KOMPARATIVNA ANALIZA DEŠAVANJA NA SVETSKOM TRŽIŠTU NA PRIMERU IZABRANOG PORTFOLIA I VAR METODE

Danica Cicmil[13], Pavle Jakšić[14], Miloš Đaković[15]

doi: 10.5937/Oditor2302054C

Pregledni rad

UDK: 336.761.5(100)"2007/2022"

Apstrakt

Tema rada se fokusira na kretanje četiri berzanska indeksa u periodu od 2007. do 2022. godine, sa ciljem procene koja kriza je imala veći uticaj na pojedinačne indekse kao i na portfolio kreiran putem analize srednje varijanse. Takođe, sam rizik meren je metodom VaR (Vrednost u riziku). Svaki indeks predstavlja jednu klasu imovine, i računarska kalkulacija korišćenjem analize srednje varijanse predložila je određene pondere, koji su korišćeni u daljim proračunima. Glavni zaključak ovog rada jeste da je kriza u 2020. imala snažniji uticaj na sve indekse, i dovela do većih volatilnosti u prihodima nego što je kriza tokom 2008. godine. Dalje, portfolio kreiran putem analize srednjih vrednosti za investitore koji nisu skloni riziku je potvrdio ove rezultate, pokazujući najveću volatilnosti u prihodima celog portfolia u 2020. godini.

Ključne reči*: VaR, finansijska kriza, analiza portfolia.*

JEL*: G110, G010*

Uvod

Istorijski smo svedoci mnogim krizama koje su se desile tokom 21-og veka. Najznačajnije su dve koje su pogodile celo svetsko tržište i to svetska ekonomska kriza 2008. godine i Covid19 kriza 2020. godine. Tema ovog rada se fokusira na kretanje četri indeksa u periodu od 2007. do 2022. godine, koji obuhvataju obe krize. Cilj je proceniti koja kriza je imala veći uticaj na pojedinačne indekse kao i na portfolio kreiran putem analize srednje varijanse. Takođe visina volatilnosti u vezi sa reakcijom na krize je izračunata putem VaR metode. Teorijski deo će biti fokusiran na objašnjenja analize srednje varijanse i VaR metoda kao centralnom delu rada.

[13] Danica Cicmil, Ekonomski fakultet Subotica, Univerzitet u Novom Sadu, Branka Bajića 9i, 21000 Novi Sad, R. Srbija, Telefon: +38164 467 0735, E-Mail: cicmildanica@yahoo.com

[14] Pavle Jakšić, Ekonomski fakultet u Subotici, Univerzitet u Novom Sadu, Pionirska 2, 15300 Loznica, telefon: +381645055833, E-mail: pavlej236@gmail.com

[15] Miloš Đaković, Ekonomski fakultet u Subotici, Univerzitet u Novom Sadu, Vladimira Nazora 8, 24000 Subotica, R. Srbija, Telefon: +38164 1322 387, E-mail: milos.djakovic@ef.uns.ac.rs

Odnos rizika i prinosa je jedna od tema o kojima se najviše diskutuje na finansijskim tržištima, jer njegovo razumevanje omogućava investitorima da donose odluke. S toga, neki investitori su skloni riziku i ne žele da preuzmu dodatnu izloženost kako bi postigli veće prinose, dok sa druge strane postoje investitori koji su spremni da preuzmu veće rizike. Procena ove dve kategorije je stoga od najveće važnosti, bez obzira na vrstu investitora. U ovom radu rizik portfolija će biti izračunat primenom VaR metode, za koji je potrebno kreirati portfolio. Portfolio će se sastojati od četiri berzanska indeksa, čiji će ponderi biti dodeljeni na osnovu analize srednje varijanse (Takino & Ishinagi, 2022).

Što se tiče vremenskog okvira, globalna slika finansijskog sveta je obuhvaćena za period od aprila 2007. do januara 2022. godine. Ovaj vremenski okvir je izabran da pokrije period obe krize koje su se zadesile u 21-om veku. Tokom ovog perioda, fokus je na periodima u kojima je volatilnost pojedinačnih indeksa i portfolia bila veća, sa ciljem da se proceni koja kriza je imala veći uticaj kako na same indekse, tako i na kreirani portfolio. Takođe će rizik biti procenjen VaR metodom i kvantifikovan. Stoga, cilj rada možemo podeliti na dva problemska pitanja: 1. Uticaja kriza na izabrane indekse, sa nastojanjem da se proceni koja je imala snažniji uticaj, i 2. Kreiranje portfolia putem analize srednje varijanse i procena rizika putem VaR metode.

Teorijske osnove

Iako je glavna ideja da se proceni uticaj kriza na indekse, a potom portfolio, jaz u znanju će biti fokusiran na VaR metodu i analizu srednje varijanse. Uopšteno govoreći, VaR kao mera je usmerena isključivo na procenu rizikaNekoliko istraživača preporučuje upotrebu istorijskog VaR-a jer je ovo najjednostavniji metod. Nasuprot tome, postoje neki koji se ne slažu sa tim jer veruju da može da obmanjuje jer ne obuhvata neočekivane promene na tržištu. Još jedna poteškoća sa kojom se može zadesiti u suočavanju sa istorijskim VaR-om je pitanje koliko bi uzorak trebalo da bude veliki da bi obuhvatio sve distribucije povrata.

Druga vrsta VaR je delta-normal VaR, koji pretpostavlja normalnu distribuciju prinosa, što nije uvek slučaj i stoga je često nepraktično. Pored toga, EWMA metoda se može koristiti za izračunavanje VaR-a, sa prednošću što su noviji događaji ponderisani više. Tehnike koje rešavaju nedostatke ranijih metoda mogu biti računski zahtevne. Jedno od rešenja koja su preporučili mnogi autori je GARCH (Generilizovana autoregresivna uslovna heteroskedastičnost) metoda. GARCH metoda uključuje dodatni parametar u proračunu volatilnosti i stoga poboljšava tačnost VaR-a. Postoji dalje niz suprotstavljenih stavova o upotrebi VaR-a, a jedan od njih je upotreba mnogih metoda izračunavanja, što dovodi do različitih rezultata (Xiang & Zhang, 2022). U ovom radu autori će primenti računanje VaR metode putem metode normalne distribucija, kao metode koja je najzastupljenija u teoriji.

Pregled literature

VaR je mera rizika koja se uglavnom koristi za merenje rizične pozicije banke ili investicione kompanije. Rane 1990-te donele su neizvesnost na finansijsko tržište (Angelidis & Degiannakis, 2019), što je dovelo do razvoja različitih modela za procenu tržišnog rizika. Ovo je uticalo na stvaranje VaR-a 1995. od strane JP Morgana, koji je objavio dokument pod naslovom Risk Metrics (Morgan/Reuters, 1995). Dokument je predstavio šta je VaR i kako se može izračunati. Čak i pre objavljivanja dokumenta, VaR je predložen kao mere tržišnog rizika (Group of Thirty, 1993). Prema JP Morganu, VaR je mera gubitka sa datom verovatnoćom tokom vremenskog horizonta. Najvažniji parametar u njegovoj formuli je standardna devijacija kao mera disperzije. Standardna devijacija ili njena kvadratna verzija - vvarijansa mogu se izračunati na mnogo načina, npr. istorijska volatilnost, EWMA (Eksponecijalni ponderisani prosek), GARCH, itd. Sam VaR se može izračunati korišćenjem simulacionih modela kao što su istorijska simulacija ili Monte Karlo simulacija. VaR metode se mogu klasifikovati u tri kategorije: parametarske metode – delta-normalni pristup, neparametarske metode – istorijska simulacija i Monte Karlo metode (Nabella, Maski, & Wahyudi, 2020). Ovaj rad obuhvata delta-normalni pristup, koji podrazumeva normalnu distribuciju prinosa.

U literaturi postoje različiti pogledi. Na primer, istorijski simulacioni model je dao bolje rezultate predviđanja od drugih metoda koje se koriste ako je veličina uzorka dovoljno velika i ako je uključen viši nivo pouzdanosti (Craig, 2019). Metode simulacije su se pokazale kao bolje od parametarskih metoda kada je u pitanju procena VaR-a (Liu & Luger, 2022). Ipak, nedostatak je u tome što je istorijska volatilnost suviše jednostavan metod za izračunavanje volatilnosti koji koristi samo formulu standardne devijacije (Marra, 2017). U ovim osnovnim informacijama, razvijen je delta-normalni pristup koji uključuje matricu kovarijanse kao dodatni parametar za proračun. Spada u grupu parametarskih VaR metoda, sa glavnom pretpostavkom o normalno raspoređenim prinosima (Kulali, 2016).

Problem i cilj rada

Problem rada se fokusira na rešavanje pitanja koja kriza je imala snažniji uticaj na pojedinačne indekse kao i na celokupni kreirani portfolio. S obzirom da ekonomija kao celina ima cikluse, krize kao fenomen nisu nešto nepoznato. Ono što ostaje nepoznato jeste kada će se koja kriza desiti, i koji sektori će biti pogođeni. Direktno u vezi sa tim, ovaj rad nastoji da da odgovor kako su se koji indeksi ponašali tokom dve krize u 21-om veku. Analiza srednje varijanse se prvo vrši da bi se kreirao optimalni portfolio. Svrha kreiranja optimalnog portfolia je da se pronađe najbolji prinos putem kombinacije sredstava. Kada se kreira optimalni portfolio, primeniće se metoda delta-normal VaR. Osvrćući se na temu VaR, glavna namera je da se izračuna najveći mogući gubitak na portfoliju sa datom verovatnoćom u datom periodu (Buczynski & Chlebus, 2020).

Metodologija

Za potrebe analize uzeta su u obzir četiri indeksa. Svaki indeks predstavlja jednu klasu imovine, a indeksi pokrivaju i razvijena i nerazvijena tržišta, i slede:

1. MSCI World Index: indeks akcija;
2. Vanguard Total Bond Market Index Fund: indeks obveznica;
3. S&P GSCI Index – indeks robe;
4. Vanguard Real Estate Index Fund Investors – indeks nekretnina.

Za početak procesa optimizacije potrebno je prikupiti podatke za sva četiri indeksa od aprila 2007. do januara 2022. Godine. U ovom radu su dnevni podaci preuzeti sa veb sajta investing.com, sa namerom da se obuhvate sve promene. Shodno tome, podaci će biti uvezeni u Python, gde će se vršiti sve analize.

Analiza srednje varijanse

Ovo poglavlje se bavi temom analize srednje varijanse, fokusirajući se na proračun i njegovo fundamentalno razumevanje. Teorija srednje varijanse je deo moderne teorije portfelja koju je razvio Hari Markovic. Ispitivao je ulogu odnosa između rizika i prinosa i otkrio da su svi investitori neskloni riziku – preferiraju manji rizik za isti očekivani iznos prinos (Reilly & Brown, 2003).

Svi investitori imaju za cilj da pronađu individualno optimalan portfolio. To znači kreiranje portfolija koji odražava njihove sopstvene preferencije u smislu investicionih očekivanja. Optimalni portfolio je portfolio koji ostvaruje najveći očekivani prinos za dati rizik, meren kao standardna devijacija (Hiller, 2022). Ova studija će koristiti portfolio kreiran od četiri različita indeksa akcija sa ciljem stvaranja optimalnog portfolia sa minimalnim rizikom. Ovaj portfolio će sadržati indekse koji odražavaju i razvijena i nerazvijena tržišta, kao i tržišta akcija, obveznica, nekretnina i roba. U tom smislu portfolio će odražavati celo tržište. Optimalni portfolio se može izračunati na osnovu cene na zatvaranju berze, očekivanog prinosa, standardne devijacije i korelacije. Očekivani prinos za portfolio može se izračunati na sledeći način (Markowitz, 1952):

$$[E(R]_p) = \sum_{i=1}^{N} w_i \cdot E(Ri) \qquad (1)$$

Gde je $E(Rp)$ očekivani prinos portfolia, w_i je ponderisanje svake klase sredstava u portfoliu i R_i su prinosi svih klasa sredstava. Prema tome, očekivani prinos portfelja je zbir ponderisanih prinosa svake klase sredstava uključenih u portfolio. S druge strane, varijansa portfolija nije jednostavno ponderisana standardna devijacija klasa aktive, jer njihova korelacija čini razliku u smislu procenjenog rizika. Diverzifikacijom je moguće postići manji rizik u portfoliju nego što ga ima sama akcija. Dakle, opšta formula za rizik portfolija može se izračunati na sledeći način (Hiller, 2022):

$$\sigma_p^2 = \sum_{i=1}^{N} \sum_{j=1}^{N} w_i w_j Cov(R_i, R_j) \tag{2}$$

Gde je σ_p^2 portfolio varijansa, Cov je kovarijansa između svaka dva sredstva imovine. I-ti red i j-ta kolona je kovarijansa između promenljivih i i j. Kovarijansa između varijable i nje same je varijansa koja predstavlja dijagonalne ulaze u matrici (Hull, 2017).

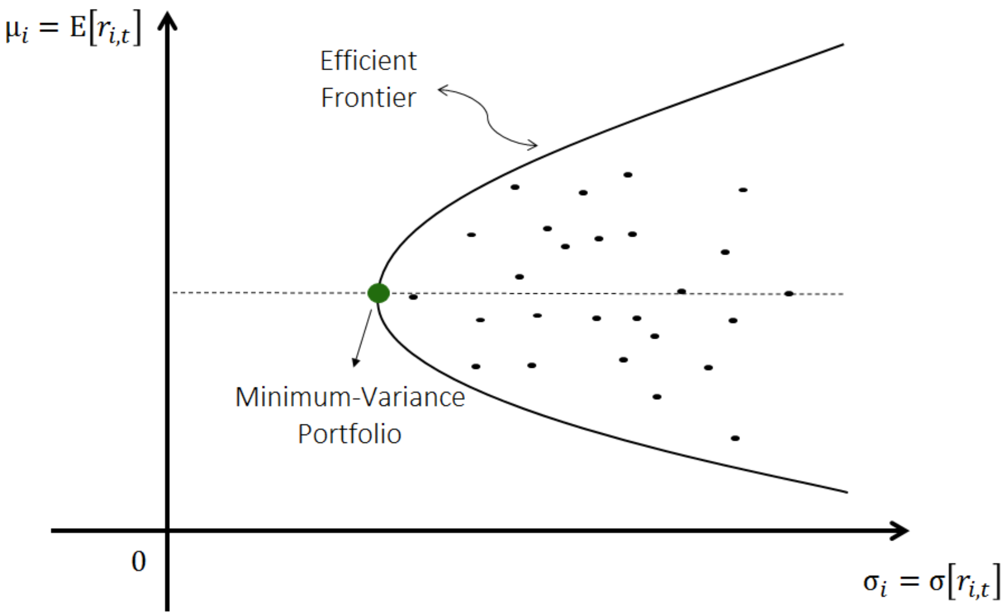
$$\begin{pmatrix} var_1 & \cdots & cov_{1n} \\ \vdots & \ddots & \vdots \\ cov_{n1} & \cdots & var_n \end{pmatrix} \tag{3}$$

Dva ograničenja su data (Markowitz, 1952):

1. $\sum_{i=1}^{n} w_i = 1$
2. $w_i \geq 0$

Prvo ograničenje je da zbir pondera svake klase imovine mora biti jednak 1, a drugo zabranjuje prodaju finansijskih instrumenata koji se ne poseduju.

Grafikon 1: Analiza srednje varijanse



Izvor: (Goncalves, 2022)

Kada se izračunaju očekivani prinosi i rizik, sve njihove kombinacije mogu biti prikazane na grafikonu (Goncalves, 2022). Linija sa optimalnim portfeljima naziva se efikasna granica. X-osa prikazuje standardnu devijaciju, a Y-osa prikazuje povrat. Pomeranje ulevo od x-ose rezultira manjom varijansom. I suprotno, pomeranje udesno dovodi do veće varijanse. Pomeranje nagore do y-ose dovodi do većeg prinosa, pomeranje nadole znači niže prinose. Portfolio koji je najdalje levo na x-osi predstavlja portfolio sa minimalnom varijansom i prikazan je kao tačka. Portfoliji koji nisu na liniji ne daju bolje rezultate. Oni nude ili veći rizik za isti prinos ili manji prinos za isti rizik.

U ovom radu, kao što je već pomenuto, koriste se četiri berzanska indeksa, pa je formula za očekivani portfolio i varijansu sledeća:

$$[E(R]_p) = w_1E(R_1) + w_2E(R_2) + w_3E(R_3) + w_4E(R_4) \quad (4)$$

R_2, R_4

(5)

Jedna od prednosti koje je donela moderna teorija portfolija (MPT) jeste uticaj na trgovce da diversifikuju svoje portfelje umesto da se koncentrišu na jednu klasu sredstava. Iako je zasnovan na mnogim restriktivnim pretpostavkama, omogućio je procenu rizika portfelja i prinosa. Neke od glavnih pretpostavki su normalna raspodela prinosa i racionalno ponašanje investitora (Rice, 2017).

Value at Risk (VaR)

VaR je statistička mera koja se generalno koristi za analizu tržišnog rizika povezanog sa finansijskim sredstvima ili portfeljima (Mensink & Neves, 1999). Datira iz 1995. godine, kada je JP Morgan objavio RiskMetrics dokument, koji je objasnio VaR kao model. Pod tim imenom je definisan tek 1995. Godine. Nakon što ga je uveo JP Morgan, postao je široko korišćena mera izloženosti tržišnom riziku. On pruža jednostavnu i lako primenljivu kvantitativnu meru za procenu ukupnog tržišnog rizika kome je neko izložen. Takođe ga koriste mnogi menadžeri rizika za procenu potencijalnog gubitka portfelja tokom određenog vremenskog perioda i na određenom nivou poverenja.

Postoje dva ključna elementa za opisivanje VaR-a (Olsen, 2020):

1. Vremenski horizont – što je veći horizont, veći je VaR. Kada se izračuna dnevni VaR, može se produžiti na više dana množenjem kvadratnog korena vremena. Ovo je slučaj kada su prinosi nezavisno i identično raspoređeni (iid) sa normalnom distribucijom (Jorion, 2007);

2. Nivo poverenja – što je viši nivo poverenja, veći je VaR i više scenarija je pokriveno. Najčešće korišćene verovatnoće su one od 95% i 99%. Ovi elementi se mogu opisati u jednoj rečenici: "Mi smo X posto sigurni da nećemo izgubiti više

ode V dolara u vremenskom periodu T" (Hull, 2015). VaR se stoga definiše kao iznos novca koji se može izgubiti tokom određenog vremenskog perioda na određenom nivou poverenja.

$VaR = \mu + \sigma N^{-1}(X)$ (6)

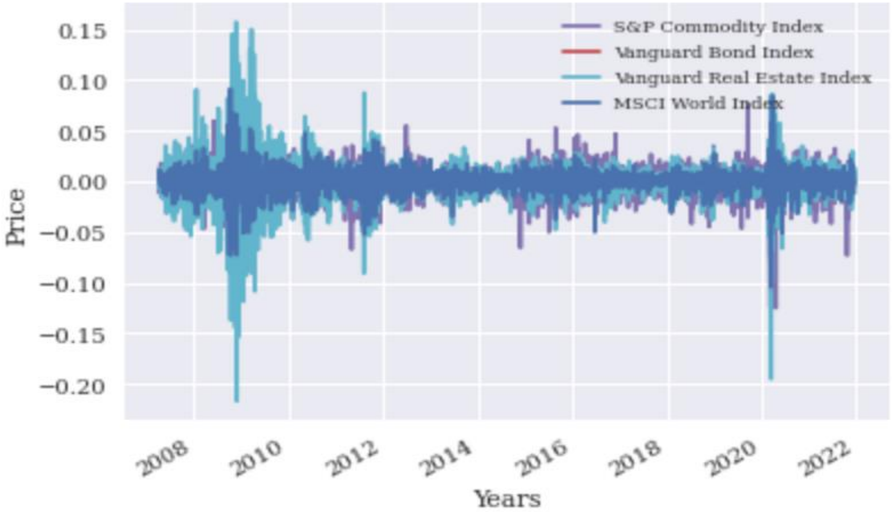
Gde je μ srednja vrednost, σ je standardna devijacija portfolia, $N^{-1}(X)$ je inverzna kumulativna normalna raspodela (Hull, 2017).

Može se reći da ako je VaR portfelja milion dnevno sa sigurnošću od 95%, postoji samo 5% šanse da će gubitak biti veći od milion. Nedostatak VaR-a je ovde izražen, jer ne govori ništa o iznosu gubitka ako dođe do ovih 5%. Iz tog razloga, VaR je često bio kritikovan i uvedena je dodatna mera, odnosno očekivani gubitak (ES) ili uslovni VaR (CVaR), koji meri prosek svih gubitaka koji su veći od VaR (Mendes, 2022). Upotreba CVaR-a umesto VaR-a ima mnogo prednosti, kao što je uključivanje gubitaka viših od VaR-a, što rešava jedan od problema povezanih sa VaR-om, ali praksa u finansijskoj industriji i dalje snažno favorizuje upotrebu VaR-a (Chipping, 2014). Drugo ograničenje VaR-a je to što daje različite rezultate u zavisnosti od korišćene metode (Bedi, Shankar, Agnihotri, & Kalra, 2018). Daljnji nedostatak o kome se raspravlja je to što VaR nema sub-aditivnost, što znači da VaR portfelja može biti veći od zbira pojedinačnih VaR-ova (Meissner, Bhaduri, Linsky, & Yuan, 2021) što uzrokuje probleme agregacije (Chen, Sit, & Wong, 2019). Rešenja za većinu nedostataka VaR-a nalaze se u CVaR-u, kao što su subaditivnost i konveksnost (Francq & Zakoian, 2019).

Rezultati rada sa diskusijama

Ovo poglavlje opisuje rezultate rada. Nakon unosa biblioteka i skupa podataka u programski jezik Python, prinosi za svaki indeks se izračunavaju.

Dijagram 1: Prinosi sva četri indeksa



Izvor: Autor na osnovu podataka sa Platforme investing.com

Kada se pogleda prezentacija prinosa sva četiri indeksa na sledećem dijagramu, može se zaključiti da je:

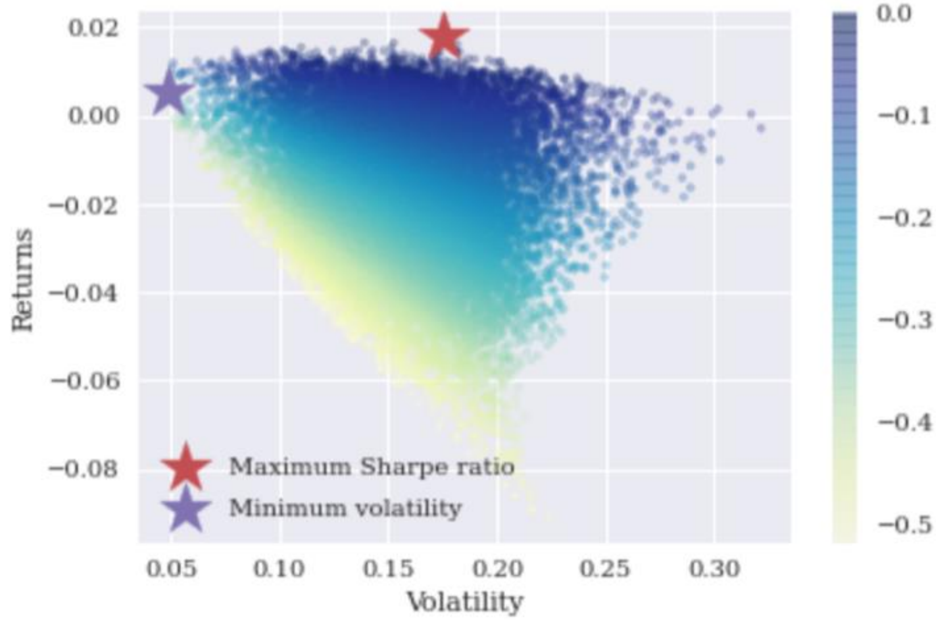
1. The Vanguard Bond index najmanje volatilan, jer njegove crvene linije nisu vidljive na grafikonu, tj. najniža volatilnost;
2. S&P Commodity indeks nije toliko izražen u poređenju sa drugim indeksima;
3. The MSCI World Index pokazuje veće devijacije i odstupanja, kao i Vanguard Real Estate indeks u poređenju sa gore navedenim indeksima, i pokazuje najveću devijaciju tokom 2008. godine, dok MSCI World indeks pokazuje najveća odstupanja tokom 2020. godine.

Sa ovim rezultatom, sada je moguće pronaći odgovarajuće ponderisanje koristeći teoriju portfolija. U ovom trenutku portfolio se može izračunati sa minimalnom volatilnošću generisanjem nasumičnih portfelja i pronalaženjem najniže standardne devijacije za date pondere. Na osnovu prethodnog grafikona, očekuje se, između ostalog, da će Vanguard Bond index biti relativno zastupljeniji i da će Vanguard Real Estate i S&P Commodity indeks, kao najpromenljiviji indeksi, dobiti manje pondere. Pošto je investitor u ovom slučaju nije sklon riziku, bira se alternativa koja nudi minimalnu volatilnost. Računarska kalkulacija korišćenjem analize srednje varijanse predlaže sledeće pondere:

1. Vanguard Bond Index - 91.01%;
2. S&P Commodity Index - 1.94%;
3. Vanguard Real Estate Index - 5.90%;
4. MSCI World Index - 1.15%.

U poređenju sa očekivanjima, svaka tačka je potvrđena, odnosno veći udeo Vanguard Bond indeksa i niži udeo Vanguard Real Estate i S&P Commodity indeksa. Dijagram 2 prikazuje sve moguće kombinacije portfelja. Investitor može da bira između svih tačaka na grafikonu, pri čemu je maksimalni Šarp racijo prikazan crvenom tačkom, a minimalni promenljivi portfolio ljubičastom tačkom. U ovom slučaju, investitor nije sklon riziku, tako da je izabrana ljubičasta tačka koja je najdalje levo. Ova tačka nudi minimalnu volatilnost, za dati prinos.

Dijagram 2: Simulirana optimizacija portfelja zasnovana na Efficient Frontier-u



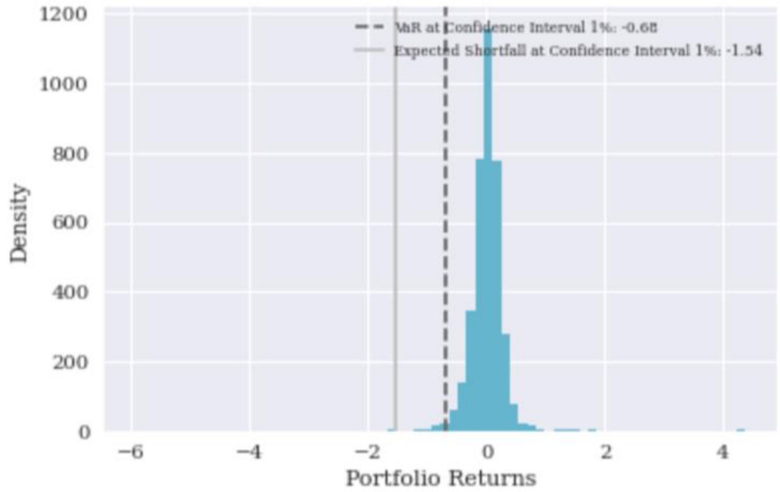
Izvor: Autor na osnovu podataka sa Platforme investing.com

Nakon dodele pondera, prinos portfelja se može prikazati grafički za dati period na dijagramu 3. Kao što se vidi na posebno iscrtanim indeksima, tako i ovde najveće odstupanje se može uočiti na kraju 2008. i 2020. godine Prinosi se kreću od -3 do +4 % u 2008. godini, dok u 2020. godini variraju od -6 do +4%, što potvrđuje da je kriza 2020. godine imala snažniji uticaj na sve klase imovine, čak i na kreirani portfolio za investitore koji nisu skloni riziku.

Dijagram 3: Ponderisani prinosi portfolia

Izvor: Autor na osnovu podataka sa Platforme investing.com

Dijagram 4: Histogram portfolio prinosa




```
99 % Confident the actual loss will not exceed -0.68 %
Expected Shortfall -1.54 %
```

Izvor: Autor na osnovu podataka sa Platforme investing.com

Dijagram 4 prikazuje distribuciju svih prinosa portfelja za period od aprila 2007. do januara 2022. godine koristeći dve mere: svetlosiva linija pokazuje očekivani gubitak(ES), a tamna tačkasta linija VaR.

VaR se ovde izračunava kao jedan procentil sortiranih negativnih prinosa, i može se biti 99% sigurno da stvarni gubitak portfelja neće preći 0,68% vrednosti portfelja u jednom danu, dok očekivani gubitak je uvek veći i iznosi 1,54%, računato kao prosek najvećih gubitaka.

Na osnovu rezultata deskriptivne statistike može se zaključiti da prinosi nisu normalno raspoređeni. Standardna devijacija je manja, asimetrija veća i kurtozis mnogo veći nego kod normalno raspoređenih prinosa. Iz rezultata može se implicirati da su prinosi blago negativno iskrivljeni, a da je kurtozis pozitivan - leptokurtik. Ovde se može prepoznati rizik od ekscesa, što znači da u nekim slučajevima dobijamo preterane prinose, bilo pozitivne ili negativne, u statistikama poznatim kao ekstremni repovi.

Zaključak

U ovom radu obrađene su različite teme vezane za programiranje, statistiku i finansijsko modeliranje sa glavnom idejom sagledavanja finansijskih kriza u 21-om veku. Nakon čitanja različite dostupne literature, jaz je identifikovan, čijom definicijom počinje rad. Zatim se detaljno opisuje metodologija istraživanja. Formule, grafikoni, parametri su definisani i predstavljeni, kao i izvori koji se koriste, tako da čitalac može da ih koristi ako mu je neki deo teško razumljiv. Rezultati proračuna i analize su detaljno opisani.

Glavni zaključak ovog rada jeste da je kriza u 2020. godini imala snažniji uticaj na sve indekse, i dovela do većih volatilnosti u prihodima nego što je kriza tokom 2008. godine. Dalje, portfolio kreiran putem analize srednjih vrednosti za investitore koji nisu skloni riziku je potvrdio ove rezultate, pokazujući najveću volatilnosti u prihodima celog portfolia u 2020. godini. Takođe, VaR je izračunat sa ciljem da se proceni i kvantifikuje rizik. Tako rezultat VaR-a sa 99% sigurnošću je kvantifikovao da gubitak portfelja neće preći 0,68% vrednosti portfelja u jednom danu. Očekivani gubitak (ES) je uvek veći i iznosi 1,54%, računato kao prosek najvećih gubitaka.

Literatura

1. Angelidis, T., Degiannakis, S. (2019). Modeling Risk in Three Markets: VaR Methods for Long and Short Trading Positions. International Conference of Computational Methods in Sciences and Engineering.
2. Bedi, P., Shankar, D., Agnihotri, S., & Kalra, J. (2018). Comparison of VaR Methods: The Case of Indian Equities. Indian Journal of Finance, 33.
3. Buczynski, M., & Chlebus, M. (2020). Old-fashioned parametric models are still the best: a comparison of a VaR approaches in several volatility states. Journal of Risk Model Validation.
4. Chen, J., Sit, T., & Wong, H. (2019). Simulation based VaR for nonlinear portfolios. Quantitative Finance.
5. Chipping, T. (2014). Scaling laws: A viable alternative to a VaR. Quantitative Finance.
6. Craig, C. (2019). How to express Risk, Confidence and (Un)Certainty.
7. Francq, C., & Zakoian, J.-M. (2019). Virtual Historical Simulation for estimating the conditional VaR of large portfolios. Journal of Exonometrics.
8. Goncalves, A. (2022). Von Andrei Goncalves: http://andreigoncalves.com/busfin4221-module2/ abgerufen
9. Group of Thirty. (1993). Derivatives: Practice and Principles. Global Derivatives Sttudy Group.
10. Hiller, T. (2022). Allocation of portfolio risk and outside options. Managerial and Decision Economics.
11. Hull, J. C. (2017). Equities, Fixed Income Securities and Derivatives. New Yersey: John Wiley & Sons.
12. https://web.wpi.edu/Pubs/ETD/Available/etd-050905-104553/unrestricted/Rajesh_Thesis.pdf abgerufen
13. Kulali, D. I. (2016). Variancee-Covariance (Delta Normal) Approach of VaR Models: An Example from Istanbul Stock Exchange. Research Journal of Finance and Accounting.
14. Liu, Y., & Luger, R. (2022). On the way to bias reduction. Emory University.

15. Markowitz, H. (1952). Portfolio Selection. The Journal of Finance, Vol. 7, No. 1.
16. Marra, S. (2017). Predicting Volatility. Lazard Asset Management.
17. Meissner, G., Bhaduri, R., Linsky, L., & Yuan, E. (2021). Portfolio Risk-Beyond Volatility. Wilmott.
18. Mendes, B. V. (2022). Computing Conditional VaR using Time-varying Copulas. Risk.
19. Morgan/Reuters, J. (1995). Risk Metrics Technical Document. JP Morgan.
20. Nabella, R., Maski, G., & Wahyudi, S. (2020). Systematic Risk Analysis using CoVaR Model: Evidence in Indonesia. Jurnal Ekonomi dan Studi Pembangunan.
21. Olsen, D. (2020). Value at Risk Models. John Wiley & Sons.
22. Rice, B. (2017). The Upside of the Downside of Modern Portfolio Theory. Investments & Wealth Institute.
23. Takino, K., & Ishinagi, Y. (2022). On mean-variance analysis of a bank's behavior. Finance Research letters.
24. Xiang, Y., & Zhang, H. (2022). Comparison and Forecasting of VaR Models for Measuring Financial Risk: Evidence from China. Discrete Dynamics in Nature and Society.

Datum prijema (Date received): 13.05.2022.
Izvršena korekcija (The first correction was made): 18.08.2023.
Datum prihvatanja (Date accepted): 25.10.2022.

COMPARATIVE ANALYSIS OF EVENTS ON THE WORLD MARKET USING THE SELECTED PORTFOLIO AND THE VAR METHOD

Danica Cicmil [16], Pavle Jakšić [17], Miloš Đaković[18]

Review paper

Abstract

The topic of the paper focuses on the movement of four stock market indices in the period from 2007 to 2022, with the aim of assessing which crisis had a greater impact on individual indices as well as on the portfolio created through mean variance analysis. Also, the risk itself was measured using the VaR (Value at Risk) method. Each index represents one asset class, and computer calculation using mean-variance analysis suggested certain weights, which were used in further calculations. The main conclusion of this paper is that the crisis in 2020 had a stronger impact on all indices, and led to greater volatility in income than the crisis in 2008. Further, a portfolio created through mean analysis for risk-averse investors confirmed these results, showing the highest volatility in the returns of the entire portfolio in 2020.

***Keywords**: VaR, financial crisis, portfolio analysis.*

***JEL**: G110, G010*

Introduction

Historically, we have witnessed many crises that occurred during the 21st century. The most significant are the two that affected the entire world market, namely the world economic crisis of 2008 and the Covid19 crisis of 2020. The topic of this paper focuses on the movement of four indices in the period from 2007 to 2022, which include both crises. The goal is to assess which crisis had a greater impact on individual indices as well as on the portfolio created through mean-variance analysis. Also, the level of volatility related to the reaction to crises was calculated using the VaR method. The theoretical part will be focused on explanations of mean variance analysis and VaR methods as the central part of the paper.

The relationship between risk and return is one of the most discussed topics in the financial markets, because understanding it allows investors to make decisions.

[16]Danica Cicmil, Faculty of Economics Subotica, University of Novi Sad, Branka Bajića 9i, 21000 Novi Sad, R. Serbia, Phone: +38164 467 0735, E-Mail: cicmildanica@yahoo.com
[17]Pavle Jakšić, Faculty of Economics in Subotica, University of Novi Sad, Pionirska 2, 15300 Loznica, phone: +381645055833, E-mail: pavlej236@gmail.com
[18]Miloš Đaković, Faculty of Economics in Subotica, University of Novi Sad, Vladimira Nazor 8, 24000 Subotica, R. Serbia, Phone: +38164 1322 387, E-mail: milos.djakovic@ef.uns.ac.rs

Therefore, some investors are risk averse and do not want to take on additional exposure in order to achieve higher returns, while on the other hand there are investors who are willing to take on higher risks. The assessment of these two categories is therefore of utmost importance, regardless of the type of investor. In this paper, the portfolio risk will be calculated using the VaR method, for which a portfolio needs to be created. The portfolio will consist of four stock indices, whose weights will be assigned based on mean variance analysis (Takino & Ishinagi, 2022).

As for the time frame, the global picture of the financial world is covered for the period from April 2007 to January 2022. This time frame was chosen to cover the period of both crises that occurred in the 21st century. During this period, the focus is on periods in which the volatility of individual indices and portfolios was higher, with the aim of assessing which crisis had a greater impact on both the indices themselves and the created portfolio. Also, the risk will be assessed by the VaR method and quantified. Therefore, the aim of the work can be divided into two problematic issues: 1. The impact of the crisis on the selected indices, with an effort to assess which one had a stronger impact, and 2. Portfolio creation through mean variance analysis and risk assessment through the VaR method.

Theoretical foundations

Although the main idea is to estimate the impact of crises on the indices and then the portfolio, the knowledge gap will be focused on the VaR method and the mean-variance analysis. In general, VaR as a measure is aimed solely at risk assessment Several researchers recommend the use of historical VaR because this is the simplest method. Conversely, there are some who disagree with it because they believe it can be misleading because it does not capture unexpected changes in the market. Another difficulty encountered in dealing with historical VaR is the question of how large the sample should be to cover all return distributions.

Another type of VaR is delta-normal VaR, which assumes a normal distribution of returns, which is not always the case and is therefore often impractical. In addition, the EWMA method can be used to calculate VaR, with the advantage that more recent events are weighted more. Techniques that address the shortcomings of earlier methods can be computationally demanding. One of the solutions recommended by many authors is the GARCH (Generalized Autoregressive Conditional Heteroscedasticity) method. The GARCH method includes an additional parameter in the volatility calculation and therefore improves the accuracy of VaR. There are also a number of opposing views on the use of VaR, one of which is the use of many calculation methods, which leads to different results (Xiang & Zhang, 2022). In this paper, the authors will apply the calculation of the VaR method using the normal distribution method, as the method that is most prevalent in theory.

Literature review

VaR is a measure of risk that is mainly used to measure the risky position of a bank or investment company. The early 1990s brought uncertainty to the financial market (Angelidis & Degiannakis, 2019), which led to the development of various models for assessing market risk. This influenced the creation of VaR in 1995 by JP Morgan, who published a paper entitled Risk Metrics (Morgan/Reuters, 1995). The document presented what VaR is and how it can be calculated. Even before the paper was published, VaR was proposed as a measure of market risk (Group of Thirty, 1993). According to JP Morgan, VaR is a measure of loss with a given probability over a time horizon. The most important parameter in his formula is the standard deviation as a measure of dispersion. Standard deviation or its squared version - vvariance can be calculated in many ways, e.g. historical volatility, EWMA (Exponential Weighted Average), GARCH, etc. VaR itself can be calculated using simulation models such as historical simulation or Monte Carlo simulation. VaR methods can be classified into three categories: parametric methods - delta-normal approach, non-parametric methods - historical simulation and Monte Carlo methods (Nabella, Maski, & Wahyudi, 2020). This paper includes the delta-normal approach, which assumes a normal distribution of returns.

There are different views in the literature. For example, the historical simulation model has produced better prediction results than other methods used if the sample size is large enough and a higher level of confidence is included (Craig, 2019). Simulation methods have proven to be better than parametric methods when it comes to estimating VaR (Liu & Luger, 2022). However, the disadvantage is that historical volatility is too simple a method to calculate volatility that only uses the standard deviation formula (Marra, 2017). In this basic information, a delta-normal approach is developed that includes the covariance matrix as an additional parameter for the calculation. It belongs to the group of parametric VaR methods, with the main assumption of normally distributed returns (Kulali, 2016).

Problem and goal of the work

The problem of the work focuses on solving the question of which crisis had a stronger impact on individual indices as well as on the entire created portfolio. Given that the economy as a whole has cycles, crises as a phenomenon are not something unknown. What remains unknown is when which crisis will occur, and which sectors will be affected. Directly related to that, this paper tries to answer how which indices behaved during two crises in the 21st century. Mean-variance analysis is first performed to create an optimal portfolio. The purpose of creating an optimal portfolio is to find the best return through a combination of assets. When the optimal portfolio is created, the delta-normal VaR method will be applied. Turning to the subject of VaR, the main intention is to calculate the largest possible loss on a portfolio with a given probability in a given period (Buczynski & Chlebus, 2020).

Methodology

For the purposes of the analysis, four indices were taken into account. Each index represents one asset class, and the indices cover both developed and underdeveloped markets, and are as follows:

1. MSCI World Index: stock index;
2. Vanguard Total Bond Market Index Fund: bond index;
3. S&P GSCI Index – commodity index;
4. Vanguard Real Estate Index Fund Investors - real estate index.

To start the optimization process, it is necessary to collect data for all four indices from April 2007 to January 2022. Years. In this paper, daily data were taken from the website investing.com, with the intention of including all changes. Accordingly, the data will be imported into Python, where all analyzes will be performed.

Analysis of mean variance

This chapter deals with the topic of mean-variance analysis, focusing on the calculation and its fundamental understanding. Mean-variance theory is part of modern portfolio theory developed by Harry Markowitz. He examined the role of the relationship between risk and return and found that all investors are risk averse – they prefer less risk for the same expected amount of return (Reilly & Brown, 2003).

All investors aim to find an individually optimal portfolio. This means creating a portfolio that reflects their own preferences in terms of investment expectations. The optimal portfolio is the portfolio that achieves the highest expected return for a given risk, measured as a standard deviation (Hiller, 2022). This study will use a portfolio created from four different stock indices with the aim of creating an optimal portfolio with minimal risk. This portfolio will contain indices that reflect both developed and underdeveloped markets, as well as equity, bond, real estate and commodity markets. In this sense, the portfolio will reflect the entire market. The optimal portfolio can be calculated based on the closing price, expected return, standard deviation and correlation. The expected return for a portfolio can be calculated as follows (Markowitz, 1952):

$$[E(R]_p) = \sum_{i=1}^{N} w_i \cdot E(Ri) \tag{1}$$

Wherein $E(Rp)$ expected portfolio return, w_i is the weighting of each asset class in the portfolio i R_i are the returns of all asset classes. Therefore, the expected return of the portfolio is the sum of the weighted returns of each asset class included in the portfolio. On the other hand, portfolio variance is not simply the weighted standard deviation of asset classes, because their correlation makes a difference in terms of estimated risk. Through diversification, it is possible to achieve a lower risk in the portfolio than the stock itself. Therefore, the general formula for portfolio risk can be calculated as follows (Hiller, 2022):

$$\sigma_p^2 = \sum_{i=1}^{N} \sum_{j=1}^{N} w_i w_j Cov(R_i, R_j) \quad (2)$$

Where is σ_p^2 the portfolio variance, Cov is the covariance between any two assets. The ith row and jth column is the covariance between variables ii and j. The covariance between the variable and itself is the variance that represents the diagonal entries in the matrix (Hull, 2017).

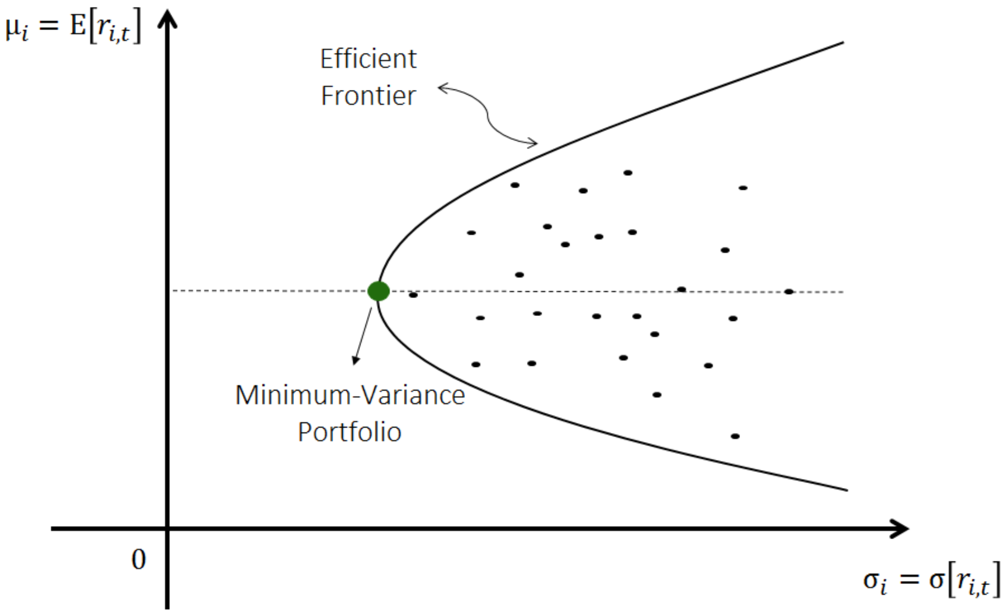
$$\begin{pmatrix} var_1 & \cdots & cov_{1n} \\ \vdots & \ddots & \vdots \\ cov_{n1} & \cdots & var_n \end{pmatrix} \quad (3)$$

Two limitations are given (Markowitz, 1952):

3. $\sum_{i=1}^{n} w_i = 1$
4. $w_i \geq 0$

The first restriction is that the sum of the weights of each asset class must be equal to 1, and the second prohibits the sale of financial instruments that are not owned.

Chart 2: Mean variance analysis



Source: (Goncalves, 2022)

Once expected returns and risk are calculated, all their combinations can be shown on a graph (Goncalves, 2022). The line with optimal portfolios is called the efficient frontier. The X-axis shows the standard deviation and the Y-axis shows the return. Moving to the left of the x-axis results in less variance. Conversely, moving to the right leads to higher variance. Moving up the y-axis results in higher returns, moving down means lower returns. The portfolio furthest to the left on the x-axis represents the portfolio with minimum variance and is shown as a dot. Portfolios that are not in line do not outperform. They offer either higher risk for the same return or lower return for the same risk.

In this paper, as already mentioned, four stock market indices are used, so the formula for the expected portfolio and variance is as follows:

$$E(R)_p = w_1E(R_1) + w_2E(R_2) + w_3E(R_3) + w_4E(R_4) \quad (4)$$

R_2, R_4

(5)

One of the benefits brought about by Modern Portfolio Theory (MPT) is influencing traders to diversify their portfolios instead of concentrating on a single asset class. Although it was based on many restrictive assumptions, it allowed the estimation of portfolio risk and return. Some of the main assumptions are the normal distribution of returns and the rational behavior of investors (Rice, 2017).

Value at Risk (VaR)

VaR is a statistical measure generally used to analyze the market risk associated with financial assets or portfolios (Mensink & Neves, 1999). It dates back to 1995, when JP Morgan published the RiskMetrics paper, which explained VaR as a model. It was defined under that name only in 1995. After being introduced by JP Morgan, it became a widely used measure of market risk exposure. It provides a simple and easy-to-apply quantitative measure for assessing the overall market risk one is exposed to. It is also used by many risk managers to estimate the potential loss of a portfolio over a period of time and at a certain level of confidence.

There are two key elements to describe VaR (Olsen, 2020):

1. Time horizon – the longer the horizon, the higher the VaR. Once daily VaR is calculated, it can be extended to multiple days by multiplying by the square root of time. This is the case when returns are independently and identically distributed (iid) with a normal distribution (Jorion, 2007);

2. Confidence level – the higher the confidence level, the higher the VaR and the more scenarios are covered. The most commonly used probabilities are those of 95% and 99%. These elements can be described in one sentence: " We are X percent certain that we will not lose more than V dollars in time period T" (Hull, 2015). VaR is therefore defined as the amount of money that can be lost over a period of time at a certain level of confidence.

$VaR = \mu + \sigma N^{-1}(X)$(6)

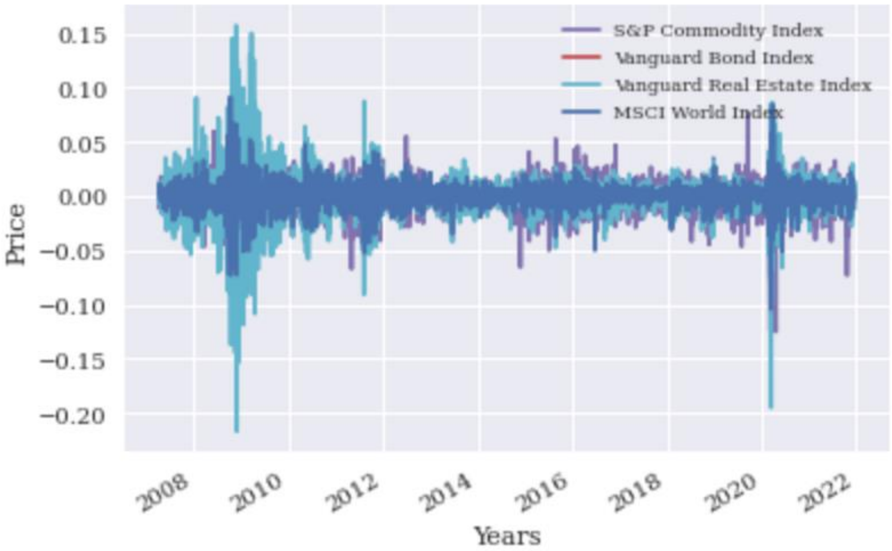
Wherein μ mean value, σ is the standard deviation of the portfolio, $N^{-1}(X)$ is the inverse cumulative normal distribution (Hull, 2017).

It can be said that if the VaR of the portfolio is 1 million per day with 95% certainty, there is only a 5% chance that the loss will be more than 1 million. The lack of VaR is pronounced here, because it does not say anything about the amount of loss if this 5% occurs. For this reason, VaR was often criticized and an additional measure was introduced, i.e. expected loss (ES) or conditional VaR (CVaR), which measures the average of all losses that are greater than VaR (Mendes, 2022). The use of CVaR instead of VaR has many advantages, such as the inclusion of losses higher than VaR, which solves one of the problems associated with VaR, but practice in the financial industry still strongly favors the use of VaR (Chipping, 2014). Another limitation of VaR is that it produces different results depending on the method used (Bedi, Shankar, Agnihotri, & Kalra, 2018). A further discussed disadvantage is that VaR does not have sub-additivity, which means that the VaR of a portfolio can be greater than the sum of the individual VaRs (Meissner, Bhaduri, Linsky, & Yuan, 2021) causing aggregation problems (Chen, Sit, & Wong, 2019). Solutions to most of VaR's shortcomings are found in CVaR, such as subadditivity and convexity (Francq & Zakoian, 2019).

Results of work with discussions

This chapter describes the results of the work. After inputting the libraries and dataset into the Python programming language, the returns for each index are calculated.

Diagram 1: Returns of all four indices



Source: Author based on data from the investing.com Platform

When looking at the presentation of the returns of all four indices in the following diagram, it can be concluded that:

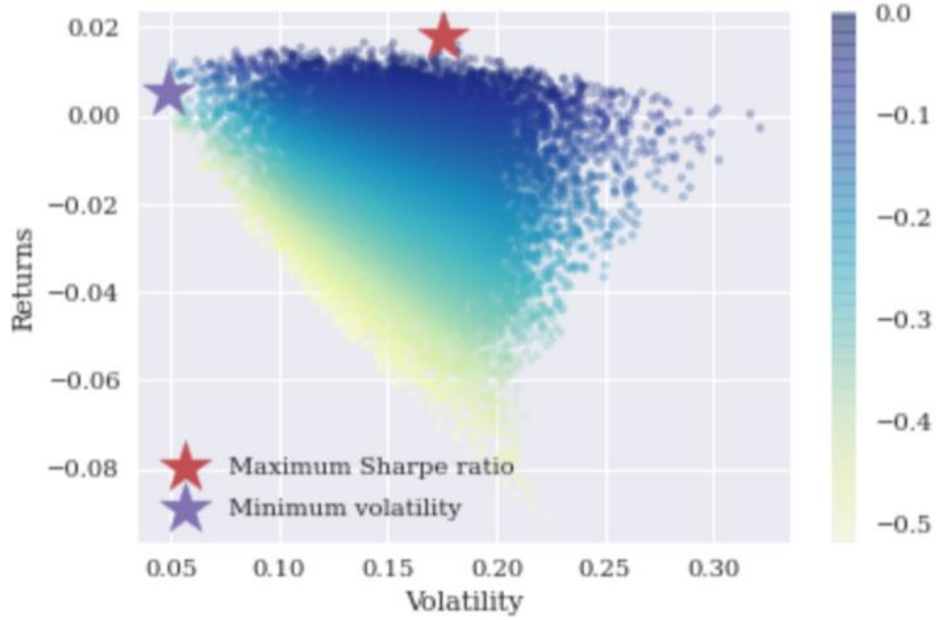
1. The Vanguard Bond index is the least volatile, because its red lines are not visible on the chart, i.e. lowest volatility;
2. The S&P Commodity index is not as pronounced compared to other indices;
3. The MSCI World Index shows higher deviations and deviations, as does the Vanguard Real Estate Index compared to the above indices, and shows the highest deviation during 2008, while the MSCI World Index shows the highest deviations during 2020.

With this result, it is now possible to find the appropriate weighting using portfolio theory. At this point a portfolio can be calculated with minimum volatility by generating random portfolios and finding the lowest standard deviation for the given weights. Based on the previous graph, it is expected, among other things, that the Vanguard Bond index will be relatively more represented and that Vanguard Real Estate and the S&P Commodity index, as the most volatile indices, will receive smaller weights. Since the investor in this case is not prone to risk, the alternative that offers minimum volatility is chosen. A computer calculation using mean-variance analysis suggests the following weights:

1. Vanguard Bond Index - 91.01%;
2. S&P Commodity Index - 1.94%;
3. Vanguard Real Estate Index - 5.90%;
4. MSCI World Index - 1.15%.

Compared to expectations, each point was confirmed, namely higher shares of the Vanguard Bond Index and lower shares of the Vanguard Real Estate and S&P Commodity indices. Diagram 2 shows all possible portfolio combinations. The investor can choose between all the points on the chart, with the maximum Sharpe ratio shown by the red dot and the minimum volatility portfolio by the purple dot. In this case, the investor is risk averse, so the purple point furthest to the left is chosen. This point offers minimum volatility, for a given yield.

Diagram 2: Simulated portfolio optimization based on the Efficient Frontier



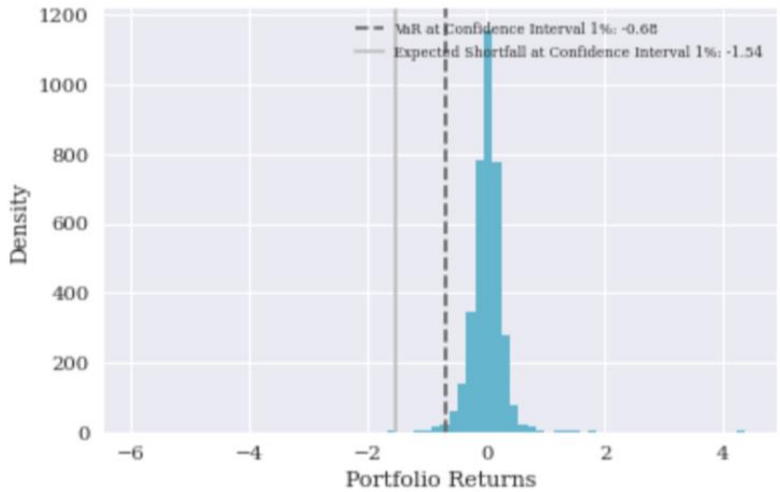
Source: Author based on data from the investing.com Platform

After assigning the weights, the return of the portfolio can be shown graphically for a given period in diagram 3. As can be seen on the specially plotted indices, here too the biggest deviation can be observed at the end of 2008 and 2020. Returns range from -3 to +4% in 2008, while in 2020 they vary from -6 to +4%, which confirms that the crisis in 2020 had a stronger impact on all asset classes, even on the portfolio created for risk-averse investors.

Diagram 3: Weighted portfolio returns

Source: Author based on data from the investing.com Platform

Diagram 4: Histogram of portfolio returns




```
99 % Confident the actual loss will not exceed -0.68 %
Expected Shortfall -1.54 %
```

Source: Author based on data from the investing.com Platform

Chart 4 shows the distribution of all portfolio returns for the period from April 2007 to January 2022 using two measures: the light gray line shows expected loss(ES) and the dark dotted line VaR.

VaR is calculated here as one percentile of sorted negative returns, and one can be 99% sure that the actual loss of the portfolio will not exceed 0.68% of the portfolio value in one day, while the expected loss is always higher and is 1.54%, calculated as an average the biggest losses.

Based on the results of descriptive statistics, it can be concluded that returns are not normally distributed. The standard deviation is lower, the skewness is higher and the kurtosis is much higher than in normally distributed returns. From the results, it can be implied that the returns are slightly negatively skewed, and that the kurtosis is positive - leptokurtic. Here one can recognize the risk of excess, which means that in some cases we get excessive returns, either positive or negative, in statistics known as extreme tails.

Conclusion

This paper deals with various topics related to programming, statistics and financial modeling with the main idea of looking at financial crises in the 21st century. After reading the various available literature, a gap was identified, with the definition of which the paper begins. Then the research methodology is described in detail. Formulas, graphs, parameters are defined and presented, as well as the sources used, so that the reader can use them if a part is difficult for him to understand. The results of calculations and analysis are described in detail.

The main conclusion of this paper is that the crisis in 2020 had a stronger impact on all indices, and led to greater volatility in income than the crisis in 2008. Further, a portfolio created through mean analysis for risk-averse investors confirmed these results, showing the highest volatility in the returns of the entire portfolio in 2020. Also, VaR is calculated in order to assess and quantify risk. Thus, the VaR result quantified with 99% certainty that the loss of the portfolio will not exceed 0.68% of the portfolio value in one day. The expected loss (ES) is always higher and amounts to 1.54%, calculated as the average of the largest losses.

Literature

1. Angelidis, T., Degiannakis, S. (2019). Modeling Risk in Three Markets: VaR Methods for Long and Short Trading Positions. International Conference of Computational Methods in Sciences and Engineering.
2. Bedi, P., Shankar, D., Agnihotri, S., & Kalra, J. (2018). Comparison of VaR Methods: The Case of Indian Equities. Indian Journal of Finance, 33.
3. Buczynski, M., & Chlebus, M. (2020). Old-fashioned parametric models are still the best: a comparison of VaR approaches in several volatility states. Journal of Risk Model Validation.
4. Chen, J., Sit, T., & Wong, H. (2019). Simulation based VaR for nonlinear portfolios. Quantitative Finance.
5. Chipping, T. (2014). Scaling laws: A viable alternative to a VaR. Quantitative Finance.
6. Craig, C. (2019). How to express Risk, Confidence and (Un)Certainty.

7. Francq, C., & Zakoian, J.-M. (2019). Virtual Historical Simulation for estimating the conditional VaR of large portfolios. Journal of Exonometrics.
8. Goncalves, A. (2022). Von Andrei Goncalves: http://andreigoncalves.com/busfin4221-module2/ abgerufen
9. Group of Thirty. (1993). Derivatives: Practice and Principles. Global Derivatives Study Group.
10. Hiller, T. (2022). Allocation of portfolio risk and outside options. Managerial and Decision Economics.
11. Hull, JC (2017). Equities, Fixed Income Securities and Derivatives. New Jersey: John Wiley & Sons.
12. https://web.wpi.edu/Pubs/ETD/Available/etd-050905-104553/unrestricted/Rajesh_Thesis.pdf abgerufen
13. Kulali, DI (2016). Variance-Covariance (Delta Normal) Approach of VaR Models: An Example from Istanbul Stock Exchange. Research Journal of Finance and Accounting.
14. Liu, Y., & Luger, R. (2022). On the way to bias reduction. Emory University.
15. Markowitz, H. (1952). Portfolio Selection. The Journal of Finance, Vol. 7, No. 1.
16. Marra, S. (2017). Predicting Volatility. Lazard Asset Management.
17. Meissner, G., Bhaduri, R., Linsky, L., & Yuan, E. (2021). Portfolio Risk - Beyond Volatility. Wilmott.
18. Mendes, BV (2022). Computing Conditional VaR using Time-varying Copulas. Risk.
19. Morgan/Reuters, J. (1995). Risk Metrics Technical Document. JP Morgan.
20. Nabella, R., Maski, G., & Wahyudi, S. (2020). Systematic Risk Analysis using CoVaR Model: Evidence in Indonesia. Jurnal Ekonomi dan Studi Pembangunan.
21. Olsen, D. (2020). Value at Risk Models. John Wiley & Sons.
22. Rice, B. (2017). The Upside of the Downside of Modern Portfolio Theory. Investments & Wealth Institute.
23. Takino, K., & Ishinagi, Y. (2022). On mean-variance analysis of a bank's behavior. Finance Research letters.
24. Xiang, Y., & Zhang, H. (2022). Comparison and Forecasting of VaR Models for Measuring Financial Risk: Evidence from China. Discrete Dynamics in Nature and Society.