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Efikasnost investicione politike i politike povećanja doprinosa u održavanju dugoročne fundiranosti sponzorisanih penzijskih planova

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Rezime: Sponzorisani penzijski planovi sa definisanim naknadama su suočeni sa dugoročnim izazovima u održavanju nivoa fundiranosti koji je propisan nacionalnom regulativom koja uređuje penzijski sistem. U relativno kratkom periodu od svega dve decenije, privatni penzijski fondovi su se suočili sa dve finansijske krize (*dot.com* kriza s početka 21. veka i globalna finansijska kriza iz 2008. godine), višegodišnjim periodom niskih kamatnih stopa nakon globalne finansijske krize, a odskora i negativnim efektima epidemije korona virusa. U takvom ambijentu, aktuelno je pitanje koji je mehanizam najefikasniji za postizanje i održavanje adekvatnog nivoa fundiranosti sponzorisanih penzijskih planova sa definisanim naknadama. Cilj rada se ogleda u ispitivanju efikasnosti investicione politike i politike povećanja doprinosa u održavanju dugoročne fundiranosti penzijskog plana, korišćenjem VAR modela i *bootstrap* reuzorkovanja za simuliranje posmatranih varijabli. Rezultati analize pokazuju da je investiciona politika efikasniji alat za postizanje fundiranosti u dugom roku, uz ograničenja u pogledu agresivnosti investicione politike.

Ključne reči: sponzorisani penzijski planovi, investiciona politika, politika povećanja doprinosa, nivo fundiranosti, *bootstrap* reuzorkovanje

JEL: G11, G17, J26, J32

Uvod

Funkcionisanje penzijskih planova se odvija prema jednostavnom principu: doprinosi se uplaćuju u penzijski fond, tako akumulirana sredstva se investiraju na finansijskom tržištu, a iz sredstava u penzijskom fondu se vrši isplata penzijskih naknada. Dakle, politika povećanja doprinosa i investiciona politika predstavljaju dva osnovna mehanizma putem kojih sponzor penzijskog plana obezbeđuje dugoročnu sigurnost isplate penzijskih naknada u uslovima izražene neizvesnosti. Gotovinski prilivi po osnovu doprinosa i investicionih prinosa su, takođe, neizvesni, to jest, ne može se sa potpunom sigurnošću predvideti njihovo kretanje u budućnosti. Shodno tome, neizvesnost sa kojom se penzijski fond suočava se mora modelirati, razvijanjem diskretnog modela sa konačnim vremenskim horizontom u kojem se donose odluke.

Sponzorisani penzijski planovi koje organizuju kompanije za svoje zaposlene mogu, u zavisnosti od načina raspodele rizika između kompanije i zaposlenih, da funkcionišu prema modelu sa definisanim naknadama i prema modelu sa definisanim doprinosima. U sponzorisanom penzijskom planu sa definisanim naknadama, kompanija, kao sponzor penzijskog plana, predstavlja ugovornu stranu koja garantuje zaposlenima isplatu penzije do kraja života, a čiji iznos zavisi od dužine radne karijere i visine ostvarenih zarada. Ovakav način razmišljanja pred kreatore investicione politike u penzijskom planu sa definisanim naknadama postavlja dva protivrečna zadatka: postizanje sigurnosti plasmana i stope prinosa koja garantuje isplatu penzija u budućnosti. Osnovni cilj investicione politike penzijskog plana predstavlja postizanje dugoročne fundiranosti penzijskog plana, to jest, u svakom trenutku sredstva u penzijskom fondu treba da budu dovoljna za isplatu penzija. Ukoliko je iznos sredstava u penzijskom fondu u dužem vremenskom periodu manji od sadašnje vrednosti projektovanih penzijskih obaveza, penzijski plan je nedovoljno fundiran i neće moći da odgovori finansijskim obavezama u budućnosti bez sprovođenja značajnih korektivnih mera.

U tom pogledu, penzijski planovi sa definisanim naknadama se dijametralno razlikuju u odnosu na penzijske planove sa definisanim doprinosima, kod kojih kompanija koja je sponzor penzijskog plana uplaćuje doprinose na individualni penzijski račun zaposlenog, a, u zavisnosti od regulative, pojedinac ima manji ili veći stepen slobode u donošenju odluka o visini stope doprinosa i načina na koji će sredstva biti investirana. Međutim, kompanija nema zakonsku obavezu uplaćivanja dodatnih doprinosa niti garantovanja isplate određenog iznosa penzije, u slučaju da su sredstva na penzijskom računu nedovoljna za isplatu zahtevanog nivoa penzije, što predstavlja ključnu razliku u odnosu na penzijske planove sa definisanim naknadama.

U savremenim uslovima poslovanja, investicione strategije penzijskih planova su sve više orijentisane ka riziku, s obzirom na to da penzijski planovi sazrevaju, to jest, osigurana populacija postepeno stari, a teret finansiranja penzijskih obaveza kontinuirano raste (Franzen, 2010, 26). Povećanje očekivanog životnog veka i prosečne starosti populacije povećava gotovinske odlive iz fonda, s obzirom na to da se povećava broj korisnika penzija i prosečan vremenski period u kojem se penzije isplaćuju. Pored demografskog rizika, inflatorni rizik i regulatorni rizik mogu značajno da utiču na poziciju fundiranosti penzijskog plana. Neočekivani rast inflacije predstavlja ozbiljan problem za penzijske planove u kojima se vrši indeksacija penzijskih naknada, pošto to značajno komplikuje proces utvrđivanja penzijskih obaveza (Clark & Monk, 2006, 44). Rizik povećanja troškova funkcionisanja penzijskog plana koji podnosi sponzor penzijskog plana usled regulatornih promena je postao naročito značajan u poslednje dve decenije.

Od početka 21. veka, penzijski planovi sa definisanim naknadama se sve više suočavaju sa značajnim izazovima u održavanju zadovoljavajuće fundiranosti. Nakon dot.com krize iz 2001. godine, usledila je globalna finansijska kriza iz 2008. godine koja je dugoročno narušila finansijsku poziciju penzijskih planova, s obzirom da se nivo fundiranosti ni deset godina nakon krize nije značajnije poboljšao (Willis Towers Watson, 2017, 2). Nakon globalne finansijske krize usledio je višegodišnji period niskih kamatnih stopa koji je, usled duže ročnosti penzijskih obaveza od ročnosti aktive, uslovio rast sadašnje vrednosti projektovanih penzijskih obaveza i pogoršanje pozicije fundiranosti penzijskih planova (Committee on the Global Financial System, 2018, 31). Epidemija korona virusa u prvom kvartalu 2020. godine je dodatno pogoršala poziciju fundiranosti penzijskih planova. Prema podacima Mercer (2020), nivo fundiranosti penzijskih planova čiji su organizatori kompanije na listi S&P 1500 indeksa je samo u martu 2020. godine opao za 3% na nivo od zabrinjavajućih 76%. Čak su i penzijski planovi u Holandiji, koji tradicionalno imaju više nivoe fundiranosti u odnosu na druge zemlje Zapadne Evrope i Severne Amerike, krajem februara 2020. godine ostvarili pad nivoa fundiranosti od 6% u odnosu na prethodni mesec, usled snižavanja kamatnih stopa i nepovoljnih kretanja na tržištu akcija izazvanih pojavom globalne epidemije (IPE Magazine, 2020).

S obzirom na značajne izazove u održavanju adekvatnog nivoa fundiranosti sponzorisanih penzijskih planova sa definisanim naknadama u prethodne dve decenije, pitanje koji je mehanizam najefikasniji u realizaciji ovog cilja sve više dobija na aktuelnosti. Cilj rada se ogleda u ispitivanju efikasnosti investicione politike i politike povećanja doprinosa u održavanju dugoročne fundiranosti sponzorisanog penzijskog plana sa definisanim naknadama. U radu je analiziran model penzijskog plana sa definisanim naknadama, čije se finansijske performanse simuliraju u velikom broju iteracija. U skladu sa navedenim ciljem istraživanja, postavljena je sledeća istraživačka hipoteza:

Investiciona politika predstavlja efikasniji mehanizam za poboljšanje pozicije fundiranosti sponzorisanog penzijskog plana sa definisanim naknadama u odnosu na politiku povećanja doprinosa.

S obzirom da je reč o penzijskom planu sa definisanim naknadama, neophodno je izvršiti modeliranje penzijskih obaveza i finansijskih sredstava. Modeliranje penzijskih obaveza podrazumeva formiranje aktuarskih i finansijskih pretpostavki. Aktuarske pretpostavke se odnose na postavku vrednosti za aktuarske varijable. Broj aktuarskih varijabli zavisi od nivoa složenosti modela penzijskog plana. Uz aktuarske pretpostavke, za uspešno modeliranje penzijskih obaveza neophodne su finansijske pretpostavke. Bez definisanja vrednosti diskontne stope, stope rasta zarada i stope inflacije, nije moguće izračunavanje sadašnje vrednosti penzijskih naknada i drugih pokazatelja penzijskih obaveza. Diskontna stopa bi trebalo da odražava ročnost penzijskih obaveza, ali i dugoročna tržišna kretanja i promene u stopi inflacije. S obzirom da u penzijskom planu sa definisanim naknadama penzijske obaveze imaju karakter izvesnosti, diskontna stopa je najčešće jednaka stopi prinosa na državne obveznice ili stopi prinosa na kvalitetne kompanijske obveznice (Bartram, 2018, 334). Ročnost ovih obveznica mora biti najmanje deset ili više godina, uvažavajući činjenicu da su penzijski planovi dugoročno orijentisani finansijski subjekti, a penzijske obaveze imaju dugoročni (višedecenijski) karakter.

Modeliranje stope rasta zarada je neophodno u penzijskim planovima u kojima se u penzijskoj formuli koristi poslednja ostvarena zarada ili prosečna zarada u toku radne karijere za obračun penzije. Aktuari u penzijskim planovima često koriste skalu zarada za projektovanje kretanja zarada. Skala zarada je prikaz povećanja zarada zaposlenih u kompaniji sa protokom vremena, to jest, sa svakom dodatnom godinom radne službe u kompaniji. Pozicija zaposlenih na skali zarade zavisi od dužine radne karijere, stečenog nivoa obrazovanja, pozicije u hijerarhiji radnih mesta i ostvarenih radnih učinaka. Velike kompanije imaju propisane skale zarada, koje aktuari primenjuju prilikom aktuarske evaluacije penzijskih planova.

Kada je reč o finansijskim sredstvima, varijable koje su od značaja su stopa doprinosa i stope prinosa različitih vrsta finansijskih instrumenata. U projektovanju stope doprinosa može se poći od stava da ova stopa treba da bude relativno stabilna, što znači da je ne bi trebalo često menjati u budućnosti. U pogledu utvrđivanja stopa prinosa, prvi korak predstavlja definisanje koje će vrste finansijskih instrumenata da čine investicioni portfolio. Dakle, u ovom koraku je neophodno utvrditi strukturu investicionog portfolija penzijskog plana. Sledeći korak podrazumeva utvrđivanje stopa prinosa različitih vrsta finansijskih instrumenata. S obzirom da za sve vrste finansijskih instrumenata postoje podaci o referentnim prinosima u prethodnom vremenskom periodu, stopa prinosa portfolija u sadašnjem trenutku se može relativno lako utvrditi. Međutim, stopa prinosa bi trebalo da odražava tržišne fluktuacije u definisanom vremenskom horizontu, što znači da se mora projektovati. Poslednji i najvažniji korak predstavlja projektovanje stopa prinosa za vremenski period koji se posmatra.

Nakon definisanja aktuarskih i finansijskih parametara može da se izvrši modeliranje penzijskih obaveza i finansijskih sredstava. Najznačajniji deo modeliranja predstavlja generisanje ekonomskih scenarija. Razlog leži u činjenici da je buduća realizacija svih varijabli koje su od značaja za penzijski plan neizvesna, to jest, ne postoji nijedna varijabla za čiju se buduću realizaciju može reći da je u potpunosti izvesna. Ekonomski scenario predstavlja opis budućeg kretanja različitih ekonomskih varijabli. Postoji veliki broj načina za generisanje ekonomskih scenarija. U određenim studijama, generisanje scenarija je izvršeno primenom stohastičkog programiranja (Kouwenberg, 2001; Kouwenberg & Zenios, 2006). Pristup dinamičkog programiranja primenjuju Rudolph & Ziemba (2004), sa ciljem optimizacije investicione strategije penzijskog plana ili društva za životno osiguranje, u smislu maksimizacije očekivane korisnosti viška finansijskih sredstava tokom životnog ciklusa.

Stohastičku simulaciju, kao kombinaciju metoda simulacije i optimizacije, primenjuje Boender (1997) sa ciljem optimizacije simulacionog modela i pronalaska skupa struktura portfolija koje najbolje zadovoljavaju kriterijum optimizacije, to jest, minimiziranje rizika nedovoljne fundiranosti.

Generisanje velikog broja ekonomskih scenarija se vrši sprovođenjem simulacije. Svrha upotrebe simulacionih tehnika je analiziranje finansijske pozicije penzijskog plana u mogućim realističnim ekonomskim scenarijima u sukcesivnim vremenskim periodima. Početna tačka u generisanju scenarija je tekuće stanje stvari, to jest, vektor vrednosti parametara koji je poznat u sadašnjem trenutku. Za svaki ekonomski scenario mogu da se izračunaju vrednosti aktive i penzijskih obaveza, što znači da će za određeni broj ekonomskih scenarija biti dobijen isti toliki broj simuliranih nivoa fundiranosti.

Izbor podataka i primenjena metodologija

Penzijske obaveze predstavljaju najvažniji element finansijske strukture penzijskih planova sa definisanim naknadama. Najvažniji pokazatelj finansijske pozicije penzijskog plana predstavlja nivo fundiranosti, kao odnos finansijskih sredstava kojima upravlja penzijski plan, i penzijskih obaveza koje se isplaćuju iz sredstava u penzijskom fondu. Za potrebe dalje analize, može se istaći da je osnovni cilj funkcionisanja penzijskog plana održavanje adekvatne pozicije fundiranosti u dugom roku. To znači da će penzijski plan dugoročno biti sposoban da ispunjava penzijske obaveze, što suštinski jeste svrha njegovog funkcionisanja. Iz te perspektive gledano, investiciona politika i politika povećanja doprinosa predstavljaju mehanizme koje sponzor penzijskog plana ima na raspolaganju da obezbedi adekvatnu poziciju fundiranosti.

Prvi korak u analizi predstavlja formulisanje modela penzijskog plana sa pretpostavljenim demografskim profilom članova. Hipotetički penzijski plan ima tri aktivna člana različite starosti. Prvi član je star 30 godina, drugi osiguranik je srednje starosti od 45 godina, dok je treći osiguranik star 60 godina i nalazi se neposredno pred penzionisanjem. Sva lica su, zaposlenjem u kompaniji, sponzoru penzijskog plana, automatski postala i članovi penzijskog plana. Pretpostavka je da su sva lica počela u kompaniji da rade sa 25 godina, a da u penziju odlaze sa navršenih 65 godina. To znači da lice sa navršenih 30 godina ima 5 godina radnog staža u kompaniji, lice sa navršenih 45 godina ima 20 godina radnog staža, a lice sa navršenih 60 godina ima 35 godina radnog staža.

Za optimalno formulisanje investicione politike i politike doprinosa neophodno je da se utvrdi visina i dinamika penzijskih obaveza. Aktuarski metod korišćen za utvrđivanje penzijskih obaveza je metod projektovanog jediničnog kredita. Penzija se utvrđuje kao procentualni iznos poslednje ostvarene zarade za svaku dodatnu godinu radnog staža. Stopa prirasta za svaku dodatnu godinu radnog staža iznosi 1,75%, što znači da osiguranik sa navršenim punim radnim stažom od 40 godina ostvaruje stopu zamene od 70%. S obzirom da poslednja zarada za osiguranike u trenutku penzionisanja nije poznata, ona se mora projektovati, što se postiže primenom metoda projektovanog jediničnog kredita. Projekcija se vrši korišćenjem skale zarada, to jest, stope rasta zarada u svakoj godini radne karijere, uz pretpostavku da je stopa rasta zarada jednaka stopi inflacije.

Za utvrđivanje penzijskih obaveza neophodno je da se izračuna aktuarska obaveza, korišćenjem metoda projektovanog jediničnog kredita. Prema ovom metodu, aktuarska obaveza se izračunava korišćenjem sledeće formule:

$$AL_x = (k\%) * \prod_{i=x}^{r-1} (1+s_i) * S_x * (x-e) * v^{r-x} * a_r$$

gde je k% stopa prirasta penzijske naknade po dodatnoj godini radnog staža, S_x je zarada osiguranika koji ima *x* godina u sadašnjem trenutku, *x-e* predstavlja broj godina od ulaska osiguranika u penzijski plan do sadašnjeg trenutka, *v* je diskontni faktor, *r-x* je broj godina od sadašnjeg trenutka do trenutka penzionisanja, a_r je sadašnja vrednost doživotnog anuiteta od jedne novčane jedinice, a

$$\prod_{i=x}^{r-1} (1+s_i)$$

$\prod_{i=x}^{r-1}(1+s_i)$ $\prod_{i=x}^{r-1}(1+s_i)$ je skala zarada za period od sadašnjeg trenutka do godine pre penzionisanja. Početna zarada za svakog osiguranika iznosi 30 hiljada novčanih jedinica (na godišnjem nivou) u trenutku ulaska u penzijski plan. To znači da se zarada svakog osiguranika mora prvo utvrditi u sadašnjem trenutku S_x, a na osnovu početne zarade S_o, projektovanjem uz korišćenje skale zarade:

$$S_x = S_0 * \prod_{i=e}^{x-1} (1+s_i)$$

Projektovanjem poslednje ostvarene zarade u godini pre penzionisanja, stiču se uslovi za utvrđivanje penzijske naknade, a samim time i aktuarske obaveze. S obzirom na to da se penzija utvrđuje na nivou godišnjeg iznosa i isplaćuje se do kraja života osiguranika, množi se sadašnjom vrednošću doživotnog anuiteta od jedne novčane jedinice. Za potrebe analize, odabrana je vrednost anuiteta za kamatnu stopu od 5% i period od 15 godina u kojem će se u proseku isplaćivati penzija.

Kada je reč o projektovanju finansijskih sredstava, dva osnovna toka priliva u penzijski fond su doprinosi i investicioni prinosi. Reč je o regularnim doprinosima koji se u propisanim vremenskim intervalima uplaćuju kao procentualni iznos zarade svakog osiguranika. Projekcije stopa prinosa su neophodne za optimizaciju portfolija. U projektovanju stopa prinosa mogu da se koriste istorijski podaci, ukoliko se polazi od pretpostavke da dobro odražavaju buduća kretanja. Ukoliko se prihvati suprotna pretpostavka, neophodno je da se podaci o prinosima projektuju, to jest, simuliraju upotrebom jedne od tehnika simulacije.

U početnom trenutku, utvrđena je aktuarska obaveza za svakog člana, a zbir individualnih obaveza daje ukupnu aktuarsku obavezu. Sredstva u penzijskom fondu su postavljena na nivo koji je jednak aktuarskoj obavezi, to jest, početni nivo fundiranosti je jednak 100%. Stopa doprinosa je utvrđena tako da ukupan normalan trošak penzijskog plana bude jednak uplaćenim doprinosima u početnom periodu. Diskontovanje penzijskih obaveza je izvršeno prema diskontnoj stopi od 5%, što je jedna od češće korišćenih diskontnih stopa u penzijskim fondovima (Chandler, 2017, 9). Diskontovanjem se dobija sadašnja vrednost budućih penzijskih obaveza.

Vremenski horizont za koji se vrši simuliranje neizvesnih ishoda iznosi 20 godina. Pretpostavlja se da osiguranici ne napuštaju penzijski plan ni na koji drugi način nego odlaskom u penziju. Osiguranici odlaze u penziju sa navršenih 65 godina života. To znači da će osiguranik starosti 60 godina uplaćivati doprinose 5 godina, a nakon toga će u narednih 15 godina primati penzije. Preostali osiguranici će doprinose uplaćivati do kraja vremenskog perioda.

Varijable koje se simuliraju su stopa inflacije, stopa prinosa akcija i stopa prinosa obveznica. Modeliranje posmatranih varijabli će biti izvršeno primenom VAR (*vector-autoregression*) metode. VAR model je pogodan za analizu zavisnosti varijable od sopstvenih prošlih vrednosti i prošlih vrednosti drugih varijabli uključenih u model. Definisanjem VAR modela, uz ocenu koliko se dobro model prilagođava stvarnim vrednostima, moguće je izvršiti predviđanje vrednosti posmatranih varijabli. Modeliranje primenom vektorske autoregresije se često koristi u analizi vremenskih serija finansijskih i ekonomskih podataka. Jedna od osnovnih prednosti VAR modela je fleksibilnost, s obzirom na to da se u model može uključiti veliki broj endogenih varijabli. S druge strane, sa povećanjem broja endogenih varijabli, povećava se broj jednačina za ocenjivanje varijabli, a, samim time, složenost modela. Model sa *n* varijabli i *p* pomaka (docnji) može da se predstavi na sledeći način (Zivot & Wang, 2006, 386):

$$Y_t = c + \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \ldots + \Pi_p Y_{t-p} + \varepsilon_t$$

za t = 1, ..., T, gde je $Y_t = (y_{1t}, y_{2t}, \ldots, y_{nt})$ *n*1* vektor varijabli, Π_i je *n*n* matrica koeficijenata, a ε_t je *n*1* vektor slučajne greške sa aritmetičkom sredinom koja je jednaka nuli i matricom kovarijansi koja se ne menja s vremenom.

U daljoj analizi se formira VAR model sa tri varijable (stopa inflacije, stopa prinosa državnih obveznica i stopa prinosa akcija). Sa sigurnošću se može tvrditi da sve varijable utiču jedna na drugu. Međutim, ne može se sa sigurnošću utvrditi kakav je karakter relacije između posmatranih varijabli, odnosno smer uzročno-posledične veze (ukoliko postoji). U skladu sa time, u analizi se koristi nerestriktivni VAR model, što znači da se sve varijable tretiraju kao endogene.

U VAR modelu, na endogene varijable mogu da utiču prethodne vrednosti varijable odabranog pomaka, ali i prethodne vrednosti drugih endogenih varijabli u modelu. Shodno tome, svaka varijabla može da se oceni zasebnom jednačinom, što znači da, koliko ima varijabli, toliko će biti i jednačina. Kada se posmatra *k* pomak za svaku od *n* varijabli, neophodno je oceniti $n+kn^2$ koeficijenata u *n* jednačina (Brooks, 2002, 333).

Na osnovu ocenjenih koeficijenata, moguće je odrediti ocenjene vrednosti različitih varijabli, kao i reziduale, koji predstavljaju razliku između ocenjene vrednosti i stvarne vrednosti varijable, čija je suma jednaka nuli. Sa tako utvrđenim rezidualima moguće je izvršiti simulaciju vrednosti varijabli. Pristup koji se koristi za simuliranje vrednosti varijabli je *bootstrap* metod reuzorkovanja. Primenom ovog metoda može uspešno da se aproksimira nepoznata populacija podataka, izvlačenjem velikog broja reuzoraka iz uzorka određene veličine (Kennedy, 2003, 76). *Bootstrap* reuzorkovanje podrazumeva nasumično izvlačenje uzoraka koji su iste veličine kao originalan uzorak, s tim da se, nakon izvlačenja, podaci vraćaju u uzorak i ponovo su na raspolaganju za izvlačenje u narednim uzorcima. Osnovna prednost primene ovog metoda leži u činjenici da omogućava generisanje podataka bez uvođenja pretpostavki o rasporedu verovatnoća postojećih podataka. S druge strane, nedostatak leži u tome da parametri uzorka mogu da budu nedovoljno značajni u oceni stvarnog rasporeda verovatnoća, pa *bootstrap* metod može da generiše uzorke čiji se parametri razlikuju od parametara originalnih podataka (Pažicky, 2017, 159).

Na uzorku reziduala biće izvršeno *bootstrap* reuzorkovanje sa veličinom reuzorka koji je jednak dužini vremenskog perioda u kojem se vrši projektovanje, a koji u ovom slučaju iznosi 20 godina. *Bootstrap* reuzorkovanje se sprovodi hiljadu puta, a u svakoj iteraciji se vrednosti reuzorkovanih reziduala pripisuju ocenjenim vrednostima varijabli, čime se formiraju simulirane vrednosti varijabli za period od 20 godina. Pri svakom ponavljanju reuzorkovanja, to jest, simulaciji, beleže se simulirane vrednosti stope inflacije, stope prinosa akcija i stope prinosa državnih obveznica. S obzirom da je stopa rasta zarade jednaka stopi inflacije, stopa inflacije utiče na visinu aktuarske obaveze. Stopa prinosa akcija i stopa prinosa obveznica utiču na iznos finansijskih sredstava u penzijskom fondu. S obzirom da odnos sredstava u penzijskom fondu i aktuarske obaveze predstavlja nivo fundiranosti, to znači da se u svakoj simulaciji dobija određeni nivo fundiranosti, to jest, u hiljadu sprovedenih simulacije biće zabeleženo hiljadu simuliranih nivoa fundiranosti.

Kao mehanizmi koje sponzor penzijskog plana ima na raspolaganju za popravljanje pozicije fundiranosti definisane su investiciona politika i politika povećanja doprinosa. Bazični model polazi od toga da investicioni portfolio penzijskog fonda čini 50% ulaganja u akcije, a preostalih 50% ulaganja u državne obveznice. Kao input za simulaciju prinosa akcija biće korišćeni prinosi S&P 500 tržišnog indeksa, za period od 1971. godine do 2017. godine, dok će za simulaciju prinosa državnih obveznica biti korišćeni prinosi američkih državnih obveznica sa rokom dospeća od 10 godina u istom vremenskom periodu. Podaci o godišnjim prinosima S&P 500 indeksa i američkih dugoročnih državnih obveznica su prikupljeni korišćenjem elektronske baze podataka o prinosima akcija, obveznica i trezorskih zapisa u SAD koju periodično ažurira A. Damodaran (Damodaran, 2020). Što se tiče stope doprinosa, stopa doprinosa je varijabla koja će biti korigovana u cilju ostvarivanja adekvatnije pozicije fundiranosti. Sponzor penzijskog plana ima diskreciono pravo da povećava stopu doprinosa, ukoliko proceni da se penzijski plan suočio sa ozbiljnim problemom nedovoljne fundiranosti.

Rezultati istraživanja

Definisanje VAR modela podrazumeva ispitivanje (ne)stacionarnosti varijabli u prvom koraku. Ispitivanje (ne)stacionarnosti bazira se na primeni testa jediničnog korena, pri čemu je postojanje jediničnog korena pokazatelj nestacionarnosti vremenske serije. Shodno tome, u Tabeli 1 su dati rezultati ADF i PP testa jediničnog korena.

Tabela 1: Rezultati ADF i PP testa jediničnog korena (varijable u nivou)

H_0:I(1), H_1: I(0)	Komponente	ADF statistika	PP statistika
Državne obveznice	Trend i konstanta	-7,824881***	-7,813525***
Inflacija	Trend i konstanta	-4,325437***	-4,483565 ***
S&P 500	Trend i konstanta	-6,583471***	-6,583976***
ADF – Augmented Dickey-Fuller test PP – Phillips-Perron Unit Root test			

**** označava statističku značajnost na nivou od 1% (Izvor: Autori)*

Nulta hipoteza ADF testa je da vremenska serija ima jedinični koren, odnosno, nestacionarna je. Za visoku apsolutnu vrednost statistike testa (s obzirom na to da statistika ima negativan predznak), može da se prihvati alternativna hipoteza da vremenska serija nema jedinični koren, to jest, stacionarna je. Ukoliko je vremenska serija nestacionarna, mora se izvršiti diferenciranje, to jest, nalaženje prve diference (razlike). Na nivou prve diference vremenska serija uglavnom dobija karakter stacionarnosti i može se dalje koristiti u VAR modelu. S obzirom da su vrednosti statistika ADF testa i PP testa statistički značajne na nivou od 1%, može se reći da se sve varijable mogu koristiti u VAR modelu u nivou, bez potrebe za diferenciranjem.

U cilju utvrđivanja prisustva autokorelacije u VAR modelu, primenjen je *Breusch-Godfrey* LM test autokorelacije kojim se testira autokorelacija grešaka u regresionom modelu. Primena ovog testa podrazumeva korišćenje reziduala iz VAR modela. S obzirom da je nulta hipoteza ovog testa da ne postoji autokorelacija za bilo koji broj pomaka do odabranog nivoa, pojava *p* vrednosti, koja je niža od odabranog nivoa značajnosti, znači odbacivanje nulte hipoteze i prihvatanje alternativne hipoteze da je autokorelacija prisutna u modelu. U Tabeli 2 su date vrednosti statistike LM testa koje pokazuju da problem autokorelacije nije izražen u VAR modelu, to jest, sve *p* vrednosti su više od nivoa značajnosti od 5% (0,05).

Tabela 2: Rezultati LM testa autokorelacije

Pomak	LRE statistika	df	p vrednost	Rao F- statistika	df	p vrednost
1	3,766581	9	0,9261	0,404216	(9,46.4)	0,9265
2	9,797198	9	0,3672	1,118433	(9,46.4)	0,3691
3	16,69316	9	0,0537	2,048268	(9,46.4)	0,0547
4 9,478434 9 0,3943				1,078481	(9,46.4)	0,3963
5	10,12946	9	0,3401	1,160349	(9,46.4)	0,3421
6	15,31719	9	0,0826	1,852333	(9,46.4)	0,0838
7	11,01011	9	0,2750	1,272806	(9,46.4)	0,2770
8	4,88993	9	0,8438	0,530805	(9,46.4)	0,8446
9	7,986835	9	0,5355	0,894890	(9,46.4)	0,5373
10	4,980341	9	0,8360	0,541110	(9,46.4)	0,8368

Izvor: Autori

Izbor pomaka u VAR modelu predstavlja sledeći važan korak u formiranju VAR modela, s obzirom na to da preveliki broj pomaka (*lag*-ova) smanjuje snagu modela usled ocene prevelikog broja parametara, dok premali broj pomaka dovodi do pojave autokorelacije (Ozcicek & McMillan, 1999, 518). U Tabeli 3 su dati kriterijumi za izbor dužine pomaka koji će biti korišćen u VAR modelu. Kao što se vidi, prema većini testova, optimalan broj pomaka je četiri i sa tom dužinom pomaka se formira model sa tri endogene varijable i dužinom pomaka k = 4.

Tabela 3: Kriterijum za odabir dužine pomaka

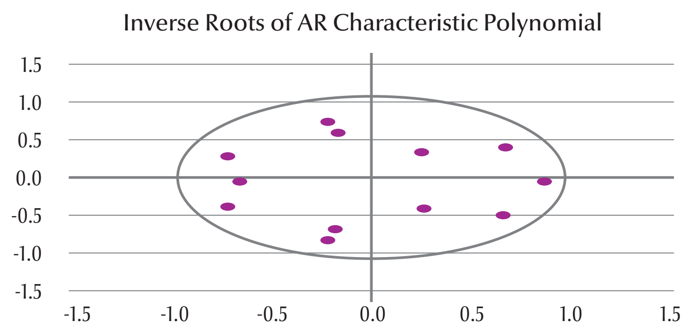
Pomak	LogL	LR	FPE	AIC	SC	HQ
0	147,8055	NA	1,72e-07	-7,063682	-6,938298*	-7,018024
1	154,2330	11,60087	1,95e-07	-6,938194	-6,436661	-6,755564
2	168,4551	23,58797	1,52e-07	-7,192934	-6,315250	-6,873330
3	178,4014	15,04070	1,49e-07	-7,239093	-5,985260	-6,782516
4	195,5965	23,48603*	1,03e-07*	-7,638855*	-6,008872	-7,045305*
5	201,5193	7,222891	1,28e-07	-7,488747	-5,482613	-6,758223
6	209,8532	8,943704	1,46e-07	-7,456254	-5,073971	-6,588758

* označava pomak izabran u skladu sa kriterijumom
LR: sekvencijalni modifikovani LR test
FPE: Final Prediction Error
AIC: Akaike information criterion
SC: Schwartz information criterion
HQ: Hannan – Quinn information criterion

Izvor : Autori

Stabilnost VAR modela se može utvrditi sprovođenjem testa stabilnosti, koji podrazumeva utvrđivanje inverznih korena AR (*autoregressive*) karakteristične jednačine (polinoma). Ukoliko su svi inverzni koreni manji od jedan, za VAR proces se može reći da je stabilan. Rezultati testa stabilnosti su prikazani na Slici 1, odakle se može videti da su svi inverzni koreni manji od jedan, što ukazuje na stabilnost (stacionarnost) VAR (4) modela.

Slika 1: Rezultati testiranja stabilnosti modela



Izvor: Autori

Izabrani VAR model sa tri endogene varijable i dužinom pomaka k = 4 omogućava formiranje regresionih jednačina sa ocenjenim vrednostima koeficijenata. Primenom ovih jednačina mogu da se izračunaju ocenjene vrednosti stope inflacije, stope prinosa na državne obveznice i stope prinosa akcija. Simulacija godišnjih stopa prinosa akcija i državnih obveznica, kao i godišnje stope inflacije je izvršena tako što su reziduali, kao odstupanja vrednosti ocenjenih primenom VAR (4) modela od stvarnih vrednosti, nasumično izabrani primenom *bootstrap* metode i pripisani ocenjenim vrednostima u svakoj iteraciji. Ovaj postupak je sproveden u svakoj od hiljadu simulacija, što znači da je iz početnog uzorka izvučeno hiljadu uzoraka iste veličine. Veličina uzoraka je određena dužinom vremenskog perioda za koji se vrši modeliranje penzijskog fonda. U ovom slučaju reč je o vremenskom periodu od 20 godina, što znači da uzorak uključuje dvadeset nasumično odabranih godišnjih opservacija za svaku od posmatranih varijabli.

U početnom trenutku, penzijske obaveze su u potpunosti pokrivene raspoloživim sredstvima, a povećanje zarada se odvija u skladu sa promenama stope inflacije. U Tabeli 4 su prikazani rezultati simulacije verovatnoće nefundiranosti penzijskog plana pri različitim stopama doprinosa u rasponu od 4% do 15% u različitim vremenskim trenucima (nakon isteka perioda od 5, 10, 15 i 20 godina). Pri simuliranju verovatnoća korišćen je portfolio koji je podjednako investiran u akcije i državne obveznice i stopa indeksacije penzija koja je jednaka prosečnoj stopi inflacije za period od pet godina pre penzionisanja.

Tabela 4: Rezultati simulacije verovatnoće nefundiranosti za procentualne promene stope doprinosa u rasponu od 4% do 15% (u procentima)

Verovatnoća nefundiranosti penzijskog plana				
Stopa doprinosa	nakon 5 godina	nakon 10 godina	nakon 15 godina	nakon 20 godina
4%	65	44,6	28,6	26,8
5%	62,6	45,6	26,2	21,4
9%	54,4	38,2	18,6	11,8
10%	54,6	34,2	19,6	11,4
14%	44,8	28,2	12,8	5,4
15%	43,6	25,2	8,8	2,8

Izvor: Autori

Kao što se vidi iz Tabele 4, za sve buduće realizacije se može izvesti zaključak da se, sa povećanjem stope doprinosa, verovatnoća nefundiranosti smanjuje. Na primer, verovatnoća da će penzijski plan biti nefundiran nakon 5 godina sa stopom doprinosa od 4% je visoka i iznosi 65%, dok sa stopom doprinosa od 15%, ta verovatnoća iznosi približno 43%. S druge strane, verovatnoća da će penzijski plan biti nefundiran nakon 20 godina, pri stopi doprinosa od 4%, iznosi približno 27%, dok, pri stopi doprinosa od 15%, ova verovatnoća iznosi približno 3%.

U Tabeli 5 su dati rezultati simulacije verovatnoće nefundiranosti penzijskog plana, uz različite strukture portfolija. Pri simuliranju je korišćena stopa doprinosa od 10% i indeksacija penzija koja odgovara prosečnoj stopi inflacije za period od 5 godina pre penzionisanja.

Tabela 5: Rezultati simulacije verovatnoće nefundiranosti, uz različite strukture portfolija (u procentima)

Izloženost portfolija akcijama	Verovatnoća nefundiranosti penzijskog fonda			
	Nakon 5 godina	Nakon 10 godina	Nakon 15 godina	Nakon 20 godina
0%	67,8	53,6	40,4	36,6
10%	58,6	40,4	23,2	18,8
20%	54	35,6	17,4	10,8
30%	45,6	27,2	10,6	5
40%	32,6	16	7,2	2,6
50%	28,6	16,6	5,8	1,8
60%	24,8	16,8	6,2	2
70%	24	16,2	5,6	2,4
80%	17,8	15,6	7,2	3,6
90%	26,8	18,4	8,4	3
100%	23,2	18,6	7,4	3,2

Izvor: Autori

Promenom strukture investicionog portfolija menadžeri mogu u značajnoj meri da utiču na verovatnoću nefundiranosti penzijskog plana. Sa vođenjem izuzetno konzervativne investicione politike verovatnoća da će penzijski plan biti nefundiran nakon 10 godina iznosi približno 53%, a nakon 20 godina približno 36%. S druge strane, ukoliko je učešće akcija u portfoliju 50%, verovatnoća nefundiranosti se drastično smanjuje i nakon 10 godina iznosi približno 16%, a nakon 20 godina iznosi približno 2%. Interesantno je da dalje povećanje učešća akcija u portfoliju ne doprinosi značajnijem smanjenju verovatnoće nefundiranosti. Pri povećanju učešća akcija u portfoliju sa 80% na 90%, verovatnoća nefundiranosti se ne smanjuje, već se povećava. Na osnovu izloženog, može da se izvede zaključak da izuzetno agresivna investiciona politika nije najpoželjnija iz perspektive finansijske stabilnosti penzijskog plana, već je poželjnije rešenje balansirani portfolio sa približno jednakom zastupljenošću akcija i državnih obveznica.

Sponzori penzijskog plana nisu zainteresovani samo za verovatnoću da li će penzijski fond biti nefundiran, već i za kvantifikaciju veličine moguće nefundiranosti. U Tabeli 6 je dat prikaz rezultata simulacije prosečnog odstupanja od nivoa fundiranosti od 100%, pri različitim stopama doprinosa i strukturama portfolija, za sve simulacije u kojima je simulirani nivo fundiranosti manji od 100%.

Tabela 6: Rezultati simulacije prosečnog odstupanja od nivoa fundiranosti od 100%, pri različitim stopama doprinosa i strukturama portfolija, (u procentima)

Nakon 10 godina											
	Učešće akcija										
Stopa doprinosa	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
5%	21,91	20,8	19,0	17,31	15,37	18,91	18,08	21,68	22,08	26,66	29,56
7,5%	21,72	19,02	16,92	15,32	16,85	18,09	20,66	23,32	24,99	23,72	26,74
10%	21,32	17,64	17,02	14,49	15,44	13,6	20,15	19,38	23,3	24,11	32,28
12,5%	20,58	18,5	15,34	15,42	14,73	15,25	20,38	20,31	25,16	26,82	29,37
15%	21,63	16,42	15,76	14,32	14,07	16,43	18,16	20,03	18,52	26,81	28,88
Nakon 20 godina											
	Učešće akcija										
Stopa doprinosa	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
5%	32,34	27,97	27,7	26,28	21,32	25,47	24,33	28,84	31,45	31,48	34,87
7,5%	30,62	24,99	27,43	23,47	21,42	22,26	29,02	31,66	30,52	33,19	28,09
10%	30,11	22,86	19,21	17,1	23,41	13,2	27,43	23,36	27,39	28,23	34,52
12,5%	29,94	26,29	19,6	21,83	21,71	14,89	20,11	22,48	26,38	23,4	29,76
15%	27,96	24,22	20,31	18,96	20,08	17,69	17,66	25,00	22,59	23,94	28,51

Izvor: Autori

Rezultati simulacije pokazuju da se prosečno odstupanje simuliranih nivoa fundiranosti od nivoa pune fundiranosti smanjuje sa povećanjem učešća akcija, ali do određenog nivoa. Na primer, nakon deset godina, odstupanje se smanjuje sve do nivoa učešća akcija od 60%. Sa daljim povećanjem učešća akcija u strukturi portfolija, prosečno odstupanje pokazuje tendenciju povećanja, to jest, smanjuje se verovatnoća nefundiranosti penzijskog plana, ali po cenu povećanja prosečnog odstupanja od nivoa pune fundiranosti. Ovakvo kretanje je karakteristično za sve nivoe stope doprinosa i za sve posmatrane vremenske periode. Prosečno odstupanje nepovoljnih simulacija u odnosu na nivo fundiranosti od 100% se povećava sa produženjem vremenskog perioda, ali je osnovni trend uočen za kraće vremenske periode isti. Povećanje učešća akcija u portfoliju utiče povoljno na smanjenje prosečnog odstupanja od nivoa pune fundiranosti, ali do određenog stepena. Nakon toga, dalje povećanje učešća akcija u portfoliju ne dovodi do smanjenja prosečnog odstupanja od nivoa pune fundiranosti. S druge strane, povećanje stope doprinosa ne predstavlja efikasan mehanizam za smanjenje prosečnog odstupanja od nivoa pune fundiranosti, s obzirom na to da povećanje stope doprinosa, pri fiksiranoj strukturi portfolija, ne dovodi do značajnijeg smanjenja prosečnog odstupanja. Efikasnost investicione politike u ovom smislu je značajno veća u odnosu na politiku doprinosa, što ukazuje na validnost postavljene istraživačke hipoteze.

Zaključak

Sponzori penzijskih planova su zainteresovani ne samo za verovatnoću da će penzijski plan dospeti u poziciju nedovoljne fundiranosti već i za veličinu potencijalne nefundiranosti. U skladu sa time, može se izvesti nekoliko konkretnih preporuka za donosioce odluka u penzijskom planu. Investiciona politika predstavlja mehanizam koji sponzori plana mogu da koriste u cilju postizanja dugoročne finansijske stabilnosti, to jest, smanjenja verovatnoće nefundiranosti penzijskog plana. U cilju smanjenja verovatnoće nefundiranosti, penzijski plan može da koristi i politiku povećanja doprinosa, dok kombinovana upotreba investicione politike i politike povećanja doprinosa daje još povoljnije rezultate.

Iz perspektive smanjenja prosečnog odstupanja nepovoljnih ishoda od nivoa pune fundiranosti, politika povećanja doprinosa ne predstavlja efikasno rešenje. Kada je reč o strukturi investicionog portfolija, nisu poželjna ni izuzetno konzervativna, ali ni izuzetno agresivna ulaganja. Najpovoljniji rezultati se ostvaruju formiranjem balansiranog portfolija, sa približno jednakom zastupljenošću akcija i državnih obveznica. Pretežna zastupljenost akcija u portfoliju doprinosi daljem smanjenju verovatnoće nefundiranosti, ali po cenu povećanja prosečnog odstupanja od nivoa pune fundiranosti. Drugim rečima, verovatnoća da će penzijski plan biti nefundiran se smanjuje, ali uz povećanje prisustva ekstremno nepovoljnih ishoda. Imajući u vidu orijentisanost penzijskih planova ka sigurnosti isplata penzija u dugom roku, ovakav način razmišljanja predstavlja neprihvatljivo rešenje za sponzore penzijskih planova.

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Efficiency of the Investment Policy and the Policy of Increasing Contributions in Maintaining the Long-Term Funding of Occupational Pension Plans

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Summary: Defined benefit occupational pension plans are facing long-term challenges in maintaining the funding level required by the pension system regulation. During a relatively short period of just two decades, private pension funds have seen two financial crises (the dot.com crisis at the beginning of the 21st century and the Global financial crisis in 2008), the period of low interest rates following the global financial crisis, and more recently, the negative effects of the corona virus epidemic as well. In such environment, the question is which mechanism is the most efficient one in achieving and maintaining the adequate level of funding for defined benefit occupational pension plans. The paper's aim is to examine the efficiency of investment policies and the policy of increasing contributions in maintaining the long-term funding of the pension fund, by using the VAR model and bootstrap resampling for simulating the observed variables. The empirical results show that the investment policy is the most efficient tool for achieving long-term funding, together with limitations in terms of the aggressiveness of the investment policy.

Keywords: occupational pension plans, investment policy, contribution rate policy, funding level, bootstrap resampling

JEL: G11, G17, J26, J32

Introduction

The functioning of pension plans is carried out in the following manner: contributions are paid into the pension fund, thus accumulated resources are invested into the financial market, and pensions are paid out from the assets in the pension fund. Therefore, the policy of increasing contributions and investment policy are two key mechanisms that enable pension plans to provide the long-term stability of retirement payments, in conditions of uncertainty. Cash inflows based on contributions and investment returns are uncertain as well, namely, their changes in the future cannot be forecasted with utmost certainty. Therefore, the uncertainty that the pension plan is facing must be adapted by developing a discrete model with a definite time horizon in which decisions are made.

Depending on the way of allocating the risk between the company and its employees, occupational pension plans can operate according to the defined benefits model and the defined contributions model. With defined benefit occupational pension plans, the companies, as pension plan sponsors, represent the contracting party that guarantees its employees the payment of pensions for the rest of their lives. The amount of retirement income depends on the length of a person's working career and their salary level. This way of reasoning poses two contradictory tasks to the creators of the investment policy in defined benefit pension plans: achieving the investment certainty and the rate of return which guarantees the future retirement payments. The primary goal of the pension plan investment policy is achieving the long-term funding of the pension plan, namely, there should be a sufficient amount of money in the pension fund for paying the pensions at any moment. If the amount of assets in the pension fund is lower than the current value of projected retirement liabilities in the long run, the pension plan is insufficiently funded, and will not be able to meet the financial obligations without implementing significant corrective measures.

In that aspect, defined benefit pension plans are completely opposite to defined contribution pension plans where the company, as the pension plan sponsor, pays the contributions directly to the individual retirement account of an employee. Depending on the regulation, an individual has more or less freedom in deciding upon the amount of contributions and the way the accumulated assets are invested. The company, however, has no legal obligation of paying extra contributions or guaranteeing the retirement payment in case the assets in the retirement account are insufficient for paying the expected amount of retirement income, which represents the key difference when compared to defined benefit pension plans.

In the modern business environment, pension plans' investment strategies are becoming more risk oriented, given that pension plans are maturing, i.e., the insured population is gradually growing older, and the burden of financing the pension obligations is continuously increasing (Franzen, 2010, 26). The rise in life expectancy and median age of the population increases cash outflows from the fund, given that the number of retired persons is increasing, as well as the average time frame within which pensions are paid. Apart from demographic risks, the inflation risk and regulatory risk can also significantly affect the funding position of pension plans. The unexpected increase in inflation poses a serious threat to pension plans that provide benefit indexation, given that it significantly complicates the process of determining pension obligations (Clark & Monk, 2006, 44). The risk of increasing the compliance costs of pension plan sponsors, due to regulatory changes, has become quite significant in the last two decades.

Since the beginning of the 21st century, defined benefit pension plans have been facing an increasing number of challenges in maintaining the appropriate funding level. After the dot.com crash in 2001, the global financial crisis occurred in 2008 which affected the pension plans' financial position in the long run, given that the funding levels have not improved significantly even ten years after the crisis (Willis Towers Watson, 2017, 2). After the Global financial crisis, the prolonged period of low interest rates ensued which, due to longer duration of pension liabilities compared to pension plan assets, conditioned the growth of the projected pension obligations and deterioration of the pension plans' funding level (Committee on the Global Financial System, 2018, 31). In the first quarter of 2020 the corona virus epidemic has additionally worsened the funding position of pension plans. According to Mercer (2020), the funding level of occupational pension plans whose sponsors are companies listed on the S&P 1500 index decreased by 3 percent in March 2020 to a worrying 76 percent. Even the pension plans in the Netherlands which traditionally have higher funding levels compared to other countries in Western Europe and North America, saw a drop in the funding level at the end of February 2020, compared to the previous month, due to the lowering of interest rates and unfavorable market changes in the stock market caused by the global epidemic (IPE Magazine, 2020).

Given the significant challenges in maintaining the adequate funding level that occupational pension plans have been facing in the past two decades, the question of which mechanism is the most efficient one in achieving this goal is gaining more popularity. The paper's aim is to examine the efficiency of investment policies and the policy of increasing contributions of the defined benefit occupational pension plan in maintaining the long-term funding. The analysis of the defined benefit pension plan model is carried out, based on the simulation of financial performances in the large number of iterations. In accordance with the research objective, the following research hypothesis has been defined:

Investment policy represents a more efficient mechanism for improving the funding position of the defined benefit occupational pension plan compared to the policy of increasing contributions.

Given the defined benefit model, it is necessary to conduct the modeling of pension liabilities and assets. The pension liabilities modeling requires the actuarial and financial assumptions. Actuarial assumptions refer to setting the values for actuarial variables. The number of actuarial variables introduced in the model depends on the complexity level of the pension plan model. Together with actuarial assumptions, financial assumptions are required for successful pension liabilities modeling. Without defining the discount rate value, salary growth and the inflation rate, it would be impossible to calculate the present value of retirement benefits and other indicators of pension liabilities. Discount rate should primarily reflect the duration of pension liabilities, but also the long-term market changes and changes of inflation rate. Given that, in the defined benefit pension plans, the future realization of pension liabilities is certain, discount rate is most often equal to the government bond or high-quality corporate bond return rate (Bartram, 2018, 334). The duration of these bonds must be at least ten or more years, considering the fact that pension plans are long-term investors and the pension liabilities reveal the long-term (decades long) duration.

Salary projection is necessary in pension plans in which the retirement benefit formula uses the final salary or the average salary during the working career for benefit calculation. Actuaries in pension plans often use the salary scale for projecting the salary changes. Salary scale is the scheme of employees' salary increase in a company as time goes by, namely, with each additional year of working service in a company. The employees' position on the salary scale depends on the length of an employee's working career, their education level, position in the organizational hierarchy and the acquired working skills. Big companies most often have defined salary scales, which actuaries utilize during actuarial evaluation of pension plan.

When it comes to pension plan assets projection, the required variables are the contribution rate and the return rate of asset classes. In projecting the contribution rate, the starting point can be that this rate should be relatively stable, meaning that it should not be changed frequently in the future. In terms of determining the return rate, the first step is defining which asset classes comprise the investment portfolio. Therefore, at this stage, it is necessary to shape the portfolio. The next step is determining the rates of return for different asset classes. Given that there are sufficient data for benchmark returns in the past for different asset classes, the portfolio's rate of return can be determined relatively easy. The return rate, however, should reflect the market fluctuations within the defined time frame, which means that it must be projected. The last and crucial step is projecting the return rate during the observed period of time.

After defining the actuarial and financial parameters the modeling of pension liabilities and pension assets can be carried out. The most significant part of modeling is generating economic scenarios. The reason lies in the fact that the future realization of all variables important in the pension plans is uncertain, namely, there is no variable whose future realization can be said to be certain. An economic scenario represents the possible evolution of future changes of economic variables. There are various ways to generate economic scenarios. In some studies, the generation of economic scenarios is performed by applying stochastic programming (Kouwenberg, 2001; Kouwenberg & Zenios, 2006). The approach of dynamic programming is applied in Rudolph & Ziemba (2004), with the aim of optimizing investment strategies of the pension plans and life insurance companies, in the sense of maximizing the expected utility of the surplus of assets during the life cycle. Stochastic simulation, as a combination of simulation and optimization methods, is applied in Boender (1997) with the aim of optimizing the simulation model and finding the portfolio which meets the optimization criteria, namely, minimizing the risk of inadequate funding.

Generating a large number of economic scenarios is done through simulation implementing. The purpose of using simulation techniques is analyzing the financial position of the pension plan in possible realistic economic scenarios in successive time periods. The starting point in generating the scenarios is the current state of affairs, namely, the vector of parameter values set in the present moment. The value of assets and pension liabilities can be calculated for each economic scenario, which means that for a defined number of scenarios the same number of simulated funding levels will be obtained.

Data Selection and Applied Methodology

Pension liabilities are the essential element of the financial structure of defined benefit pension plans. The most important indicator of the pension plan's financial position is the funding level, as the ratio of assets managed by the pension plan, and the pension liabilities which are paid from the pension fund. For further analysis, it can be pointed out that the basic aim of functioning of defined benefit pension plans is maintaining the adequate funding in the long run. It means the pension plan would be able to meet the pension liabilities in every point of time in future. Accordingly, investment policy and the contribution rate policy are mechanisms used by the pension plan to ensure the adequate funding position in the long run.

The first step in the analysis is to create the pension plan model with the assumed demographic profiles of its members. This hypothetical pension plan has three members of different ages. The first member is aged 30; the second member is a middle-aged 45-year-old, whereas the third one is 60 years old and about to retire. All the individuals, by being employed in a company that sponsors the pension plan, have automatically become pension plan members. The assumption is that all members started working in the company at the age of 25, and that they will retire at the age of 65. This means that a person aged 30 has 5 years of service in the company, a person aged 45 has 20 years of service, and a person aged 60 has 35 years of service.

For the formulation of the investment policy and the contribution rate policy it is necessary to project the amount of pension liabilities. Actuarial method used for determining the pension liabilities is a method of projected unit credit. Retirement benefit is calculated as the percentage amount of the final salary for each additional year of service. The accrual rate is 1.75% for each additional year of service, which means that the individual with 40 years of service achieves the replacement rate of 70%. Given that the final salary at retirement is unknown, it must be projected, which is achieved by applying the method of projected unit credit. The projection is done by using the salary scale, namely, the salary increases in each year of the employee's working career, under the assumption that the salary increases are equal to the inflation rate.

For projecting the pension liabilities, it is necessary to calculate the actuarial liability by using the projected unit credit method. According to this model, actuarial liability is calculated by using the following formula:

$$AL_x = (k\%) * \prod_{i=x}^{r-1}(1+s_i) * S_x * (x-e) * v^{r-x} * a_r$$

where k% denotes the accrual rate per an additional year of service, S_x denotes the salary of an individual at the x attained age, presently, *x-e* denotes the length of period of time since the employee joined the pension plan until the present moment, *v* is the discount factor, *r-x* is the length of period of time from the present moment until the retirement, a_r is the present value of the whole-life annuity, and

$$\prod_{i=x}^{r-1}(1+s_i)$$

is the salary scale for the period of time from the present moment until the year prior to retirement. The initial salary of each member is 30 thousand monetary units (annually) in the moment of joining the pension plan. It means that the salary must be determined firstly in the present moment S_x, based on the initial salary S_o, by using the salary scale:

$$S_x = S_0 * \prod_{i=e}^{x-1}(1+s_i)$$

By projecting the final salary in the year before retirement, the conditions for determining the retirement benefit are met, as well as the actuarial liability. Given that the retirement benefit is calculated as the annual amount and is being paid until the retiree's death, it is multiplied by the present value of whole-life annuity. For further analysis, the annuity value for the 5% interest rate and the 15 years period within which the pension will be paid on average is chosen.

When it comes to projecting assets, the two main inflows into the pension fund are contributions and investment returns. The contributions are being paid in the defined time intervals as percentage amounts of members' salaries. Projections of the return rate are necessary for portfolio optimization. In projecting the return rate, historical data can be used, if the assumption that they reflect future changes accurately is accepted. If the opposite assumption is accepted, the rates of return data must be projected, namely, simulated by using one of the simulation techniques.

At the initial moment, the actuarial liability is determined for each member, and the sum of individual liabilities gives the total actuarial liability. The pension assets are set on the level equal to the actuarial liability. Hence, the initial funding level equals 100%. The contribution rate is determined so that the total normal cost of a pension plan is equal to the contributions paid at the initial moment. The discounting of pension liabilities is done by applying the 5% discount rate, which is commonly used in pension plans (Chandler, 2017, 9). Discounting gives the present value of future pension liabilities.

The time horizon used for simulating uncertain outcomes is 20 years. It is assumed that pension plan members do not leave the pension plan in any way other than retiring. Insured persons retire at the age of 65. This means that the insured person aged 60 will pay the contributions for 5 years, and after that will draw the retirement benefits in the following 15 years. The rest of the insured persons will pay the contributions until the end of the time frame.

The variables being simulated are the inflation rate, return rate of stocks and return rate of bonds. Modeling of the observed variables will be done by applying the VAR (vector-autoregression) method. The VAR model is suitable for analyzing the dependency of a variable from its own past values and the past values of other variables included in the model. By defining the VAR model, with the evaluation of how well the model adapts to the real values, it is possible to conduct forecasting of the observed variables. Modeling by applying vector-autoregression is often used in analyzing the financial and economic data time series. One of the basic advantages of the VAR method is its flexibility, given that a large number of endogenous variables can be included in the model. On the other hand, with the increasing number of endogenous variables, the number of regression equations increases too, as well as the model's complexity. Model with *n* variables and *p* lags can be represented in the following way (Zivot & Wang, 2006, 386):

$$Y_t = c + \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \ldots + \Pi_p Y_{t-p} + \varepsilon_t$$

for t = 1, ..., T, where $Y_t = (y_{1t}, y_{2t}, ..., y_{nt})$ $n*1$ is variable vector, Π_i are $n*n$ coefficient matrices, and ε_t is $n*1$ white noise vector process with arithmetic mean equal to zero and time invariant covariance matrices.

In further analysis, the VAR model with three variables (inflation rate, government bond return rate and stock return rate) is formed. It can be stated with certainty that all variables influence one another. It cannot be stated, however, what is the character of correlation between the observed variables, that is, the direction of causal relation (if there is one). In accordance with that, the unrestrictive VAR model is used in the analysis, which means that all variables are treated as endogenous.

In the VAR model, endogenous variables can be affected by previous variable values of chosen lags, but also by the previous values of other endogenous variables in the model. Hence, each variable can be evaluated by a separate equation, which means that the number of equations is equal to the number of variables. When each *k* lag is observed for each of the *n* variables, it is necessary to estimate the $n+kn^2$ coefficients in *n* equations (Brooks, 2002, 333).

Based on the estimated coefficients, it is possible to determine the estimated values of variables, as well as residuals, which represent the difference between the estimated value and the actual value of the variable whose sum equals zero. With residuals obtained from the VAR model the simulation is performed. The approach used for simulating the variables is bootstrap method of resampling. By applying this method, the unknown population can be successfully approximated by drawing samples from the sample of the set size (Kennedy, 2003, 76). Bootstrap resampling means random drawing of samples that are of the same size as the original sample, with returning the data in the sample after drawing and having them at disposal for the next samples drawing. The basic advantage of applying this method lies in the fact that it enables generating data without introducing the assumptions about the distribution of the underlying data. On the other hand, a drawback lies in the fact that parameters of a sample can be statistically insufficiently significant in estimating the true distribution, so the bootstrap method can generate samples whose parameters differ from those of original data (Pažicky, 2017, 159).

The sample of residuals will be *bootstrap* resampled with the sample size equal to the length of a time period in which projecting is made, which is 20 years in this case. *Bootstrap* resampling is carried out one thousand times, and within each iteration the values of resampled residuals are attributed to the estimated values of variables, thus forming simulated values of variables for a period of 20 years. With each new resampling (simulation), simulated values of inflation rate, return rate of stocks, and return rate of government bonds are collected. Given that the salary growth rate equals the inflation rate, inflation rate affects the level of actuarial liability. The return rate of stocks and the return rate of bonds affect the pension plan assets. Since the ratio of assets and actuarial liability represents the funding level, it means that each simulation generates a different funding level, namely, in one thousand simulations one thousand simulated funding levels will be obtained.

Investment policy and contribution rate policy are defined as mechanisms that pension plan has at its disposal for improving the funding position. The basic model stems from the fact that the investment portfolio is invested 50% in stocks and the remaining 50% in government bonds. As the input for the stock return simulation S&P 500 index data will be used, for the period from 1971 to 2017, whereas the Treasury bonds with 10 years maturity in the same time period will be used for the simulation of government bond returns. Data about annual returns of S&P 500 index and long-term Treasury bonds are gathered by using the electronic database of the returns of stocks, bonds, and treasury notes in the United States, periodically updated by A. Damodaran (Damodaran, 2020). As for the contribution rate, it is to be adjusted with the aim of achieving a more adequate funding position. Sponsor of the pension plan has a discretionary right to increase the contribution rate in case the pension plan faces the grave issue of insufficient funding.

Research Findings

Defining the VAR model means testing (non) stationarity of variables in the first step. Testing (non) stationarity is based on applying the unit root test, where the existence of unit root shows non-stationarity of a time series. Thus, the results of ADF and PP unit root tests are given in Table 1.

Table 1: The Results of ADF and PP Unit Root Tests (Variables in Level)

H_0:I(1), H_1: I(0)	Components	ADF statistics	PP statistics
Government bonds	Trend and constant	-7.824881***	-7.813525***
Inflation	Trend and constant	-4.325437***	-4.483565 ***
S&P 500	Trend and constant	-6.583471***	-6.583976***
ADF – Augmented Dickey-Fuller test PP – Phillips-Perron Unit Root test			

**** denotes statistical significance at the level of 1 % (Source: Authors)*

The null hypothesis of the ADF test is that a time series has unit root, namely, it is non-stationary. For high absolute value of test statistics (given that the statistics is preceded by a negative sign) an alternative hypothesis can be accepted that a time series has no unit root, i.e. it is stationary. If the time series is non-stationary, differentiation must be done, i.e. finding the first difference. For the first difference data time series commonly retrieves the stationary character and can be used further in the VAR model. Given that the ADF and PP tests' statistics are statistically significant at the level of 1% it can be said that all variables can be used in the VAR model, without the need of differentiation.

With the aim of determining the presence of serial correlation in the VAR model, the Breusch-Godfrey LM serial correlation test is applied, which tests the serial correlation errors in the regression model. The application of this test means using the residuals from VAR model. Given that the null hypothesis of this test is that there is no serial correlation of any lag order up to the chosen level, the occurrence of *p* value which is lower that the chosen level of significance, means rejecting the null hypothesis and accepting an alternative one that serial correlation is present in the model. Table 2 gives the values of LM test statistics which show that serial correlation problem is not high in the VAR model, namely, all *p* values are higher than the significance level of 5% (0.05).

Table 2: The Results of the LM Serial Correlation Test

Lag	LRE statistics	df	p value	Rao F- statistics	df	p value
1	3.766581	9	0.9261	0.404216	(9,46.4)	0.9265
2	9.797198	9	0.3672	1.118433	(9,46.4)	0.3691
3	16.69316	9	0.0537	2.048268	(9,46.4)	0.0547
4	9.478434	9	0.3943	1.078481	(9,46.4)	0.3963
5	10.12946	9	0.3401	1.160349	(9,46.4)	0.3421
6	15.31719	9	0.0826	1.852333	(9,46.4)	0.0838
7	11.01011	9	0.2750	1.272806	(9,46.4)	0.2770
8	4.88993	9	0.8438	0.530805	(9,46.4)	0.8446
9	7.986835	9	0.5355	0.894890	(9,46.4)	0.5373
10	4.980341	9	0.8360	0.541110	(9,46.4)	0.8368

Source: Authors

The choice of lags in the VAR model is the next important step in forming a VAR model, given that an excessive number of lags diminishes the strength of the model due to the estimation of an excessive number or parameters, whereas a meager number of lags brings about serial correlation (Ozcicek & McMillan, 1999, 518). Table 3 presents the criteria for choosing the lag length which is to be used in the VAR model. As it can be seen, according to most tests, an optimal number of lags is four, and with that lag length a model with three endogenous variables and lag length k = 4 is formed.

Table 3: Criteria for Choosing Lag Length

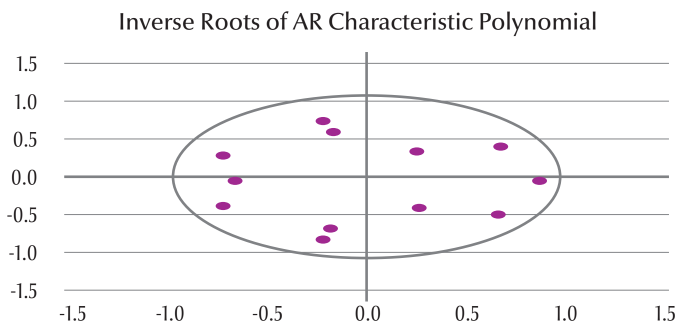
Lag	LogL	LR	FPE	AIC	SC	HQ
0	147.8055	NA	1.72e-07	-7.063682	-6.938298*	-7.018024
1	154.2330	11.60087	1.95e-07	-6.938194	-6.436661	-6.755564
2	168.4551	23.58797	1.52e-07	-7.192934	-6.315250	-6.873330
3	178.4014	15.04070	1.49e-07	-7.239093	-5.985260	-6.782516
4	195.5965	23.48603*	1.03e-07*	-7.638855*	-6.008872	-7.045305*
5	201.5193	7.222891	1.28e-07	-7.488747	-5.482613	-6.758223
6	209.8532	8.943704	1.46e-07	-7.456254	-5.073971	-6.588758

* Denotes the lag chosen in accordance with the criteria
LR: sequential modified LR test
FPE: Final Prediction Error
AIC: Akaike information criterion
SC: Schwartz information criterion
HQ: Hannan – Quinn information criterion

Source: Authors

The stability of the VAR model can be determined by conducting a stability test, which means determining the inverse roots of the AR (autoregressive) characteristic polynomial. If all inverse roots are less than one, it can be said that the VAR model is stable. Stability test results are shown in Figure 1, where it can be seen that all inverse roots are less than one, which implies the stability (stationarity) of the VAR (4) model.

Figure 1: Stability Test Results



Source: Authors

The chosen VAR model with three endogenous variables and lag length of k=4 enables the formation of regressive equations with estimated coefficient values. By applying these equations, estimated values of the inflation rate, government bond rate of return and stock rate of return can be calculated. The simulation of annual return rates of stocks and government bonds, as well as annual inflation rate is conducted, so the residuals, as differences between the values estimated by the VAR (4) model and the actual values, are being randomly chosen via bootstrap method and attributed to the estimated values in each iteration. This procedure is conducted in each of a thousand simulations, which means that one thousand samples of the same size are drawn from the initial sample. Sample size is determined by the length of the time period for which the modeling of the pension plan is performed. In this case, it is a 20-year time frame, which means that the sample includes twenty randomly chosen annual observations for each of the observed variables.

At the starting point, pension liability is fully covered with pension assets, and salaries are being increased in accordance with inflation rate changes. Table 4 shows the simulation results for the probability of underfunding of the pension plan with various contribution rates ranging from 4% to 15% in different moments of time in the future (after the expiration of a 5-, 10-, 15-, and 20-year period, respectively). A portfolio that is equally invested in stocks and government bonds and the pension indexation rate that is equal to the average inflation rate for the period of five years before retirement is used in the simulation.

Table 4: Simulation Results for the Probability of Underfunding for Percentual Changes of the Contribution Rate Ranging from 4% do 15% (in percentages)

Probability of pension plan underfunding				
Contribution rate	After 5 years	After 10 years	After 15 years	After 20 years
4%	65	44.6	28.6	26.8
5%	62.6	45.6	26.2	21.4
9%	54.4	38.2	18.6	11.8
10%	54.6	34.2	19.6	11.4
14%	44.8	28.2	12.8	5.4
15%	43.6	25.2	8.8	2.8

Source: Authors

As it can be seen in Table 4, for all future realizations a conclusion can be drawn that, as the contribution rate increases, the probability of underfunding decreases. For example, the probability that a pension fund will be underfunded after 5 years with a 4% contribution rate is high and amounts to 65%, while, with the 15% contribution rate, that probability approximately amounts to 43%. On the other hand, the probability that a pension fund will be underfunded after 20 years, with a 4% contribution rate, amounts to approximately 27%, whereas with a 15% contribution rate, this probability approximately amounts to 3%.

Table 5 gives the results of the simulation of the probability of underfunding with different portfolio structures. A 10% contribution rate has been used for the simulation, together with pension indexation which matches the average inflation rate for the 5-year period prior to retirement.

Table 5: Simulation Results of the Probability of Underfunding, with Different Portfolio Structures (in percentages)

Portfolio exposure to stocks	Probability of pension plan underfunding			
	After 5 years	After 10 years	After 15 years	After 20 years
0%	67.8	53.6	40.4	36.6
10%	58.6	40.4	23.2	18.8
20%	54	35.6	17.4	10.8
30%	45.6	27.2	10.6	5
40%	32.6	16	7.2	2.6
50%	28.6	16.6	5.8	1.8
60%	24.8	16.8	6.2	2
70%	24	16.2	5.6	2.4
80%	17.8	15.6	7.2	3.6
90%	26.8	18.4	8.4	3
100%	23.2	18.6	7.4	3.2

Source: Authors

By changing the portfolio structure, managers can significantly influence the probability of the pension plan being underfunded. By leading an extremely conservative investment policy, the probability that the pension plan will become underfunded after 10 years amounts to approximately 53%, and after 20 years to approximately 36%. On the other hand, if the stocks account for 50% of portfolio, the probability of underfunding decreases drastically and after 10 years amounts to approximately 16%, and after 20 years to approximately 2%. It is interesting that a further increase of stock percentage in a portfolio does not contribute to a significant decrease of the probability of underfunding. With a stock exposure increase from 80% to 90%, the probability of underfunding does not decrease, but rather increases. Based on what was previously stated, from the perspective of the pension plans' financial stability, a conclusion can be drawn that a more desirable solution is a balanced portfolio with an approximately equal share of stocks and government bonds, rather than an extremely aggressive investment policy.

Pension plan sponsors are interested not only in the probability of pension plans being underfunded, but also in the underfunding gap quantification. Table 6 shows the results of a simulation of the average deviation from the 100% funding level, with different contribution rates and portfolio structures, for all simulations in which the simulated level of funding is less than 100%.

Table 6: Results of the Simulation of the Average Deviation from the full Funding Level, with Different Contribution Rates and Portfolio Structures (in percentages)

After 10 years											
	Stock exposure										
Contribution rate	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
5%	21.91	20.8	19.0	17.31	15.37	18.91	18.08	21.68	22.08	26.66	29.56
7.5%	21.72	19.02	16.92	15.32	16.85	18.09	20.66	23.32	24.99	23.72	26.74
10%	21.32	17.64	17.02	14.49	15.44	13.6	20.15	19.38	23.3	24.11	32.28
12.5%	20.58	18.5	15.34	15.42	14.73	15.25	20.38	20.31	25.16	26.82	29.37
15%	21.63	16.42	15.76	14.32	14.07	16.43	18.16	20.03	18.52	26.81	28.88
After 20 years											
	Stock exposure										
Contribution rate	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
5%	32.34	27.97	27.7	26.28	21.32	25.47	24.33	28.84	31.45	31.48	34.87
7.5%	30.62	24.99	27.43	23.47	21.42	22.26	29.02	31.66	30.52	33.19	28.09
10%	30.11	22.86	19.21	17.1	23.41	13.2	27.43	23.36	27.39	28.23	34.52
12.5%	29.94	26.29	19.6	21.83	21.71	14.89	20.11	22.48	26.38	23.4	29.76
15%	27.96	24.22	20.31	18.96	20.08	17.69	17.66	25.00	22.59	23.94	28.51

Source: Authors

Simulation results show that the average deviation of the simulated funding levels from the full funding is decreasing as the stock amount increases, only to a certain level, however. For example, after ten years, deviation is decreasing all the way to the point of 60% stock exposure. With the further increase of stock portion in the portfolio structure, average deviation shows tendency of increase, namely, the pension plan underfunding probability is decreasing, but at the expense of increasing the average deviation from the level of full funding. Movement like this is typical for all contribution rates and for all observed time periods. Average deviation of undesirable simulations from full funding is increasing if the time period is extended, but the basic trend noted during shorter time periods is the same. Increasing the stock exposure favorably affects the reduction of average deviation from the full funding, but to an extent. Afterwards, further increase of the stock portion in portfolio does not lead to a decrease of average deviation from the full funding. On the other hand, increase of the contribution rate is not an effective mechanism for reducing the average deviation from the full funding level, given that the increase of contribution rate, with a fixed portfolio structure, does not lead to a more significant decrease of the average deviation. The efficiency of the investment policy in this sense is significantly higher when compared to the contribution rate policy, which implies the validity of the set research hypothesis.

Conclusion

Pension plan sponsors are interested not only in the probability that the pension fund will reach the position of insufficient funding, but also in the scale of the potential underfunding gap. Accordingly, several concrete recommendations for decision makers in pension plans can be made. Investment policy represents a mechanism which can be used by plan sponsors with the aim of achieving long-term financial stability, namely, reducing the probability of the pension plan becoming underfunded. In terms of reducing the probability of underfunding, the pension plan sponsors can use the policy of increasing contributions as well, whereas the combined usage of investment policy and the policy of increasing contributions gives even more favorable results.

From the perspective of reducing the average deviation of unfavorable outcomes from the full funding level, policy of increasing contributions does not make an efficient solution. When it comes to the portfolio structure, neither extremely conservative nor extremely aggressive portfolio structures are desirable. The most favorable results are achieved by forming a balanced portfolio, with approximately equal shares of stocks and government bonds. Extremely high stock exposure contributes to the further decrease of the probability of underfunding, but at the expense of increasing the average deviation from the full funding level. In other words, the probability that the pension plan will be underfunded is decreasing, but with the increasing presence of extremely unfavorable outcomes. Having in mind that pension plans are oriented towards safe long-term pension payouts, this way of reasoning is an unacceptable solution for pension plan sponsors.

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