Sequence-of-returns risk in the management of retirement savings

Andrzej SOŁDEK, Maciej STACHNIO[1]
Warsaw School of Economics, Triple A - Risk Finance Poland

Abstract. The purpose of the paper is to show the importance of the sequence-of-returns risk in the management of retirement savings. In the process of regular accumulation and withdrawal of savings, the sequence-of-returns risk may lead to significantly different results when it comes to the accumulated assets and benefits paid to people with the same saving history and realised average investment rates of return. The sensitivity to sequence risk increases along with the growth of the accumulated pension portfolio. The peak sensitivity period has been termed the retirement risk zone and, according to the results of a series of analyses, covers a dozen or so years before and a few years after retirement. The impact of the sequence of returns is very important in a defined contribution pension systems where investment risks are borne by individual investors. At the same time, the risk of sequence of returns is the most poorly recognised and analysed risk in the process of retirement saving. The planned introduction of employee capital plans in Poland inspired the analysis of the impact the sequence of returns on the Polish market has on the accumulation and withdrawal of retirement savings. This paper presents the results of research into the impact made by the sequence of returns on retirement assets accumulated on the US, Japanese and Australian markets. These show considerable diversity among the accumulated assets and the replacement rate of retirement savers resulting from the overall effect of historical market volatility and the sequence of returns. The purpose hereof is to demonstrate how, in Polish conditions, the behaviour of contribution parameters that have a decisive impact on the saving results and rates of return may affect the accumulated assets and withdrawn benefits. Simulation of a potential participant in employee capital plans confirms a very high sensitivity to the sequence of returns over the period of the retirement risk zone. It is a critical trait that must be taken into consideration while determining the glide path in the phases of saving and distribution of benefits. The sequence-of-returns risk should also be taken into consideration while assessing the efficiency of investment strategies in the management of retirement savings.

Key words: sequence-of-returns risk, portfolio size effect, retirement savings.
JEL Codes: G11, G17, J32.

---

[1] Contact with authors: Andrzej Sołdek, Collegium of Business Administration, Warsaw School of Economics, al. Niepodległości 162, 02-554 Warszawa, Poland; e-mail: a.soldek@pnet.pl. Maciej Stachnio. e-mail: macieks89@wp.pl.

1. Introduction

The launch of employee capital plans is an element of the governmental Responsible Development Strategy. The main purpose of the new retirement solution is to promote assets-backed retirement savings[2]. Concurrently, the development of the funded pension pillar in Poland may indirectly result in the increase in pensions owing to higher economic growth. The so-called auto-enrolment, which is a commitment by employers to offer employees participation in a retirement plan, is supposed to be a key tool to assure high participation of employees in capital plans. It should be expected that, similarly as in other markets[3], in terms of investment strategies, most participants will not make independent investment decisions and they will be assigned default options. The draft law specifies that for those people who do not select an investment strategy, the so-called target date funds will be offered[4]. Just as auto-enrolment solves the problem of inertia in the process of making the decision to start saving for retirement, a well-designed default option is a chance to offer investment and a cost-efficient method of retirement saving.

The purpose of this paper is to show the impact of the sequence-of-returns risk on the management of retirement savings. Depending on the realised path of rates of return on the capital market, the savers who, during accumulation, paid in the same amount of contributions and gained the same average rate of return and volatility over the entire saving period, may accumulate significantly different assets and receive different amounts of retirement benefits. The impact of sequence goes up along as the accumulated assets grow. The peak sensitivity period, termed the retirement risk zone, covers a dozen or so years before and a few years after retirement [Milevsky et al. 2015, p. 52]. The presented analyses of the US, Japanese and Australian markets, made based on historical rates of return, show a significant dependence of the accumulated assets and withdrawn retirement benefits on the sequence of returns and effect of portfolio size. Similar conclusions result from a simulation taking into account the income parameters and historical distribution of rates of return for the Polish market. High sensitivity of the result to the sequence of the rates of return in the retirement risk zone, demonstrated by the final amount of accumulated assets and withdrawal amounts, is a critical feature which should be taken into consideration when determining the glide path in the saving and benefits distribution stages[5].

---

[2] The role of capital pension schemes is described e.g. by Nyce. et al. [2011, pp. 272-274]
[3] On the US and UK markets most participants do not make independent decisions and their contributions are managed in line with the strategy selected by the pension plan's sponsor. The review of results of research regarding the process of making investment decisions by participants in pension plans is presented in Schroders [2014, p. 13].
[4] It offers the same strategies for people of similar time before retirement, and the glide path in the saver's life cycle assumes that the share of risk assets decreases as the retirement age approaches. In the decumulation phase, this share remains at the minimum level.
[5] Since the 2008 crisis, a broad debate has been ongoing regarding the proper allocation of assets in life-cycle funds. A particularly hot dispute occurred in the United States and pertained to the level of exposure of target date funds in the years preceding the retirement.

2. Sequence-of-returns risk, portfolio size effect, and retirement risk zone

The main parameters affecting the volume of accumulated assets and retirement benefits include the amount of contribution, periods of retirement savings and withdrawal, and the rate of return on invested capital. Numerous simulations demonstrate this relation in various markets[6]. The 60:30:10 principle proves that for the retirement result, the rate of return is of primary importance. It shows that per one zloty withdrawn as a retirement benefit, 10 groszy came from contributions, 30 from profits realised during the accumulation period and as many as 60 groszy from profits in the withdrawal phase [Ezra 2009, pp. 44-45]. This principle is a good illustration of the well-known compound interest mechanism in long-term saving. It stresses the importance of rates of return as a key determinant of the accumulated assets and retirement benefits withdrawn. In particular, it draws attention to the importance of market rates of return in the decumulation realised in form of programmed withdrawal. With this type of retirement benefit, the accumulated assets are still invested in capital markets. It should be noted, that the authors assumed a constant, deterministic rate of return from a retirement portfolio over the entire period of accumulation and withdrawal of benefits. The simplification adopted by the authors results in the analysis fully overlooking the impact of the market risk and sequence of returns, which are of key importance for generating retirement savings and benefits. The volatility of market rates of return and its impact of retirement savings is an issue which has been analysed in depth both by academics and market experts. The sequence-of-returns risk is definitely less known and researched.

The sequence-of-returns risk is defined as a dependence of the savings result on the unfavourable order of rates of return [Basu et al. 2012, pp. 6-7]. It occurs in the savings process, wherein portfolio payments or withdrawals are made. In the case of a lump sum contribution, the result depends only on the rates of return; their order is irrelevant. Persons with the same history or payments to and withdrawals from the fund and with the same average rates of return and standard deviations, in conditions of a different order of rates of return, may gain significantly different values of accumulated assets and withdrawn benefits. In the definitions of sequence-of-returns that may be found in literature, some authors limit the risks only to the withdrawal phase. They indicate higher sensitivity of the amount of withdrawn benefits to the order of rates of return than in the accumulation phase. Others stress the weight of the risk for investment solutions during the accumulation phase [Basu et al. 2012, pp. 6-7].

---

[6] For the US market, according to Schroders' analysis [2014, p. 15], a person starting work at 25 years of age with initial remuneration of USD 40k a year, with a 1% increase in remuneration in real terms, and retiring at 65 years of age at 15% contribution, will obtain replacement rate of 56%, at a rate of return totalling 3.9% in real terms, and 45% replacement rate at 2.9%. At a contribution of 5%, the required rates of return to obtain 56% and 45% replacement rate amount to, respectively, 8.3% and 7.5%. At 10% contribution, the required rates of return are 5.6% and 4.7%, whereas at contribution at 20% - 2.6% and 1.5%. For contribution at 25%, the required rates of return are 1.5% and 0.4%.

The impact of negative rates of return depends on their placement over the entire saving period. If the negative market conditions occur at the beginning of the saving process, there is still time for making up. Unfavourable consequences of negative rates of return at the initial stage of the saving process are mitigated by the impact of new contributions and the effects of investing them. If, however, negative rates of return occur at the end of the accumulation phase, and the withdrawals are realised as annuity, then such decreases translate directly to the entire retirement capital and, in consequence, reduction of the benefit paid out over the entire retirement period[7]. Sensitivity to the rates of return grow along with the increase in assets accumulated in the portfolio. Subsequent rates of return influence the contribution and investment result accumulated to date. Along with the increase of assets in time, the share of investment results in the change of portfolio value grows, and the significance of contributions drops. A symbolic point, at which rates of return gain higher importance for the result, is when accumulated assets exceed the present value of future contributions. From then on, the result of investing accumulated assets will be more important than the effects of investing future contributions. This key determinant was indicated by Basu and Drew [2009], who introduced the notion of the portfolio size effect into the literature. The importance of the relation between the retirement saving result and the cumulative effect of returns sequence and portfolio size was also stressed by Shiller [2005]. Similarly, in Neuman's opinion [Basu et al., 2012, pp. 6-7], for a saver in the second half of the capital accumulation period, the order of returns is as important as their amount. The author stressed that it is potentially the highest retirement risk, of which the clients are unaware.

The sequence of returns is also very important in the first years of withdrawal of benefits in the form of programmed withdrawal or withdrawal by instalments. The rates of return realised in that period influence the assets which, reach their peak over the life-cycle. The need to realise a part of portfolio if negative rates of return occur causes a significant reduction of the period the remaining funds will suffice for. Milevsky and Macqueen [2015, p. 51] presented an analysis of the sequence of returns over the decumulation phase based on an example of a person who at 65 years of age realises regular withdrawals of USD 750 a month from a portfolio of USD 100k. The authors showed three variants of the order of returns with the same average of 7%. In the worst-case variant in the first year of benefits withdrawal, the portfolio's rate of return was negative and totalled -13%. In the variant in which the benefit was paid out for the longest period, the rate of return in the first year of withdrawals was +27%. The difference between the funded retirement withdrawals between extreme variants was 14 years.

Many authors indicate the period of the highest sensitivity to rates of return when the assets gain their maximum value as decisive for the retirement result. Rates of return

---

[7] This is well illustrated by Schroders [2012]. Assets accumulated after 40 years of savings will be by 15% higher if the negative rate of return occurs in the 10th year of savings, when compared to a drop thereof in the 30th year. If the rates are positive at +20% at 50 years of age, the final assets will go up by 10%, and if the same rate of return occurs at 20 years of age, this growth will be 5%.

are of key importance for the amount of assets accumulated at the end of the saving period and the amount of benefits withdrawn, whereas the inflow of contribution is of secondary significance. To stress the sensitivity to rates of return over the period in which the accumulated assets are the highest, Milevsky and Macqueen [2015, p. 52] deemed this period the retirement risk zone. It is most often determined as the 10 years before and 5 years after retirement. The dependence of investment results on asset allocation makes that the decision about portfolio structure in the retirement risk zone is of key importance. The allocation in this period is a significant success factor in retirement saving. This is well illustrated by the academic debate between the advocates of the life-cycle strategy and those who recommend opposite strategies. The first indicate the need to preserve the value of the accumulated capital through the reduction of exposure to risk assets in the risk zone and to maintain such low allocation over the withdrawal period [Pfau 2009; Poterba et al. 2006]. The advocates of the strategy based on increasing the share of risk assets and maintaining allocation in equities at high level in the entire risk zone stress the significance of this period for capital appreciation [Basu, Drew 2009].

The impact of the sequence of returns, combined with portfolio size, is well illustrated by simulations in which the value of accumulated assets obtained with historical rates of return is compared to outcomes of variants with ascending and descending order of returns. Such an analysis makes it possible to show that given the same composition of the rates of return sample, the order of rates in individual variants of permutations brings various results of savings. Although the occurrence of extremely positive or extremely negative sequence of rates of return is highly unlikely, such simulations show well that the assessment of investment strategy's efficiency, from the savers' point of view, must not be limited to the distribution of the rates of return and their sequences must not be overlooked.

The described relations are very important for those who put their savings in defined contribution retirement funds, in which the investment risk is borne individually. These funds do not offer redistribution of profits between various age groups of contributors, and the value of accumulated assets depends on the contributions paid and individual path of realised rates of return in saving period. In their investment decisions, retirement savers must take into account, among others, market risk, inflation risk and longevity risk. The sequence-of-returns risk and its significant impact on the saving result is one of the least realised and researched retirement risks. One of the reasons for low knowledge among experts and savers, may be the method of measurement and assessment of investment results. The global standard of presenting investment results [GIPS 2012] recommends applying a time-weighted rate of return to assess investment efficiency. It is a measure wherein the impact of flows in and out of the portfolio is eliminated. Rates of return calculated in this manner allow the comparison of results between competing products or assessment of results against benchmarks, i.e. relevant stock market indexes. The flows are not taken into consideration due to an assumption that the managers have no influence on the dates payments and withdrawals made by clients. For investment funds, in which

lump sums are usually paid, the rate of return calculated based on time and money-weighted formula is the same. The investment effect for the client and rate of return at which the manager is evaluated, are coincident. If flows in and out of portfolio occur, which is typical of long-term saving schemes and retirement funds, the internal rate of return (i.e. money-weighted rate of return) is the proper measure of investment efficiency for the saver.

The method of measuring, reporting and assessing the results is based, in line with market standards, mainly on time-weighted rates of return. Similarly, incentive schemes and a manager's performance ranking are based on rates of return calculated in this manner. During the design and assessment of investment solutions, attention is focused on the risk adjusted rate of return, and the sequence risk is overlooked. It should be stressed that the time-weighted rates of return over the saving period are not identical with investment effects for clients. This problem was noticed by the Canadian regulator, who introduced the obligation to report the money-weighted rate of return in annual statement presented to the client [RBC Wealth Management 2016]. In Poland, before fundamental changes in the investment policy of Open Pension Funds (OFE) were introduced in 2014, the Polish Financial Supervision Authority and Analizy Online [Analizy Online 2014] published investment results based both on money-weighted and time-weighted rates of return. Also in later analyses, experts of the company Analizy Online [2017], when justifying the selection of measures to assess the investment results of OFE, indicated that due to the nature of savings accumulation based on regular payments, the internal rate of return (IRR) would be adopted to analyse OFE's rates of return. In academic research and market reports assessing the efficiency of retirement funds, however, time-weighted rates of return were dominant. Rankings of funds and presentations of results in popular press articles were composed in the same manner. The importance of portfolio size and sequence of returns has not been sufficiently analysed in the statutory reviews of the retirement system, conducted twice[8]. The conclusions from the analysis of investment efficiency of OFE and indexation of accounts with Social Insurance Institution (ZUS) were supposed to be used as basis for decision as regards the future of the capital pension pillar. The discussion of the methods employed to evaluate the results obtained by OFE and ZUS showed insufficient awareness of the difference resulting from the application of money or time-weighted rates of return to assess the efficiency of the portfolio management from the point of view of their participants' interests. The importance of the money-weighted rates of return and order of rates of return for the assessment of the efficiency of investment strategies for the client was stressed in the dispute between government experts and professors Otto and Wiśniewski [2013, p. 4][9]. Also the experts of the Pension Fund Societies'

---

[8] Cf. the Ministry of Labour and Social Policy and the Ministry of Finance [2013], Review of the operation of the pension system. Security owing to sustainability and Information of the Council of Ministers for the Sejm of the Republic of Poland regarding the consequences of the acts of 25.03.2011 and 06.12.2013, along with proposed changes, draft dated 31.10.2016.

[9] The authors presented the sensitivity of the internal rate of return to the order of increase or decrease, thus putting the 13 historical rates of return in ascending and descending orders.

Chamber of Commerce [IGTE 2016, p. 7], in public consultations of the draft review, stressed that during the assessment of the effects of long-term saving, one should focus on the sensitivity of the accumulated capital to the sequence of returns and portfolio effect. They stressed that the negative market trend over the last two years of the analysed period on the Polish market had a significant impact on the comparison presented in the draft review. In both reviews of the pension system, when comparing the balance of account with OFE with those handled by ZUS, an explanation was missing that the results were largely affected by negative rates of return occurring at the end of the assessed period. The comparison in the second review also failed to take into consideration the fact that the sequence-of-returns risk was mitigated by the pre-retirement transfer mechanism and the comparison should be made for the combined effect of OFE account and the portion transferred to the ZUS sub-account.

3. Sequence-of-returns risk and portfolio effect risk on the largest retirement markets

Using the long history of mature capital markets, one can analyse the impact of the volatility of rates of return and sequence risk on the results of retirement saving. An interesting simulation of the hypothetical replacement rates for cohort saving for retirement between 1940 and 2010 for the US and Japanese markets was presented by Antolin et al. [2009]. The analysis shows the combined impact of market and sequence-of returns risk on people saving in these markets, with assumptions of typical income and work experience[10]. The simulation shows considerable diversity of replacement rates for individual cohorts in both markets. The replacement rates for the US market, at 60% allocation in equities and 40% in bonds, were between 20-50. For Japan this diversity was higher and ranged from a few to 80%. High volatility of benefits results both from different average rates of return over the analysed 40-year periods and from the sequence of returns. It is worth noting that the lowest values of replacement rates occurred for those cohorts for which the last years of capital accumulation coincided with market crises (1974-75, 2008).

The difference between the average rates of return and the actual investment effect for the customer is well-illustrated by the analysis of Morningstar experts [2017] who specialise in the assessment of effectiveness of mutual and pension funds. In their research, the target date funds were compared with balanced fund as a typical investment selected by a retail client[11]. Over the analysed period of 2006-2016, the balanced fund recorded higher rates of return and lower risk measured by standard

---

[10] This example assumes that the saver starts working at 25 years of age, continues working for 40 years and retires at 65. The annual contribution paid is 5% of remuneration, an increase in remuneration of 2% a year in real terms is adopted. It was assumed that the withdrawals are realised in the form of 20-year term annuity, the price of which results from long-term interest rates upon conversion to annuity. In this case the rates of return during the withdrawal period affect the volatility of benefit and the analysis of the impact made by sequence-of-returns is limited only to the accumulation phase.
[11] Allocation of the balanced fund in equities was at 60%.

deviation than all target date funds analysed to date. In the analyses, the closing balance of a one-off investment of almost USD 50k in a balanced fund was compared with the same amount paid in regular contributions by a participant in target date funds. They (apart from funds with the shortest investment horizon), despite having attained lower average rates of return than the balanced fund, demonstrated higher value of accumulated assets at the end of the analysed period thanks to the advantageous order of rates of return. The authors stressed that the principal reason for the better effect for clients of target date funds were the relatively better rates of returns of these funds over the final years of analysis, when the size of the portfolio was higher.

Considerable diversification of replacement rates, similarly as in the American and Japanese markets, is demonstrated by the simulation of the result of retirement saving in Australian funds [Basu et al. 2012, pp. 13-14]. Analysis of the Australian market is interesting for two reasons. Firstly, it is a market with the largest share of defined contribution funds[12]. Another factor is the clear growth in equities volatility recorded in the second half of the analysed period. Equities are the main category in which the contributions of participants in Australian retirement funds are invested. Based on the historical data of rates of return in the period of 1900-2011 from the Australian and US 73 40-year paths of realising rates of return were calculated[13]. The results of simulation showed that the highest retirement capital obtained by the savers who retired in 2000 would have been by 380% higher than that recorded by savers with lowest capital who retired in 1974. The authors of the report stress that the diversity of the amount of accumulated capital results from the difference in average rates of return and their sequence. To conduct a detailed analysis of these two effects, the paths of rates of return which yielded the worst and best result and two paths with the same amount of accumulated assets were compared. In the worst-case scenario, over the last ten years, seven rates of return were below the average rate of return from the entire period, and the rate of return in the penultimate year was lower than average by two standard deviations. For the best result, the rates of return over the last ten years were better than the long-term average. What is also interesting is the comparison of two paths completed in 1940 and 1978 which yielded the same result of accumulated assets, amounting to 1.9 million. Despite the fact that the arithmetical mean rate of return for the path completed in 1978 was by 71 base points higher and the geometric mean was by 33 base points higher than the path ending in 1942, the unfavourable order of returns in path ended in 1978 over the last ten years levelled the potential benefit resulting from the higher average rates of return. These examples are a good illustration of the impact of sequence of returns on the value of accumulated retirement savings.

---

[12] According to the Towers Watson [2011] report, in 2010 approx. 80% of retirement assets in Australia were accumulated in fixed-contribution fund, whereas this share in the US was 57%, 40% in the UK and only 2% in Japan.

[13] In the analysis [Basu et al. 2012, pp. 6-7] a simplified allocation of assets in default option was assumed. The retirement portfolio was made up in 36% of Australian equities, 30% US equities, 16% national bonds, 10% US treasury bonds and 8% of money market bills. The nominal mean rate of return for such a portfolio over the period of 1900-2011 amounted to 10% at standard deviation of 11%.

4. The sequence-of-returns risk and portfolio effect risk on the Polish market

To demonstrate the significance of sequence of returns, the authors of this article conducted an analysis taking into consideration the characteristics of a potential member of the projected employee retirement plans. It was assumed that the participant joins the plan at 25 years of age. Initial earnings are equal to the national average at PLN 4,000. In the following years the earnings will grow in line with the adopted career curve, with the most dynamic growth occurring between 26 and 35 years of age (annual growth of 7% was assumed) and between 36 and 45 years of age (5% annually). Contribution of 4% of gross remuneration is transferred to the retirement plan (2% of the employee's contribution, 1.5% of employer's contribution and payment from the budget). In total, during 40 years of retirement saving PLN 204.7k will be paid. The period of participation in the plan was divided into accumulation phase (accrual of savings for future retirement) and decumulation phase (withdrawal of retirement payments). The second one being assumed as the time when retirement savings are still invested on the capital market. To adequately illustrate the effects of sequence of returns and separate them from the impact of changes in allocation in time (which occurs in the life-cycle strategies), in the analysis of the accumulation phase constant allocation at 60% on risk assets ("equities") was assumed and 40% in safe assets ("bonds"). In the analysis of the decumulation phase, 100% allocation in bonds was assumed. Data regarding historical rates of return date back to 2002-2017. As rate of return from equity the changes in the Warsaw Stock Exchange index were assumed (taking into account dividends), for bonds annual rates of return from the Citigroup Poland Government Bond Index All Maturities Local Terms[14] were used. Annual rates of return from the period of 16 years were repeated 2.5 times. In total, all this gives 40 years of rates of return, which corresponds to the assumed horizon of accumulating retirement savings for a 25-year-old joining the programme.

4.1 Impact of sequence in the accumulation phase

The simulation included a forecast of the value of accumulated assets for three paths of rates of return. The first 40-year path covers the 2.5 times repeated annual historical rates of return for balanced portfolio (60% equities and 40% bonds). Two other paths include rates of return in an ascending and descending order, respectively. These artificial rate of return paths are a good illustration of the importance of the sequence of returns, as all the moments of distributions are the same in all variants. The results of simulation are presented in Figure 1 and Table 1.

---

[14] The average annual geometric nominal rate of return from the WSE index for the years 2002-2017 totalled 10.0% (arithmetic mean 13.4%) at standard deviation of 25.8%. The maximum annual rate of return from the WSE index in this period totalled 46.9% (in 2009) and the highest negative annual rate of return amounted to -51.1% (in 2008). For the SBPLL bond index, the geometrical annual rate of return was 6.5% (arithmetic mean of 6.6%). Volatility measured with standard deviation was 5.2%. The highest value of the annual rate of return from bonds over the 16 analysed years was 20.0% (recorded in 2002) and the lowest value was 0.2% (for 2016).

The internal rates of return on ascend path are almost twice as high as in the historical path and in the descending path - lower nearly by half. Very high diversity was recorded in the values of assets at the end of the accumulation period. With the same set of rates of return, the result of the ascending path is over 8 times higher and the result of the descending part is 3.5 times lower when compared to the historical path result. These huge differences result solely from sequence of returns.

Table 1. Results of saving in a retirement plan – accumulation phase

Retirement plan	Returns path in the accumulation phase		
	Historical	Descending	Ascending
Total contributions paid (nominal value)	204,707	204,707	204,707
Assets at the end of the accumulation phase (nominal value)	1,686,096	486,584	14,300,274
Internal rate of return (IRR) during accumulation phase	9.9%	4.5%	18.0%

Source: Authors' own calculation.

Figure 1. Assets in the accumulation phase (year end) - logarithmic scale (log10)
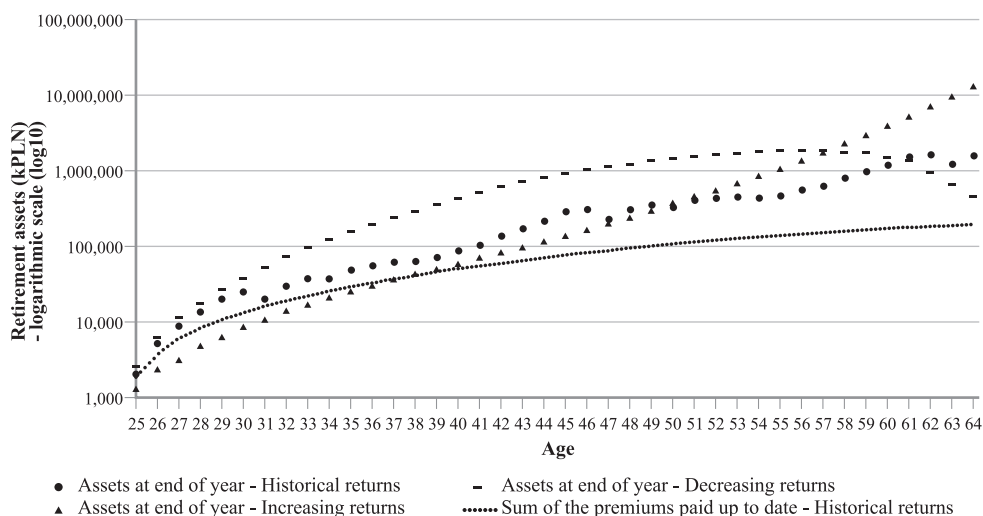

Figure 1 shows that despite a long domination of assets of the descending returns path which occurred for as many as 33 of 40 years of accumulation (due to very high returns and quick accumulation in the initial period), the deeply negative returns in the pre-retirement period fully cancel this effect out, yielding the final result worse than the historical path. On the other hand, the laborious accumulation

in the ascending returns path, although burdened with losses in the initial saving period (deep, in relative terms although minor in nominal terms), brings, however, a perfect end-effect owing to high returns in the pre-retirement period. The final result of accumulation in historical path is somewhere between the results of the descending and ascending paths. Just based on this simple relation of order, one may suspect that the deciding stage for the diversification of the saving result is the pre-retirement process.

We obtain interesting results when determining internal rates of return and assets at the end of the accumulation phase for 10,000 random historical permutations of historical rates of return[15]. Table 2 presents the distributions of these permutations' statistics. The distribution of internal rates of return in terms of order (position statistics) corresponds to the distribution of assets (it is a property of internal rate of return (IRR)) but is more symmetrical. For IRR, the mean is very close to median, whereas for assets, the mean is clearly higher. The distribution of assets demonstrates a strong right-side asymmetry, has a "heavy" right tail and maximum over seven times higher than the mean or median.

Table 2. Statistics of assets distribution at the end of accumulation phase and IRR in 10,000 random permutations of historical returns path

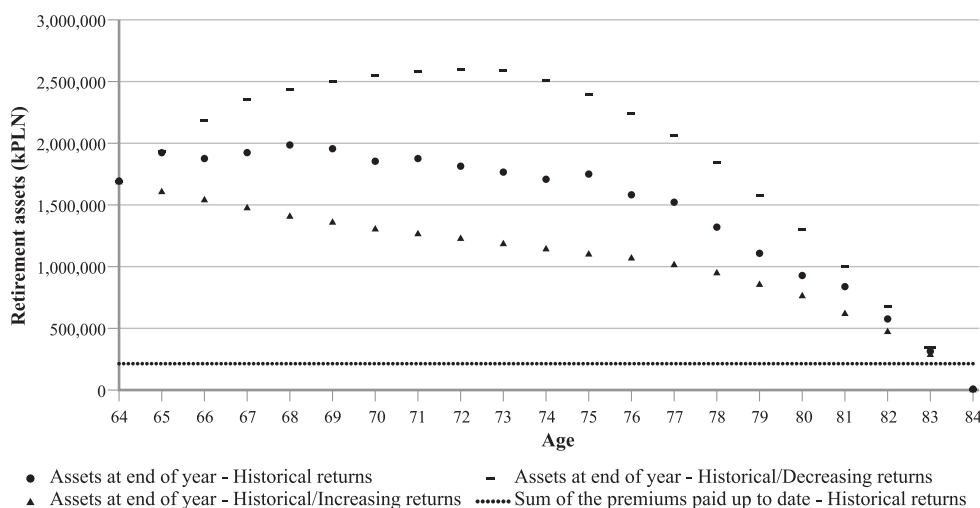| Result	Internal rate of return (IRR) during accumulation phase	Assets at the end of the accumulation phase
1st percentile	8.0%	1,065,999
5th percentile	8.6%	1,234,933
10th percentile	9.0%	1,346,777
25th percentile	9.6%	1,576,335
Median (percentile 50%)	**10.4%**	**1,897,200**
Average	**10.4%**	**2,015,729**
75th percentile	11.2%	2,325,158
90th percentile	12.0%	2,825,451
95th percentile	12.4%	3,182,328
99th percentile	13.3%	3,987,724

Source: Authors' own calculation.

---

[15] The total number of possible settings of the set of 40 rates of return is 40! and it is an enormous number. Despite the fact that 10,000 permutations is just a small part of this number, it is a sample that is sufficient to illustrate the diversity of results which stems from the sequence of returns.

The comparison of the distribution of these permutations' statistics with the results for the historical path, both descending and ascending in Table 1 shows that the descending path determines the minimum of distribution of assets at the end of the accumulated phase and the ascending path sets the maximum. The historical path turned out to be better than 33% and worse than 67% permutations within the sample.

4.2 Impact of sequence in the decumulation phase

Assuming that the capital remains in the retirement fund, also over the withdrawal period (decumulation phase), the sequence of returns is also significant in this phase and, as we will demonstrate, may considerably influence the amount of benefits paid. The starting point for the analysis of the decumulation phase are the assets collected in the accumulation phase, at historical returns path.

Figure 2. Assets in the decumulation phase (year end) - natural scale

- ● Assets at end of year - Historical returns
- – Assets at end of year - Historical/Decreasing returns
- ▲ Assets at end of year - Historical/Increasing returns
- ⋯⋯ Sum of the premiums paid up to date - Historical returns

Source: Authors' own calculation.

The impact of sequence in the decumulation phase was presented (similarly as for the accumulation phase) in variants of three returns paths: historical, descending and ascending, for a safe portfolio comprised in 100% of bonds. Figure 2 shows the projection of retirement assets remaining within the portfolio at the end of individual years of the decumulation phase for each of the three paths. It is easy to notice that the assets in the descending path are at any time higher (except for the starting and end point) and in ascending path they are lower than when compared with the historical path. In the decumulation phase, the descending path is thus the best, and historical path is intermediate, and the ascending path - the worst.

Negative returns in initial years of the decumulation phase cause a quick drop in funds and affect all future withdrawals (only a minor part of withdrawals has been realised). It is a reverse relation than in the case of the accumulation phase, wherein the ascending path yielded the best result and the descending path - the worst.

The fundamental part of the difference between individual paths develops over the first 5 years after retirement and is maintained over a number of years thereafter. The strongest impact on the total amount of withdrawals and average replacement value is made by rates of return obtained in the first few years after retirement, as these rates will be reflected in most of retirement withdrawals, and returns in later periods will not be as powerful.

Table 3 presents the major results of the retirement withdrawal phase. The amount of annual benefit is converted each time by dividing the funds remaining in the plan by the number of years left for the participant to reach 85 years of age. The average monthly pension has been calculated as the total amount withdrawn from the plan, divided by 240 months (20 years x 12 months).

Table 3. Results of saving in a retirement plan – decumulation phase

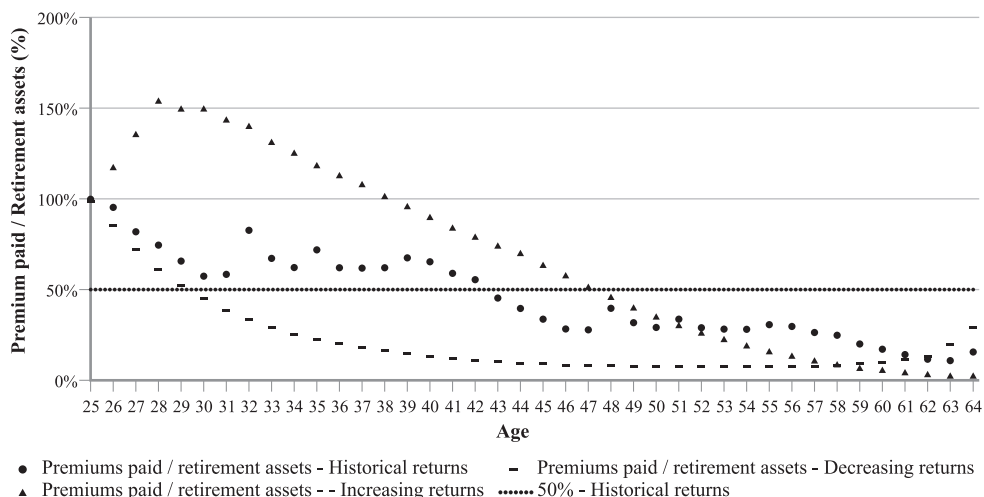| Retirement plan period	Returns path in the decumulation phase		
	Historical	Descending	Ascending
Internal rate of return (IRR) during decumulation phase (20 years)	7.5%	10.6%	4.3%
Total benefits paid out (nominal values)	3,569,808	4,641,618	2,679,260
Average monthly pension (nominal values)	14,874	19,340	11,164

Source: Authors' own calculation.

When comparing the total amount of withdrawn retirement benefits with the value of assets collected at the end of the accumulation phase (both amounts for historical path), we can see that over a half of the withdrawn funds come from returns on investment already generated in the accumulation phase. On one hand, this confirms the considerable importance of keeping the funds invested and properly managed during the decumulation phase, which is concurrent with the 60:30:10 principle described earlier and presented by Ezra [2009, pp. 44-45]. On the other hand, it is a result of extraordinarily high returns on bonds on the Polish market, with average level of 6.5% over the period of 16 years (2002-2017). This above-average high rate of return is significant also for the earlier discussed results of the accumulation phase (which realises on average a 6.5% return on bonds and an additional 3.5% premium for equity investment). It should be noted, however, that in the analysed period, the Polish financial market was still realising the risk premium for a developing market and over a longer period one needs to expect further convergence to the developed markets which will reduce the premium.

4.3 Risk zone. Investment portfolio size effect

The determination of risk zone is a very important issue for designing investment solutions for saving purposes. The dropping share of assets coming from contributions paid in total assets is a key measure of the growing importance of rates of return for the development of portfolio value. When the total amount of contributions in relations to assets is lower than 50%, the rate of return is the decisive factor affecting capital accumulation (portfolio size effect). Figure 3 shows the change in the share of contributions paid in assets for three variants of rates of return. The comparison to the line of 50% share of contributions paid illustrates a different starting point for the portfolio size effect for the analysed rate of return paths.
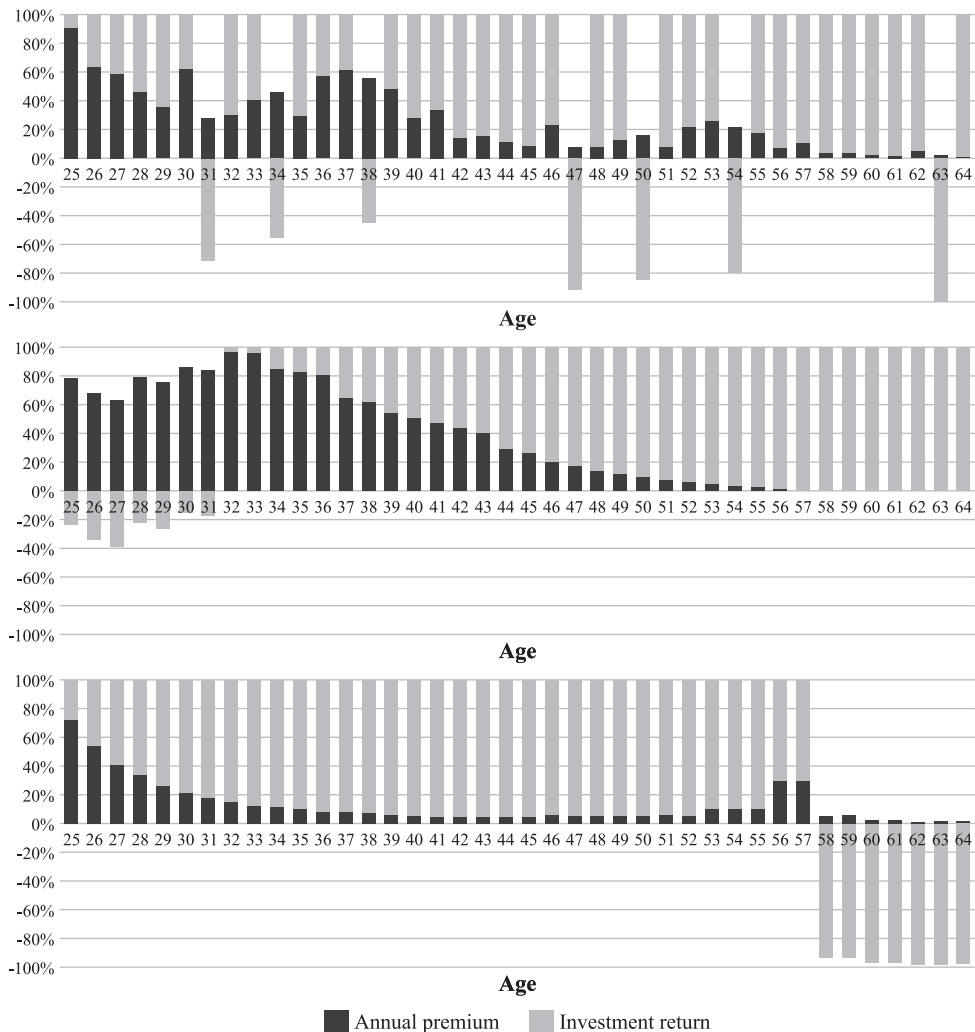
Figure 3. Contributions paid in the percentage of assets (at the beginning of the year)

Source: Authors' own calculation.

The growing importance of the rates of return, along with the increase of portfolio value is demonstrated by the analysis of the sources of growth in retirement investments presented in Figure 4. For the historical path, the dominant importance of returns on investments (as compared with contributions) is visible as soon as after 15 years of saving. The comparison of the relation of investment results to contributions for descending and ascending paths of returns is a good illustration of the combined impact of sequence of returns and portfolio size on the accumulation of capital. For the ascending path (favourable) the dominant importance of investment results is becoming visible after 15 years (similarly as for the historical path) and for the descending path (unfavourable) - as soon as in the third year of saving.

Figure 4. Source of growth in retirement investments by path of returns: historical (top panel), ascending (middle panel) and descending (bottom panel)

Source: Authors' own calculation.

5. Conclusions

The simulation conducted for a potential participant in employee capital plans demonstrates the significant importance of the sequence of returns and the portfolio effect for the process of accumulating retirement savings and withdrawal of benefits. In combination with the presented experience from international markets, it shows the need to take into consideration the sequencing risk when designing investment

solutions, assessment of the efficiency of investment strategies and communication of investment results to participants in retirement plans.

The importance of the risk zone for the result of the savings process is linked with the proposal of various solutions for the management of sequence risk in this key period of saving. Some academics and market experts recommend life-cycle strategies as the best for preserving the accumulated capital. Other methods for curbing the negative impact of rates of return when the accumulated assets are high include portfolio insurance using option strategies, guarantees of rates of return provided by entities offering the product and diversification, both geographical and in terms of the class of assets.

The importance of sequencing risk and portfolio effect for the retirement outcomes leads to a conclusion that when assessing the investment strategies risk based on the asset allocation glide path, the average money-weighted allocation (i.e. the amount of retirement assets accumulated at the given point) should be compared as opposed to the simple arithmetical mean of percentage allocations over the investment period. The sequence of returns and portfolio effect should also be taken into consideration when assessing the efficiency of investment strategies employed for management of retirement savings. The assessment of strategy merely based on moments of distribution is incorrect.

In annual statements of results presented to clients, asset managers in employee capital plans should provide the money-weighted and not only time-weighted rates of return.

References

Analizy Online, 2014, *Ranking OFE wg wartości hipotetycznego konta* (June 2014).

Analizy Online, 2017, *Efektywność OFE na tle innych form oszczędzania.* Report for IGTE, (access: 03.03.2018).

Antolin P., Payet S., Yermo J., 2010, *Assessing Default Investment Strategies in Defined Contribution Pension Plans*. OECD Working Papers on Finance, Insurance and Private Pensions, 2, OECD Publishing.

Antolin P., 2009, *Private Pensions and the Financial Crisis: How to Ensure Adequate Retirement Income from DC Pension Plans*, OECD Journal: Financial Market Trends – Volume 2009, 2.

Basu A., Doran B., Drew M., 2012, *Sequencing Risk: A Key Challenge to Sustainable Retirement Incomes*, Finsia (Financial Services Institute of Australasia), Sydney.

Basu A., Drew M., 2009 *Portfolio size effect in retirement accounts: what does it imply for lifecycle asset allocation funds?*, "Journal of Portfolio Management", 35(3), pp. 61-72.

Ezra D., Collie B., Smith M., 2009, *The Retirement Plan Solution: The Reinvention of Defined Contribution*, Wiley Finance, pp. 44-45.

Global Investment Performance Standards Handbook, 2012, CFA Institute, https://www.cfapubs.org/doi/pdf/10.2469/ccb.v2012.n4.full (access: 09.02.2018).

Izba Gospodarcza Towarzystw Emerytalnych (IGTE), 2016, *Stanowisko w ramach konsultacji społecznych projektu Przeglądu przygotowanego przez MPiPS*.

Information of the Council of Ministers for the Sejm of the Republic of Poland regarding the consequences of the acts of 25 March 2011 and 06 December 2013, including suggested changes, 2016, draft dated 31.10.2016.

Milevsky M. A., Macqueen A. C., 2015, *Pensionize your Nest Egg. How to Use Product Allocation to Create a Guaranteed Income for Life*, Wiley.

Morningstar Manager Research, 2017, 2017 Target-Date Fund Landscape, https://corporate1.morningstar.com/ResearchLibrary/article/803362/2017-target-date-fund-landscape/ (access: 01.02.2018).

Ministry of Labour and Social Policy and Ministry of Finance, 2013, *Review of the operation of the pension system. Security owing to sustainability*.

Nyce S.A., Schieber S.J., 2011, *Ekonomiczne konsekwencje starzenia się społeczeństw*, PWN, Warszawa.

Otto W., Wiśniewski M., 2013, *Stopy zwrotu: OFE i ZUS*, Wydział Nauk Ekonomicznych UW, http://kobe.org.pl/wp-content/uploads/2013/06/Stopa-zwrotu-OFE-i-ZUS.pdf (access: 05.01.2018).

Poterba J., Rauh J., Venti S., Wise D., 2006, *Lifecycle Asset Allocation Strategies and the Distribution of 401(k) Retirement Wealth*, NBER Working Paper Series, 11974.

Pfau, W. D., 2009, *The Portfolio Size Effect and Lifecycle Asset Allocation Funds: A Different Perspective*, "Journal of Portfolio Management", https://ssrn.com/abstract=1699525 (access: 08.03.2018).

RBC Wealth Management, 2016, *Time weighted vs. money-weighted rates of return.* http://www.rbcphnic.com/_assets-custom/pdf/understanding-differences-between-twrr-mwrr-eng.pdf (access: 04.01.2018).

Schroders, 2014, *Investment Perspectives Lessons Learned in DC from Around World*, pp. 13-15.

Shiller R., 2005, *The Lifecycle Personal Accounts Proposal for Social Security; A review.* NBER Working Paper Series, 11300.

Towers Watson 2011, *Global pension asset study*, New York.

Abbreviations
IGTE – Pension Fund Societies' Chamber of Commerce (*Izba Gospodarcza Towarzystw Emerytalnych*); IRR - internal rate of return; OFE – Open Pension Fund (*Otwarty Fundusz Emerytalny*); ZUS – Social Insurance Institution (*Zakład Ubezpieczeń Społecznych*).