or in different formats with the aim of spotting unknown patterns in data or hidden connections between data;
- management of human migration, asylum and state border surveillance: in particular, it includes systems that would be used as polygraph means or means to reveal the emotional state of an individual; systems intended for competent authorities/institutions for risk assessment (including security risk, illegal immigration risk or health risk) represented by an individual who intends to enter or has entered the territory of the Republic of Serbia; systems intended for competent authorities/institutions for checking the authenticity of travel documents, especially through checking the security features of those documents; systems intended to assist competent authorities/institutions in considering applications for asylum, visas, residence and work permits and related processes (related processes include checking criminal and misdemeanor convictions, the existence and type of complaints made in connection with the relevant applications, etc.), and in for the purpose of making decisions regarding the subject requests (Title 2.3 of the Guidelines).

The adoption of the Guidelines is a step forward in shaping the legal framework for the use of AI in the Republic of Serbia, with the fact that the Guidelines do not have mandatory force, but rather represent a soft law instrument that in principle guides the future development of AI and its application by law enforcement services. They are not fully aligned with the EU Regulation on AI because they do not contain a list of prohibited or unacceptable practices of using the AI system for security purposes. The guidelines, in fact, include systems prohibited in the EU as high-risk systems, such as, for example, biometric identification and categorization of individuals, that is, systems intended for remote biometric identification of an individual in real time as well as subsequent remote biometric identification.

The question arises whether the use of the AI system for security and police purposes is defined by the Guidelines as high-risk, sufficient to prevent its malicious use by law enforcement services in the Republic of Serbia? Is the

Government's Conclusion as a legal act defining the Guidelines sufficient to prevent services from mass surveillance through the AI systems? The answer to these questions is denied, especially considering the experience with the unsuccessful attempt to pass the Law on Internal Affairs in the period 2020-2022. which was supposed to de facto legalize the use of biometric surveillance. The use of biometric surveillance was foreseen, among other things, in public space, that is, at high-risk public gatherings based on the minister's order (Vasilkov, 2023). Non-governmental organizations and civil society, with their activism, debates and criticisms, managed to postpone the legislative process of legalizing the prohibited and high-risk practice of biometric surveillance, despite the explanation of the MUP representative as the proposer, that these systems greatly contribute to increasing the security of citizens, and that they are already a standard practice in EU. Namely, the civil society points out that Serbia has repeatedly been on the "leaked" lists of users of powerful face recognition software such as *Clearview AI* and *Griffeye*, as well as that AI systems have been acquired with which it is possible to process biometric and other data, such as " smart" cameras, *Social Links*, *Maltego* and *Mozenga* software, as well as programs for advanced facial recognition (European Western Balkans, 2023).

Conclusion

Security, police action and the work of law enforcement services on the one hand and the protection of human rights and fundamental freedoms on the other have always been opposite poles, irreconcilable opposites, topics that divide and polarize the public, especially human rights defenders and security experts and professionals. When we add to this antagonism and debates about who is older, security or human rights, whether the protection of one of these values excludes the protection and respect of the other, how much security is enough and what is the area of protected privacy and the level of respect for human rights, we add the application system AI for security purposes we get a very challenging, risky and rather difficult equation with three unknowns.

AI biometric systems marked as prohibited and high-risk in the Regulation on AI will cease to be applied, that is, they will begin to be applied in the manner provided by the Regulation, 6 months after its publication in the Official Gazette of the EU with the obligation of full implementation in the next two years, which marks the establishment of the first legislative framework which regulates the application of the AI system in the field of law enforcement. Member States will have to find a transparent, responsible and proportionate way and form of using prediction systems, using biometrics and other techniques for border surveillance, criminal prosecution and the fight against terrorism, which law enforcement services intend to use.

The regulation of certain practices of the application of AI in the field of law enforcement in the Republic of Serbia is defined by the Strategy on the

Application of Artificial Intelligence 2020 - 2025 and the Ethical Guidelines from 2023. The attempt to legally introduce biometric surveillance through the proposed Law on Internal Affairs in 2022 disturbed the public and enraged human rights representatives in Serbia. What lies ahead in the coming period, especially until the end of 2024, when the Law on Internal Affairs is expected to be adopted, is the continuation of the "struggle" between supporters of more security on the one hand and supporters of human rights protection on the other. One type of possible solution to this social security phenomenon, as well as the recommendation that emerges from this research, can be the connection of existing policies in the area of AI with individual laws, that is, partial legal regulation through the amendment of existing legislation. Thus, certain laws could regulate the application of the AI system, especially in the field of law enforcement, such as the aforementioned Law on Internal Affairs and the Law on Border Control, which would regulate the use of the AI system at border crossings and the supervision and protection of the state border. The Law on the Organization and Competence of State Authorities for Combating High-Tech Crime would contain provisions prohibiting the use of the AI system for actions that threaten high-tech security. The Criminal Code and the Law on Criminal Procedure would ensure a sufficient level of human rights protection in the application of the AI system in criminal law matters, and the Law on the Security and Information Agency would, with amendments, prevent the arbitrary and indiscriminate use of the AI system and also enable a greater degree of protection of human rights and freedoms. This way of building legal infrastructure and legal regulation would contribute not only to building standards and practices of legal use of biometric and other high-risk AI systems in the national legal order of the Republic of Serbia, but also to the improvement of international security cooperation with EU law enforcement services such as Europol and Frontex, then Interpol and finally on a bilateral basis when security cooperation with other countries using the AI system proves to be a necessity.

References

1. Byrne W. H., T. Gammeltoft-Hansen. 2023. Untangling the Legal Infrastructure of Schengen. MOBILE Working Paper, No. 21. DOI: <https://doi.org/10.31235/osf.io/9h4e3>
2. Codagnone C. et al., 2022. Identification and assessment of existing and draft EU legislation in the digital field. Study for the special committee on Artificial Intelligence in a Digital Age (AIDA). Policy Department for Economic, Scientific and Quality of Life Policies. European Parliament, Luxembourg, doi: 10.2861/73141.
3. Council of Europe. 2023. Draft Framework Convention on artificial intelligence, human rights, democracy and the rule of law. (dostupno na web

- sajtu: <https://rm.coe.int/-1493-10-1b-committee-on-artificial-intelligence-cai-b-draft-framework/1680aee411>)
4. Engel A. 2024. Facial Recognition Technologies in the Public Sector: Observations from Germany. Chapter. In The Cambridge Handbook of Facial Recognition in the Modern State, edited by Rita Matulionyte and Monika Zalnieriute, 186–97. Cambridge Law Handbooks. Cambridge: Cambridge University Press.
 5. Euroactiv. 2024. Da li smo spremni za Veštačku inteligenciju? Indeks pokazuje da smo na 57. mestu, Srbija će uložiti 100 miliona evra. (dostupno na web sajtu: <https://euractiv.mondo.rs/tehnologija/a6320/Da-li-je-Srbija-spremna-za-vestacku-inteligenciju.htm>)
 6. Euroactiv. 2024a. Šta je "organizacija globalno partnerstvo za veštačku inteligenciju"? Srbiji donosi brojne benefite i razvoj tehnologije (dostupno na web sajtu: <https://euractiv.mondo.rs/tehnologija/a6482/Sta-je-organizacija-Globalno-partnerstvo-za-vestacku-inteligenciju-i-sta-znaci-za-Srbiju.html>)
 7. European Commission. 2021. Proposal for a Regulation Of The European Parliament and of The Council Laying Down Harmonised Rules on Artificial Intelligence (Artificial Intelligence Act) and Amending Certain Union Legislative Acts. COM/2021/206 final.
 8. European Union Agency for Fundamental Rights (EU FRA). 2019. Facial recognition technology: fundamental rights considerations in the context of law enforcement. (dostupno na web sajtu: https://fra.europa.eu/sites/default/files/fra_uploads/fra-2019-facial-recognition-technology-focus-paper-1_en.pdf)
 9. European Western Balkans. 2023. Akt EU o veštačkoj inteligenciji će onemogućiti nekontrolisan biometrijski nadzor u Srbiji. (dostupno na web sajtu: <https://europeanwesternbalkans.rs/akt-eu-o-vestackoj-inteligenciji-ce-onemoguciti-nekontrolisan-biometrijski-nadzor-u-srbiji/>)
 10. Evropski Parlament. 2024. Akt o umjetnoj inteligenciji. Zakonodavna rezolucija Evropskog parlamenta od 13. ožujka 2024. o Prijedlogu uredbe Evropskog parlamenta i Vijeća o utvrđivanju usklađenih pravila o umjetnoj inteligenciji (Akt o umjetnoj inteligenciji) i izmjeni određenih zakonodavnih akata Unije (COM(2021)0206 – C9-0146/2021 – 2021/0106(COD)). P9_TA(2024)0138.
 11. Friedl P., G.G. Gasiola. 2024. Examining the EU's Artificial Intelligence Act. VerfBlog. DOI: 10.59704/789d6ad759d0a40b (dostupno na web sajtu: <https://verfassungsblog.de/examining-the-eus-artificial-intelligence-act/>)
 12. Fuster G.G. 2020. Artificial Intelligence and Law Enforcemen - Impact on Fundamental Rights. Study requested by the LIBE committee. doi:10.2861/880024
 13. Garvie C., et al., 2016. The Perpetual Line-Up. Unregulated Police Face Recognition, Georgetown Law Center on Privacy & Technology. (dostupno na web sajtu: <https://www.perpetuallineup.org/>)

14. Gikay A.A. 2023. Live Facial Recognition for Law Enforcement: The European Union's Regulatory Approach Should be Informed by UK Police's Practice. (dostupno na web sajtu: <https://eulawanalysis.blogspot.com/2023/11/live-facial-recognition-for-law.html>)
15. Gikay A.A. 2023. Regulating use by law enforcement authorities of live facial recognition technology in public spaces: an incremental approach." The Cambridge Law Journal 82, no. 3 (2023): 414–49. <https://doi.org/10.1017/S0008197323000454>
16. Hayes P. et al., 2020. Algorithms and values in justice and security. AI & SOCIETY 35: 533–555. <https://doi.org/10.1007/s00146-019-00932-9>
17. Interpol&UNICRI. 2019. Artificial Intelligence and Robotics for Law Enforcement. (dostupno na web sajtu: <https://unicri.it/artificial-intelligence-and-robotics-law-enforcement>)
18. Kremidas-Courtney C., H. Linderstal. 2023. The convergence of new technologies endangering human agency. Friends of Europe. (dostupno na web sajtu: <https://www.friendsofeurope.org/insights/the-convergence-of-new-technologies-endangering-human-agency/>)
19. Madiega T., H. Mildebrath. 2021. Regulating facial recognition in the EU. European Parliamentary Research Services (EPRS). Brussels. DOI:10.2861/140928. (dostupno na web sajtu: [https://www.europarl.europa.eu/RegData/etudes/IDAN/2021/698021/EPRS_IDA\(2021\)698021_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/IDAN/2021/698021/EPRS_IDA(2021)698021_EN.pdf))
20. Maslej N. et al., 2024. The AI Index 2024 Annual Report. AI Index Steering Committee, Institute for Human-Centered AI. Stanford University, Stanford, CA. (dostupno na web sajtu: <https://aiindex.stanford.edu/report/>)
21. OECD 2024. OECD AI Policy Observatory. AI in Serbia (dostupno na web sajtu: <https://oecd.ai/en/dashboards/countries/Serbia>)
22. OECD. 2022. Recommendation of the Council on Artificial Intelligence, OECD/LEGAL/0449. (dostupno na web sajtu: <https://legalinstruments.oecd.org/en/instruments/oecd-legal-0449>)
23. Perry L.W. et al., 2013. Predictive Policing: The Role of Crime Forecasting in Law Enforcement Operations. Rand Corporation. ISBN: 978-0-8330-8148-3. (dostupno na web sajtu: https://www.rand.org/pubs/research_reports/RR233.html)
24. Prlja D., G. Gasmi., i V. Korać. 2021. Veštačka inteligencija u pravnom sistemu EU. Institut za uporedno pravo. Beograd. ISBN 978-86-80186-73-3
25. Reclaim your face. 2024. EU AI Act will fail commitment to ban biometric mass surveillance (Deutsche Version unten). (dostupno na web sajtu: <https://reclaimyourface.eu/eu-ai-act-will-fail-commitment-to-ban-biometric-mass-surveillance/>)
26. Samoili S. et al., 2021. AI Watch. Defining Artificial Intelligence 2.0. Towards an operational definition and taxonomy for the AI landscape. Publications Office of the European Union. European Parliament, Luxembourg, doi:10.2760/019901.

27. Sánchez-Monedero J., L. Dencik. 2022. The politics of deceptive borders: 'biomarkers of deceit' and the case of iBorderCtrl. *Information, Communication & Society*. 25:3, 413-430. (dostupno na web sajtu: <https://www.tandfonline.com/doi/full/10.1080/1369118X.2020.1792530>)
28. Share Fondacija. 2024. Usvojen AI Akt: Ljudska prava ostala u drugom planu. (dostupno na web sajtu: <https://www.sharefoundation.info/sr/usvojen-ai-akt-ljudska-prava-ostala-u-drugom-planu/>)
29. Statewatch. 2023. Europe's techno borders. EuroMed Rights & Statewatch. (dostupno na web sajtu: <https://www.statewatch.org/publications/reports-and-books/europe-s-techno-borders/>).
30. Strategy for the development of artificial intelligence in the Republic of Serbia for the period 2020-2025., "Official Gazette of RS", no. 96/2019.
31. The China Academy of Information and Communications Technology. 2022. Artificial Intelligence White Paper. (dostupno na web sajtu: https://cset.georgetown.edu/wp-content/uploads/t0442_AI_white_paper_2022_EN.pdf)
32. UNESCO. 2022. Recommendation on the Ethics of Artificial Intelligence. (dostupno na web sajtu: <https://unesdoc.unesco.org/ark:/48223/pf0000381137>)
33. Vasilkov Z. 2023. Unutrašnji poslovi i bezbednost u pravu Evropske unije nakon Lisabonskog ugovora. Zadužbina Andrejević: Beograd. ISBN 978-86-525-0429-9
34. Wendehorst C., Y. Duler. 2021a. Biometric Recognition and Behavioural Detection Assessing the ethical aspects of biometric recognition and behavioural detection techniques with a focus on their current and future use in public spaces. BRIEFING Requested by the JURI AND PETI committees Policy Department for Citizens' Rights and Constitutional Affairs. Directorate-General for Internal Policies PE 697.131 (dostupno na web sajtu: [https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/697131/IPOL_BRI\(2021\)697131_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/697131/IPOL_BRI(2021)697131_EN.pdf))
35. Wendehorst C., Y. Duler. 2021b. Biometric Recognition and Behavioural Detection Assessing the ethical aspects of biometric recognition and behavioural detection techniques with a focus on their current and future use in public spaces. European Parliament Study requested by the JURI AND PETI committees Policy Department for Citizens' Rights and Constitutional Affairs. Directorate-General for Internal Policies. doi: 10.2861/982599
36. White House Office of Science and Technology Policy. 2022. The Blueprint for an AI Bill of Rights: Making Automated Systems Work for the American People. (dostupno na web sajtu: <https://www.whitehouse.gov/ostp/ai-bill-of-rights>)
37. XReality Safety Intelligence (XRSI).2024. Biometrically-Inferred Data (BID). (dostupno na web sajtu: <https://xrsi.org/definition/biometrically-inferred-data-bid>).

38. Conclusion on the adoption of Ethical guidelines for the development, application and use of reliable and responsible artificial intelligence. Official Gazette of RS", No. 23/2023.
39. Zhang D. et al., 2022. The AI Index 2022 Annual Report. AI Index Steering Committee, Stanford Institute for Human-Centered AI, Stanford University. (dostupno na web sajtu: <https://aiindex.stanford.edu/ai-index-report-2022/>)

UČINAK NOVIH ULAGANJA NA TROŠKOVE MATERIJALA I ENERGIJE U PRIVREDI REPUBLIKE SRBIJE

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Apstrakt

U radu se ispituje učinak poslovnih prihoda i ulaganja u nekretnine, postrojenja i opremu na troškove materijala i energije u privrednim društvima Republike Srbije, i to na nivou privrede i privrednih sektora. Istraživanje se zasniva na zvaničnim podacima koje je objavila Agencija za privredne registre Republike Srbije, koja uključuju deset privrednih sektora za period od 2013. do 2022. godine, izvršeno je putem panel modela. Rezultati kointegracijskih testova pokazali su da postoji dugoročan odnos ravnoteže između razmatranih veličina. Učinak poslovnih prihoda na troškove materijala, goriva i energije na dugi rok je pozitivan. Učinak ulaganja u nekretnine, postrojenja i opremu na troškove materijala goriva i energije na dugi rok je statistički značajan i negativan na nivou privrede i u sektorima Prerađivačke industrije, Snabdevanje električnom energijom, Trgovine na veliko i malo i Saobraćaja i skladištenja, dok je u slučaju sektora Usluga smeštaja i ishrane taj učinak pozitivan.

Ključne reči: ulaganja u stalna sredstva, poslovni prihodi, poslovni rashodi, Srbija, The UN Goal 12, panel model.

JEL: M210, O33

Uvod

U ovom radu ispituje se učinak i ulaganja u nekretnine, postrojenja i opremu na troškove materijala i energije u privrednim društvima Republike Srbije, i to na nivou privrede i privrednih sektora. Istraživanje se zasniva na podacima koji su preuzeti iz Godišnjih biltena finansijskih izveštaja koje izdaje Agencija za privredne registre Republike Srbije. Baza podataka obuhvata zbirne podatke svih privrednih društava u Srbiji i njihovu analitiku po sektorima delatnosti za period od 2013. do 2022. godine.

Preliminarne analize podataka objavljenih od strane Agencije za privredne registre pokazuju da godišnja stopa rasta novih ulaganja (računato kao razlika između

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tekuće i prethodne godine uvećana za troškove amortizacije) u nekretnine, postrojenja i opremu u periodu od 2013. do 2022. godine iznosi oko 13,1%, varirajući u rasponu od 9,3% u 2014. godini do 18,6% u 2021. godini. Prirodno je očekivanje da su nova ulaganja proizvodi najsavremenije tehnologije, koji povećavaju efikasnost upotrebe materijala i energije u procesu proizvodnje, i posledično smanjuju relativnu visinu njihovih troškova. Takvo očekivanje je polazna hipoteza u ovom radu koja glasi:

H0 - Povećana ulaganja u nekretnine, postrojenja i opremu rezultiraju manjom potrošnjom materijala i energije u procesu proizvodnje.

Povećanje prihoda, kao rezultat povećanja proizvodnje, je prirodni uzrok rasta troškova. Našu pažnju takođe je privuklo pitanje učinka rasta prihoda na rast troškova materijala i energije, koje je izraženo u sledećoj hipotezi:

H1 – Povećanje troškova materijala i energije manje je od povećanja prihoda.

Ako rezultati istraživanja pokažu tačnost polaznih hipoteza, možemo da smatramo da su ulaganja u nekretnine, postrojenja i opremu proizvod najsavremenijih tehnologija, i da kao takva ukazuju na intenzivan privredni razvoj u Republici Srbiji. Ovaj stav namerno ne formulišemo u obliku hipoteze, već ćemo ga koristiti kao indikator za naredna istraživanja.

U narednom delu dajemo pregled literature iz date oblasti, zatim informacije o podacima i metodologiji istraživanja, empirijsku analizu, rezultate i zaključak.

Pregled literature

U ekonomskoj teoriji često se ističe značaj identifikovanja međuzavisnosti investicija i potrošnje materijala i energije kao jedne od determinanti formiranja novostvorene vrednosti. Imajući u vidu klimatske i izazove očuvanja životne sredine, potrošnja materijala i energije se sve češće posmatra kao ograničavajući faktor ostvarivanja održivog privrednog rasta i proizvodnje. Nesporno je da potrošnja energije predstavlja značajnu determinantu privrednog rasta i razvoja. Intenzivna ulaganja u rast obima proizvodnje imala su za posledicu, između ostalog, i značajno povećanje potrošnje energije i materijala poslednjih decenija. Član 10 Pariskog sporazuma ističe značaj dugoročne vizije ostvarivanja razvoja i transfera tehnologije koja će unaprediti otpornost na klimatske promene i smanjiti emisiju gasova sa efektom "staklene bašte". Sporazumom je uspostavljen tehnološki okvir sa smernicama za formulisanje politike i mera kojima se ubrzava razvoj i transfer navedene tehnologije (United Nations, 2015). U cilju smanjenja troškova potrošnje goriva i tradicionalnih energenata, Evropska unija ističe kao prioritet promociju i razvoj obnovljivih izvora energije. Postavljen je cilj da se do 2030. godine ostvari učešće obnovljivih energetske izvora u ukupnoj potrošnji energije u Evropskoj uniji u visini od najmanje 27 procenata (European

Parliament, 2016). Ostvarivanje zaštite životne sredine kao cilja ekonomske i socijalne politike pretpostavlja brojne promene u privredi sa različitim efektima na energetske intenzivne privredne sektore. Iz tog razloga, neophodno je istražiti efekte investicija u stalna sredstva i tehnoloških promena na potrošnju materijala i energije, kao i uticaj potrošnje energije i materijala na privredni rast.

Veoma mali broj empirijskih studija istražuje uticaj investicija u stalna sredstva na smanjenje troškova materijala i energije u proizvodnji. Analizirajući pokazatelje tehničkog progresa Vasylenko navodi i smanjenje stope troškova materijala i rada kao rezultat investicija. Međutim, mogućnost investicija da utiču na smanjenje troškova materijala nije merena (Vasylenko, 2021). Shaobo et al. su ispitivali uticaj troškova materijala na obim investicija u stalna sredstva u Kini i došli su do zaključka da postoji dugoročan statistički značajan uticaj (Shaobo et al., 2021). Takođe, vršena su istraživanja efekata pozitivnih i negativnih promena u ceni sirove nafte, koje predstavljaju značajnu determinantu visine troškova energije, na investicije preduzeća (Maghyreh, Abdoh, 2020). Navedeni rezultati su značajni, između ostalog i zbog pozitivnog odnosa vrednosti investicija preduzeća i konkurentnosti njegovog proizvoda na tržištu (Jiang et al., 2015).

Postoji nekoliko empirijskih studija koje istražuju povezanost investicija u stalna sredstva i potrošnje energije i materijala na makro nivou. Koristeći podatke o agregatnim pokazateljima rumunske privrede u periodu 1994-2014. godine, Popescu et al. su utvrdili prisustvo visoke, pozitivne i statistički značajne parcijalne korelacije stalnog kapitala po radniku i potrošnje materijala (0,818), dok je parcijalna korelacija stalnog kapitala po radniku i potrošnje energije niska, negativna i nije statistički značajna (-0,260) (Popescu et al., 2019). Na osnovu rezultata moguće je zaključiti da investicije u stalna sredstva uzrokuju rast potrošnje materijala.

Takođe, empirijske studije ističu povezanost investicija u stalna sredstva, privrednog rasta i potrošnje energije. Određen broj studija istražuju ovaj odnos u Kini gde je nagli rast investicija u stalna sredstva povezan sa dvocifrenim rastom stope energetske potrošnje u periodu 2003-2006. godine. Iz tog razloga, ekonomska politika i tržišna tražnja naglašavaju potrebu optimizacije privredne strukture i industrije uz nagli razvoj logističkog sektora. Ranije studije potvrdile su dugoročnu, pozitivnu i statistički značajnu korelaciju investicija u stalna sredstva i energetske potrošnje (Lili, Peng, 2011). Takođe, pronađen je i pozitivan i statistički značajan uticaj investicija u stalna sredstva na CO₂ emisiju (Wang et al., 2019).

Međutim, analizirajući odnos investicija u stalna sredstva u sektoru saobraćaja i skladištenja i potrošnje energije, Wang i Dong zaključuju da investicije u stalna sredstva imaju negativan, statistički značajan uticaj na energetske potrošnje uz ispoljavanje različite visine efekta među regionima (Wang, Dong, 2023). Navedeni rezultati ukazuju na potrebu i značaj da investicije u stalna sredstva

budu usmerene na nabavku energetske efikasne opreme. Takođe, rezultati istraživanja su pokazali da postoje razlike u efektima investicija u stalna sredstva na energetske potrošnje u sektorima privrede. Prema Wang et al. investicije u stalna sredstva u poljoprivredi imaju indirektan, pozitivan i statistički značajan efekat na potrošnju energije čija ocenjena vrednost iznosi 0,360, dok je ocenjena vrednost efekta u sekundarnoj industriji niža i iznosi 0,108 (Wang et al., 2020).

Znatno je veći broj empirijskih istraživanja odnosa energetske potrošnje i privrednog rasta imajući u vidu da je potrošnja energije značajan faktor proizvodnog procesa i ostvarivanja privrednog rasta. S druge strane, moguće je posmatrati privredni rast kao faktor uticaja na tražnju energenata i materijala koji se koriste kao sirovine u procesu proizvodnje. Testiranje uzročnosti privrednog rasta od energetske potrošnje može biti značajno jer ukazuje na stepen energetske zavisnosti privrede. Polazeći od toga da investicije u stalna sredstva mogu ostvarivati i indirektan efekat na privredni rast posredstvom uticaja na potrošnju energije i materijala, biće dat pregled rezultata relevantnih empirijskih istraživanja o uticaju energetske potrošnje na privredni rast.

U velikom broju empirijskih studija utvrđeno je prisustvo pozitivnog i statistički značajnog uticaja energetske potrošnje na privredni rast (Pao, Fu, 2013), (Ito, 2017), (Jebli, Youssef, 2015). Slični rezultati prisutni su i u empirijskim studijama Alper i Oguz (Alper, Oguz, 2016) i Anwar et al. (Anwar et al., 2017).

Pojedina istraživanja ukazuju da postoje razlike u kratkoročnoj i dugoročnoj uzročnoj vezi između potrošnje energije i privrednog rasta u zavisnosti od stepena ekonomske razvijenosti zemalja. U opsežnom istraživanju, Ahmed i Azam su pronašli da je "hipoteza rasta" odnosno uticaj energetske potrošnje na privredni rast potvrđena kod 25 zemalja među kojima je 7 zemalja visokog dohotka, 14 zemalja srednjeg dohotka i 4 zemlje niskog dohotka. Međutim, kod znatno više zemalja (40) utvrđeno je da privredni rast utiče na potrošnju energije, dok je obostrani uticaj energetske potrošnje i privrednog rasta potvrđen kod 18 zemalja (Ahmed, Azam, 2016). Efekte privrednog rasta na potrošnju energije iz obnovljivih izvora ispitivao je Mbarek et al. potvrđujući jednosmernu uzročnost privrednog rasta na povećanje potrošnje obnovljive energije koja je statistički značajna u kratkom i dugom roku u razvijenim zemljama, dok je u zemljama u razvoju prisutan samo kratkoročan efekat (Mbarek et al., 2018). Pri tom, pojedine empirijske studije ističu da privredni rast statistički značajno utiče na povećanje pre svega industrijske potrošnje energije u zemljama niskog i srednjeg dohotka. Međutim, ovaj efekat izostaje u zemljama visokog dohotka (Narayan, Doytch, 2017).

Empirijske studije o uticaju energetske potrošnje na privredni rast u post tranzicionim zemljama su malobrojne. Većina istraživanja potvrđuje da povećanje potrošnje energije ima statistički značajan uticaj na rast BDP-a, što dodatno ističe značaj daljeg istraživanja faktora koji imaju efekte na energetske potrošnje.

Takođe, rezultati ovih istraživanja pokazuju da su privrede post tranzicionih zemalja, koje su članice Evropske unije, u većoj meri energetske zavisne u odnosu na privrede starih članica EU (Kasperowicz, Štreimikiene, 2016), (Bercu et al., 2019), (Šikić, 2020).

Kao što se iz pregleda merodavne literature može sagledati, u literaturi nije posebno razmatrano koliko nova ulaganja u nekretnine, postrojenja i opremu doprinose smanjenju troškova materijala i energije. Ovo pitanje je zanimljivo ne samo sa stanovišta privrednog rasta, već i sa stanovišta uticaja privrednog rasta na životnu sredinu.

Relativno visoka stopa privrednog rasta u Republici Srbiji podstakla je autore da, koristeći bazu podataka Agencije za privredne registre, analiziraju učinak ulaganja u nekretnine postrojenja i opremu na broj zaposlenih po privrednim sektorima (Beke-Trivunac i Peković, 2021) i po velični privrednih društava (Beke-Trivunac i Peković, 2022). Ovo je prvo istraživanje učinka ulaganja na efikasnost troškova materijala i energije u Republici Srbiji.

Podaci i metoda

Podaci za analizu i ocenu učinka ulaganja u nekretnine, postrojenja i opremu preduzetnih entiteta na efikasnost troškova preuzeti su iz Godišnjih biltena finansijskih izveštaja koje je uradila Agencija za privredne registre Republike Srbije za 2014, 2016, 2018, 2020 i 2022. godinu.

Razmatrani podaci obuhvataju iznose na pozicijama bilansa uspeha: Troškovi materijala i energije, i Poslovni prihodi, kao i iznosa na poziciji bilansa stanja: Nekretnine, postrojenja i oprema. Analizom su obuhvaćeni podaci za entitete grupisane po privrednim sektorima. Objavljeni statistički podaci APR-a obuhvataju deset privrednih sektora: A - Poljoprivreda, šumarstvo i ribarstvo; B – Rudarstvo; C – Prerađivačka industrija; D- Snabdevanje električnom energijom; E – Snabdevanje vodom; F – Građevinarstvo; G – Trgovina na veliko i malo; H – Saobraćaj i skladištenje; I – Usluge smeštaja i ishrane; J – Informisanje i komunikacija.

Serije podataka odnose se na period od 2013. do 2022. godine. Podaci kojima raspolažemo su u ekonometrijskoj literaturi poznati pod nazivom panel podaci. Oni predstavljaju kombinaciju uporednih podataka (eng. *Cross-section*) i vremenskih serija. Ovakvi podaci omogućavaju analizu strukture, odnosno heterogenosti između sektora, ali i analizu promena strukture tokom vremena. Za analizu panel podataka razvijeni su ekonometrijski modeli poznati pod nazivom modeli panela.

Tabela 1. Definicija i oznake korišćenih serija i izvor podataka

Oznaka serija	Definicija i izvor podataka
<i>Troškovi</i>	Troškovi materijala, goriva i energije. Godišnji bilteni finansijskih izveštaja koje je uradila Agencija za privredne registre Republike Srbije za 2014, 2016, 2018, 2020 i 2022. godinu.
<i>Prihodi</i>	Poslovni prihodi. Godišnji bilteni finansijskih izveštaja koje je uradila Agencija za privredne registre Republike Srbije za 2014, 2016, 2018, 2020 i 2022. godinu.
<i>Oprema</i>	Nekretnine, postrojenja i oprema. Godišnji bilteni finansijskih izveštaja koje je uradila Agencija za privredne registre Republike Srbije za 2014, 2016, 2018, 2020 i 2022. godinu.

Logaritam varijabli (*LN**Troškovi*, *LN**Prihodi*, *LN**Oprema*) su korišćeni za formulisanje istraživačkog modela:

$$LN*Troškovi*_{it} = \alpha_0 + \beta_1 LN*Prihodi*_{it} + \beta_2 LN*Oprema*_{it} + u_{it}$$

gde se indeks *i* odnosi na uporedne podatke, tj. sektore *i* = 1, 2, ..., 10, a *t* na vremensku dimenziju panela, tj. vremenski period *t* = 2013, 2014, ..., 2022. Modeli zasnovani na logaritamskoj transformaciji originalne serije su poželjniji, iz najmanje dva razloga. Prvo, većina modela ocenjenih u literaturi zasnovana je na logaritamskim transformacijama serijama. To omogućava poređenje sa rezultatima drugih istraživanja. Drugo, tumačenje koeficijenata u takvim modelima je intuitivnije. Koeficijenti u ovim modelima su elastičnosti, koji pokazuju za koliko će se promeniti zavisna varijabla za 1% promene nezavisnih varijabli.

U ekonometrijskom delu ovog istraživanja analizu počinjemo sa grafičkim prikazom panel podataka. U tu svrhu koristimo linijske grafike na kojima ćemo prikazati parove vremenskih serija za svaki sektor posebno. Nakon toga ispitaćemo međusobnu zavisnost uporednih podataka, tj. zavisnost između sektora – CD test (Pesaran, 2004), njihovu homogenost – delta tilda test (Pesaran i Yamagata, 2008), a takođe i stacionarnost vremenskih serija – CIPS test (Pesaran, 2007). Kointegracioni test (Westerlund, 2005) će se koristiti da bi se utvrdilo postojanje dugoročne međuzavisnosti između *LN**Troškova*, *LN**Prihoda* i *LN**Opreme*. Kointegracioni koeficijenti kako na dugi tako i na kratak rok za sve panele zajedno i svaki posebno će se oceniti korišćenjem nekoliko alternativnih ocena da bi se proverila robusnost rezultata o međusobnoj povezanosti *LN**Troškova*, *LN**Prihoda* i *LN**Opreme* na dugi rok. Radi se o sledećim ocenama: FMOLS ocena (eng. *fully modified ordinary least squares*) – potpuno

modifikovana ocena najmanjih kvadrata; (Kao i Chiang, 2000; Pedroni, 2000, 2001; Phillips i Moon, 1999), DOLS ocena (eng. *dynamic ordinary least squares*) – ocena dinamičkih najmanjih kvadrata; (Mark i Sul, 2003; Stock i Watson, 1993), MG ocene (eng. *mean group*) – ocena sredine grupa (Pesaran i Smith, 1995); AMG ocena (eng. *augmented mean group*) – proširena ocena sredine grupa (Teal i Eberhardt, 2010); a takođe PMG/ARDL ocena (eng. *pooled mean group / autoregressive distributed lags*) – objedinjena ocena sredine grupa / autoregresione raspoređene docnje (Pesaran et al., 1999).

U ekonometrijskoj analizi panel podataka korišćeni su statistički paketi Stata 15, Eviews 10 i R4.3.2.

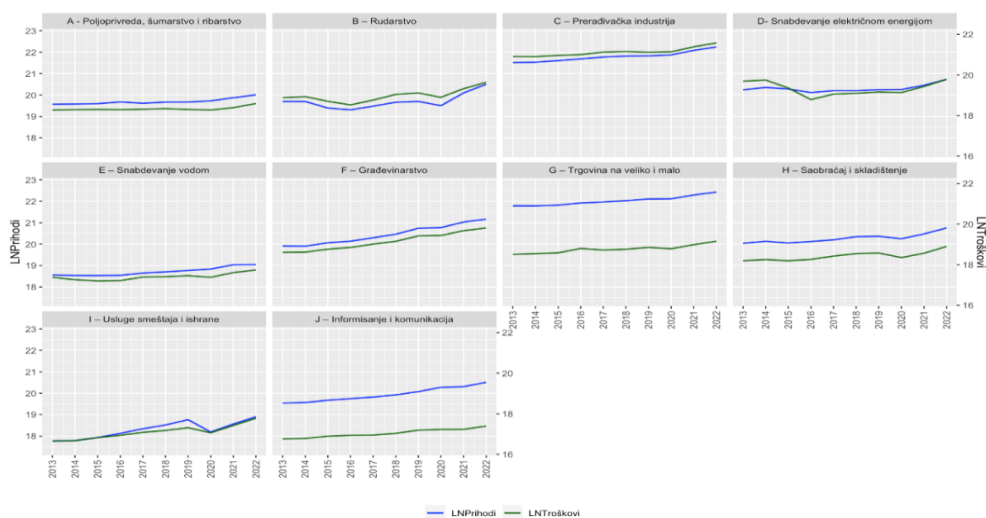
Empirijska analiza

Glavni cilj analize u ovom istraživanju je da istraži učinak ulaganja u nekretnine, postrojenja i opremu na efikasnost upotrebe materijala i energije, preduzetnih entiteta u deset sektora Republike Srbije u periodu 2013-2022. Ovaj cilj će se postići ispitivanjem međusobne povezanosti vrednosti nekretnina, postrojenja i opreme s jedne strane sa troškovima materijala, goriva i energije i poslovnih prihoda s druge strane. Osnovna istraživačka hipoteza je da povećanje vrednosti nekretnina, postrojenja i opreme u sektorima Republike Srbije dovodi do smanjenja troškova materijala, goriva i energije. Istovremeno, za očekivati je da će rast poslovnih prihoda biti brži od rasta troškova materijala, goriva i energije.

Grafički prikaz podataka

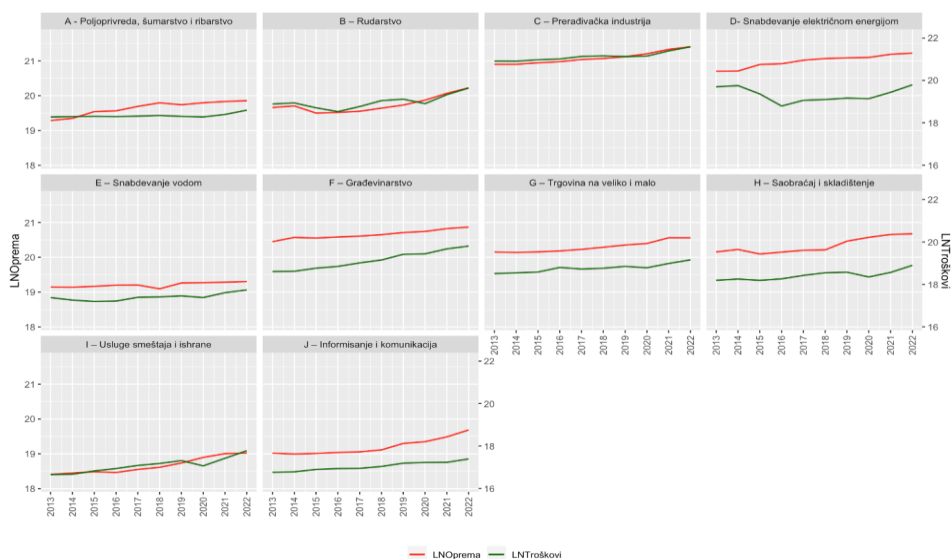
Empirijsku analizu počinjemo grafičkim prikazom panel podataka. Uobičajeni grafički prikaz panel podataka je linijski grafik, tj. vremenska serija za svaki sektor posebno. Na taj način možemo uporediti tendenciju promena promenljivih tokom vremena u svakom sektoru i videti da li pri tome ima nekih opštih tendencija, tj. pozitivnog ili negativnog rasta. Prikazom dve promenljive istovremeno na istom grafiku možemo uočiti njihov međusobni odnos, tj. usklađenost u njihovom razvoju tokom vremena i eventualno ukazati na to da li naša hipoteza ima osnova da bude prihvaćena u nekom od sektora.

Napominjemo da je na Slikama 1 – 3 svaka serija prikazana na svojoj osi, pa stoga nivoi tih serija nisu uporedivi. Ono na šta obraćamo pažnju je međusobni odnos dinamike serija. Na Slici 1 jasna je tendencija da se serije *LNPrihoda* i *LNTroškova* kreću kod većine sektora skoro paralelno i da u svim panelima imaju pozitivan trend. To nam kazuje da se očekuje rezultat u daljoj analizi koji će ukazati na pozitivnu i statistički značajnu povezanosti ove dve serije.



Slika 1. Panel podaci serija *LNPrihodi* i *LNTroškovi* sektora Republike Srbije

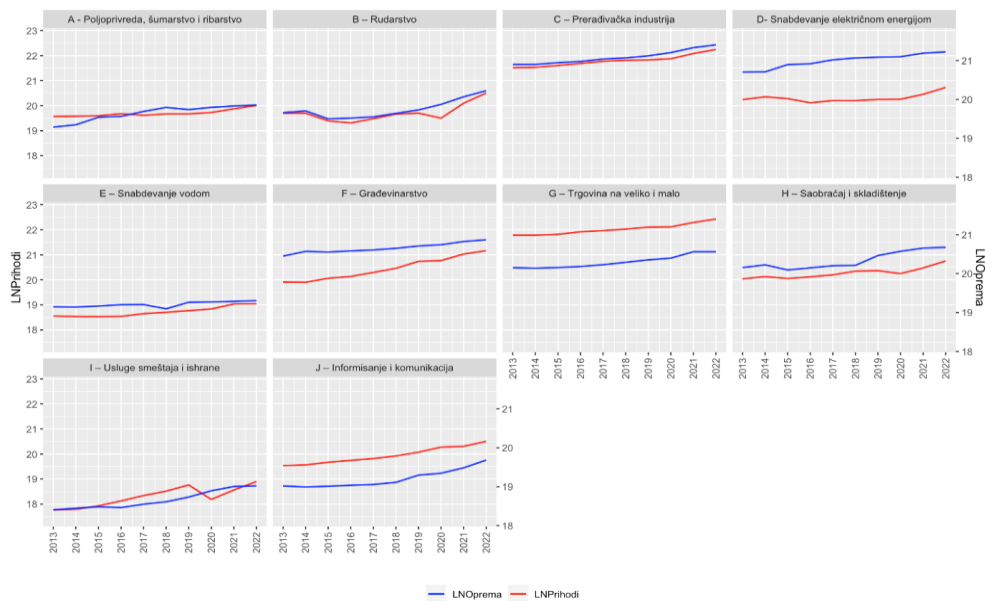
Na Slici 2 date su serije *LNTroškova* i *LNOpreme*. Mada obe serije pokazuju tendenciju rasta tokom vremena, može se uočiti kod većeg broja panela da se serije u pojedinim godinama kreću u suprotnom smeru, tj. u periodu porasta *LNOpreme*, dolazi do pada u seriji *LNTroškovi* i obratno. To se najbolje uočava na panelima D i H. Ovakav međusobni odnos serija nam sugerise da je za očekivati njihovu negativnu povezanost.



Slika 2. Panel podaci serija *LNOprema* i *LNTroškovi* sektora Republike Srbije

Naposletku, na Slici 3 date su serije *LNPrihodi* i *LNOprema*. Ono što je rečeno kod grafika serija *LNTroškova* i *LNOpreme* može se ponoviti i u slučaju

međusobnog odnosa serija *LN*Prihodi i *LN*Oprema. Naime, kod većeg broja panela ove dve serije se u pojedinim godinama kreću u suprotnom smeru, tj. u periodu porasta *LN*Opreme, dolazi do pada u seriji *LN*Prihodi i obratno. To se najbolje uočava na panelima D i H.



Slika 3. Panel podaci serija *LN*Oprema i *Ln*Prihodi sektora Republike Srbije

Test zavisnosti uporednih podataka

U primenjenom delu istraživanja prvo su primenjeni testovi nezavisnosti i homogenosti uporednih podataka da bi se izabrali robusniji testovi jediničnog korena i kointegracije. Za testiranje hipoteze o nezavisnosti uporednih podataka u panelima koristimo CD test (Pesaran, 2004), a rezultati su prikazani u Tabeli 2. Kod sve tri serije nulta hipoteza o nezavisnosti uporednih podataka je odbačena na nivou značajnosti od 1%. Drugim rečima zaključujemo o postojanju zavisnosti uporednih podataka.

Tabela 2. Test statistike zavisnosti uporednih podataka

Promenljiva	Pesaran CD
LNTroškovi	18.01
LNPrihodi	18.43
LNOprema	15.53

Napomena: Srednje vrednosti uporednih podataka su uklonjene tokom izračunavanja korelacija. Stepen slobode za sve testove je 45. *P*-vrednosti za sve statistike testova su manje od 1%.

Izvor: Izračunavanja autora

Pošto su kod sve tri serije identifikovane zavisnosti uporednih podataka to nam sugerše da pri izboru testova jediničnog korena biramo onaj test koji nije osetljiv na prisustvo zavisnosti uporedivih podataka. To je slučaj sa tzv. drugom generacijom testova jediničnog korena.

Test homogenosti

Homogenost kointegracionih koeficijenata znači da nema varijacije u ovim koeficijentima među panelima. Nulta hipoteza o homogenosti znači drugim rečima da su uticaji poslovnih prihoda i nekretnina, postrojenja i opreme na troškove materijala, goriva i energije jednaki u svim sektorima što je prilično restriktivna pretpostavka. Međutim, odbacivanje ove hipoteze stvara dodatne probleme, jer se u tom slučaju moraju izabrati oni testovi jediničnog korena i kointegracije koji su neosetljivi na odsustvo homogenosti u panelima.

Homogenost kointegracionih koeficijenata je istražena primenom delta tilda i prilagođenog delta tilda testa (Pesaran i Yamagata, 2008). Rezultati testa prikazani su u Tabeli 3. Nulta hipoteza homogenosti je odbačena na nivou značajnosti od 1%. Drugim rečima ovaj rezultat ukazuje na to da su kointegracioni koeficijenti heterogeni, tj. variraju od sektora do sektora.

Tabela 3. Test homogenosti

Test	Statistika	P-vrednost
$\tilde{\Delta}$	3.339	<.01
$\tilde{\Delta}_{prilagođen}$	4.311	<.01

Napomena: Nulta hipoteza je da su kointegracioni koeficijenti homogeni.

Izvor: Izračnavanje autora

Test jediničnog korena

Prve generacije testova jediničnog korena su osetljive na odsustvo homogenosti među panelima i nezavisnosti među uporednim podacima. Druga generacija testova jediničnog korena u panelima nudi rešenja u prevazilaženju ovog problema, napuštajući pretpostavke o nezavisnosti uporednih podataka i homogenosti panela. Najznačajniji test druge generacije, Uporedni IPS test (CIPS) predložio je Pesaran (2007), a nazvan je po Im, Pesaran & Shin (2003).

Rezultati primene CIPS testa za jedinične korene u heterogenim panelima, tj. u prisustvu zavisnosti uporednih podataka prikazani su u Tabeli 4. Nulta hipoteza je da svi paneli sadrže jedinični koren, protiv alternativne hipoteze da su neki paneli stacionarni.

Tabela 4. Pesaranova CIPS test statistika za jedinične korene u heterogenim panelima

Promenljiva	Bez trenda	Sa trendom
Nivo		
<i>LN</i> Prihodi	-0.926	-1.527
<i>LN</i> Oprema	-2.286*	-3.381**
<i>LN</i> Troškovi	-1.503	-1.960
Prva razlika		
<i>LN</i> Prihodi	-2.289	-2.682
<i>LN</i> Oprema	-3.859***	-3.898***
<i>LN</i> Troškovi	-2.179	-1.918

Napomena: individualne specifikacije dinamike u svakoj regresiji su zasnovane na Wald-ovom testu kompozitne linearne hipoteze o parametrima modela. Zvezdice ukazuju na nivoe značajnosti: 10% (*), 5% (**) i 1% (***).

Izvor: Izračunavanje autora

Pesaran CIPS test pokazuje za sve serije, osim *LN*Oprema, da nultu hipotezu o jediničnom korenu u svim panelima nije moguće odbaciti. Međutim, pošto imamo posla sa prilično kratkim vremenskim serijama (samo 10 opservacija), rezultate Pesaran CIPS testa treba tretirati sa izvesnim ogradama zbog njihove manje snage kada su vremenske serije kratke. Grafikoni za serije (Slike 1 – 3), za neke od panela pokazuju jasan trend koji sugerise moguću nestacionarnost. Stoga bismo nastavili sa analizom pod pretpostavkom da su sve serije prvog reda integrisanosti.

Test kointegracije

Da bismo testirali hipotezu o postojanju dugoročne veze između ulaganja u nekretnine, postrojenja i opremu sa troškovima materijala, goriva i energije u sektorima Republike Srbije koristimo jedan od testova kointegracije (Westerlund, 2005). Pri tome smo koristili dve varijante testa u zavisnosti kako je definisana alternativna hipoteza. Dok nulta hipoteza ukazuje na odsustvo kointegracije, alternativna hipoteza je da su svi paneli kointegrirani ili da su neki od panela kointegrirani. Takođe smo varirali pretpostavku o ponašanju autoregresionog (AR) parametra u ovom testu. U jednoj varijanti AR parametar je jednak u svim panelima, dok u drugoj varijanti on varira među panelima. Rezultati Westerlund testa su dati u Tabeli 5.

Tabela 5. Westerlundov test panel kointegracije

Test	Statistika	P-vrednost
Odnos varijanse (AR parametri variraju među panelima, trend nije uključen, nulta hipoteza: Nema kointegracije, alternativna hipoteza: Neki od panela su kointegrirani)	2.413	<.01
Odnos varijanse (AR parametri jednaki u svim panelima, trend nije uključen, nulta hipoteza: Nema kointegracije, alternativna hipoteza: Svi paneli su kointegrirani)	0.041	.484
Odnos varijanse (AR parametri variraju među panelima, trend je uključen, nulta hipoteza: Nema kointegracije, alternativna hipoteza: Neki od panela su kointegrirani)	1.285	.099
Odnos varijanse (AR parametric jednaki u svim panelima, trend je uključen, nulta hipoteza: Nema kointegracije, alternativna hipoteza: Svi panel su kointegrirani)	1.075	.142

Izvor: Izračunavanje autora

Westerlundov test kointegracije je potvrdio postojanje kointegracije među tri posmatrane serije u nekim od 10 sektora (prvi i treći red u Tabeli 5). Istovremeno se nije potvrdilo da su svi paneli posmatrani zajedno kointegrirani (drugi i četvrti red u Tabeli 5).

Ocene dugoročnih koeficijenata modela

Pošto je utvrđeno da postoji dugoročna povezanost tri serije pristupilo se oceni regresionog modela panela u cilju dobijanja ocena dugoročnog uticaja poslovnih prihoda i nekretnina, postrojenja i opreme na troškove materijala, goriva i energije. Da bi se istražilo u kojoj meri su rezultati ocene uticaja robustni s obzirom na korišćenje različitih ocena i softverskih algoritama, regresioni modeli panela su ocenjeni korišćenjem pet različitih metoda ocenjivanja (FMOLS, DOLS, MG, Aug MG i PMG/ARDL) i dva statistička softvera (Stata i EViews). Rezime ocenjenih regresionih modela panela predstavljeni su u Tabeli 6.

Tabela 6. Dugoročni kointegracioni koeficijenti za privredna društva – ukupno Republike Srbije

Metod ocenjivanja	<i>LN</i> Prihodi	<i>LN</i> Oprema
FMOLS (EViews)	1.007***	-0.241**
DOLS (EViews)	0.998***	-0.237**
MG (Stata)	1.069***	-0.285
Aug MG (Stata)	0.849***	-0.245
PMG/ARDL (EViews)	0.561***	-0.164***

Napomena: Kod metoda MG i Aug MG svi koeficijenti predstavljaju proseke po grupama. Proseci koeficijenta izračunati su kao neponderisane sredine. Kod metoda Aug MG zajednički dinamički proces uključen je kao dodatni regresor. Zvezdice ukazuju na nivoe značajnosti ocenjenih koeficijenata: 10% (*), 5% (**) i 1% (***).

Izvor: Izračunavanje autora

Podsećamo da su sve serije pre analize transformisane korišćenjem logaritamske transformacije. To znači da se ocenjeni koeficijenti u ovim kointegracionim regresijama panela mogu tumačiti kao elastičnosti. Za ilustraciju koristimo rezultate ocena metodom FMOLS dobijene korišćenjem softverskog algoritma programa EViews. Koeficijent za *LNPrihodi* je 1.007, što znači da u proseku promena poslovnih prihoda od 1% dovodi do povećanja troškova materijala, goriva i energije za 1.007% za 10 sektora privrede Republike Srbije. Treba takođe primetiti da je ovaj uticaj statistički značajan na 1% nivou značajnosti. Koeficijent za *LNOprema* je -0.241, što znači da u proseku promena vrednosti nekretnina, postrojenja i opreme od 1% dovodi do smanjenja troškova materijala, goriva i energije za 0.241% za sektore privrede Republike Srbije. Ovaj koeficijent je statistički značajan na nivou od 5%.

Ako pogledamo predznak i statističku značajnost ocenjenih koeficijenata u Tabeli 6 možemo primetiti sledeće. Postoji varijacija među ocenjenim koeficijentima, ali u slučaju koeficijenta uz promenljivu *LNPrihodi* većina je bliska jedinici, svi koeficijenti su sa pozitivnim predznakom i visoko su statistički značajni (1% nivo značajnosti). Koeficijenti uz promenljivu *LNOprema* su svi sa negativnim predznakom i bliski vrednosti -0.25, no nisu svi u statističkom smislu značajno različiti od nule (kod MG i Aug MG metoda ocenjivanja). Na osnovu toga možemo zaključiti da je pozitivan uticaj poslovnih prihoda na troškove materijala, goriva i energije potvrđen sa visokom pouzdanošću, dok je u slučaju vrednosti nekretnina, postrojenja i opreme taj uticaj negativan i potvrđen u manjoj meri no uticaj poslovnih prihoda.

Poslednji metod ocenjivanja u Tabeli 6 je PMG/ARDL i on je izabran jer omogućava istraživanje dugoročne i kratkoročne kointegracijske korelacije između ulaganja u nekretnine, postrojenja i opremu s jedne i troškove materijala, goriva i energije s druge strane i poslovnih prihoda. Panel ARDL metoda ima prednosti u odnosu na tradicionalnije tehnike kointegracije, kao što je Johansenov kointegracioni test, jer se može koristiti bez obzira na stepen integrisanosti serija. Koristeći panel ARDL, ocenjuju se i dugoročni i kratkoročni koeficijenti odjednom. Rezultati ocene metodom PMG/ARDL dati su u Tabeli 7.

Tabela 7. Panel ARDL (PMG) ocene (zavisna promenljiva: *LNTroškovi*)

Promenljiva	Dugoročna jednačina		
	Koeficijent	t-statistika	P-vrednost
<i>LNPrihodi</i>	0.561	13.15	<.01
<i>LNOprema</i>	-0.164	-3.79	<.01
Kratkoročna jednačina			
Jednačina kointegracije	-0.318	-2.52	.01
Δ <i>LNPrihodi</i>	1.005	6.01	<.01
Δ <i>LNOprema</i>	0.026	0.27	.78
Konstanta	3.181	2.63	.01

Napomena: Švarcov kriterijum (SIC) je korišćen za izbor optimalne dužine kašnjenja. Izabran je ARDL(1,1,1) model sa konstantom.

Izvor: Izračunavanja autora

Koeficijent korekcije greškom (jednačina kointegracije u Tabeli 7) je u skladu sa osnovnim pretpostavkama konvergencije kako bi se potvrdila dugoročna ravnotežna priroda modela. To uključuje da jednačina kointegracije bude negativna, značajna i manja od jedan (Pesaran et al., 1999). Jednačina kointegracije u iznosu -0.318 u Tabeli 7 objašnjava da je stopa prilagođavanja nazad u dugoročnu ravnotežu 31.8% i da je značajna na 1% nivoa značajnosti. Na kratak rok, samo je uticaj poslovnih prihoda značajan na nivou značajnosti manjem od 1% sa pozitivnim predznakom, dok je uticaj vrednosti nekretnina, postrojenja i opreme na kratak rok pozitivan, ali beznačajan u statističkom smislu.

Panel ARDL je dugoročna ocena ravnoteže i stoga se dugoročnim koeficijentima obično pridaje veći značaj. Kratkoročno povećanje i poslovnih prihoda i nekretnina, postrojenja i opreme dovelo bi do povećanja troškova materijala, goriva i energije. Međutim, to nije slučaj na duži rok, barem u periodu od 2013. do 2022. godine, kada serija nekretnina, postrojenja i opreme negativno utiče na seriju troškova materijala, goriva i energije. Uticaj poslovnih prihoda na dugi rok ostaje i dalje pozitivan. Takođe treba primetiti da na dugi rok u odnosu na kratak rok raste uticaj nekretnina, postrojenja i opreme, dok se uticaj poslovnih prihoda smanjuje. Ovi dugoročni koeficijenti su uneti i u poslednjem redu Tabele 6, i nešto su niži po svojoj vrednosti od odgovarajućih koeficijenata dobijenih ostalim metodama ocenjivanja.

Zaključujemo da kointegracioni test zasnovan na modelu panela PMG/ARDL takođe potvrđuje da postoji dugoročna veza između serija troškova materijala, goriva i energije, poslovnih prihoda i nekretnina, postrojenja i opreme u slučaju sektora Republike Srbije za period koji se istražuje (2013-2022).

Naposletku, ocenili smo koeficijente kointegracije na nivou individualnih sektora pomoću ocene metoda sredine grupa (MG) i proširene sredine grupa (Aug MG), a rezultati su prikazani u Tabeli 8. Koeficijenti kointegracije panela su pokazali da su poslovni prihodi imali statistički značajan pozitivan uticaj na troškove materijala, goriva i energije u svim sektorima i ukupno. Pri tome je ovaj koeficijent bio najniži u sektoru *Usluga smeštaja i ishrane* (0.623), a najviši u sektoru *Snabdevanje električnom energijom* (1.995).

Tabela 8. Dugoročni kointegracioni koeficijenti sektora Republike Srbije

Sektor	MG		AugMG	
	<i>LN</i> Prihodi	<i>LN</i> Oprema	<i>LN</i> Prihodi	<i>LN</i> Oprema
A – Poljoprivreda, šumarstvo i ribarstvo	0.716***	-0.103	0.418**	-0.031
B – Rudarstvo	0.704***	0.268	0.166	0.425
C – Prerađivačka industrija	1.290***	-0.506	1.221***	-0.540**
D – Snabdevanje električnom energijom	1.995***	-1.262***	0.993*	-1.327***
E – Snabdevanje vodom	0.907***	-0.449	0.550***	-0.133
F – Građevinarstvo	0.926***	0.078	0.933***	0.094
G – Trgovina na veliko i malo	1.673***	-1.061***	1.730***	-1.039***
H – Saobraćaj i skladištenje	1.184***	-0.226**	1.216***	-0.228**
I – Usluge smeštaja i ishrane	0.623***	0.485***	0.594***	0.400**
J – Informisanje i komunikacija	0.672***	-0.076	0.668***	-0.067
Privredna društva - ukupno	1.069***	-0.285	0.849***	-0.245

Izvor: Izračunavanje autora

Što se tiče uticaja nekretnina, postrojenja i opreme rezultati su mešoviti. Tako u slučaju *Prerađivačke industrije*, *Snabdevanja električnom energijom*, *Trgovine na veliko i malo*, i *Saobraćaja i skladištenja* uticaj ulaganja u nekretnine, postrojenja i opremu na troškove materijala, goriva i energije je statistički značajan i negativan, a jedino u slučaju sektora *Usluga smeštaja i ishrane* taj uticaj je pozitivan. Na nivou *Privrednih društava ukupno* uticaj je kod oba metoda ocenjivanja identifikovan kao negativan, ali dobijena ocena nije statistički značajno različita od nule. Kod ostalih sektora uticaj nekretnina, postrojenja i opreme na troškove materijala, goriva i energije nije bio statistički značajan, kao ni na nivou privrede kao celine.

Zaključak

Na početku zaključka potrebno je još jedanput ponoviti najveće ograničenje analize sprovedene u ovom istraživanju, a to je relativno mala veličina uzorka, tj. kratkoća vremenske serije u podacima panela. Ovo ograničenje objašnjava u

velikoj meri varijacije u dobijenim ocenama uticaja poslovnih prihoda i nekretnina, postrojenja i opreme na troškove materijala, goriva i energije.

Na temelju analize koju smo sprovedi koristeći godišnje panel podatke privrednih sektora Republike Srbije u razdoblju od 2013. do 2022. godine potvrdila se naša hipoteza, tj. možemo zaključiti sledeće:

1. Rezultati kointegracijskih testova pokazali su da postoji dugoročni odnos ravnoteže između troškova materijala, goriva i energije, poslovnih prihoda i nekretnina, postrojenja i opreme.
2. Uticaj poslovnih prihoda na troškove materijala, goriva i energije je na dugi rok pozitivan. Povećanje poslovnih prihoda za 1% vodi povećanju troškova materijala, goriva i energije za oko 0,9%.
3. Uticaj nekretnina, postrojenja i opreme na troškove materijala, goriva i energije je na dugi rok negativan. Povećanje vrednosti nekretnina, postrojenja i opreme za 1% vodi smanjenju oko troškova materijala, goriva i energije za 0,25%. Posmatrano po sektorima, uticaj ulaganja u nekretnine, postrojenja i opremu na troškove materijala, goriva i energije je statistički značajan i negativan u *Prerađivačkoj industriji*, *Snabdevanju električnom energijom*, *Trgovini na veliko i malo*, i *Saobraćaju i skladištenju*, a jedino u slučaju sektora *Usluga smeštaja i ishrane* taj uticaj je pozitivan.

Pitanje koliko nova ulaganja u nekretnine, postrojenja i opremu doprinose smanjenju troškova materijala i energije zanimljivo je ne samo sa stanovišta privrednog rasta, već i sa stanovišta njegovog učinka na očuvanje životne sredine.

Izjava zahvalnosti

Autori se zahvaljuju Dr Zlatku Kovačiću na pomoći oko empirijske ocene modela.

Literatura

1. Ahmed M., & M. Azam. 2016. Causal nexus between energy consumption and economic growth for high, middle and low income countries using frequency domain analysis. *Renewable and Sustainable Energy Reviews* 60: 653-678.
2. Alper A., & O. Oguz. 2016. The role of renewable energy consumption in economic growth: Evidence from asymmetric causality. *Renewable and Sustainable Energy Reviews* 60: 953-959.
3. Anwar A., N. Arshed, & N.N. Kousar. 2017. Renewable Energy Consumption and Economic Growth in Member of OIC Countries. *European Online Journal of Natural and Social Sciences* 6, (1): 111-129.

4. Beke-Trivunac J. & D. Peković. 2021. The impact of investments in permanent assets on the increase in the number of employees and their salaries by entrepreneurial sectors. *Revizor* 95-96, (24): 7-16.
5. Beke-Trivunac J. & D. Peković. 2022. The effects of investments in permanent assets on employment and salaries by enterprise size. *Revizor* 97-98, (25): 7-19.
6. Bercu A.M., G. Paraschiv, & D. Lupu. 2019. Investigating the Energy-Economic Growth-Governance Nexus: Evidence from Central and Eastern European Countries. *Sustainability* 11, (12): 3355.
7. European Parliament. 2016. Promotion of renewable energy sources in the EU, EU policies and Member State approaches. European Union.
8. Im K.S., M.H. Pesaran, & Y. Shin. 2003. Testing for unit roots in heterogeneous panels. *Journal of Econometrics* 115: 53-74.
9. Ito K. 2017. CO2 emissions, renewable and non-renewable energy consumption, and economic growth: Evidence from panel data for developing countries. *International Economics* 151: 1-6.
10. Jebli M.B., & S.B. Youssef. 2015. Output, renewable, and non-renewable energy consumption and international trade: Evidence from a panel of 69 countries. *Renewable Energy* 83: 799-808.
11. Jiang F., K.A. Kim, J.R. Nofsinger, & B. Zhu. 2015. Product market competition and corporate investment: Evidence from China. *Journal of Corporate Finance* 35: 196-210.
12. Kao C., & M.H. Chiang. 2000. On the estimation and Inference of a cointegrated regression in panel data. In B.H. Baltagi et al. (Eds.). *Nonstationary panels, panel cointegration and dynamic panels*: 179-222. Amsterdam: Elsevier.
13. Kasperowicz R., & D. Štreimikiene. 2016. Economic growth and energy consumption: comparative analysis of V4 and the “old” EU countries. *Journal of International Studies* 9, (2): 181-194.
14. Lili L., & Q. Peng. 2011. The impact of China’s investment increase in fixed assets on ecological environment: an empirical analysis. *Energy Procedia* 5: 501-507.
15. Maghyreh A., & H. Abdoh. 2020. Asymmetric effects of oil price uncertainty on corporate investment. *Energy Economics* 86: 104622.
16. Mark N.C., & D. Sul. 2003. Cointegration vector estimation by panel DOLS and long-run money demand. *Oxford Bulletin of Economics and Statistics* 65: 655-680.
17. Mbarek B. M., K. Saidi, & M. Amamri. 2018. The relationship between pollutant emissions, renewable energy, nuclear energy and GDP: empirical evidence from 18 developed and developing countries. *International Journal of Sustainable Energy* 37, (6): 597-615.

18. Narayan S., & D. Doytch. 2017. An investigation of renewable and non-renewable energy consumption and economic growth nexus using industrial and residential energy consumption. *Energy Economics* 68: 160-176.
19. Pao H.T., & H.C. Fu. 2013. Renewable energy, non-renewable energy and economic growth in Brazil. *Renewable and Sustainable Energy Reviews* 25: 381-392.
20. Pedroni P. 2000. Fully modified OLS for heterogeneous cointegrated panels. Department of Economics Working Papers No 2000-03. Department of Economics, Williams College.
21. Pedroni P. 2001. Fully modified OLS for heterogeneous cointegrated panels. In Baltagi B. H., T.B. Fomby, & R. Carter Hill, (Eds.). *Nonstationary panels, panel cointegration, and dynamic panels*: 93-130. Emerald Group Publishing Limited: Bingley, UK.
22. Pesaran M. H. 2004. General diagnostic tests for cross section dependence in panels. *Cambridge Working Papers in Economics*, 0435.
23. Pesaran M. H. 2007. A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics* 22, (2): 265-312.
24. Pesaran M. H., i T. Yamagata. 2008. Testing slope homogeneity in large panels. *Journal of Econometrics* 142, (1): 50-93.
25. Pesaran M.H., & R.P. Smith. 1995. Estimating long-run relationships from dynamic heterogeneous panels. *Journal of Econometrics* 68, (1): 79-113.
26. Pesaran M.H., Y. Shin, & R.P. Smith. 1999. Pooled Mean Group estimation of dynamic heterogeneous panels. *Journal of American Statistical Association* 94, (446): 621-634.
27. Phillips P.C.B., & B.E. Hansen. 1990. Statistical inference in instrumental variables regression with I(1) processes. *The Review of Economic Studies*, 57: 99.
28. Phillips P.C.B., & H. Moon. 1999. Linear regression limit theory for nonstationary panel data. *Econometrica* 67, (5): 1057-1111.
29. Popescu H.G., V.J. Andrei, E. Nica, M. Mieila, & M. Panait. 2019. Analysis on the impact of investment, energy use and domestic material consumption in changing the Romanian economic paradigm. *Technological and Economic Development of Economy* 25, (1): 59-81.
30. Shaobo L., P. Hongxia, T. Hao, & L. Fangfang. 2021. Asymmetric impacts of economic policy uncertainty, capital cost, and raw material cost on China's investment. *Economic Analysis and Policy* 72: 129-144.
31. Stock J., & M.W. Watson. 1993. A simple estimator of cointegrating vectors in higher order integrated systems. *Econometrica* 61, (4): 783-820.
32. Šikić F.T. 2020. The impact of energy consumption on economic growth in developed and post-transition countries of European Union. *Zbornik radova Ekonomskog fakulteta Rijeka* 38, (2): 475-497.

33. Teal F., & M. Eberhardt. 2010. Productivity analysis in global manufacturing production. Economics Series Working Papers 515. University of Oxford, Department of Economics.
34. United Nations. 2015. Paris Agreement. dostupno na web-sajtu: https://unfccc.int/sites/default/files/english_paris_agreement.pdf
35. Vasylenko, Y. 2021. Conditions for Successful Active Investment in Terms of the State and the Far-sighted Interests of the Business. *Ekonomika* 100, (1): 6-32.
36. Wang R., Z. Qi, & Y. Shu. 2020. Research of multiple effects on fixed asset investment on energy consumption by three strata of industry in China. *Environmental Science and Pollution Research* 27: 41299-41313.
37. Wang S., J. Wang, L. Shijie, F. Chuanglin, & F. Kuishuang. 2019. Socioeconomic driving forces and scenario simulation of CO₂ emissions for a fast-developing region in China. *Journal of Cleaner Production* 216: 217-229.
38. Wang X., & F. Dong. 2023. The dynamic relationships among growth in the logistics industry, energy consumption and carbon emission: recent evidence from China. *Journal of Petroleum Exploration and Production Technology* 13: 487-502.
39. Westerlund J. 2005. New simple tests for panel cointegration. *Econometric Reviews* 24: 297-316.

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THE EFFECT OF NEW INVESTMENTS ON THE COST OF MATERIAL AND ENERGY IN THE SERBIAN ECONOMY

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Abstract

The paper examines the effect of revenue and investment in real estate, plants and equipment on the cost of materials and energy in the companies of the Republic of Serbia, at the level of the overall economy on the one hand and the economic sectors on the other. The research, which is based on the official data published by the Serbian Business Registers Agency, includes ten economic sectors for the period from 2013 to 2022, and was conducted using panel models. The results of the cointegration tests showed that there is a long-run equilibrium between the variables in question. The effect of revenue on the cost of material, fuel and energy is positive in the long run. The effect of investment in real estate, plants and equipment on the cost of material, fuel and energy is statistically significant and negative in the long run at the level of the overall economy and in the sectors of Manufacturing Industry, Electricity Supply, Wholesale and Retail Trade and Transport and Storage, while it is positive only in the sector of Accommodation and Food Services.

Key words: investment in fixed assets, revenue, operating expenses, Serbia, The UN Goal 12, panel model

JEL: M210, O33

Introduction

This paper examines the impact of investments in real estate, plant and equipment on the costs of materials and energy in companies in the Republic of Serbia, at the level of the economy and economic sectors. The research is based on data taken from the Annual Financial Statement Bulletins published by the Business Registers Agency of the Republic of Serbia. The database includes aggregate data on all companies in Serbia and their analytics by industry sector for the period from 2013 to 2022.

Preliminary analyses of data published by the Business Registers Agency show that the annual growth rate of new investments (calculated as the difference between the current and previous year increased by depreciation costs) in real estate, plant and equipment in the period from 2013 to 2022 is around 13.1%,

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varying in the range from 9.3% in 2014 to 18.6% in 2021. It is natural to expect that new investments are products of state-of-the-art technology, which increase the efficiency of material and energy use in the production process, and consequently reduce the relative cost of these investments. Such an expectation is the starting hypothesis in this paper, which is:

H0 - Increased investments in real estate, plant and equipment result in lower consumption of materials and energy in the production process.

An increase in income, as a result of an increase in production, is a natural cause of an increase in costs. Our attention was also drawn to the question of the effect of income growth on the growth of material and energy costs, which is expressed in the following hypothesis:

H1 – The increase in material and energy costs is less than the increase in income.

If the research results show the accuracy of the initial hypotheses, we can consider that investments in real estate, plant and equipment are the product of the most modern technologies, and as such indicate intensive economic development in the Republic of Serbia. We deliberately do not formulate this position in the form of a hypothesis, but will use it as an indicator for subsequent research.

In the following section, we provide an overview of the literature in the given area, then information on the data and research methodology, empirical analysis, results and conclusion.

Literature review

Economic theory often emphasizes the importance of identifying the interdependence of investment and consumption of materials and energy as one of the determinants of the formation of newly created value. Given the climate and environmental challenges, the consumption of materials and energy is increasingly seen as a limiting factor in achieving sustainable economic growth and production. It is undeniable that energy consumption is a significant determinant of economic growth and development. Intensive investments in the growth of production have resulted, among other things, in a significant increase in energy and material consumption in recent decades. Article 10 of the Paris Agreement emphasizes the importance of a long-term vision of achieving the development and transfer of technology that will improve resilience to climate change and reduce greenhouse gas emissions. The agreement established a technological framework with guidelines for formulating policies and measures to accelerate the development and transfer of the aforementioned technology (United Nations, 2015). In order to reduce the costs of fuel consumption and traditional energy sources, the European Union prioritizes the promotion and development of renewable energy sources. The goal is to achieve a share of renewable energy sources in the total energy consumption in the European Union of at least 27 percent by 2030 (European Parliament, 2016). Achieving environmental

protection as an economic and social policy objective assumes numerous changes in the economy with different effects on energy-intensive economic sectors. For this reason, it is necessary to investigate the effects of investments in fixed assets and technological changes on material and energy consumption, as well as the impact of energy and material consumption on economic growth. Very few empirical studies have investigated the impact of investments in fixed assets on reducing material and energy costs in production. Analyzing indicators of technical progress, Vasylenko also cites a reduction in the rate of material and labor costs as a result of investments. However, the ability of investments to affect the reduction of material costs has not been measured (Vasylenko, 2021). Shaobo et al. examined the impact of material costs on the volume of investments in fixed assets in China and concluded that there is a long-term statistically significant impact (Shaobo et al., 2021). Also, research has been conducted on the effects of positive and negative changes in the price of crude oil, which is a significant determinant of energy costs, on corporate investments (Maghyereh, Abdoh, 2020). The above results are significant, among other things, due to the positive relationship between the value of a company's investments and the competitiveness of its product in the market (Jiang et al., 2015)

There are several empirical studies that investigate the relationship between fixed asset investment and energy and material consumption at the macro level. Using data on aggregate indicators of the Romanian economy in the period 1994-2014, Popescu et al. found the presence of a high, positive and statistically significant partial correlation between fixed capital per worker and material consumption (0.818), while the partial correlation between fixed capital per worker and energy consumption is low, negative and not statistically significant (-0.260) (Popescu et al., 2019). Based on the results, it can be concluded that fixed asset investment causes an increase in material consumption.

Also, empirical studies highlight the connection between fixed asset investment, economic growth and energy consumption. A number of studies investigate this relationship in China, where the rapid growth of fixed asset investment is associated with a double-digit growth rate of energy consumption in the period 2003-2006. For this reason, economic policy and market demand emphasize the need to optimize the economic structure and industry with the rapid development of the logistics sector. Previous studies have confirmed a long-term, positive and statistically significant correlation between fixed asset investments and energy consumption (Lili, Peng, 2011). Also, a positive and statistically significant impact of fixed asset investments on CO₂ emissions was found (Wang et al., 2019).

However, by analyzing the relationship between fixed asset investments in the transport and storage sector and energy consumption, Wang and Dong conclude that fixed asset investments have a negative, statistically significant impact on

energy consumption, with different levels of effect across regions (Wang, Dong, 2023). The above results indicate the need and importance of investing in fixed assets to be directed towards the purchase of energy-efficient equipment. Also, the research results showed that there are differences in the effects of fixed asset investments on energy consumption across sectors of the economy. According to Wang et al. Investments in fixed assets in agriculture have an indirect, positive and statistically significant effect on energy consumption, the estimated value of which is 0.360, while the estimated effect value in secondary industry is lower and amounts to 0.108 (Wang et al., 2020).

There is a significantly greater number of empirical studies on the relationship between energy consumption and economic growth, given that energy consumption is a significant factor in the production process and the achievement of economic growth. On the other hand, it is possible to observe economic growth as a factor influencing the demand for energy and materials used as raw materials in the production process. Testing the causality of economic growth from energy consumption can be significant because it indicates the degree of energy dependence of the economy. Starting from the fact that investments in fixed assets can also have an indirect effect on economic growth through the impact on energy and material consumption, an overview of the results of relevant empirical studies on the impact of energy consumption on economic growth will be given.

A large number of empirical studies have found a positive and statistically significant impact of energy consumption on economic growth (Pao, Fu, 2013), (Ito, 2017), (Jebli, Youssef, 2015). Similar results are also present in the empirical studies of Alper and Oguz (Alper, Oguz, 2016) and Anwar et al. (Anwar et al., 2017).

Some research indicates that there are differences in the short-term and long-term causal relationship between energy consumption and economic growth depending on the level of economic development of countries. In a comprehensive study, Ahmed and Azam found that the “growth hypothesis” or the impact of energy consumption on economic growth was confirmed in 25 countries, including 7 high-income countries, 14 middle-income countries and 4 low-income countries. However, in significantly more countries (40), it was found that economic growth affects energy consumption, while the mutual impact of energy consumption and economic growth was confirmed in 18 countries (Ahmed, Azam, 2016). The effects of economic growth on the consumption of energy from renewable sources were examined by Mbarek et al. confirming the unidirectional causality of economic growth on the increase in renewable energy consumption, which is statistically significant in the short and long term in developed countries, while in developing countries only a short-term effect is present (Mbarek et al., 2018). In addition, some empirical studies point out that economic growth has a statistically significant impact on the increase in industrial energy consumption, especially in

low- and middle-income countries. However, this effect is absent in high-income countries (Narayan, Doytch, 2017).

Empirical studies on the impact of energy consumption on economic growth in post-transition countries are few. Most research confirms that an increase in energy consumption has a statistically significant impact on GDP growth, which further emphasizes the importance of further research into factors that have effects on energy consumption. Also, the results of these studies show that the economies of post-transition countries, which are members of the European Union, are more energy dependent than the economies of old EU member states (Kasperowicz, Štreimikiene, 2016), (Bercu et al., 2019), (Šikić, 2020).

As can be seen from the review of the relevant literature, the literature does not specifically consider how much new investments in real estate, plants and equipment contribute to reducing the costs of materials and energy. This issue is interesting not only from the point of view of economic growth, but also from the point of view of the impact of economic growth on the environment.

The relatively high rate of economic growth in the Republic of Serbia prompted the authors to analyze, using the database of the Business Registers Agency, the impact of investments in real estate, plant and equipment on the number of employees by economic sectors (Beke-Trivunac and Peković, 2021) and by the size of business entities (Beke-Trivunac and Peković, 2022). This is the first study of the impact of investments on the efficiency of material and energy costs in the Republic of Serbia.

Data and method

Data for the analysis and assessment of the impact of investments in real estate, plant and equipment of business entities on cost efficiency were taken from the Annual Financial Statement Bulletins prepared by the Business Registers Agency of the Republic of Serbia for 2014, 2016, 2018, 2020 and 2022.

The data considered include amounts in the income statement items: Costs of materials and energy, and Operating income, as well as amounts in the balance sheet item: Real estate, plant and equipment. The analysis includes data for entities grouped by economic sectors. The published statistical data of the APR cover ten economic sectors: A - Agriculture, forestry and fishing; B - Mining; C - Manufacturing; D - Electricity supply; E - Water supply; F - Construction; G - Wholesale and retail trade; H - Transport and storage; I - Accommodation and food services; J - Information and communication.

The data series refer to the period from 2013 to 2022. The data we have is known in the econometric literature as panel data. It is a combination of cross-section data and time series. Such data enable the analysis of structure, i.e. heterogeneity between sectors, but also the analysis of structural changes over time.

Econometric models known as panel models have been developed for the analysis of panel data.

Table 1. Definition and designations of the series used and data source

Series code	Definition and data source
<i>Costs</i>	Costs of materials, fuel and energy. Annual financial report bulletins prepared by the Business Registers Agency of the Republic of Serbia for 2014, 2016, 2018, 2020 and 2022.
<i>Revenues</i>	Business revenues. Annual financial report bulletins prepared by the Business Registers Agency of the Republic of Serbia for 2014, 2016, 2018, 2020 and 2022.
<i>Equipment</i>	Real estate, plant and equipment. Annual financial report bulletins prepared by the Business Registers Agency of the Republic of Serbia for 2014, 2016, 2018, 2020 and 2022.

The logarithms of the variables (*LN*Troškovi, *LN*Prihodi, *LN*Oprema) were used to formulate the research model:

$$LN\text{Troškovi}_{it} = \alpha_0 + \beta_1 LN\text{Prihodi}_{it} + \beta_2 LN\text{Oprema}_{it} + u_{it}$$

where the index *i* refers to the comparative data, i.e. sectors $i = 1, 2, \dots, 10$, and *t* to the time dimension of the panel, i.e. time period . Models based on the logarithmic transformation of the original series are preferable, for at least two reasons. First, most models evaluated in the literature are based on logarithmic transformations of the series. This allows comparison with the results of other studies. Second, the interpretation of the coefficients in such models is more intuitive. The coefficients in these models are elasticities, which show how much the dependent variable will change for a 1% change in the independent variables.

In the econometric part of this research, we begin the analysis with a graphical representation of panel data. For this purpose, we use line graphs on which we will display pairs of time series for each sector separately. After that, we will examine the mutual dependence of the comparative data, i.e. the dependence between sectors – CD test (Pesaran, 2004), their homogeneity – delta tilde test (Pesaran and Yamagata, 2008), and also the stationarity of the time series – CIPS test (Pesaran, 2007). The cointegration test (Westerlund, 2005) will be used to determine the existence of long-term interdependence between *LN*Troškova, *LN*Prihoda and *LN*Opreme. The cointegration coefficients in both the long and short run for all panels together and each separately will be estimated using several alternative estimates to check the robustness of the results on the mutual connection *LN*Troškova, *LN*Prihoda and *LN*Opreme in the long run. These are the following estimates: FMOLS estimate (eng. fully modified ordinary least

squares) – fully modified least squares estimate; (Kao and Chiang, 2000; Pedroni, 2000, 2001; Phillips and Moon, 1999), DOLS estimate (dynamic ordinary least squares); (Mark and Sul, 2003; Stock and Watson, 1993), MG estimate (mean group) (Pesaran and Smith, 1995); AMG estimate (augmented mean group) (Teal and Eberhardt, 2010); and also PMG/ARDL estimate (pooled mean group / autoregressive distributed lags) (Pesaran et al., 1999).

In the econometric analysis of panel data, the statistical packages Stata 15, Eviews 10 and R4.3.2 were used.

Empirical analysis

The main objective of the analysis in this research is to investigate the effect of investments in real estate, plant and equipment on the efficiency of material and energy use of business entities in ten sectors of the Republic of Serbia in the period 2013-2022. This objective will be achieved by examining the interrelationship of the value of real estate, plant and equipment on the one hand with the costs of materials, fuel and energy and operating income on the other. The main research hypothesis is that an increase in the value of real estate, plant and equipment in the sectors of the Republic of Serbia leads to a decrease in the costs of materials, fuel and energy. At the same time, it is expected that the growth of operating income will be faster than the growth of the costs of materials, fuel and energy.

Graphical display of data

We begin the empirical analysis with a graphical representation of panel data. The usual graphical representation of panel data is a line graph, i.e. a time series for each sector separately. In this way, we can compare the tendency of changes in variables over time in each sector and see whether there are any general tendencies, i.e. positive or negative growth. By displaying two variables simultaneously on the same graph, we can observe their mutual relationship, i.e. the consistency in their development over time and possibly indicate whether our hypothesis has grounds to be accepted in any of the sectors.

We note that in Figures 1 – 3 each series is shown on its own axis, and therefore the levels of these series are not comparable. What we pay attention to is the mutual relationship of the dynamics of the series. In Figure 1, there is a clear tendency that the series *LNPrihoda* and *LNTroškova* move almost in parallel in most sectors and that they have a positive trend in all panels. This tells us that a result is expected in further analysis that will indicate a positive and statistically significant connection between these two series.

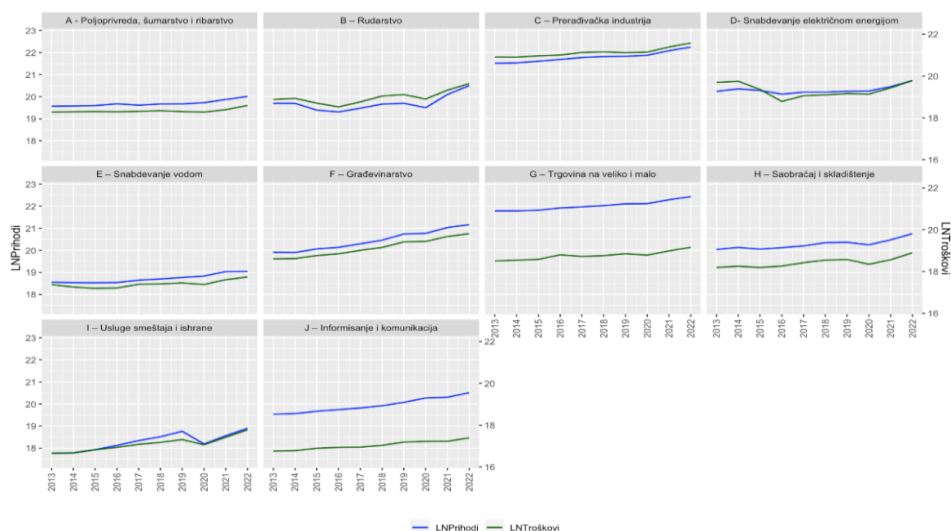


Figure 1. Panel data series *LNPrihodi* and *LNTroškovi* sectors of the Republic of Serbia

Figure 2 shows the series *LNTroškova* and *LNOprema*. Although both series show a tendency to grow over time, it can be seen in a larger number of panels that in some years the series move in the opposite direction, i.e. in a period of growth *LNOprema*, there is a decline in the series *LNTroškovi* and vice versa. This is best seen in panels D and H. This mutual relationship of the series suggests that their negative correlation is to be expected.

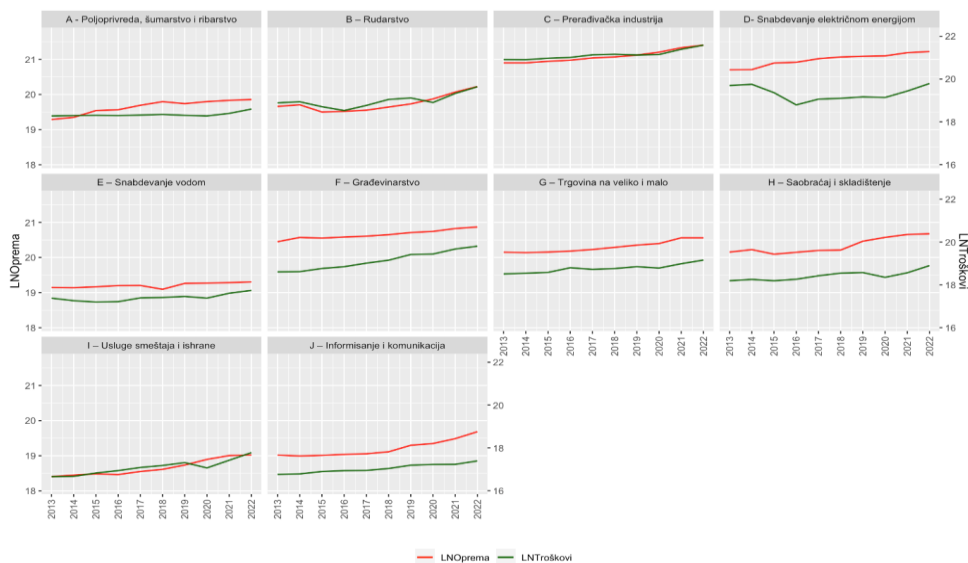


Figure 2. Panel data series *LNOprema* and *LNTroškovi* sectors of the Republic of Serbia

Finally, Figure 3 shows the series *LN*Prihodi and *LN*Oprema. What was said about the graphs of series *LN*Troškova and *LN*Oprema can be repeated in the case of the mutual relationship between series *LN*Prihodi and *LN*Oprema. Namely, in a larger number of panels, these two series move in the opposite direction in some years, i.e. in the period of increase *LN*Oprema, there is a decrease in the series *LN*Prihodi and vice versa. This is best seen in panels D and H.

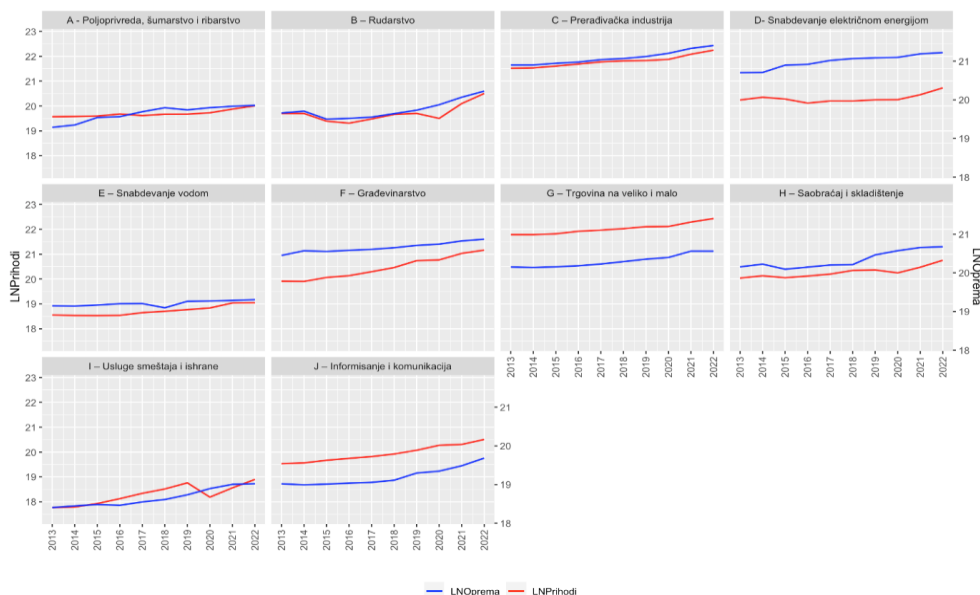


Figure 3. Panel data series *LN*Oprema and *LN*Prihodi sectors of the Republic of Serbia

Comparative data dependency test

In the applied part of the research, the tests of independence and homogeneity of comparative data were first applied in order to select more robust unit root and cointegration tests. To test the hypothesis of independence of comparative data in panels, we use the CD test (Pesaran, 2004), and the results are shown in Table 2. For all three series, the null hypothesis of independence of comparative data was rejected at the 1% significance level. In other words, we conclude that the comparative data are dependent.

Table 2. Test of dependence statistics of comparative data

Variable	Pesaran CD
LN Costs	18.01
LN Revenuess	18.43
LN Equipment	15.53

Note: Means of the comparative data were removed during the calculation of correlations. The degrees of freedom for all tests are 45. The p-values for all test statistics are less than 1%.

Source: Author's calculations

Since the dependencies of the comparative data were identified in all three series, this suggests that when choosing unit root tests, we should choose the test that is not sensitive to the presence of dependencies of the comparable data. This is the case with the so-called second generation of unit root tests.

Homogeneity test

The homogeneity of the cointegration coefficients means that there is no variation in these coefficients across panels. The null hypothesis of homogeneity means in other words that the effects of business income and property, plant and equipment on the costs of materials, fuel and energy are equal across sectors, which is a rather restrictive assumption. However, rejecting this hypothesis creates additional problems, because in this case, one must choose those unit root and cointegration tests that are insensitive to the absence of homogeneity in the panels.

The homogeneity of the cointegration coefficients was investigated using the delta tilde and the adjusted delta tilde test (Pesaran and Yamagata, 2008). The test results are shown in Table 3. The null hypothesis of homogeneity is rejected at the 1% significance level. In other words, this result indicates that the cointegration coefficients are heterogeneous, i.e. vary across sectors.

Table 3. Homogeneity test

Test	Statistics	P-value
$\tilde{\Delta}$	3.339	<.01
$\tilde{\Delta}_{prilagođen}$	4.311	<.01

Note: The null hypothesis is that the cointegration coefficients are homogeneous.

Source: Author's calculations

Unit root test

First-generation unit root tests are sensitive to the lack of homogeneity across panels and independence across comparisons. Second-generation unit root tests in panels offer solutions to overcome this problem, abandoning the assumptions of independence of comparisons and homogeneity of panels. The most important test

of the second generation, the Comparative IPS test (CIPS), was proposed by Pesaran (2007), and is named after Im, Pesaran & Shin (2003).

The results of applying the CIPS test for unit roots in heterogeneous panels, i.e. in the presence of dependence of comparisons, are shown in Table 4. The null hypothesis is that all panels contain a unit root, against the alternative hypothesis that some panels are stationary.

Table 4. Pesaran's CIPS test statistics for unit roots in heterogeneous panels

Variable	Without trend	With trend
Level		
<i>LNPrihodi</i>	-0.926	-1.527
<i>LNOprema</i>	-2.286*	-3.381**
<i>LNTroškovi</i>	-1.503	-1.960
First difference		
<i>LNPrihodi</i>	-2.289	-2.682
<i>LNOprema</i>	-3.859***	-3.898***
<i>LNTroškovi</i>	-2.179	-1.918

Note: Individual specifications of the dynamics in each regression are based on the Wald test of the composite linear hypothesis on the model parameters. Asterisks indicate the significance levels: 10% (*), 5% (**), and 1% (***).

Source: Author's calculations

The Pesaran CIPS test shows for all series, except *LNOprema*, that the null hypothesis of a unit root in all panels cannot be rejected. However, since we are dealing with rather short time series (only 10 observations), the results of the Pesaran CIPS test should be treated with some caution due to their lower power when the time series is short. The series plots (Figures 1 – 3) for some of the panels show a clear trend suggesting possible non-stationarity. Therefore, we would continue the analysis assuming that all series are first-order integrated.

Cointegration test

To test the hypothesis of a long-term relationship between investment in real estate, plant and equipment and the costs of materials, fuel and energy in the sectors of the Republic of Serbia, we use one of the cointegration tests (Westerlund, 2005). We used two variants of the test depending on how the alternative hypothesis is defined. While the null hypothesis indicates the absence of cointegration, the alternative hypothesis is that all panels are cointegrated or that some of the panels are cointegrated. We also varied the assumption about the behavior of the autoregressive (AR) parameter in this test. In one variant, the AR parameter is the same in all panels, while in the other variant it varies among panels. The results of the Westerlund test are given in Table 5.

Table 5. Westerlund's panel cointegration test

Test	Statistic	P-value
Variance ratio (AR parameters vary across panels, trend not included, null hypothesis: No cointegration, alternative hypothesis: Some of the panels are cointegrated)	2.413	<.01
Variance ratio (AR parameters equal across all panels, trend not included, null hypothesis: No cointegration, alternative hypothesis: All panels are cointegrated)	0.041	.484
Variance ratio (AR parameters vary across panels, trend included, null hypothesis: No cointegration, alternative hypothesis: Some of the panels are cointegrated)	1.285	.099
Variance ratio (AR parameters equal across all panels, trend included, null hypothesis: No cointegration, alternative hypothesis: All panels are cointegrated)	1.075	.142

Source: Author's calculations

The Westerlund cointegration test confirmed the existence of cointegration among the three observed series in some of the 10 sectors (first and third rows in Table 5). At the same time, it did not confirm that all panels observed together are cointegrated (second and fourth rows in Table 5).

Estimation of long-term model coefficients

Since it was determined that there is a long-term relationship between the three series, a panel regression model was estimated in order to obtain estimates of the long-term impact of operating income and property, plant and equipment on the costs of materials, fuel and energy. In order to investigate the extent to which the impact assessment results are robust given the use of different estimates and software algorithms, the panel regression models were estimated using five different estimation methods (FMOLS, DOLS, MG, Aug MG and PMG/ARDL) and two statistical software (Stata and EViews). A summary of the estimated panel regression models is presented in Table 6.

Table 6. Long-term cointegration coefficients for companies – total of the Republic of Serbia

Evaluation method	<i>LNPrhodi</i>	<i>LNOprema</i>
FMOLS (EViews)	1.007***	-0.241**
DOLS (EViews)	0.998***	-0.237**
MG (Stata)	1.069***	-0.285
Aug MG (Stata)	0.849***	-0.245
PMG/ARDL (EViews)	0.561***	-0.164***

Note: For the MG and Aug MG methods, all coefficients are group averages. Coefficient averages are calculated as unweighted means. For the Aug MG method, the joint dynamic process is included as an additional regressor. Asterisks indicate the significance levels of the estimated coefficients: 10% (*), 5% (**), and 1% (***).

Source: Author's calculations

We recall that all series were transformed using logarithmic transformation before analysis. This means that the estimated coefficients in these panel cointegration regressions can be interpreted as elasticities. For illustration, we use the results of FMOLS estimations obtained using the EViews software algorithm. The coefficient for *LNPrihodi* is 1.007, which means that on average a 1% change in operating income leads to an increase in material, fuel and energy costs by 1.007% for 10 sectors of the economy of the Republic of Serbia. It should also be noted that this effect is statistically significant at the 1% significance level. The coefficient for *LNOprema* is -0.241, which means that on average a 1% change in the value of real estate, plant and equipment leads to a decrease in material, fuel and energy costs by 0.241% for sectors of the economy of the Republic of Serbia. This coefficient is statistically significant at the 5% level.

If we look at the sign and statistical significance of the estimated coefficients in Table 6, we can notice the following. There is variation among the estimated coefficients, but in the case of the coefficient with the variable *LNPrihodi*, most are close to unity, all coefficients are positive and highly statistically significant (1% significance level). The coefficients with the variable *LNOprema* are all negative and close to the value of -0.25, but not all are statistically significantly different from zero (for MG and Aug MG estimation methods). Based on this, we can conclude that the positive impact of operating income on the costs of materials, fuel and energy is confirmed with high reliability, while in the case of the value of property, plant and equipment, this impact is negative and confirmed to a lesser extent than the impact of operating income.

The last estimation method in Table 6 is PMG/ARDL and it was chosen because it allows for the investigation of the long-term and short-term cointegration correlation between investments in property, plant and equipment on the one hand and the costs of materials, fuel and energy on the other hand and operating income. The panel ARDL method has advantages over more traditional cointegration techniques, such as the Johansen cointegration test, because it can be used regardless of the degree of integration of the series. Using panel ARDL, both long-run and short-run coefficients are estimated at once. The results of the PMG/ARDL estimation method are given in Table 7.

Table 7. Panel ARDL (PMG) estimates (dependent variable: *LNTroškovi*)

Variable	Long-run equation		
	Coefficient	<i>t</i> -statistic	<i>P</i> -value
<i>LNPrihodi</i>	0.561	13.15	<.01
<i>LNOprema</i>	-0.164	-3.79	<.01
Short-term equation			
Cointegration equation	-0.318	-2.52	.01
Δ <i>LNPrihodi</i>	1.005	6.01	<.01
Δ <i>LNOprema</i>	0.026	0.27	.78
Constant	3.181	2.63	.01

Note: The Schwarz Criterion (SIC) was used to select the optimal lag length. The ARDL(1,1,1) model with a constant was chosen..

Source: Author's calculations

The error correction coefficient (cointegration equation in Table 7) is consistent with the basic convergence assumptions to confirm the long-run equilibrium nature of the model. This includes that the cointegration equation is negative, significant, and less than one (Pesaran et al., 1999). The cointegration equation of -0.318 in Table 7 explains that the adjustment rate back to the long-run equilibrium is 31.8% and is significant at the 1% significance level. In the short run, only the effect of operating income is significant at the less than 1% significance level with a positive sign, while the effect of property, plant, and equipment values in the short run is positive but statistically insignificant.

Panel ARDL is a long-run equilibrium estimate and therefore the long-run coefficients are usually given more weight. A short-run increase in both operating income and property, plant, and equipment would lead to an increase in the costs of materials, fuel, and energy. However, this is not the case in the long run, at least in the period from 2013 to 2022, when the series of property, plant and equipment negatively affects the series of costs of materials, fuel and energy. The impact of operating income in the long run remains positive. It should also be noted that in the long run, compared to the short run, the impact of property, plant and equipment increases, while the impact of operating income decreases. These long-term coefficients are also entered in the last row of Table 6, and are somewhat lower in value than the corresponding coefficients obtained by other estimation methods.

We conclude that the cointegration test based on the PMG/ARDL panel model also confirms that there is a long-term relationship between the series of costs of materials, fuel and energy, operating income and property, plant and equipment in the case of the sector of the Republic of Serbia for the period under investigation (2013-2022).

Finally, we estimated the cointegration coefficients at the individual sector level using the mean group (MG) and augmented mean group (Aug MG) estimation methods, and the results are presented in Table 8. The panel cointegration coefficients showed that operating income had a statistically significant positive impact on material, fuel and energy costs in all sectors and in total. This coefficient was lowest in the Accommodation and Food Services sector (0.623) and highest in the Electricity Supply sector (1.995).

Table 8. Long-term cointegration coefficients of the sector of the Republic of Serbia

Sector	MG		AugMG	
	<i>LNPrihodi</i>	<i>LNOprema</i>	<i>LNPrihodi</i>	<i>LNOprema</i>
A – Agriculture, forestry and fishing	0.716***	-0.103	0.418**	-0.031
B – Mining	0.704***	0.268	0.166	0.425
C – Manufacturing	1.290***	-0.506	1.221***	-0.540**
D – Electricity supply	1.995***	- 1.262***	0.993*	-1.327***
E – Water supply	0.907***	-0.449	0.550***	-0.133
F – Construction	0.926***	0.078	0.933***	0.094
G – Wholesale and retail trade	1.673***	- 1.061***	1.730***	-1.039***
H – Transport and storage	1.184***	-0.226**	1.216***	-0.228**
I – Accommodation and food services	0.623***	0.485***	0.594***	0.400**
J – Information and communication	0.672***	-0.076	0.668***	-0.067
Business enterprises - total	1.069***	-0.285	0.849***	-0.245

Source: Author's calculations

Regarding the impact of property, plant and equipment, the results are mixed. Thus, in the case of Manufacturing, Electricity Supply, Wholesale and Retail Trade, and Transport and Storage, the impact of investments in property, plant and equipment on the costs of materials, fuel and energy is statistically significant and negative, and only in the case of the Accommodation and Food Services sector is this impact positive. At the level of Business Enterprises, the overall impact was identified as negative by both assessment methods, but the resulting assessment is not statistically significantly different from zero. In the other sectors, the impact of property, plant and equipment on the costs of materials, fuel and energy was not statistically significant, nor at the level of the economy as a whole.

Conclusion

At the beginning of the conclusion, it is necessary to reiterate the greatest limitation of the analysis conducted in this research, which is the relatively small sample size, i.e. the shortness of the time series in the panel data. This limitation largely explains the variations in the obtained estimates of the impact of business income and real estate, plant and equipment on the costs of materials, fuel and energy.

Based on the analysis we conducted using annual panel data of the economic sectors of the Republic of Serbia in the period from 2013 to 2022, our hypothesis was confirmed, i.e. we can conclude the following:

1. The results of the cointegration tests showed that there is a long-term equilibrium relationship between the costs of materials, fuel and energy, business income and real estate, plant and equipment.
2. The impact of business income on the costs of materials, fuel and energy is positive in the long run. An increase in business income by 1% leads to an increase in the costs of materials, fuel and energy by about 0.9%.
3. The impact of real estate, plant and equipment on the costs of materials, fuel and energy is negative in the long run. An increase in the value of property, plant and equipment by 1% leads to a decrease in the costs of materials, fuel and energy by 0.25%. Observed by sector, the impact of investments in property, plant and equipment on the costs of materials, fuel and energy is statistically significant and negative in Manufacturing, Electricity Supply, Wholesale and Retail Trade, and Transport and Storage, and only in the case of the Accommodation and Food Services sector is this impact positive.

The question of how much new investments in property, plant and equipment contribute to the reduction of the costs of materials and energy is interesting not only from the point of view of economic growth, but also from the point of view of its impact on environmental protection.

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References

1. Ahmed M., & M. Azam. 2016. Causal nexus between energy consumption and economic growth for high, middle and low income countries using frequency domain analysis. *Renewable and Sustainable Energy Reviews* 60: 653-678.

2. Alper A., & O. Oguz. 2016. The role of renewable energy consumption in economic growth: Evidence from asymmetric causality. *Renewable and Sustainable Energy Reviews* 60: 953-959.
3. Anwar A., N. Arshed, & N.N. Kousar. 2017. Renewable Energy Consumption and Economic Growth in Member of OIC Countries. *European Online Journal of Natural and Social Sciences* 6, (1): 111-129.
4. Beke-Trivunac J. & D. Peković. 2021. The impact of investments in permanent assets on the increase in the number of employees and their salaries by entrepreneurial sectors. *Revizor* 95-96, (24): 7-16.
5. Beke-Trivunac J. & D. Peković. 2022. The effects of investments in permanent assets on employment and salaries by enterprise size. *Revizor* 97-98, (25): 7-19.
6. Bercu A.M., G. Paraschiv, & D. Lupu. 2019. Investigating the Energy-Economic Growth-Governance Nexus: Evidence from Central and Eastern European Countries. *Sustainability* 11, (12): 3355.
7. European Parliament. 2016. Promotion of renewable energy sources in the EU, EU policies and Member State approaches. European Union.
8. Im K.S., M.H. Pesaran, & Y. Shin. 2003. Testing for unit roots in heterogeneous panels. *Journal of Econometrics* 115: 53-74.
9. Ito K. 2017. CO2 emissions, renewable and non-renewable energy consumption, and economic growth: Evidence from panel data for developing countries. *International Economics* 151: 1-6.
10. Jebli M.B., & S.B. Youssef. 2015. Output, renewable, and non-renewable energy consumption and international trade: Evidence from a panel of 69 countries. *Renewable Energy* 83: 799-808.
11. Jiang F., K.A. Kim, J.R. Nofsinger, & B. Zhu. 2015. Product market competition and corporate investment: Evidence from China. *Journal of Corporate Finance* 35: 196-210.
12. Kao C., & M.H. Chiang. 2000. On the estimation and Inference of a cointegrated regression in panel data. In B.H. Baltagi et al. (Eds.). *Nonstationary panels, panel cointegration and dynamic panels*: 179-222. Amsterdam: Elsevier.
13. Kasperowicz R., & D. Štreimikiene. 2016. Economic growth and energy consumption: comparative analysis of V4 and the “old” EU countries. *Journal of International Studies* 9, (2): 181-194.
14. Lili L., & Q. Peng. 2011. The impact of China’s investment increase in fixed assets on ecological environment: an empirical analysis. *Energy Procedia* 5: 501-507.
15. Maghyereh A., & H. Abdoh. 2020. Asymmetric effects of oil price uncertainty on corporate investment. *Energy Economics* 86: 104622.
16. Mark N.C., & D. Sul. 2003. Cointegration vector estimation by panel DOLS and long-run money demand. *Oxford Bulletin of Economics and Statistics* 65: 655-680.

17. Mbarek B. M., K. Saidi, & M. Amamri. 2018. The relationship between pollutant emissions, renewable energy, nuclear energy and GDP: empirical evidence from 18 developed and developing countries. *International Journal of Sustainable Energy* 37, (6): 597-615.
18. Narayan S., & D. Doytch. 2017. An investigation of renewable and non-renewable energy consumption and economic growth nexus using industrial and residential energy consumption. *Energy Economics* 68: 160-176.
19. Pao H.T., & H.C. Fu. 2013. Renewable energy, non-renewable energy and economic growth in Brazil. *Renewable and Sustainable Energy Reviews* 25: 381-392.
20. Pedroni P. 2000. Fully modified OLS for heterogeneous cointegrated panels. Department of Economics Working Papers No 2000-03. Department of Economics, Williams College.
21. Pedroni P. 2001. Fully modified OLS for heterogeneous cointegrated panels. In Baltagi B. H., T.B. Fomby, & R. Carter Hill, (Eds.). *Nonstationary panels, panel cointegration, and dynamic panels*: 93-130. Emerald Group Publishing Limited: Bingley, UK.
22. Pesaran M. H. 2004. General diagnostic tests for cross section dependence in panels. *Cambridge Working Papers in Economics*, 0435.
23. Pesaran M. H. 2007. A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics* 22, (2): 265-312.
24. Pesaran M. H., i T. Yamagata. 2008. Testing slope homogeneity in large panels. *Journal of Econometrics* 142, (1): 50–93.
25. Pesaran M.H., & R.P. Smith. 1995. Estimating long-run relationships from dynamic heterogeneous panels. *Journal of Econometrics* 68, (1): 79-113.
26. Pesaran M.H., Y. Shin, & R.P. Smith. 1999. Pooled Mean Group estimation of dynamic heterogeneous panels. *Journal of American Statistical Association* 94, (446): 621–634.
27. Phillips P.C.B., & B.E. Hansen. 1990. Statistical inference in instrumental variables regression with I(1) processes. *The Review of Economic Studies*, 57: 99.
28. Phillips P.C.B., & H. Moon. 1999. Linear regression limit theory for nonstationary panel data. *Econometrica* 67, (5): 1057-1111.
29. Popescu H.G., V.J. Andrei, E. Nica, M. Mieila, & M. Panait. 2019. Analysis on the impact of investment, energy use and domestic material consumption in changing the Romanian economic paradigm. *Technological and Economic Development of Economy* 25, (1): 59-81.
30. Shaobo L., P. Hongxia, T. Hao, & L. Fangfang. 2021. Asymmetric impacts of economic policy uncertainty, capital cost, and raw material cost on China's investment. *Economic Analysis and Policy* 72: 129-144.
31. Stock J., & M.W. Watson. 1993. A simple estimator of cointegrating vectors in higher order integrated systems. *Econometrica* 61, (4): 783-820.

32. Šikić F.T. 2020. The impact of energy consumption on economic growth in developed and post-transition countries of European Union. *Zbornik radova Ekonomskog fakulteta Rijeka* 38, (2): 475-497.
33. Teal F., & M. Eberhardt. 2010. Productivity analysis in global manufacturing production. *Economics Series Working Papers* 515. University of Oxford, Department of Economics.
34. United Nations. 2015. Paris Agreement. dostupno na web-sajtu: https://unfccc.int/sites/default/files/english_paris_agreement.pdf
35. Vasylenko, Y. 2021. Conditions for Successful Active Investment in Terms of the State and the Far-sighted Interests of the Business. *Ekonomika* 100, (1): 6-32.
36. Wang R., Z. Qi, & Y. Shu. 2020. Research of multiple effects on fixed asset investment on energy consumption by three strata of industry in China. *Environmental Science and Pollution Research* 27: 41299-41313.
37. Wang S., J. Wang, L. Shijie, F. Chuanglin, & F. Kuishuang. 2019. Socioeconomic driving forces and scenario simulation of CO₂ emissions for a fast-developing region in China. *Journal of Cleaner Production* 216: 217-229.
38. Wang X., & F. Dong. 2023. The dynamic relationships among growth in the logistics industry, energy consumption and carbon emission: recent evidence from China. *Journal of Petroleum Exploration and Production Technology* 13: 487-502.
39. Westerlund J. 2005. New simple tests for panel cointegration. *Econometric Reviews* 24: 297-316.

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Tabela 5. Troškovi distribucije dobara iz Subotice u maloprodajne objekte

Indikatori	Period			Ukupno
	Mesec 1	Mesec 2	Mesec 3	
Pređena razdaljina (km)	12.926	11.295	13.208	37.429
Korišćeno gorivo (litar)	3.231	2.823	3.302	9.356
Vrednost korišćenog goriva (RSD)	242.378	211.790	247.653	701.821
Ukupno provedeno vreme u vožnji (sati)	314	266	417	997
Vrednost ukupno provedenog vremena u vožnji (RSD)	47.048	39.890	62.570	149.508
Broj vožnji	98	77	102	277
Ukupna vrednost (RSD)	0	0	0	0
Broj preveženih paleti (komad)	1.179	976	1358	3.513
Ukupna prevežena količina (kg)	602.600	429.225	711.116	1.742.941
Suma (RSD)	974.222	870.864	1.100.813	2.945.899

Izvor: Nikolić, 2010;

Napomena: Vrednosti u tabeli ne sadrže porez na dodatu vrednost (PDV)

Grafike, dendrograme, dijagrame, šeme i slike treba unositi u sam tekst rada (ne koristiti opciju Float over text) i numerisati ih prema redosledu njihovog pojavljivanja. Njihovi nazivi se moraju pozicionirati neposredno iznad grafika, dendrograma, dijagrama, šeme ili slike na koju se odnose. Kod navođenja naslova, izvora i napomena koristiti isti stil koji je predhodno prikazan za formiranje tabela. Tokom pisanja rada u originalnom tekstu treba markirati pozive na određeni grafik, dendrogram, dijagram, šemu ili sliku (Graph 2.). Svi grafici, dendrogrami, dijagrami, šeme i slike u radu se svojom veličinom moraju uklapati u zadati format strane, te moraju biti centralno postavljeni. Fotografije nisu poželjne u predmetnom radu, a ukoliko se one ne mogu izbeći molimo Vas da koristite optimalnu rezoluciju (preniska rezolucija dovodi do pikselacije i krzavih ivica, dok previsoka samo povećava veličinu fajla bez doprinosa čitljivosti rada).

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Literatura se navodi na kraju rada pre apstrakta na engleskom jeziku, abecednim redom, prema prezimenu autora. ***Molimo Vas da reference navodite u originalu (na jeziku na kome su objavljene) u obimu u kom su korišćene/citirane tokom pisanja***

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Literatura

1. Nikolić N., M. Marković, i P. Petrović. 2016. Poreski bilans. Oditor 2, (1): 13-17.

Prilikom unošenja literaturnih jedinica unosite korišćenjem **Čikaškog šablona za stil**, minimum 10 literaturnih jedinica. Sva korišćena literatura mora biti citirana u radu.

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Summary in English which should be written at the end of the paper. It should contain the text which is the same as in the summary written in Serbian at the beginning of the paper.

Key words: *note, maximally, five, key, words.*

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Nik Holmes⁴², John Peters⁴³

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Table 5. The distribution cost

Indicators	Period			Total
	2013	2014	2015	
Fixed costs	12.926	11.295	13.208	37.429
Variable costs	3.231	2.823	3.302	9.356

Source: Nikolic, 2016;

Graphs, diagrams, schemes and pictures should be entered within the text of article (do not use option Float over text) and numerated according to order of their appearance. Their titles have to be positioned immediately above the graph, diagram, scheme or picture to which they relate. Please, have in mind that all titles, sources and notes have to be written by identical style which was used for tables formatting. During the article writing please mark in the main text all calls to a certain graph, diagram, scheme or picture (*Graph 2.*). All graphs, diagrams, schemes and pictures within the paper have to fit the specified format of the page, as well as they have been centrally positioned.

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Literature

1. Vall J. 2014. Accounting theory. Valid, New York.
2. Parks D., W. Robberts. 2016. Macroeconomic indicators. Finance 23, (4): 462-476.