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Macro longevity risk and the choice between annuity products: Evidence from Denmark ☆

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ABSTRACT

We study a unique data-set containing individuals who were given the opportunity to substitute a guaranteed pension product with relatively low levels of risk for a market-sensitive pension product with both a higher degree of financial risk and exposure to macro longevity risk. Implicitly there is a longevity hedge built into the guaranteed product that is abolished when one switches to the market-sensitive product. The analysis shows that situations might arise where expected pension payments in the market-sensitive product fall below expected pension payments in the guaranteed product, despite the fact that the former has a higher expected return from financial assets. We find that young male residents of Copenhagen with a degree in economics who are guaranteed a low return on their pension savings and have moderate pension wealth are more likely to switch to the market-sensitive pension product.

1. Introduction

Pension systems around the world are challenged by unexpected increases in life expectancy (i.e. macro longevity risk), historically low interest rates, and increased Solvency II capital requirements. Consequently, the pension industry has witnessed a move from guaranteed pension products to market-sensitive pension products. The result is a significant risk transfer, from risk accruing to the pension provider to risk accruing to the individual pension holder. Even in countries like the Netherlands and Denmark, which have consistently been rated "the best pension systems in the world", we observe a move towards more uncertainty.[1] In Denmark, to take just one example, around 10% of pension contributions went to market-sensitive products in 2005. In 2017 around 75% of pension contributions went to market-sensitive products (FSA, 2017).

The transfer of financial and longevity risk when moving from guaranteed to market-sensitive products significantly adds to the complexity of the choice of pension product. This leads to an increase in the required degree of financial literacy of the individual to optimally plan and prepare for retirement. This is important as it is well-documented that individuals consistently make errors regarding financial decisions; see Mitchell (1988) and Van Rooij et al. (2011). It also raises the question of how to correctly inform pension holders about the multiple risk factors they face when they move away from a guaranteed product with a relatively low level of risk to a market-sensitive product.

Given these developments towards more risky pension products and the complexity associated with such products, it is important to understand what types of individuals choose a riskier (both in terms of financial and longevity risks) product, and what types choose a less risky one. Such studies have been sparse, not least due to the lack of data. Historically, the literature on pension choices has mainly investigated the puzzling unexplainably low demand for annuitization; see Beshears et al. (2014), Brown (2001), and Bütler and Teppa (2007). We, however, investigate the choice between two annuity products rather than a lump sum.

To the best of our knowledge we are the first to provide empirical evidence on real transition decisions between annuity products. We study a unique setting where pension holders in a Danish pension fund were offered the choice to switch from a guaranteed product to a market-sensitive product. More specifically, their

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[1] 2018 Melbourne Mercer Global Pension Index. https://www.mercer.com/our-thinking/mmgpi.html.

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option was to choose between (i) macro longevity protection and little financial risk/low expected returns (the guaranteed product) and (ii) higher financial risk/higher expected return but also higher macro longevity risk (the market-sensitive product). Thus, in our setting, individuals were offered the opportunity to shift to a product with more financial risk and more macro longevity risk.[2] We ignore micro longevity risk as it is treated similarly in the two annuity products in our setting. For a thorough treatment of micro longevity risk, see Milevsky (2020), Chen et al. (2015), and Donnelly et al. (2013).

Recent developments in longevity and the associated risk (Oeppen and Vaupel, 2002; Blake and Morales, 2017; Pascariu et al., 2018) demonstrate that there is a need to understand how unexpected increases in life expectancy influence pensions. Qiao and Sherris (2013) investigate macro longevity risk and highlight its importance because benefit payments can be expected to decrease and the volatility of payments expected to increase over time. Maurer et al. (2013) show that many households with constant relative risk aversion prefer deferred annuities, that vary due to unexpected mortality developments, over deferred guaranteed annuities. The latter type of annuity is expensive because its fair price includes longevity risk. Macro longevity risk in pooled funds is investigated by Piggott et al. (2005), who update the expectations of the individuals within group self-annuitisation in which macro longevity risk is not allowed to be shared among cohorts. De Waegenaere et al. (2017), De Waegenaere et al. (2018), and Broeders et al. (2019) explicitly investigate various sharing rules for different types of macro longevity risk.

This paper illustrates how changes in macro longevity affect expected pension payments in the market-sensitive product, based on actual changes in mortality rates in Denmark. These illustrations show that situations might arise where expected pension payments in the market-sensitive product fall below expected pension payments in the guaranteed product, despite the fact that the market-sensitive product has higher expected returns from financial assets. The reason for this is that the market-sensitive product does not hedge longevity risk to the same extent as the guaranteed product. Consequently, if there are no increases in life expectancy, the expected pension payments in the market-sensitive product will dominate the expected pension payments in the guaranteed product. However, in Denmark, like in many other countries, future gains in life expectancies have consistently been underestimated (Oeppen and Vaupel, 2002; Murphy and Topel, 2006; Fund, 2012).

At this point we consider what types of individuals choose to switch from a guaranteed product to a market-sensitive product. We find that being young, male, living in Copenhagen, having an economics degree and moderate levels of pension wealth increases the probability that the individual will switch to a market-sensitive product. We also find that the higher the guaranteed return, the lower the probability of switching. This is interesting because a higher guarantee means that a larger fraction of pension savings must be allocated to the risk-free asset to secure the guarantee. We conclude that the built-in longevity hedge works in favour of the guaranteed product. Also, given that women live on average longer than men, the hedge of macro longevity risk in the guaranteed product should make the guarantee relatively more attractively to women. In support of this hypothesis, we find that women are less likely to relinquish the guarantee.

This paper is organised as follows. First we investigate the differences between the two products the pension holders can choose in Section 2. In Section 3 we analyse which type of pension holders switch from guaranteed to market-sensitive pensions. Lastly we conclude in Section 4.

Table 1
Level of guarantees.

Date of admission	Level of guarantee
Before 1 January 1990	3.70% or 4.25 %
1 January 1990 – 31 December 1996	3.70%
1 January 1997 – 30 June 1999	3.00%
1 July 1999 – 1 July 2005	2.00%
From 1 July 2005	0.00%

2. Pension products

We have access to a unique-data set from a Danish pension fund that offered its members a one-time voluntary switch from a guaranteed to a market-sensitive pension product. Until the mid-2000s the fund only offered guaranteed average interest rate products. The level of the guaranteed returns was determined at the start of the contract, i.e. when the individual became a member of the pension fund. The higher the prevailing interest rate on the market upon entering the contract, the higher the guarantee. Due to falling interest rates during the last decades, the guarantees offered by the fund have also fallen. As a result the members have been offered different guarantees, depending on their date of admission (Table 1), ranging from 4.25% to 0.00%. Pension holders with a guaranteed interest rate above zero are grouped into a separate division within the pension fund called Division 1.

In May 2007, the 31,497 pension holders in Division 1 – who at the time had a guaranteed product – were offered a choice to voluntarily give up the guarantee in return for an investment strategy that enabled more risky investments and thus higher expected returns. It is important to stress that this transition was an individual voluntary choice, i.e. each member (with a guarantee) chose individually whether or not to switch from a guaranteed to a market-sensitive product. The pension holders received individual information from the pension fund describing the expected consequences of their choices.[3]

2.1. The guaranteed pension product

A guaranteed pension product includes a return guarantee that is fixed and life-long. After the creation of a pension contract the guarantee does not depend on subsequent interest rate movements, contribution rates, or developments in longevity. Thus, these products ensure pension holders a minimum annual return on their pension savings.[4] The pension savings can be increased above the guaranteed rate due to bonus payments, which occurs if the actual investment performance exceeds the guaranteed return (thus they are only exposed to the upside). Pension holders were

[2] When investigating the effect of longevity, it is important to distinguish between micro longevity risk and macro longevity risk. The former involves the risk that an *individual* might live longer (or shorter) than the longevity forecast. This is an idiosyncratic risk that can be shared among individuals. Macro longevity risk, on the other hand, is the risk that the life expectancy of the population increases. This is a systematic risk. When the pool of individuals is large enough, micro longevity risk can be shared among the individuals in the pool. This means that the expected path of pensions will be unaffected by the existence of micro longevity risk. However, systematic macro-wide changes in longevity cannot be shared as they affect everybody in the pool.

[3] Source: A general information guide, “Pensionsvalg 2007”, was attached to the letter and individual pension overview received by Division 1 pension holders.

[4] There has been a debate in Denmark about whether the annual guarantee should be understood as a minimum return every single year or as an average annual return during the accumulation phase. A 2016 court ruling by the Danish Supreme Court made clear that these are guaranteed average annual minimum returns and thus not a return that the member can expect every single year. The Supreme Court case dealt with a different pension fund than the one we study, but the ruling means that the guaranteed return in our pension fund is to be understood similarly as the average return over a number of years and not a guaranteed return every single year.

told that their guaranteed rate of return was close to the prevailing interest rate on the market and that life expectancies had increased relative to when the members originally signed the pension contract. For these reasons, the pension fund had to mainly invest in safe assets and buy return protection to honour the return guarantees. Moreover, members were informed that future expected Solvency II capital requirements would most likely lower expected returns for individuals with a guaranteed product as no bonus payments would be expected in the future. Overall this implied that the expected returns from the pension fund's investments would be lower than the guaranteed return.

Furthermore, pension holders were told that if life expectancies continued to increase, only the minimum annual return would be added to their pension savings (any return above that level would be added to the reserve to circumvent unexpected increases in life expectancy). However, pension payments could not be reduced below the certain minimum level. Thus, even if not explicitly stated, the fact that the pension fund was not allowed to reduce pensions below a certain minimum level, no matter the increase in life expectancies, means that an implicit longevity hedge was built into the guaranteed pension contract.

2.2. The market-sensitive pension product

A market-sensitive pension product, on the other hand, is one in which there is no positive minimum floor on returns, though sometimes a zero lower bound, and no hedge against macro longevity risks. Members were told that if they switched to the market-sensitive product, the guaranteed rate of return would be lowered to 0%, allowing the pension fund to invest more freely in, e.g. stocks and other higher-yielding assets. Members were thus informed that pensions would be expected to increase at a higher rate in the market-sensitive product (compared to the guaranteed product) but also with higher risk/variance. The information material did not distinguish between the accumulation and decumulation phase, i.e. the 0% guarantee implicitly only applied to the accumulation phase as pension payments in the decumulation phase would be reduced if the pension fund performed consistently badly in the financial market or experienced unexpected increases in life expectancy.

Members were also told that if they gave up the guarantee, they would receive a compensation equal to 20% of their accumulated pension wealth, i.e. the pension wealth of members would be increased by 20% if they switched to the market-sensitive product. The reason was that the return protection had a positive net present value at the time of the switch, i.e. the proceeds from the sale of the return protection would be added to the accounts of the members who switched. It is important to stress that the information material did not provide further details on how the 20% was calculated. Similarly, the 20% applied to all members, regardless of their level of guarantee.

Members were also told that life expectancies had been increased in the market-sensitive product compared to the guaranteed one. This meant that in the new product, pensions had to cover a longer period during retirement, i.e. measured at the time of switch, the expected pension payments during retirement would be lower. The increase in pension wealth at the time of the switch, i.e. the 20% that would be added to the individual's account, was thus not large enough to cover the cost of the assumed increase in life expectancy in the market-sensitive product. However, the higher expected return in the market-sensitive product (due to a higher fraction of stocks and other risky assets in the investment portfolio of the market-sensitive product) implied that expected pensions would increase at a faster rate than in the guaranteed product. After some time, when enough higher expected returns in the new product had been harvested, expected pensions would be expected to exceed those from the guaranteed product. This is illustrated in Fig. 1 based on the information sent to the pension holders by the pension fund. Basically, a pension holder would give up expected pensions today in return for higher expected pensions at some future point. Finally, the information material did mention a potential risk that pensions might be reduced further due to even higher life expectancies. However, this was only labelled as a "theoretical" risk because the market-sensitive product was already based on expected improvements in longevity. In contrast to the guaranteed product, the market-sensitive product contains no minimum level that needs to be maintained regardless of an increase in longevity. In other words, there is no longevity hedge built into the market-based contract and this was not explicitly stated in the information material or in the general advice given to the pension holders from the pension fund, as shown in Table 2.

2.3. Expected pension payments by product type

We illustrate the two pension products using a numerical example of the expected pension payments in the decumulation phase.[5] We assume that the risk-free rate is 4.25%, the guaranteed return is 2%, the expected excess return on the risky stock is 4%, and the volatility 20%.[6] We normalise initial pension wealth to €100, 000 (DKK 750, 000). In Fig. 2 a solid line represents the expected pension payment of a guaranteed product, while a dashed line depicts the minimum pension payments corresponding to a guaranteed rate of 2%.[7] To embed the 2% floor into the guaranteed product, the investment strategy is tailored accordingly. The "residual" (i.e. the part of pension savings that is not invested to secure the guarantee) can be invested in risky assets and interpreted as a risky bonus on top of the guarantee. For the figure we assumed that the residual is invested fully in risky assets. The confidence interval depicts the risk of the bonus.

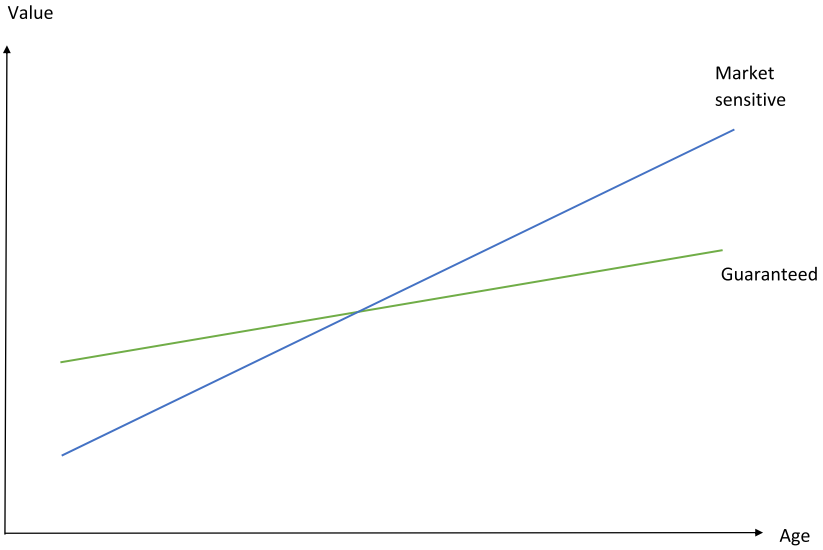
The market-sensitive product is more exposed to financial risk because the total capital can be invested in risky assets rather than just the residual. At the same time, the market-sensitive product is also exposed to macro longevity risk. The Danish life expectancies are based on the Lee and Carter (1992) forecast, with data from 1978 to 2007. We update the longevity forecasts after three years based on a rolling window of 30 years. Table 3 shows that the remaining life expectancy of an individual who was 67 in 2007 – the year of the transition – is 15 years and 4 months. Conditional on that person surviving to the age of 70 in 2010, he is expected to live 12 years and 5 months based on the forecasts with data from 1978 to 2007. However, if the updated forecasts are used, i.e. based on actual data from 1981 to 2010, this individual is expected to live 13 years and 8 months. The unforeseen deviations in longevity thus lead to an unexpected increase of 1 year and 3 months in remaining life expectancy. The table is read analogously for the other two updates. We observe that each update leads to an increase in forecasted survival rates and thus remaining life expectancy.

Fig. 3 shows the impact of both types of risk, i.e. financial risk and longevity risk, on the market-sensitive product. The confidence intervals show the financial risk (we assume a diversified portfolio

[5] Unlike Charupat and Milevsky (2002), Horneff et al. (2010), Hanewald et al. (2013), Steinorth and Mitchell (2015), and De Kort and Vellekoop (2017), who study the optimal investment mix in the decumulation phase of variable annuities with possible riders and/or optimal annuitisation (which is not a choice individuals can freely make in Denmark).

[6] Based on the observation that the average one to twenty year maturity euro spot rate in 2007 was between 4.0% and 4.5% (https://www.ecb.europa.eu/stats/financial_markets_and_interest_rates/euro_area_yield_curves/html/index.en.html). For empirical validation of our choice of the equity premium, see Dimson et al. (2008) and Mehra and Prescott (1985), among others.

[7] This figure, together with Fig. 3, is based on Balter and Werker's (2020) framework.

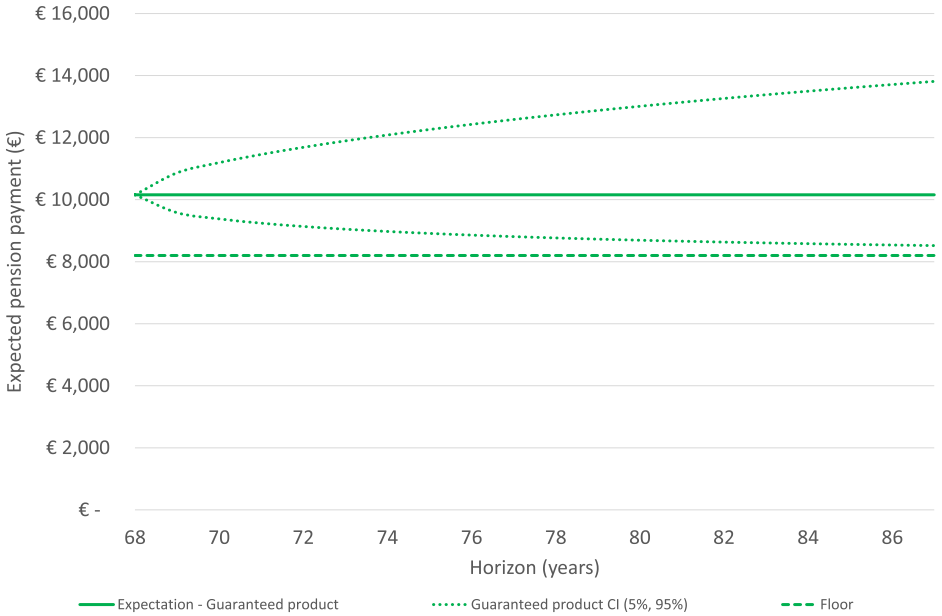


This figure is an exact replica of the figure provided in the information material, i.e. there were no numbers on the axes or further clarifications about the figure.

Fig. 1. Development in the value of pension accounts for different products.

Table 2
Advice given to pension holders from the pension fund.

Keep guarantee
- Believe that bond returns will exceed stock returns in the long run - Prefer yearly stable additions to the pension account - Are close to retirement or are already retired
Abolish guarantee
- Believe that stock returns exceed bond returns in the long run - Prefer yearly variable additions to the pension account depending on the size of annual returns - Are healthy - Plan to work for many years



The solid line indicates the expected pension payment of a guaranteed product with a full risk exposure of the bonus, dotted lines the 90%-confidence interval (CI), and the dashed line the minimum guaranteed pension payments.

Fig. 2. Guaranteed pension product.

Table 3
Unforeseen increases in life expectancy.

Data\Age	67	70	73	76
2007	15y4m	12y5m	9y8m	7y3m
2010		13y8m	10y8m	8y2m
2013			12y3m	9y4m
2016				10y7m

Life expectancy of an individual who was i) 67 years old in 2007 based on data up to 2007; ii) 70 years old in 2010 based on data up to 2007 and, after a change in the forecasts, based on data up to 2010; iii) 73 years old in 2013 based on data up to 2007, 2010, and 2013; and iv) 76 years old in 2016 based on data up to 2007, 2010, 2013, and 2016.

in which 35% is invested in the risky asset and the rest risk-free).[8] To illustrate how an unexpected change in future survival rates affects expected pension payments, Fig. 3 shows the consequences of an update of survival rates every three years. As the individuals were asked to switch in 2007, we first depict the expected pension payments depending on the survival forecasts that are based on the historical data for Danish males up to 2007. After a three year update of the survival forecasts, i.e. updating the data-set with the new observations, as provided in Table 3, an unforeseen longevity deviation leads to a change in the expected pension payments from that point onwards until the next update.[9]

Imagine two males, who prior to retirement, are given the choice to keep the guaranteed product or switch to the market-sensitive product. Mr. Low-Risk keeps the guaranteed product and Mr. High-Risk switches, reflecting the difference in financial risk and macro longevity risk. As Fig. 2 shows, Mr. Low-Risk expects to receive €10,156 every year until he dies. The only risk involved is the exposure of the bonus to the financial market returns. Mr. High-Risk expects to receive €10,691 every year, conditional on forecasts/expected survival rates to remain unchanged until he dies. Since the pension fund invests 35% of Mr. High-Risk's remaining pension wealth in risky assets he benefits from the risk premium leading to the higher expected pension payments. However, as the exposure to financial risk is higher, this means that there is also more risk, which explains the wider confidence intervals. Yet, the crucial difference between the annuity products is the following. In 2007, both Mr. Low-Risk and Mr. High-Risk will retire at the age of 67 and are expected to die at the age of 82 years and 4 months. Three years later, in 2010 – we assume that both are still alive – they have a remaining life expectancy of 12 years and 5 months. However, the forecasted survival rates, which were based on the last 30 years of observations, are now updated, leading to new life expectancies. Suddenly Mr. Low-Risk and Mr. High-Risk are expected to live another 13 years and 8 months. Mr. High-Risk's expected pension payments are recalculated based on the new forecasted survival rates, leading to a drop to €9,757, while Mr. Low-Risk's pension payments are not lowered. Hence, Mr. High-Risk is exposed to macro longevity risk but Mr. Low-Risk is not. Initially, in 2007, Mr. High-Risk did not expect this change in forecasts to happen as the forecasts had already anticipated future improvements in life expectancy. The unforeseen part that arises due to new observations is the macro risk leading to the ex post shocks in Fig. 3.

The main learning from Fig. 2 and Fig. 3 is that situations can arise where the negative effect of unforeseen longevity shocks dominates the positive effect of the unrestricted risk exposure in the market-sensitive product. In the illustrations presented here, the expected pension payments are higher in the market-sensitive product during the early years of retirement. If unforeseen increases in longevity do not occur, expected pension payments continue to be higher in the market-sensitive product. Unexpected increases in longevity can reduce pension payments in the market-sensitive product, however. Multiple and large increases in mortality tables can lower expected pension payments in the market-sensitive product so much that they become lower than expected pension payments in the guaranteed product. In our numerical example, pension payments are lower already after the first update in mortality tables. In this regard, it is important to point out that the forecasts have consistently underestimated future gains in life expectancies (Oeppen and Vaupel, 2002; Murphy and Topel, 2006; Fund, 2012).

The illustrations in this section show that there is a built-in longevity hedge in the guaranteed product that protects the pension holder from unforeseen longevity increases. At the same time this guarantee restricts the risk exposure and lowers the expected returns, resulting in lower expected pension payments during retirement, all else equal. In the market-sensitive product, unforeseen longevity shocks can have a large impact on future pension payments. Potentially, they can even lead to lower pension payments than with the guaranteed product. Moreover, the example shows that the choice of pension product is not a simple choice, as it depends on expectations in terms of both financial risk and longevity risk.

3. Empirical study

This section provides empirical evidence on real transition decisions between annuity products. In particular we study what type of pension holders switch from a guaranteed product to a market-sensitive product.

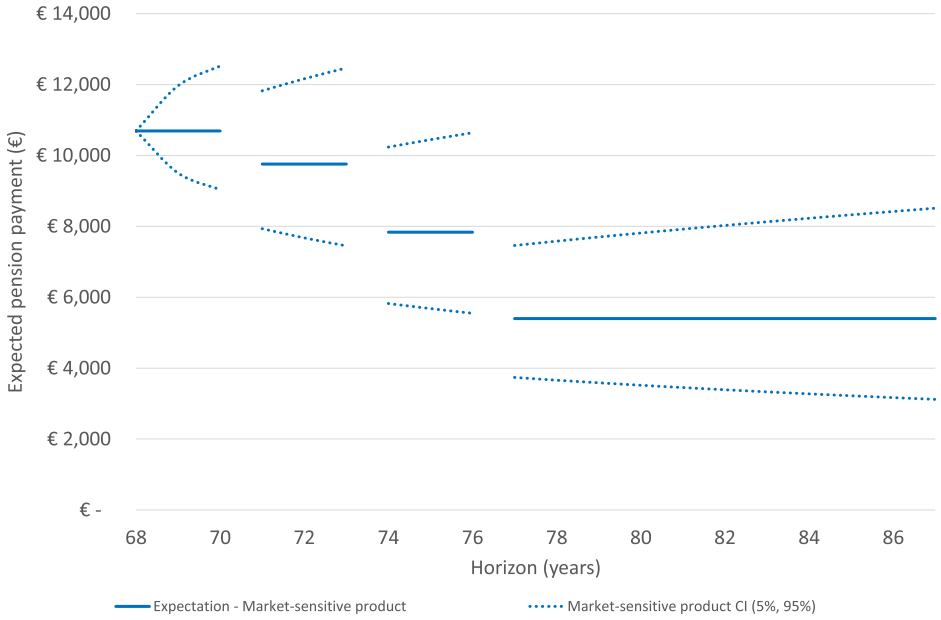
3.1. Data

Our data contain information on each member of the Danish pension fund, Juristernes og Økonomernes Pensionskasse (JØP), which serves lawyers and economists. Fully funded and owned by its more than 60,000 members, JØP managed assets worth DKK 78 billion (approximately €10.5 billion) in 2018. We use the data to investigate which type of individual would voluntarily switch from a guaranteed to a market-sensitive product.

We have information on various personal characteristics and financial information. Table 4 contains descriptive statistics and reports the mean of the explanatory variables. The dependent variable "Election outcome" is a dummy variable that takes the value 1 if a pension holder in Division 1 voluntarily chose to opt out of the current guaranteed contract. Table 4 shows that 18% made that choice. The male dummy variable for gender shows that more than half (56%) of the pension holders are male, which corresponds well with the higher labour force participation rates of men. The majority of pension holders are married (65%). Age is divided into four categories, which clearly indicates that the pension fund has relatively young members, with almost 70% of them under the age of 50. For almost all members the level of education corresponds to a university degree at bachelor level or higher. Education is divided into four field categories: economics and business economics, political science, law, and others. Around 29% of the pension holders have a degree in economics or business economics, 20% a degree in political science, and 33% in law. Regarding the geographical location, we distinguish between those living in Copenhagen or elsewhere. More than 50% of the members live in Copenhagen. In terms of the levels of the guaranteed return, 30% of the members

[8] Both figures are based on a Merton model, a simplified setting in which there is a risky asset and a bank account returning the risk-free rate. The guaranteed product is constructed as a hybrid product of a fixed and a variable annuity, and for the market-sensitive product survival probabilities are explicitly added to the variable annuity as in Balter and Werker (2020).

[9] Note that we assume no correlation between the financial market and unexpected changes in life expectancies, therefore the impact of longevity risk can occur in any financial scenario.



A solid line indicates the expected pension payment of a market-sensitive product with a risk exposure of 35%, and the dotted lines depict the optimistic and pessimistic financial quantiles. The expected pension payments for the first three years of the market-sensitive product are based on the mortality table forecasts, with data from 1978 to 2007, while the three updates are based on a rolling window of 3 years ahead, each based on Danish data for males.

Fig. 3. Market-sensitive pension product.

Table 4
Summary statistics.

Guarantee	Total	2%	3%	3.7%	4.25%
Election outcome	17.9%	31.8%	23.8%	16.0%	2.8%
Male	56.2%	50.7%	50.0%	52.8%	67.4%
Married	65.4%	56.1%	65.7%	69.8%	71.5%
Age 20-49	69.6%	93.6%	93.2%	89.1%	18.7%
Age 50-59	18.1%	4.3%	5.0%	8.7%	45.6%
Age 60-69	10.3%	2.1%	1.8%	2.2%	29.2%
Age 70-100	2.0%	0.0%	0.0%	0.0%	6.6%
Economics degree	28.6%	31.4%	36.1%	28.8%	22.6%
Political science degree	19.3%	26.3%	23.1%	20.3%	9.7%
Law degree	33.8%	24.5%	26.2%	31.0%	49.0%
Other degree	18.3%	17.8%	14.7%	19.9%	18.8%
Copenhagen	50.6%	54.9%	48.7%	46.7%	49.9%
Outside Copenhagen	49.4%	45.1%	51.3%	53.3%	50.1%
Pension wealth low	48.5%	96.7%	61.2%	30.1%	8.6%
Pension wealth medium	22.1%	3.1%	37.7%	52.8%	10.0%
Pension wealth high	29.4%	0.1%	1.1%	17.1%	81.3%
Number of observations	31,497	10,044	3,730	8,129	9,594
Distribution of observations		31.9%	11.8%	25.8%	30.5%

in Division 1 had the highest level of 4.25%; 26% had a 3.7% level of guarantee; 12% a 3% level of guarantee; and 32% a 2% level of guarantee. Finally, we have information on the size of pension wealth. This is divided into three different categories. Table 4 shows that almost 50% of the pension holders have pension wealth below DKK 400,000 (approximately €55,000), whereas almost 30% have pension wealth above DKK 800,000 (approximately €110,000).

Columns 3 to 6 depict the summary statistics for those with a specific level of guarantee. Since the level of guarantee depends on the date of admission, older individuals typically have higher guarantees. Individuals with high guarantees differ from the other members in that almost none of them switched to the market-sensitive product. More males have a high guarantee (consistent with previous gender-specific labour force participation rates). Those with a higher guarantee are on average older and almost half of those with the highest guarantee has a law degree. Finally, as they entered at an earlier point in time they have accumulated more pension wealth.

3.2. Probit model

Let Y be the "Election outcome" for an individual. This is a binary variable equal to one if the individual switched to the market-sensitive product, and zero if the individual kept the guaranteed product. The probit model (McFadden, 1976) describes the probability of an individual switching:

$$P(Y=1|X) = \Phi(\beta_0 + \beta X),$$

where Φ is the cumulative distribution function of the standard normal distribution, X is a vector of explanatory variables, β is the corresponding vector of coefficients, and β_0 is the intercept. Coefficient estimates are obtained by maximising the likelihood function, and standard errors are based on computation of the information matrix. The average marginal effects are given by:

$$\frac{\partial P(Y=1|X)}{\partial X_i} = \phi(\beta_0 + \beta X)\beta_i,$$

where ϕ is the standard normal density $\phi(\beta_0 + \beta X) = (2\pi)^{-1/2}\exp\left(-(\beta_0 + \beta X)^2/2\right)$ that scales β_i. The reference groups comprise of single females, aged 20 to 29, who do not have an economics degree, reside outside Copenhagen, and posses a pension wealth of less than DKK 400,000 (approximately €55,000) and a 2% guarantee.

Table 5 presents marginal effects from the probit estimation exploring the relationship between the election outcome and the set of independent variables listed above. In column one, for the total population of guaranteed individuals, we see that all except two variables (married and high pension wealth) are individually significant at a 5% level. Further, the likelihood ratio test is jointly significant with a $\chi^2(12)$ of 4376.21. We see that males have a slightly higher probability (2.6%) of relinquishing the guarantee. Marital status has no significant effect on the decision, whereas compared to being young (between the ages of 20 and 29), the older the pension holder, the more likely the individual is to remain in the current contract. Being above the age of 50 decreases the probability 20-39%. We observe regional differences as pension

Table 5
Results from probit estimation.

Guarantee	Total	2%	3%	3.7%	4.25%
Male	0.0258***	0.0395***	0.0379**	0.0227**	0.0141***
	(6.27)	(4.29)	(2.72)	(2.80)	(3.71)
Married	-0.00405	0.00536	0.00731	-0.00183	-0.0127***
	(-0.95)	(0.57)	(0.50)	(-0.21)	(-3.59)
Guarantee 3%	-0.0645***				
	(-10.19)				
Guarantee 3.7%	-0.129***				
	(-20.43)				
Guarantee 4.25%	-0.187***				
	(-17.24)				
Age 50-59	-0.196***	-0.441***	-0.312***	-0.250***	-0.0363***
	(-20.65)	(-12.08)	(-6.32)	(-9.66)	(-9.46)
Age 60-69	-0.308***	-0.609***	-0.456***	-0.259***	-0.0701***
	(-16.81)	(-7.82)	(-3.83)	(-4.84)	(-10.58)
Age 70-100	-0.387***	0	0	0	-0.0949***
	(-5.58)	(.)	(.)	(.)	(-5.10)
Economics degree	0.00964*	-0.0140	0.00233	0.0399***	0.00503
	(2.19)	(-1.41)	(0.16)	(4.65)	(1.30)
Copenhagen	0.0332***	0.0735***	0.0519***	0.0129	0.00282
	(8.05)	(7.86)	(3.74)	(1.60)	(0.85)
Pension wealth medium	0.0349***	0.0172	0.0259	0.0628***	0.000225
	(5.68)	(0.64)	(1.83)	(6.62)	(0.03)
Pension wealth high	-0.00140	-0.0724	-0.0552	0.0225	-0.00745
	(-0.15)	(-0.52)	(-0.68)	(1.74)	(-1.38)
Number of observations	31,497	10,044	3,730	8,129	9,594
R^2	14.78%	3.44%	2.75%	4.07%	11.19%

t statistics in parentheses.
* ($p < 0.05$), ** ($p < 0.01$), *** ($p < 0.001$).

holders in Copenhagen are more likely to abolish their guarantees. We find strong significant effects that the higher the level of guarantee, the less likely individuals are to abandon it. Compared to a 2% level of guarantee an individual with a 4.25% level of guarantee is 18.7% less likely to relinquish it. Finally, medium levels of pension wealth increase the probability of giving up one's guarantee by 3.5%. All in all, this case study shows that demographic characteristics influence the decision to switch from a guaranteed to a market-sensitive product. In particular, male residents of Copenhagen with an economics degree who have low guarantees and moderate pension wealth were more likely to give up their guarantees.

We find it particularly interesting that individuals with a high guarantee are more likely to keep their guarantee, i.e. they do not switch to the market-sensitive product. There are two effects at play. On the one hand, the higher the guarantee, the lower the fraction of pension wealth that can be invested freely, and thus that can earn the expected risk premium, i.e. the higher the guarantee, the lower the expected pension payments, *ceteris paribus*. On the other hand, about a third (see Table 4) of the guarantees were close to the prevailing risk-free rate at the time the pension holders were offered the choice to switch product. If the pension holders anticipated further declines in the interest rate level, this could persuade some of them to stick to their relatively high guarantee. Moreover, the implicit longevity hedge built into the guaranteed product was potentially very valuable, more so than the economic compensation offered to switch. The one-time choice between longevity protection with less financial risk versus no longevity risk with more financial risk implies that we cannot identify the pattern that people who buy longevity risk protection invest riskier as found by Milevsky and Kyrychenko (2008).

There is a high correlation between age and the level of the guarantee as people who joined the fund earlier are typically older and have been granted higher guarantees. Consequently we run a regression that allows us to investigate whether older pension holders are more or less inclined to give up the guarantee for a fixed level of guarantee. We find that on top of the level effect, also older pension holders are more inclined to stick to the guarantee. This indicates that people closer to retirement are more risk averse and thus less likely to make life-changing decisions.

Since females have higher life expectancies (Zarulli et al., 2018; Hu and Goldman, 1990; Murphy et al., 2007; Johnson et al., 2000), they would benefit more from a macro longevity hedge.[10] This hypothesis is confirmed for females as they have a preference for sticking to the guaranteed product.

4. Conclusion

This paper examines the choice of pension product. We focus on a unique setting where pension holders were given the opportunity to switch from a guaranteed product that included longevity protection and little financial risk/low expected returns to a market-sensitive product with higher financial risk/higher expected return but also higher longevity risk.

We illustrate the expected pensions in the two products. All else equal, expected pension payments are lower in the guaranteed pension product. This is because a larger fraction has to be invested in the safe asset to secure the guarantee. However, as there is no hedge against unforeseen increases in longevity in the market-sensitive pension product, expected pension payments will

[10] The longer people live, the more likely they are to be exposed to periodic macro longevity updates. Note, there is a difference between micro and macro longevity risk here. For micro longevity risks, it is the variance of longevity risk that matters (the second moment), i.e. the risk that the individual lives longer than the average of the cohort (Milevsky, 2020), whereas for macro longevity risk, the first moment matters, i.e. the risk that the average longevity of the cohort will increase after an update of survival rates. Our pension holders are exposed to macro longevity risk.

be negatively affected by macro longevity improvements. Expected pensions might even end up being lower in market-sensitive products when there are frequent and large improvements in longevity. In our data, we find that young men living in Copenhagen and with moderate levels of pension wealth are more likely to switch from the guaranteed to the market-sensitive product. Also, the higher the guaranteed return, the lower the probability of switching.

The risk transfer of both financial risk and longevity risk significantly adds to the complexity of the pension products. This raises the question of how to correctly inform pension holders about the multiple risk factors. The market-sensitive product offered higher expected return, but with multiple risk factors adding significantly to the uncertainty. The information material pension holders received about potential future outcomes with the market-sensitive product was not particularly detailed on the mechanisms, i.e. vague, nor were they offered information about the uncertainty of their future expected pensions. This increased the required degree of financial literacy of the individual to optimally plan and prepare for retirement. Moreover, understanding the mechanisms behind these products also adds insights into the funds themselves, not to mention the supervisory authorities. All these factors serve as motivation for properly modelling the differences between guaranteed and market-sensitive pension products when accounting for both financial risk and longevity risk. Finally, as the longevity risk is transferred to the pension holder in the market-sensitive product, a natural demand for hedging this risk arises. This calls for the creation of a liquid and transparent market for individualistic longevity products (Blake et al., 2013, 2019).

Declaration of competing interest

There is no competing interest.

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