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Benefits of collective risk sharing in defined contribution pension systems

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OCCASIONAL-09 / 2016

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28 November 2016

Abstract

This paper compares pension benefits in individual and collective pension contracts with a simulation study. An advantage of collective contracts is the ability to share gains and losses with generations that have not yet started working. Even collective contracts that allocate surpluses and deficits only to current participants slightly outperform individual contracts, because collective schemes implicitly allow the young to borrow against future labour income. A hybrid IDC/CDC contract also slightly outperforms a purely individual contract for the same reason. A regulatory ban on equity investment during the retirement period significantly worsens the performance of individual contracts. The benefits of collective contracts are lower in simulations with a smaller equity premium.

1 Introduction

An important question in the policy debate on the Dutch pension system is the extent to which individual and collective pension contracts can provide similar combinations of risk and return. The question is whether a collective contract, in which risks are shared between all working and retired age cohorts and possibly also future generations, can outperform an individual contract, in which each age cohort accumulates savings in its own fund. Collective risk sharing provides added value if it results in a higher mean pension for the same degree of risk, or if it gives more insurance against negative financial shocks for the same mean or median pension benefits.

This study quantifies the benefits of collective sharing of tradable risks, such as equity and interest rate risk, with a simulation study. We take into account uncertainty on financial markets and provide a probability distribution of pension benefits in individual and collective contracts. We choose the investment strategy and benefit payment rule in the individual contract to match the collective contract as closely as possible. For the same median, collective contracts give up to 15 per cent higher pension payments in bad economic scenarios than the individual contract. The size and distribution of pension benefits is determined using an asset liability model. The model contains economic scenarios based on a detailed description of financial markets, with yearly stock and bond returns, interest rates and inflation.

We focus less on the role of collective contracts in redistributing non-tradable risks between generations, such as inflation risk and macrolongevity risk. Boelaars et al. (2015) argue that the possibility to share non-tradable risks is the primary advantage of collective contracts (see also Bovenberg and Mehlkopf, 2014).

Earlier CPB studies concluded that the added value of collective risk sharing is limited in terms of improving the allocation of tradable financial risks. The benefits of risk sharing with future participants are proportional to the length of the adjustment period for reducing surpluses and deficits. The longer this adjustment period, the smaller is the effect of financial shocks on any single generation. Because young workers may be unwilling to join funds with a large deficit, the practical length of the adjustment period is limited. The Dutch Financial Assessment Framework requires an adjustment with 1/10 towards required solvency from 2015 onwards.

The impulse response analysis of Boelaars et al. (2015) finds that a collective contract that recovers 10 per cent of surpluses and deficits per year allocates only 4 per cent of financial shocks to future participants. An individual contract can largely replicate the exposure to financial risks in a collective contract by using a lifecycle investment strategy, in which the share of equities in the investment portfolio is gradually reduced from 100% at the start of the career to 0% at the end of retirement. An impulse response method is easy to replicate and clearly isolates the effect of different types of shocks, but is less suitable to analyze the relation between shocks and their economic importance. The results obtained by

Westerhout et al. (2014) with a utility function approach are in line with those by Boelaars et al. (2015).

In order to pinpoint the sources of the disparities in individual and collective contracts, we start by analyzing a simple individual and collective contract using a very stylized financial model. We then gradually make both the pension contracts and our description of financial markets more realistic. Section 2 outlines the research method. Section 3 presents the results. Section 4 further discusses the findings, and section 5 concludes.

2 Research method

This chapter describes the ALM model, the setup of the individual and collective contracts and the outcome variables. We also detail the assumptions we make to facilitate a comparison of the individual and collective contracts, as well as a hybrid contract.

Assumptions

The collective contract has degressive accrual of pension rights. This means that the allocation of new pension rights is actuarially fair. When the interest rate rises, all workers receive more pension rights per euro contributed. The increase is proportionally larger for young workers than for older workers because of cumulative interest.[1]

We ignore legal restrictions on investments in risky assets post-retirement in individual contracts.[2] We also disregard regulations on the recovery of funding deficits and the distribution of surpluses in collective contracts. The collective contracts have no indexation ambition. Pension right adjustments are only based on nominal financial returns, not on inflation.

We abstract from demographic trends and uncertainty in individual and aggregate life expectancy. All individuals in all cohorts start working at age 25, retire at 67 and die at 87. The cohorts have equal size. The real wage remains constant over the life cycle.

Model

The cashflows of the pension funds are simulated with the ALM model that was also used in the CPB evaluation of the Dutch pension agreement. The model is detailed in Draper et al. (2014) and Michielsen (2015).

[1] Currently, collective pension funds in the Netherlands are characterized by uniform accrual. Under uniform accrual, each contributor receives the same nominal pension rights regardless of his/her current age. This rule ignores the notion that a euro contributed by a young worker can accrue investment returns for a longer period than a euro from an older worker. Uniform accrual thus constitutes a transfer from younger to older workers. These transfers would prevent a clean comparison between individual and collective contracts.

[2] We conduct a sensitivity analysis in which the individual contract does not invest in equities after retirement, and in which the individual contract is allowed to have an equity exposure of more than 100% of financial assets.

Economic scenarios

We use two economic scenario sets. The first is a Black Scholes model with only equity risk (no interest and inflation risk). The mean stock return is 7.23% (geometric) or 9.14% (arithmetic); the bond return, price- and wage inflation are deterministic and equal to 2.53%, 2.02% and 2.53%, respectively.

The second scenario set is derived from the model in Koijen, Nijman and Werker (2010), calibrated with data that are relevant for Dutch pension funds (Draper, 2014). Some parameters are adjusted to match the equity premium and ultimate forward rate to the expectation of the Dutch Commission Parameters (Langejan et al., 2014). The mean stock return is 7.65% (geometric) or 9.44% (arithmetic). The mean return on five year bonds is 3.53% (geometric) or 3.69% (arithmetic); price- and wage inflation 2.00% and 2.51% (geometric) or 2.01% and 2.52% (arithmetic), respectively. For both sets, we simulate 5000 scenarios.

Contracts

The pension contribution is equal in the individual and collective contracts, namely 10% of the pensionable wage.

In the benchmark individual contract, nominal financial returns in excess of the risk free rate are distributed equally across the remaining retirement years. The individual contracts continue to invest in risky assets after retirement, rather than purchasing an annuity at the retirement date.

Participants in the collective contract accrue nominal annuity units in an actuarially fair manner. In each year, the present value of the fund's new liabilities exactly equals the new contributions. Young workers receive more rights per euro contributed, because they have a longer investment horizon. The number of newly accrued annuity units for each age group is determined by the nominal term structure.

In the benchmark individual and collective contracts, we choose the investment strategies, rules for pension right adjustments and benefit payments to create a level playing field:

- instantaneous, uniform and complete adjustment of pension rights to financial shocks in the collective contract.
- constant investment strategy over the life cycle and uniform adjustment of planned benefit payments in the individual contract.

We then make the contracts more realistic, by shifting financial risk to the beginning of the life cycle (see Table 1 and Table 2). Young individuals have a greater ability to absorb negative investment returns, because they are better able to adjust their savings rate and labour supply. In contrast, the elderly have larger accrued savings, and less time to recover any losses. We do not explicitly model variable contributions, but do provide outcome statistics to indicate whether financial risks are concentrated at the beginning or the end of life. We modify the contracts by introducing:

Table 1: Description of CDC contracts

Contract	Properties
CDC benchmark	Asset mix of 50% equity, 50% five-year bonds. Immediate, complete and uniform adjustment to shocks; target funding ratio 100%
CDC open	Partial adjustment (1/10); future right accruals share in current shocks. That is, all rights are adjusted by (Funding Ratio - 100) / 10.
CDC closed	Partial adjustment (1/10); future right accruals isolated from current shocks.
CDC closed alt	Partial adjustment (1/10); future participants isolated from current shocks, but not future right accruals of current participants.

Table 2: Description of IDC contracts and hybrid contract

Contract	Properties
IDC benchmark	Constant asset mix of 50% equity, 50% five-year bonds. Planned benefit payments uniformly adjusted to shocks.
IDC open replica	Asset mix varies over the life cycle; gradual adjustment of planned benefit payments using the same method as for right adjustments in CDC closed. We choose the asset mix to match the median of the average replacement rate over the retirement period in CDC open. We restrict short selling. All asset weights are positive and add up to 100%.
IDC open alt 1	We allow short selling. The IDC contract borrows against the risk free rate to increase its exposure to equity and long-term bonds to more than 100% of accumulated assets early in the life cycle.
IDC open alt 2	No equity exposure after retirement.
IDC closed replica	Asset mix varies over the life cycle; gradual adjustment of planned benefit payments using the same method as for right adjustments in CDC closed. We choose the asset mix to match the median of the average replacement rate over the retirement period in CDC closed.
Hybrid	Participants invest 80% of their contributions in an IDC scheme with life cycle investment profile and gradual adjustments to shocks. The remaining 20% is invested in a collective buffer fund that fully invests in equity. The rights accrual and adjustment rules for this buffer fund are the same as in the CDC closed contract. Each year, participants rebalance their holdings between the IDC and collective buffer fund in an actuarially fair manner such that 80% of the present value of planned future payments is invested in the IDC fund, and 20% in the collective buffer.[3]

- partial adjustment to financial shocks of 10 per cent per year in the collective contract. We consider both an open and a closed adjustment mechanism for financial shocks (AFS). In the open AFS, future right accruals share in the adjustment of the funding ratio to 100 per cent. The expected value of new rights is thus less than the contribution payments if the fund has a deficit, and more if it has a surplus. In case of a deficit, the future holds more right cuts than increases in expectation. The closed AFS corrects any funding imbalances by only adjusting already accrued rights. Future participants are thus not affected by current surpluses or deficits, nor is the expected value of future right accumulations of current participants.[4]
- increased equity exposure at the beginning of the life cycle in the individual contract, coupled with a gradual reduction with age. The individual contract also gradually adjusts the planned benefit payments in response to financial shocks. That is,

[3] The rebalancing mechanism is such that if a participant increases the amount invested in his or her IDC scheme by 20%, all planned future payments are increased by 20%. We apply the same rule for the collective buffer.
[4] One could also consider an alternative closed AFS in which future right accruals of current participants share in the correction of current funding imbalances, but future participants do not. For example, if a fund's investment portfolio has lost 20 per cent of its value last year, the rights that a 26-year old will accrue in the next ~15 years would be cut to recover the deficit, but the future accruals of a 25-year old new entrant are not affected.

planned payments in the near future are adjusted less than planned payments further away.

Lastly, we consider a hybrid option in which participants invest 80% of their contributions in an IDC fund and 20% in a collective buffer fund that only invests in equities. Each year, participants rebalance their holdings between the two funds to maintain this 80/20 ratio. A hybrid contract like this has clearly articulated ownership rights for 80% of participants' pensions, and also shares equity risk across generations through the collective buffer, which is not possible in a purely individual contract.

The partial adjustment in the collective contract and the differential adjustment of planned payments in the individual contract are beneficial for people who prefer to adjust their consumption habits gradually when their pension gains or loses value - rather than immediately moving to a new living standard that can be sustained until the end of life (Alessie and Lusardi, 1997).

The partial adjustment mechanism in the CDC contracts generates an implicit exposure to equity as a percentage of accumulated pension savings that differs per age group. For young workers, future right accruals are sizable compared to accumulated savings. In the CDC open and CDC closed alt contracts, the exposure of future right accruals to current stock market developments thus gives them an implicit equity exposure of more than 100 per cent in terms of accumulated savings. In the CDC closed contract, the young's future accumulations are not affected by the current funding ratio. Their implicit equity exposure is higher than the fund's portfolio equity share, but remains below 100 per cent. Figure 1 and Figure 2 depict the equity exposure in the IDC contracts over the life cycle.

The CDC closed contract offers young workers a marginal exposure of more than 100 per cent to the fund's total portfolio. To see this, imagine a fund that invests all of its assets in equity. When equity prices drop by one per cent, the pension rights of the elderly are cut by less than one per cent. As a consequence, young workers lose more than one per cent.[5] In the scenario set without interest rate risk, an individual contract can closely replicate the implicit exposure to financial risks in the CDC closed contract without short selling. As cash and bonds of all maturities are perfect substitutes in a world without interest risk, borrowing cash is equivalent to reducing bond holdings. Hence, since the implicit equity exposure in the CDC closed contract is less than 100 per cent, there is no need for borrowing.

In a world with interest risk, medium- and long-term bonds provide valuable diversification to equities. Without short selling, the individual contract can only increase its equity exposure early in the life cycle by reducing its holding of medium- and long-term bonds, resulting in a less-diversified portfolio. The CDC closed contract can thus also add value when there are multiple financial risk factors.[6]

[5] Though the exposure exceeds 100 per cent for small financial shocks, no participant can lose more than his or her total accumulated rights after a shock.

[6] It is difficult for the IDC contract to increase its implicit equity exposure with out-of-the-money call options. These options have low expected returns to compensate call writers for large unhedgeable downside risks (Ni, 2009; Boyer and Vorking, 2014).

Figure 1: Equity exposure in IDC contracts in BS scenarios (only equity risk)

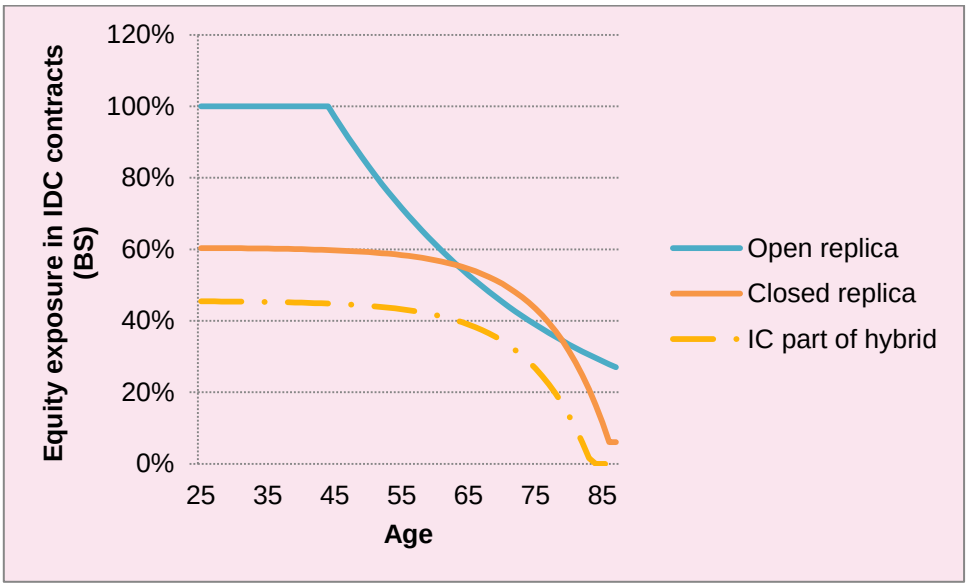
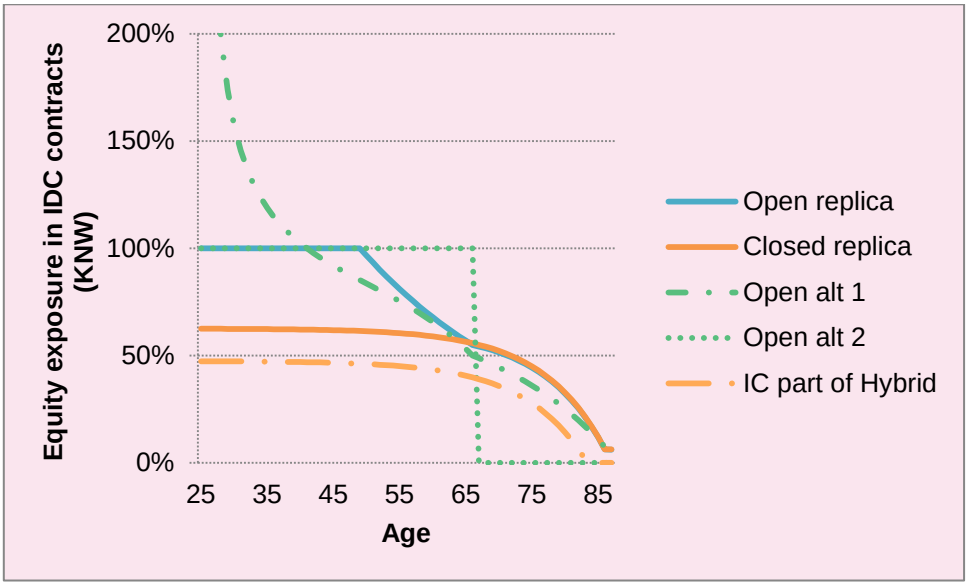


Figure 2: Equity exposure in IDC contracts in KNW scenarios (equity, interest and inflation risk)



The CDC and IDC contracts also differ in their allocation of interest rate risk over the life cycle. In the CDC contract, changes in the long end of the yield curve also affect the elderly through the collective funding ratio despite a short remaining life expectancy. As old participants bear some of the interest risk arising from the young's liabilities, the old have a higher interest exposure relative to the duration of their own pension rights.[7] Whereas this mismatch does not imply a worse probability distribution of pension payments from the perspective of a 25-year old, it does mean that retirees are more likely to be confronted with

[7] Old participants are still somewhat insulated from interest changes due to the partial adjustment mechanism.

large unexpected adjustments if the interest risk is not sufficiently hedged. The IDC contract can match the interest risk for each age group to the duration of their pension payments.

Our sample hybrid contract features some advantages of both the IDC and CDC contracts. For the individual part of the pension contract, older individuals do not share in the interest risk of younger workers.[8] Near the end of the life cycle, the majority of an individual's equity exposure stems from his or her share in the collective buffer fund. Because of the partial adjustment rule for this collective buffer, old individuals do not suffer large consumption losses when the collective buffer generates negative returns. By comparison, advanced-age individuals are increasingly unable to smooth financial shocks in a pure IDC contract when their remaining lifetime decreases.

The difference in sensitivity to interest shocks can be eliminated by fully hedging the interest risk in both contracts, through swaps or a matching portfolio of bonds. It is difficult to fully hedge this risk in practice, since long-term swap and bond markets are not very liquid. The degree to which hedging is desirable also depends on the expected correlation between interest rates and inflation. Whereas CDC funds may be extra inclined to hedge since they sometimes give nominal guarantees to participants, IDC contracts will be more inclined to hedge nominal interest risk if it primarily consists of real interest- rather than inflation risk.

We consider a starting fund that has no assets or liabilities in the first year (2014). The cohort with age 25 in the first year is the first cohort to accumulate a full pension in the fund. The replacement rates for the cohorts born between 1948 and 1990 gradually increase because the cohorts have contributed to the fund for an increasing number of years. In this way, the results are not affected by assumptions about initial conditions, and there is no confusion about the phasing out of transition effects.

Outcome variables

We compare the contracts using the replacement rates and the yearly relative change in real pension payments.

The replacement ratio is defined as the gross occupational pension benefits divided by the pensionable wage of current employees. The replacement ratio differs per cohort, year and scenario. For each cohort and scenario, we calculate the average replacement ratio during the retirement period and present its probability distribution with the mean, median, and various percentiles over the 5000 scenarios.[9] We pay particular attention to the 5th percentile as a 'bad' scenario and the 95th percentile as a 'good' scenario.[10]

[8] To facilitate comparison with the other contracts, the collective buffer fund uses the nominal term structure to discount its liabilities. Therefore, even though this fund does not invest in bonds, changes in the term structure affect pension payments and right adjustments for the collective buffer.
[9] With our demographic assumptions, there is no need to weight the yearly ratios by survival probabilities.
[10] Differences in replacement rates cannot be interpreted as redistributions in market value. In principle, the CDC contracts do not redistribute market value: with partial adjustment, young generations are exposed to more risk than retirees but also receive the premium for that risk. Still, there may be minor imbalances, for example due to the discrete time horizon. The IDC contract does not redistribute market value across generations by definition.

The yearly relative change in real pension payments is a measure of the remaining risk that participants face during the pension period. Also here, we present the median and high and low percentiles. An IDC contract with a life cycle investment profile concentrates risk at the beginning of the career compared to a constant asset mix. If financial returns are as expected during the working life, the life cycle contract has a lower remaining risk during the pension period, since it invests less in equity and more in bonds after retirement. A narrow distribution of the yearly relative change indicates a small probability of large adverse shocks after retirement.

We focus on the outcome variables for a steady state cohort. The per-cohort replacement rates in the CDC contracts increase for a long time. With the partial adjustment mechanism, young participants share in the risks of the old. Since we start with an empty fund, the initial old have accrued little pension rights and the initial young hence assume little additional risk. This reduces the uncertainty of the first young's pension benefits, but also lowers them in expectation. In turn, subsequent cohorts have higher median pensions because they assume more risk from the first young, but lower pensions than a steady-state cohort as the first young assumed little risk from the first old. The replacement rates converge for the cohort that starts working about 85 years after the start of our simulations.

3 Results

We first present the results for the Black-Scholes scenarios with only equity risk. In the analysis for the KNW scenarios with equity, interest and inflation risk, we also discuss the IDC variants in which we allow short selling or disallow equity risk after retirement.

Figure 3: Development of median replacement rates per cohort in CDC contracts (BS scenarios)

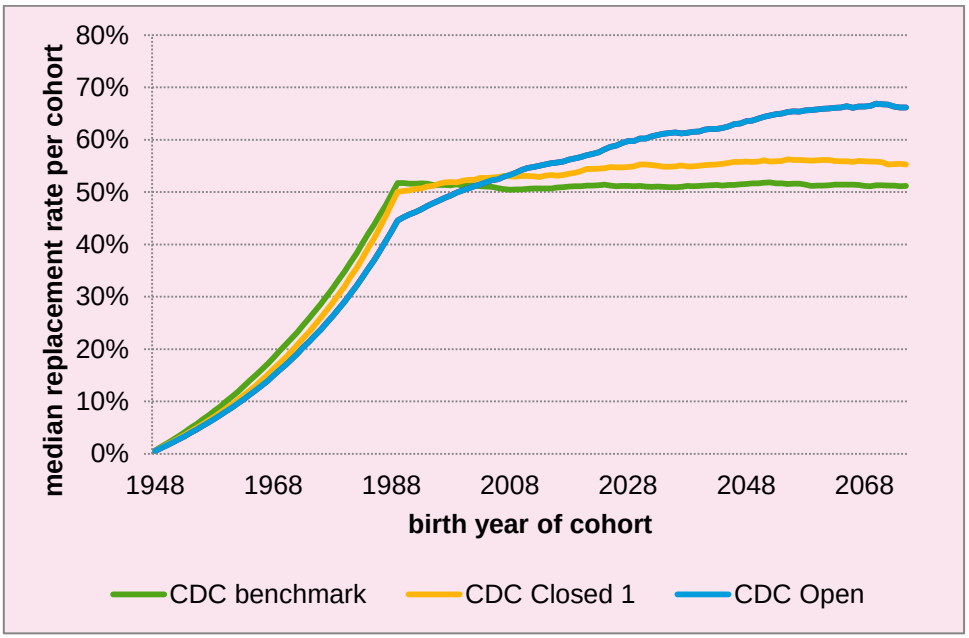
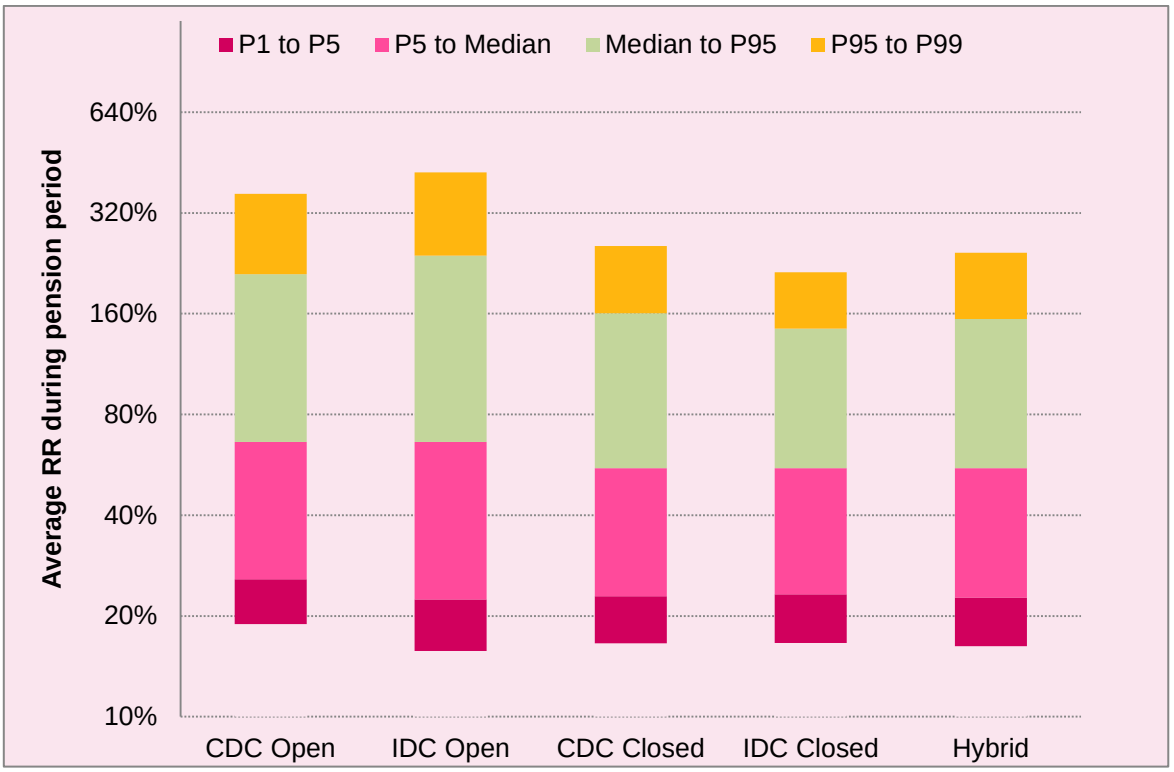


Figure 3 depicts the replacement rates per cohort over time. Up until birth year 1990, the replacement rates increase in all contracts, as the number of accrual years in the fund increases. Afterwards, the replacement rates in the benchmark contract stabilize. The replacement rates in the Open and Closed contracts increase for a much longer period. The replacement rates for all IDC contracts (not presented here) are flat after the 1990 cohort, because the cumulation effects discussed at the end of section 2 are not present.

Figure 4 shows the steady-state probability distribution of mean replacement rates for the open and closed contracts. We present detailed tables of the replacement rates for all comparisons in the Appendix. The medians of CDC and IDC are equal by design. The two closed contracts give comparable results, but the CDC open contract provides better protection in bad scenarios than its IDC counterpart. We will compare the different CDC and IDC contracts below in some more detail.

Figure 4: Summary of replacement rate pdf's in CDC and IDC contracts (BS scenarios)



The CDC and IDC benchmark contracts are identical at the scenario level (see Figure 5). The median average replacement rate during the pension period is 51.2%. The median replacement rate and the width of the 95% confidence interval increase slightly over the pension period. because of cumulative financial risk. The bandwidth of yearly changes is quite large: consumption is immediately and fully adjusted after a shock. so a 10 per cent decrease in portfolio value directly translates into a 10 per cent decrease in consumption in all subsequent years. The relative yearly changes are hence uncorrelated: after a downward year-on-year change. the retiree does not face further year-on-year adjustments in expectation.

Figure 5: Outcomes for benchmark CDC and IDC contracts (BS scenarios)

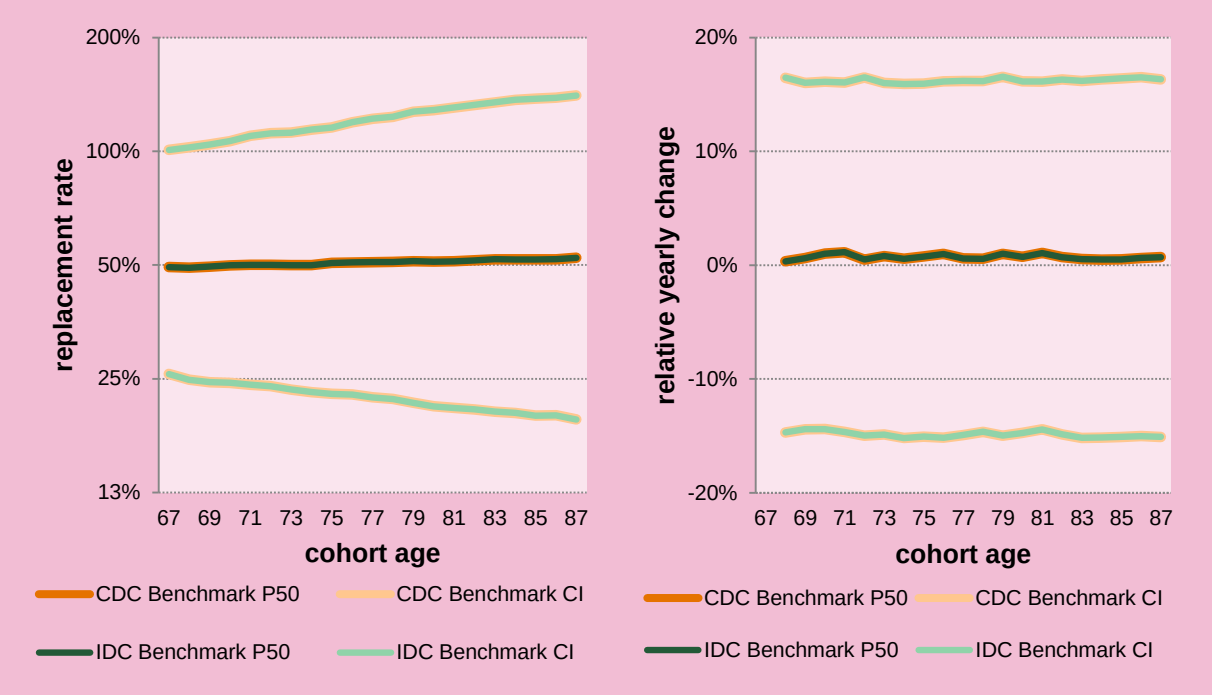


Figure 6: Outcomes for open CDC and IDC contracts (BS scenarios)

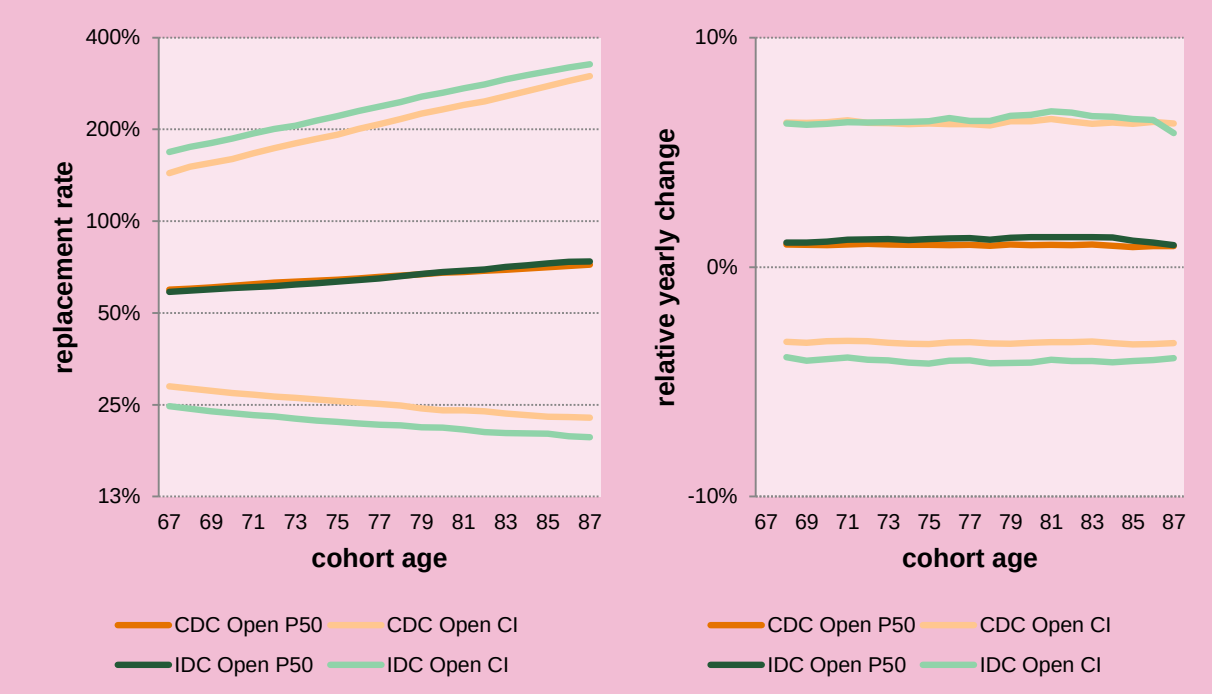


Figure 6 displays the outcome for the open CDC contract and IDC replica. The CDC open contract features an adjustment period for financial shocks; the IDC contract has a life cycle investment strategy and consumption smoothing rule. The CDC open contract reaches a

replacement rate of 66.2%. For the same asset mix as the benchmark CDC contract, both the median replacement rate and the median funding ratio are approximately 30 per cent higher than in the benchmark. With the partial adjustment, the fund only distributes 10 per cent of any surplus each year. Therefore, the fund accumulates a buffer that results in higher median pension benefits. The higher steady-state payoffs are not caused by market value redistribution away from initial retirees, who are compensated for lower median benefits with downside insurance.

For the same median average replacement rate, the 5th percentile is 3.3 percentage points or 14.8% higher in the CDC open contract than in the IDC open replica (see Figure 4). The IDC contract has 13.6% higher benefits in the 95th percentile. The CDC open contract thus offers less volatility for the same benefits in a typical scenario. The CDC open contract allows individuals to take equity risk before the start of their working life, and to implicitly invest more in equity than their financial wealth. In this way, it achieves better time diversification than an IDC contract, since the total pension result is less dependent on stock returns in any single year.

The yearly changes are less volatile than in the benchmark contracts, both for CDC and IDC. In the CDC open contract, the 5th percentile is -3.3% compared to -15.2% in the benchmark. In the CDC contract, this is due to the partial adjustment mechanism; in the IDC contract because of the consumption smoothing rule. After a negative financial return, there is a sequence of small negative adjustments rather than one large adjustment in the benchmark. Though the individual year-on-year adjustments are modest, they are positively correlated. A decrease in payments this year will in expectation be followed by a further decrease next year.

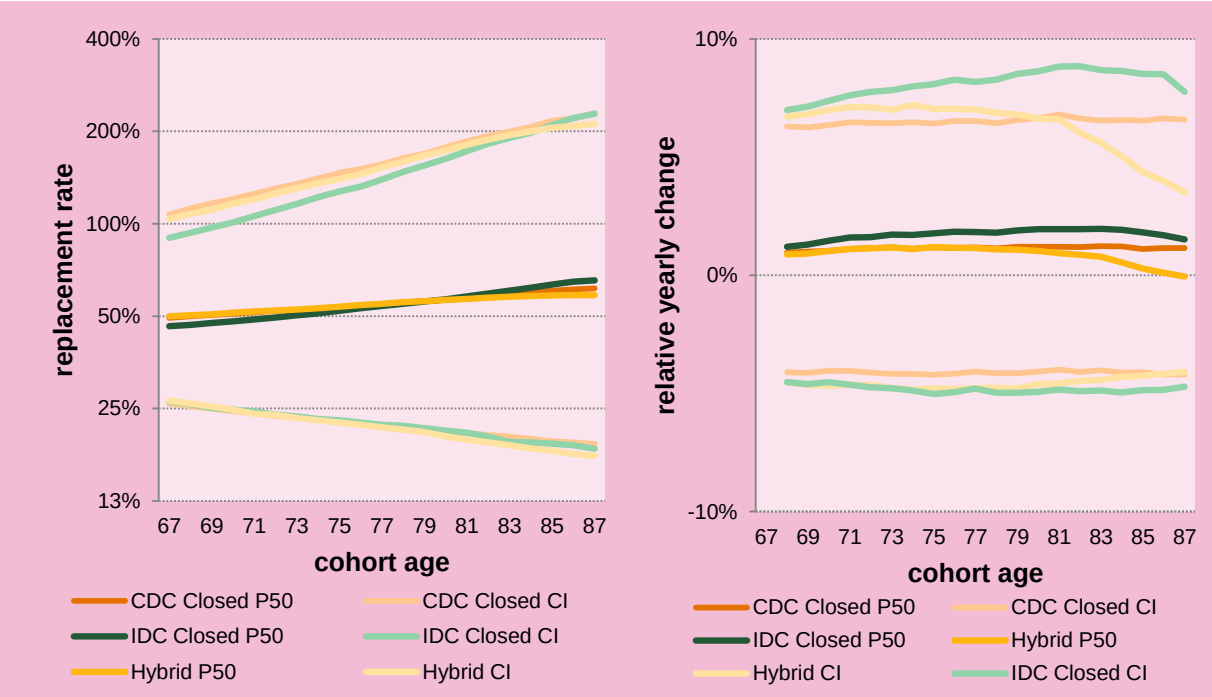
The CDC closed contract has a lower steady-state replacement rate of 55.3%. Comparing the distribution of the mean replacement rate over the pension period (Figure 4), the IDC contract has a slightly higher 5th percentile (23.2% vs 22.9%), and a slightly lower 95th percentile (144.3% vs 160.7%) than the CDC contract. The 5th percentile of the hybrid contract is slightly lower still at 22.7%.

The median replacement rate is on average during the pension period the same in IDC and CDC by construction, but increases somewhat more steeply over the pension period in the IDC contract than in the CDC contract (**Error! Not a valid bookmark self-reference.**). For a retiree, the average duration of the planned payments in the IDC contract is lower than the average duration of the collective liabilities in the CDC contract. Both contracts adjust future payments by the portfolio return in excess of the duration-weighted interest rate. With an upward-sloping yield curve, the same portfolio return thus results in a larger payment adjustment for old individuals in the IDC than in the CDC contract. For a young individual, the reverse applies. This explains why the median payment at 67 is higher in the CDC contract than in IDC.

At the end of the life cycle, the volatility of yearly changes in the hybrid contract decreases significantly, as the effective equity exposure for very old individuals becomes very low: it

approaches zero in the IDC part (see Figure 1), and their effective exposure through the collective buffer also decreases through the partial adjustment rule.

Figure 7: Outcomes for closed CDC and IDC contracts (BS scenarios)



Scenario set with interest and inflation risk

We now compare the collective and individual contracts using the KNW scenario set, to see whether individual and CDC and IDC contracts perform differently in the presence of interest and inflation risk.

First, we look at contracts without interest rate hedging (Figure 8). The IDC contracts have a life cycle pattern of stock holdings according to Figure 2, and invest the remaining wealth in five year bonds.

Contrary to the scenarios without interest risk, the IDC closed contract now slightly underperforms the CDC closed. The 5th percentile in IDC closed is 4.6% lower, and the other percentiles are also worse than the CDC counterpart. Exposure to interest risk offers valuable diversification to equity risk. Without short selling, the IDC contract cannot replicate the implicit equity exposure in the CDC contract early in the life cycle without reducing its bond holdings. The IDC contract can thus only attain the same expected return as CDC with slightly suboptimal diversification, even if the CDC contract does not share risks with future participants. The 5th percentile in IDC open is 12% lower than in CDC open. The hybrid contract performs similar to the IDC closed contract; it has a 1% lower 5th percentile, but a 1.5% higher mean for the same median.

The replacement rates over the pension period follow a similar pattern as in the Black-Scholes scenarios. The yearly relative changes become more volatile in the IDC contracts at

the end of life however, as the smoothing period for financial shocks becomes progressively shorter.

Figure 8: Summary of replacement rate pdf's in CDC and IDC contracts (KNW scenarios)

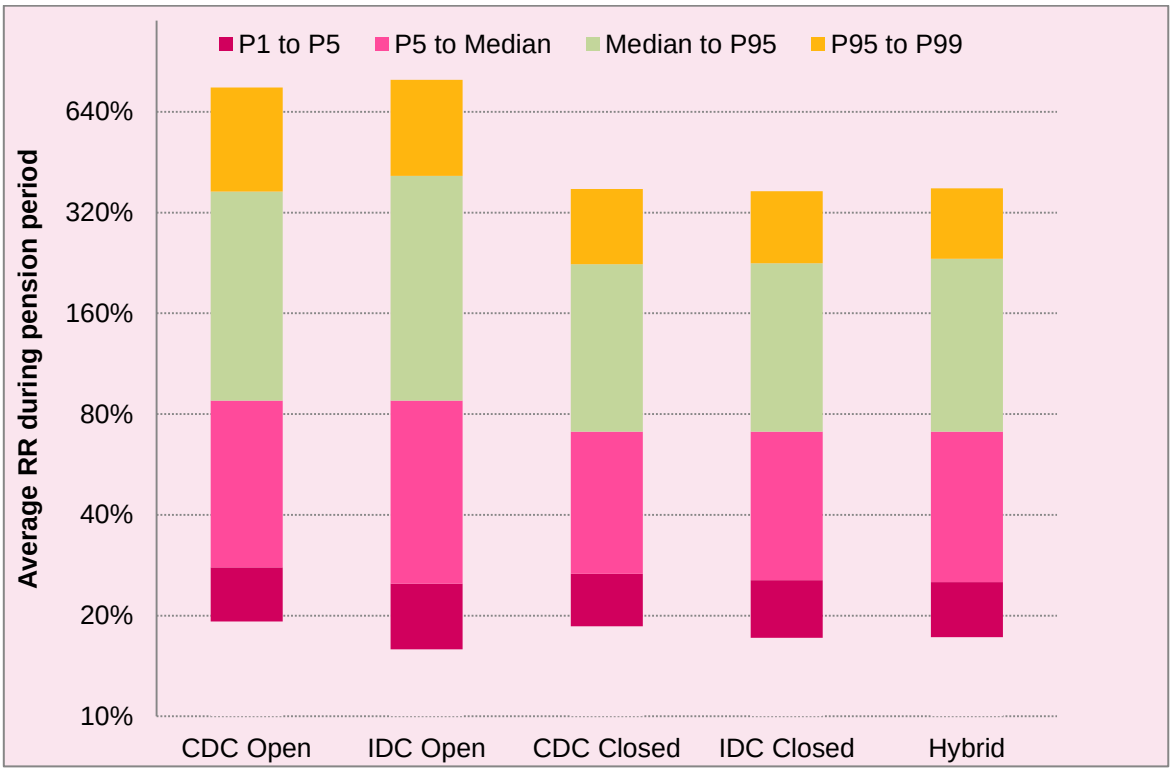
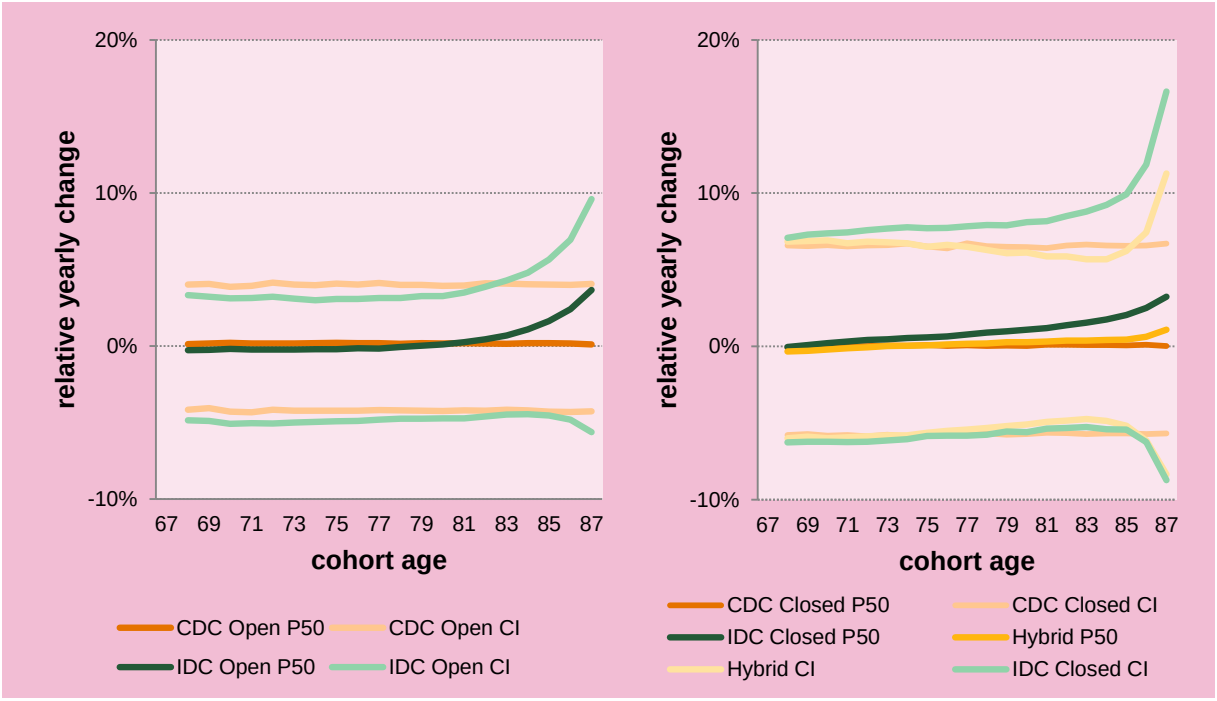


Figure 9: Relative yearly changes for open and closed contracts (KNW scenarios)



In the scenarios with interest risk, the volatility of yearly changes increases at the end of life for the IDC contract. The investment portfolio mostly consists of five-year bonds during the retirement period. While not being very risky, these bonds still bear some interest rate risk. From age 80 onwards, the individual becomes increasingly less able to smooth negative bond returns over his remaining life. An 86-year old in the CDC contract in contrast shares all investment risks with younger individuals and future generations, so the bandwidth of yearly changes remains approximately constant during retirement. The hybrid contract has a smaller bandwidth of yearly changes.

Next, we study the sensitivity of the performance of the IDC contract with respect to restrictions on its investment possibilities. As we explained in section 2, young individuals have an implicit equity exposure of more than 100% of accumulated savings in the CDC open contract. We investigate whether the IDC contract can better approximate the CDC open contract if we allow the IDC contract to have a greater equity exposure early on. Also, we look at the impact of regulation that disallows equity risk after retirement in IDC contracts, as is currently the case in the Netherlands.

Figure 10: Replacement rate pdf's in alternative IDC contracts (KNW scenarios)

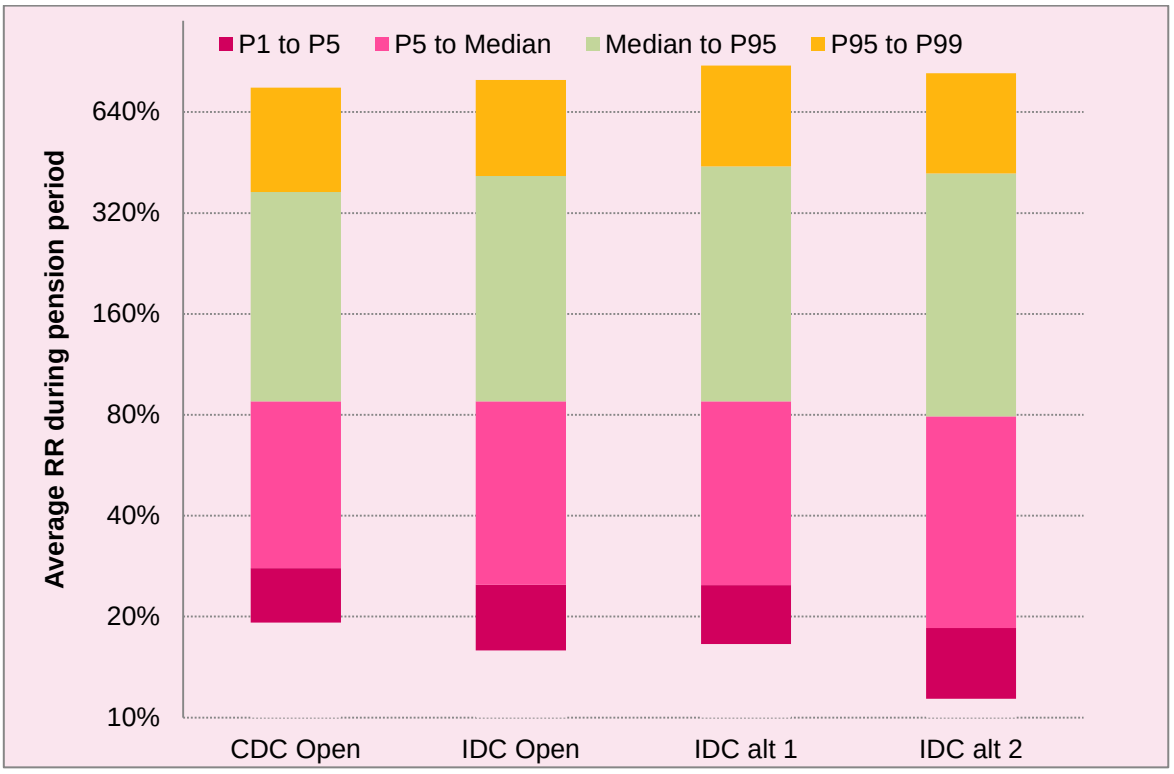


Figure 10 depicts the results. Allowing equity exposures higher than 100% (IDC alt 1) does not affect the 5th percentile, but results in a higher pension in the 1st percentile (4.3% higher) and also in optimistic scenarios (~7% higher). Restricting equity investment after retirement substantially worsens the probability distribution of the mean replacement rate. Even if the IDC fund invests its complete portfolio in equity between age 25 and 67, it is not

able to reach the median replacement rate of the CDC open contract. Furthermore, the 5th and 1st percentile are more than 25% lower than in the IDC open replica.

The length of the retirement period is non-negligible. The remaining life expectancy at retirement is more than 19 years in the Netherlands[11]; long enough to make it attractive to take advantage of the equity premium. The disadvantage of not being able to invest in equity is substantial, as accumulated assets are at their peak at the beginning of the retirement period. Comparatively, not being able to have a leveraged equity exposure early on is less problematic as accumulated savings are still small. An IDC contract can compensate largely by keeping the equity exposure at 100% for longer than a completely unrestricted strategy would (see Figure 2).

In the Appendix, we evaluate the sensitivity of our results with respect to the economic scenario sets. Using scenarios from the Dutch pension provider APG, with lower interest rates and equity returns, we come to qualitatively similar conclusions, although the magnitude of the benefits of the CDC contracts decreases a bit. We also study contracts with more sophisticated bond holding strategies.

4 Conclusion

Risk sharing with future generations in collective defined contribution contracts has a modest added value. For the same median replacement ratios, open CDC contracts can give 12-14% higher benefits in adverse economic scenarios. In a world with only equity risk, CDC contracts that do not share risks with future participants cannot offer better risk-return combinations than IDC contracts. In a world with multiple risk factors, including interest rate risk, closed CDC contracts also outperform individual replicas. CDC contracts are able to circumvent shortselling constraints, and can spread investment risks for the elderly better than IDC contracts. A hybrid contract does not generate a better ex ante distribution of the average replacement rate than a purely individual contract, but can achieve less volatile yearly changes during the retirement period.

Our findings suggest that the benefits of IDC contracts of better allocating interest risk between generations are small. The partial adjustment mechanism in CDC contracts combined with an interest hedge can insulate older retirees from negative interest rate shocks.

[11] Source: Statistics Netherlands

Appendix

Sensitivity analyses

In this Appendix, we conduct two sensitivity analyses. The first is with respect to the financial market assumptions. The interest rates in the Black-Scholes and KNW scenarios are considerably higher than currently observed in the Eurozone. For example, the return on 5-year Eurozone bonds as of December 2014 is around 0.5%, whereas the geometric long-term averages are 2.53% and 3.53% in the Black-Scholes and KWN sets, respectively. Both sets also have a high equity premium, measured as the difference between the average stock and bond returns. of more than 4% (geometric) or around 6.6% (arithmetic). A high reward for risk potentially increases the benefits of intergenerational risk sharing.

To see whether the conclusions from the main text are robust in an environment that more closely resembles financial market conditions at the end of 2014, we repeat the analysis using a scenario set from the Dutch pension provider APG. This scenario set is more conservative, and has a long-term geometric average stock and five-year bond return of 4.54% and 1.38% respectively. The geometric average wage and price inflation are 1.40% and 1.35%. The equity premium, using the definition from the previous paragraph, is 3.16% (geometric) or 4.26% (arithmetic). This scenario set is based on ten state variables, compared to two for the KNW set, so it allows more flexible yield curve patterns and a richer history-dependence. The substantial differences in key summary statistics compared to the KNW scenario set make the APG scenario set a useful candidate to evaluate the robustness of our conclusions.

The CDC contracts are unchanged from the main text: they invest 50 per cent of their assets in equity and 50% in five-year bonds. We recalibrate the IDC life cycle strategies such that the median average replacement rates match those in the respective CDC contracts. The new equity exposures are similar to those in the main text.

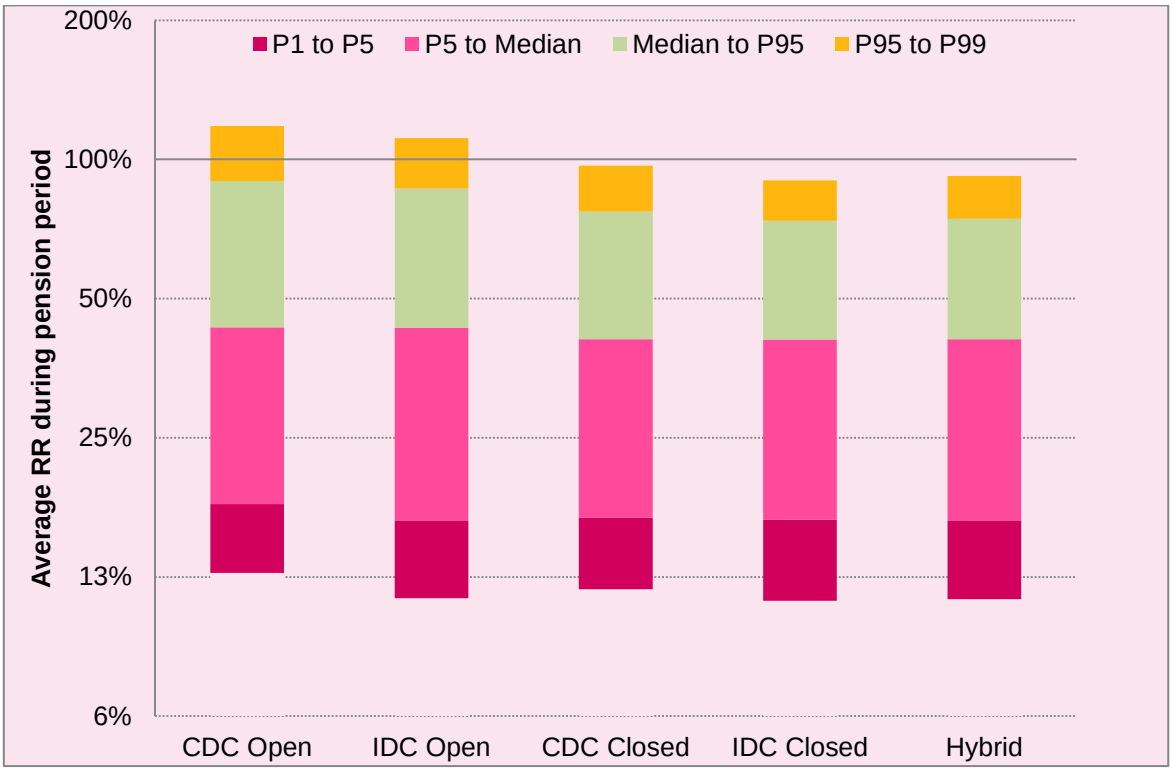
Figure 11 depicts the results for the APG set. Firstly, the median replacement rates are much lower than in the KNW set, owing to the lower interest rates and equity premium. The benefits of collective contracts are also lower than for the KNW scenarios. The 5th percentile of the CDC open contract is 8.5% higher than in the IDC replica, compared to 12% for the KNW set. The added value of the CDC closed contract is further reduced; the 5th percentile is only 1% higher than the IDC replica, compared to 4.6% in the KNW set.

These results lend support to the conjecture that when returns to risk are lower, so are the benefits of being able to assume financial market risk before the start of your career. Looking at the CDC closed contract, it is less advantageous to be able to have a marginal exposure of more than 100% to a portfolio with a worse risk-return combination.

Our second robustness analysis concerns the duration of the bond portfolio in the CDC and IDC contracts. An often heard argument is that collective contracts misallocate interest rate risk between generations. Changes in the far end of the yield curve have a negative effect on

the collective funding ratio and thus on the elderly's pension payments, even if their remaining lifetime is only five to ten years. In an individual contract, the duration of the bond portfolio can be more closely tailored to the duration of the cohort's expected benefit payments. Following this principle, the IDC contract would invest in long-term bonds at the beginning of the life cycle and in short-term bonds near the end of life.

Figure 11: Summary of replacement rate pdf's in CDC and IDC contracts (APG scenarios)



To reflect this idea, we modify the investment strategies as follows. The collective contract invests its bond share (50%) in 16 year bonds, which roughly matches the duration of liabilities for a typical fund. In the IDC contract, the bond duration equals min{ 87 – current age , 30 }.[12] We cap the bond duration at 30 because of liquidity issues for bonds with longer durations. Again, we calibrate the equity and bond exposure in the IDC contract to match the median replacement rates. For this robustness analysis, we use the KNW scenario set.

The results are shown in Figure 12. Using longer duration bonds does not improve the relative performance of the IDC contract. When the CDC open contract invests 50% of its portfolio in 16-year bonds, the IDC replica still falls short of the CDC open's median replacement rate when it fully invests in equity at all ages, by 2 percentage points. Naturally, an all-equity portfolio makes the pension result very volatile. The 5th percentile of the CDC closed contract is 6.3% higher than the IDC replica. The CDC contract's ability to generate more than 100% marginal exposure becomes more important when the bond portfolio generates a higher return and has a lower correlation with stock returns.

[12] This is longer than the duration of the planned pension payments in the IDC contract for most ages, for two reasons. First, we compensate for the inability to hold longer-duration bonds at young ages. Second, to offset the short-selling limitation, the IDC closed replica holds bonds with a longer duration than the planned pension payments.

Figure 12: Summary of replacement rate pdf's in CDC and IDC contracts with different bond durations (KNW scenarios)

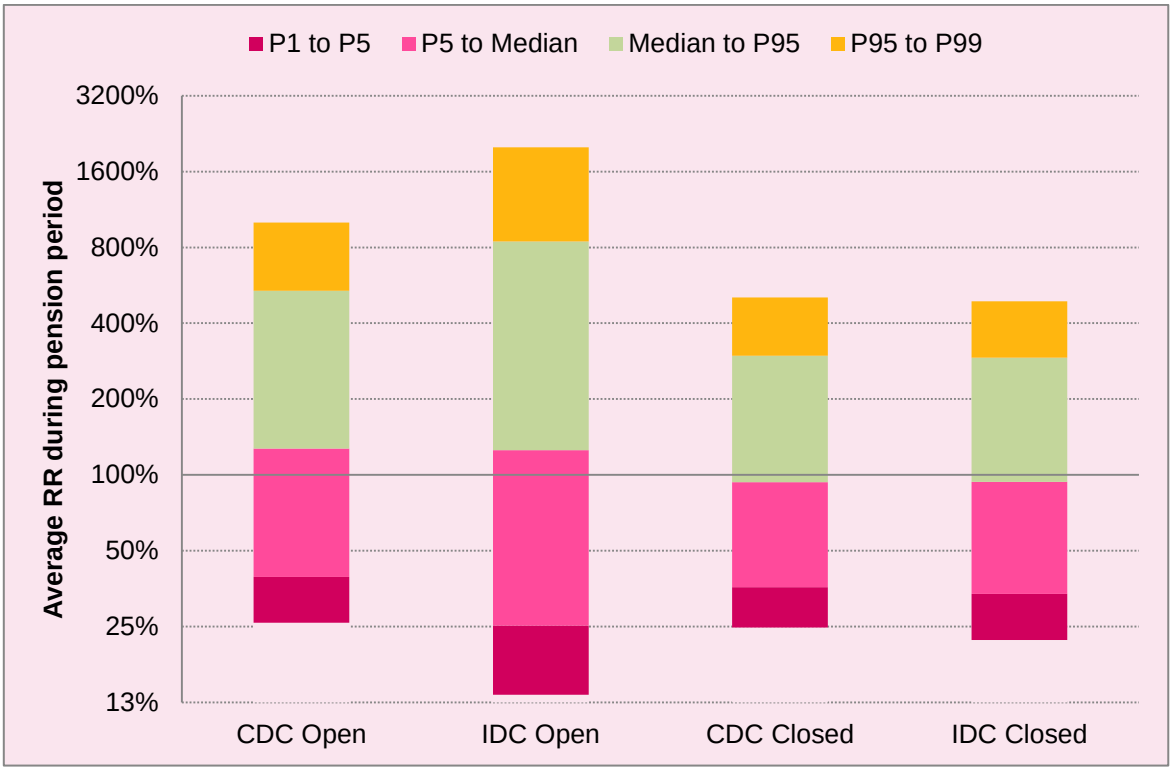
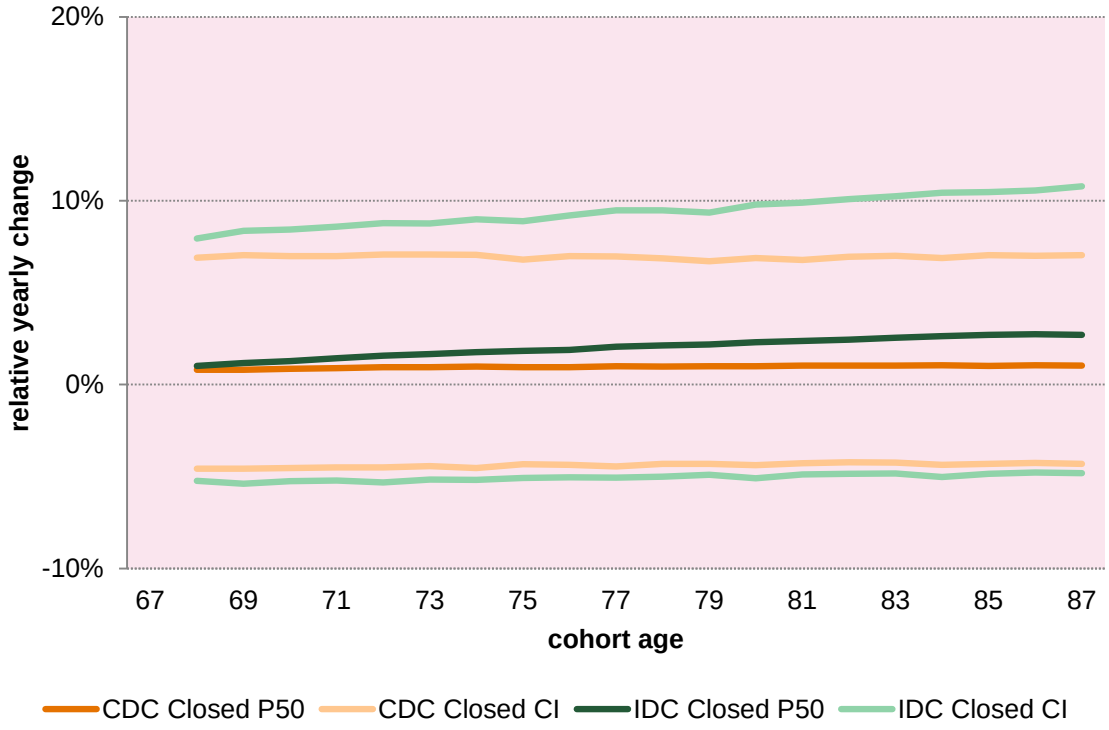


Figure 13: Relative yearly changes in CDC closed and IDC replica with different bond durations



Whereas a different allocation of interest rate risk across generations does not necessarily influence the ex ante pension result, it could lead to a lower volatility of yearly changes in the IDC contract. Comparing Figure 13 to Figure 9, the increase in volatility in the IDC contract at advanced ages is lower than in the main text. At high ages, the duration of bond holdings is less than 5 years, so the benefits are less prone to change in response to interest rate shocks. However, the volatility of yearly changes remains higher than in the CDC contract. These results suggest that the IDC contract's ability to better allocate interest risk is not quantitatively important, and that the smoothing period in CDC contracts reasonably protects the elderly against interest shocks.

Tables

In this section, we present the numbers behind the boxplot figures in the main text and the Appendix.

Table 1: Summary of replacement rate statistics in CDC and IDC contracts (BS scenarios)

	CDC Open	IDC Open	CDC Closed	IDC Closed	Hybrid
	In %				
Mean	86.6	90.6	68.9	66.0	67.4
Median	66.2	66.2	55.3	55.3	55.3
P99	364.9	422.7	254.7	213.0	243.4
P97.5	273.6	307.1	199.6	179.2	189.5
P95	210.2	238.7	160.7	144.3	154.3
P5	25.7	22.4	22.9	23.2	22.7
P2.5	22.2	18.5	19.3	19.6	19.1
P1	18.9	15.7	16.6	16.6	16.2

Table 2: Summary of replacement rate statistics in CDC and IDC contracts (KNW scenarios)

	CDC Open	IDC Open	CDC Closed	IDC Closed	Hybrid
	In %				
Mean	130.3	136.6	91.6	91.2	92.7
Median	87.8	87.8	70.8	70.8	70.8
P99	757.0	797.4	376.6	370.5	378.2
P97.5	501.9	557.8	287.7	282.8	298.8
P95	370.1	412.3	224.4	226.0	232.8
P5	27.9	24.9	26.7	25.5	25.2
P2.5	22.9	19.8	22.3	21.1	20.9
P1	19.2	15.9	18.6	17.2	17.2

Table 3: Summary of replacement rate statistics in IDC variants (KNW scenarios)

	CDC Open	IDC Open	IDC alt 1	IDC alt 2
	In %			
Mean	130.3	136.6	143.2	133.7
Median	87.8	87.8	87.8	79.1
P99	757.0	797.4	881.3	836.2
P97.5	501.9	557.8	605.5	603.9
P95	370.1	412.3	441.0	419.9
P5	27.9	24.9	24.9	18.5
P2.5	22.9	19.8	20.3	14.5
P1	19.2	15.9	16.6	11.4

Table 4: Summary of replacement rate statistics in CDC and IDC contracts (APG scenarios)

	CDC Open	IDC Open	CDC Closed	IDC Closed	Hybrid
	In %				
Mean	46.9	46.2	43.0	42.4	42.5
Median	43.3	43.3	40.9	40.8	40.8
P99	118.1	111.1	97.0	90.0	92.1
P97.5	101.6	97.7	86.4	81.9	83.0
P95	89.8	86.6	77.2	73.7	74.4
P5	18.0	16.6	16.8	16.6	16.6
P2.5	15.2	13.6	13.8	13.7	13.6
P1	12.7	11.2	11.8	11.1	11.2

Table 5: Summary of replacement rate statistics in CDC and IDC contracts with different bond durations (KNW scenarios)

	CDC Open	IDC Open	CDC Closed	IDC Closed
	In %			
Mean	187.0	250.7	121.0	119.1
Median	127.3	125.4	93.6	93.7
P99	1002.5	1998.9	506.7	489.2
P97.5	708.3	1231.8	376.1	374.8
P95	538.0	845.2	297.2	291.9
P5	39.3	25.2	35.8	33.7
P2.5	33.2	18.4	30.4	27.9
P1	25.8	13.4	24.8	22.1

References

Alessie, R. and A. Lusardi, 1997, Consumption, saving and habit formation, *Economics Letters*, Volume 55, Issue 1, 15 August, 103-108.

Boyer, B. H. and Vorkink, K., 2014, Stock Options as Lotteries. *The Journal of Finance*, 69: 1485–1527.

Boelaars, I., M.A.H. Cox, M.H.C. Lever en R.J. Mehlkopf, 2015, The allocation of financial risks during the life cycle in individual and collective DC pension contracts, CPB Discussion Paper 317, www.cpb.nl.

Chen, Z., J. de Haan and E. Ponds, 2015, De kwantitatieve waarde van risicodeling binnen pensioenfondsen, *TPE Digitaal*, 9 (1), 21-33.

Draper, N., 2014, A financial market model for the US and the Netherlands, CPB Background Document, CPB, Den Haag. www.cpb.nl.

Draper, N., C. van Ewijk, M.H.C. Lever and R. Mehlkopf, 2014, Stochastic Generational Accounting Applied to Reforms of Dutch Occupational Pensions, *Economist*, 162:287-307.

Michielsen, T.O., 2015, Asset liability management model for pension analyses, CPB Background Document, www.cpb.nl.

Ni, S.X., 2009, Stock option returns: A puzzle, Working paper, Hong Kong University of Science and Technology.

Westerhout, E.W.M.T., J.P.M. Bonenkamp and D.P. Broer, 2014, Collective versus Individual Pension Schemes: a Welfare-Theoretical Perspective, CPB Discussion Paper 287.