

MODELIRANJE ZAKONSKE KAZNE KAMATNE STOPE: SLUČAJ REPUBLIKE SRPSKE

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Apstrakt

Proces obračunavanja zakonske zatezne kamate treba da predvidi da uslovi na tržištu mogu varirati tokom vremena. U tom smislu, fiksiranje kamatne stope koja se koristi za obračunavanje zateznih kamata ne može biti adekvatno rešenje. Pristup krive prinosa mogao bi biti koristan u situacijama kada tržište nije dovoljno duboko, kao što je slučaj sa tržištem obveznica na Banjalučkoj berzi. Pored toga, implikacija politike pretpostavlja prepoznavanje različitih rezultata primenjene funkcije akumulacije za prostu kamatu na jednoj strani, i složenu kamatu na drugu stranu. Pravni okvir treba da pokazuje najmanje jednak interesovanje za kamate koje se smatraju neopravdano niskim, kao i za one koje se smatraju neopravdano visokim.

JEL: C58, G20, K35

Uvod

Zakonska zatezna kamatna stopa ima značajne implikacije na različite aktere u pravnom i ekonomskom sistemu. Nominalno, zakonska kamatna stopa i zakonska zatezna kamatna stopa, izgledaju kao slični koncepti, ali naprotiv, ova dva pojma suštinski mogu biti različiti. Prvi podrazumeva određivanje najviše granice kamate koja se može naplatiti na bilo koji dug, a drugi kamatu koja treba da odražava određenu kaznu za dužnika koji nije postupio po svojim obavezama.

Stoga je ideja zakonske zatezne kamate da istovremeno obešteći zajmodavce i kazni dužnika. Iako je veza zajmodavac-dužnik uglavnom povezana sa zajmovima, u ovom kontekstu ista veza bi mogla nastati kao rezultat bilo kog pravnog generalno. U svakom slučaju, kada jedna strana u ugovoru ne ispunjava svoje obaveze u skladu sa tim, mogli bismo postaviti drugačiji odnos koji podrazumeva obračunavanje i naplatu neke kamate.

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Pravna perspektiva po pitanju obračuna kamata mogla bi se okarakterisati kao prilično „linearna“ kako kratkoročno tako i dugoročno. Ovaj atribut ima zanimljive matematičke implikacije, koje mogu biti sagledane sa intuitivnog aspekta, koje bi ukratko mogle biti opisane kao razlika između proste kamate i složene kamate, odnosno prostog i složenog kamatnog računa. Takođe, intuitivno govoreći, čini se da pravno gledište o ovom pitanju zanemaruje koncept efektivne kamatne stope.

Funkcija akumulacije omogućava ispravan konceptualni pristup definisanju efektivne kamatne stope. Dakle, određena količina novca vremenom raste, a intenzitet tog rasta, opet intuitivno, treba da bude prava mera oportunitetnog troška za stranu u sporazumu kojoj je određena količina novca uskraćena.

U ovom radu nudimo alternativni pristup suprotan sadašnjem zakonskom rešenju u Republici Srpskoj (RS), koji podrazumijeva da se prosta kamata, ili složena kamata, obračunavaju na način da obezbede adekvatnu naknadu za oštećenu stranu u ugovoru uz jasno poštovanje tržišnih uslova u određenom trenutku. Ovo pitanje se posebno javlja kada je zakonska stopa kazne, odnosno zatezna kamatna stopa, utvrđena kao zakonska kategorija i kada je predviđena tržišna dinamika u okviru tog zakonskog rešenja jednaka nuli. Sa druge strane, motivacija za takvo rešenje je da se zabrani kamatna stopa koja prelazi zakonsku kamatnu stopu, gdje se ovakva pojava klasificuje kao lihvarstvo, odnosno kao čin pozajmljivanja novca po kamatnoj stopi koja se smatra nerazumno visokom. Međutim, sa druge strane, ne postoji zakonska barijera koja sprečava zaštitu stranke koja stoji kao poverilac i koja treba da bude obeštećena za pozajmljivanje novca, ili neisplatu po dogovoru.

Konceptualno, dilemu koja je izložena u ovoj analizi mogli bismo pojednostaviti na sledeći način:

Da li zakonski okvir treba da pokazuje bar jednako interesovanje za kamate koje se smatraju neopravdano niskim, kao i za one koje se smatraju neopravdano visokim?

Moralno i društveno privlačna pozicija u kojoj zajmodavac dobija daleko više javno izražene simpatije i empatije u odnosu na dužnika, odnosno poverioca, kao drugu stranu u cjelokupnom odnosu, ne bi trebalo da bude prepoznata u zakonodavnom okviru. Ovde se, u konceptu odnosa zajmodavac-dužnik, u opštoj percepciji, pogrešno eksplicitno prepostavlja direktna implikacija između banaka ili nekih drugih finansijskih institucija i povjerioca. U tom smislu, možemo ponuditi jednostavan primer gde je uobičajena primena zakonske zatezne kamate. Ukoliko radnik ne dobije platu u roku, primaće isplate u RS sa kamatnim stopama koje se obračunavaju po fiksnoj stopi dnevno od 0,3 procenata poena i metodu obračuna proste kamate koji se primenjuje na neisplaćeni iznos.

U ovom radu biće izloženo pitanje smanjenja efektivnih stopa zakonskih kazni tokom vremena za slučaj RS u matematičko-analitičkom okviru. Takođe, uporedićemo ovaj slučaj sa regionalnim primerima.

Pristup krive prinosa u obračunskoj kamatnoj stopi mogao bi ponuditi rješenje u kojem referentna kamatna stopa ne postoji, kao što je to slučaj sa Bosnom i

Hercegovinom i RS. Zamjene za ovu veličinu, kao što je korišćenje prosečnih kamatnih stopa na depozite, takođe mogu dati zadovoljavajući rezultat, ali ponekad postojanje ogromne razlike između aktivnih i pasivnih kamatnih stopa može da izazove određeno pitanje primenljivosti u tom smislu. Tržišne prilike u RS bi se mogle okarakterisati u skladu sa gore navedim stavom.

Sledeći odeljak pruža kratak pregled literature. Zatim sledi kratka razrada metodologije koja se koristi, a zatim sledi deo kojio iznosi rezultate. Diskusija je okončana završnim napomenama.

Pregled literature

Pravna teorija i praksa nudi različite perspektive na problem zakonske zatezne kamate. Ako je definisna kao fiksna veličina, onda je ideja da postoji neka varijabilna komponenta koja bi trebalo da odražava dinamiku tržišta tokom vremena, razumna.

Iako su koncepti i ideje kojima se bavimo u ovom radu suštinski isti, načini sprovođenja tih koncepata i ideja često variraju u različitim pravnim, društvenim i kulturnim okruženjima.

U Rumuniji, zakonska zatezna kamatna stopa je određena prema referentnoj kamatnoj stopi Narodne banke Rumunije koja je kamatna stopa monetarne politike, odnosno referentna kamatna stopa, plus 8 procenatnih poena (Apan & Sabou, 2014).

Etiopski građanski zakonik i turski zakon o obligacionim odnosima priznaju autonomiju stranaka da se dogovore o klauzuli o kazni za kašnjenje u plaćanju kao svojevrsnoj *ex-ante* proceni moguće štete od neizvršavanja obaveze, odnosno kao o sankciji za neizvršenje obaveza (Kamil, 2017).

U Hrvatskoj je zakonska stopa zatezne kamate regulisana Zakonom o obveznim odnosima i Zakonom o finansijskom poslovanju i predstecajnoj nagodbi. Takođe, Zakon o obligacionim odnosima reguliše najviše ugovorne kamate u trgovinskim i drugim odnosima. Prema prosečnoj kamatnoj stopi na stanja kredita datih na period duži od godinu dana nefinansijskim preduzećima, zatezne kamate se obračunavaju u skladu sa čl. 29. Zakona o obligacionim odnosima 35/05. - 126/21. a u skladu sa čl. 3 i 12a Zakona o finansijskom poslovanju i predstecajnom poravnjanju.

Slično ovom konceptu, u Srbiji postoji praksa da se stope zateznih kamata za dinare u dužničko-poverilačkim odnosima objavljaju na sajtu Narodne banke Srbije. Ovo je definisano Zakonom o zateznoj kamati.

Moguće je imati konkretniji obim kamata koji se odnosi na zatezne kamate i univerzalne klauzule u ugovorima o kreditnim karticama zatezne kamate. U tom smislu, možemo uvesti univerzalnu klauzulu o neizmirenim obavezama, gde je nametnuto da se zatezna kamata pokreće zakašnjnjem u plaćanju bilo kom poveriocu (Ausubel & Dawsey, 2008).

Visoko regulisana oblast zakonske zatezne kamatne stope je ključna prepostavka za različite finansijske instrumente, kao što su CDS ugovori (eng. Credit Default

Swaps). Posledično, ovo može imati efekat povećanja efikasnosti ulaganja za firme koje su sklone prekomernom ulaganju (Jieying & Wang, 2020). Takođe, kompanije koje imaju CDS ugovore o svom dugu sa kojima se trguje, mogu da održe veće koeficijente leveridža i duže dospeće duga (Saretto & Tookes, 2013). Nadalje, kompanije koje imaju CDS ugovore o svom dugu sa kojima se trguje, su povećale svoj učinak tehnoloških inovacija mjereno patentima i patentnim citatima (Chang, Chen, Sarah, Zhang, & Zhang, 2019).

Pored navedenog, Urošević i Grga ističu značaj kursa na kamatne stope (Urošević & Grga, 2014). Ovo bi moglo imati specifične implikacije u kontekstu kamatnih stopa u Bosni i Hercegovini, a samim tim i RS. Nećemo ovo postavljati kao posebno pitanje u ovoj analizi s obzirom na ortodoksnii okvir režima valutnog odbora koji se primenjuje u našem slučaju.

Pitanje zakonskih zateznih kamata, po svojoj suštini, predstavlja spoj različitih problema koji potiču iz prava i ekonomije. Ona je usko povezana sa stečajem kao naučnim i praktičnim problemom, gde stečajni sudija, kao jedan od aktera u stečajnom postupku, dobija nemoguć zadatak ekonomske kalkulacije bez relevantnih tržišnih podataka da isto izračuna. (Zywicki & Rajagopalan, 2017).

Izložićemo problem sa ekonomske, tačnije, kvantitativne tačke gledišta.

Metodologija

Iznos koji se duguje definisaćemo kao glavnici – često poznat kao početni iznos uloženog novca (kapitala). Nakon određenog vremenskog perioda, iznos novca koji se prima treba da bude veći i taj ukupan iznos novca je akumulirana vrednost. Ovaj iznos novca jeste uvećana glavnica za iznos kamate. Kamata kao pojam je predviđena vrednošću vremena, opet u novčanim jedinicama. Takođe, period merenja u smislu jedinica u kojoj se meri vreme je jedan od važnih inputa u proračunu.

Pojam *efektivne kamatne stope*, ili diskontne stope, je povezana sa iznosom novca, ili jednostavno nazvano kamatom, koji se plaća jednom u toku obračunskog perioda. Dalje, navedeni iznos može biti plati na kraju posmatranog perioda, tada bi govorili o dekurzivnom obračunu kamate, ili na počektu perioda, kada govorimo o anticipativnom obračunu kamatne stope. Generalno, teorija kamate ima različite moguće pravce dalje upotrebe u smislu ovog izlaganja. Može se percepcija razvijati u pravcu vrednovanja finansijskih proizvoda (Cox, Ross, & Rubinstein, 1979), aktuarskom vrednovanju u imovinskom osiguranju (Bowers & Newton, 1997; Klugman, Panjer, & Wilmot, 2004), životno i penziono osiguranje (Parmenter, 1999; Bowers & Newton, 1997).

Za početak, razmotrimo situaciju u kojoj se kamata plaća više puta po periodu merenja, odnosno obračunskom periodu, te se kamatna stopa i diskont se nazivaju nominalnim. Kamata se može plaćati češće, pa onda možemo reći da je „ispodgodišnja“ ili „složena“ ako se primjenjuje konzistentno u toku određnog broja ispodgodišnjih obračunskih perioda. Označimo nominalnu kamatnu stopu sa $i^{(m)}$, gdje

se ona plaća m puta godišnje, gde isti broj predstavlja koliko puta se efektivna kamatna stopa složene kitalizacije koristi za svakog $m - \text{tor}$ perioda. U konretnom slučaju $\overline{i^{(m)}}$ je efektivna kamatna stopa za $m - \text{tw}$ period (Rotar, 2007).

Ako želimo da izmerimo kamatu u bilo kom određenom trenutku vremena onda uvodimo veličinu poznatu kao *intenzitet kamate* (Gerber, 1997). Ovaj koncept intuitivno može biti objašnjen u kontekstu gdje imamo situaciju da se nominalna kamatna stopa $i^{(m)}$, koja se primjenjuje m puta godišnje. Ako je broj obračuna složene kamate beskonačan, onda se sila kamate može označiti δ i konceptualno shvatiti kao granična vrijednost $i^{(m)}$ (Bowers & Newton, 1997). Dakle, možemo zapisati sljedeću relaciju:

$$\delta = \lim_{m \rightarrow \infty} i^{(m)}. \quad (1)$$

Vratimo se opet na našu funkciju akumulacije $a(t)$.

Ova funkcija daje akumulisanu vrijednost za vremensku dimenziju za koju znamo da je veća od nule, odnosno $t \geq 0$, za inicijanu investiciju od 1, gdje se vreme mjeri u godinama. U skladu sa navedenim možemo zapisati sljedeća svojstva:

1. $a(0) = 1$

2. $a(t)$ je generalno rastuća funkcija ako kamata nije negativna i biće neprekidna ako kamata kontinuirano raste. U skladu sa navedenim možemo označiti iznos novca u trenutku t sa $A(t)$ i definisana je kao funkcija iznosa. Sa druge strane, sa $A(0)$ označavamo osnovicu duga. Ako nastavimo, možemo postaviti izraz koji je pogodan za poređenje različitih funkcija iznosa:

$$a(t) = \frac{A(t)}{A(0)}$$

Očigledno je da važi $a(t)A(0) = A(t)$ ili formulisano jednostavnije, $A(t)$ umnožak $a(0)$.

Da zaključimo, kamatu smo definisali kao razliku između akumulirane vrednosti i glavnice, a to nije tako praktično za svakodnevno poslovanje. Pogodnije je koristiti meru kamate koja se razvija pomoću funkcije akumulacije – efektivnu kamatnu stopu. Efektivna kamatna stopa je iznos novca koji će jedna jedinica uložena na početku perioda zaraditi tokom perioda, sa kamatom koja se plaća na kraju perioda (Finan, 2017).

Označimo efektivnu kamatnu stopu sa i i onda dalje možemo zapisati $i = a(1) - a(0) = a(1) - 1$.

Prosta kamata i složena kamata imaju različite vrste funkcije akumulacije povezane sa svakim načinom obračuna kamate. Možemo nastaviti prema pretpostavci koja pojednostavljuje stvari. Imamo početnu investiciju od 1 jedinice novca. Ova investicija donosi stalnu kamatu koja je jednaka i . Ako je tako, tada na kraju prvog perioda imamo akumulisanu vrijednost datu sa $a(1) = 1 + i$. Dalje, na kraju drugog obračunskog perioda $a(2) = 1 + 2i$. Da zaključimo na kraju n-tog perioda imamo:

$$a(n) = 1 + in, n \geq 0 \quad (2)$$

Dakle, funkcija akumulacije je linearne funkcije i to je poznato kao prosti kamatni račun. Takođe, efektivna kamatna stopa, u ovom slučaju, $i = a(1) - a(0) = a(1) - 1$ naziva se kamatna stopa prostog kamatnog računa.

Prosta kamata se primjenjuje na zakonsku zateznu kamatu u RS i BiH. Dakle, u tom pristupu efektivna kamatna stopa se smanjuje. Ako počnemo sa izrazom (2) možemo napisati sledeće:

$$i_n \frac{a(n) - a(n-1)}{a(n-1)} = \frac{[1 + in - i(n-1)]}{1 + i(n-1)} = \frac{i}{1 + i(n-1)}, n \geq 1.$$

Dalje, povećanje efektivne kamatne stope kroz različite vremenske periode je svojevrsni indikator kretanja efektivne kamatne stope. Dakle, možemo napisati:

$$i_{(n+1)} - i_n = i / (1 + in) - i / (1 + i(n-1)) = -i^2 / ((1 + in)(1 + i(n-1))) < 0$$

Rezultat

Zakon o zakonskoj stopi zatezne kamate u RS i FBiH pretpostavlja obračunavanje proste kamate. S tim u vezi, možemo pretpostaviti sledeću hipotetičku situaciju. Preduzetnici sa spekulativnim načinom razmišljanja će imati svoje gotovinske tokove teško opterećene troškovima zakonskih zateznih kamata. U takvim okolnostima, gde se obračunava obična kamata, ona ili on će platiti efektivnu kamatnu stopu koja se smanjuje tokom vremena. Sa druge strane, njen ili njegov kolega, hipotetički preduzetnik koji deluje kao poverilac, ili zajmodavac u ovoj situaciji, može očekivati da će primiti akumuliranu vrednost koja uključuje početnu glavnici i obračunatu kamatu, ali sa opadajućom efektivnom kamatnom stopom tokom vremena. Koja vrsta preduzetnika se stimuliše u ovom B2B odnosu? Da li pravni okvir pruža uslove za pozitivnu ili negativnu selekciju?

U slučaju RS od 2018. nominalna kamatna stopa je fiksirana u „kodu“ Zakona. Nema prostora za bilo kakvu vrstu prilagođavanja – stvarne kamatne stope su potpuno van okvira.

Teško je definisati gde je zakonska kazna za one koji su u večnom dužničkom stanju, što je često u slučaju krhkog zakonskog okvira. Dakle, stopi zakonske kazne treba

dodati kamatnoj stopi koja odražava stvarnu cenu kapitala, a ukupno te dve, intuitivno govoreći, treba da daju „fer“ zakonsku kaznu.

Jedna od pretpostavki za ovu vrstu je da postoji konstantna efektivna kamatna stopa. Dakle $i=const$ je početna pretpostavka, a ako se to primeni na ranije pomenutu relaciju za odnos trenda efektivne kamatne stope, možemo napisati: $i_{n+1} - i_n = const$

Ovo se može postići primenom eksponencijalne funkcije u procesu akumulacije kamate tokom t perioda. Ovo se može zapisati kao:

$$a(t) = (1+i)^t, \text{ za } t \geq 0.$$

Na ovaj način smo uveli složeni kamatni račun. Sljedeći korak je da uvedemo kamatnu stopu na način da je definisana kao:

$$\begin{aligned} i_n &= (a(n) - a(n-1)) / a(n-1) = ((1+i)^n - (1+i)^{(n-1)}) / (1+i)^{(n-1)} = \\ &= \frac{(1+i)(1+i)^{(n-1)}}{(1+i)^{(n-1)}} - \frac{(1+i)^{(n-1)}}{(1+i)^{(n-1)}} = 1 + i - 1 = i \end{aligned}$$

Dalje, moramo dozvoliti da kamata varira u skladu sa dešavanjima na tržištu – to je jedini način da se obezbedi pravična kompenzacija za gubitak kreditora, odnosno povjerioca. Ako koristimo terminologiju iz računovodstva, onda ovde želimo da koristimo kamatnu stopu, i potencijalno da dodamo neku vrstu kaznene marže, koja će pošteno vrednovati „tržišnu“ (ili „trenutnu“) vrednost obaveza. Na primer, u industriji osiguranja, ova stopa se koristi za izveštaje regulatorima koji se odnose na testiranje novčanih tokova u kontekstu adekvatnosti rezervi. Jedan od pristupa u tom pogledu je jednostavno produženje krive prinosa i zamrzavanje poslednje vidljive stope.

Takođe, u nekim slučajevima kada finansijska tržišta nisu dovoljno duboka, pristup krive prinosa može se koristiti ne samo za ekstrapolaciju već i za potrebe interpolacije. Kada tržište obveznica ne nudi obveznice sa različitim rokovima dospeća, tada koristimo rezultate krive prinosa za diskontovanje za one vremenske distance koje nisu ponuđene dostupnim kotacijama na tržištu, odnosno nisu dostupne za uključivanje u sam proces vrednovanja neke obaveze.

Ovaj pristup može prepostaviti različitu složenost modela. Možemo imati modele kao što su jednostavni linearni modeli, ali i složenije takozvane splajn modele (eng. spline). Takođe, postoji značajan jaz između makroekonomista i ekonomista koji se bave finansijama, u pristupu modeliranju krive prinosa. Prvi se fokusiraju na ulogu očekivanja inflacije i buduće realne ekonomske aktivnosti u određivanju prinosa. Sa druge strane „finansijaši“ izbjegavaju eksplicitnu upotrebu takvih odrednica (Diebold, Rudebusch, & Aruoba, 2004). Međutim, teško je naći primer koji prepostavlja fiksiranje na dnevnoj bazi, bez razmatranja bilo kakve dinamike na krivoj prinosa.

U odnosu na zakonsko rješenje zatezne kamatne stope u RS, zemlje u okruženju dozvoljavaju određenu dinamiku upućivanjem na referentne kamatne stope koje periodično objavljaju centralne banke. Izgovor za nekorištenje ovog pristupa mogao bi biti nedostatak referentnih kamatnih stopa za BiH. Ipak, postavljanje kamatne stope kao konstantne je možda iz pravne perspektive jednostavno rešenje, ali iz perspektive ekonomskog zdravog razuma, to je besmislica. U odnosu na zakonsko rješenje zatezne kamatne stope u RS, zemlje u okruženju dozvoljavaju određenu dinamiku upućivanjem na referentne kamatne stope koje periodično objavljaju centralne banke. Centralna banka predstavlja finansijsku instituciju od izuzetnog značaja koja je odgovorna za monetarnu politiku države i direktno utiče na finansijsko tržište (Bakić, 2022).

Interesovanje za određivanje krive prinosa odavno je prisutno u ekonomskoj literaturi, te stoga postoji veliki broj autora koji su se bavili ovom temom. Zbog toga se pojavio veliki broj modela. Kao što vidimo u tabeli 1, različite centralne banke koriste različite pristupe.

Tabela 1 Procena volatilnosti Centralne banke i srodnih modela određivanja krive prinosa (Pereda, 2009)

Centralna banka	Model
Belgija	Nelson-Siegel, Svensson
Kanada	Svensson
SAD	Fisher-Nychka-Zervos (Spline)
Finska	Nelson-Siegel
Francuska	Nelson-Siegel, Svensson
NJemačka	Svensson
Italija	Nelson-Siegel
Japan	Fisher-Nychka-Zervos (Spline)
Norveška	Svensson
Spain	Svensson
Velika Britanija	Anderson and Sleath (Spline) (until 2001 Svensson)
Švedska	Fisher-Nychka-Zervos (Spline), before Svensson
Švajcarska	Svensson
EU	Svensson

Nelson i Sigel (eng. Nelson and Siegel) uveli su u potrebu model koji koristi u velikoj mjeri i danas. Možemo zapisati sljedeće (Nelson & Siegel, 1987):

$$y(\tau) = \beta_{0t} + \beta_{1t} \frac{1 - \exp(-\lambda\tau)}{\lambda\tau} + \beta_{2t} \left(\frac{1 - \exp(-\lambda\tau)}{\lambda\tau} - \exp(-\lambda\tau) \right)$$

gdje su $\beta_{0t}, \beta_{1t}, \beta_{2t}$ i λ parametri, a sa τ obilježavamo vremenski period.

Godine 1994, Svenson (eng. Svensson) uveo je u upotrebu model koji svojevrsna nadogradnja Nelson-Sigelovog modela. Ovaj model definše buduće kamatne stope na sljedeći način (Svensson, 1994):

$$y_t(\tau) = \beta_0 + \beta_1 \exp\left(-\frac{\tau}{\lambda_1}\right) + \beta_2 \frac{\tau}{\lambda_1} \exp\left(-\frac{\tau}{\lambda_1}\right) + \beta_3 \frac{\tau}{\lambda_2} \exp\left(-\frac{\tau}{\lambda_2}\right)$$

gdje s $\beta_0, \beta_1, \beta_2, \beta_3, \lambda_1, \lambda_2$ parametri τ je vremenski period.

Kada govorimo o kamatnoj stopi koja se koristi za diskontovanje, moramo imati u vidu niz faktora koji utiču na kamatnu stopu. Kao što smo ranije pomenuli, ne postoji konsenzus o opšteprihvaćenoj metodologiji za određivanje kamatnih stopa u različitim okolnostima njene primene.

Ako krenemo od izraza (1), lako se može pokazati da možemo zapisati $e^\delta = 1+i$. Možemo se zapitati kolika je početna vrednost kapitala ako znamo konačnu vrednost kapitala i odgovarajuću kamatnu stopu, odnosno intenzitet kamate u jedinici vremena. Zatim dolazimo do pojma diskontnog faktora za slučaj kontinuirane kapitalizacije definisane sa $v_t = e^{-\delta t}$ (Parmenter, 1999). Potrebno je napomenuti da u ovakvoj perspektiv t ne mora da bude cijeli broj.

Dakle, možemo koristiti trenutne stope sa tržišta obveznica da konstruišemo krivu prinosa i primenimo te rezultate direktno u procesu obračunavanja zakonske zatezne kamatne stope. Vremenski okvir kao dimenzija za veličinu uzorka, je kategorija o kojoj se može raspravljati. Ako je vremenski okvir preuzak, kao što je nerijetko u slučaju finansijskih tržišta RS, onda bismo imali upitnu veličinu uzorka. Sa druge strane, ako je previše široka, onda bi relevantnost u kontekstu korišćenja trenutnih tržišnih informacija mogla biti dovedena u pitanje.

Primjer razrade krive prinosa u našem slučaju uzima u obzir cijelokupno trgovanje obveznicama na Banjalučkoj berzi u posljednjih 6 mjeseci. Zanimljivo je da je u tom periodu prometovano samo 14 obveznica, što ide uz činjenicu da tržište nije dovoljno duboko. Početni skup podataka (Prilog I, tabela 3) je smanjen na samo šest redova kao što je prikazano u tabeli 2 (Prilog I). Nelson-Sigelov pristup je prepostavio one obveznice koje imaju Makulejevu duraciju (eng. Macaulay duration) veću od 0,5, a Svenssonov pristup je prepostavio one obveznice koje imaju tržišni prinos veći od dva. Razrada ovih pitanja, sagledavanje nekih opštih pitanja u vezi sa pristupom krive prinosa, te pružanje dubljih analiza u tom pogledu prepostavlja značajno drugačiji pravac izlaganja.

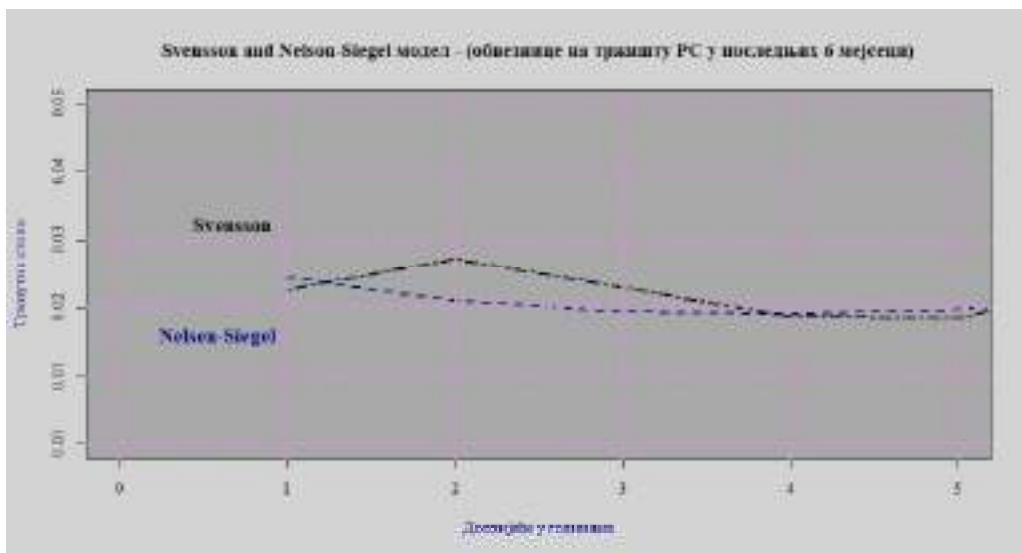
Na slici 1 imamo Nelson-Siegel i Svenson model za Banjalučku berzu (podaci prikazani u prilogu I). Izračun je realizovan pomoću R paketa *YieldCurve* (Consiglio & Guirrer, 2011).

Diskusija

Definisanje budućih kamatnih stopa, zasnovanih na trenutnim stopama, gde se različiti datumi dospeća obveznica koriste za diferenciranje obračunate kamate, ili diskontne stope, zasnovano na različitim dužinama vremenskog perioda na koji se ta stopa primenjuje, prilično je stara ideja (Schiller and McCulloch 1987).

Ideja o terminskoj strukturi kamatnih stopa u svojoj ranoj fazi imala je različite modalitete realizacije. Vašiček je pretpostavio da spot kamatna stopa prati proces difuzije. Takođe, ovaj pristup pretpostavlja da cena diskontne obveznice zavisi samo od spot kursa. Konačno, ova perspektiva pretpostavlja tržišta koja su efikasna (Vasicek 1977).

Krive prinosa mogu imati različite oblike. Obično su neki standardni tipovi njih monotoni, „grbavi“ i u obliku latiničnog slova S (poslednji je retkost). U određenim slučajevima, „grba“ se može pojaviti kao šiljak kao neka vrsta ekstremnog izgleda. U kontekstu relativno nelikvidnih tržišta, Svenssonov model bi mogao da proizvede krivinu koja ima ogromne, „šiljke“. Dalje, nelikvidnost je kao atribut immanentna onim tržištima koja nisu razvijena.



Slika 1 Svenson i Nelson-Siegels model zasnovan na obveznicama koje kotiraju na Banjalučkoj berzi

Sa druge strane, Nilsen i Sigel su ponudili model koji pretpostavlja rešavanje diferencijalne jednačine drugog reda. Ovaj pristup dobija vizuelnu glatkoću transformacijom problema nelinearne procene u relativno jednostavne linearne probleme. Ako idemo dalje, mogli bismo reći da se kontekst za takav postupak uspostavlja fiksiranjem parametra oblika koji su uzrok nelinearnosti (Annaert, Claes, De Ceuster, & Zhang, 2013).

Podaci sa tržišta koji nisu dovoljno duboka nisu adekvatni za predviđanje u izvan uzorka. U tom pogledu, model određivanja cena mogao bi biti otvoren za potencijalne greške ako se primeni na određivanje cene dugoročne obveznice. Ali, u kontekstu prikupljanja zakonskih zateznih kamata, ovo možda nije presudno.

Zadovoljili smo se korišćenjem Makalejeve duracije, mada se mogao primeniti i modifikovani oblik ove mjere osjetljivosti. Gruba procena se takođe može uraditi na osnovu datuma dospeća, odnosno jednostavnog dospijeća.

Za potrebe obračuna zakonske zatezne kamate, vremenski period duži od pet godina može biti irrelevantan. Sa druge strane, u bankarstvu se po konvenciji transakcije koje imaju rok dospeća kraće od jedne godine diskontuju uz prostu kamatu. Za ovo postoji jasno matematičko rezonovanje.

Proračuni jednostavne i složene kamate će imati isti rezultat za one slučajeve gde je vremenski raspon ili jednak 0 ili je jednak 1. Ali, za one slučajeve u kojima je period merenja manji od 1, složena kamata daje manji prinos i suprotno za periode koji su veći od 1, prosta kamata će rezultirati manjom količinom novca akumuliranog tokom vremena. U dodatku imamo teoremu i dokaz u tom pogledu.

Slika 1 pokazuje da smo obezbedili pristojnu konvergenciju između Nelson-Sigelovog i Svenssonovog modela. Ovome je doprinelo sužavanje uzorka. Dakle, prvi pristup prepostavlja tipove regresije koji minimiziraju razliku između posmatranih tržišnih stopa u nekom funkcionalnom obliku, a kasnije je neka vrsta nadogradnje. Sa druge strane, postoje metode uklapanja krive koje se koriste na u trgovačkim okvirima na berzama, a to su inverzivni tipovi modela. U tom smislu, ići dalje bi podrazumevalo razmatranje „hibridnih“ metoda regresije. Često pominjani primer u tom kontekstu je metoda uklapanja Smit-Vilsonove (Smith-Wilson) krive. Ovo je pristup kernel regresije i postoji potencijal za dalja razmatranja u kontekstu BiH.

Zaključak

Kriva prinosa se može modelovati na osnovu inputa dostupnih sa tržišta obveznica koje su listirane na Banjalučkoj berzi. Dalje, bilo koji model, bilo onaj koji nudi Svenson ili onaj koji nude Nelson i Sigels, može ponuditi rešenje za adekvatno obračunavanje zakonskih zateznih kamata.

Jasne implikacije politike mogu se sažeti u dva glavna pravca:

- Prvo, korišćenje krive prinosa u definisanju tačne zakonske zatezne kamatne stope omogućava adekvatno obračunavanje u tom pogledu.
- Drugo, zakonska zatezna kamatna stopa treba da prepostavi prostu kamatu za merne jedinice manje od 1, a složenu kamatu za merne jedinice veće od 1.

Rešavanje dileme između Svenssonovog i Nelson-Sigelovog modela podrazumeva pregled trenutnih tržišnih postavki. Na osnovu podataka iz februara 2022., kratkoročno, mogli bismo pronaći dovoljno razloga za zagovaranje upotrebe

Svenssonovog modela, iako Nelson-Sigels nudi vizuelno privlačniji rezultat u ovom konkretnom slučaju.

Korišćenje prve uočljive kamatne stope u jednom od dva modela za transakcije koje imaju vreme merenja manje od 1 ima jasno opravdanje kao što je objašnjeno u Prilogu II. Ovu stopu samo treba postaviti na dnevnoj bazi. Ovo bi moglo pokrenuti novu debatu, zasnovanu na dva modela prezentacije kao na slici jedan. Dakle, početne stope značajno se razlikuju. Razrada ovog pitanja pretpostavila je drugaćiji pravac diskusije i izlazi iz okvira ove analize.

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MODELING THE LEGAL PENAL INTEREST RATE: THE CASE OF THE REPUBLIC OF SERBIA

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Abstract

The process of calculating statutory default interest should anticipate that market conditions may vary over time. In this sense, fixing the interest rate used for the calculation of default interest cannot be an adequate solution. The yield curve approach could be useful in situations where the market is not deep enough, as is the case with the bond market on the Banja Luka Stock Exchange. In addition, the policy implication presupposes the recognition of the different results of the applied accumulation function for simple interest on the one hand, and compound interest on the other hand. The legal framework should show at least equal interest in interest rates that are considered unreasonably low, as well as in those that are considered unreasonably high.

Keywords: *yield curve, theory of interest and default, accumulation function, bond market.*

JEL: *C58, G20, K35*

Introduction

The legal default interest rate has significant implications for various actors in the legal and economic system. Nominally, the legal interest rate and the legal default interest rate look like similar concepts, but on the contrary, these two terms can be different. The first involves determining the highest limit of interest that can be charged on any debt, and the second an interest that should reflect a certain penalty for a debtor who has not complied with his obligations.

Therefore, the idea of statutory default interest is to both compensate the lender and punish the debtor. Although the lender-borrower relationship is generally associated with loans, in this context the same relationship could arise as a result of any legal general. In any case, when one party to the contract does not fulfill its obligations accordingly, we could establish a different relationship that implies the calculation and collection of some interest.

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The legal perspective on interest calculation could be characterized as quite "linear" both in the short and long term. This attribute has interesting mathematical implications, which can be seen from an intuitive aspect, which could be briefly described as the difference between simple interest and compound interest, that is, simple and compound interest account. Also, intuitively speaking, the legal view on this issue seems to ignore the concept of effective interest rate.

The accumulation function enables a correct conceptual approach to defining the effective interest rate. Therefore, a certain amount of money grows over time, and the intensity of that growth, again intuitively, should be the true measure of the opportunity cost for the party in the agreement that is denied a certain amount of money.

In this paper, we offer an alternative approach contrary to the current legal solution in the Republika Srpska (RS), which implies that simple interest, or compound interest, is calculated in such a way as to provide adequate compensation for the injured party in the contract with clear respect for market conditions at a certain time. This question arises especially when the legal penalty rate, that is, the default interest rate, is established as a legal category and when the predicted market dynamics within that legal solution is equal to zero. On the other hand, the motivation for such a solution is to prohibit an interest rate that exceeds the legal interest rate, where this phenomenon is classified as usury, that is, as an act of lending money at an interest rate that is considered unreasonably high. However, on the other hand, there is no legal barrier that prevents the protection of the party who stands as a creditor and who should be compensated for borrowing money, or non-payment as agreed.

Conceptually, we could simplify the dilemma presented in this analysis as follows:

Should the legal framework show at least as much interest in interest rates that are considered unreasonably low as in those that are considered unreasonably high?

The morally and socially attractive position in which the lender receives far more publicly expressed sympathy and empathy in relation to the debtor, that is, the creditor, as the other party in the overall relationship, should not be recognized in the legislative framework. Here, in the concept of the lender-debtor relationship, in the general perception, a direct implication between banks or some other financial institutions and the creditor is wrongly assumed. In this sense, we can offer a simple example where the legal default interest is commonly applied. If the worker does not receive his salary within the deadline, he will receive payments in RS with interest rates calculated at a fixed daily rate of 0.3 percentage points and the simple interest calculation method that is applied to the unpaid amount.

over time for the case of RS will be presented in a mathematical - analytical framework. Also, we will compare this case with regional examples.

The yield curve approach in the calculation interest rate could offer a solution in which the reference interest rate does not exist, as is the case with Bosnia and Herzegovina and the RS. Substitutes for this size, such as using average interest rates on deposits, can also give a satisfactory result, but sometimes the existence of a huge difference between active and passive interest rates can cause some question of applicability in this sense. Market opportunities in the RS could be characterized in accordance with the above-mentioned position.

The next section provides a brief review of the literature. Then follows a brief elaboration of the methodology used, followed by a section presenting the results. The discussion ended with concluding remarks.

Overview literature

Legal theory and practice offer different perspectives on the problem of statutory default interest. If it is defined as a fixed quantity, then the idea that there is some variable component that should reflect the dynamics of the market over time is reasonable.

Although the concepts and ideas we deal with in this paper are essentially the same, the ways in which those concepts and ideas are implemented often vary in different legal, social, and cultural environments.

In Romania, the legal default interest rate is determined according to the reference interest rate of the National Bank of Romania, which is the monetary policy interest rate, i.e. the reference interest rate, plus 8 percentage points (Apan & Sabou, 2014).

The Ethiopian Civil Code and the Turkish Law on Obligations recognize the autonomy of the parties to agree on a penalty clause for late payment as a kind of *ex-ante* assessment of possible damage from non-performance, i.e. as a sanction for non-performance (Kamil, 2017).

In Croatia, the legal interest rate is regulated by the Law on Obligations and the Law on Financial Operations and Pre-Bankruptcy Settlement. Also, the Law on Obligation Relations regulates the highest contractual interest rates in trade and other relations. According to the average interest rate on loan balances given for a period longer than one year to non-financial companies, default interest is calculated in accordance with Art. 29 of the Law on Obligations 35/05. - 126/21. and in accordance with Art. 3 and 12a of the Law on Financial Operations and Pre-Bankruptcy Settlement.

Similar to this concept, in Serbia there is a practice of publishing default interest rates for dinars in debtor-creditor relations on the website of the National Bank of Serbia. This is defined by the Law on Default Interest.

It is possible to have a more specific scope of interest relating to late interest and universal late interest clauses in credit card agreements. In this sense, we can introduce a universal clause on outstanding obligations, where it is

imposed that default interest is triggered by late payment to any creditor (Ausubel & Dawsey, 2008).

The highly regulated area of the legal default interest rate is a key assumption for various financial instruments, such as CDS contracts (Credit Default Swaps). Consequently, this may have the effect of increasing investment efficiency for firms prone to overinvestment (Jieying & Wang, 2020). Also, companies that have CDS contracts on their debt traded can maintain higher leverage ratios and longer debt maturities (Saretto & Tookes, 2013). Furthermore, companies that have traded CDS contracts on their debt increased their technological innovation performance as measured by patents and patent citations (Chang, Chen, Sarah, Zhang, & Zhang, 2019).

In addition to the above, Urošević and Grga emphasize the importance of the exchange rate on interest rates (Urošević & Grga, 2014). This could have specific implications in the context of interest rates in Bosnia and Herzegovina, and therefore in the RS. We will not raise this as a separate issue in this analysis given the orthodox framework of the currency board regime that applies in our case.

The issue of legal default interest, in its essence, represents a combination of different problems originating from law and economics. It is closely related to bankruptcy as a scientific and practical problem, where the bankruptcy judge, as one of the actors in the bankruptcy procedure, is given the impossible task of economic calculation without relevant market data to calculate the same. (Zywicki & Rajagopalan, 2017).

We will present the problem from an economic, more precisely, quantitative point of view.

Methodology

We will define the amount owed as the principal - often known as the initial amount of invested money (capital). After a certain period of time, the amount of money received should be greater and that total amount of money is the accumulated value. This amount of money is the principal increased by the amount of interest. Interest as a concept is provided by the value of time, again in monetary units. Also, the measurement period in terms of units in which time is measured is one of the important inputs in the calculation.

The term *effective interest rate*, or discount rate, is related to the amount of money, or simply called interest, that is paid once during the accounting period. Furthermore, the stated amount can be the salary at the end of the observed period, then we would talk about the decursive calculation of interest, or at the beginning of the period, when we talk about the anticipatory calculation of the interest rate. In general, interest theory has various possible directions of further use in terms of this presentation. Perception can develop in the direction of valuation of financial products (Cox, Ross, & Rubinstein, 1979), actuarial valuation in property insurance (Bowers & Newton,

1997; Klugman, Panjer, & Wilmot, 2004), life and pension insurance (Parmenter, 1999); Bowers & Newton, 1997).

To begin with, let's consider the situation in which the interest is paid several times per measurement period, that is, the calculation period, and the interest rate and discount are called nominal. Interest can be paid more often, so we can say that it is "subannual" or "compound" if it is applied consistently during a certain number of subannual accounting periods. Let's denote the nominal interest rate with $i^{(m)}$, where it is paid m several times a year, where the same number represents how many times the effective interest rate of compound capitalization is used for each $m - \text{year}$ period. In the concrete case, $\overline{i^{(m)}}$ it is the effective interest rate for $m - \text{year}$ the period (Rotar, 2007).

If we want to measure interest at any given point in time, we introduce a quantity known as *interest rate* (Gerber, 1997). This concept can be intuitively explained in the context where we have a situation where the nominal interest rate $i^{(m)}$, which is applied m once a year. If the number of calculations of compound interest is infinite, then the force of interest can be marked δ and conceptually understood as a limit value $i^{(m)}$ (Bowers & Newton, 1997). So, we can write the following relation:

$$\delta = \lim_{m \rightarrow \infty} i^{(m)}. \quad (1)$$

Let's go back to our accumulation function again $a(t)$.

This function gives an accumulated value for the time dimension that we know is greater than zero, ie $t \geq 0$, for an initial investment of 1, where time is measured in years. In accordance with the above, we can write down the following properties:

1. $a(0) = 1$

2. $a(t)$ is generally an increasing function if the interest rate is non-negative and will be continuous if the interest rate is continuously increasing. In accordance with the above, we can denote the amount of money at the moment t with $A(t)$ and it is defined as a function of the amount. On the other hand, $A(0)$ we denote the debt base. Continuing, we can set up an expression suitable for comparing different sum functions:

$$a(t) = \frac{A(t)}{A(0)}$$

Obviously it does $a(t)A(0) = A(t)$ or formulated more simply, $A(t)$ a multiple $a(0)$.

To conclude, we have defined interest as the difference between the accumulated value and the principal, which is not so practical for everyday business. It is more convenient to use a measure of interest that is developed using the accumulation function - the effective interest rate. The effective interest rate is the amount of money that one unit invested at the beginning of the period will earn during the period, with interest paid at the end of the period (Finan, 2017).

Denote the effective interest rate by i and then we can write down $i = a(1) - a(0) = a(1) - 1$.

Simple interest and compound interest have different types of accumulation functions associated with each method of calculating interest. We can proceed with a simplifying assumption. We have an initial investment of 1 unit of money. This investment yields constant interest that is equal to i . If so, then at the end of the first period we have the accumulated value given by $a(1) = 1 + i$. Furthermore, at the end of the second accounting period $a(2) = 1 + 2i$. It concludes at the end of the n th period we have:

$$a(n) = 1 + in, n \geq 0 \quad (2)$$

So the accumulation function is a linear function and it is known as simple interest calculus. Also, the effective interest rate, in this case, $i = a(1) - a(0) = a(1) - 1$ is called the interest rate of the simple interest account.

Simple interest is applied to statutory default interest in the RS and BiH. So, in that approach, the effective interest rate decreases. If we start with expression (2) we can write the following:

$$i_n = \frac{a(n) - a(n-1)}{a(n-1)} = \frac{[1 + in - i(n-1)]}{1 + i(n-1)} = \frac{i}{1 + i(n-1)}, n \geq 1.$$

Furthermore, the increase of the effective interest rate through different periods of time is a kind of indicator of the movement of the effective interest rate. So we can write:

$$i_{(n+1)} - i_n = i / (1 + in) - i / (1 + i(n-1)) = -i^2 / ((1 + in)(1 + i(n-1))) < 0$$

The result

The Law on the Legal Interest Rate in RS and FBiH assumes the calculation of simple interest. So the team in connect, we can to assume will follow hypothetical house the situation. Entrepreneurs with speculative in a way of thinking have own cash flows who will burden women costs legal tensile interest. such circumstances, where calculation ordinary Interest, she or he will to pay effective interest rate rate which reduces during time. With others sides, hers or his colleague, hypothetical

entrepreneur which one it works like creditor, or lender in this one situation, it can to expect it will to receive accumulated value which includes to begin with principal and calculated interest, but with will decrease effective interest rate rate during time. Which Species entrepreneur stimuli s in this M B 2 B relationship? li legal frame supply conditions For positive or negative selection?

In the case of RS, since 2018, the nominal interest rate has been fixed in the " code " of the Law. There is no room for any kind of adjustment – the actual interest rates are completely out of the question.

It is difficult to define where the legal penalty lies for those who are in a perpetual state of debt, which is often the case with a fragile legal framework. Therefore, the legal penalty rate should be added to the interest rate that reflects the real cost of capital, and the total of the two, intuitively speaking, should give a "fair" legal penalty.

One of the assumptions for this type is that there is a constant effective interest rate. So $i=const$ is the initial assumption, and if it is applied to the previously mentioned relationship for the effective interest rate trend ratio, we can write: $i_{n+1} - i_n = const$

This can be achieved by applying an exponential function to the process of accumulating interest over time^t period. This can be written as:

$$a(t) = (1+i)^t, \text{ за цијеле вриједности } t \geq 0.$$

In this way, we introduced a compound interest account. The next step is to introduce the interest rate in such a way that it is defined as:

$$\begin{aligned} i_n &= (a(n) - a(n-1)) / a(n-1) = ((1+i)^n - (1+i)^{(n-1)}) / (1+i)^{(n-1)} = \\ &= \frac{(1+i)(1+i)^{(n-1)}}{(1+i)^{(n-1)}} - \frac{(1+i)^{(n-1)}}{(1+i)^{(n-1)}} = 1 + i - 1 = i \end{aligned}$$

Furthermore, we must allow the interest rate to vary in accordance with market developments - this is the only way to ensure fair compensation for the creditor's loss. If we use accounting terminology, then we want to use an interest rate here, and potentially add some kind of penalty margin, that will fairly value the "market" (or "current") value of the liabilities. For example, in the insurance industry, this rate is used for reports to regulators related to cash flow testing in the context of reserve adequacy. One approach in this regard is simply to extend the yield curve and freeze the last visible rate.

Also, in some cases where financial markets are not deep enough, the yield curve approach can be used not only for extrapolation but also for interpolation purposes. When the bond market does not offer bonds with different maturities, then we use the results of the yield curve for discounting for those time distances that are not offered

by available quotations on the market, that is, they are not available for inclusion in the actual process of valuing a liability.

This approach can assume different model complexity. We can have models such as simple linear models, but also more complex so-called spline models. Also, there is a significant gap between macroeconomists and financial economists in their approach to yield curve modeling. The former focus on the role of inflation expectations and future real economic activity in determining returns. On the other hand, "financiers" avoid the explicit use of such terms (Diebold, Rudebusch, & Aruoba, 2004). However, it is difficult to find an example that assumes fixing on a daily basis, without considering any dynamics on the yield curve.

In relation to the legal solution of the default interest rate in the RS, neighboring countries allow certain dynamics by referring to the reference interest rates periodically published by the central banks. The excuse for not using this approach could be the lack of reference interest rates for BiH. However, setting the interest rate as constant may be a simple solution from a legal perspective, but from the perspective of economic common sense, it is nonsense. In relation to the legal solution of the default interest rate in the RS, neighboring countries allow certain dynamics by referring to the reference interest rates periodically published by the central banks. The Central Bank represents a financial institution of exceptional importance that is responsible for the monetary policy of the state and directly affects the financial market (Bakić, 2022).

Interest in determining the yield curve has long been present in economic literature, and therefore there are a large number of authors who have dealt with this topic. Because of this, a large number of models appeared. As we can see in Table 1, different central banks use different approaches.

Table 2 Volatility assessment of the Central Bank and related yield curve determination models (Pereda, 2009)

Central bank	Model
Belgium	Nelson-Siegel, Svensson
Canada	Svensson
USA	Fisher-Nychka-Zervos (Spline)
Finland	Nelson-Siegel
France	Nelson-Siegel, Svensson
Germany	Svensson
Italy	Nelson-Siegel
Japan	Fisher-Nychka-Zervos (Spline)
Norway	Svensson
Spain	Svensson
United Kingdom	Anderson and Sleath (Spline) (until 2001 Svensson)
Sweden	Fisher-Nychka-Zervos (Spline), before Svensson

Central bank	Model
Switzerland	Svensson
EU	Svensson

Nelson and Siegel introduced a model that is still widely used today. We can write the following (Nelson & Siegel, 1987):

$$y(\tau) = \beta_{0t} + \beta_{1t} \frac{1 - \exp(-\lambda \tau)}{\lambda \tau} + \beta_{2t} \left(\frac{1 - \exp(-\lambda \tau)}{\lambda \tau} - \exp(-\lambda \tau) \right)$$

where are $\beta_{0t}, \beta_{1t}, \beta_{2t}$ и λ parameters, and with τ we mark a period of time.

In 1994, Svensson (eng. Svensson) introduced a model that is a kind of upgrade of the Nelson-Siegel model. This model defines future interest rates as follows (Svensson, 1994):

$$y_t(\tau) = \beta_0 + \beta_1 \exp\left(-\frac{\tau}{\lambda_1}\right) + \beta_2 \frac{\tau}{\lambda_1} \exp\left(-\frac{\tau}{\lambda_1}\right) + \beta_3 \frac{\tau}{\lambda_2} \exp\left(-\frac{\tau}{\lambda_2}\right)$$

where s $\beta_0, \beta_1, \beta_2, \beta_3, \lambda_1, \lambda_2$ parameters τ is a period of time.

When we talk about the interest rate used for discounting, we must keep in mind a number of factors that affect the interest rate. As we mentioned earlier, there is no consensus on a generally accepted methodology for determining interest rates in different circumstances of its application.

If we start from expression (1), it can be easily shown that we can write $e^\delta = 1 + i$. We can ask ourselves what the initial value of the capital is if we know the final value of the capital and the corresponding interest rate, i.e. the intensity of interest per unit of time. Then we come to the notion of discount factor for the case of continuous capitalization defined by $v_t = e^{-\delta t}$ (Parmenter, 1999). It should be noted that in this perspective t it does not have to be a whole number.

Thus, we can use current rates from the bond market to construct a yield curve and apply those results directly to the process of calculating the statutory default interest rate. Time frame as a dimension for sample size is a debatable category. If the time frame is too narrow, as is often the case with RS financial markets, then we would have a questionable sample size. On the other hand, if it is too broad, then the relevance in the context of using current market information could be questioned.

The example of working out the yield curve in our case takes into account the entire trading of bonds on the Banja Luka Stock Exchange in the last 6 months. Interesting is is in vol period circulated only 14 bonds, what? It's going with the fact the market is not enough deeply. The initial data set (Appendix I, Table 3) was reduced to only

six rows as shown in Table 2 (Appendix I). The Nelson-Sigels approach assumed those bonds that have a Macaulay duration greater than 0.5, and the Svensson approach assumed those bonds that have a market yield greater than two. Elaborating on these issues, looking at some general issues related to the yield curve approach, and providing more in-depth analysis in this regard assumes a significantly different direction of presentation.

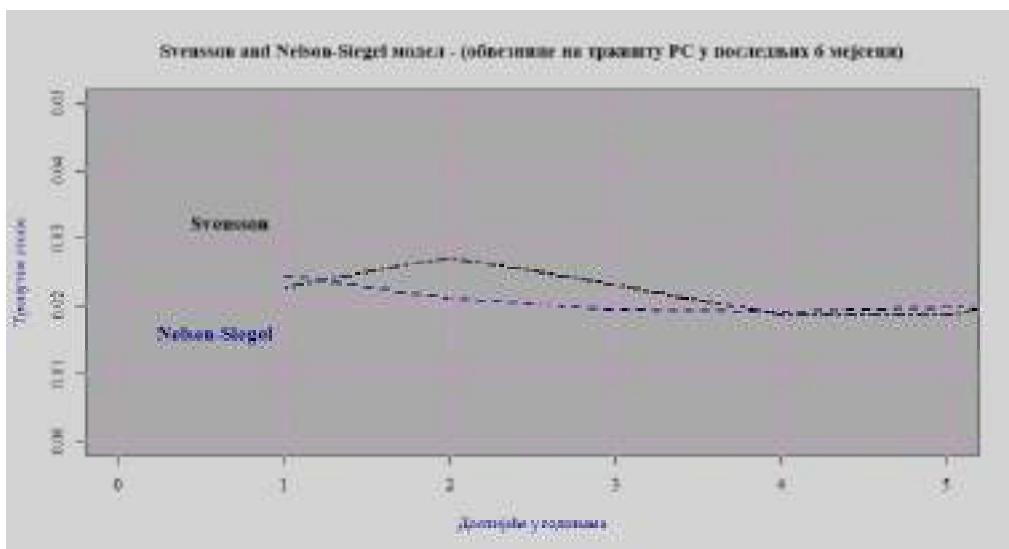
In Figure 1, we have the Nelson-Siegel and Svenson model for the Banja Luka Stock Exchange (data shown in Appendix). The calculation was carried out using the R package *YieldCurve* (Consiglio & Guirri, 2011).

Discussion

Defining future interest rates, based on current rates, where different bond maturity dates are used to differentiate the accrued interest, or discount rate, based on different lengths of time over which the rate is applied, is a fairly old idea (Schiller and McCulloch 1987).

The idea of the term structure of interest rates in its early phase had different modalities of realization. Vasiček assumed that the spot interest rate follows a diffusion process. Also, this approach assumes that the price of the discount bond depends only on the spot rate. Finally, this one perspective assumes the market which is effective (Vasicek 1977).

They are guilty yield can have different shapes. Usually are some standard types them monotonous, " humped " and in the form of the Latin letter S (last is rarity). certain in cases of " hump ". can appear like a spike like let Species extreme it seems context relatively non-liquid market, Svenssonov model would could produce curve which has huge spikes. Further, insolvency is like an attribute immanent the one marketing team which they are not developed.



The painting 2Svenson and Nelson-Siegels model based on bonds listed on the Banja Luka Stock Exchange

On the other hand, Nielsen and Siegel proposed a model that assumes the solution of a second-order differential equation. This approach gains visual smoothness by transforming nonlinear estimation problems into relatively simple linear problems. If we go further, we could say that the context for such a procedure is established by fixing the shape parameters that are the cause of the nonlinearity (Annaert, Claes, De Ceuster, & Zhang, 2013).

Market data that is not deep enough and not adequate for out-of-sample forecasting. In this respect, the pricing model could be open to potential errors if applied to the pricing of a long-term bond. But, in the context of collecting statutory default interest, this may not be crucial.

We were content with using Macaulay's duration, although a modified form of this sensitivity measure could also be applied. A rough estimate can also be made based on the maturity date, that is, simple maturity.

For the purposes of calculating the statutory default interest, a period of time longer than five years may be irrelevant. On the other hand, in banking, by convention, transactions with a maturity of less than one year are discounted with simple interest. There is a clear mathematical reasoning for this.

Calculations of simple and compound interest will have the same result for those cases where the time span is either equal to 0 or equal to 1. But, for those cases where the measurement period is less than 1, compound interest gives a lower return and vice versa for periods that are greater of 1, simple interest will result in a smaller amount of money accumulated over time. In the appendix we have a theorem and a proof in this regard.

Figure 1 shows that we obtained a decent convergence between the Nelson-Siegels and Svensson models. This was contributed by the narrowing of the sample. Thus, the first approach assumes regression types that minimize the difference between observed market rates in some functional form, and the later is some kind of upgrade. On the other hand, there are curve fitting methods that are used in stock market trading frameworks, which are inverse types of models. In this sense, going further would imply consideration of "hybrid" regression methods. An often mentioned example in this context is the Smith-Wilson curve fitting method. This is a kernel regression approach and there is potential for further consideration in the BiH context.

Conclusion

The yield curve can be modeled based on inputs available from the bond market listed on the Banja Luka Stock Exchange. Furthermore, either model, either the one offered by Swenson or the one offered by Nelson and Siegels, can offer a solution for the adequate calculation of statutory default interest.

Sure implications politics can with wife in two main direction:

- First, use the word they are guilty yield in defining that's right legal tightens interest rates enable it adequately calculation in vol view.
- Second, the legal default interest rate should assume simple interest for units of measurement less than 1, and compound interest for units of measurement greater than 1.

Solving the dilemma between the Swenson and Nelson-Siegels models involves a review of current market settings. Based on the February 2022 data, in the short term, we could find enough reason to advocate the use of Svensson's model, although Nelson-Sigels offers a more visually appealing result in this particular case.

The use of the first observable interest rate in one of the two models for transactions that have a measurement time of less than 1 has a clear justification as explained in Annex II. This rate just needs to be set on a daily basis. This could start a new debate, based on the two presentation models as in figure one. Therefore, the starting rates differ significantly. Elaboration of this issue assumed a different direction of discussion and goes beyond the scope of this analysis.

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