Defined Benefit Pension De-Risking Strategy: Determinants of Pension Buy-ins

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Abstract

Many firms have sought to de-risk their pension provision by closing or freezing their defined benefit (DB) pension plans. This shifts future pension risk onto employees, but it does not de-risk the firm's existing obligations. Pension buy-ins and buy-outs, which are a form of insurance, have become an established option for de-risking such obligations in several developed economies. This paper investigates the influence on pension buy-in transactions of the degree of risk associated with a firm's DB pension obligations and, because of the substantial costs involved, the sponsor firm's financial position. We employ hand-collected data between 2007 and 2017 to examine how pension fund and firm financial characteristics are related to both the occurrence and timing of buy-ins. Using probit analysis of UK FTSE 350 firms and a wide range of robustness checks, the findings show that firms that sponsor riskier DB pension funds, associated with higher investment risk and longer investment horizon, are more likely to engage in a pension buy-in transaction. We also find evidence that firms with greater financial slack are more likely to engage in buy-ins. Survival analysis reveals that those characteristics also tend to be significant influences upon the timing of buy-in transactions. Our study contributes to the literature on risk management in general and the literature on pension de-risking in particular, and it paves the way for research on pension buy-ins and buy-outs in other countries. Implications for firms with DB pension obligations and the insurance companies that offer pension buy-ins are identified.

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1. Introduction

Under a defined benefit (DB) pension plan, a sponsor firm undertakes that its employees will be provided with a prescribed level of retirement income, based on a formula that reflects remuneration and years of service. During future retirees' period of employment, the firm makes regular payments into a pension fund, but there is a risk that further contributions will be needed to safeguard the promised level of retirement benefits. A turbulent investment environment and poor capital market conditions, uncertainty regarding plan beneficiaries' longevity, and changes in government policies and accounting standards, can all leave a sponsor firm at risk of having to make substantial unplanned additional payments to remedy a deficit, if fund assets are deemed insufficient to meet likely obligations. For example, the Global Financial Crisis lowered the value of pension funds and returns on pension investments; the Organisation for Economic Co-operation and Development (OECD) reported a drop of $5.4 trillion in the value of global pension assets at the end of 2008 (Yermo and Severinson, 2010). Mercer's Pension Risk Survey (Mercer, 2019) suggests that the pension deficits for UK FTSE 350 firms soared to £67bn from £51bn on 30 August 2019 because of the uncertainty posed by Brexit. Such problems regarding DB pension plans can reduce firms' cash flow (Cheng and Swenson, 2018), constrain their investment decisions (Chaudhry, Yong, and Veld, 2017) and have a negative impact on the size (Chircop and Kiosse, 2015) and volatility (Amir, Guan, and Oswald, 2010) of reported profits.

Many firms have therefore sought to de-risk their pension provision by closing their DB plans to new members (Choy, Lin, and Officer, 2014; Vafeas and Vlittis, 2017; Lane Clark & Peacock, 2018). Instead, new employees are enrolled in defined contribution (DC) plans, under which sponsor firms make designated payments to the pension fund, which is invested to provide unspecified future

retirement benefits. Some firms have gone further in de-risking their pension provision by freezing DB accruals for existing plan members. In such cases, an individual employee's future retirement benefits will be a mixture of DB and DC elements.

In replacing DB pension plans with DC schemes, firms effectively transfer future pension risk to their employees (Josiah, Gough, Haslam, and Shah, 2014; Munnell and Soto, 2007). This is likely to be unpopular with employees and hence could have negative repercussions for the employer. Indeed, Choy et al. (2014) found that, the greater the resistance that might come from a firm's employees, the less likely that the freezing of a large DB pension plan will proceed. However, even if a DB pension plan is successfully closed or frozen, the firm still carries the risk attached to previously accrued DB obligations (Choy et al., 2014), because it continues to be responsible for ensuring that the plan will be able to meet its obligations. Thus, closing or freezing DB plans does not completely de-risk the sponsor firm's position. The remaining risk can be substantial.

As a solution, the market has developed pension 'buy-ins' and 'buy-outs', whereby – in return for a premium – an insurance company assumes some or all of a firm's DB pension obligations and associated risk. If acceptable to pension fund trustees, this is likely to give both the trustees and beneficiaries increased confidence that obligations will be met as they fall due.

As Lin, Shi, and Arik (2017, p. 367) comment, 'Pension buy-ins and buy-outs have become an important aspect of managing pension risk in recent years'. The UK led the way in pension de-risking, but attitudes and techniques largely pioneered in the UK have been manifest in other countries too (Lin, MacMinn, and Tian, 2015). For example, the first US pension buy-in, of $75m, was completed in 2011, and General Motors reduced its pension liabilities by $26bn by completing a pension buy-out with Prudential Insurance Company of America (Lin et al., 2015). According to Sablak and Soi (2021), in the US during 2020 there were at least 432 buy-out contracts, with a total premium of

$25bn. Buy-outs are more common than buy-ins in the US (Geddes, Howard, Conforti, and Steinmetz, 2014), but in Canada – where the market is also well developed– buy-ins were predominant in 2019 and 2020 (Dickner and Abi-Assal, 2021). On the other hand, buy-out deals seem more popular in the Netherlands, where buy-ins are mainly a stepping-stone towards a full buy-out, such as the early deal between the food manufacturer Hero and Aegon (Moss, 2011).

The UK market is well served in terms of comprehensive information (Lane Clark & Peacock, 2018). The scale of UK buy-in transactions can be gleaned from Appendix A, which lists the buy-in transactions that form the basis for our empirical sample.[1] All but one of the transactions involves the removal of over £100m of pension obligations, and two transactions are over £1bn, rising to three instances if the five separate transactions of Smiths Group are combined. The average amount of pension obligation insured per transaction was just under £300m. Given the significant sums involved, firms will consider carefully whether to engage in pension buy-ins. Several factors are likely to affect their decisions, but the very limited previous research on buy-ins has not examined antecedents.

Prior research on pension de-risking more generally has found that both fund-level and firm-level characteristics are related to the decision to close or freeze DB pension plans (Comprix and Muller, 2011; Choy et al., 2014). However, the way in which buy-ins address DB pension risks and their significant cost mean that findings might differ significantly from simple closure or freezing decisions. In this paper, we therefore examine pension fund risk characteristics and firm financial slack as determinants of the decision to engage in a pension buy-in. Our proposition is that the degree of risk associated with a firm's DB pension obligations will increase the likelihood that it engages in

[1] Because of the small number of buy-out transactions in the UK market, we only examine pension buy-ins in this paper.

a buy-in transaction as a form of pension de-risking, but that the expense of such transactions will mean that a firm's financial slack will be positively associated with whether it engages in buy-in activity.

Using probit analysis of hand-collected data relating to FTSE 350 UK companies between 2007 and 2017, we find that firms that sponsor riskier DB pension funds, in terms of higher investment risk and longer investment horizon, are more likely to engage in buy-in transactions. Our results hold while controlling for corporate governance variables, industry sector and the general price of pension buy-ins, and they are robust to lagging the determinant variables and to using alternative measures of the key variables. We also find evidence that firms with greater financial slack are more likely to implement pension buy-ins to reduce a given level of pension risk. That evidence is stronger for an alternative proxy based on tangible assets than for our initial variable based on relative holdings of cash and cash equivalents.

To complement our main analysis and to enhance our understanding of the influence of the various factors, we employ survival analysis to investigate the timing of the commencement of engagement in pension buy-ins. The findings confirm that the factors that influence firms to engage in pension buy-ins also tend to influence the speed with which they do so.

The research offers three main contributions. First, in examining a relatively new financial product available to corporations, it contributes to the literature on risk management in general, and on pension de-risking in particular. Our empirical evidence is consistent with the risk management perspective that pension investment risk and investment horizon influence firms to undertake pension de-risking strategies. However, in contrast to DB pension closures and freezes – which financially weaker firms are more likely to implement – in the case of pension buy-ins, it is firms with greater financial slack that are more likely to engage in them, because they are better able to bear the costs

involved. Second, we extend the limited literature on pension buy-ins themselves. Although two previous studies (Lin et al., 2015; Lin et al., 2017) developed analytical models to understand the pricing of pension buy-ins, to our knowledge no previous study has empirically investigated the determinants of firms' decisions to undertake pension buy-ins. Third, while a limited number of previous studies have investigated the factors that influence the occurrence of other forms of pension de-risking (Comprix and Muller, 2011; Choy et al., 2014; Vafeas and Vlittis, 2016, 2017), our study extends the literature by also examining influences upon the *timing* of an important type of pension de-risking.

Our findings may be of interest to firms that are seeking to de-risk their DB pension plan obligations and to the insurance companies that offer pension buy-ins, as they highlight the importance of considering the pension fund's investment risk and investment horizon, and they confirm the need to factor in a firm's ability to meet the cost of buy-in transactions, which is not insignificant.

The remainder of the paper is structured as follows. Section 2 provides further background information on buy-ins, discusses relevant previous literature, and develops the hypotheses. Section 3 describes the sample selection process and presents descriptive statistics. The main tests and results are presented and discussed in Section 4. Section 5 provides the conclusions.

2. Background and hypothesis development

In this section, we first provide further background information on DB pensions, pension buy-ins and the development of the UK market for buy-ins. Drawing on the limited empirical literature on other approaches to pension de-risking, we then develop hypotheses about the determinants of pension buy-in decisions.

2.1. Pension buy-ins

UK occupational pension plans, whether of the defined benefit or defined contribution variety, are voluntary, private schemes that are legally independent of the sponsor firm. They are overseen by pension trustees, who have a fiduciary responsibility to act in the best interests of the pension beneficiaries. Thus, although the assets and liabilities of DB pension plans are reported in the financial statements of the sponsor firm, and although the employer retains responsibility for funding the plan so that DB obligations can be met, the investment strategy of the pension fund reflects the responsibilities and priorities of the pension trustees rather than the preferences of the sponsor firm. Furthermore, any proposal by a firm to de-risk its DB pension exposure through a pension buy-in must be acceptable to the trustees, whose duties are owed to the beneficiaries alone, within the framework of pensions law.

Pension buy-ins are financial tools that allow sponsor firms to transfer all or some of their DB pensions obligations risk to an insurance company, in exchange for a payment that includes a significant premium. The greater the risk that a pension fund poses for the sponsor firm, the greater the potential benefit a buy-in offers. The sponsor firm purchases an annuity, based on a valuation of some bundle of future obligations to beneficiaries. This policy is held as an asset within the pension fund (D'Amato et al., 2018). The insurance company makes regular payments to pension trustees to match the pension benefits required to be paid to the relevant former employees. However, the pension plan continues to administer the benefit payments and the sponsor firm retains responsibility in the event of default by the insurance company. Buy-ins have been popular in the UK, but less so in the US, where the buy-out is more familiar (Geddes et al., 2014).[2] A firm may choose to propose

[2] Lane Clark & Peacock (2016) reports different types of pension buy-in and buy-out transactions: pensioner buy-in, full buy-out, pensioner buy-out and buy-in. The pensioner buy-in (buy-out) is defined as a buy-in (buy-out) that covers payments to current pensioners and their dependants. Full pension buy-out is a contract covering all known liabilities in a pension plan, usually followed by winding up the pension plan. Buy-in represents a purchase of a bulk annuity contract

a pension buy-in according to its desired level of reduction in pension obligations risk and its financial circumstances and priorities.

When an insurance company is approached for a quotation, it will assess the risk attached to the pension plan to determine the feasibility and pricing of a pension buy-in. It will also be interested in how well the pension plan is funded (Lin et al., 2017) and it might require the sponsor firm to top the fund up prior to a buy-in transaction. However, some firms might not be in a position to make the payments demanded by the insurance company. Overall, agreement among an insurer, the pension fund trustees and the sponsor firm is needed before a pension buy-in transaction can take place.

The world's first buy-in transaction took place in the UK in 2006 (Blake, Cairns, and Dowd, 2008). Although the Global Financial Crisis initially impaired the development of the market (Monk, 2009), Biffis and Blake (2009) soon identified the increasing popularity of such transactions in the UK. 2014 marked a milestone, when the UK pension buy-in and buy-out market reached an annual volume of £14.2 bn. A leading firm of pension industry consultants, Lane Clark & Peacock (2015), reported that the pricing of pension buy-ins stabilised in 2015, so it was expected that more employers would choose to engage in pension buy-ins to reduce pension risk. According to the *Mercer Global Pension Buy-out Index*, in March 2018 the average insurance buy-in premium for £100mn of pension accounting liabilities was £14mn.

Pension buy-ins and buy-outs are growing internationally (Lin et al., 2017), but the market for buy-ins in the UK is probably the most developed in the world (Geddes et al., 2014) and provides opportunities for original research. In an early comment, Blake et al. (2008) estimated the potential size of the market at about £800bn. The increased number of suppliers has expanded the capacity of

with an insurance company as an investment to match some or all of a pension plan's liabilities. For reasons related to sample size and data availability, this research does not take account of different types of buy-in contract.

the market to support pension buy-in transactions and more competitive pricing of premiums has been driving the growth of deals. By 2015, the UK market had reached an annual volume of £10bn (Lane Clark & Peacock, 2015). In this paper, we focus on the pension buy-ins of large UK listed (FTSE 350) firms between 2007, when the market became established, and 2017.

Since the market is relatively new and data on transactions are limited, there is little empirical literature focusing on pension buy-ins. Lin et al. (2015) developed an optimisation model predicting that poor implementation of pension de-risking strategies increases firm risk, and that implementation is sensitive to various costs. Lin et al. (2017)'s analytical models assess the pricing of various risks embedded in pension buy-ins or buy-outs. Other research (Blake et al., 2008; Biffis and Blake, 2009) has explored pension buy-ins and buy-outs to investigate how employers transfer mortality risk to insurance companies via insurance contracts, but it has not studied the factors associated with firms' decisions to engage in pension buy-ins.

Nevertheless, some work has explored influences on the closure and freezing of DB pension plans (Comprix and Muller, 2011; Choy et al., 2014). We follow previous research on influences on de-risking in examining pension fund and firm financial characteristics. Where they appear relevant to buy-ins, we have considered the variables they use to be candidates for our models. We have also considered whether the direction of influence would be expected to be the same. Building on this prior research and an understanding of buy-ins, we employ basic economic reasoning to develop our hypotheses (Wooldridge, 2013, p.4).

2.2. Hypotheses

2.2.1. Pension fund characteristics

Risk management theory suggests that firms have incentives to manage risk to increase shareholder value (Mayers and Smith, 1987; Smith and Stulz, 1985). From the perspective of a sponsor firm that is interested in de-risking its pension provision, there are two dimensions of pension plan risk that are likely to influence its motivation to engage in a pension buy-in. These dimensions reflect the two sides of the pension fund's financial situation: the risk attached to the return on its assets; and the risk associated with its liabilities or obligations. We develop hypotheses relating to these in turn.

The risk attached to a pension fund's return on assets is affected by its investment strategy, in particular the allocation to equities and bonds.[3] A higher allocation to equities can offer higher returns over the long term and so lower the total contributions required from the sponsor firm, but it also poses higher investment risk for the pension fund as the equity market is more volatile than the debt market (Cocco and Volpin, 2007). The sponsor firm of a pension plan with a high proportion of its assets held as equities faces a higher risk of large, unexpected calls for additional contributions if the value of equities falls and the pension plan's valuation is deemed insufficient. A buy-in effectively prices some portion of this risk and transfers it to an insurance company. Firms that sponsor pension funds that hold a higher proportion of more volatile equity assets (Amir et al., 2010) are thus more likely to engage in pension buy-ins and so de-risk their pension provision.[4] We therefore posit that:

Hypothesis 1: *There is a positive relationship between pension asset allocation to equities and the decision to engage in pension buy-ins.*

[3] 'Alternative' investments may also be held, but the balance between equities and bonds tends to be the focus of research into pension fund investment strategies (see, for example, Chircop and Kiosse, 2015).
[4] Some advisers recommend reducing equity in the build-up to a transaction if it looks like a deal would otherwise be unreachable because of anticipated volatility. However, there is still a wide range in the proportion allocated to equities where a buy-in transaction takes place (see Table 2).

However, the higher the riskiness of a pension fund's investment strategy, the higher the premium that will be required by the insurance company, which might make buy-ins too expensive or unattractive for a sponsor firm. Thus, while higher investment risk acts as an incentive to sponsor firms to de-risk their obligations by means of a pension buy-in, the intuition is that, past a certain point, the size of the associated premium might act as a disincentive to engaging in a buy-in. We therefore check for an inverted-U relationship by including the square of the term relating to allocation to equities in one of the model specifications in the empirical analysis.

The second dimension of pension fund risk relates to the longevity of beneficiaries. Mortality assumptions are used to estimate projected benefit obligations that need to be funded for pension plan members. However, many firms have had to make further payments to their DB pension plan to address unanticipated increases in life expectancy. The less mature a plan, the greater the mortality risk and the longer its investment horizon. Thus, pension funds with longer investment horizons face more uncertainty in relation to benefits to be paid out than do funds with shorter investment horizons, and so they pose a higher risk (Amir et al., 2010). Sponsor firms of funds with longer investment horizons have a greater incentive to remove mortality risk via pension buy-ins (Blake et al., 2008; Biffis and Blake, 2009). We therefore posit that:

Hypothesis 2: *There is a positive relationship between pension fund investment horizon and the decision to engage in pension buy-ins.*

However, the degree of uncertainty associated with the investment horizon of a pension fund also affects the size of the premium that is likely to be sought by an insurance company. Thus, past a certain point, the size of the associated premium might act as a disincentive to engaging in a buy-in. We therefore again also check for an inverted-U relationship by including the square of the term relating to investment horizon in one of the model specifications in the empirical analysis.

2.2.2. Firm financial characteristics

Pensions are a major cost and have a significant relation with firm financial policy. For example, Bartram (2018) found that financially weaker firms make lower pension contributions and Rauh (2009) suggests that financial distress plays a significant role in pension policy making. Thus, firms in a weaker financial condition might be expected to be particularly keen to undertake a freeze, given the financial burden and risk that DB pension plans impose on the sponsor. Indeed, Munnell and Soto (2007) found that there is a significant negative relationship between profitability and the probability of firms freezing their DB pension plans. Similarly, Comprix and Muller (2011) indicate that firms with poorer operating cash and financial position are more likely to freeze their DB pension plan. They also suggest that pension plans with lower funding levels – which represent a latent claim on the finances of the sponsor company – are more likely to be frozen. Moreover, Vafeas and Vlittis (2017) provide evidence that financially distressed firms are more likely to freeze their DB pension plans.

However, given the cost of buy-in transactions (see Appendix A), the motivations for sponsor firms to engage in pension buy-ins are likely to play out differently. Indeed, having modelled the pricing of buy-ins and buy-outs, Lin et al. (2017) suggest that financially constrained firms should not implement them. Furthermore, it is not just the buy-in premium that makes significant demands upon a firm's funds, but the insurance company might require additional contributions to the pension fund to reduce any funding gap before the transaction can go ahead. Thus, a decision to engage in a pension buy-in can effectively crystallise the latent claim upon the sponsor firm of an underfunded pension plan.

Therefore, although prior empirical research suggests that firms with poorer financial condition are more likely to close or freeze DB pension plans in an effort to de-risk their pension provision, we

suggest that financially weaker firms are less likely to engage in a buy-in to address the 'frozen' defined benefits for which they are still responsible. On the other hand, whether in association with a DB pension freeze or not, financially strong firms will be in a better position to reduce the financial risk of pension fund commitments by means of a pension buy-in. Thus, the relationship between firm financial condition and buy-in behaviour (positive) is expected to be the opposite of that found in studies of pension freezing behaviour (negative).

Previous research (Fresard, 2010; Lungeanu, Stern, and Zajac, 2016; Opler, Pinkowitz, Stulz, and Williamson, 1999) shows that holding liquid assets brings real benefits, because cash-rich firms have greater financial slack and so are better able to take advantage of strategic opportunities. Fresard (2010), for example, found a positive impact of relative cash reserves on firm value. Therefore, firms that hold greater cash reserves, relative to their peers, are more likely to be able to meet the financial commitment of an attractive buy-in opportunity. We therefore posit that:

Hypothesis 3. *There is a positive relationship between cash holding and the decision to engage in pension buy-ins.*

Thus, we understand the decision to engage in buy-ins as centred on the nexus between the dimensions of the risk relating to the pension fund itself and the financial slack of the sponsor firm. The characteristics of the pension fund will affect not only the motivation of the firm to de-risk via a buy-in but also the willingness of insurance companies to contract and the size of the premium they seek, which in turn will affect the affordability of the transaction for the sponsor firm. All this occurs within the context of pensions law and can only take place with the agreement of the pension fund trustees, who act under a fiduciary duty to the beneficiaries.

The hypotheses are tested using probit analysis. We also employ survival analysis to investigate the time to the pension buy-in event.[5] For the survival analysis, the hypotheses relating to the decision to engage in pension buy-ins should accordingly be re-interpreted in terms of timing. Investigating influences upon the timing of a de-risking action is itself a novel focus for the pension de-risking literature.

3. Sample selection and descriptive statistics

3.1. Sample selection

The population for our study is UK FTSE 350 firms for the period 2007 to 2017. We begin with 2007, because the world's first buy-in transaction took place in the UK in 2006 (Blake et al., 2008; Lane Clark & Peacock, 2016). To deal with survivorship bias, we allow firms to exit and enter the FTSE 350 Index.

Pension buy-in information is hand-collected from an authoritative practitioner research report produced by Lane Clark & Peacock LLP[6] (Lane Clark & Peacock, 2018). The list provided in Appendix A contains 34 transactions involving 28 unique sponsor firms. Three firms engaged in more than one transaction, but we treat the first as the event because the series of transactions might well have been agreed at the beginning of the process. The sample selection process is summarised in Panel A of Table 1.

[5] Survival analysis has been used extensively in the medical sciences. It has also been adopted in finance to investigate the exit of venture capital or time-to-receiving funding (Gompers, 1995; Cumming and MacIntosh, 2001) and to study IPO survival (Espenlaub, Khurshed, and Mohamed, 2012; Ahmad and Jelic, 2014).

[6] Founded in 1947, Lane Clark & Peacock (LCP) is a major UK-based firm of financial, actuarial and business consultants. It is a leading provider of advice in areas such as pensions, investment and insurance. One of its key activities is the provision of advice to pension plan trustees and corporate sponsors on complex UK and international pensions issues. For example, at the time of writing it claims to advise 43 of the FTSE 100 on their pension schemes. See www.lcp.uk.com. LCP has been reporting on buy-ins and buy-outs for several years. The report from which our data are drawn is LCP's eleventh annual report on the buy-in, buy-out and longevity swap market. See https://www.lcp.uk.com/pensions-benefits/publications/lcp-pension-de-risking-2018/.

[Insert Table 1 here]

We derive a list of FTSE 350 firms with their industry code from the Bloomberg database.[7] We collect financial and pension information from Standard and Poor's Capital IQ database between 2004 and 2017.[8] We begin with 618 unique firms, then exclude those with no evidence of having a DB pension plan. This gives us 360 firms, of which 28 engaged in at least one buy-in transaction. Of these 360 firms, full accounting information is not available for 186 of them, which leads to the loss of 4 of the buy-in events from the sample. This leaves for analysis 1,168 firm-year observations and 174 unique firms, of which 24 engaged in pension buy-ins.[9] Panel B of Table 1 provides information about the distribution of the transactions across the period of the study.

3.2. Control variables and tests

To test our hypotheses, we also include pension fund-related control variables (relating to plan size and funding level) and firm-level control variables (relating to size, operating cash flow, firm risk and leverage). Pension de-risking in general, and engaging in a buy-in in particular, represent strategic decisions (Vafeas and Vlittis, 2016; 2017) that are very likely to involve the board of directors (Fama and Jensen, 1983), so we also control for a basic set of board characteristics: board size proxies for experience and knowledge that may help in grasping the buy-in opportunity and making the decision; board independence is expected to support the protection of employee interests; and the proportion of female directors on the board might have an influence on attitudes to risk (Croson and Gneezy, 2009).

[7] There are nine industry categories: Basic materials, Communications, Consumer – cyclical, Consumer – non-cyclical, Energy, Financial, Industrial, Technology, and Utilities.

[8] Although we focus on pension buy-ins from 2007 to 2017, we collect an extra three years' financial information to permit the calculation of firms' risk (*ROA_VOL*).

[9] For some versions of our model, the dataset used is reduced because of further missing information. Details are provided in the relevant tables.

3.3. Descriptive statistics

Table 2 provides descriptive statistics for dependent and explanatory variables. All the continuous variables are winsorised at the top and bottom 1%. The average pension fund is 89.4% funded, with 59.5% of its asset allocated to equities. On average, plan size is just over one third (37.5%) of firms' total assets.

[Insert Table 2 here]

The pairwise correlation coefficients across the variables are shown in Table 3. We note that the main independent variables (*EQUITY*, *HOR* and *ZCH*) have positive correlations with *BI*. There is no problematic high bivariate correlation among the variables.

[Insert Table 3 here]

We conduct a T-test to examine the mean differences between *NON_BI* (*N = 969*) and *BI (N = 199)* samples, with a total of 1,168 firm-year observations. Table 4 shows several significant differences between the two groups in independent or control variables. *EQUITY* is significantly higher at firms that engage in pension buy-ins (0.636) as compared to those firms that do not (0.586). This shows that the pension funds of firms that engage in pension buy-ins hold more volatile assets. In addition, pension funds of firms that engage in pension buy-ins tend to have higher *HOR* (4.887) than those that do not (4.528). This suggests that pension funds that engage in pension buy-ins tend to be less mature. These differences are suggestive of merit in the hypotheses. In addition, *FUND* is higher in the sample of *BI* (0.923) than the sample of *NON_BI* (0.888), which suggests that firms engaging in pension buy-ins sponsor significantly better funded pension funds than firms that do not engage in such an approach. *BI* firms (8.265) tend to be larger than *NON_BI* firms (7.934) in terms

of their size (*SIZE*). *NON_BI* firms tend to have higher leverage (*LEV*) but fewer independent directors (*BOARD_INDEPENDENT)* on their boards than *BI* firms.

[Insert Table 4 here]

4. Empirical analyses and results

In this section, we present our findings on the influences on pension buy-in decisions.

4.1. Pension fund and firm financial characteristics as determinants of pension buy-ins

This section presents our baseline model and the initial empirical results for pension fund and firm financial characteristics in a probit model, which broadly takes the following form (firm *i* and year *t* subscripts are dropped in the text for expositional convenience):

$$BI_t = \beta_0 + \beta_1 EQUITY_{i,t} + \beta_2 EQUITY\_SQUARE_{i,t} + \beta_3 HOR_{i,t} + \beta_4 HOR\_SQUARE_{i,t} + \beta_5 ZCH_{i,t} + \beta_6 FUND_{i,t} + \beta_7 PLAN\_SIZE_{i,t} + \beta_8 SIZE_{i,t} + \beta_9 CF_{i,t} + \beta_{10} LEV_{i,t} + \beta_{11} ROA\_VOL_{i,t} + \beta_{12} BOARD\_SIZE_{i,t} + \beta_{13} BOARD\_INDEPENDENT_{i,t} + \beta_{14} BOARD\_FEMALE_{i,t} + \sum \beta_s Year\_dummy + \sum \beta_r Industry\_dummy + \sigma \quad (1)$$

The dependent variable (*BI* at year *t*) is a dummy variable, equal to 1 if a firm engages in a pension buy-in, and 0 otherwise. *EQUITY* is the percentage of pension assets allocated to equities during year *t*; *EQUITY_SQUARE* is the square of *EQUITY*; *HOR* is the natural logarithm of projected benefit obligations divided by service costs in year *t*; *HOR_SQUARE* is the square of *HOR*; *ZCH* is the standardised ratio of cash holdings to total assets during year *t* following the method from MacKay and Philips (2005) and Fresard (2010), where cash includes cash equivalents and short-term investments; *FUND* is the fair value of pension assets divided by projected benefit obligations during year *t*; *PLAN_SIZE* is the projected benefit obligations divided by firm total assets during year *t*; *SIZE* is the natural logarithm of total market capitalisation in year *t*; *CF* is the cash flow from operating activities divided by total assets during year *t*; *LEV* is the total long-term debts divided by total assets

during year *t*; and *ROA_VOL* is the standard deviation of return on assets over the last three years, where return is measured as net income. The corporate governance control variables are as follows: *BOARD_SIZE* is the natural logarithm of the number of directors; *BOARD_INDEPENDENT* is the percentage of independent directors; and *BOARD_FEMALE* is the percentage of female directors. We control omitted variables that are related to firm and year by introducing firm and year dummy variables. Table 5 presents the results of estimating Equation (1).

[Insert Table 5 here]

We begin by examining the variables that constitute the three hypotheses relating to pension fund and firm financial characteristics. There is a significant positive relationship between pension asset allocation to equities (*EQUITY*) and buy-ins (*BI*)[10] in Column (1). This indicates that pension funds whose sponsor firms engage in pension buy-ins tend to be ones that experience higher investment risk. This supports Hypothesis 1. The possibility of an inverted-U relationship was checked for in the version of the model shown in Column (3), but it was not evident, as indicated by *EQUITY_SQUARE* not being significant. Column (2) of Table 5 reports the marginal effects of the probit model in Column (1) and indicates the economic significance of the findings. For example, a one percentage point increase in *EQUITY* increases the probability that a firm engages in pension buy-ins by 0.44%.

There is also a significant positive relationship between pension investment horizon (*HOR)* and buy-ins (*BI*). This indicates that sponsor firms of pension funds with a longer investment horizon are more likely to reduce or remove pension obligation risk via pension buy-ins. This supports Hypothesis 2. Again, the possibility of an inverted-U relationship was checked for in Column (3) of

[10] *BI* is the main dependent variable that captures a firm's implementation of pension buy-ins. The following example demonstrates how this variable is coded. If Firm X implemented a pension buy-in in the year 2012, then *BI* is coded as 0 for the years before the buy-in (2009-2011), 1 in 2012 and will remain as 1 throughout the rest of the period (2012-2017). In the data, Firm X's *BI* record for the period of 2009-2017 will be recorded as 0, 0, 0, 1, 1, 1, 1, 1, 1.

the model. The negative coefficient on *HOR_SQUARE* indeed shows that there is some attenuation of the relationship between pension fund investment horizon and the decision to engage in pension buy-ins. Our explanation for the attenuation is that the required premiums are likely to become disproportionately expensive after a certain point. Nevertheless, the basic insight that longer investment horizon tends to drive interest in buy-in behaviour on the part of sponsor firms appears to obtain.[11]

Turning to the hypothesis relating to firm financial characteristics, there is a significant positive relationship between relative cash holding (*ZCH)* and buy-ins (*BI*), but only at a 10% significance level. We thus find some limited support for Hypothesis 3, which views relative cash holding as an indicator of management's ability to take advantage of strategic opportunities. The finding suggests that sponsor firms with a high relative cash holding compared with their peers are more likely to reduce pension obligation risk via pension buy-ins, which can be explained by the need to pay a substantial premium to insurance companies. The evidence is consistent with Lin et al.'s (2017) suggestion that financially poorer firms will find pension buy-ins too costly for them. The marginal effect in Column (2) suggests that a one-unit increase in *ZCH* increases by 2.6% the probability that a firm engages in pension buy-ins.

The results also show a significant positive relationship between funding status (*FUND*) and buy-ins (*BI*), which suggests that the better funded the pension fund, the more likely are pension buy-in transactions. In some cases, this might reflect improvements to the pension fund's financial strength made by the sponsor firm prior to concluding a deal with an insurance company. We also note that

[11] Because the correlations between *EQUITY* and *HOR* and their respective square terms are high, only simple versions of the variables are used in subsequent versions of the model.

firms with more independent directors (*BOARD_INDEPENDENT*) are more likely to engage in pension buy-ins, which might reflect expertise or experience at other companies.

4.2. Robustness checks

In this section, we report the results of some robustness checks and offer some further insights.

First, to check for the possible influence of the Global Financial Crisis, we also ran the models from 2010 rather than from 2007. There were some changes in the control variables, but the key results for pension fund and firm financial characteristics remained the same (see Online Appendix, Section 1).

Second, as the buy-in market developed, the pricing of buy-in premiums became more competitive. We therefore controlled for the general level of pricing of pension buy-ins by utilising the Mercer Global Pension Buyout Index,[12] which was available from 2013. *EQUITY* and *HOR* remain significant at the 1% level, whereas *ZCH* increases in significance to the 5% level, with an increased marginal effect. In the case of the introduced variable for the pricing of pension buy-ins (*PRICE*) itself, we find a negative coefficient, which might be expected; but it is insignificant and so should not be interpreted as evidence of a negative relationship with the probability of engaging in pension buy-ins (*BI*). Overall, even though the sample size is much reduced, the introduction of *PRICE* confirms, and to some extent strengthens, support for the hypotheses (see Online Appendix, Section 2).

[12] Mercer is a US human resources consulting firm. Headquartered in New York City, it is the world's largest outsourced asset manager (https://www.mercer.com/our-thinking/global-pension-buyout-index.html). The Mercer Global Pension Buyout Index was launched in early 2013 and monitors the general trend in the pricing of pension bulk annuity transactions in the US, UK, Ireland, Canada and Germany. Mercer uses up-to-date monthly pricing information from each country to estimate the cost of insuring a sample plan's current retirees as a percentage of the equivalent estimated accounting liability.

Third, given the strategic nature of buy-in decisions, we considered the possibility of lag effects of the determinants; pension fund and firm characteristics in year *t-1* might influence firms to engage in pension buy-ins in year *t*. We therefore re-estimated Equation (1) with a lag of one year for determinant variables. We generally find evidence consistent with our main results (see Online Appendix, Section 3). However, the positive relationship between ZCH_{t-1} and BI_t is insignificant. We note the possibility that, even if preparations were made well in advance, it would likely be the current financial situation and prospects that would lead the board to approve, delay or abandon a buy-in transaction.

Finally, to provide a check that our results are not unduly sensitive to the choice of proxy, we use alternative measures for some of the determinants. We do not have a plausible alternative to *EQUITY* for Hypothesis 1, but we provide alternatives for Hypotheses 2 and 3. We employ alternative measures for three of the pension fund variables (*HOR*, *PLAN_SIZE* and *FUND*) and the main firm financial variable (*ZCH*). Following Guan and Lui (2016), we use the current benefit payouts scaled by projected benefit obligations to measure *HOR**. Following Anantharaman and Lee (2014) and Rauh (2009), we measure *PLAN_SIZE** as the natural logarithm of the fair value of pension assets and *FUND** as the difference between pension assets and projected benefit obligations scaled by projected benefit obligations.

Cash (and its equivalents) is a key component of financial slack, but a firm with low cash holdings might nevertheless have unused debt capacity and so be able to raise external financing to take advantage of an opportunity (Hahn and Lee, 2009). Building on the measure of expected asset liquidation value of a firm from Almeida and Campello (2007) and the findings of Berger, Ofek and Swary (1996), Alemida and Campello (2007) suggest that the tangibility of a firm's assets captures its ability to obtain external financing. It is expected that firms that have more tangible assets

(including, but not limited to, cash) have better access to external financing and so are more likely to engage in pension buy-ins. Thus, *ZCH* is replaced in the model by *TANGIBLE* to capture the financial slack of the company.

The results for the alternatively specified model are reported in the Online Appendix (Section 4). We find a negative and significant relationship (1% significance) between *HOR** and *BI*, which suggests that firms that sponsor DB pension plans with shorter investment horizons are less likely to engage in pension buy-ins. The finding is consistent with our main results and so Hypothesis 2 is still supported using a different measure for *HOR* and with the replacement of *FUND* and *PLAN_SIZE* by *FUND** and *PLAN_SIZE**, respectively.

We also find that there is a significant positive relationship between *TANGIBLE* and *BI*, so firms with greater financial slack as proxied by tangible assets are more likely to engage in pension buy-ins. Because *TANGIBLE* is significant at the 5% level, this strengthens support for Hypothesis 3, *ZCH* having been significant at only the 10% level in the main analysis (but at the 5% level when controlling for the effect of buy-in prices).

We also find a significant positive relationship between *PLAN_SIZE** and *BI*. This is the first significant result for plan size in any of our results, which suggests that total size of the pension plan rather than its size relative to the size of the firm might influence the likelihood of a pension buy-in taking place. There could be several reasons for this, including incentives for insurance companies that provide the buy-ins, perhaps deriving from economies of scale and transaction costs. This might be worth investigating in future research.

4.3. Survival analysis

To investigate the influence of our independent variables further, we employ survival analysis to gain insights into the timing of the buy-in event. This also helps deal with right truncation of the data and can help overcome any limitations of the measure of *BI* that we employ.

We combine time variable (*Year*) and event variable (*BI*) to measure the duration of occurrence of pension buy-ins (*DUR_BI*) in the survival analysis. The duration is referred to as the number of years from the start of the sample period. A firm is assumed to have a probability of implementing pension buy-ins. In order to conduct the survival analysis, we choose the semi-parametric approach, the Cox proportional hazard model. It can result in a more accurate estimation as it does not impose any structure on the base line hazard. The following Cox proportional hazard model is used to explore the pension fund and firm financial characteristics that might affect the timing of engagement in pension buy-ins:

$$h_i(DUR\_BI) = h_0(t)\exp\{\beta_0 + \beta_1 EQUITY_{i,t} + \beta_2 HOR_{i,t} + \beta_3 ZCH_{i,t} + \beta_4 FUND_{i,t} + \beta_5 PLAN\_SIZE_{i,t} + \beta_6 SIZE_{i,t} + \beta_7 CF_{i,t} + \beta_8 LEV_{i,t} + \beta_9 ROA\_VOL_{i,t} + \beta_{10} BOARD\_SIZE_{i,t} + \beta_{11} BOARD\_INDEPENDENT_{i,t} + \beta_{12} BOARD\_FEMALE_{i,t} + \sum \beta_r Industry\_dummy + \sigma\} \quad (2)$$

The dependent variable (*DUR_BI*) is the time (in years) for firms to engage in a pension buy-in. All other variables are as previously defined. A significantly positive value of a β parameter indicates that an increase in the corresponding variable leads to a significantly shorter time for a firm to engage in a pension buy-in.

Table 6 summarises the behaviour of the sample under the survival analysis, in tabulated form and in a diagram of the Kaplan-Meier survival estimate. For the probit analysis, we excluded 4 firms because of some unavailable information, but these firms have some complete years of information

which are of value in the survival analysis, so we include them and begin with 28 unique firms. The 4 firms right censor because they begin to have missing information before their buy-in event, as reflected in the 'Net lost' column. This leaves the expected 24 firms with buy-ins.

[Insert Table 6 here]

Table 7 reports the results from estimating the Cox proportional hazard in Equation (2). There are several significant findings.[13]

[Insert Table 7 here]

We find evidence, at the 5% level of significance, that *EQUITY* is positively related to the time-to-engage in pension buy-ins. This suggests that pension funds with a higher proportion allocated to equities are quicker to engage in pension buy-ins, which supports the adapted version of Hypothesis 1. In addition, we find that pension funds with longer investment horizon are quicker to engage in pension buy-ins, thus supporting the adapted version of Hypothesis 2.

We also find some evidence that firms with more cash and cash equivalents (*ZCH*) are quicker to engage in pension buy-ins; but the relevant coefficient is only significant at the 10% level, so support for the adapted version of Hypothesis 3 is only marginal. However, given that the probit analysis found that *TANGIBLE* was more significant than *ZCH* as a measure of financial slack, we re-ran the survival analysis using *TANGIBLE* (see Online Appendix, Section 5). Again, it proved to be more significant, at the 5% level, thus strengthening support for the hypothesis that financial slack affects the timing of pension buy-ins.

[13] Some listed firms outside the FTSE 350 have also engaged in pension buy-ins. We therefore incorporated these further firms into our survival analysis as a robustness check. The results were not significantly different and are not reported here.

4.4. Overview of the results

Strong evidence was found for our two hypotheses regarding the influence of pension fund risk characteristics on both the occurrence and the timing of buy-in behaviour. Even though it may be possible to change a pension fund's investment strategy in a way that affects its risk characteristics, this is a matter for the trustees rather than the sponsor firm, and we found the expected positive relationship with the proportion of the pension fund allocated to equities, which affects the riskiness of the pension fund portfolio (Cocco and Volpin, 2007; Amir et al., 2010). We also found evidence of the expected positive influence of investment horizon, although there were signs that this influence is attenuated, which we posited might occur because of the expense of premiums beyond a certain point as investment horizon risk increases.

The issue of affordability was reflected in the evidence we found on the influence of firms' financial slack on the occurrence and timing of buy-ins, although the picture was more mixed than in the case of the pension fund variables. In our main analysis, the significance of the influence of relative cash holdings was marginal, generally being at the 10% level in both the probit analysis and the survival analysis.[14] However, an alternative measure of financial slack, tangible assets, was found to be significant at the 5% level in both the probit analysis and the survival analysis. Thus, we cautiously conclude that firms with more (less) financial slack are more (less) likely to engage in pension buy-ins, as Lin et al.'s (2017) modelling suggested, and they are likely to do so earlier (later).

Overall, we find that the results from the survival analysis are broadly consistent with the main probit analysis regarding the influence of the independent variables on pension buy-ins.

[14] The lagged version of the variable was insignificant in the probit analysis (see Online Appendix, Section 3), although the standard version was significant at the 5% level in the model for 2013-2017 that contained a control variable for the general pricing of pension buy-ins (see Online Appendix, Section 2).

5. Conclusion

This study investigated the determinants of pension buy-in transactions, which have become an established approach as firms with defined-benefit (DB) pension plans seek to enhance their pension de-risking strategies. Whereas the closure or freezing of a DB plan simply shift future pensions risk from the sponsor firm to employees, but leave existing DB obligations unaltered, buy-ins contribute to the de-risking of those obligations by transferring a portion of them to a third party (an insurer) – but at a cost.

The probit analysis reported in this study provides evidence that firms with DB pension funds that face higher investment risk and have longer investment horizon are more likely to engage in buy-in transactions. We also find some evidence that firm financial slack also increases the probability of a buy-in transaction, because financially stronger firms are better able to afford the substantial costs involved. Survival analysis, which has not been applied in previous pension de-risking research, confirms the significance of the pension fund and firm financial variables regarding the timing of initial buy-in transactions. Our results are robust to a wide range of checks, including using alternative proxies for some explanatory variables, lagging independent and control variables, and controlling for the pricing of pension buy-ins. Thus, we provide support for our hypotheses on the factors that influence both the occurrence and timing of pension buy-in transactions.

The research offers three main contributions. First, in examining a relatively new financial product available to corporations, it contributes to the literature on risk management in general, and on pension de-risking in particular. Our empirical evidence is consistent with the risk management perspective that pension investment risk and investment horizon influence firms to undertake pension de-risking strategies. However, in contrast to DB pension closures and freezes – which, it has been shown, financially weaker firms are more likely to effect – in the case of pension buy-ins, it is firms

with greater financial slack that are more likely to engage in them, because they are better able to bear the costs involved. Second, we extend the limited literature on pension buy-ins themselves. While two previous studies (Lin et al., 2015; Lin et al., 2017) developed models to understand the pricing of pension buy-ins (without empirical data), to our knowledge no previous study has investigated the potential influences upon firms' decisions to undertake pension buy-ins. Third, while a limited number of previous studies have investigated the factors that influence the occurrence of other forms of pension de-risking (Comprix and Muller, 2011; Choy et al., 2014; Vafeas and Vlittis, 2016, 2017), our study extends the literature by examining influences upon the *timing* of an important type of pension de-risking.

Our findings may be of interest to firms that are seeking to de-risk their DB pension plan obligations and to the insurance companies that offer pension buy-ins, as they highlight the importance of considering the pension fund's investment risk and investment horizon, and of the need to factor in a firm's ability to meet the cost of a buy-in transaction, which is not insignificant.

As the first of its kind, this paper has limitations, but it also paves the way for future research, particularly as the number of buy-in transactions continues to grow, in the UK and internationally (Geddes et al., 2014; Lin et al., 2017). Larger datasets in the future should provide opportunities for some of the issues raised in this paper to be investigated in greater depth. For example, future research could attempt to understand more about the influence of the absolute size of DB pension funds and corporate governance variables upon pension buy-in behaviour. Larger datasets might also permit different kinds of buy-ins to be studied. Furthermore, data from countries other than the UK could provide opportunities to examine pension buy-outs, which have some similarities to buy-ins but merit separate analysis. They were insufficient in number in the UK to include in this paper, but they are much more common than buy-ins in the US.

Appendix A: Pension buy-in transactions for FTSE 350 firms between 2007 and 2017

Name	Size (£m)*	Sector	Insurer	Type	Year
3I GROUP PLC	200	Financial Services	Pension Insurance Corporation	Pensioner buy-in	2017
A.G. BARR PLC	35	Unknown	Canada Life	Buy-in	2016
BBA AVIATION PLC	270	Aviation	Legal & General	Pensioner buy-in	2008
CABLE & WIRELESS COMMUNICATI	1050	Communications	Prudential	Pensioner buy-in	2008
COBHAM PLC	280	Aerospace & Defence	Rothesay Life	Pensioner buy-in	2013
DAIRY CREST GROUP PLC	150	Food Producer	Legal & General	Pensioner buy-in	2008
DAIRY CREST GROUP PLC	150	Food Producer	Legal & General	Pensioner buy-in	2009
GKN LTD	120	Engineering	Rothesay Life	Pensioner buy-in	2014
GKN LTD	190	Engineering	Pension Insurance Corporation	Pensioner buy-in	2016
GLAXOSMITHKLINE PLC	900	Pharmaceutical	Prudential	Pensioner buy-in	2010
HOME RETAIL GROUP LTD	280	Retail	Prudential	Pensioner buy-in	2011
HUNTING PLC	110	Energy	Paternoster (now Rothesay Life)	Pensioner buy-in	2007
INTERSERVE PLC	300	Construction	Aviva	Pensioner buy-in	2014
JARDINE LLOYD THOMPSON GROUP	120	Employee benefits consulting	Prudential	Pensioner buy-in	2013
KINGFISHER PLC	230	Retail	Legal & General	Pensioner buy-in	2015
LAND SECURITIES GROUP PLC	110	Property	JUST	Pensioner buy-in	2016
LONDON STOCK EXCHANGE GROUP	160	Financial Services	Pension Insurance Corporation	Pensioner buy-in	2011
MORGAN ADVANCED MATERIALS PL	160	Engineering	Lucida	Pensioner buy-in	2008
NEXT PLC	125	Retail	Aviva	Pensioner buy-in	2010
PEARSON PLC	600	Education	Aviva	Pensioner buy-in	2017
PHOENIX GROUP HOLDINGS	1180	Financial services	Phoenix Life	Pensioner buy-in	2016
RANK GROUP PLC	700	Gambling	Rothesay Life	Full risk transfer	2008
SMITH & NEPHEW PLC	190	Medical	Rothesay Life	Pensioner buy-in	2013
SMITHS GROUP PLC	250	Engineering	Paternoster (now Rothesay Life)	Pensioner buy-in	2008
SMITHS GROUP PLC	150	Engineering	Rothesay Life	Pensioner buy-in	2011
SMITHS GROUP PLC	170	Engineering	Pension Insurance Corporation	Pensioner buy-in	2013
SMITHS GROUP PLC	250	Engineering	Pension Insurance Corporation	Pensioner buy-in	2016
SMITHS GROUP PLC	210	Engineering	Canada Life	Pensioner buy-in	2017
SSE PLC	245	Energy	Pension Insurance Corporation	Pensioner buy-in	2016
TATE & LYLE PLC	350	Food Producer	Legal & General	Pensioner buy-in	2012
TAYLOR WIMPEY PLC	205	Housebuilding	Partnership	Pensioner buy-in	2014
UNILEVER PLC	130	Consumer goods	Legal & General	Pensioner buy-in	2014
VESUVIUS PLC	320	Engineering	Pension Insurance Corporation	Pensioner buy-in	2012
WEIR GROUP PLC/THE	240	Engineering	Legal & General	Pensioner buy-in	2007
Total value (£m)	10130				
Mean value (£m)	297.94				
Total number of Buy-ins	34				

Source: Lane Clark & Peacock (2018)

* This column shows the value of pension obligations insured by the buy-in transaction.

Appendix B: Definitions of variables

Hypothesis	Variable	Definition
	Main dependent variable used in probit analysis	
	BI_t	Dummy variable, equals 1 if firm engages in pension buy-in, 0 otherwise (*NON_BI*)
	Pension fund characteristics	
H1	$EQUITY_t$	Pension assets allocated to equities at time *t* divided by total pension assets at time *t*
	$EQUITY\_SQUARE_t$	Square of $EQUITY_t$
H2	HOR_t	Natural logarithm of projected benefit obligations at time *t* divided by service costs at time *t*.
(H2)	HOR_t*	Current benefit payments at time *t* scaled by projected benefit obligations at time *t*
	HOR_SQUARE_t	Square of HOR_t
	$FUND_t$	Fair value of pension assets divided by projected benefit obligations at time *t*
	$FUND_t$*	Difference between pension assets and projected benefit obligations scaled by projected benefit obligations at time *t*
	$PLAN\_SIZE_t$	Projected benefit obligations divided by firm total assets at time *t*
	$PLAN\_SIZE_t$*	Natural logarithm of the fair value of pension assets at time *t*
	Firm financial characteristics	
	ROA_VOL_t	Standard deviation of return on assets (net income divided by total assets) over the last three years
	$SIZE_t$	Natural logarithm of total market capitalisation at time *t*
	CF_t	Cash flow from operating activities at time *t* divided by total assets at time *t*
H3	ZCH_t	The difference between a firm's cash holding to total assets ratio and the industry-year mean, divided by industry-year standard deviation, at time *t*, where cash includes cash equivalents and short-term investments
(H3)	$TANGIBLE_t$	The total of cash holding, .715*receivables, .547*inventory and .535*PPE, divided by total assets, at time *t*, where PPE is property, plant and equipment
	LEV_t	Long-term liabilities at time *t* divided by total assets at time *t*
	Board characteristics	
	$BOARD\_SIZE_t$	Natural logarithm of number of directors in year *t*
	$BOARD\_INDEPENDENT_t$	Percentage of independent directors on board during year *t*
	$BOARD\_FEMALE_t$	Percentage of female directors on board during year *t*
	The Mercer Global Pension Buyout Index	
	$PRICE_t$	The average of estimated price of a pension annuity transaction for current retirees as a percentage of the equivalent estimated accounting liability in the past 12 months
	Main dependent variable used in survival analysis	
	DUR_BI_t	Time to engage in pension buy-in

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Table 1: Sample selection and distribution of buy-in transactions across time

Panel A: Sample selection				Panel B: Distribution of pension buy-ins across time		
Sample selection criteria	Firm-year observations	Unique firms	Number of pension funds with buy-ins	Year	Unique firms	Pension buy-ins
FTSE 350 during 2007-2017	4,209	618	28	2007	113	1
				2008	113	5
				2009	129	1
Less Firms without evidence of defined benefit pension plans	(948)	(258)		2010	119	2
				2011	107	1
				2012	102	2
				2013	101	2
	3,261	360	28	2014	100	4
				2015	97	1
Less Firms missing full accounting information	(2,093)	(186)	(4)	2016	95	3
				2017	92	2
Final sample	1,168	174	24	Total	1168	24

Note: this table reports the sample selection process and the sample distribution over the period 2007-2017. Panel A reports that the initial sample for FTSE 350 firms between 2007 and 2017 has 618 unique firms and 4,290 firm-year observations. We exclude those with no evidence of having a DB pension plan and those lacking full accounting information. This leaves for analysis 1,168 firm-year observations and 174 unique firms, of which 24 engaged in a pension buy-in. Panel B reports the sample distribution by year between 2007 and 2017.

Table 2: Summary statistics

	N	Mean	St.Dev	Min	Max	p25	Median	p75
BI	1168	0.094	0.292	0	1	0	0	0
EQUITY	1168	0.595	0.173	0.073	1	0.484	0.599	0.720
HOR	1168	4.589	0.991	2.541	7.948	3.900	4.401	5.033
FUND	1168	0.894	0.120	0.467	1.267	0.818	0.898	0.969
PLAN_SIZE	1168	0.375	0.380	0.002	1.911	0.117	0.254	0.492
SIZE	1168	7.990	1.390	5.575	11.563	6.949	7.689	8.771
CF	1168	0.100	0.056	-0.065	0.291	0.064	0.091	0.129
ZCH	1168	0.061	0.894	-3.005	1.362	-0.354	0.287	0.701
TANGIBLE	1168	0.283	0.126	0.005	0.609	0.193	0.286	0.379
LEV	1168	0.236	0.153	0	0.717	0.128	0.218	0.325
ROA_VOL	1168	0.018	0.020	0.001	0.178	0.006	0.012	0.023
BOARD_SIZE	1168	2.231	0.233	1.609	2.996	2.079	2.197	2.398
BOARD_INDEPENDENT	1168	5.790	1.981	0	16	4	5	7
BOARD_FEMALE	1168	15.119	10.795	0	50	9.090	13.333	22.222

Note: this table reports descriptive statistics for pension buy-ins, pension fund characteristics, firm financial characteristics and board characteristics. Pension buy-in data are hand-collected from a commercial research report (Lane Clark & Peacock, 2018). Accounting information is collected from Standard and Poor's Capital IQ database. All continuous variables have been winsorised at the top and bottom 1%. All variables are defined in Appendix B.

Table 3: Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) *BI*	1.000													
(2) *EQUITY*	0.188*	1.000												
(3) *HOR*	0.215*	-0.264*	1.000											
(4) *FUND*	0.095*	-0.187*	0.135*	1.000										
(5) *PLAN_SIZE*	0.034	0.045	0.166*	0.064*	1.000									
(6) *SIZE*	0.053	-0.108*	-0.091*	0.029	-0.088*	1.000								
(7) *CF*	0.001	0.026	-0.084*	0.071*	0.106*	0.078*	1.000							
(8) *ZCH*	0.059*	-0.031	-0.024	0.040	-0.378*	0.066*	-0.032	1.000						
(9) *TANGIBLE*	-0.026	0.082*	-0.183*	-0.033	0.012	-0.162*	0.138*	0.025	1.000					
(10) *LEV*	-0.010	0.039	0.035	0.204*	-0.065*	-0.019	0.076*	0.096*	0.065*	1.000				
(11) *ROA_VOL*	-0.065*	-0.050	-0.015	0.046	0.016	-0.109*	0.105*	-0.029	-0.003	-0.089*	1.000			
(12) *BOARD_SIZE*	0.001	-0.078*	-0.132*	0.037	-0.130*	0.563*	-0.013	0.055	-0.182*	-0.020	-0.020	1.000		
(13) *BOARD_INDEPENDENT*	0.093*	-0.125*	-0.027	0.064*	-0.059*	0.710*	-0.069*	-0.006	-0.212*	-0.043	-0.018	0.692*	1.000	
(14) *BOARD_FEMALE*	0.112*	-0.185*	0.105*	0.164*	0.033	0.413*	0.019	-0.024	-0.170*	0.047	-0.079*	0.169*	0.380*	1.000

Note: this table reports pairwise correlation coefficients between the variables. P-values are reported in parentheses. *, **, *** indicate statistical significance, at the 10%, 5%, and 1% level, respectively. All variables are defined in Appendix B.

Table 4: Two-sample T-test of mean differences between *NON_BI* and *BI* firms

	NON_BI (N = 969)	*BI* (N = 199)	Diff	St_Err	t_value
EQUITY	0.586	0.636	-0.050	0.013	-3.7***
HOR	4.528	4.887	-0.359	0.076	-4.7***
ZCH	0.045	0.136	-0.090	0.070	-1.3
TANGIBLE	0.285	0.280	0.005	0.010	0.5
FUND	0.888	0.923	-0.035	0.009	-3.75***
PLAN_SIZE	0.371	0.393	-0.021	0.030	-0.7
SIZE	7.934	8.265	-0.332	0.108	-3.1***
CF	0.101	0.098	0.003	0.005	0.55
LEV	0.242	0.208	0.035	0.012	2.9***
ROA_VOL	0.018	0.018	0	0.002	0.05
BOARD_SIZE	2.225	2.263	-0.038	0.180	-2.1**
BOARD_INDEPENDENT	5.688	6.292	-0.604	0.153	-3.95***
BOARD_FEMALE	14.890	16.238	-1.348	0.840	-1.6

Note: this table reports t-tests for the mean of each variable in the analysis. The second column reports the mean of the variable for the sample of firms that do not engage in pension buy-ins. The third column reports the mean of the variable for the sample of firms that engage in pension buy-ins. *, **, *** indicate statistical significance, at the 10%, 5%, and 1% level, respectively. All variables are defined in Appendix B.

Table 5: Pension fund and firm financial characteristics as determinants of pension buy-ins in a probit model

$$BI_t = \beta_0 + \beta_1 EQUITY_{i,t} + \beta_2 EQUITY\_SQUARE_{i,t} + \beta_3 HOR_{i,t} + \beta_4 HOR\_SQUARE_{i,t} + \beta_5 ZCH_{i,t} + \beta_6 FUND_{i,t} + \beta_7 PLAN\_SIZE_{i,t} + \beta_8 SIZE_{i,t} + \beta_9 CF_{i,t} + \beta_{10} LEV_{i,t} + \beta_{11} ROA\_VOL_{i,t} + \beta_{12} BOARD\_SIZE_{i,t} + \beta_{13} BOARD\_INDEPENDENT_{i,t} + \beta_{14} BOARD\_FEMALE_{i,t} + \sum \beta_s Year\_dummy + \sum \beta_r Industry\_dummy + \sigma$$

Dependent variable: BI			
	(1)	(2)	(3)
VARIABLES	Probit coefficient	Marginal effect	Probit coefficient
EQUITY$_t$	3.6948***	0.4367	0.8581
	(0.5363)	(0.0859)	(2.1822)
EQUITY_SQUARE$_t$			2.3871
			(1.8112)
HOR$_t$	0.4473***	0.0529	2.6869***
	(0.1198)	(0.0150)	(0.7527)
HOR_SQUARE$_t$			-0.2070***
			(0.0678)
ZCH$_t$	0.2205*	0.0261	0.1879
	(0.1230)	(0.0144)	(0.1221)
FUND$_t$	2.1295*	0.2517	1.9324
	(1.1349)	(0.1333)	(1.2612)
PLAN_SIZE$_t$	0.1804	0.0213	0.1399
	(0.3035)	(0.0362)	(0.3201)
SIZE$_t$	0.0641	0.0076	0.0503
	(0.1220)	(0.0145)	(0.1301)
CF$_t$	2.2513	0.2661	2.8636
	(2.3331)	(0.2784)	(2.4259)
LEV$_t$	-0.7591	-0.0897	-0.7460
	(0.7224)	(0.0840)	(0.7457)
ROA_VOL$_t$	-8.0655	-0.9534	-8.3138
	(5.4417)	(0.6403)	(5.4945)
BOARD_SIZE$_t$	-0.9113	-0.1077	-0.8959
	(0.6923)	(0.0815)	(0.7265)
BOARD_INDEPENDENT$_t$	0.1834**	0.0217	0.2003**
	(0.0877)	(0.0106)	(0.0942)
BOARD_FEMALE$_t$	0.0080	0.0009	0.0098
	(0.0093)	(0.0011)	(0.0091)
Constant	-8.5861***		-13.3511***
	(1.9442)		(2.6401)
Observations	1,168		1,168
Industry dummy	YES		YES
Year dummy	YES		YES
Pseudo R^2	0.303		0.330

Note: this table reports the results of a probit model for the determinants of pension buy-ins. The dependent variable is a dummy variable, 1 if a firm engages in a pension buy-in, 0 otherwise. Column (3) checks for non-linearity in the influence of *EQUITY* and *HOR* by including the square of those terms in the model specification. We report both the coefficient and marginal effect in the table. 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 variables are defined in Appendix B.

Table 6: Kaplan-Meier survival function for firms that engage in pension buy-ins

Time	Beginning total	Pension buy-ins	Net lost	Survivor function	Std. error	[95% Conf. Int.]	
2007 (2)	28	1	1	0.9655	0.0339	0.7795	0.9951
2008 (3)	26	5	1	0.7427	0.0839	0.5346	0.8683
2009 (4)	20	1	0	0.7035	0.0856	0.4987	0.8480
2010 (5)	19	2	1	0.6645	0.0915	0.4534	0.8097
2011 (6)	16	1	1	0.6230	0.0947	0.4113	0.7772
2012 (7)	14	2	0	0.5340	0.0999	0.3244	0.7050
2013 (8)	12	2	0	0.4450	0.1012	0.2456	0.6269
2014 (9)	10	4	0	0.2670	0.0919	0.1108	0.4527
2015 (10)	6	1	0	0.2225	0.0867	0.0823	0.4048
2016 (11)	5	3	0	0.0890	0.0598	0.0155	0.2458
2017 (12)	2	2	0	0.0000			
Total		24	4				

Note: this table reports the results of a survival function for the determinants of the timing of pension buy-ins. The dependent variable is *DUR_BI*. The first and second columns report the number of firms that are available to engage in their first pension buy-in in a particular year, and the third column reports the number of firms that engaged in their first pension buy-in in the specified year. The fourth column indicates the number of firms lost from the sample because of missing information before their buy-in; they are included for earlier years because the data adds to the statistical quality of the model. The fifth to seventh columns report the cumulative hazard function, its standard errors and the confidence intervals, respectively. Figures in parentheses in the first column refer to the diagram below.

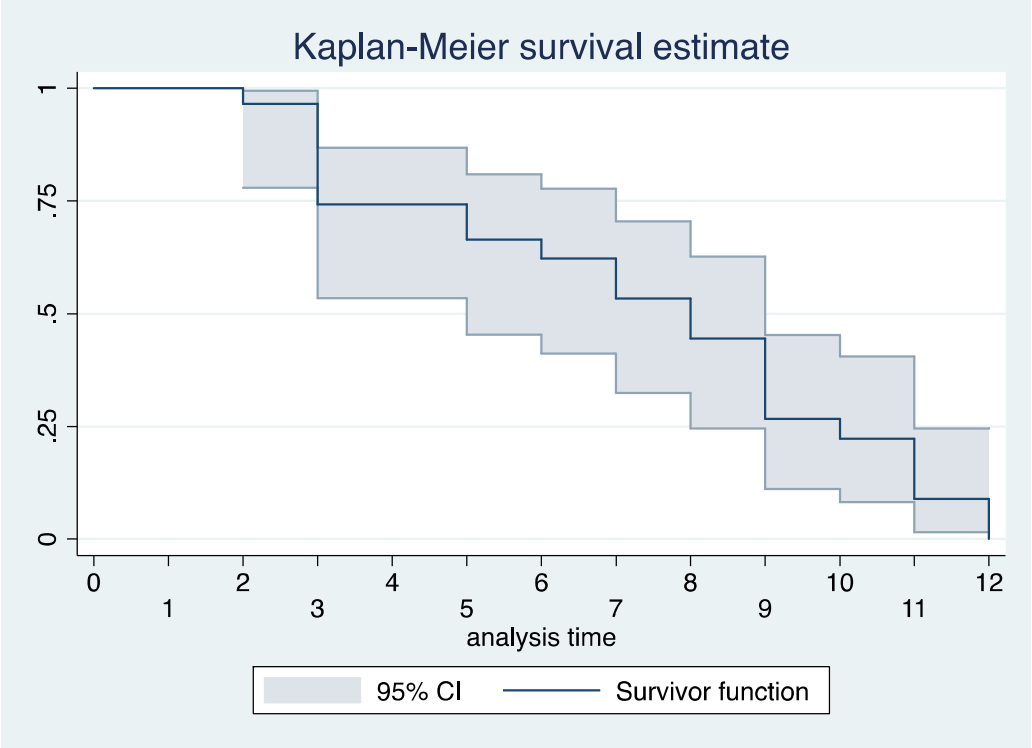

Table 7: Survival analysis for the determinants of pension buy-in timing

$$h_i(DUR\_BI) = h_0(t)\exp\{\beta_0 + \beta_1 EQUITY_{i,t} + \beta_2 HOR_{i,t} + \beta_3 ZCH_{i,t} + \beta_4 FUND_{i,t} + \beta_5 PLAN\_SIZE_{i,t} + \beta_6 SIZE_{i,t} + \beta_7 CF_{i,t} + \beta_8 LEV_{i,t} + \beta_9 ROA\_VOL_{i,t} + \beta_{10} BOARD\_SIZE_{i,t} + \beta_{11} BOARD\_INDEPENDENT_{i,t} + \beta_{12} BOARD\_FEMALE_{i,t} + \sum \beta_r Industry\_dummy + \sigma\}$$

Dependent variable: *DUR_BI*	
	(1)
VARIABLES	Coefficient
EQUITY$_t$	3.557**
	(1.399)
HOR$_t$	0.394*
	(0.206)
ZCH$_t$	0.191*
	(0.095)
FUND$_t$	5.813***
	(1.897)
PLAN_SIZE$_t$	0.254
	(0.438)
SIZE$_t$	0.0112
	(0.231)
CF$_t$	-1.385
	(5.047)
LEV$_t$	-2.432**
	(1.238)
ROA_VOL$_t$	-8.036
	(8.674)
BOARD_SIZE$_t$	0.301
	(1.083)
BOARD_INDEPENDENT$_t$	0.125
	(0.189)
BOARD_FEMALE$_t$	-0.0378
	(0.0238)
Observations	146
Industry dummy	YES
Log likelihood	-93.73
No. firms	28
No. firms engaging in buy-ins	24
No. firms right censoring	4

Note: this table reports the results of survival analysis for the determinants of the timing of pension buy-ins. The dependent variable is the time in years to the pension buy-in event. 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 variables are defined in Appendix B.

Online Appendix

"Defined benefit pension de-risking strategy: determinants of pension buy-ins"

By Li and Cowton

This appendix contains four additional specifications of the probit model and one additional specification of the survival analysis, which complement the main analysis. Each of the sections presents a table that is referred to at an appropriate point in the paper.

Section no.	Title
1	Checking for the possible influence of the Global Financial Crisis
2	Addition of control variable for general pricing of pension buy-ins in probit model of determinants of buy-ins (2013-2017)
3	Accounting for the possible lag effect of the determinants of *BI*
4	Alternative measures for the determinants of *BI*
5	Replacement of *ZCH* with *TANGIBLE* in the survival analysis for the determinants of pension buy-in timing

1. Checking for the possible influence of the Global Financial Crisis

$$BI_t = \beta_0 + \beta_1 EQUITY_{i,t} + \beta_2 EQUITY\_SQUARE_{i,t} + \beta_3 HOR_{i,t} + \beta_4 HOR\_SQUARE_{i,t} + \beta_5 ZCH_{i,t} + \beta_6 FUND_{i,t} + \beta_7 PLAN\_SIZE_{i,t} + \beta_8 SIZE_{i,t} + \beta_9 CF_{i,t} + \beta_{10} LEV_{i,t} + \beta_{11} ROA\_VOL_{i,t} + \beta_{12} BOARD\_SIZE_{i,t} + \beta_{13} BOARD\_INDEPENDENT_{i,t} + \beta_{14} BOARD\_FEMALE_{i,t} + \sum \beta_s Year\_dummy + \sum \beta_r Industry\_dummy + \sigma$$

Table A1: Probit model (2010-2017) with restricted sample for the determinants of *BI*

Dependent variable: BI		
	(1)	(2)
VARIABLES	Probit coefficient	Marginal effect
EQUITY$_t$	3.6882***	0.5237***
	(0.5955)	(0.1066)
HOR$_t$	0.4699***	0.0667***
	(0.1206)	(0.0185)
ZCH$_t$	0.2570*	0.0365*
	(0.1379)	(0.0192)
FUND$_t$	1.5524	0.2204
	(1.1708)	(0.1660)
PLAN_SIZE$_t$	0.1767	0.0251
	(0.3226)	(0.0460)
SIZE$_t$	0.1100	0.0156
	(0.1286)	(0.0187)
CF$_t$	3.3939	0.4819
	(2.6823)	(0.3865)
LEV$_t$	-0.7708	-0.1094
	(0.7961)	(0.1127)
ROA_VOL$_t$	-9.1766	-1.3031
	(6.9903)	(0.9770)
BOARD_SIZE$_t$	-0.8387	-0.1191
	(0.7545)	(0.1064)
BOARD_INDEPENDENT$_t$	0.1885**	0.0268**
	(0.0926)	(0.0133)
BOARD_FEMALE$_t$	0.0081	0.0011
	(0.0106)	(0.0015)
Constant	-7.8236***	
	(2.0150)	
Observations	813	
Industry dummy	YES	
Year dummy	YES	
Pseudo R^2	0.284	

Note: to check for the possible influence of the Global Financial Crisis, we also ran the models from 2010 rather than from 2007. This table reports the results of a probit model with restricted sample (2010-2017) for the determinants of pension buy-ins. The dependent variable is a dummy variable, 1 if a firm engages in pension buy-ins, 0 otherwise. We report both the coefficient and marginal effect in the table. 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 Appendix B of the paper.

2. Addition of control variable for general pricing of pension buy-ins in probit model of determinants of buy-ins (2013-2017)

$$BI_t = \beta_0 + \beta_1 EQUITY_{i,t} + \beta_2 HOR_{i,t} + \beta_3 ZCH_{i,t} + \beta_4 FUND_{i,t} + \beta_5 PLAN\_SIZE_{i,t} + \beta_6 SIZE_{i,t} + \beta_7 CF_{i,t} + \beta_8 LEV_{i,t}$$
$$+ \beta_9 ROA\_VOL_{i,t} + \beta_{10} BOARD\_SIZE_{i,t} + \beta_{11} BOARD\_INDEPENDENT_{i,t} + \beta_{12} BOARD\_FEMALE_{i,t}$$
$$+ \beta_{13} PRICE_{i,t} + \sum \beta_s Year\_dummy + \sum \beta_r Industry\_dummy + \sigma$$

Table A2: Probit model (2013-2017) with control variable for general pricing of pension buy-ins

Dependent variable: BI		
	(1)	(2)
VARIABLES	Probit coefficient	Marginal effect
EQUITY$_t$	3.6767***	0.6300
	(0.7301)	(0.1357)
HOR$_t$	0.5128***	0.0879
	(0.1346)	(0.0242)
ZCH$_t$	0.4000**	0.0685
	(0.1590)	(0.0283)
FUND$_t$	0.7701	0.1320
	(1.2991)	(0.2213)
PLAN_SIZE$_t$	0.2948	0.0505
	(0.3574)	(0.0623)
SIZE$_t$	0.0725	0.0124
	(0.1582)	(0.0273)
CF$_t$	2.7364	0.4689
	(2.6554)	(0.4503)
LEV$_t$	-1.2657	-0.2169
	(0.9767)	(0.1700)
ROA_VOL$_t$	-9.5483	-1.6361
	(10.9510)	(1.8611)
BOARD_SIZE$_t$	-0.2061	-0.0353
	(0.8728)	(0.1491)
BOARD_INDEPENDENT$_t$	0.1816*	0.0311
	(0.1031)	(0.0174)
BOARD_FEMALE$_t$	0.0146	0.0025
	(0.0140)	(0.0024)
PRICE	-0.0105	-0.0018
	(0.0266)	(0.0046)
Constant	-6.7725	
	(4.7104)	
Observations	469	
Industry dummy	YES	
Year dummy	YES	
Pseudo R^2	0.267	

Note: this table reports the results of a probit model for the determinants of pension buy-ins controlling for general pricing of buy-ins (*PRICE*) using the Mercer Global Pension Buyout Index as a proxy. *PRICE* is the average of estimated monthly annuity prices from insurers as a percentage of accounting liability in the past 12 months. The dependent variable is a dummy variable, 1 if a firm engages in pension buy-ins, 0 otherwise. We report both the coefficient and marginal effect in the table. 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 other variable definitions are reported in Appendix B of the paper.

3. Accounting for the possible lag effect of the determinants of *BI*

$$BI_t = \beta_0 + \beta_1 EQUITY_{i,t-1} + \beta_2 HOR*_{i,t-1} + \beta_3 ZCH_{i,t-1} + \beta_4 FUND*_{i,t-1} + \beta_5 PLAN\_SIZE*_{i,t-1} + \beta_6 SIZE_{i,t-1} + \beta_7 CF_{i,t-1} + \beta_8 LEV_{i,t-1} + \beta_9 ROA\_VOL_{i,t} + \beta_{10} BOARD\_SIZE_{i,t-1} + \beta_{11} BOARD\_INDEPENDENT_{i,t-1} + \beta_{12} BOARD\_FEMALE_{i,t-1} + \sum \beta_s Year\_dummy + \sum \beta_r Industry\_dummy + \sigma$$

Table A3: Probit model with lag effect of the determinants of *BI*

Dependent variable: BI		
	(1)	(2)
VARIABLES	Probit coefficient	Marginal effect
$EQUITY_{t-1}$	2.7972***	0.3789
	(0.4645)	(0.0828)
HOR_{t-1}	0.4158***	0.0563
	(0.1253)	(0.0179)
ZCH_{t-1}	0.0393	0.0053
	(0.1250)	(0.0169)
$FUND_{t-1}$	2.4063**	0.3260
	(1.1833)	(0.1620)
$PLAN\_SIZE_{t-1}$	0.0284	0.0038
	(0.3230)	(0.0438)
$SIZE_{t-1}$	0.1159	0.0157
	(0.1209)	(0.0168)
CF_{t-1}	2.0265	0.2745
	(2.1438)	(0.2962)
LEV_{t-1}	-0.9690	-0.1313
	(0.6672)	(0.0881)
ROA_VOL_t	-3.0201	-0.4091
	(2.9826)	(0.4037)
$BOARD\_SIZE_{t-1}$	-0.5286	-0.0716
	(0.5856)	(0.0793)
$BOARD\_INDEPENDENT_{t-1}$	0.0931	0.0126
	(0.0785)	(0.0107)
$BOARD\_FEMALE_{t-1}$	0.0056	0.0008
	(0.0103)	(0.0014)
Constant	-8.6865***	
	(2.0026)	
Observations	1,036	
Industry dummy	YES	
Year dummy	YES	
Pseudo R^2	0.240	

Note: this table reports the results of a probit model that introduces a one-year lag for the influence on *BI* of all independent and control variables, except *ROA_VOL*. The dependent variable is a dummy variable, 1 if a firm engages in pension buy-ins, 0 otherwise. We report both the coefficient and marginal effect in the table. 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 Appendix B of the paper.

4. Alternative measures for the determinants of *BI*

$$BI_t = \beta_0 + \beta_1 EQUITY_{i,t} + \beta_2 HOR*_{i,t} + \beta_3 TANGIBLE_{i,t} + \beta_4 FUND*_{i,t} + \beta_5 PLAN\_SIZE*_{i,t} + \beta_6 SIZE_{i,t} + \beta_7 CF_{i,t}$$
$$+ \beta_8 LEV_{i,t} + \beta_9 ROA\_VOL_{i,t} + \beta_9 BOARD\_SIZE_{i,t} + \beta_{10} BOARD\_INDEPENDENT_{i,t}$$
$$+ \beta_{11} BOARD\_FEMALE_{i,t} + \sum \beta_s Year\_dummy + \sum \beta_r Industry\_dummy + \sigma$$

Table A4: Probit model with alternative measures for the determinants of *BI*

Dependent variable: BI		
	(1)	(2)
VARIABLES	Probit coefficient	Marginal effect
EQUITY$_t$	3.8342***	0.4328
	(0.5956)	(0.0813)
HOR$_t$*	-72.4264***	-8.1762
	(22.0937)	(2.4848)
TANGIBLE$_t$	2.0212**	0.2282
	(0.9639)	(0.1138)
FUND$_t$*	2.1829	0.2464
	(1.3518)	(0.1510)
PLAN_SIZE$_t$*	0.1601*	0.0181
	(0.0922)	(0.0111)
SIZE$_t$	-0.0542	-0.0061
	(0.1442)	(0.0163)
CF$_t$	2.6446	0.2985
	(2.2550)	(0.2574)
LEV$_t$	-0.8478	-0.0957
	(0.7375)	(0.0819)
ROA_VOL$_t$	-7.7813	-0.8784
	(5.5970)	(0.6421)
BOARD_SIZE$_t$	-0.9778	-0.1104
	(0.8254)	(0.0923)
BOARD_INDEPENDENT$_t$	0.2019*	0.0228
	(0.1096)	(0.0124)
BOARD_FEMALE$_t$	0.0100	0.0011
	(0.0099)	(0.0011)
Constant	-4.4569**	
	(1.8993)	
Observations	1,168	
Industry dummy	YES	
Year dummy	YES	
Pseudo R^2	0.342	

Note: this table reports the results of a probit model for the determinants of pension buy-ins using alternative measures for *HOR*, *FUND* and *PLAN_SIZE* and replacing *ZCH* with *TANGIBLE*. *TANGIBLE* is computed as $\frac{cas \quad holdings + .715 * receivables + .547 * inventory + .535 * PPE}{total\ assets}$ for each firm-year. PPE is property, plant and equipment. The coefficients in the measure are taken from Berger et al. (1996). All other variable definitions are reported in Appendix B of the paper. The dependent variable is a dummy variable, 1 if a firm engages in pension buy-ins, 0 otherwise. We report both the coefficient and marginal effect in the table. Robust standard errors are reported in parentheses. *, **, and *** represent significance levels of 10%, 5%, and 1%, respectively (two-tailed). Standard errors clustered by firm.

5. Replacement of *ZCH* with *TANGIBLE* in the survival analysis for the determinants of pension buy-in timing

$$h_i(DUR\_BI) = h_0(t)\exp\{\beta_0 + \beta_1 EQUITY_{i,t} + \beta_2 HOR_{i,t} + \beta_3 TANGIBLE_{i,t} + \beta_4 FUND_{i,t} + \beta_5 PLAN\_SIZE_{i,t} + \beta_6 SIZE_{i,t} + \beta_7 CF_{i,t} + \beta_8 LEV_{i,t} + \beta_9 ROA\_VOL_{i,t} + \beta_{10} BOARD\_SIZE_{i,t} + \beta_{11} BOARD\_INDEPENDENT_{i,t} + \beta_{12} BOARD\_FEMALE_{i,t} + \sum \beta_r Industry\_dummy + \sigma\}$$

Table A5: Survival analysis for the determinants of pension buy-in timing with *TANGIBLE* as the measure of financial slack

Dependent variable: *DUR_BI*	
	(1)
VARIABLES	Coefficient
EQUITY$_t$	3.663**
	(1.457)
HOR$_t$	0.413**
	(0.193)
TANGIBLE$_t$	2.921**
	(1.383)
FUND$_t$	5.922***
	(1.927)
PLAN_SIZE$_t$	0.165
	(0.412)
SIZE$_t$	-0.0111
	(0.233)
CF$_t$	-2.184
	(5.233)
LEV$_t$	-2.571**
	(1.210)
ROA_VOL$_t$	-8.491
	(8.988)
BOARD_SIZE$_t$	0.419
	(1.228)
BOARD_INDEPENDENT$_t$	0.156
	(0.199)
BOARD_FEMALE$_t$	-0.0322
	(0.0241)
Observations	146
Industry dummy	YES
Log likelihood	-92.8
No. firms	28
No. firms engaging in BIs	24
No. firms right censoring	4

Note: this table reports the results of replacing *ZCH* with *TANGIBLE* as the proxy for financial slack in the survival analysis for the determinants of the timing of pension buy-ins. The dependent variable is the time in years to the pension buy-in event. 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 Appendix B of the paper.