CONSTANT PROPORTION INSURANCE STRATEGY (CPPI) AS A GUARANTEE FOR PENSION FUND ASSETS

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Abstract: Pension funds are of the important members of the financial system, which inject a substantial amount of money into the economy in the form of investments in stocks, bonds, and other securities. On the other hand, they generate income for current employees when they retire. Thus, efficient management of pension funds is of paramount interest to current members of funds. Efficient management in the context of pension funds firstly refers to guaranteed minimum income, which can be ensured through different investment strategies. One of the widely used strategies is the constant proportion portfolio insurance strategy. In this article, we apply this model to test its effectiveness for the Balanced pension fund of C-Quadrat Asset Management Armenia. This model guarantees that the minimum amount of asset value will be received irrespective of market behaviors. As results show, compared to the current portfolio structure constant proportion insurance strategy results in higher average terminal value and return. Besides, it ensures that the minimum floor value will be kept with a low standard deviation.

Keywords: portfolio management, constant proportion portfolio, floor value, risky portfolio, rebalancing, pension fund management.

JEL Classification: C60, G11, G12, G17, G23, G40.

1. Introduction

Investment funds, specifically pension funds have been one of the cornerstones, on which the entire financial system leans. Flows into and out of pension funds determine the main pipelines through which financial assets and cash change hands to hands.

Although pension fund assets comprise a standard portfolio that needs to be managed to generate enough return for investors, using the words "enough return" in the context of pension funds is a little bit bizarre. "What is enough return?" question is one of several highlighted problems that has

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been a subject of debate among fund managers for several decades. Considering pension funds as standard portfolios of financial assets one should not forget about the liabilities that the manager must satisfy before pension funds members. Liabilities do not refer to accounting liabilities but the responsibilities to generate enough income for retirees. For that objective assets of pension funds need to be managed in a defined and specific way. Retirees may require fund managers to earn returns that would be enough to cover inflation losses or be compatible with average real GDP growth. One of the widely used methods in finance, constant proportion portfolio insurance strategy (CPPI), can be applied to somehow guarantee enough returns for fund members. Although this model has started to be used in funds recently its merits can offer a vast improvement over the commonly used standard strategies such as indexing, modern portfolio theory, etc. What is not decent today is the frequent use of “as high as possible return” words by pension fund managers, which can mislead investors when choosing pension plans. Future retirees need not as high as possible returns but enough returns with a specific objective (covering inflation, etc.). This problem is more severe in countries where participation in pension funds is mandatory (such as Armenia) because in mandatory pension funds all employees participate irrespective of their needs. Lack of knowledge may be a real problem when choosing the right plan. Eventually, retirees cannot orientate in requiring a decent level of return which will allow plan managers to mislead investors by taking excessive risks. That is why CPPI can play the role of stabilizer between pension fund managers and members, between whom there is a high level of conflict of interests. CPPI strategy is a method by which some kind of floor value is chosen for fund portfolio assets. The strategy tries not to breach this floor as a minimum acceptable level by investing in risky assets only when the current value of assets is higher than the floor value. When assets value approaches the floor value, strategy automatically rebalances portfolio by allocating more money to risk-free assets. In this way, it tries to keep assets value above floor level. Defining floor value is also flexible. There are several ways to define floor value in terms of pension fund liabilities. Some of them are used in this article.

So, the second chapter introduces the main findings in this field. The third chapter realizes the methodology for research, mainly the CPPI model. The fourth chapter shows the results of the CPPI application and discovers its merits. The fifth and sixth chapters are devoted to conclusions and references, respectively.

2. Literature review

CPPI model has been introduced by Perold André in 1986. Since then, it has become of the widely used methods for portfolio insurance. It gives lots of advantages for pension funds over other used methods for assets management in terms of insurance of portfolio's minimum acceptable value as well as its practical application. After Perold, Fischer Black, Robert Jones (1987), Rouhani (1989), and others extended the CPPI strategy for application for more asset classes and scenarios. Bertrand, Bertrand and Prigent (2001) compared option-based insurance strategy with CPPI and figured out that if multiplicator is allowed to vary during the time it becomes very similar to option-based portfolio insurance. By making them similar they calculated options greeks for CPPI to analyze its behaviors in different market behavior. Mantilla-García (2014) developed strategies using CPPI that allows dynamic multiplicator. What he found is that the time-varying multiplicator is lower than the commonly applied fixed multiplicator, and it gives a higher average return. Besides, he connected the covariances between risky assets and terminal values of CPPI. A. Gulveren (2016) applied CPPI in pension funds taking into account future random income and risky asset path. He developed an exotic option to decrease the probability of gap risk, which is a major problem of CPPI. He compared the CPPI with cushion option and without cushion option and developed an algorithm to apply CPPI with discrete trading dates. Tepocin and Korn (2017) applied CPPI for defined contribution type pension fund. They generated different scenarios for future random income and find optimal values of multiplicator for each scenario. Carvalho, Gaspar and Sousa (2018) have compared CPPI with option-based portfolio insurance and stop-loss insurance strategy. What they find is that CPPI has a path-dependent risk, that is when asset value breaches floor value, investments can be only made in a risk-free asset. They showed that taking multiplicator higher than one will make this problem more severe.

Overall, the most of researches in this field has been devoted to gap risk management and strategy development with time-varying multiplicator.

3. Research methodology

Constant proportion portfolio investment strategy (CPPI)

CPPI strategy, in essence, is a portfolio rebalancing technique, by which a bigger part of assets is allocated to risky assets when the difference between the current value of assets and floor value becomes wider. That is when the current value of fund assets is more than enough for floor value, then we can take more risk and invest more money in risky assets. Conversely, when current account value approaches and tries to breach floor value, then a large part of assets are directed to riskless assets, e.g., government bonds and deposits. This strategy does have several similarities with derivatives contracts, especially with the put option (Agic-Sabeta, 2016, P. 94-95). As buying a put option gives you the right to insure yourself against underlying asset devaluation, and take advantages when an asset rises in value, so is CPPI, which insures against downside risks but gives opportunities when markets are bullish.

Now let's take a look at the main aspects of the CPPI model. Assume that asset value at time t is AV_t; floor value is Fl_t; the length of insurance is T (0≤t≤T); C is the cushion, the difference between asset value and floor value at time t, $C_t = AV_t - Fl_t$; m is multiplicator which, when multiplied by cushion, will show the amount that can be invested in the risky assets; R_t is the risky asset return; r_t is the risk-free return.

At time t+1 asset value can be represented by the following formula:

$$AV_{t+1} = mC_t(1 + R_t) + (AV_t - mC_t)(1 + r_t) \quad (1)$$

for period t+n:

$$AV_{t+n} = mC_{t+n-1}(1 + R_{t+n-1}) + (AV_{t+n-1} - mC_{t+n-1})(1 + r_{t+n-1}) \quad (2)$$

m (multiplicator), which determines weight in the risky asset, can be defined in terms of the risky asset's maximum tolerable loss. If a risky asset plunges in value and loses more than 1/m of its value, then floor value cannot be guaranteed, thus the CPPI model will become useless (Xing, Xue, Feng, Wu, 2014, P. 2-3). Let's assume that rebalancing occurs at every t period and rewrite formula (2) differently to show the importance of multiplicator, supposing that risky asset return at time t is minus 1/m.

$$R_t = -\frac{1}{m} \tag{3}$$

$$AV_{t+1} = mC_t(1 - 1/m) + (AV_t - mC_t)(1 + r_t) \tag{4}$$

$$AV_{t+1} = mC_t - C_t + AV_t - mC_t + (AV_t - mC_t)r_t \tag{5}$$

$$AV_{t+1} = (AV_t - C_t) + (AV_t - mC_t)r_t \tag{6}$$

Taking into consideration, that $Fl_t = AV_t - C_t$,

$$AV_{t+1} = Fl_t + (AV_t - mC_t)r_t \tag{7}$$

It is obvious that $AV_t - mC_t \leq AV_t - C_t = Fl_t$

$$AV_{t+1} = Fl_t + (AV_t - mC_t)r_t \leq Fl_t + Fl_t(r_t) = Fl_t(1 + r_t) \tag{8}$$

From this transformation (formula (8)) it follows that portfolio assets value at time t+1 will be less than or equal to t period floor value increased by risk-free return. This is the most extreme example when it is assumed that floor value increases with the risk-free asset (Carvalho, Gaspar, Sousa, 2018, P. 9-10): if $Fl_{t+1} = Fl_t(1 + r_t)$, then $AV_{t+1} \leq Fl_{t+1}$. If one takes another model for the floor value path, the results will be different. So, if someone assumes that floor value increases with inflation then asset value may even be greater than floor value (only if risk-free asset exceeds inflation). Thus, as an implication from this, we can emphasize that when the floor value growth rate is bigger than the risk-free rate, then m is the inverse of maximum tolerable loss of risky asset value (Mantilla-García, 2014, P. 11-12). After this, it is crucial to define the upper limit of m. In case when floor value increases with risk-free assets or more rapidly than the maximum value of m should be a number, inverse of which is the maximum possible loss of value of the risky asset. As an upper limit for m, we take the inverse of the Expected shortfall (Conditional Value at Risk, CVaR) of the risky asset, because this will be the maximum possible loss of assets, the probability of which is very low (1%, or 5% depending on the level of confidence). CVaR is the average of losses that are bigger than the estimated Value at Risk. One can also use VaR as an asset loss measure, but as a maximum limit, CVaR is more appropriate, because it shows the maximum loss although the probability of getting CVaR is very low. The lower limit of m is 1 because m cannot be less than 1 when assets should lose more than 100% of their value, which is not possible.

Defining floor value is the next crucial task in implementing the CPPI strategy. Usually, floor value is chosen equal to funds' future liabilities, which will ensure that at all times assets value is greater than or equal to liabilities-incidentally, keeping funding ratio (assets/liabilities) at 100% and higher is the main task in pension fund management. There are several ways to define floor value. Some of them are:

1. Percentage of the initial value (P). Floor value is a fixed value for all periods and is calculated as a percentage of AV_0 (P=80%, 90%, 150%, etc.)

Thus,

$$Fl_1 = Fl_2 = \cdots = Fl_T = AV_0 * P \tag{9}$$

2. Maximum drawdown (MD). Maximum drawdown is the difference between the maximum and minimum value of an asset (in percentage) during some period until another maximum value is recorded when a new drawdown is obtained. So, if the MD is 20%, it means that until now asset value maximum loss has been 20% from the peak value recorded during that time. By inserting maximum drawdown into CPPI we instruct the model not to allow assets' value to decrease more than maximum drawdown. At each period t floor value is determined in a flowing way:

$$Max_t = max(Max_{<t}, AV_t) \tag{10}$$

$$Fl_t = Max_t * (1 - MD), \tag{11}$$

where $\text{Max}_{<t}$ is the maximum of asset value until period t; Max_t is the bigger of current asset value and $\text{Max}_{<t}$; MD is the maximum tolerable drawdown in percentage.

That means if asset value does reach a new maximum it becomes the base on which floor value is computed. The floor value remains the same unless a new maximum is reached.

3. **Risk-free asset (r_t) or Inflation (π_t).** This method is used when pension fund manager sicks to keep assets' value above value scaled by risk-free return or inflation (Fulli-Lemaire, 2013. P. 3-4).

$$Fl_{t+1} = Fl_t * (1 + r_t) \tag{12}$$

$$Fl_{t+1} = Fl_t * (1 + \pi_t) \tag{13}$$

The first case (risk-free asset) is the one, for which we have determined the maximum possible value of the multiplicator. If $\pi_t > r_t$, it applies to the second case too.

These three methods for defining floor value can be considered as funds' liabilities from the perspective of the fund manager. Floor values must be preserved at all costs to return guaranteed money to retires. Thus, it becomes liabilities, but this should be confused with liabilities from an accounting point of view.

To use the CPPI model and test its viability we use the asset classes in the actual portfolio structure of the Balanced fund of C-Quadrat Asset management at the end of 2019. Fund mainly invested in deposits, government bonds, stock ETFs, corporate bonds, and 4 bond ETFs. As a starting point, the value of the fund assets is assumed to be 100.

We model the future values of these assets as the Wiener process.

$$A(T)_i = A(0)_i e^{\left[\left(\mu_i - \frac{\sigma_i^2}{2}\right)T + \sigma_i \sqrt{T}\varepsilon\right]} \tag{14}$$

where A is the value of an asset; μ and σ are mean and standard deviation, respectively; z is Wiener process; ε is a sample from a standard normal distribution (Hull, 2012, P. 447-448).

μ and σ are computed as mean and standard deviations of historical data of monthly returns. We simulate two portfolios of ETFs, one with stock investments and another with fixed-income investments. In this way, it is easier to apply strategy than with dozens of ETFs.

For government bonds, we calculate the average and standard deviation of the G5I bond index published by the Central bank of Armenia, which includes all government bonds with maturities higher than 5 years, and simulate future values of the index. We do the same for corporate bonds (by calculating yield spread between corporate and government bonds and creating a similar index).

For deposits, we take the average deposit rates denominated in Armenian dram and USD (USD rates converted to Armenian dram subtracting or adding the average change in the exchange rate), We simulate rates via Cox–Ingersoll–Ross model. The main insight of this model is the mean reversion of rates towards their long-term average.

$$dr = a(\theta - r)dt + \sigma\sqrt{r}dz, \tag{15}$$

where r is the rate; a is adjustment speed; θ is the long-term average of rates; σ is the standard deviation; z is a Wiener process (Hull, 2012. P. 685-686).

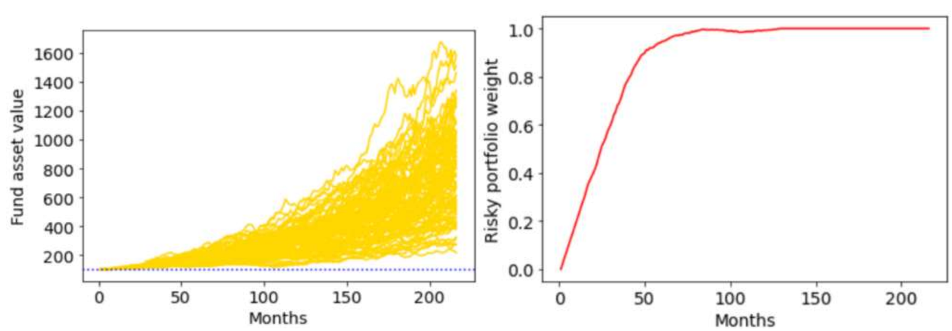
Each asset, and hence fund portfolio has been simulated for 1000 scenarios. The returns of assets, denominated in foreign currency, have been converted to AMD adjusted by FX risk. We take T to equal to 216 months (18 years) as the first investors in funds were born in 1974 and will be paid in 18 years. We assume that there is no contribution from or repayment to fund members.

4. Results

Recall that CPPI is a two-asset strategy. So, we need to somehow convert our five assets classes to two classes. Although it may not fully represent the situation, the variations will not be severe to hinder us from making implications. We construct two portfolios: risky asset portfolio, which we compose with stock ETFs, bond ETFs, and corporate bonds. The weights of each asset class are defined by dividing its value by the sum of values of all three risky asset classes according to the data available at the end of 2019. As a risk-free portfolio, we take government bonds and deposits with weights determined with the same methodology as risky assets. We take deposits as risk-free assets because it does not have a market value, so it does not expose the portfolio to market risk. Although deposits are riskier than government bonds, putting them on risky assets can be problematic too, because risky assets usually have inherent high market risk, and that is why they are called risky. Considering also the fact that CPPI applies only two asset classes, it seems deposits are on the right basket.

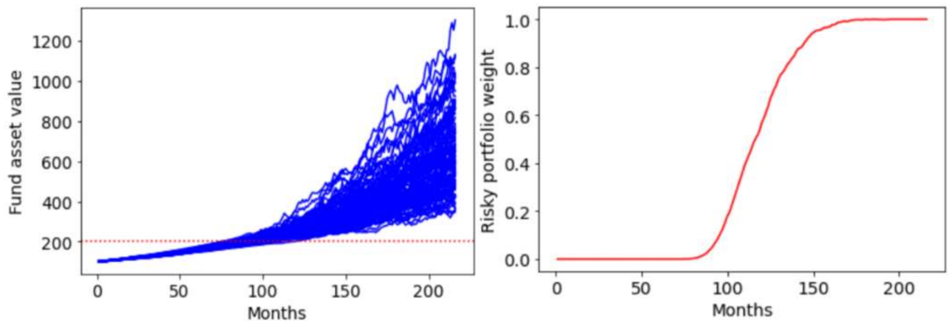
For the floor value, firstly we will apply the fixed percentage method, setting P equals 100% and 200%. These will ensure that fund value never drops below 100 in the first case and 200 in the second case. We take m equal to 3 as commonly used in finance.

Fig. 1. Simulation of fund portfolio values and weights in risky portfolio (CPPI, floor=100)



As we can see for a floor value of 100, CPPI ensures that asset value never breaches floor value and is always above it. For that, strategy gradually increases weights in the risky asset, because when time passes, it becomes less likely that asset value will drop in value below 100. The main drawback is that the standard deviation of terminal value increases.

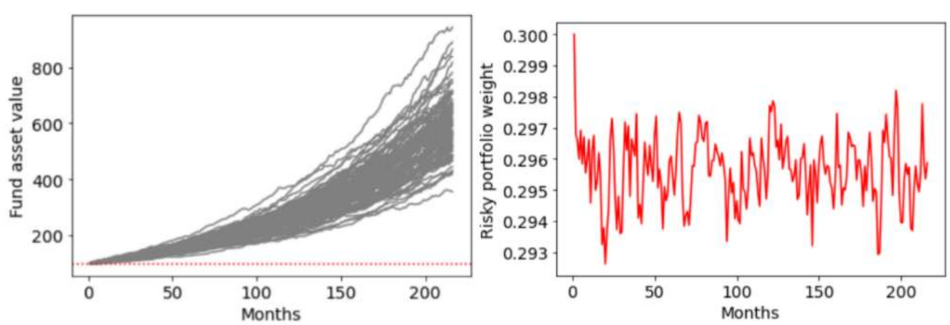
Fig. 2. Simulation of fund portfolio values and weights in risky portfolio (CPPI, floor=200)



For 200 floor value, we encounter very interesting behavior. Since during initial periods asset value is below the floor value of 200, CPPI allocates all money to the risk-free asset until the 200 value is obtained. After that, it gradually increases the weights in risky assets and keeps portfolio value above floor value. It is easy to notice that after that variance of fund assets value increases too because the portfolio starts to include risky assets. The main merit of this method is that it ensures that the fund manager will get the guaranteed value in the end (100 or 200).

Now, let's use the model for Maximum drawdown with MD=10% and m=3.

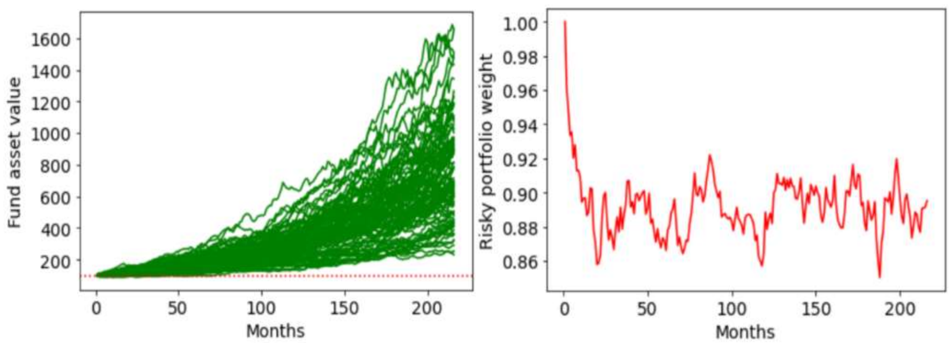
Fig. 3. Simulation of fund portfolio values and weights in risky portfolio (CPPI, MD=10%)



As we see maximum drawdown method gives steady results: risky asset weights change very slightly. This is because historical standard deviations of risky assets were not too high. That is why frequent breaches of floor values have not happened. The most visible advantage of maximum drawdown is the low standard deviation of fund portfolio's terminal values, which is what most fund managers seek to achieve.

Now let's try with MD=20% and m=5, which is a riskier behavior.

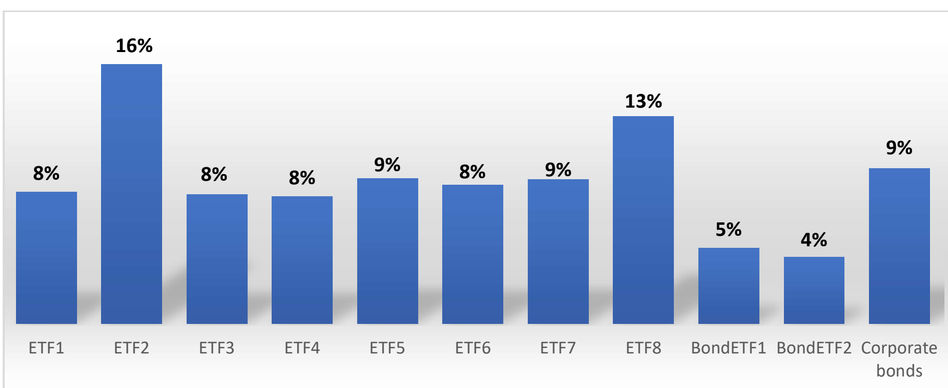
Fig. 4. Simulation of fund portfolio values and weights in risky portfolio (CPPI, MD=20%)



This case is a little bit risky and that is why it gives high weights in risky assets (86%-92%). Although it ensures that Maximum drawdown is kept at acceptable levels, the variation of future values of assets is quite high, which makes this model susceptible to risky assets' abnormal behaviors.

We should also find the upper and lower bounds of the multiplicator. For that reason, CVaR values were computed in the historical method. CVaR was calculated for 7 stock ETFs, 2 bond ETFs and corporate bonds index.

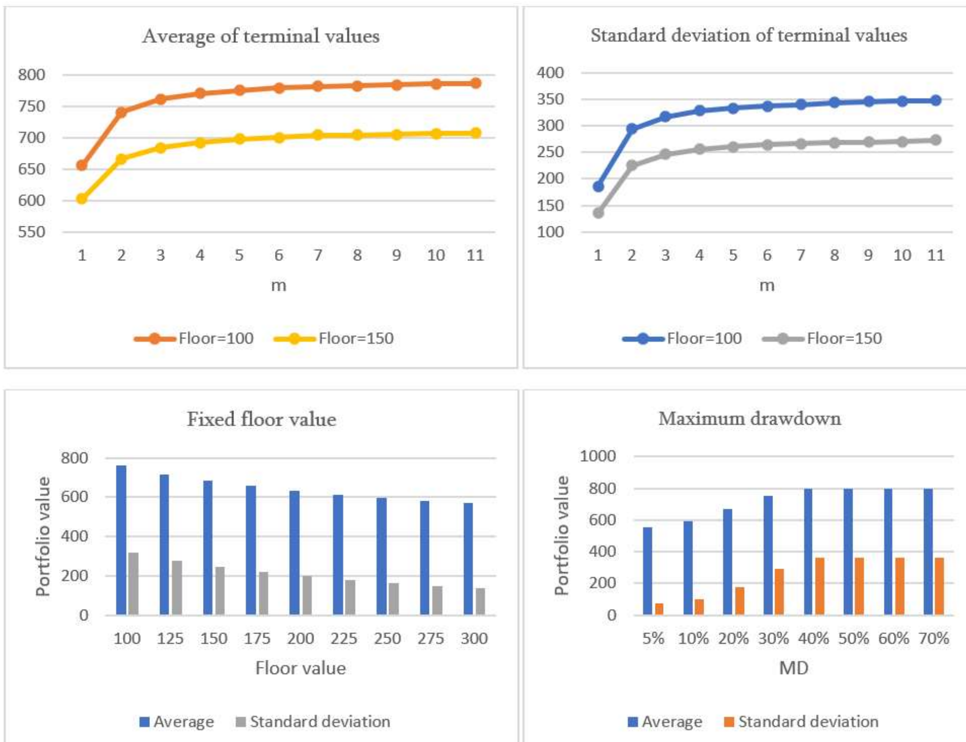
Fig. 5. Expected shortfalls (CVaR) of risky assets



The average expected shortfall was 9%, and therefore the maximum value of m would be 11. Although this method will work efficiently for floor values increased with the risk-free asset (third case), it sets a secure upper level, beyond which higher m values will expose fund assets to high losses.

To see how average terminal values and their standard deviations change as we change multiplicator, let's look at the charts below.

Fig. 6. Behaviors of averages and standard deviations of terminal portfolio values



As we can see, setting higher multiplicator values increases terminal average values of the portfolio. Standard deviations increase too. But the rate of change in average and standard deviation declines as m increases. This means, that there is no need to add values of multiplicator starting from some point. Besides, when we set higher floor value which must be guaranteed, average terminal value, as well as standard deviations decline. That means by increasing floor value we make fund manager be risk-averse, which is essential in pension fund management. Regarding maximum drawdown, we notice identical patterns. When maximum drawdown is chosen to be low (m=3), average and standard deviation of terminal values are low, because strategy allocates a lower percentage of money to risky assets. When we give fund manager flexibility by setting MD higher, the strategy automatically allocates a larger part of investable money to risky assets. Although the CPPI model gives better returns compared to the current portfolio (except for certain floor and MD values), its main advantage is that using the CPPI fund manager can ensure that some fixed percentage of the portfolio will be received by retirees. Besides, the maximum drawdown method ensures that portfolio value never plunges in value significantly.

5. Conclusions

Although the CPPI strategy is widely used in portfolio insurance, its advantages for pension fund management have not been fully realized. We applied the CPPI strategy with different values of multiplicator to check how portfolio value is affected by different levels of riskiness. We figured out that the optimal value for multiplicator is between 3 and 5, beyond which marginal utility of multiplicator declines. Lower m values can be chosen for other mandatory pension funds in Armenian, conservative and fixed income, portfolios of which are mainly composed of riskless assets. We also chose two types of floor values, fixed (static) and maximum drawdown (dynamic). They both turned out to be a better choice compared to the current portfolio strategy of the pension fund. When CPPI is applied, it gives optimal weights in risky and risk-free assets, according to which fund manager will rebalance its portfolio. Considering floor value as a liabilities of pension fund manager towards future retirees CPPI will ensure that fund liabilities will be honored on time and in full amount. Managing fund in this way will resemble defined benefit pension fund, management of which has always been more difficult but efficient than defined contribution funds.

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ՖԻՔՍՎԱԾ ՀԱՄԱՄԱՍՆՈՒԹՅԱՄԲ ՊՈՐՏՖԵԼԻ ԱՊԱՀՈՎԱԳՐՄԱՆ ՍՏՐԱՏԵԳԻԱՆ ՈՐՊԵՍ ԿԵՆՍԱԹՈՇԱԿԱՅԻՆ ՖՈՆԴԻ ԱԿՏԻՎՆԵՐԻ ԵՐԱՇԽԱՎՈՐ

Դավթյան Տ.Մ.

Ամփոփում: Կենսաթոշակային ֆոնդերը ֆինանսական համակարգի կարևորագույն անդամներից են, որոնք մեծ քանակությամբ դրամական միջոցներ են ներարկում տնտեսություն՝ բաժնետոմսերում, պարտատոմսերում և այլ արժեթղթերում ներդրումներ իրականացնելով: Մյուս կողմից դրանք գեներացնում են եկամուտ ներկա աշխատողների համար, երբ նրանք հասնեն կենսաթոշակային տարիքին: Այսպիսով, կենսաթոշակային ֆոնդերի արդյունավետ կառավարումը կարևոր նշանակություն ունի ֆոնդերի ներկա մասնակիցների համար: Կենսաթոշակային ֆոնդերի կառավարման համատեքստում արդյունավետ կառավարումը առաջին հերթին վերաբերում է նվազագույն եկամտի երաշխավորմանը, որը կարող է իրականացվել տարբեր ներդրումային ստրատեգիաներով: Ամենակիրառվող մոդելներից մեկը ֆիքսված համամասնությամբ պորտֆելի ապահովագրման ռազմավարությունն է: Այս հոդվածում կիրառվում է CPPI մոդելը C-Quadrat Asset Management Armenia-ի հավասարկշռված ֆոնդի համար՝ դրա արդյունավետությունը թեստավորելու նպատակով: Այս մոդելը երաշխավորում է, որ ակտիվի որոշակի նվազագույն մեծություն կապահովագրվի անկախ շուկայի վարքագծից: Ինչպես արդյունքները ցույց են տալիս, ֆիքսված համամասնությամբ պորտֆելի ռազմավարությունը հանգեցնում է ավելի բարձր միջին վերջին արժեքի և եկամտաբերության ի համեմատ պորտֆելի ներկա կառուցվածքի: Բացի այդ, այն երաշխավորում է, որ նվազագույն floor արժեքը պահպանվի ցածր ստանդարդ շեղումով:

Բանալի բառեր: պորտֆելի կառավարում, ֆիքսված համամասնությամբ պորտֆել, floor արժեք, ռիսկային պորտֆել, կենսաթոշակային ֆոնդի կառավարում:

СТРАТЕГИЯ ПОСТОЯННОГО СТРАХОВАНИЯ (CPPI) КАК ГАРАНТИЯ АКТИВОВ ПЕНСИОННОГО ФОНДА

Давтян Т.М.

Аннотация: Пенсионные фонды являются важными участниками финансовой системы, которые вливают в экономику значительные суммы денег в виде инвестиций в акции, облигации и другие ценные бумаги. С другой стороны, они приносят доход нынешним сотрудникам после выхода на пенсию. Таким образом, эффективное управление пенсионными фондами представляет первостепенный интерес для действующих участников фондов. Эффективное управление пенсионными фондами в первую очередь связано с гарантией минимального дохода, который может быть обеспечен с помощью различных инвестиционных стратегий. Одна из широко используемых стратегий — это стратегия страхования портфеля с постоянной пропорцией. В ~~этой~~ статье ~~мы~~ применена~~им~~ эта~~у~~ модель, чтобы проверить ее эффективность для Сбалансированного пенсионного фонда C-Quadrat Asset Management Armenia. ~~Эта~~ М~~м~~одель гарантирует получение минимальной стоимости активов независимо от поведения рынка. Как показывают результаты, по сравнению с текущей структурой портфеля стратегия страхования с постоянной пропорцией приводит к более высокой средней конечной стоимости и доходности. Кроме того, это гарантирует, что минимальное значение будет поддерживаться с низким стандартным отклонением.

Ключевые слова: управление портфелем, портфель с постоянной пропорцией, минимальная стоимость (floor), рискованный портфель, ребалансировка, управление пенсионным фондом.