DVOSMERNA VEZA INFLACIJE I INFLACIONE NEIZVESNOSTI: SLUČAJ SRBIJE

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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 EGARH 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 potrvđena 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*

JEL:*E31, E52,C22, C52*

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 (Karahan 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 sugeriše postojanje negativnog odnosa između inflacione neizvesnosti i prosečne stope inflacije.

Radni papir je struktuiran 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 predstavljni 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) sugeriše 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 pirlog 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 potrvđena 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:

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

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: (Boleresleva, 1986)

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

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 emprijskim 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):

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

gde su γ_i parametri koje treba oceniti, d(·) označava indicator funkcije definisan kao:

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

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):

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

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

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:

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

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

Za ovaj model testirana je nulta hipoteza primenom Granger-ovog testa kauzalnosti, H0: $\beta_1 = \beta_2 = \cdots = \beta_k = 0$, 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, H0: $\beta_1 = \beta_2 = \cdots = \beta_m = 0$, smer korelacije utvrđuje se na bazi sume koeficijenata uz inflacionu neizvesnost.

Rezultati empirijske analize

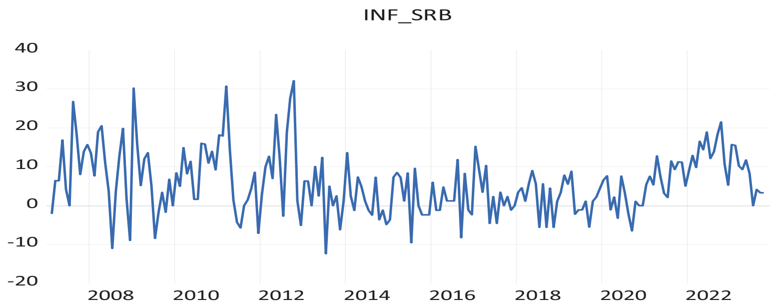
U empirijskoj analizi koristili smo mesečne podatke o harmonizovanom indeksu potrošačkih cena (HICP) dobijene sa vebsajta zavoda za statistiku Srbije. Empirijska analiza je sprovedena za period januar 2007–oktobar 2023. godine. Vrednost mesečne inflacije izračunata je kao: $\pi_t = ln\frac{CPI_t}{CPI_{t-1}} * 1200$, 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 statiske 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.

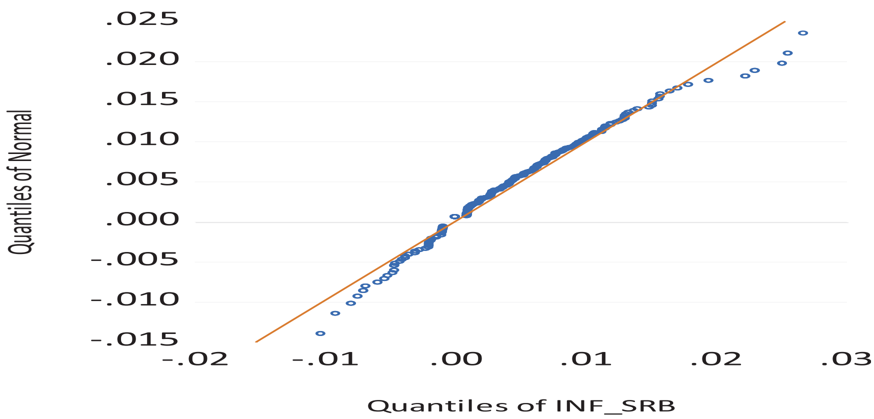
Tabela 1. Deskriptivna statistika

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 EGARH 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 istarživanja su pokazali da inflacija utiče na rast inflacione neizvesnosti čime je potrvđena 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 rezulati 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 potrvđena 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.

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BIDIRECTIONAL LINKAGE between inflation and inflation uncertainty: case of serbia

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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 EGARH 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 wards: *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:

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

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 GARH 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)

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

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):

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

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):

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

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

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 Grager 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:

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

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

For this model, the null hypothesis was tested using the Granger causality test, H0: $\beta_1 = \beta_2 = \cdots = \beta_k = 0$, 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.

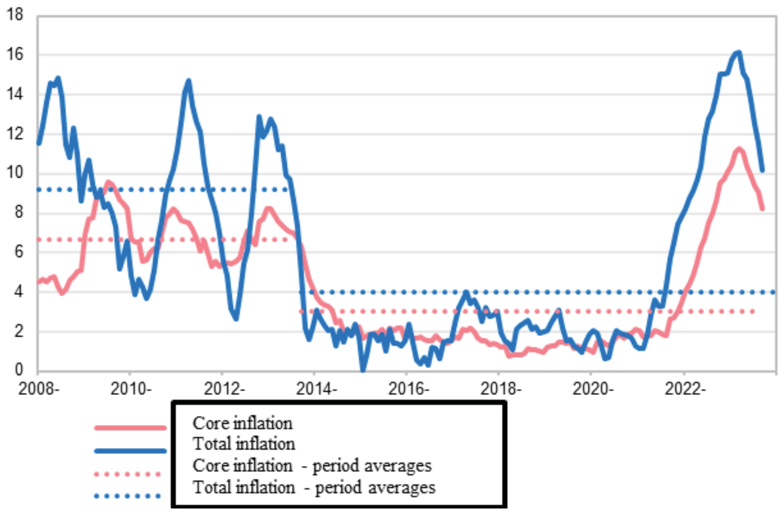
Similarly, for the second hypothesis examining the impact of inflation uncertainty on inflation, H0: $\beta_1 = \beta_2 = \cdots = \beta_m = 0$, the direction of the correlation is determined based on the sum of the coefficients with inflation uncertainty.

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.

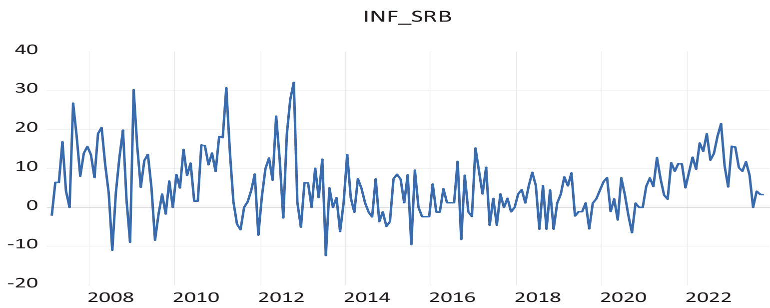
Inflation in Serbia was volatile in the period 2008-2013., which was influenced by shocks from the international environment (growth in world prices of oil and primary agricultural products) during 2010 and 2012, as well as the effects of the depreciation of the dinar in conditions of expansive fiscal 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.

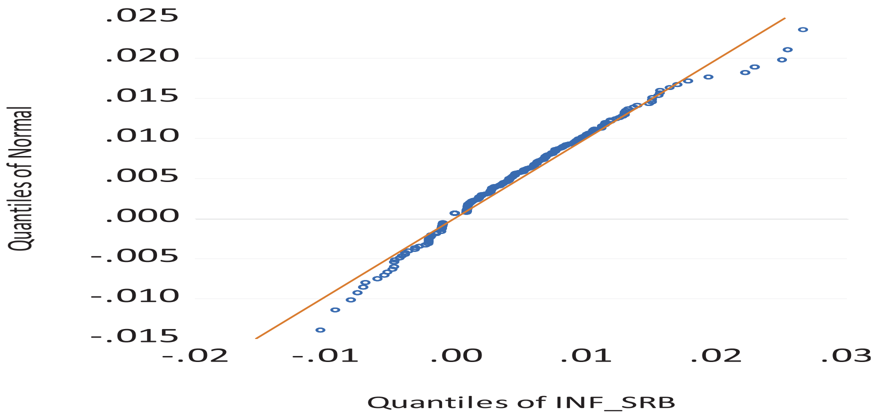
Table 1. Descriptive statistics

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 EGARH 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.

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