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## THE TRADE-OFF BETWEEN CONTRIBUTION AND BENEFIT VARIABILITY IN A HYBRID PENSION SCHEME

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Accumulating funds for retirement in a defined contribution (DC) pension scheme carries a risk of an unknown benefit amount for the member. On the other hand, as a scheme sponsor, the employer bears the risk of a variable contribution amount in a defined benefit (DB) pension scheme. In order to share the risk between a member and an employer, hybrid pension schemes, which combine features of both DC and DB schemes, were introduced in many countries. According to the chosen model of risk sharing, the variability of an employer's contributions or a member's benefit can be reduced. The aim of this paper is to investigate a conditional contribution hybrid pension scheme and analyze how the member's benefit and employer's contribution will vary in the presence of financial and demographic risk. It is compared with a traditional DC scheme and some common types of hybrid schemes.

**Keywords:** hybrid pension scheme, risk sharing, occupational pension

### 1. INTRODUCTION

Additional retirement saving schemes have become an important feature of many pension systems around the world. In order to reduce the burden placed on public pension systems due to an aging population, many countries have started promoting private pension provision (OECD, 2017, 150). Among these, occupational pension schemes play an important role. Two traditional forms of occupational schemes – defined benefit (DB) and defined contribution (DC) – have experienced decreasing and increasing popularity respectively in the last decades. This shift from DB to DC schemes has been common in many countries, including UK

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and USA (Kruse, 1991; Wise, 2001, 122; Turner, Hughes, 2008; Bovenberg, Gradus, 2015). Since in a DB scheme the benefit amount is guaranteed by the employer (a scheme sponsor), many employers have experienced big changes in contribution amounts due to volatility in financial markets and faster than expected increases in life expectancy. On the other hand, in a DC scheme, the employer's contribution amount is fixed. However, the financial and demographic factors which cause changes in the employer's contribution amount in a DB scheme also cause benefit variability for the member in a DC scheme. For many employers neither solution was appropriate. Lack of risk sharing opportunities in the two traditional pension schemes has led to the creation of new forms of occupational pension schemes. These are known as hybrid schemes, combining features of both traditional forms (Turner, 2014; Wesbroom, Reay, 2005). Some of them closely resemble DB schemes, introducing an element of risk sharing by making the benefit amount conditional on some events, typically the change in funding level of the scheme. Examples include conditional indexation schemes, common in the Netherlands (Blommestein et al., 2009). Other hybrids were created by introducing some kind of a guarantee into a DC scheme, for example concerning the minimum rate of investment returns that should be applied to a member's fund or a minimum benefit amount. These can be found in Switzerland (Bütler, Staubli, 2010). Finally, there are also hybrid schemes that consist of two sections, one mimicking the DB scheme and the other a DC scheme. Such schemes, called sequential hybrids and combination schemes, can be found in Switzerland, USA and UK (Wesbroom, Reay, 2005).

Hybrid pension schemes allow for the employer's contribution variability to be reduced in comparison with a DB scheme, while also reducing the member's benefit variability in comparison with a DC scheme. Many authors have carried out research investigating the exact risk sharing features for common types of hybrid schemes (see e.g. Blommestein et al., 2009; Cooper, 2005). It can be noted that many types of hybrid schemes offer protection from risk tailored to one of the two parties involved – either employer or member. In order to offer protection to both sides, a new type of hybrid scheme, a conditional contribution pension scheme, was created (Gierusz, 2019).

In this scheme a target benefit amount is set, and the contribution needed to achieve this target is recalculated every year. A maximum change in the employer's contribution is set in advance. If the required contribution exceeds this maximum, the member has to pay the rest of the required contribution. However, it is uncommon for members to be willing to adjust the contribution they pay every year. Behavioral economics points out factors such as inertia, meaning members may be more likely to pay one level of contribution throughout their scheme membership (see e.g. Madrian, Shea, 2000). Hence in this paper the conditional contribution scheme was modified. While the employer still needs to adjust the contribution amount based on the calculated required contribution (up to a specified maxi-

mum), the member does not change their contribution, instead accepting a variability in the benefit amount this might cause.

The aim of this paper is to investigate how an employer's contribution and a member's benefit variability changes when the maximum contribution set for the employer is modified in a conditional contribution scheme. The results are compared with benefit variability in a traditional DC scheme, as well as two types of hybrid pension schemes which are common modifications of a DC scheme – DC with an underpin and a combination hybrid.

## 2. MODELS AND ASSUMPTIONS

A basic version of the used model calculates the benefit amount which will be paid out from a traditional DC pension scheme. All calculations and assumptions relate to real values. It is assumed that a target benefit amount (expressed as a replacement rate) is set, and contribution amount is calculated based on some deterministic assumptions about future financial and demographic conditions. It is assumed that once the member reaches retirement age, the funds accumulated within the scheme will be used to purchase a life annuity. Financial and demographic risks are then introduced by assuming that the annual rate of investment returns achieved by the scheme and increases in life expectancy (which determines how long the benefit will be paid for) are random variables with known distributions. By performing simulations in the R package, a distribution of possible replacement rates was found.

In the conditional contribution pension scheme the contribution rate is recalculated every year based on observed financial and demographic conditions in order to secure the target replacement rate. A maximum employer's contribution variability  $K$  is set. This means that the employer's contribution cannot be lower or higher than the level set in a DC scheme plus or minus  $K$  percentage points. If the required contribution never exceeds DC contribution plus or minus  $K$ , the target replacement rate will be secured. Otherwise the member should pay the remainder of the contribution or, as assumed in this paper, leave the contribution unchanged and accept the variability in replacement rate this can cause. Simulations in R allow one to find the distribution for an employer's contribution paid and the member's replacement rate.

In a DC with an underpin scheme a minimum replacement rate is set. Every year a projection of the replacement rate that the scheme will achieve is made. If this projection is lower than the required minimum, the employer must pay additional contributions into the scheme. The member does not change their contribution amount. Simulations in R allow one to find the distribution for an employer's contribution and the member's replacement rate.

Finally, in a combination hybrid scheme two sections, a DB and a DC one are created. Half of the required benefit is provided by the DB section (employer's contribution may need to be adjusted to achieve the target). Half of benefit should be provided by the DC section, however, as the member does not modify their contribution rate the actual benefit may vary. Simulations in R allow one to find distribution for an employer's contribution and member's replacement rate.

The assumptions used to calculate the contribution rate in a DC scheme are summarized in Table 1.

Table 1. Assumptions used in modelling

Assumption	Value
Member's age on joining the scheme	25
Retirement age	65
Target replacement rate (% of final salary)	30%
Minimum replacement rate (% of final salary)	25%
Annual rate of investment returns (pre-retirement)	3.4%
Annual interest rate (post-retirement)	1%
Annual rate of salary increase	1.5%
Annual administration charge pre-retirement (% of fund)	0.5%
Administration charge post-retirement (% of payment)	1%
Remaining lifetime in years at age 65	23

Own work (see also: Gierusz, 2019).

Based on the deterministic assumptions summarized in Table 1, the contribution rate in a DC scheme was calculated as 11.8% of a member's salary. It was divided equally between member and employer, with each party paying a contribution of 5.9% of the salary.

Financial and demographic risks were then introduced by assuming that the annual rate of investment returns and remaining lifetime at 65 are random variables with known probability distributions (Gierusz, 2019). The rate of return was assumed to follow a normal distribution, with unknown mean  $\mu$  and a known standard deviation of 8%. The unknown mean  $\mu$  was also assumed to be a normally distributed random variable with an expected value of 3.4% and standard deviation 2%. Initially, the expected value of  $\mu$  was used as an assumption for rate of investment returns. In subsequent years a Bayesian approach was used to update the assumption for rate of investment returns, according to the formula (1):

$$\frac{\sigma^2}{\sigma^2 + n\sigma_0^2} \mu_0 + \frac{n\sigma_0^2}{\sigma^2 + n\sigma_0^2} \bar{x} \quad (1)$$

where  $\mu_0$  is the expected value of mean  $\mu$  (3.4%),  $\sigma_0$  is the standard deviation of mean  $\mu$  (2%),  $\sigma$  is the standard deviation of annual rate of return (8%),  $n$  is the number of observed rates of return (number of years) and  $\bar{x}$  is the mean observed rate of return (Murphy, 2007).

A similar model was used for the remaining future lifetime at 65. It was assumed that at time 0, when a member joins the scheme, the expected remaining lifetime of a person aged 65 is 19 years. It is assumed that every year over the next forty years until the member reaches 65 years the remaining lifetime at 65 will increase by a value which follows normal distribution with an unknown mean and standard deviation 0.01. The unknown mean is a normally distributed random variable itself, with an expected value of 0.1 and standard deviation 0.02. Initially, it is assumed that every year the remaining lifetime at 65 will increase by the expected value (0.1). In subsequent years the Bayesian approach, as shown in formula (1), was used to update the assumption for changes to remaining lifetime at 65.

Simulations of different rates of return and changes to remaining lifetime were run and the distribution of average change to the employer's contribution rate and the member's replacement rate were obtained.

### 3. RESULTS

In a DC scheme the average replacement rate obtained by the member was equal to 0.303 of the final salary, close to the target replacement rate of 0.3. There was, however, some variability in the replacement rate achieved, depending on the realized scenario of financial and demographic conditions. Standard deviation of the replacement rate was 0.1 of the final salary. The distribution of replacement rates obtained in simulations is summarized in Fig. 1.

The lowest replacement rate obtained in the simulations was 0.11 of the final salary. This was lower than 0.25 (assumed to be the minimum required replacement rate in a DC with underpin scheme) in 34% of scenarios.

If an employer wanted to provide the target replacement rate of 0.3 of the final salary (as in a DB scheme) by varying their contribution every year, the average difference in contribution paid and the set DC contribution would be 6.9% of the salary.

Next, the conditional contribution scheme was investigated. It was assumed that the maximum difference between the employer's contribution set in a DC scheme and actual contribution paid  $K$  is 5% of the salary. The average replacement rate the member received from this scheme was 0.306, similar to DC and the target replacement rates. However, the variability of replacement rates was smaller than in a DC scheme, with standard deviation equal to 0.07 of the final salary. The distribution of replacement rates obtained in simulations is summarized in Fig. 2.

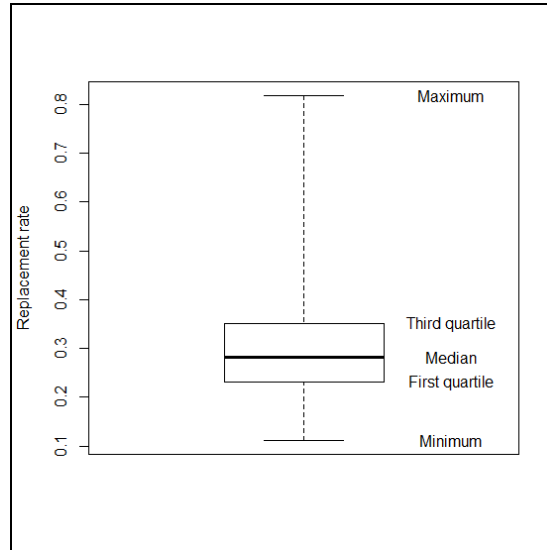


Fig. 1. Boxplot for the distribution of replacement rates in a DC scheme. Own work

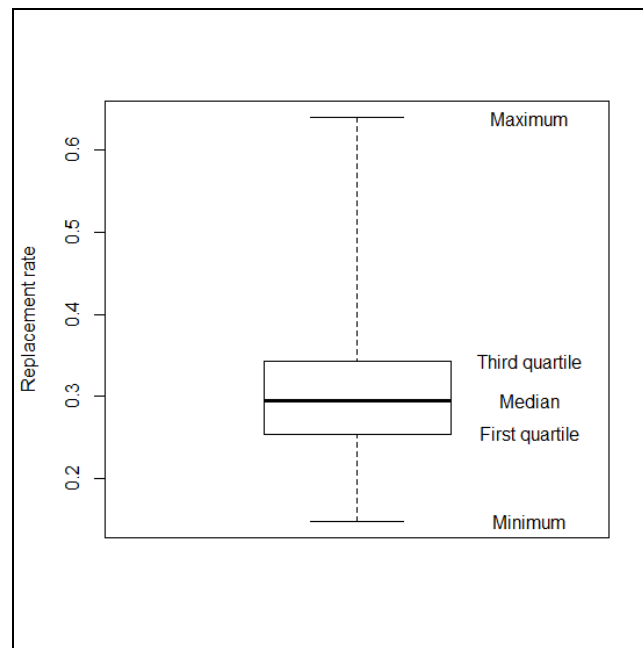


Fig. 2. Boxplot for the distribution of replacement rates in a conditional contribution scheme. Own work

The lowest replacement rate obtained was 0.15 of the final salary, higher than in a DC scheme. The replacement rate was lower than the minimum in 22% of scenarios, less often than in a DC scheme. The average difference between an employer's contribution paid and the set DC contribution was 3.1% of the salary.

To investigate the changes to contribution and replacement rates further, two scenarios were chosen. In the first one, called a moderate one, financial and demographic conditions were broadly similar to the assumed. Figure 3 presents an employer's contribution paid each year in a DC and conditional contribution schemes.

For the moderate scenario, the average difference between the employer's contribution and set contribution in conditional contribution scheme was 4%. It was possible for the employer to decrease their contribution rate as well as increase it. The replacement rate which the member obtained on retirement was equal to 0.38, slightly higher than the target. In a traditional DC scheme the replacement rate would have been 0.35 of the final salary.

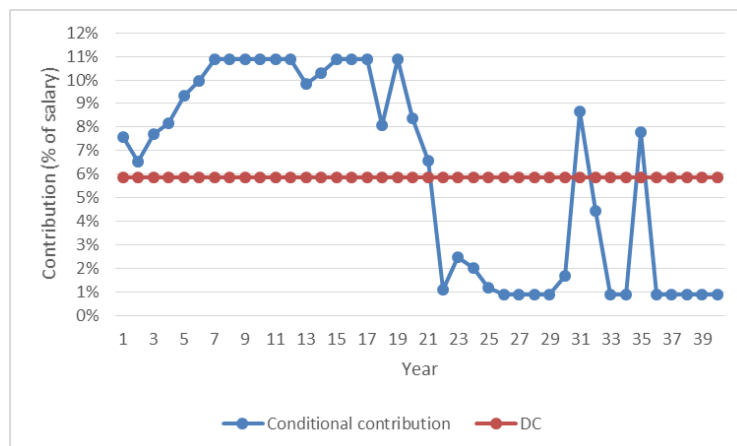


Fig. 3. Employer's contribution paid in a DC and conditional contribution schemes for the moderate scenario. Own work

In the second scenario, a pessimistic one, financial and demographic conditions were worse than assumed, with an average rate of return equal to  $-0.1\%$  and average yearly increase in life expectancy equal to 0.2. Figure 4 presents the employer's contribution paid each year in a DC and conditional contribution schemes.

For the pessimistic scenario, the average difference between the employer's contribution and set contribution in the conditional contribution scheme was 4.5%. The employer needed to pay a higher contribution in all years. The replacement rate which the member obtained on retirement was equal to 0.17, lower than the target but higher than the replacement rate achieved in a traditional DC scheme of 0.12.

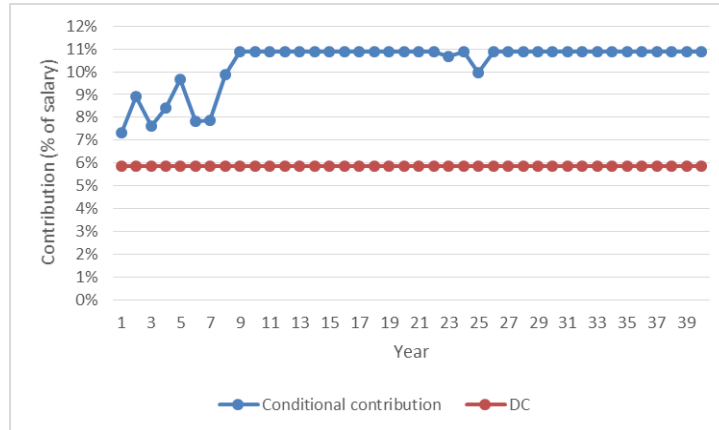


Fig. 4. Employer's contribution paid in a DC and conditional contribution schemes for the pessimistic scenario. Own work

By varying the maximum difference between the employer's contribution paid and the set DC contribution  $K$  the variability of the member's replacement rate and employer's contribution can be adjusted. This is shown in Table 2.

Table 2. Variability of the member's replacement rate and employer's contribution in the conditional contribution scheme for different values of  $K$

Value of $K$	Average difference between the employer's contribution and set DC contribution	Standard deviation of the member's replacement rate	Percentage of scenarios for which the member's replacement rate was lower than 0.25
4%	2.7%	0.077	25%
5%	3.1%	0.073	22%
6%	3.5%	0.069	21%

Own work.

As can be seen in Table 2, decreasing the value of  $K$  by one percentage point decreases variability of the employer's contribution (measured by average difference between paid and set DC contribution) by about 0.4 percentage points. At the same time it increases the variability of the member's benefit (measured by standard deviation of replacement rates obtained) by 0.004 of the final salary. It also increases the chance of the replacement rate being below the set minimum. Increasing the value of  $K$  increases the employer's contribution variability and decreases the member's benefit variability to a similar extent.

The results were also compared with other common types of hybrid schemes, namely DC with an underpin and a combination hybrid. For the underpin it was



assumed that the replacement rate cannot be lower than 0.25 of the final salary. In the combination hybrid half of the target replacement rate has to be provided by the employer in the DB section, and the other half is targeted in the DC section. The results are summarized in Table 3.

Table 3. Variability of the member's replacement rate and employer's contribution in different hybrid schemes

Scheme	Average difference between the employer's contribution and set contribution	Standard deviation of the member's replacement rate	Percentage of scenarios for which the member's replacement rate was lower than 0.25
DC	0.0%	0.100	34%
Conditional contribution ( $K = 5\%$ )	3.1%	0.073	22%
DC with an underpin	1.0%	0.087	0%
Combination hybrid	3.5%	0.050	13%

Own work.

As shown in Table 3, introducing risk sharing increases the variability of the employer's contribution but decreases the variability of the member's replacement rate in comparison to a DC scheme. In the DC with an underpin scheme the replacement rate cannot be lower than the targeted minimum, however, the variability of the actual rate is higher than in the conditional contribution scheme. The combination hybrid scheme lowers the variability of the replacement rate, but increases the employer's contribution by introducing a DB section in the scheme.

#### 4. CONCLUSIONS

In this paper a conditional contribution hybrid scheme was investigated. In this scheme the employer's contribution is adjusted in order to provide the member with a target replacement rate. However, the maximum variability in the employer's contribution is set – the actual contribution paid by the employer cannot exceed the set DC contribution plus or minus  $K$  percent of salary. If the required change in contribution is actually greater than  $K$ , the member's benefit will be affected.

Simulations run in the R package for different financial and demographic scenarios show that introducing risk sharing in this way decreases the variability of the member's benefit (standard deviation of replacement rates decreases from 0.1 in

a DC scheme to 0.07 in a conditional contribution scheme with  $K$  set to 5% of salary). At the same time it introduces variability in the employer's contribution.

In addition, by varying the value of  $K$ , the variability in the employer's contribution and member's replacement rate can be changed. Changing the value of  $K$  by one percentage point changes the average difference in the employer's contribution and set DC contribution by about 0.4 percentage points, and changes the standard deviation of the member's replacement rate by 0.004 of the final salary.

In a DC with an underpin scheme the replacement rate variability was found to be greater than in a conditional contribution scheme, however, this scheme guarantees a minimum level of the member's replacement rate, which is not found in the other schemes investigated. The combination hybrid scheme lowers the replacement rate variability by introducing a DB section. This may not be practical under the laws and regulations of a particular country, or desirable by the employer.

## LITERATURE

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## KOMPROMIS POMIĘDZY ZMIENNĄ WYSOKOŚCIĄ SKŁADEK I ŚWIADCZEŃ W HYBRYDOWYM PROGRAMIE EMERYTALNYM

### Streszczenie

Gromadzenie środków celem zapewnienia dodatkowego świadczenia na emeryturze w programie o zdefiniowanej składce (DC) wiąże się dla uczestnika z ryzykiem nieznannej wysokości świadczenia. Z drugiej strony pracodawca, jako sponsor programu, ponosi ryzyko nieznannej wysokości składki w programie o zdefiniowanym świadczeniu (DB). Aby umożliwić podział ryzyka między pracodawcę i uczestnika, w wielu krajach wprowadzono programy hybrydowe, łączące w sobie cechy programów DC i DB. W zależności od przyjętego sposobu podziału ryzyka zmienność wysokości składek pracodawcy i świadczenia uczestnika może być zredukowana. Celem artykułu jest zbadanie programu hybrydowego o warunkowej składce i przeanalizowanie, jak składki pracodawcy i świadczenie uczestnika zmieniają się w obliczu ryzyka finansowego i demograficznego. Wyniki porównano z otrzymanymi w przypadku tradycyjnego programu DC i innych programów hybrydowych.

**Słowa kluczowe:** hybrydowy program emerytalny, podział ryzyka, program zakładowy

