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

Jozefina Beke Trivunac[35], **Drinka Peković**[36]

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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

[35] Profesor emeritus, dr Jozefina Beke Trivunac, Alfa BK Univerzitet, Fakultet za finansije, bankarstvo i reviziju, Palmira Toljatija 3, Novi Beograd, Srbija, e-mail: jozefina.beke@live.com
[36] Docent, dr Drinka Peković, Alfa BK Univerzitet, Fakultet za finansije, bankarstvo i reviziju, Palmira Toljatija 3, Novi Beograd, Srbija, e-mail: drinkapekovic@gmail.com

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 energetskih 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 energetski 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 (Maghyereh, 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 CO_2 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 energetsku potrošnju 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 energetski efikasne opreme. Takođe, rezultati istraživanja su pokazali da postoje razlike u efektima investicija u stalna sredstva na energetsku potrošnju u sektorima privrede. Prema Wang et al. investicije u stalna sredstva u poljoprivredi imaju indirektan, pozitivan i statistički znajačan 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 energetsku potrošnju.

Takođe, rezultati ovih istraživanja pokazuju da su privrede post tranzicionih zemalja, koje su članice Evropske unije, u većoj meri energetski 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**
Troškovi	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.
Prihodi	Poslovni prihodi. Godišnji bilteni finansijskih izveštaja koje je uradila Agencija za privredne registre Republike Srbije za 2014, 2016, 2018, 2020 i 2022. godinu.
Oprema	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 ($LNTroškovi$, $LNPrihodi$, $LNOprema$) su korišćeni za formulisanje istraživačkog modela:

$$LNTroškovi_{it} = \alpha_0 + \beta_1 LNPrihodi_{it} + \beta_2 LNOprema_{it} + u_{it}$$

gde se indeks i odnosi na uporedne podatke, tj. sektore $i = 1, 2, \dots, 10$, a t na vremensku dimenziju panela, tj. vremenski period $t = 2013, 2014, \dots, 2022$. 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 $LNTroškova$, $LNPrihoda$ i $LNOpreme$. 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 $LNTroškova$, $LNPrihoda$ i $LNOpreme$ 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.

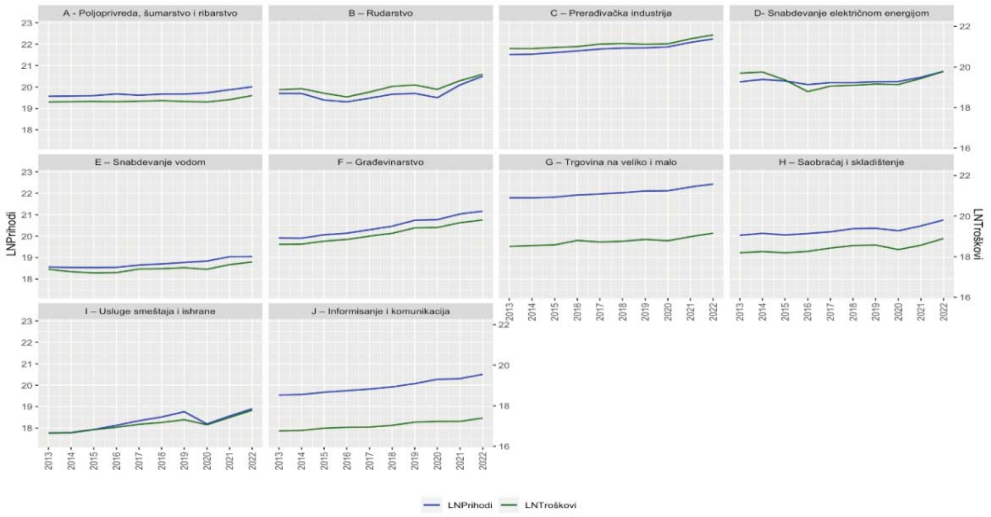
Empirijska analiza

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

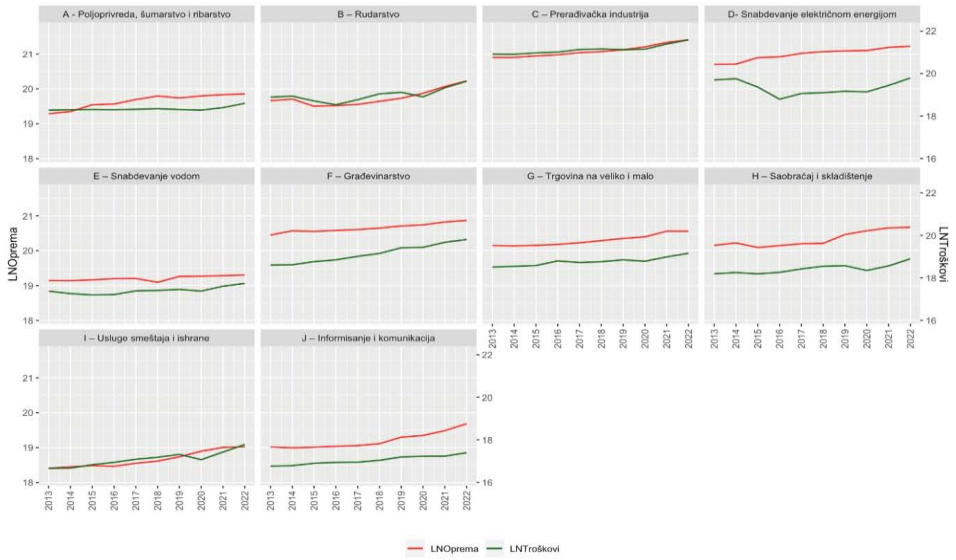
Empirijsku analizu počinjemo grafičkim prikazom panel podataka. Uobičajeni grafički prikaz panel podataka je linijski grafik, tj. vremenska serija za svaki sektor posebno. Na taj način možemo uporediti tendenciju promena promenljivih tokom vremena u svakom sektoru i videti da li pri tome ima nekih opštih 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 daljnoj analizi koji će ukazati na pozitivnu i statistički značajnu povezanosti ove dve serije.



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

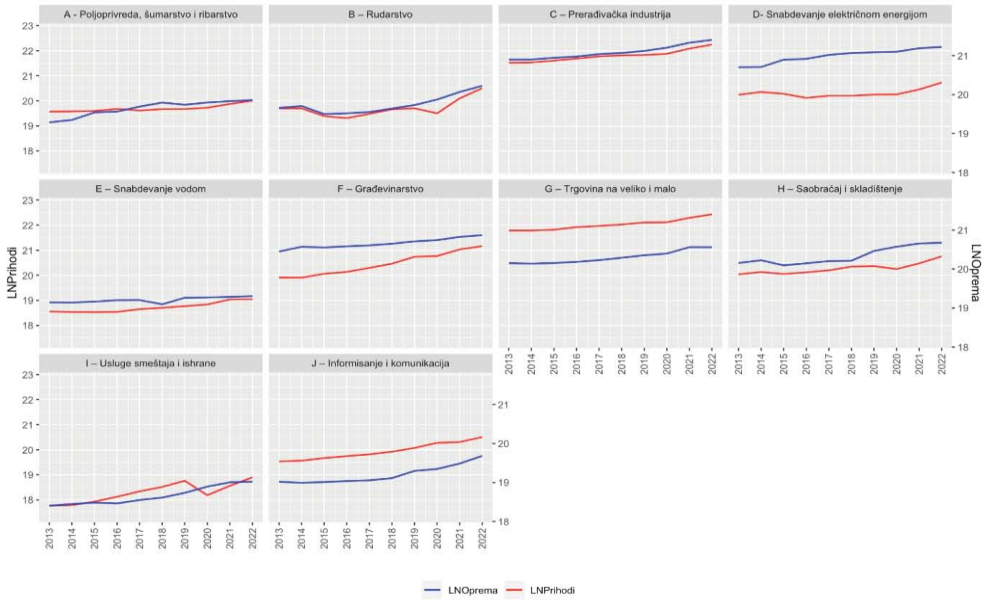
Na Slici 2 date su serije $LNTroškova$ i $LNOpreme$. Mada obe serije pokazuju tendenciju rasta tokom vremena, može se uočiti kod većeg broja panela da se serije u pojedinim godinama kreću u suprotnom smeru, tj. u periodu porasta $LNOpreme$, dolazi do pada u seriji $LNTroškovi$ i obratno. To se najbolje uočava na panelima D i H. Ovakav međusobni odnos serija nam sugeriše 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 *LNPrihodi* i *LNOprema*. Naime, kod većeg broja panela ove dve serije se u pojedinim godinama kreću u suprotnom smeru, tj. u periodu porasta *LNOpreme*, dolazi do pada u seriji *LNPrihodi* i obratno. To se najbolje uočava na panelima D i H.



Slika 3. Panel podaci serija *LNOprema* i *LnPrihodi* 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 sugeriše 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: Izračanavanje 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		
LNPrihodi	-0.926	-1.527
LNOprema	-2.286*	-3.381**
LNTroškovi	-1.503	-1.960
Prva razlika		
LNPrihodi	-2.289	-2.682
LNOprema	-3.859***	-3.898***
LNTroškovi	-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 $LNOprema$, 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 sugeriše 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 kointegrisani ili da su neki od panela kointegrisani. 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 kointegrisani)	2.413	<.01
Odnos varijanse (AR parametri jednaki u svim panelima, trend nije uključen, nulta hipoteza: Nema kointegracije, alternativna hipoteza: Svi paneli su kointegrisani)	0.041	.484
Odnos varijanse (AR parametri variraju među panelima, trend je uključen, nulta hipoteza: Nema kointegracije, alternativna hipoteza: Neki od panela su kointegrisani)	1.285	.099
Odnos varijanse (AR parametric jednaki u svim panelima, trend je uključen, nulta hipoteza: Nema kointegracije, alternativna hipoteza: Svi panel su kointegrisani)	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 kointegrisani (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	*LNPrihodi*	*LNOprema*
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**
LNPrihodi	0.561	13.15	<.01
LNOprema	-0.164	-3.79	<.01
	Kratkoročna jednačina		
Jednačina kointegracije	-0.318	-2.52	.01
ΔLNPrihodi	1.005	6.01	<.01
ΔLNOprema	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 koeficijenat 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**	
	LNPrihodi	***LNOprema***	***LNPrihodi***	***LNOprema***
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 sproveli 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

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

Jozefina Beke Trivunac[37], **Drinka Peković**[38]

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%,

[37] Professor Emeritus, PhD Jozefina Beke Trivunac, Alfa BK University, Faculty of Finance, Banking and Auditing, Palmira Toljatija 3, New Belgrade, Serbia, e-mail: Jozefina.beke@live.com
[38] Assistant Professor, PhD Drinka Peković, Alfa BK University, Faculty of Finance, Banking and Auditing, Palmira Toljatija 3, New Belgrade, Serbia, e-mail: drinkapekovic@gmail.com

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
Costs	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.
Revenues	Business revenues. Annual financial report bulletins prepared by the Business Registers Agency of the Republic of Serbia for 2014, 2016, 2018, 2020 and 2022.
Equipment	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 ($LNTroškovi$, $LNPrihodi$, $LNOprema$) were used to formulate the research model:

$$LNTroškovi_{it} = \alpha_0 + \beta_1 LNPrihodi_{it} + \beta_2 LNOprema_{it} + u_{it}$$

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 $LNTroškova$, $LNPrihoda$ and $LNOpreme$. 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 $LNTroškova$, $LNPrihoda$ and $LNOpreme$ 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.

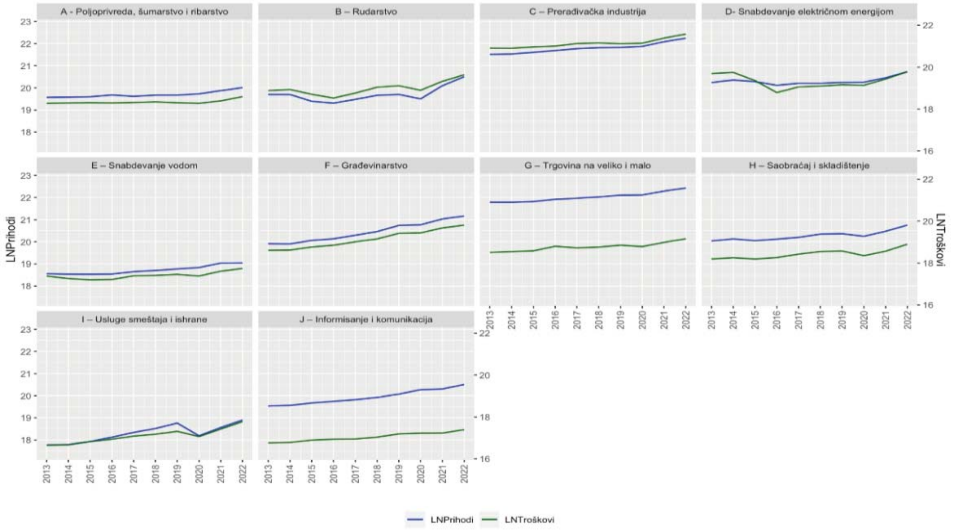

Figure 1. Panel data series *LNPrihodi* and *LNTroškovi* sectors of the Republic of Serbia

Figure 2 shows the series *LNTroškova* and *LNOpreme*. 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 *LNOpreme*, 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.

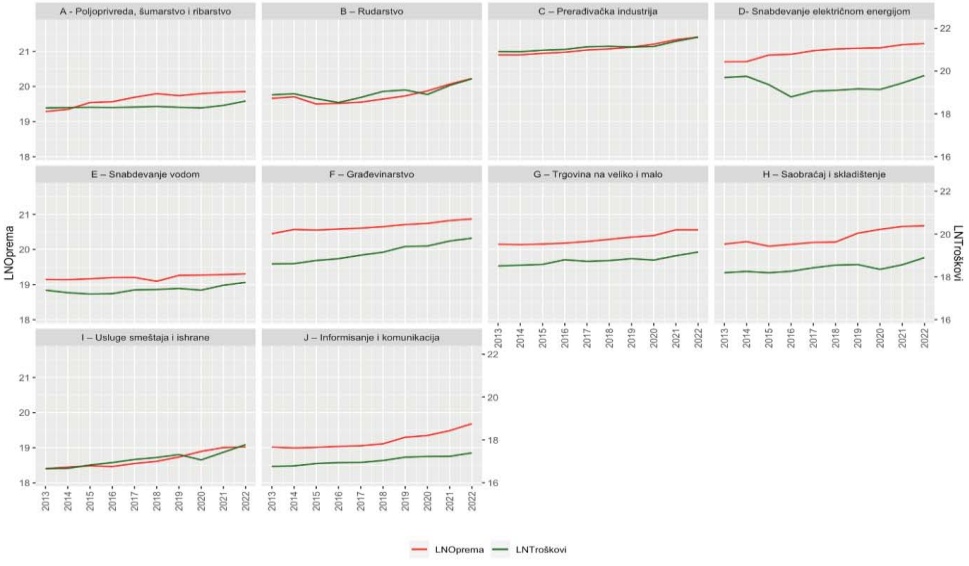

Figure 2. Panel data series *LNOprema* and *LNTroškovi* sectors of the Republic of Serbia

Finally, Figure 3 shows the series *LNPrihodi* and *LNOprema*. What was said about the graphs of series *LNTroškova* and *LNOpreme* can be repeated in the case of the mutual relationship between series *LNPrihodi* and *LNOprema*. 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 *LNOpreme*, there is a decrease in the series *LNPrihodi* and vice versa. This is best seen in panels D and H.

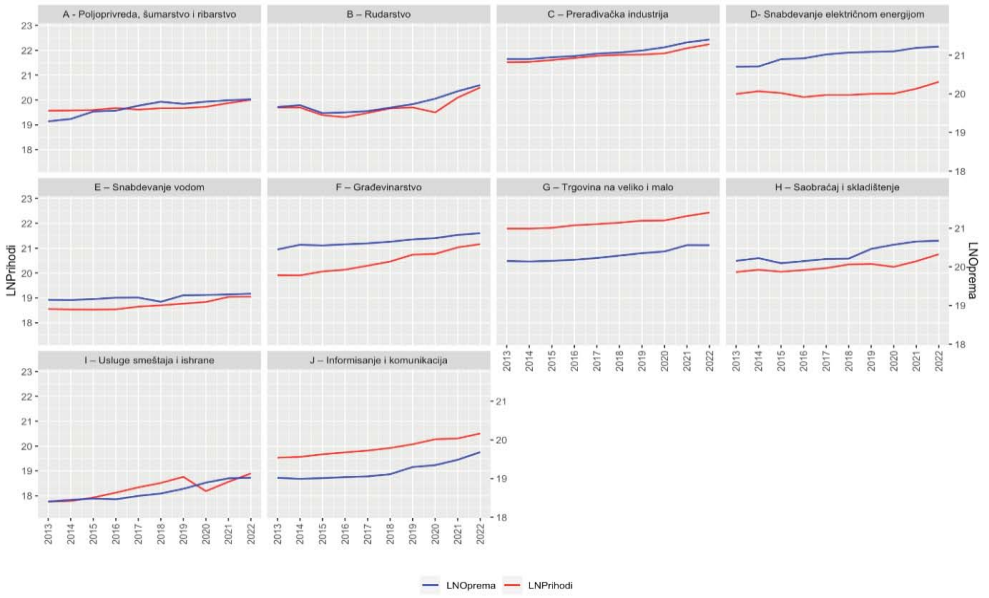

Figure 3. Panel data series *LNOprema* and *LnPrihodi* sectors of the Republic of Serbia

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
$\tilde{\Delta}_{prilagoden}$	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		
LNPrihodi	-0.926	-1.527
LNOprema	-2.286*	-3.381**
LNTroškovi	-1.503	-1.960
First difference		
LNPrihodi	-2.289	-2.682
LNOprema	-3.859***	-3.898***
LNTroškovi	-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	*LNPrihodi*	*LNOprema*
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	***t-statistic***	***P-value***
LNPrihodi	0.561	13.15	<.01
LNOprema	-0.164	-3.79	<.01
	Short-term equation		
Cointegration equation	-0.318	-2.52	.01
ΔLNPrihodi	1.005	6.01	<.01
ΔLNOprema	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**	
	LNPrihodi	***LNOprema***	***LNPrihodi***	***LNOprema***
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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