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Pension De-Risking and Firm Risk: Traditional versus Innovative Strategies

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JEL classification: G22 G23 G31 G32

Pension De-Risking Choice and Firm Risk: Traditional versus Innovative Strategies

Abstract

We examine the determinants of firms' defined benefit pension plan de-risking strategy choices, and their impact on firm risk using a unique dataset covering FTSE 100 firms for the period of 2009-2017. In particular, we investigate which firm financial and pension fund characteristics influence de-risking strategy choices and their impact on firm risk, proxied with earnings and return volatility, default and credit risk. Results show that de-risking strategies are more likely to be implemented when pension plans have a longer investment horizon, indicating a higher level risk exposure due to investment uncertainty. We find that firms with larger pension plans prefer innovative de-risking strategies (buy-in/buy-out and longevity swap), as these reduce the risk more effectively removing various pension fund risk altogether, over the traditional ones (soft and hard freezing). Firms with higher market capitalization and that are financially unconstrained implement innovative pension de-risking strategies as they have the ability to pay the cash premiums required. We also find that pension de-risking strategies reduce firm risk. Hard freezing and pension buy-ins/buy-outs have the most significant impact in reducing firm risk. In contrast, soft freezing and longevity swaps tend to have a weaker or no impact on the overall firm risk.

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1. Introduction

In the past few years, firms are under great pressures in maintaining their defined-benefit (DB) pension plans as pension contributions and liabilities are increasing. In 2017, pension liabilities of FTSE 100 firms were, on average, 38 percent of their total market capitalization[1] - historically the highest level ever (Lane, Clark and Peacock, 2017). There is also a decreasing trend in pension funding ratios, from 97 to 86 percent over the period of 2006-2016 (The Pension Regulator, 2016)[2], signalling firms' increasing likelihood of not to be able to make payments. As pension plans mature and longevity increases, firms will face with greater pension payment obligations in the future. In addition, pension obligations also limit firms' financial management options and current investment capacity because earnings may have to be used to honour pension promises made to employees by previous management. Accordingly, firms sponsoring DB pension plans have increasingly focused on reducing pension obligations to alleviate its impact on firm's investment and strategic decisions, which in turn would reduce shareholders' risk exposure.

Firms could opt for various DB pension de-risking strategies.[3] Traditional methods, such as *soft or hard freezing*, aim to transfer pension obligations risks to employees and pass investment and longevity risk and other associated risks from the firm to employees (Ippolito, 1995, 1997; Broadbent, Palumbo, and Woodman, 2006). Alternatively, using more innovative strategies recently introduced, such as *pension buy-ins, buy-outs* or *longevity swaps*, firms can transfer some or all pension obligations risks to third parties, such as insurers, by paying a premium.

There is a growing literature on the impact of DB pension de-risking on firm risk and a number of studies examine the effect of freezing (Martin and Henderson, 1983; Bodie, Light, Morck, and Taggart, 1985; Maher, 1987; Wiedman and Wier, 2004; McKillop and Pogue, 2009; McFarland et al., 2009; Milevsky and Song, 2010; Choy et al., 2014; Lin et al., 2015). Empirical evidence shows that DB pension plan freezing may decrease overall firm financial risks as it reduces the growth rate of pension benefits and costs as well as employee

[1] FTSE 100 firms paid a total of £17.3 billion as pension contributions in 2017.

[2] Between 2006 and 2016, UK DB pension assets increased from £770 billion to £1,341 billion, and DB pension liabilities rose from £792 billion to £1,563 billion (The Pensions Regulator, 2016). Increases in pension assets and liabilities indicate that firms will face huge payment obligations when their DB pension plans reach maturity.

[3] For example, only 27 of the FTSE 100 firms provided DB pension plan to all of their employees in 2017 (Lane, Clark, and Peacock, 2017), suggesting that the remainder have frozen their DB pension plans.

compensation (Milevsky and Song, 2010). Similarly, firms with lower pension risks are found to have higher credit ratings, signalling decreasing credit risk (McKillop and Pogue, 2009). In contrast, it is argued that de-risking through freezing may reduce firm value due to costs such employee resistance, drop in employee motivation and productivity, which may off-set its the benefits (McFarland et al., 2009; Lin et al., 2015). Freezing is also found to increase managerial risk-taking as it reduces the inside debt that aligns managers' incentives with those of the bondholders (Choy et al., 2014). Overall, evidence on the impact of de-risking on firm risks are inconclusive. Moreover, previous studies only examine the effectiveness of traditional methods of pension de-risking.[4] There is a dearth of literature on the impact of the innovative forms of de-risking methods on firm risks. Relatedly, there is also no empirical evidence on how firms choose amongst different pension de-risking strategies, or between the traditional and innovative ones.

In this paper, we ask three novel questions on pension de-risking strategies that have not been addressed previously. First, we are interested in how firms choose between alternative de-risking strategies. This decision may relate to the specific financial condition of the firm as well as factors related to the firm specific DB plan. Accordingly, we examine the firm and pension plan specific financial factors that influence the choice of different pension de-risking strategies. In particular, we investigate which firm financial characteristics (such as market capitalization, dividend payments, cash flow from operating activities, leverage and capital expenditure) and pension fund characteristics (such as pension asset allocations, fund horizons, funding levels and plan size) influence these choices. We also compare determinants of the traditional versus innovative strategies. We contribute to the literature by providing the first empirical evidence on the determinants of de-risking strategy choices.

Second, we examine the impact of different pension de-risking strategies on firm risk. Pension de-risking may lead to changes in the firms' market value as pension obligations relate to the firm risk and the creditworthiness of firms. However, literature is inconclusive on the direction of the impact. In addition, literature is limited to examining traditional de-risking strategies, i.e. *freezing*. Innovative de-risking methods are substantially different from traditional pension de-risking strategies as they transfer pension obligation risks to third

[4] Innovative de-risking strategies has attracted the attention of researchers but only from an asset pricing perspective (see for example, Blake and Burrows, 2005; Lin and Cox, 2008; Lin, Shi and Arik, 2017).

parties. Hence, it is not known how alternative de-risking strategies may or may not lead to different risk shifting outcomes as they also incur different costs for firms. Our paper contributes to the literature by providing the first evidence on the innovative de-risking strategies' impact on firm risk. In particular, this is the first empirical paper to investigate the pension buy-in, buy-out and longevity swap market in this context. Our analysis enhances the understanding of whether innovative pension de-risking strategies can effectively reduce the firm risk.

Third, we contribute to the literature by employing a broader set of international firms listed in the London Stock Exchange. A shortcoming of the literature is that evidence drawn is often based on US data. Hence, we use a unique hand-collected data covering all FTSE 100 firms with DB pension plans for the period of 2009-2017. The UK provides a unique setting to conduct empirical research on pension de-risking as UK policy-makers view pension buy-ins and buy-outs positively as a safe process for removing pension obligations from firms.[5]

Our results show that de-risking strategies are more likely to be implemented when pension plans have a longer investment horizon, indicating a higher level risk exposure due to investment uncertainty. We find that firms with larger pension plans prefer innovative de-risking strategies (buy-in/buy-out and longevity swap), as these reduce the risk more effectively removing various pension fund risk altogether, over the traditional ones (soft and hard freezing). Firms with higher market capitalization and that are financially unconstrained seems to have the ability to implement innovative pension de-risking strategies as these require upfront cash premiums to be paid. We also find that pension de-risking strategies reduce firm risk. Hard freezing and pension buy-ins/buy-outs have the most significant impact in reducing firm risk. In contrast, soft freezing and longevity swaps tend to have a weaker or no impact on the overall firm risk.

The remainder of this paper is structured as follows. Section 2 provides a background of alternative pension de-risking strategies available to the firm and in Section 3 we present the previous literature. Section 4 provides the data and methodology. Section 5 present the results and Section 6 concludes.

[5] The emergence of the pension buy-in and buy-out markets in the UK was driven by the introduction of the Pensions Act 2005 and by new accounting standards (Monk, 2009).

2. Background of pension de-risking strategies

Pension de-risking strategies can be classified as *soft freezing, hard freezing*, *buy-ins*, *buy-outs* and *longevity swap*. In this section, we provide a background to each of these strategies and their development in the UK market.

2.1. Freezing

Freezing DB pension plan transfers the pension risk from employers to employees (Atanasova and Hrazdil, 2010). There are differences between the two types of freezing, *soft freezing* and *hard freezing*, where the latter is likely to lead to significant changes in the level of pension obligations (Choy et al., 2014). Hence, in this paper we treat soft and hard freezing as two separate pension de-risking strategies. In soft freezing new employees are barred from joining the DB pension plan, while existing employees who are currently in the plan continue to accrue pension benefits and vesting service (Munnell, Golub-Sass, Soto, and Vitagliano, 2007). Under soft freezing, the number of pension participants no longer increases, and pension liabilities increase more slowly than otherwise (Comprix and Muller, 2011). However, soft freezing may increase firm risk. This is because it may lead to an increase in firms' costs of providing DB pension to existing members as fewer younger employees would be contributing to the plan. In hard freezing firms stop DB pension plan for all employees. The value of pension benefits ceases increasing after the date of the freeze, and pension assets remain in the pension plan to be paid out when the employees retire (Munnell et al., 2007). All benefits paid to employees are fixed at the level prevailing at the date of the freeze. In a hard freeze firms' benefit responsibility is significantly reduced since more pension benefits are paid out to employees. Hard freezing reduces contribution costs significantly. It is argued that hard freezing impact on firms and pension funds are more significant in comparison to soft freeze (Comprix and Muller, 2011; Choy et al., 2014).

Freezing is regarded as a key de-risking strategy in the UK and traditionally dominated the UK occupational pension system, where only a small proportion of employees were offered defined-contribution (DC) pension plans. The proportion of members in open DB pension plans declined sharply, from 66 to 19 percent between 2006 and 2016, and the percentage of DB pension plans remaining open to all employees dropped from 43 percent in 2006 to 13 percent in 2016 (The Pension Regulator, 2016). Overall, in recent years, given the relatively high proportion of DB pension assets, UK firms have been taking significant measures to de-risk by ceasing to accrue benefits for either new or all employees.

2.2. Buy-ins and buy-outs

In pension buy-ins and buy-outs innovative financial instruments are utilised to transfer pension obligations to insurers or other financial institutions (Lin et al., 2017). A buy-in is an insurance policy that covers a proportion of the pension liabilities and is held as an asset by the DB pension plan. The insurance contract removes the risks of investment, longevity, interest rate changes and inflation for the plans' members. In buy-ins, firms retain the responsibility of paying pension benefits if the insurer defaults. Hence, insurers only take on part of the pension risk that is arising from corporate insolvency.[6] In buy-outs, an insurance policy is issued to each member individually which enables the scheme to close. Hence, firms transfer all pension obligations to insurers removing them entirely from their financial statements. In addition to buy-ins, buy-outs also remove the future running expenses for the pension plan. Firms choose between pension buy-ins and buy-outs depending on their desired level of reduction in pension obligations. Premiums for buy-outs are higher than buy-ins as the insurers undertake more risk in buy-out contracts.

There is an established and growing market for pension buy-ins and buy-outs in the UK (Lin et al., 2017), which has expanded since 2006 following significant pension regulation changes with the introduction of the Pensions Act 2005 and by new pension accounting standards. The size of the market increased from £2.9 billion in 2007 to £12.3 billion in 2017 (Lane et al., 2017). Such growth could be attributed to the UK policy-makers positive view of pension buy-in and buy-out transactions as a safe process for removing pension obligations from firms' liabilities (Monk, 2009).

2.3. Longevity swaps

Longevity risk is the risk of increasing life expectancy of policy holders, which can eventually result in higher pay-out ratios than expected for pension funds. Key actuarial assumptions on future pension obligations about mortality rates, discount rates, salary and price inflation draws attention to the impact of longevity risk on DB pension obligations. Longevity swaps are insurance policies that only remove the longevity risk from the DB

[6] Buy-out transactions were originally used to transfer insolvent firms' pension assets and liabilities to insurance firms, but are now used by solvent firms seeking to transfer their pension obligations.

pension plan (Blake and Burrows, 2005), giving certainty over the length of time that the pension plan will be required to make payments.[7] For example, in the UK an increase of one year in the mortality rate would increase pension obligations by 4.5 percent (The Accounting Standard Board, 2007). In the UK, life expectancy at 65 has increased by four years for males and 3.7 years for females over the past two decades. Although the life expectancy assumptions fall in recent years, there is an argument whether this can be a new trend or a temporary slow-down. Slowdown of the life expectancy provides an opportunity to a competitive longevity swaps' pricing. An increasing interest for longevity swaps reflects on the volume of these contracts more than doubled between 2016 and 2017 from £2.6 to £6.4 billion (Lane et al., 2018).

3. Literature review

3.1. Determinants of pension de-risking strategies

Firms' choice of de-risking strategy may depend on pension investment horizons and investment strategies. Firms with longer investment horizons for their pension plans (indicating pension fund maturity) may be more likely to implement pension de-risking strategies as they are exposed to greater pension plan risk. Such firms' pension plans tend to have a larger number younger employees, which eases the implementation of de-risking as the firm may face less resistance from younger employees (Munnell et al., 2007).[8] It is argued that buy-ins and buy-outs are more attractive for pension plans that have low-risk investment strategies (Lane, Clark and Peacock, 2018) as they are similar to annuity contracts that match existing asset types and the annuity price. Firms holding less volatile assets in their pension funds are more likely to implement a buy-in or buy-out (Lin et al., 2015). In contrast, longevity swaps may be more suitable for pension plans with high levels of investment risk seeking to remove the longevity risk (Lin et al., 2015).

[7] The process of longevity swap transactions is complex, as regulations prevent UK pension plans from undertaking transactions directly with the reinsurer offering the longevity swap. Therefore, the sponsoring firm must find an intermediary insurer to take responsibility for administering payments. This intermediary insurer can transact with reinsuring firm to complete the longevity swap, and the sponsoring firm must pay the intermediary. The intermediary insurer bears the credit risk of the longevity reinsurer. Employing an intermediary insurer makes longevity transaction complex and increases the costs of transactions (Lane, Clark and Peacock, 2018).

[8] Munnell et al. (2007) argues that middle-age employees have far more to lose than younger workers when firms freeze their DB pension plans.

Costs that incur to the firm, as well as to the pension fund, may be another factor influencing the choice of de-risking strategy. For example, freezing of DB pension plans does not require immediate and significant payments from sponsoring firms (Choy et al., 2014). However, firms engaging in pension buy-outs may need more financial resources to make additional contributions to pension plans and eliminate the pension deficit before transferring them to an insurance firm. Bartram (2018) found that companies with less profitability have lower contributions and funding levels. Thus, this may indicate that these companies are difficult to engage in pension buy-ins or buy-outs. Also, these firms may be difficult to pay an insurance premium to the insurers. Longevity swaps, in contrast, are less costly and more affordable for the firm and the pension fund (Cox et al., 2013). The upfront costs of longevity swaps are much lower than other de-risking strategies (Lin et al., 2015), which makes it an ideal choice to remove only the longevity risk when removing all pension risks is too expensive.

Firm's leverage may determine the decision of de-risking the pension plan. Empirical evidence shows that highly leveraged firms are risk averse (Rauh, 2008) and are more likely to reduce risk-taking on pension investment to decrease the likelihood of triggering debt covenants (Amir et al., 2010). In addition, Vafeas and Vlittis (2018) suggest that less levered firms are less likely to remove DB pension plans as they can benefit from the tax shield. In contrast, Cocco and Volpin (2007) finds that highly leverage firms are more risk-taking in pension investment in the UK. Rauh (2008) explains that the difference between the UK and the US on the impact of leverage on pension investment strategy is caused by the differences in institutional setting. UK regulations appear to allow pension trustees more freedom to take risk on pension plans. Therefore, we expect that highly leverage firms are less likely to engage in de-risking strategies. In addition, firms with higher leverage indicate poorer financial condition, and such firms may find payment of an upfront premium for pension buy-ins, buy-outs less affordable.

Dividend and investment policies could also be a determinant of the choice of de-risking strategy. Often, pension contributions crowd out dividend payments and investments (Liu and Tonks, 2013). Firms where pension contributions constrain on dividends may benefit more from freezing, buy-ins and buy-outs since they remove pension obligations directly, thus reducing firms' future pension contributions. In contrast, longevity swaps have a lesser impact on pension contributions as they only freeze mortality assumptions. Therefore, we expect that firms with less dividend payments are more likely to engage in pension de-risking.

Finally, economic scale of the firm and pension plan size could also be determinant factors of the choice of de-risking strategy. Firms with larger pension funds are more likely to choose longevity swaps as they were originally designed for such plans in terms of complexity and costs (Lane, Clark and Peacock, 2018). Firms with smaller pension plans may prefer buy-ins or buy-outs as these would be comparatively affordable for smaller plans. Firms with higher funding levels may also choose pension buy-ins or buy-outs as higher funding levels leads to lower costs. In particular, less resistance is prompted from employees if the pension fund is fully funded. On the other hand, freezing a large DB pension plan may provoke more resistance from employees because it significantly affects employees' benefits (Comprix and Muller, 2011).

3.2. The impact of pension de-risking on firm risk

Previous literature's findings on the impact of pension de-risking strategies on firm risk are inconclusive. Some studies suggest that reducing pension obligations makes firms less risky because it reduces various costs as well as leverage. Others argue that it changes firms' risk-taking behaviour through managerial compensation channel and consequently makes them riskier. We explain these arguments below.

The direct effect of various DB pension plan de-risking is reduction in the overall firm risk. Firms freezing DB pension plans transfer the pension risk to their employees as it does not need to guarantee the payment of benefits for the life of their employees upon their retirement. Firms that remove pension obligations through pension buy-ins and buy-outs transfer responsibility for paying pension benefits to insurance firms. Utilising longevity swaps reduces the mortality risk of pension plans and the volatility of pension contributions caused by changes in the mortality rate. Hence, removing pension risks through de-risking may reduce overall firm risk. Testing these arguments empirically, Milevsky and Song (2010) document a positive market reaction to soft and hard freezing of 75 US firms DB pension plan announcements. They explain that firm risks are reduced because of soft freezing reducing the growth rate of pension benefits and hard freeze decreasing pension costs and employee compensation. Moreover, they find positive impact to be more pronounced for firms that are likely to face financial distress if they had maintained their traditional pension plans and the associated long-term promises. In contrast, McFarland et al. (2009), examining a dataset of

82 US firms, report negative or insignificant abnormal market returns following the announcement of freezing DB pension plans. They argue that costs may off-set the benefits of freezing DB pension plans, including the costs of replacement pension plans, employees' resistance, possible drop in employee motivation and productivity, and market caution about the long-term effect of freezing DB pension plans. In a similar vein, Lin et al. (2015), developing an optimization model, argue that poor implementation of pension de-risking strategies increases firm risk, and that implementation is sensitive to various costs. Hence, the costs of pension buy-ins and buy-outs, and longevity swaps cannot be ignored.

Pension obligations are viewed as an integral part of corporate debt (Martin and Henderson, 1983; Bodie et al., 1985; McKillop and Pogue, 2009). These studies find that corporate credit ratings are associated with the level of pension obligations, where a higher pension risk leads to a lower rating. For example, McKillop and Pogue (2009) examines the relationship between funding risk of DB pension plans and corporate debt ratings of FTSE 100 firms. They find that the probability of obtaining a higher debt rating is lower for firms with higher pension risk. Moody's regards key DB pension de-risking strategies, such as termination and buy-outs, as credit positive. Overall, both academic research and anecdotal evidence suggest that pension de-risking strategies have a significant impact on firms' credit ratings; hence, reducing pension obligations are expected to reduce firms' risk.

Another mechanism that may link pension obligations, de-risking and firm risks is the managerial incentives. Sundaram and Yermack (2007) posit that DB pension plans are an important form of incentive-aligning "*inside debt*". They argue that unsecured debt-like claims, such as the DB pension plans, align interests of managers more closely with those of outside debt holders (Sundaram and Yermack, 2007).[9] Hence, firms are likely to take on more risk if the managers are compensated through equity-like rather than debt-like incentive mechanisms. Sundaram and Yermack (2007) provide empirical evidence for their arguments by finding that firm risks reduce as the CEO's pension value increases relative to his/her equity value. Choy et al. (2014) find that firms' risk increases – in terms of operating activities, research and development, and financing strategies – following a hard freeze.

[9] This is because managers of the firms with more debt bear the same default risk faced by the firms' outside creditor (Choy et al., 2014).

4. Methodology and Data

4.1. Methodology

4.1.1 Determinants of the de-risking strategy choice

We estimate the following multinomial logit model to examine the firm and pension plan specific financial factors that influence the choice of de-risking strategy:

$$\Pr(PDS_t = s) = \delta_0 + \delta_1 BOND_{t-1} + \delta_2 HOR_{t-1} + \delta_3 FUND_{t-1} + \delta_4 PLAN\_SIZE_{t-1} + \delta_5 DIV\_PAYOUT_{t-1} + \delta_6 LEV_{t-1} + \delta_7 CAPEX_{t-1} + \delta_8 MACAP_{t-1} + \delta_9 CF_{t-1} + \mu \quad (1)$$

where; *PDS* is log-odds ratio of the probability of choosing one of the following options: no pension de-risking strategy implemented (coded as 0), soft freeze (1), hard freeze (2), pension buy-ins or buy-outs (3)[10], and longevity swap (4). In other specifications, we also examine the differences between the traditional and innovative pension de-risking strategies. In this alternative setting, *PDS* is coded as 0 if a firm does not implement a pension de-risking strategy, 1 if a firm soft or hard freezes DB pension plans, and 2 if a firm engage in pension buy-ins, buy-outs or longevity swaps.

Pension plan specific variables are *BOND, HOR, FUND and PLAN_SIZE. BOND* is the percentage of pension assets allocated to bonds. Pension investment strategy indicate the investment risk of pension fund. Pension funds with lower investment risk are more likely to implement buy-ins or buy-outs while those with higher investment risk are more likely to choose longevity swaps (Lin et al., 2015). Hence, we expect the percentage of pension assets allocated to bonds are related to pension de-risking strategies (Blake, 2001; JLT Employee Benefits, 2014). *HOR,* indicating pension horizon, is the natural logarithm projected benefit obligations divided by service costs. We expect that firms are more likely to implement a de-risking strategy if they have a higher *HOR*. Such firms have an older workforce and higher service costs; therefore, face greater risk due to uncertainty of investments with longer maturity (Amir et al., 2010). *FUND* is the fair value of pension assets divided by projected benefit obligations. We expect that firms are more likely to de-risk their pension plans if they

[10] This research does not distinguish between buy-in and buy-out transactions and does not take account of different types of pension buy-in and buy-out contracts. Thus, this research focuses on the aggregated determinants and effect of pension buy-ins and buy-outs.

have higher funding levels. For example, in buy-in and buy-out transactions, lower funding levels with underfunded pension obligations lead to costlier de-risking as premium payments are higher for such funds. *PLAN_SIZE* is the projected benefit obligations divided by total assets. The choice of the strategy may depend on the size of the obligations. For example, longevity swaps are designed primarily for large pension plans owing to their complexity and costs. Firms with smaller pension plans may face less resistance from employees so it may be easier for them to freeze pension plans.

Firm specific variables are *DIV_PAYOUT, LEV, CAPEX, MACAP and CF. DIV_PAYOUT* is the dividend payout ratio. Firms facing pension contribution constraints tend to make lower dividend payouts (Liu and Tonks, 2013); hence, we expect firms with lower dividends have greater incentive to freeze pension plans. However, dividend also signals the firms' financial strength (Benartzi, Michaely, and Thaler, 1997). These firms with higher dividend payments are expected to be more likely to implement pension buy-ins, buy-outs or longevity swaps. *LEV* is the long-term debt divided by the sum of long-term debt and market value of equity. Given that higher leverage is positively related to risk-taking of pension plans (Cocco and Volpin, 2007), it is expected that there is negative relationship between leverage and pension de-risking strategies. *CAPEX* is the capital expenditure divided by total assets. We expect that firms with a higher capital expenditure ratio are more likely to de-risk pension plans as such firms would be more sensitive to pension plan risk exposures. *MACAP* is the natural logarithm of market capitalization. Firms with higher market capitalization have more ability to afford to pay for pension de-risking costs. *CF* is the cash flow from operating activities divided by total equities. Firms' financial resources, measured by operating cash flow, are expected to be related to pension de-risking strategies. For example, in buy-ins and buy-outs firms need to pay a upfront cash payment to insurance firms; If firms choose to transfer all their pension obligations via buy-outs, they are required to make additional contributions to eliminate the pension deficits. Therefore, more cash may be required to execute these transactions. In contrast, soft and hard freezing are not expected to relate to firms' financial resources as they do not require any immediate payments. Similarly, in longevity swaps sponsors make an upfront payment and a fixed stream of payments over a substantial number of years, but these cost firms significantly less than buy-ins/buy-outs.

4.1.2 Impact of pension de-risking on firm risk

We measure firm overall risk with three alternative indicators using *earning volatility,* a balance sheet based risk metric, *volatility of total returns*, a market based indicator and Altman's *Z-score,* capturing the probability of default. We estimate the following models:

$$Std\_ROA_t = \delta_0 + \delta_1 Soft_{t-2} + \delta_2 Hard_{t-2} + \delta_3 Buyin_{t-2} + \delta_4 Longevity_{t-2} + \delta_5 SALES_t + \delta_6 SALES\_GROWTH_t + \delta_7 MB_t + \delta_8 ROA_t + \delta_9 LEV_t + \delta_{10} CAPEX_t + \delta_{11} MACAP_t + \sum \beta_s Year\_dummy + \sum \beta_r Industry\_dummy + \delta_{12} IMR + \delta_{13} Miss\_IMR + \mu \quad (2)$$

$$Std\_RETURN_t = \delta_0 + \delta_1 Soft_{t-2} + \delta_2 Hard_{t-2} + \delta_3 Buyin_{t-2} + \delta_4 Longevity_{t-2} + \delta_5 SALES_t + \delta_6 SALES\_GROWTH_t + \delta_7 MB_t + \delta_8 ROA_t + \delta_9 LEV_t + \delta_{10} CAPEX_t + \delta_{11} MACAP_t + \sum \beta_s Year\_dummy + \sum \beta_r Industry\_dummy + \delta_{12} IMR + \delta_{13} Miss\_IMR + \mu \quad (3)$$

$$ZScore_t = \delta_0 + \delta_1 Soft_{t-2} + \delta_2 Hard_{t-2} + \delta_3 Buyin_{t-2} + \delta_4 Longevity_{t-2} + \delta_5 FUND_t + \delta_6 LEV_t + \delta_7 SALES\_GROWTH_t + \delta_8 SIZE_t + \delta_9 PROFIT_t + \delta_{10} TANGIBILITY_t + \sum \beta_s Year\_dummy + \sum \beta_r Industry\_dummy + \delta_{13} IMR + \delta_{14} Miss\_IMR + \mu \quad (4)$$

where; *Std_ROA* is the standard deviation of earnings before interest and tax scaled by total assets, measured over the last three years. *Std_RETURN* is the standard deviation of total returns, measured over the current and the last three years. ZScore is the Altman Z-score (Altman, 2000), which is downloaded from Capital IQ database.[11] $Soft_{t-2}$, $Hard_{t-2}$, $Buyin_{t-2}$ and $Longevity_{t-2}$ are defined as soft freezing, hard freezing, pension buy-in and buy-out, and longevity swap, respectively. We use a two-year lag for each of the pension de-risking strategies as we expect a gradual effect of pension de-risking on firm overall risk.

Following the literature, we use a set of control variables that may also have an impact on firm risks (Hovakimian et al., 2009; Choy et al., 2014). *SALES* is the natural logarithm of sales or revenues. *SALES_GROWTH* is the difference in *SALES* between times t and t-1. *MB* is the market to-book ratio of assets, computed as the ratio of the market value of assets to the book

[11] Capital IQ calculates the Zscore with the following formula: 3.3*EBIT/Total Assets + 1.0*Sales/total Assets + 1.4*Retained Earnings/Total Assets + 1.2*Net Working Capital/Total Assets.

value of assets. *ROA* is the earnings before interest and tax divided by total assets. Other control variables are defined as previous.

The sample we employ in these estimations only includes firms that has chosen to implement a de-risking strategy as we are aiming to capture the impact of various de-risking strategies on firm risk. Hence, there could be a potential sample selection bias problem if the unobserved determinants of firm risk also affect firms' choice of whether to de-risk pension plans or not. To correct the selection bias, we use Heckman's two-step estimating procedure (Heckman, 1979). We run a first-stage probit model by estimating equation 1 and derive the inverse Mills ratio *(IMR).*[12] In cases where sufficient observations are not available, we set the *IMR* equal to 0 (Choy et al., 2014). *Miss_IMR* is an indicator variable, that equals to 1 if observations are available for *IMR*, and 0 otherwise. Year fixed-effects control for prevailing market conditions, and firm fixed-effects control for the possibility that unspecified firm-specific factors may influence the analyses.

We also utilise a measure that captures the *credit risk* of the firm. We expect that pension de-risking strategies may have impact on credit risk. We use the changes in credit rating in the following ordered probit model:

$$\Delta \mathrm{CR}_t = \delta_0 + \delta_1 \Delta PDS_{t-1} + \delta_2 \Delta StdROA_t + \delta_3 \Delta FUND_t + \delta_4 \Delta LEV_t + \delta_5 SALES\_GROWTH_t + \delta_6 \Delta SIZE_t + \delta_7 \Delta PROFIT_t + \delta_8 \Delta TANGIBILITY_t + \mu \quad (5)$$

where ΔCR[13] is the difference in credit rating between times *t* and *t*-1. ΔPDS is the difference in *PDS*. ΔStd_ROA is the change in the standard deviation of the return on assets, computed by earnings before interest and tax scaled by total assets at time *t*, measured over

[12] Lennox, Francis, and Wang (2011) point out that absence of "exclusion restriction" in the first-stage probit model may create serious multicollinearity in the second stage. Therefore, *Horizon* is validly excluded from the second-stage equations, (2), (3) and (4). This is justified because pension funds' investment horizon is unlikely to correlate directly with firm risk, as no previous literature documents a direct relationship between investment horizon and firm risk measures. Given that UK pension funds are managed by pension trustees, pension funds' investment horizons are indirectly related to sponsoring firms; thus, the exclusion restriction is satisfied. Nevertheless, multicollinearity is checked by including the *inverse Mills ratios* in all models. The VIF score is lower than 2 in all models, which is less than the cut-off point 10. Therefore, the *inverse Mills ratios* does not cause any multicollinearity. [2]The probit model results are not tabulated in here.

[13] The credit ratings are issued by credit rating agency, Standard & Poor's, and collected from the Thomson One Banker database. Following the credit rating literature (Alissa, Bonsall, Koharki, and Penn, 2013), credit rating is treated as an ordinal variable, coded from 1 to 17. The highest credit rating of AAA is coded as 17 and a credit rating equal to or lower than CCC+ is coded as 1. Therefore, a positive ΔCR suggests an increase in credit rating, while a negative ΔCR suggests a decrease in credit rating

the last three years, from time *t*-1; Δ*FUND* is the change in *FUND* at time *t* from time *t*-1; Δ*LEV* is the change in *LEV* at time *t* from *t*-1; Δ*SIZE* is the change in *SIZE* at time *t* from time *t*-1. Δ*PROFIT* is the changes in operating income scaled by total assets at time *t* from time *t*-1; and Δ*TANGIBILITY* is the change in total property, plant and equipment scaled by total assets at time *t* from time *t*-1. All other control variables are defined as previous.

4.2. Data and descriptive statistics

Our unique dataset comprises of FTSE 100 firms that has DB pension plans and covers the period of 2009 to 2017. We identify firms that implemented a de-risking strategy during this period and construct our dataset by combining data from various different sources. We hand-collect DB pension plan particulars and information on soft and hard freezing from the annual reports of the firms. Data on pension buy-ins, buy-outs and longevity swaps are hand-collected from research reports provided by Lane, Clark and Peacock (2018) and Hymans Robertson (2017). We treat multiple pension buy-in transactions for the same firm in the same year as a single pension buy-in event for the firm. Firms' financial and accounting information are obtained from Thomson One Banker and Capital IQ databases. Data is merged into a single unbalanced panel dataset.

Table 1 provides descriptive statistics for the explanatory and control variables used in the empirical analyses. All continuous variables are winsorized at the top and bottom 1%. On average, 42 percent pension assets are allocated to bonds. Pension funds have an average funding level of 91 percent, and the average pension plan size is about one third (37%) of a firm's total assets. Following Choy et al. (2014), we use the standard deviation of returns on assets (*Std_ROA*) to measure firm risk, which, on average, is 0.02. Alternative measure of firm risk is the volatility of total returns (*Std_RETURN*), showing a mean of 0.013. The mean of *Zscore* is 2.379. The average difference in credit rating (Δ*CR*) between year *t* and *t*-1 is -0.01, indicating that, on average, the sample firms experienced downgrades. Pairwise correlation coefficients across the variables used in each regression model are shown in Table 2, showing that multicollinearity would not be an issue in the model. Table 3 provides yearly distribution of de-risking strategies used by the sample firms. There are 14 soft-freeze events, 18 hard freeze events, 19 buy-in/buy-out events and nine longevity swap events across the sample years.

[Insert Tables 1, 2 and 3 Here]

Table 4 Panel A reports t-test comparing the firm financial and pension fund characteristics between firms that did (*PDS*) and did not (*NON*) employ a pension de-risking strategy. We find that pension funds that engage in pension de-risking strategies have invested more on bonds, have longer investment horizons, and higher funding levels. Firms that implemented a de-risking strategy have less leverage compared to those that did not. In addition, Panel B of Table 4 reports t-test comparing firms that engage in traditional pension de-risking strategies (i.e. soft and hard freezing) and firms that engage in innovative de-risking strategies (i.e. pension buy-ins, buy-outs and longevity swaps). We find that pension funds that engage in innovative strategies tend to be larger in size and have a longer investment horizon. They also have lower market capitalization and leverage.

[Insert Table 4 Here]

5. Results

5.1. Determinants of the choice of pension de-risking strategies

We estimate Equation 1 with a multinomial logit estimator and results are presented in Table 5. Columns 1 to 4 report the results by comparing each pension de-risking strategy with the choice of no implementation (i.e. *PDS* equals to 0 set as the benchmark). We find that *HOR* is positive and significant for all strategies. It suggests that firms with longer investment horizon are more likely to implement a de-risking strategy. This is consistent with the prior literature that firms with longer investment horizon face more uncertainty (Amir et al., 2010). Hence, they are more likely to remove the uncertainty embedded in the DB pension plans via de-risking. We find that the coefficient of *PLAN_SIZE* is negative and statistically significant in columns 1 to 3. This shows that firms with larger DB pension plans are less likely to de-risk via freezing or buy-ins/buy-outs. Firms with higher leverage (*LEV*) are also less likely to use hard freeze and buy-ins/buy-outs. This is consistent with the prior literature (Cocco and Volpin, 2007) that highly leveraged firms tend to take more risk, hence are less likely to de-risk pension plans. In addition, we find a larger coefficient for buy-in/buy-outs. This shows that leveraged firms, which are more likely to face more financial constraints, may find pension buy-ins/buy-outs too costly to implement. We find that firms with more cash flow (*CF*) have a higher likelihood of implementing buy-ins/buy-outs (column 3). This result shows that financially stronger firms are able to purchase pension buy-ins/buy-outs contracts. However, firms with less cash flow, or financially poorer, are more likely to choose longevity swaps as they are more affordable (Cox et al., 2013; Lin et al., 2015). In addition, pension fund with more pension asset allocated to bonds (*BOND*) and firms with higher market capitalization (*MACAP*) are more likely to choose longevity swaps. This indicates that firms with less pension investment risks tend to remove their mortality risk via longevity swaps.

[Insert Table 5 Here]

In columns 5 to 7, we present results for models where the benchmark is set as the soft freeze, comparing it to the options of hard freeze, buy-ins/buy-outs and longevity swaps (i.e. *PDS* equals to 1 is set as the benchmark). The positive and significant coefficient of *HOR* in all columns suggest that pension funds with longer investment horizon are more likely to choose hard freeze, buy-ins/buy-outs and longevity swap over the soft freeze. Firms seem to prefer strategies that reduces the risk more effectively when the pension horizon is longer given the increased uncertainty. Hard freeze is preferred as it has more significant impact on reduction of pension risk compared with soft freeze (column 5). Similarly, buy-ins/buy-outs and longevity swaps have a specific aim to remove pension risk. Levered firms (*LEV*) are more likely to choose soft freeze over hard freeze or over pension buy-ins/buy-outs. This confirms our earlier results that highly leveraged firms have less incentive to remove debt-like pension obligations from their balance sheet. We find that firms with higher market capitalization (*MACAP*) are more likely to buy an insurance contract in the form of pension buy-ins/buy-outs or longevity swaps rather than soft freezing. Larger pension plans (*PLAN_SIZE*) with more pension assets allocated to bonds (*BOND*) are more likely to implement longevity swaps over soft freezing of DB pension plans. These results are consistent with the fact that most of the longevity swaps are purchased by larger pension plans (Lin et al., 2015). Firms with less cash flows (*CF*) are more likely to implement longevity swaps over soft freezing. This, once again, supports that longevity swaps require less upfront cash payment, hence this may be more affordable for firms with less cash flows (Cox et al., 2013).

In column 8 and 9 we present the results that compares the choice of insurance contracts (buy-ins/buy-outs and longevity swap) with the hard-freezing decision (i.e. *PDS* equals to 2 is set as a benchmark). We find that firms with less leverage are more likely to implement pension buy-ins/buy-outs over hard freezing. Firms with higher market capitalization (*MACAP*), with larger pension funds (*PLAN_SIZE*), and more asset allocated to bonds (*BOND*) are more likely to implement longevity swaps over hard freezing. This may be because longevity swaps are a form of insurance policy and need a lower initial capital requirement (Cox et al., 2013).

Column 10 presents the results comparing pension buy-ins/buy-outs and longevity swaps (i.e. *PDS* equals to 3 is set as a benchmark). We find that firms are more likely to implement longevity swaps over pension buy-ins/buy-outs when pension funds are larger (*PLAN_SIZE*) with more pension assets allocated to bonds (*BOND*), and with shorter investment horizon (*HOR*). This suggests that firms with more investment uncertainty are more likely to choose pension buy-ins/buy-outs, which have a significant impact on removing all types of pension fund risk. Firms with more leverage (*LEV*) and less cash flows (*CF*) are more likely to implement longevity swaps over pension buy-ins/buy-outs. This indicates that firms with better financial position find pension buy-ins/buy-outs more affordable, which is consistent with the findings of Lin et al. (2017) showing that financial poorer firms are less likely to engage in pension de-risking.

[Insert Table 6 Here]

In a subsequent analysis, we also compare the drivers of the broader groups of traditional de-risking strategies (soft and hard freezing) versus innovative de-risking strategies (pension buy-ins, buy-outs and longevity swaps). Results are presented in Table 6. We start with comparing both groups of strategies to the baseline of no de-risking in columns 1 and 2. We find that firms with longer investment horizon (*HOR*) are more likely to engage in de-risking. Again, this supports that pension fund with more uncertainty are more likely to engage in pension de-risking strategies. Smaller pension plans (*PLAN_SIZE*) are more likely to implement a traditional de-risking strategy due to they find them easier to de-risk small pension plans (column 1). In column 3 we compare the two sub-groups and find that firms with longer investment horizon, facing higher levels of risk due to uncertainty, are more likely choose innovative methods over traditional methods. We also find that firms choose innovative strategies if they have a larger plan (column 2). This result supports that it is easier to transfer the pension risk to employees than transferring the pension risk to insurers when firms have smaller pension plans as they may face less resistance from employees. Firms with higher market capitalization (*MACAP*) and lower leverage (*LEV*) tend to choose innovative strategies to de-risk pension plans. This shows that better financial conditions are required for buying insurance policies to de-risk, as such transactions have significant upfront costs.

To summarise, our findings in this section highlights two major themes related to the firms' choice of pension de-risking strategies. Firstly, we observe that firms with longer investment horizon are more likely to engage pension de-risking strategies that allows firms to remove pension risk significantly. Secondly, usage of innovative strategies to remove pension risk is strongly related to the financial condition of the firm. This is mainly driven by significant upfront costs of insurance policies.

5.2. Impact of pension de-risking on firm risk

We present the results for estimating equation (2) in Table 7 (Columns 1 and 2). We find that coefficients of $Soft_{t-2}$, $Hard_{t-2}$, $Buyin_{t-2}$, and $Longevity_{t-2}$ are negative and statistically significant (at the minimum 10% level). Column 2 provides consistent results with Column 1 after including the *Inverse Mills ratio (IMR)* and *Miss IMR*. Overall, results show that applying a pension de-risking strategy reduces the earnings volatility of firm. In columns 3 and 4, we present results for estimating equation (3). We do not find a significant coefficient for $Soft_{t-2}$. Choice of soft freeze as a de-risking strategy does not seem to reduce firm risk measured by the volatility of returns. We find that $Hard_{t-2}$, $Buyin_{t-2}$ and $Longevity_{t-2}$ are statistically significant and have a negative relationship with *Std_RETURN.* However, $Longevity_{t-2}$ loses its significance when controlled for selection bias with *IMR*. These findings suggest that hard freezing, and pension buy-in/buy-out reduce the volatility in the total returns of firms. In sum, results show that implementing hard freezing, pension buy-ins/buy-outs and longevity swaps reduce firm risk. However, the evidence on the impact of soft freezing is weak. This is perhaps because soft freezing imposes the closure of DB pension plans to new employees only and the existing employees continue to accrue pension benefits, hence the pension obligations continue to increase. Therefore, soft freezing probably has least impact on overall firm risk than other pension de-risking strategies.

[Insert Table 7 Here]

Table 8 presents the results for estimating equation (4). We find that both hard freezing ($Hard_{t-2}$) and pension buy-ins/buy-outs ($Buyin_{t-2}$) have a statistically significant positive relationship with Altman Z-Score *(Zscore)*. Implementation of hard freezing and pension buy-ins/buy-outs reduce the firm's probability of default. However, there is no evidence that soft freezing ($Soft_{t-2}$) and longevity swaps ($Longevity_{t-2}$) have an impact on default risk. This is consistent with the above explanation. In addition, longevity swaps only remove the longevity risk from DB pension plans, which may be relatively less significant to firm's default risk. Results are consistent after controlling the selection bias (Column 2). Table 9 presents the results for estimating equation (5). Here we use an aggregate indicator (*PDS*) that captures whether the firm implements any of the de-risking strategies. The results show that ΔPDS is significantly related to ΔCR (Column 1), also after controlling for potential selection bias (Column 2). All employed control variables are consistent with the previous literature (Hovakimian et al., 2009; Alissa et al., 2013). This result confirms that there is a reduction in firm' credit risk after the implement of pension de-risking strategies.

[Insert Table 8 and 9 Here]

Overall, this sub-section provides empirical evidence that some of the pension de-risking reduce the firm risk. Hard freezing saves firms' substantial expenditures as it reduces contribution costs and stops the growth of pension benefit payments (McFarland et al., 2009). Pension buy-ins/buy-outs transfer pension obligation risk to insurance firms. Therefore, these two strategies are viewed positively by the market and credit rating agencies. In contrast, soft freezing and longevity swaps tend to have a lower impact on firm risk. For soft freezing what is observed is probably due to the fact that it only stops new employees joining DB pension plans while the existing pension obligations are still increased. Longevity swaps only remove the mortality risk from DB pension plans and other risks, such as investment, interest and inflation, may still be prevailing for firms.

6. Conclusion

In this paper, we examine the determinants of DB pension de-risking strategies and their impact on firm risk using a unique hand-collected dataset covering all FTSE 100 firms for the period of 2009-2017. In particular, we investigate which firm financial and pension fund characteristics influence de-risking strategy choices and their impact on firm risk. We find that firms with longer investment horizon, indicating more investment uncertainty, are more likely to implement a de-risking strategy. Such firms prefer buy-in/buy-outs, innovative methods that reduce the risk more effectively, removing various pension fund risk altogether. In contrast, a lower pension investment risk leads to reducing only the mortality risk via longevity swaps. We also show that firms with larger pension plans prefer longevity swaps, which are more affordable as they require less upfront cash payment. We also find that usage of innovative strategies to remove pension risk is strongly related to the financial condition of the firm. Financially stronger firms prefer buy-ins/buy-outs as they can afford the higher premiums to get into these insurance contracts. On the contrary, financially poorer firms, with less cash flow, are more likely to utilise longevity swaps as they are more affordable. Highly levered firms, showing more risk-taking behaviour, are less likely to de-risk pension plans. Our evidence is consistent with the previous literature (Lin et al 2010) that insurance policy can create a financial pressure for firms with poor financial conditions. Hence, cost of de-risking need to be taken into account.

Our results also show that implementing hard freezing and pension buy-ins/buy-outs de-risking strategies reduce firm risk more effectively. Hard freezing saves firms' substantial expenditures as it reduces contribution costs and stops the growth of pension benefit payments. Pension buy-ins/buy-outs transfer pension obligation risk to insurance firms. These strategies are viewed positively by the market and credit rating agencies. In contrast, soft freezing and longevity swaps tend to have a lower impact on firm risk. This is perhaps soft freezing only stops new employees joining DB pension plans while the existing pension obligations are still increased. Longevity swaps only remove the mortality risk and other risks, such as investment, interest and inflation, may still be prevailing for firms.

Our research has policy implications for pension policy-makers and sponsoring firms that are planning to de-risk their DB pension plans. Results show that transferring pension liability risks to insurers or financial institutions is an effective method for sponsoring firms to off-load their pension risk. Hence, pension policy-makers might encourage the development of innovative pension de-risking strategies to reduce pension risk for firms with DB pension plans. However, most sponsoring firms appear to be concerned about the costs of pension de-risking strategies such as pension buy-ins, buy-outs and longevity swaps. Therefore, they need to trade-off the costs and benefits of de-risking. The UK has led the way in adopting alternative pension de-risking strategies, and other countries, such as the United States, have now starting to use innovative strategies.

Appendix: Definitions of variables

Variables	**Definition**
Dependent variables	
PDS	Indicator variable equals 0 if the firm does not implement any pension de-risking strategies, 1 if the firm soft freezes its DB pension plan, 2 if the firm hard freezes its DB pension plan, 3 if the firm implements a pension buy-in or buy-out, and 4 if the firm implements a longevity swap.
Std_ROA	Standard deviation of earnings before interest and tax scaled by total assets, measured over the last three years.
Std_RETURN	Standard deviation of total return at time *t*, measured over the current year and last three years.
ΔCR	Difference between credit ratings at times *t* and *t-1* for the sponsoring firm. The highest credit rating is coded as 17 and the lowest credit rating as 1. A positive value indicates an increase in credit rating.
ZScore	Downloaded from Capital IQ database directly and calculated as 3.3∗EBIT/Total Assets + 1.0*Sales/total Assets + 1.4∗Retained Earnings/Total Assets + 1.2∗Net Working Capital/Total Assets.
Main Independent Variables	
Soft	Equals 1 if firm soft freezes DB pension plans, 0 otherwise.
Hard	Equals 1 if firm hard freezes DB pension plans, 0 otherwise.
Buyin	Equals 1 if firm engages in pension buy-in or buy-out, 0 otherwise.
Longevity	Equals 1 if firm engages in longevity swap, 0 otherwise.
Control variables	
BOND	Pension assets allocated to bonds at time *t* divided by total pension assets.
HOR	Natural logarithm of projected benefit obligations *t* divided by service costs.
FUND	Fair value of pension assets divided by projected benefit obligations.
PLAN _SIZE	Projected benefit obligations divided by total assets.
DIV_PAYOUT	Dividend payout ratio.
LEV	Long-term debt divided by the sum of long-term debt and the market value of equity.
CAPEX	Capital expenditure divided by total assets.
SIZE	Natural logarithm of total assets.
CF	Cash flow from operating activities divided by total equity.
SALES	Natural logarithm of sales or revenues.
SALES_GROWTH	Natural logarithm of sales from time *t* to time *t-1* .
MB	Market-to-book ratio of assets, computed as the ratio of the market value of assets (book value of assets minus book value of equity plus market value of equity) to the total book value of assets.
ROA	Earnings before interest and tax divided by total assets.
MACAP	Natural logarithm of total market capitalization.
IMR	Inverse mill ratio
Miss_IMR	Indicator variable equal to 1 if observations are available for IMR, and 0 otherwise.
TANGIBILITY	The changes in total property, plant and equipment scaled by total assets.
PROFIT	Operating income scaled by total assets.

Table 1: Descriptive statistics

	Mean	St.Dev	Min	Max	25th	Median	75th
PDS	1.332	1.056	0	4	1	1	2
Std_ROA	0.020	0.028	0	0.347	0.007	0.012	0.024
Std_RETURN	0.013	0.011	0.001	0.070	0.005	0.009	0.016
Zscore	2.379	1.698	0	6.847	1.315	2.316	3.366
ΔCR	-0.032	0.829	-6	5	0	0	0
BOND	0.424	0.171	0.030	0.840	0.299	0.428	0.540
HOR	4.582	0.932	2.853	7.447	3.976	4.415	4.994
FUND	0.912	0.115	0.562	1.247	0.845	0.910	0.973
PLAN_SIZE	0.372	0.374	0.004	1.893	0.129	0.243	0.484
DIV_PAYOUT	0.770	1.077	0	8.700	0.383	0.525	0.732
LEV	0.239	0.163	0	0.976	0.136	0.204	0.300
CAPEX	-0.047	0.034	-0.161	0	-0.063	-0.040	-0.023
MACAP	22.557	1.440	16.049	25.195	21.753	22.471	23.421
CF	0.338	0.635	-3.240	2.899	0.172	0.284	0.477
SALES	22.515	1.389	19.295	26.186	21.369	22.495	23.529
SALES_GROWTH	0.036	0.217	-0.669	1.596	-0.022	0.031	0.086
MB	1.621	0.683	0.552	3.982	1.088	1.449	1.961
ROA	0.142	0.072	0	0.384	0.099	0.137	0.178
SIZE	23.009	1.544	20.298	27.406	21.793	22.822	23.978
PROFIT	0.097	0.079	-0.164	0.385	0.050	0.089	0.133
TANGIBILITY	0.258	0.237	0.001	0.878	0.069	0.164	0.391

Note: This table reports descriptive statistics for sample of FTSE 100 firms with DB pension plans between 2009 and 2017. The soft and hard freezing of DB pension plan data is hand-collected from annual report. Pension buy-in and buy-out data is hand-collected from research report (Lane, Clark and Peacock, 2016; Hymans Robertson, 2017). Longevity swap information is hand-collected from research report (Lane, Clark and Peacock, 2016; Hymans Robertson, 2017). Accounting information is collected from Thomson One Banker. All continuous variables have been winsorized at the top and bottom 1%. All variable definitions are reported in Appendix.

Table 2: Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) *PDS*	1.000										
(2) *Std_ROA*	0.022	1.000									
(3) *Std_RETURN*	-0.115*	0.221*	1.000								
(4) *Zscore*	0.005	0.097*	-0.097*	1.000							
(5) *ΔCR*	0.107	-0.174*	-0.103	0.069	1.000						
(6) *BOND*	0.178*	-0.173*	-0.055	-0.163*	-0.037	1.000					
(7) *HOR*	0.364*	-0.014	-0.085*	-0.017	0.209*	0.209*	1.000				
(8) *FUND*	0.069	-0.020	0.059	-0.066	0.048	0.232*	0.179*	1.000			
(9) *PLAN_SIZE*	0.240*	0.044	0.090*	0.087*	0.089	0.037	0.336*	-0.030	1.000		
(10) DIV_PAYOUT	0.008	-0.002	-0.069	-0.113*	-0.090	-0.025	-0.013	-0.044	-0.083*	1.000	
(11) LEV	-0.211*	-0.058	0.156*	-0.446*	0.041	-0.069	0.069	0.029	-0.151*	0.066	1.000
(12) CAPEX	0.092*	-0.070	0.058	-0.165*	0.079	0.075	0.197*	0.015	-0.006	0.046	0.032
(13) MACAP	0.090*	-0.029	-0.198*	-0.120*	-0.209*	0.127*	-0.322*	-0.131*	-0.153*	0.048	-0.328*
(14) CF	0.021	0.024	-0.025	0.127*	0.045	-0.066	-0.077	-0.046	0.082	0.000	-0.067
(15) SALES	-0.048	-0.124*	-0.116*	-0.103*	-0.133*	0.086	-0.292*	-0.134*	-0.089*	0.103*	-0.017
(16) SALES_GROWTH	-0.029	-0.066	-0.038	0.024	0.206*	-0.016	-0.011	0.052	-0.059	0.026	-0.077
(17) MB	0.174*	0.023	-0.176*	0.531*	0.140*	-0.077	0.062	-0.025	0.274*	-0.031	-0.445*
(18) ROA	0.084	0.044	-0.147*	0.621*	0.196*	-0.191*	-0.060	-0.123*	0.185*	-0.088*	-0.287*
(19) SIZE	0.015	-0.084	-0.076	-0.449*	-0.134*	0.141*	-0.222*	-0.005	-0.306*	0.053	0.162*
(20) PROFIT	0.101*	-0.017	-0.161*	0.475*	0.317*	-0.107*	0.011	-0.062	0.111*	-0.094*	-0.263*
(21) TANGIBILITY	-0.102*	-0.061	0.063	-0.130*	-0.090	0.039	-0.083	0.087*	0.004	-0.043	0.159*

Variables	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
(12) CAPEX	1.000									
(13) MACAP	-0.206*	1.000								
(14) CF	0.010	0.045	1.000							
(15) SALES	-0.164*	0.706*	-0.002	1.000						
(16) SALES_GROWTH	0.027	-0.056	0.070	0.071	1.000					
(17) MB	-0.026	0.013	0.202*	-0.224*	0.031	1.000				
(18) ROA	-0.369*	-0.023	0.209*	-0.146*	0.061	0.715*	1.000			
(19) SIZE	-0.057	0.722*	-0.062	0.765*	0.025	-0.445*	-0.420*	1.000		
(20) PROFIT	-0.152*	-0.034	0.256*	-0.170*	0.292*	0.629*	0.751*	-0.300*	1.000	
(21) TANGIBILITY	-0.567*	0.147*	-0.038	0.063	0.056	-0.164*	-0.012	0.079	-0.008	1.000

* shows significance at the .05 level

Table 3: Sample split by pension de-risking strategy across years

Year	Soft freeze	Hard freeze	Buy-in/Buy-out	Longevity swap	Total firms
2009	2	0	1	2	67
2010	4	3	3	0	64
2011	4	4	3	2	72
2012	1	3	1	0	70
2013	2	0	3	2	62
2014	0	3	1	2	60
2015	1	0	1	0	62
2016	0	2	4	0	50
2017	0	3	2	1	54
Total	14	18	19	9	561

Note: This table presents the distribution of pension de-risking strategy observations per year.

Table 4: T-test of mean differences

Panel A: Two-sample t-test of mean differences between *NON* and *PDS* firms

	Mean NON Firms	Mean PDS Firms	Difference	Std. Error	t-value
BOND	0.374	0.435	-0.061	0.026	-2.35*
HOR	3.949	4.684	-0.736	0.142	-5.2***
FUND	0.874	0.919	-0.045	0.018	-2.55*
PLAN_SIZE	0.305	0.361	-0.056	0.054	-1.05
DIV_PAYOUT	0.863	0.748	0.116	0.163	0.7
LEV	0.289	0.236	0.053	0.025	2.1*
CAPEX	-0.047	-0.046	-0.001	0.005	-0.1
MACAP	22.593	22.55	0.042	0.224	0.2
CF	0.347	0.333	0.015	0.102	0.15

Panel B: Two-sample t-test of mean differences between firms that engage in traditional versus innovative de-risking

	Mean Traditional	Mean Innovative	Difference	Std. Error	t-value
BOND	0.43	0.457	-0.026	0.02	-1.3
HOR	4.564	5.187	-0.622	0.106	-5.85***
FUND	0.921	0.912	0.009	0.013	0.7
PLAN_SIZE	0.296	0.634	-0.338	0.04	-8.55***
DIV_PAYOUT	0.718	0.875	-0.157	0.123	-1.25
LEV	0.254	0.159	0.095	0.018	5.1***
CAPEX	-0.047	-0.042	-0.005	0.004	-1.25
MACAP	22.476	22.866	-0.39	0.172	-2.3*
CF	0.303	0.456	-0.152	0.08	-1.9

Note: This table reports t-test for two sample mean differences. NON indicates firms that do not implement any pension de-risking strategy. PDS indicates firms that implement one of the pension de-risking strategies. Panel A compares the mean of variables in the group of firms that did not engage in pension de-risking and firms that engage in pension de-risking strategies. Panel B compares the mean of variables in the group of firms that engage in traditional pension de-risking strategies (i.e. soft and hard freezing) and firms that engage in innovative pension de-risking strategies (i.e. pension buy-ins, buy-outs and longevity swaps). t statistics in parentheses. * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 5: Multinomial logit regression for the choice of pension de-risking strategies

	NON vs SF	NON vs HF	NON vs BIO	NON vs LS	SF vs HF	SF vs BIO	SF vs LS	HF vs BIO	HF vs LS	BIO vs LS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$BOND_{t-1}$	1.046	1.649	-0.135	5.860**	0.603	-1.181	4.814**	-1.784	4.211*	5.995**
	(1.445)	(1.988)	(2.067)	(2.432)	(1.494)	(1.599)	(2.199)	(1.827)	(2.499)	(2.445)
HOR_{t-1}	1.354***	2.203***	2.571***	1.934***	0.849***	1.217***	0.580*	0.368	-0.269	-0.637**
	(0.371)	(0.451)	(0.475)	(0.500)	(0.283)	(0.301)	(0.333)	(0.239)	(0.358)	(0.311)
$FUND_{t-1}$	2.849*	2.830	1.858	1.098	-0.019	-0.991	-1.751	-0.972	-1.732	-0.760
	(1.536)	(2.427)	(3.333)	(4.013)	(1.982)	(2.863)	(3.757)	(2.777)	(4.165)	(4.860)
$PLAN\_SIZE_{t-1}$	-2.492***	-4.234***	-2.319**	1.041	-1.742*	0.173	3.533***	1.914	5.275***	3.361***
	(0.936)	(1.213)	(1.076)	(1.094)	(0.978)	(0.917)	(0.862)	(1.196)	(1.207)	(0.891)
DIV_PAYOUT_{t-1}	-0.166	-0.258	-0.001	0.071	-0.092	0.166	0.237	0.258	0.329	0.072
	(0.143)	(0.206)	(0.107)	(0.123)	(0.183)	(0.134)	(0.147)	(0.202)	(0.213)	(0.137)
LEV_{t-1}	-0.824	-4.860**	-11.706***	-1.629	-4.036**	-10.882***	-0.805	-6.846**	3.231	10.077***
	(1.579)	(2.472)	(3.191)	(2.853)	(2.014)	(2.885)	(2.440)	(3.135)	(2.889)	(3.335)
$CAPEX_{t-1}$	-5.290	6.493	-2.041	9.535	11.783	3.250	14.825	-8.533	3.042	11.576
	(7.308)	(10.557)	(9.554)	(17.603)	(7.855)	(8.580)	(17.564)	(10.223)	(18.123)	(18.485)
$MACAP_{t-1}$	-0.060	0.077	0.487	0.995***	0.136	0.546*	1.054***	0.410	0.918**	0.508
	(0.212)	(0.317)	(0.342)	(0.372)	(0.275)	(0.317)	(0.354)	(0.358)	(0.413)	(0.413)
CF_{t-1}	0.215	0.118	1.236*	-0.312**	-0.097	1.021	-0.527**	1.118	-0.430	-1.548**
	(0.242)	(0.271)	(0.683)	(0.155)	(0.179)	(0.714)	(0.247)	(0.722)	(0.285)	(0.663)
Constant	-5.073	-12.205	-22.260**	-35.984***	-7.132	-17.187**	-30.911***	-10.054	-23.778***	-13.724
	(6.050)	(8.298)	(8.947)	(8.614)	(6.813)	(7.719)	(7.811)	(8.568)	(9.072)	(9.372)
Log p-likelihood	-533.980									
R^2	0.229									
Wald chi^2	172.642									
N	561									

Note: This table reports the results of a multinomial regression model that regresses the pension de-risking strategy decisions on firm financial characteristics and pension fund characteristics. The dependent variable is *PDS*. NON indicates firms that do not implement any pension de-risking strategy. SF is soft freezing, HF is hard freezing, BIO is buy-in or buy-out, and LS is longevity swap. Robust standard errors are reported in parentheses. *, **, and *** represent significance levels of 10%, 5%, and 1%, respectively (two-tailed). Standard errors clustered by firm. All variable definitions are reported in the Appendix.

Table 6: Multinomial logit regression for the choice of traditional versus innovative de-risking strategies

	NON vs Traditional	NON vs Innovative	Traditional vs Innovative
	(1)	(2)	(3)
BOND$_{t-1}$	1.144	1.173	0.029
	(1.431)	(1.967)	(1.497)
HOR$_{t-1}$	1.407***	2.160***	0.753***
	(0.366)	(0.453)	(0.242)
FUND$_{t-1}$	2.686*	2.366	-0.320
	(1.499)	(2.703)	(2.268)
PLAN_SIZE$_{t-1}$	-2.351***	-0.431	1.920***
	(0.867)	(1.005)	(0.617)
DIV_PAYOUT$_{t-1}$	-0.173	0.040	0.213*
	(0.141)	(0.087)	(0.115)
LEV$_{t-1}$	-0.878	-6.823***	-5.945***
	(1.591)	(2.621)	(2.088)
CAPEX$_{t-1}$	-4.743	-0.896	3.847
	(7.384)	(9.036)	(7.723)
MACAP$_{t-1}$	-0.024	0.605**	0.629**
	(0.208)	(0.286)	(0.246)
CF$_{t-1}$	-0.015	0.289	0.304
	(0.238)	(0.567)	(0.692)
Constant	-5.812	-24.706***	-18.895***
	(5.966)	(7.419)	(5.706)
Log p-likelihood	-369.744		
R^2	0.220		
Wald chi^2	74.946		
N	561		

Note: This table reports the results of a multinomial regression model that regresses the pension de-risking strategy decisions on firm financial characteristics and pension fund characteristics. The dependent variable is *PDS*. NON indicates firms that do not implement any pension de-risking strategy. Traditional includes soft and hart freezing. Insurance includes buy-in/buy-out and longevity swap. Robust standard errors are reported in parentheses. *, **, and *** represent significance levels of 10%, 5%, and 1%, respectively (two-tailed). Standard errors clustered by firm. All variable definitions are reported in the Appendix.

Table 7: Impact of pension de-risking strategies on firm risk

Dependent variable:	*Std_ROA*$_t$		*Std_RETURN*$_t$	
	(1)	(2)	(3)	(4)
Soft$_{t-2}$	-0.0071**	-0.0070**	0.0003	0.0007
	(0.0032)	(0.0034)	(0.0015)	(0.0015)
Hard$_{t-2}$	-0.0268*	-0.0278*	-0.0114***	-0.0104**
	(0.0140)	(0.0145)	(0.0041)	(0.0042)
Buyin$_{t-2}$	-0.0139**	-0.0139**	-0.0060**	-0.0052*
	(0.0054)	(0.0061)	(0.0026)	(0.0029)
Longevity$_{t-2}$	-0.0112*	-0.0114*	-0.0043*	-0.0036
	(0.0060)	(0.0065)	(0.0025)	(0.0026)
SALES$_t$	-0.0118	-0.0117	0.0010	0.0011
	(0.0073)	(0.0074)	(0.0016)	(0.0015)
SALES_GROWTH$_t$	0.0196***	0.0190***	0.0027	0.0028
	(0.0068)	(0.0069)	(0.0025)	(0.0024)
MB$_t$	0.0098	0.0092	0.0015	0.0015
	(0.0076)	(0.0076)	(0.0018)	(0.0018)
ROA$_t$	-0.1007	-0.0974	0.0289*	0.0277*
	(0.0932)	(0.0942)	(0.0167)	(0.0164)
LEV$_t$	0.0421	0.0405	0.0152*	0.0139
	(0.0322)	(0.0351)	(0.0089)	(0.0088)
CAPEX$_t$	-0.1148**	-0.1212**	0.0487*	0.0524**
	(0.0573)	(0.0576)	(0.0252)	(0.0262)
MACAP$_t$	0.0054	0.0055	-0.0047***	-0.0047***
	(0.0054)	(0.0054)	(0.0014)	(0.0013)
IMR		-0.0014		0.0034
		(0.0057)		(0.0025)
Miss_IMR		-0.0002		-0.0071
		(0.0139)		(0.0056)
Constant	0.1529	0.1531	0.0904**	0.0897**
	(0.1150)	(0.1166)	(0.0425)	(0.0420)
Observations	552	552	544	544
Adjusted R^2	0.103	0.102	0.198	0.200
Number of firms	81	81	79	79
Firm fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES

Note: This table reports the results of a year and firm fixed-effects regression that examines whether pension de-risking strategies are likely to have an impact on firms' earnings volatility and total return volatility. Robust standard errors are reported in parentheses. *, **, and *** represent significance levels of 10%, 5%, and 1%, respectively (two-tailed). Standard errors clustered by firm. All variable definitions are reported in the Appendix.

Table 8: Impact of pension de-risking strategies on Altman Z-Score

Dependent variable:	$Zscore_t$	
	(1)	(2)
$Soft_{t-2}$	0.1232	0.1221
	(0.1046)	(0.1010)
$Hard_{t-2}$	0.5729***	0.6218***
	(0.1749)	(0.1646)
$Buyin_{t-2}$	0.4072**	0.4147**
	(0.2024)	(0.2056)
$Longevity_{t-2}$	0.1601	0.1742
	(0.2903)	(0.2924)
$FUND_t$	-1.6365***	-1.5855**
	(0.5838)	(0.6072)
LEV_t	-0.2231	-0.1939
	(0.2581)	(0.2468)
$SALES\_GROWTH_t$	-0.1701	-0.1745
	(0.1461)	(0.1431)
$SIZE_t$	2.8427***	2.7681***
	(0.6757)	(0.6782)
$PROFIT_t$	1.6446**	1.6541**
	(0.7474)	(0.7381)
$TANGIBILITY_t$		0.0524
		(0.1405)
IMR		0.0143
		(0.3041)
Miss_IMR	5.9687*	5.9431*
	(3.2283)	(3.1608)
Constant	0.1232	0.1221
	(0.1046)	(0.1010)
Observations	530	530
Adjusted R^2	0.253	0.257
Number of firms	78	78
Firm fixed effects	YES	YES
Year fixed effects	YES	YES

Note: This table reports the results of a year and firm fixed-effects regression that examines whether pension de-risking strategies are likely to have an impact on default risk measured by Altman Z-score. Robust standard errors are reported in parentheses. *, **, and *** represent significance levels of 10%, 5%, and 1%, respectively (two-tailed). Standard errors clustered by firm. All variable definitions are reported in the Appendix.

Table 9: Impact of pension de-risking strategies on credit rating changes

Dependent variable:	ΔCR_t	
	(1)	(2)
ΔPDS_{t-1}	0.3365**	0.3245***
	(0.1350)	(0.1247)
ΔStd_ROA_t	-0.6924	-0.5716
	(4.3601)	(4.1302)
$\Delta FUND_t$	2.4193**	2.4136**
	(1.1270)	(1.1323)
ΔLEV_t	-1.2709	-1.2031
	(1.2708)	(1.3023)
$SALES\_GROWTH_t$	0.9454**	1.0061**
	(0.3905)	(0.3991)
$\Delta SIZE_t$	0.2807	0.2476
	(0.2840)	(0.2884)
$\Delta PROFIT_t$	1.6403	1.9214
	(1.5546)	(1.6372)
$\Delta TANGIBILITY_t$	-0.3623	-0.2361
	(1.5390)	(1.5030)
IMR		-0.1346
		(0.2345)
Miss_IMR		0.4913
		(0.7033)
Observations	264	264
Pseudo R^2	0.104	0.107

Note: This table reports the results of an ordered probit model that examines whether pension de-risking strategies affect sponsoring firms' credit ratings. Robust standard errors are reported in parentheses. *, **, and *** represent significance levels of 10%, 5%, and 1%, respectively (two-tailed). Standard errors clustered by firm. All variable definitions are reported in the Appendix.

References

Accounting Standard Board, 2007. Reporting statement: Retirement benefits - disclosures. Report, London: Accounting Standard Board.

Alissa, W., Bonsall, S. B., Koharki, K., Penn, M. W., 2013. Firms' use of accounting discretion to influence their credit ratings. Journal of Accounting and Economics 55, 129–147.

Altman, E.I., 2000. Predicting financial distress of firms: revisiting the Z-score and ZETA models. Stern School of Business, New York University, 9-12.

Atanasova, C., Hrazdil, K., 2010. Why do healthy firms freeze their defined-benefit pension plans? Global Finance Journal 21, 293–303.

Bartram, S.M., 2018. In good times and in bad: Defined-benefit pensions and corporate financial policy. Journal of Corporate Finance, 48, 331-351.

Benartzi, S., Michaely, R., Thaler, R., 1997. Do changes in dividends signal the future or the past? Journal of Finance 52, 1007–1034.

Blake, D., 2001. UK pension fund management: How is asset allocation influenced by the valuation of liabilities? Discussion Paper PI0104, The Pensions Institute, London.

Blake, D. and Burrows, W., 2001. Survivor bonds: Helping to hedge mortality risk. Journal of Risk and Insurance, 68(2), 339-339.

Blake, D., Cairns, A., Dowd, K., 2008. The birth of the life market. Asia-Pacific Journal of Risk and Insurance 3, 1–32.

Bodie, Z., Light, J. O., Morck, R., Taggart, R. A., 1985. Corporate pension policy: An empirical investigation. Financial Analysts Journal pp. 10–16.

Broadbent, J., Palumbo, M., Woodman, E., 2006. The shift from defined benefit to defined contribution pension plans: implications for asset allocation and risk management Paper prepared for the Working Group on Institutional Investors, Global Savings and Asset Allocation established by the Committee on the Global Financial System.

Cardinale, M., 2007. Corporate pension funding and credit spreads. Financial Analysts Journal 63, 82–101.

Choy, H., Lin, J., Officer, M. S., 2014. Does freezing a defined benefit pension plan affect firm risk? Journal of Accounting and Economics 57, 1–21.

Clark, G. L., Monk, A. H., 2007. The crisis in defined benefit corporate pension liabilities part ii: Current solutions and future prospects. Pensions: An International Journal 12, 68–81.

Comprix, J., Muller, K. A., 2011. Pension plan accounting estimates and the freezing of defined benefit pension plans. Journal of Accounting and Economics 51, 115–133.

Cocco, J.F. and Volpin, P.F., 2007. Corporate governance of pension plans: the UK Evidence. Financial Analysts Journal, 63(1), 70-83.

Cox, S.H., Lin, Y., Tian, R. and Zuluaga, L.F., 2013. Mortality portfolio risk management. Journal of Risk and Insurance, 80(4), pp.853-890.

Gopalakrishnan, V., Sugrue, T., 1993. An empirical investigation of stock market valuation of corporate projected pension liabilities. Journal of Business Finance and Accounting 20, 711–724.

Heckman, J., 1979. Sample selection bias as a specification error. Econometrica 47, 153–161.

Hovakimian, A., Kayhan, A., Titman, S., 2009. Credit rating targets.

Hymans Robertson, 2017. Buy-outs, buy-ins and longevity hedging - h1 2017. Tech. rep., London: Hymans Robertson.

Ippolito, R. A., 1995. Toward explaining the growth of defined contribution plans. Industrial Relations: A Journal of Economy and Society 34, 1–20.

Ippolito, R. A., 1997. Pension Plans and Employee Performance: Evidence, Analysis, and Policy. Chicago, IL: University of Chicago Press.

JLT Employee Benefits, 2014. Getting your scheme buyout ready. London: Trustee Solutions Ltd and JLT Employee Benefits.

Lane, Clark and Peacock, 2016. 10 years on... and one million pensions in the uk have now been insured through buy-ins and buy-outs. Tech. rep., Lane and Clark and Peacock LLP, Winchester.

Lane, Clark and Peacock, 2017. 150bn to go backwards lcp accounting for pensions 2017. Report, Lane and Clark and Peacock LLP, Winchester.

Lane, Clark and Peacock, 2018. Pension de-risking steps up a gear. Report, Lane and Clark and Peacock LLP, Winchester.

Lennox, C. S., Francis, J. R., Wang, Z., 2011. Selection models in accounting research. The Accounting Review 87, 589–616.

Lin, Y. and Cox, S.H., 2008. Securitization of catastrophe mortality risks. Insurance: Mathematics and Economics, 42(2), 628-637.

Lin, Y., MacMinn, R. D., Tian, R., 2015. De-risking defined benefit plans. Insurance: Mathematics and Economics 63, 52–65.

Lin, Y., Shi, T. and Arik, A., 2017. Pricing Buy-Ins and Buy-Outs. Journal of Risk and Insurance, 84(S1), 367-392.

Liu, W., Tonks, I., 2013. Pension funding constraints and corporate expenditures. Oxford Bulletin of Economics and Statistics 75, 235–258.

Maher, J., 1987. Pension obligations and the bond credit market: An empirical analysis of accounting numbers. Accounting Review 62, 785–798.

Martin, L. J., Henderson, G. V., 1983. On bond ratings and pension obligations: A note. Journal of Financial and Quantitative Analysis 18, 463–470.

McFarland, B., Pang, G., Warshawsky, M., 2009. Does freezing a defined-benefit pension plan increase firm value? empirical evidence. Financial Analysts Journal 65, 47–59.

McKillop, D., Pogue, M., 2009. The influence of pension plan risk on equity risk and credit ratings: A study of ftse100 firms. Journal of Pension Economics and Finance 8, 231–252.

Milevsky, M. A., Song, K., 2010. Do markets like frozen defined benefit pensions? an event study. Journal of risk and insurance 77, 893–909.

Monk, A. H., 2009. Pension buyouts: What can we learn from the uk experience? Working paper.

Munnell, A. H., Golub-Sass, F., Soto, M., Vitagliano, F., 2007. Why are healthy employers freezing their pensions? Journal of Pension Benefits 14, 3.

NISA, 2013. Defining the pension de-risking spectrum. Clayton, MO: NISA Investment Advisors, LLC.

Rauh, J.D., 2008. Risk shifting versus risk management: Investment policy in corporate pension plans. The Review of Financial Studies, 22(7), 2687-2733.

Sullivan, R., 2019. Uks first longevity swap draws a crowd. Financial Times, 24 May.

The Pensions Regulator, 2016. The Purple Book: DB Pensions Universe Risk Profile 2016. London: The Pensions Regulator.

Vafeas, N. and Vlittis, A., 2018. Independent directors and defined benefit pension plan freezes. Journal of Corporate Finance, 50, 505-518.

Wallbank, A., 2017. Longevity swap to buy-in. Available at: https://www.ipe.com/pensions/pensions/briefing/longevity-swap-to-buyin/10021432.article.

Wiedman, C. I., Wier, H. A., 2004. The market value implications of postretirement benefit plans and plan surpluses: Canadian evidence. Canadian Journal of Administrative Sciences 21, 229–241.

Wills Towers Watson, 2016. Global pension assets study 2016. Available at: https://www.willistowerswatson.com/en/insights/2016/02/global-pensions-asset-study2016.