

# APPLICATION OF DEFERRED ANNUITIES IN AN OCCUPATIONAL PENSION SCHEME

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## 1. Introduction

Occupational pension schemes are an important element of the pension systems of many countries. In the face of problems related to the financing of public systems, private forms of saving for retirement are becoming crucial (Antolin et al. 2012, p. 7). In recent years, changes in the types of occupational pension schemes can be observed. The once popular defined benefit (DB) schemes are replaced by defined contribution (DC) schemes (Wise 2001, p. 122; Turner and Hughes 2008; Bovenberg and Gradus 2015). As a result the risk associated with financing the pension scheme is transferred from the employer to the member. In order to enable risk sharing hybrid schemes have been developed in many countries by combining elements of two traditional forms (Turner 2014; Broeders et al. 2013). They are often a modification of the DB scheme e.g. by introduction of an indexation conditional on the financial position of the scheme, as is the case in the Netherlands (Blommestein et al. 2009, Ponds and van Riel 2009). On the other hand, the growing popularity of DC schemes has contributed to the development of hybrid programs that modify such a scheme by, for example, introduction of a guarantee on the minimum rate of return on investment, as is the case in Switzerland (Bütler and Staubli 2010). In addition, many authors search for solutions that would offer the benefits of the DC scheme for the employer (pre-determined contributions) with the advantages of the DB scheme for the member (pre-determined benefits).

Sutcliffe (2010) presented a proposal for a retirement program which satisfies the above criteria. It uses a deferred pensions financed by a single premium (SPDA – single premium deferred annuity). Aim of this paper is to construct a model that would allow to calculate expected benefit amount in a scheme financed by SPDA, and to compare it with an amount that could be achieved in a traditional DC scheme. Second aim is to extend the concept of SPDA scheme to allow for the risk of high annuity prices to be shared between member and employer.

## 2. Scheme financed by SPDA

Scheme which uses single premium deferred annuities (SPDA) was described by Sutcliffe in 2010. SPDA is an insurance product which can be purchased at any time by paying a single premium, in exchange for payment of the benefit (pension) which will start at a certain point in the future. The insurance company sets the

price of the deferred pension by adopting assumptions as to the probability of survival of the insured until the start of payment, further life expectancy from the time of start of payment or the interest rate used to discount future value of benefit to the time of purchase.

In a scheme financed by SPDA a contribution (determined in advance as a percentage of the member's salary) is paid every year. It is used to purchase a deferred pension, the payment of which will begin when the member retires at a certain age in the future. In this way, the contributions are defined in advance (as in the DC scheme), while the benefit is fixed (as in the DB scheme) at the time the deferred pension is bought. The use of various types of deferred annuities, e.g. those offering a benefit adjusted with inflation, paid for a specified period of time or until the end of the member's life, allows the type of benefit to be adapted to the requirements of a given occupational scheme or a given member. An additional advantage of this solution is the fact that the investment risk and the longevity risk are borne by the insurance company offering the deferred pension, and not by the employer (as in the DB scheme) or the member (as in the DC scheme). Insurance companies are subject to strict legal regulations, which reduces the risk that the benefit will not be paid to the member (Sutcliffe 2010, pp. 16-18).

The disadvantage of this solution is the underdeveloped market of deferred pensions in many countries, which means that buying this product may not be possible or may be very expensive (Blake 1999, p. 360). In addition, the costs that the insurance company will take into account when calculating the pension price may be higher than the management costs in the program offered by the employer. Sutcliffe (2010, p. 21) notes that the use of deferred pensions will likely result in a lower amount of benefit than that obtained in the DC or DB scheme. The member is also exposed to the risk of an unknown purchase price of the deferred pension, which may increase in relation to the assumed.

### 3. Assumptions

In order to compare benefit amount that could be achieved in a scheme financed by SPDA and a traditional DC scheme models of both schemes were constructed. It was assumed that a member saves for their retirement for 35 years, during which contributions are paid annually at the start of each year, and retires aged 60. Contribution rate was set at 3.5% of salary, the required contribution in the new occupational schemes in Poland. The assumptions are summarized in Table 1.

**Table 1.** Assumptions used in modelling benefit amount in pension schemes

Parameter	Value
Retirement age	60 years
Saving period	35 years
Contribution rate	3.5% of salary
Salary increase rate	1% per annum

*Source: own work.*

In a DC scheme, the contributions are accumulated in the member's account with an investment rate of return earned by the scheme's investments. Model assumes that investment rate each year is a random variable following normal distribution with mean 3% and standard deviation 8%. At retirement value accumulated in the account is used to purchase an annuity from an insurance company. The price of this annuity is calculated using interest rate of 1% and expected future lifetime of a person aged 60 according to the formula:

$$a_{\overline{n}|} = \frac{1 - \left(\frac{1}{1+i}\right)^n}{i} \quad (1)$$

where  $i$  is the annual interest rate and  $n$  is the expected future lifetime in whole years. If expected future lifetime is not an integer, an additional payment equal to a fraction of the last year survived will be made. It is assumed that when the member joins the scheme the expected future lifetime of a person aged 60 is equal to 21.85 (GUS 2018), and by the time of member's retirement in 35 years this expected future lifetime for a person aged 60 will have increased by a certain amount every year. This amount is a random variable which follows normal distribution, with mean 0.1 and standard deviation 0.05 (see also Gierusz 2019).

In a scheme financed by SPDA contribution paid is used to purchase a deferred annuity from an insurance company. This annuity is priced by calculating the value of annuity payable to a person aged 60 (as described above) and discounting it to the time of purchase using a certain discount rate, according to the formula:

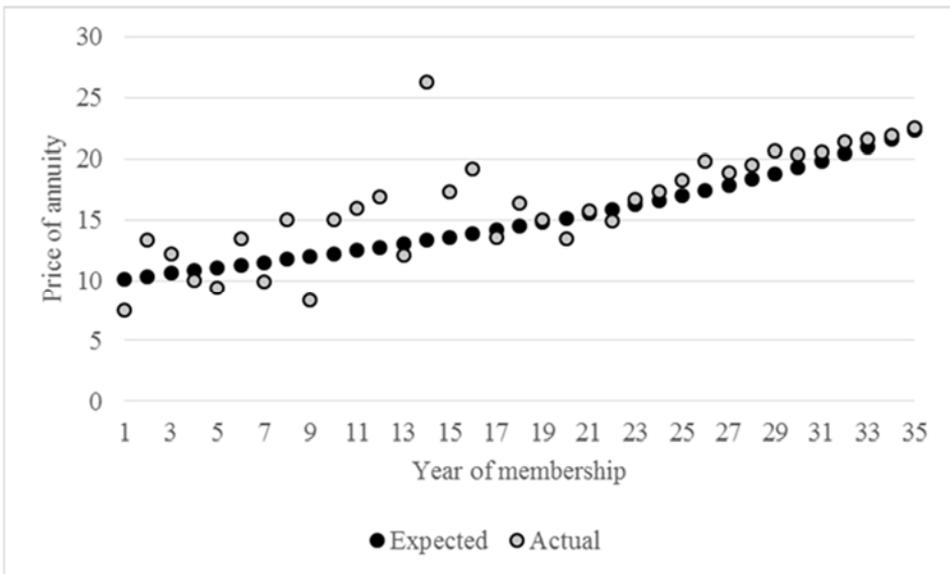
$${}_k|a_{\overline{n}|} = \left(\frac{1}{1+r}\right)^k {}_k p_x a_{\overline{n}|} \quad (2)$$

where  $r$  is the annual discount rate,  $k$  is the number of years remaining till member reaches 60 years of age,  $x$  is the current member's age,  ${}_k p_x$  is the probability that a member aged  $x$  survives the next  $k$  years.

It is assumed that discount rate follows normal distribution, with mean  $\mu$  and standard deviation 1%. Mean  $\mu$  itself is also a random variable following normal distribution, with mean 2% and standard deviation 0.5%. A lower mean for discount rate was chosen than for an investment rate (2% vs 3%) due to the fact that discount rate is set by insurance company based on expected return on investments that will be used to back up the pension guarantee. These are likely to be more secure investments, such as corporate and government bonds, in comparison with investments that could be used by a DC scheme, such as equities and other more risky assets (see also Sutcliffe 2010, p.22). In addition, the insurance company will include its costs and profit margins in the discount rate. The insurance company also takes into account probability that the member will survive from the time of purchase to retirement using life Tables as published by (GUS 2018). The amount of member's pension is then calculated as the sum of all the deferred pensions purchased during the scheme membership.

#### 4. Results

Method of simulation of different financial and demographic scenarios was used to calculate and compare benefit amounts that could be achieved in both pension schemes. One of those scenarios is presented in more detail below. Figure 1 shows expected deferred annuity prices (calculated assuming that random variables – discount rate and expected future lifetime – will take values equal to expected value) and actual deferred annuity prices observed in this particular scenario.

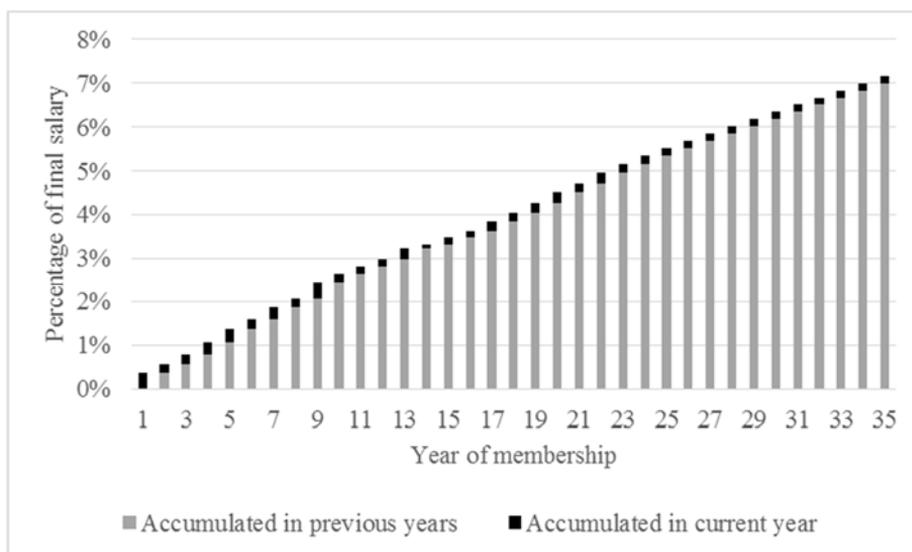


**Fig. 1.** Expected and actual deferred annuity prices in analysed scenario

*Source: own work.*

As shown in Figure 1, expected annuity prices increase with time left to retirement. This is mostly due to shorter discounting period. Using these expected prices, the expected benefit amount (expressed as % of member's final salary) was 7.3%. The actual prices were broadly similar to expected, with some deviations, for example in year 14 when the actual price was much higher than expected due to low discount rate in this year.

Each year a contribution rate paid into the scheme financed by SPDA was used to purchase a deferred pension payable from age 60. Figure 2 presents how the total member's pension (sum of all deferred pensions purchased each year) was accumulated. Amounts are expressed as percentage of member's final salary. Each year the total pension accumulated by that time is split between accumulated in previous years and accumulated in current year.



**Fig. 2.** Pension (expressed as % of final salary) accumulated each year, split between accumulated in the current and in previous years

Source: own work.

As shown in Figure 2, the pension amount (expressed as % of final salary) increases in an almost linear way. Black rectangles show how much of the pension was bought using current year’s contribution, and grey show total pension benefit bought in previous years.

In this scenario, at retirement the total pension amount was equal to 7.2% of final salary. In comparison, the replacement rate that could have been achieved from a DC scheme was slightly higher, and equal to 8.3% of final salary.

The simulations were then repeated 10000 times and for each scheme mean and standard deviation of benefit amount were calculated. These are shown in Table 2.

**Table 2.** Mean and standard deviation of benefit amount as % of final salary in each scheme – simulation results

Scheme	Mean benefit amount	Standard deviation of benefit amount
DC	8.1%	2.5%
SPDA	7.5%	0.8%

Source: own work.

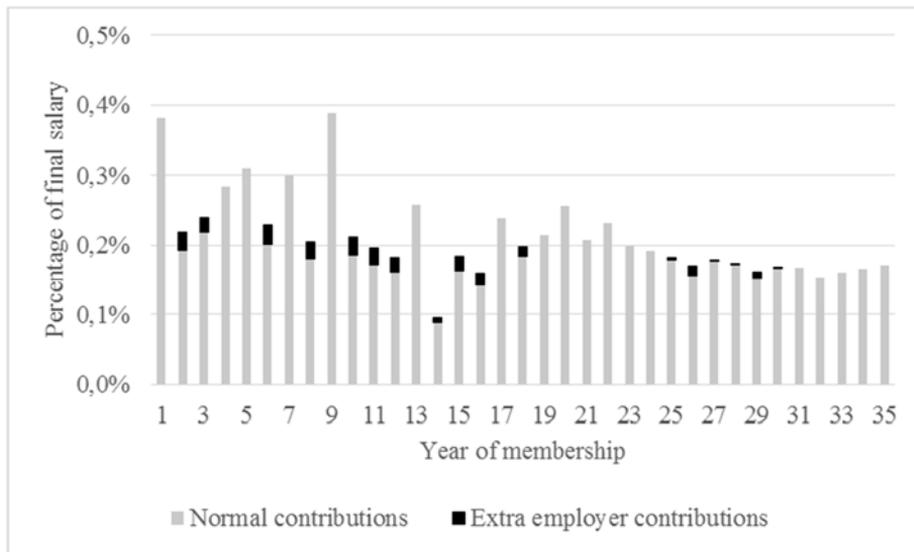
The mean replacement rate for a DC scheme was slightly higher than in the SPDA scheme due to higher mean investment rate assumed for reasons explained above. The variability of results was much lower in case of SPDA scheme, as it is not subject to year on year variability in investment rates, but only to variability in annuity prices. An additional advantage is that the member can observe the amount of pension that is being accumulated in SPDA every year (as shown in Figure 2), but in a DC scheme the pension amount remains unknown until retirement when it is purchased, hence member is also at risk of sudden changes in either investment rate or annuity price at retirement.

In the scenario investigated in more detail above the replacement rate obtained in SPDA scheme (7.2%) was slightly below the expected (7.3%). This was due to high deferred annuity prices in some years. Member in this scheme is exposed to risk of high annuity prices, leading to a low benefit obtained from the scheme. In order to share this risk between member and employer the following modification of SPDA scheme was constructed, making it a hybrid scheme. If the actual deferred annuity price in a given year was much higher than the expected price, additional employer contribution was paid into the scheme so that the effect of higher actual price did not lower significantly the amount of pension bought.

Firstly a price indicator for a given year was calculated as a ratio of actual and expected prices minus 1, expressed in %. Secondly, a new required deferred annuity price was calculated as follows:

- if the price indicator was below 5% required price stayed the same as actual price,
- if the price indicator was between 5% and 20%, the required price was equal to expected price times 105%,
- if the price indicator was over 20% the required price was equal to expected price times (100% + price indicator – 15%).

The benefit amount purchased in a given year was then based on the required price, and employer had to pay an extra contribution equal to a difference between the amount required to purchase such a benefit and the contribution paid that year. Figure 3 presents benefit amount purchased each year in the hybrid SPDA scheme.



**Fig. 3.** Pension (expressed as % of final salary) bought each year, split between amount bought by normal contributions and extra employer contributions

Source: own work.

In the investigated scenario the actual price was higher than the expected price by more than 5% in 17 out of 35 scheme years. In those years extra contributions were paid by employer, increasing the amount of benefit bought to 7.4%. Simulations of different scenarios were then run and results are summarized in Table 3.

**Table 3.** Mean and standard deviation of benefit amount as % of final salary in SPDA scheme and hybrid SPDA scheme – simulation results

Scheme	Mean benefit amount	Standard deviation of benefit amount	Proportion of scenarios were benefit was lower than expected
SPDA	7.5%	0.8%	42%
Hybrid SPDA	7.7%	0.7%	30%

Source: own work.

As shown in Table 3, by sharing the risk of high deferred annuity prices between member and employer the mean benefit amount was increased, and variability of the benefit amount was lowered. This was achieved by additional employer contributions. Mean employer contribution was 3% of member's final salary, and on average the contribution was required in 11.8 out of 35 scheme years.

## 5. Conclusions

Pension scheme financed by SPDA combines features of a DC scheme (fixed contribution amount) with those of a DB scheme (part of benefit amount is fixed once the deferred annuity is purchased). The simulations performed in this paper have shown that the mean benefit amount obtained by the member from such a scheme was lower than that which could be obtained in a traditional DC scheme, but it was characterized by a lower variability (lower standard deviation of benefit amount). An additional advantage of SPDA scheme is that the member can monitor the amount of benefit already purchased at any time of the scheme membership, in contrast to the DC scheme where the benefit remains unknown until retirement.

One of the main risks to the member in scheme financed by deferred annuities is the risk of high annuity prices. A modification of the scheme allows to share this risk between member and employer by obliging the employer to pay additional contributions in years when annuity prices are much higher than expected. Such a hybrid scheme was proposed and investigated in this paper. Simulations have shown that the mean benefit amount was slightly higher than in a SPDA scheme with no risk sharing, with lower standard deviation and lower proportion of scenarios where the benefit was lower than expected.

## References

- Antolin P., Payet, S., Yermo J., (2012), *Coverage of private pension systems: evidence and policy options*, OECD Working Papers on Finance, Insurance and Private Pensions, No. 20, OECD Publishing, <http://dx.doi.org/10.1787/5k94d6gh2w6c-en>
- Blake D., (1999), *Annuity markets: problems and solutions*. The Pensions Institute Discussion Paper PI-9907, The Pensions Institute, Cass Business School, City University, London.
- Blommestein H., Janssen P., Kortleve N., Yermo J., (2009), *Moving beyond the "DB vs. DC" debate: the appeal of hybrid pension plans*. *Rotman International Journal of Pension Management*, 2 (2), 66-76.
- Bovenberg L., Gradus R., (2015), *Reforming occupational pension schemes: the case of the Netherlands*. *Journal of Economic Policy Reform*, 18 (3), 244-257.
- Broeders D., Chen A., Rijsbergen D., (2013), *Valuation of liabilities in hybrid pension plans*. *Applied Financial Economics*, vol. 23, no. 15.
- Bütler M., Staubli S., (2010), *Payouts in Switzerland: explaining developments in annuitization*. Pension Research Council Working Paper 2010-23, Philadelphia.
- Gierusz A., (2019), *Modele podziału ryzyka w hybrydowych pracowniczych programach emerytalnych*. Wydawnictwo Uniwersytetu Gdańskiego, Gdańsk.
- GUS (2018), *Life expectancy tables of Poland 2017*. Statistics Poland, Warsaw.
- Ponds E.H.M., van Riel B., (2009), *Sharing risk: The Netherlands' new approach to pensions*. *Journal of Pension Economics and Finance*, 8, 91-105.
- Sutcliffe C., (2010), *Back to the future: a long term solution to occupational pension crisis*. The Pensions Institute Discussion Paper PI-1011, The Pensions Institute, Cass Business School, City University, London.

- Turner J.A., Hughes G., (2008), *Large declines in defined benefit plans are not inevitable: the experience of Canada, Ireland, the United Kingdom and the United States*. Pensions Institute Discussion Paper PI-0821, London.
- Turner J.A., (2014), *Hybrid pensions: risk sharing arrangements for pension plan sponsors and participants*. Society of Actuaries Research Report.
- Wise D.A, (2001), *United States: Support in retirement: where we are and where we are going*. [in:] Börsch-Supan A.H., Miegel M. (eds.), *Pension reform in six countries. What can we learn from each other?* (111-138). Springer-Verlag.