Why are pension schemes frozen, and how does a freeze affect the employer's risk?

Why Are Pension Schemes Frozen, and How Does a Freeze Affect the Employer's Risk?

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ABSTRACT

Defined benefit (DB) pension schemes involve substantial risks and costs for employers. So employers have frozen (or closed) their schemes. Using data on firms in the FTSE 100 index, we study the characteristics of employers who hard froze (no new members or accruals) their DB scheme, and the effect of this on the employer's risk. We find that the probability of a hard freeze is a negative function of employer size, operating cash flow and unionization; and a positive function of a previous soft freeze (no new members). We also find that a hard freeze reduces total, unsystematic and credit risk; and increases systematic and asset risk.

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1. Introduction

There are two main types of occupational pension scheme - defined benefit (DB) and defined contribution (DC). Employers sponsoring a DB scheme promise to pay members a pension for the rest of their lives (effectively a lifetime annuity) based on each member's final or average salary. This pension promise is independent of the risks arising from investment returns, interest rates, longevity, salary levels, inflation rates and regulations. All these risks are assumed by the employer, and only employer default risk is borne by the members. In contrast, DC schemes do not create any risks for the employer, as they just pay a proportion of each member's salary into that member's pension pot, with all the risks falling on the members.

DB deficits are the responsibility of the employer, and in recent decades these risks have caused some very large deficits. For example, in August 2016 the Pension Protection Fund 7800 index showed an aggregate deficit of £459.4 billion for UK DB schemes, giving an average funding ratio (assets/liabilities) of only 76.1%. The major causes of deficits have been poor investment performance, increased longevity, very low interest rates, and new regulations imposing additional costs on DB schemes.

These large deficits, and the risks of even larger deficits, have had a range of adverse consequences for DB employers. Underfunded DB schemes require higher employer contributions, which has often led to company resources being diverted from discretionary expenditure such as investment, dividends, marketing, training etc, (Bartram, 2017; Bunn and Trivedi, 2005; Campbell et al. 2012; Liu and Tonks, 2013; Rauh, 2006). Deficits have been tackled by asset-backed funding, and/or the contribution of contingent assets by employers. Higher pension contributions and changes in accounting and actuarial practice have created lower and more volatile employer accounting profits, a reduction in the employer's credit rating leading to an increase in their cost of capital; and a drop in their share price[1]. As a DB scheme's size increases relative to the employer, its adverse effects on the employer also increase. In some cases the DB scheme is many times larger than the employer, e.g. in 2003 British Airways two pension schemes were nine times larger than the company's market capitalization, and in 2019 the 600 Group's pension liabilities were 13.4 times larger than its market capitalization.

[1] Campbell et al. (2012), Cardinale (2007), Carroll and Niehaus (1998), Franzoni (2009), Gallagher and McKillop (2010a, 2010b), Maher (1987, 1996), Wang and Zhang (2014), Watson Wyatt (2005).

The freeze decision matters to the company's employees, its investors, those who lend it money, and the tax authorities. Given the superiority of DB schemes for members, members have a clear interest in preventing their DB scheme from being frozen. Investors have an interest in the freeze decision as it can affect many aspects of the company - risk, returns, leverage, labour costs, liquidity, corporate social responsibility, dividends, and R&D and capital expenditure. A freeze can also alter various measures of the employer's risk, affecting their cost of capital. Since employer contributions to a replacement DC scheme are almost always lower than to the frozen DB scheme, the employer has a smaller tax shield, and so tends to pay more tax.

The previous literature, principally for the US, has found evidence that a very wide range of factors affect the probability of a subsequent freeze, and that a freeze has many effects on the employer. However, many of these studies have reached contradictory conclusions. We add to this literature by studying the causes and effects of UK freezes. Since there are substantial differences in the DB pension regulatory and institutional environment between countries, the US results may not be generalizable to other countries. We study both the reasons for a freeze and its effects on employer risk for the UK to investigate the extent to which the US results are generalizable.. This is the first study to use five different market-based measures of employer risk (total risk, systematic risk, unsystematic risk, asset risk and credit risk) when studying the effects of a freeze, to see whether they all react in the same direction to a freeze. We also examine the effects of four explanatory variables on both the closure decision and employer risk which have not been considered by previous researchers – a prior soft freeze, the equity percentage of the pension fund, and changes in R&D and CAPEX.

We find that in the UK hard freezes are not primarily caused by the financial distress of the employer. They are associated with a range of employer characteristics - employer size, operating cash flow, unionization and a previous soft freeze (i.e. no new members); none of which relate to employer financial distress. A hard freeze (i.e. no more contributions) reduces the total, unsystematic and credit risk of the employer, but increases their systematic and asset risk. This is consistent with the immediate direct effects of a freeze described in section 3A and with five previous empirical studies, but conflicts with those of three earlier studies.

In Section 2 we outline various ways of reducing or removing pension costs and risks, including freezing (or closing) the DB scheme, and Section 3 considers the effects of a freeze on the employer. Section 4 reviews the empirical evidence on the causes and effects of a freeze, and

Section 5 describes our data. Our empirical analysis is in Section 6, with our results in Section 7. Our robustness check is in Section 8, and Section 9 concludes.

2. *Removing or Reducing Pensions Costs and Risk*

For an employer who wishes to escape from the costs and risks of a DB scheme, there are a number of choices. One possibility is to wind-up (or terminate) the scheme, which will involve a full buy-out of the entire scheme with an insurance company. In the UK a wind-up triggers a legal requirement for the employer to immediately fully fund the scheme, which may be impossible[2]. Alternatively, employers can buy-out the liabilities of a particular group of scheme participants (usually pensioners) with an insurance company, but this generally requires a substantial initial payment, and leaves the costs and risks of the remaining participants with the employer. Finally, employers can engage in a buy-in or longevity swap to insure some of the risks of a particular group of scheme participants, with the scheme continuing in operation. The employer makes payments to the insurance company to insure the specified costs and risks, but ultimate responsibility for all scheme costs remains with the employer. These ways of dealing with the costs and risks of a DB scheme either involve a large up-front payment; or making regular payments to insure some of the risks, leaving the final liability for the scheme with the employer.

Employers want a way of reducing or eliminating their exposure to a DB scheme's costs and risks without having to make a large up-front payment, or having to make a series of insurance or swap payments; and freezing (or closing) a scheme meets these two conditions. DB schemes can be frozen in two main ways[3]. A soft freeze occurs when no-one can join the scheme, but existing active members continue making contributions and accruing benefits. A hard freeze is when no-one can join the scheme, and active members cannot make any further contributions or accrue new benefits. A soft or hard freeze puts the scheme into 'run-off', and it will automatically close when all the current members and pensioners have died. Freezing DB schemes has been widely adopted in both the US and UK. From about 1990 onwards UK companies have been freezing their DB schemes in increasing numbers, and replacing them with DC schemes (see Table 1). In 2006 the proportion of open UK DB schemes was 66%, but by 2020 this had dropped to 24%. Not only do DC schemes involve no risk for the employer, but they usually have much lower employer

[2] Superfunds have recently emerged in the UK as a cheaper alternative to full buy-outs. The superfund becomes the scheme sponsor, which frees the employer from any future costs and risks. But a superfund may require a large initial payment from the employer to compensate for taking on these costs and risks.

[3] Partial freezes, where the pensions of only some scheme members are frozen, are uncommon in the UK, and US partial freezes have not been analysed by previous researchers.

contribution rates than DB schemes. In 2014 the average employer contribution rate for UK private sector DC schemes was only 18% of the DB rate, and by 2019 this figure had fallen to 16% (Office for National Statistics, 2019). In the US a freeze also has the benefit that the scheme immediately switches from valuing its liabilities at the pension benefit obligation (PBO), to using the accumulated benefit obligation (ABO), which will be considerably smaller (Begley et al. 2015; Atanasova and Hrazdil, 2010). During run-off the scheme matures, and its assets and liabilities decline. This reduces the costs and risks to which the employer is exposed, which gradually decline towards zero. This risk reduction is faster for hard frozen schemes, as no additional benefits are accrued.

[TABLE 1 near here]

The proportions of US DB schemes that were frozen are listed in Table 2. This shows that over the 2003-2013 period there was a rapid increase in the proportion of US schemes that were hard frozen and, in contrast to the UK, in 2013 hard frozen schemes were much more common in the US than soft frozen schemes.

[TABLE 2 near here]

There are some negative effects associated with freezing a scheme. First, if a scheme is closed to new members the average age of active members tends to increase. If, as is common, the scheme has age-independent contribution and accrual rates, the inter-generational cross-subsidy from young to old active members decreases, causing the scheme's funding ratio to drop over time (Campbell et al. 2006). Second, frozen schemes, particularly hard frozen schemes, will probably have a negative cash flow, and need to hold some highly liquid investments in order to make the pension payments. These assets will generally have a lower expected return than less liquid assets. Third, since the number of active members of soft frozen schemes falls over time, and there are no active members of hard frozen schemes, deficits are difficult or impossible to rectify by raising the contribution rate. Therefore, to reduce under-funding risk, the pension fund will probably reduce its allocation to risk bearing assets, which will reduce the fund's expected return (Butt, 2011; Biggs, 2015; Panis and Brien, 2015). Frozen DB schemes in run-off may also seek to hedge their risks. Finally, as a scheme's assets and liabilities shrink, its economies of scale in both administration and investment reduce, increasing the average cost per participant.

3. Direct and Indirect Effects of a Freeze

Choy et al. (2014) and Silverstein (2020) propose that a hard freeze has two offsetting effects on the employer's risk - a direct effect and an indirect effect. The direct effect of a hard freeze stops the accrual of any additional liabilities, and over time scheme assets and liabilities decrease to zero as participants die. The indirect effect is that a hard freeze causes a change in the risk preferences of the employer's senior management.

3A. Direct Effects. If an employer freezes their DB scheme the direct effect reduces, and ultimately eliminates, the pension-related risks to which they are exposed. Therefore, the unsystematic and total risk of the employer's equity returns decrease. However, the effect on the firm's equity beta is ambiguous. Their equity beta is:-

$$\beta_E = Cov(R_M, R_i)/Var(R_M), \quad \text{where } Cov(R_M, R_i) = Cov(R_M, R_E) + Cov(R_M, R_P) \qquad (1)$$

β_E is the equity beta of the employer

R_M is the return on the stock market

R_i is the return, including its pension scheme, on the firm that freezes its DB scheme

R_E is the return on the employer, ignoring its pension scheme

R_P is the return on the pension scheme

If the value of $Cov(R_M, R_P)$ is negative, the value of $Cov(R_M, R_i)$ increases when the scheme is frozen, which increases the firm's equity beta. The value of $Var(R_M)$ may drop as the risk of the frozen scheme is removed from the market index calculation, which will also tend to increase the employer's equity beta. Even if $Cov(R_M, R_P)$ is positive, provided the proportionate reduction in $Var(R_M)$ is larger than the proportionate reduction in $Cov(R_M, R_P)$, the employer's equity beta increases when the scheme is frozen. Therefore, the systematic risk of the employer can rise, while its total and unsystematic risk both fall.

As well as these initial effects, a hard freeze means that the annual accrual of new pension liabilities ceases. The effect of this on the consolidated leverage (debt/assets) of the employer plus the pension scheme depends on whether consolidated liabilities exceed consolidated assets. Table 3 shows that the leverage ratios for the employers in our sample are much smaller than unity; and their pension deficits are not large enough to reverse this relationship. When total liabilities are less than total assets, a hard freeze which decreases the scheme's assets and liabilities by an equal amount relative to expectations leads to a consolidated leverage that is below expectations. A lower leverage makes the employer less risky.

[TABLE 3 near here]

A hard freeze also leads to a sharp drop in employer contributions, as their contributions to the replacement DC scheme are almost always much smaller than their DB contributions. So, after a hard freeze the employer has higher profits. Since pension contributions are tax deductible, this reduction in pension contributions is split between increases in the employer's tax bill and their net profits. The employer may respond in a variety of ways. They may use the increase in net profit to create new tax deductions such as higher investment, which lowers net profits to their previous level, except for any extra profit generated by the additional investment. The employer may respond by issuing debt with tax deductible interest payments that return net profits to their previous level, except for any increase in net profits generated by using the proceeds for investment. The employer might use the increase in net profits in ways that are not tax deductible, such as increasing dividends, or creating a cash reserve to cover possible losses on new risky ventures. Therefore, freezing a DB scheme can lead to some mixture of higher taxes, higher net profits, higher investment, higher leverage, higher dividends and a larger capital reserve for risky projects. These changes will then have further repercussions for the employer. For example, higher leverage will tend to increase the employer's equity risk and cost of capital, and lower their credit rating. A larger capital reserve, coupled with more money for investment, may encourage investment in riskier activities, e.g. R&D. In summary, the direct effects of freezing a scheme on the employer are an empirical question.

3B. Indirect Effects. The indirect effects of a hard freeze operate through inside debt, which is the present value of accumulated pension and other deferred employee compensation. In the US senior managers are usually members of a supplemental executive retirement plan (SERP), as well as being members of the employer's DB scheme. SERPs provide additional and often substantial pension provision; but according to US law must be unfunded and unsecured, and so expose senior executives to employer bankruptcy risk with the priority of only unsecured creditors. Therefore SERPs create inside debt that aligns the interests of senior executives with those of the employer's debt holders, making them more risk averse than otherwise (Sundaram and Yermack, 2007). A hard freeze of a company's DB scheme typically leads to the SERP also being hard frozen (Choy et al. 2014; Begley et al. 2015), which reduces the alignment of senior management with the employer's debt holders, and increases their willingness for the employer to take on more risk. Since SERPs are an important part of the inside debt of senior executives of large US companies, they have been used by Choy et al. (2014) and Silverstein (2020) to explain increases in company risk following a hard freeze.

This effect is weaker in the UK than in the US, as there are no SERPs in the UK[4]. In the UK, where a DB scheme exists, senior executives will usually be members, and a hard freeze means they will no longer accrue additional benefits. By switching senior management pension scheme accrual from DB to DC, they become less exposed to employer default, and so more willing for the total risk of the company they manage to increase[5]. DB schemes (and SERPs in the US) are an important proportion of inside debt. Therefore, hard freezing a DB scheme reduces the inside debt of the CEO and other senior managers; reducing their alignment with the firm's bond holders.

US studies of the effects of reductions in CEO inside debt on corporate risk taking have found they lead to higher return volatility, default risk, R&D expenditure and leverage; and lower diversification and working capital (Bennett et al., 2015; Cassell et al., 2012; Milidonis et al., 2019; Sheikh, 2019; and Van Bekkum, 2016). In the UK Kabir et al. (2018) found that reductions in CEO inside debt lead to higher R&D expenditure; but Li and Zhao (2020) did not find any change in return volatility, R&D expenditure, capital expenditure or cash holdings. Due to the wide range of direct and indirect effects, the consequences of a freeze on the employer's risk and other variables are an empirical question.

4. Empirical Evidence on the Causes and Effects of Freezes

Past empirical research on freezes has focussed on two main questions - what causes a freeze[6]; and what are the effects of a freeze? The studies of the effects of a freeze can be divided into those using panel regression[7], and those employing event studies[8]., The causes and effects of a freeze are intertwined, and Sections 2 and 3 discuss the expected effects of freeze. Freezing a pension scheme is a choice, and the causes of a freeze are its predicted effects, relative to the

[4] In 2021 there were 560 executive pension plans in the UK, but these schemes are DC, and so have no effect on the risk appetite of the employer.

[5] UK DB scheme benefits are insured by the Pension Protection Fund (PPF), which pays 90% of the promised pension, with a cap on pensions (£37,315 per year for 2021-2022). In June 2018 the European Court of Justice upheld an appeal by Grenville Hampshire against this cap, and in June 2020 the PPF lost its appeal against this judgement. The PPF must now ensure that every pensioner receives at least half the pension they were promised, even if this pension is above the PPF cap. However, since this judgement was only confirmed after our data period, senior management with large pensions will have expected to suffer a substantial reduction in their pensions if their DB scheme defaulted.

[6] Atanasova and Hrazdil, 2010; Beaudoin et al. 2010; Begley et al. 2015; Choy et al. 2014; Comprix and Muller, 2011; Huang and Qiu, 2022; Hwang and Hong, 2023; Ioannidou et al. 2022; Kim et al. 2015; Munnell and Soto, 2007; Rauh et al. 2020; Silverstein, 2021; Vafeas and Vlittis, 2018; Yu, 2016.

[7] Adrjan and Bell, 2018; Atanasova and Hrazdil, 2010; Choy et al. 2014; Hwang and Hong, 2023; Phan and Hegde, 2013; Rauh et al. 2020; Silverstein, 2021.

[8] Biggs, 2015; Champagne et al. 2017; Gardner et al. 2014; McFarland et al. 2009; Milevsky and Song, 2010; Phan and Hegde, 2013; Rubin, 2007.

status quo or some alternative course of action. The causes of a freeze have been investigated by searching among many variables for those that increase the probability of a subsequent freeze. It has been argued that the main cause of a subsequent freeze is that the employer is in financial distress, and a freeze is expected to have the effect of improving the financial position of the employer. This is an empirical question which we investigate.

4A. The Freeze Decision

Previous research on US DB schemes has found that the probability of a freeze is affected by a wide range of over thirty variables. They find it is a positive function of the probability of employer bankruptcy, employer credit risk, a loss making employer, the scheme's level of annual benefit accrual, the PBO minus the ABO, the ratio of (pensioners/total participants), scheme assets are less than the PBO, lower interest rates, the proportion of independent directors of the employer, the introduction of accounting standard SFAS 158, the number of schemes sponsored by the company, the employer's age, the percentage of other companies in the same industry that have DC schemes, an increase in disclosure requirements, and after an increase in the employer's sales. The probability of a freeze is decreased by scheme size, the ABO, the ratio of (actives/total employees), the unemployment rate, the unionization of the employer's workforce, the sponsor's return on assets and lagged stock returns, industry cash flow volatility, CEO accumulated pension benefits, and the employer's size, fixed assets, intangible assets, debt/equity ratio, (operating income/total assets) ratio, the employer's interest coverage, the length of tenure of the employer's CEO, and after an increase in dividends paid by the employer. Previous studies have reached opposite conclusions on whether a higher funding ratio increases or decreases the probability of a freeze.

There have been two recent studies for the UK. Li et al. (2021) analysed the reasons for freezing UK DB schemes using a random effects logit model, and their conclusions are different from those of the US studies. Using ten explanatory variables, they analysed data on hard freezes between 2009 and 2017 by FTSE 350 companies. They find that the probability of a hard freeze is a positive function of both employer and scheme assets and the funding ratio; and a negative function of the employer's leverage and the annual level of benefit accrual. Their findings for employer and scheme assets and the annual level of benefit accrual directly contradict those for US studies, suggesting there are important differences, e.g. pension scheme regulations, between the US and UK in the causes of a freeze.

Horton et al. (2021) studied data from 1999 to 2013 on firms in the FTSE All Share index with a DB scheme. They excluded observations after a hard freeze. Using 19 explanatory variables and the Cox proportional hazard model, as for the US, they found that the probability of a hard freeze of a UK scheme is reduced when the CEO is a scheme member, and the market value and leverage of the employer are higher. However, in contrast to the US results, the probability of a hard freeze is increased by high cash flow volatility, and when a large proportion of total CEO compensation is in the form of salary and bonuses. This later difference may be due to the lack of SERP DB schemes in the UK. A survey of UK private sector DB schemes by Aon (2022) found that 32% of those that are not hard frozen had regulatory or contractual restrictions on a hard freeze, while 7% were due to paternalistic company views.

The freeze decision appears to be governed by a wide range of factors, which does not permit the simple conclusion that employers in a weak financial position with poorly funded schemes are more likely to freeze their DB scheme to reduce their costs and risk. For example, while Begley et al. (2015), Munnell and Soto (2007), Rauh et al. (2020) and Silverstein (2021) find that a higher funding ratio lowers the probability of a freeze for the US; Atanasova and Hrazdil (2010) and Choy et al. (2014) find the opposite result. We investigate this question for a different country with a different set of regulatory and institutional arrangements.

4B. The Effects of a Freeze

Previous research has investigated the effects of a freeze on a range of measures of the employer - returns, risk, leverage, R&D, CAPEX, liquidity, innovation, labour costs, corporate social responsibility, and CEO benefits. If a freeze increases the employer's profits, the employer's share price should rise on the announcement of a freeze, generating a higher return over the announcement. In an efficient market, if the freeze does not change the employer's systematic risk, once the effects of a freeze are impounded into the share price, returns on the employer's equity should revert to their pre-freeze level. However, if a freeze leads to a long-term change in the employer's systematic risk, both returns and systematic risk should change in the same direction in the long run. Therefore, while returns should rise on the announcement, the expected direction of change in long term returns is unclear.

Studies of the effect of a freeze on the employer's returns have reached conflicting conclusions. For the US Yu (2016) found that returns rise on the announcement day, and Milevsky and Song (2010), Rubin (2007) and Atanasova and Hrazdil (2010) demonstrated a rise in returns over a longer period (20 to 250 days after the announcement). Five other US studies did not find any significant effect of a freeze on returns for periods ranging from one day after the announcement to one year later (Champagne et al. 2017; Hwang and Hong, 2023; McFarland et al. 2009; Phan and Hegde, 2013; Vafeas and Vlittis, 2018). For the UK Gardner et al. (2014) also found no significant effect on returns for the 20 days after the announcement of a hard freeze.

US freezes have led to an increase in leverage (Phan and Hegde, 2013; Choy et al. 2014; Vafeas and Vlittis, 2018), which implies an increase in risk. Previous studies have measured the leverage of just the employer, not the consolidated entity of the employer plus the DB scheme, despite the widespread agreement that the consolidated entity approach is superior (Bartram, 2016; Jin et al. 2006). As the assets and liabilities of a frozen scheme gradually shrink, the leverage of the consolidated entity decreases. This gives the employer the scope to issue new debt and increase the leverage of the consolidated entity towards its pre-freeze level, which increases the leverage of the employer alone above its pre-freeze level. So, while US studies have found that employer leverage rises after a freeze, the increase in leverage of the consolidated entity will be smaller, and may be negative.

For US companies freezes have been found to lead to either no change in R&D, or an increase (Choy et al. 2014; Phan and Hegde, 2013), and a reduction in capital expenditure (Choy et al. 2014; Vafeas and Vlittis, 2018). Since R&D is riskier than capital expenditure, this suggests an increase in investment risk. Since employer contribution rates for DC schemes are much lower than for DB schemes, a freeze may lead to an increase in the employer’s liquidity. However, Phan and Hegde (2013) find that a hard freeze tends to reduce US employer liquidity. Rauh et al. (2020) found a hard freeze reduces the labour costs of US employers by 13.5%, and Adrjan and Bell (2018) showed that a hard freeze of UK DB schemes leads to a drop in labour costs. However, a hard freeze of UK private sector DB schemes led to 77% offering some form of concession to members, e.g. improved benefits such as enhanced DC, ill health early retirement, redundancy terms, early retirement, and revaluation of frozen benefits (Aon, 2022). To compensate for the loss of pension benefits, there is a one-time increase in US CEO pension benefits just before a freeze, (Stefanescu et al. 2018). When US companies hard freeze their DB scheme this lowers the loyalty and productivity of inventors, leading to less innovation (Duong et al., 2022). Anantharaman et al. (2022) show that when US firms freeze their DB scheme they increase their corporate social responsibility. Huang and Qiu (2022) discovered that in the year before a hard freeze, insiders in US companies reduce their sales of company stock, anticipating a positive effect of the freeze on the sponsor's share price.

We concentrate on researching the effects of freezing a DB scheme on employer risk, which has been measured in ten different ways by previous authors. They have used market data to compute equity betas (Champagne et al. 2017), asset betas (Choy et al. 2014), unsystematic risk (Champagne et al. 2017), credit ratings (Atanasova and Hrazdil, 2010; Choy et al. 2014), *Z* scores (Li and Kara, 2022), bond yields (Choy et al. 2014) and the standard deviation of equity returns (Silverstein, 2021; Li and Kara, 2022). Prior research has also used accounting data to measure risk - the standard deviation of earnings (EBITDA) (Choy et al. 2014), the standard deviation of the return on assets (Choy et al. 2014; Silverstein, 2021; Li and Kara, 2022), and the standard deviation of the return on investment (Silverstein, 2021).

All but one of the previous studies of the effect of a freeze on employer risk have used US data. Using three accounting measures of risk, Silverstein (2021) found that a hard freeze leads to an increase in employer risk. Similarly, Choy et al. (2014) found that a hard freeze increases the volatility of accounting returns. They also found that a hard freeze leads to an increase in asset betas (ignoring the effects of the pension scheme on the asset beta). Choy et al. (2014) concluded that a hard freeze results in a drop in the employer's credit rating and an increase in the interest rate the employer pays on its debt, which implies an increase in risk. However, Atanasova and Hrazdil (2010) showed that a freeze reduces the probability of a credit downgrade, and increases the probability of a credit upgrade, which implies the credit rating agencies thought risk was now lower. In an event study using GARCH regression, Champagne et al. (2017) found that a freeze increases the average variation in the employers' systematic risk (equity betas), with a more or less equal number of increases and decreases in the individual betas. The GARCH residuals indicate that a freeze reduces unsystematic risk. These empirical studies show that investors react to a freeze, and this reaction may be an increase, or possibly a decrease, in systematic risk.

Champagne et al. (2017) also tried to find variables to explain the effects of a freeze on systematic and unsystematic risk. They found that systematic risk is reduced by leverage, and increased by the funding ratio trend; while unsystematic risk is increased by pension fund asset returns. As well as employer risk, a freeze also affects the risk of the pension scheme. The pension beta (Jin et al. 2006) of US schemes increases after a freeze (An et al., 2013). For the UK, Li and Kara (2022) found that a hard freeze reduces the standard deviation of accounting and equity returns, and lowers the estimated probability of default.

These papers have reached different conclusions on the effects of a freeze on employer risk. Silverstein (2021) and Choy et al. (2014) found an increase in total risk for the US, while Li and Kara (2022) found total risk decreased in the UK. Credit risk in the US increased according to Choy et al. (2014), but decreased in the US (Atanasova and Hrazdil, 2010) and in the UK (Li and Kara, 2022). Champagne et al. (2017) concluded that US equity betas increased, and Choy et al., 2014) discovered that US asset betas also increased. Finally Champagne et al. (2017) showed that US unsystematic risk decreased. Therefore there are differences in the results between different US studies, different measures of risk, and between studies of the US and UK. We investigate these five different risk measures for the UK in our empirical study.

5. Data and Descriptive Statistics

Our annual data is for 2003-2019, and our sample is 125 companies with a DB pension scheme that were members of the FTSE 100 index at some point between 2003 to 2019.[9] The hard and soft freeze dates and the change of CEO were collected manually from annual reports, and company announcements, and on average there are eight years between a soft freeze, and a subsequent hard freeze. No UK scheme has been unfrozen. Annual trade union membership, as a proportion of employees by industry, was downloaded from Trade Union Membership 2019[10]. We use the effective duration of DB pension liabilities as a proxy for the maturity of DB schemes and, following Zhao and Sutcliffe (2021), measure it as:

$$\text{Pension Effective Duration} = \frac{L_{i-x} - L_{i+x}}{2L_i x} \quad (2)$$

where x is the change in the discount rate, and L_{i-x} and L_{i+x} are the DB pension liabilities when the discount rate is $i \pm x$. We manually collected the data to compute the effective duration from the sensitivity analysis section of each company's annual reports. The funding ratio of DB schemes, company market capitalization, operating cash flow, net income, equity percentage of the pension fund, pension liabilities (PBO), pension assets, operating assets, effective corporate tax rate and other financial data were extracted from Bloomberg. The daily rates on three-month

[9] We tried to get data for 2003-2019 for all those companies that were included in the FTSE 100 index at some time during 2003-2019 and had a DB pension scheme. But some companies were not listed during the early years, others were de-listed from the London Stock Exchange for various reasons, e.g. bankruptcy, privatization, acquisition by another organizations, etc. Some companies only had a DB scheme after an acquisition, and others removed their DB schemes through wind-ups or buy-outs.

[10] Department of Business, Energy & Industrial Strategy (2020): https://www.gov.uk/government/statistics/trade-union-statistics-2019

LIBOR, which proxies for the risk-free rate, and returns on UK 30-year gilts came from Eikon. Market capitalizations in a foreign currency were converted to pound sterling using official exchange rates from World Bank Open Data[11].

Figure 1 plots the proportion each year of companies in our sample with a hard frozen scheme. There is a clear upward trend, increasing from 2% in 2003 to 60% in 2019. Figure 1 also shows the number of schemes in our sample that were newly hard frozen each year. In 2011 the number of employers who hard froze their DB scheme jumped to a higher annual rate (between 8 and 12) that was maintained for the next seven years. Figure 2 has the distribution of hard freezes in our sample by industrial sector. It shows that most hard freezes were in consumer services (22 companies), financials (19 companies) and industrials (11 companies); and two thirds of our sample is from these three industries. Figure 2 also shows that utilities (one company) and telecommunications (three companies) had far fewer freezes, in line with Aon (2022) that regulated industries are restricted from freezing their schemes.

Table 3 contains descriptive statistics of our 14 explanatory variables for our company-year observations. It splits the observations between employers who hard froze their DB scheme, and those who did not. The mean of the 1,837 *Freeze* dummy variable (1 if the scheme is hard frozen, and 0 otherwise) is 0.176, with a standard deviation of 0.381, and a median of zero. Using both parametric and non-parametric tests, employers with hard frozen schemes have higher funding ratios, smaller market capitalizations, lower operating cash flows, lower employee unionization, lower equity proportions, are more likely to have previously been soft frozen, have lower leverage, higher rates of sales growth and higher increases in R&D expenditure. These univariate results are in line with those of previous US empirical studies (employer size, unionization and leverage have a negative effect). Table 4 has the correlation coefficients between the 14 variables in our regression model. No correlation is above 0.33, so multicollinearity is not a problem.

[TABLE 4 near here]

6. *Empirical Analysis*

In our empirical analysis we address two related questions - what causes employers to freeze their DB schemes, and what are the effects of a freeze on the employer's risk. We focus on hard freezes because they have the largest immediate effect on the employer.

[11] World Bank: databank.worldbank.org/reports.aspx?source = 2&series =PA.NUS.FCRF&country =

6A. The Freeze Decision

Some previous researchers have set the 0-1 dependent variable (*Freeze*) to one in the year of the freeze and in all subsequent years for which the scheme remains frozen. Other researchers have set the freeze variable to one in the freeze year and included post-freeze observations with a zero freeze dependent variable, presumably because there was no freeze decision in these post-freeze years. Most researchers are unclear on their definition of the freeze variable. The probability of deciding to freeze a scheme can only be determined by variables known before the freeze decision is made, not what happens afterwards. The evidence cited above shows that freezing a scheme can lead to changes in many aspects of the employer, and so the values of the explanatory variables after a freeze may well be different from those that led to the freeze decision. Regression coefficients estimated with the freeze variable set to one in the year of the freeze and in subsequent years measure the difference between employers with frozen and non-frozen schemes. Regressions where the freeze variable is one in the freeze year and zero in post-freeze years conflate observations where the scheme is unfrozen, with those in the years following the freeze year. Since a freeze may cause the values of the explanatory variables in subsequent years to be different from their pre-freeze values, the estimated coefficients of such regressions are biased. To prevent confounding the effects of a freeze with the causes of a freeze, we removed the post-freeze observations from the panel regression in equation (3).

To investigate the probability of each of our 14 explanatory variables causing a freeze, we regress the hard freeze dummy (zero for the years before the freeze, and one in the freeze year) on 14 explanatory variables using probit regression. Our regression model is:-

$$\begin{aligned} Freeze_t = {} & \alpha + \beta_1 FR_{t-1} + \beta_2 Size_{t-1} + \beta_3 OCF_{t-1} + \beta_4 Loss_{t-1} + \beta_5 ED_{t-1} + \beta_6 Union_{t-1} + \beta_7 LEV_{t-1} + \beta_8 SFreeze_{t-1} \\ & + \beta_9 Equity_{t-1} + \beta_{10} \Delta CEO_t + \beta_{11} \Delta Sales_t + \beta_{12} \Delta DIV_t + \beta_{13} \Delta R\&D_t + \beta_{14} \Delta CAPEX_t + \varepsilon_t \qquad (3) \end{aligned}$$

Freeze is a dummy variable equal to one in the year when the employer's DB scheme is hard frozen, and zero before the hard freeze year. Observations after the freeze year are dropped.

FR is the funding ratio of the DB scheme, calculated as the market value of pension assets divided by the total pension liability.

Size is the natural logarithm of the employer's market capitalization (£ million).

OCF is the employer's operating cash flow, deflated by its total assets.

Loss is a dummy variable equal to one if the employer reported a negative net income, and zero otherwise.

ED is the effective duration of the employer's total pension liability (years).

Union is the percentage the employer's labour force that is unionized.

LEV is the leverage ratio (%) computed as the consolidated long-term debt divided by the consolidated total assets.

SFreeze is a 0-1 dummy variable that is one if the scheme has previously been soft frozen.

Equity is the equity percentage of the pension fund assets.

ΔCEO is a dummy variable equal to one if there is a change of CEO, and zero otherwise.

ΔSales is $(S_t - S_{t-1})/S_{t-1}$, where S_t is total sales revenue in year t.

ΔDIV is the change of dividend pay-out ratio (calculated as dividends paid divided by net income).

ΔR&D is the ratio of the change in R&D expenses to total assets.

ΔCAPEX represents the change in the ratio of capital expenditure to total assets.

Ten of our explanatory variables have previously been found to have a significant effect by US researchers. Based on the empirical results for the US, we expect the regression coefficients of these variables to have the following signs: *FR* - mixed previous results; *Size* - negative; *OCF* - negative; *Loss* - positive; *ED* - positive; *Union* - negative; *LEV* - negative; *SFreeze* - no previous results; *Equity* - no previous results; *ΔCEO* - positive; *ΔSales* - positive; *ΔDIV* - negative; *ΔR&D* - no previous results; *ΔCAPEX* - no previous results. The two UK studies found *LEV* had a negative effect as in the US, *FR* had a positive effect and, in contrast to the US results, *Size* had both a positive and negative effect. Equation (6) has four explanatory variables which have not been examined previously. We expect *SFreeze* to have a positive effect on the probability of a hard freeze, as it is a step on the road towards a hard freeze. Schemes contemplating a hard freeze may derisk their pension fund investments, and so *Equity* will have a negative sign. If employers freeze their DB scheme due to financial distress it is likely that they have previously reduced their discretionary expenditure on R&D and CAPEX, and so *ΔR&D* and *ΔCAPEX* will have negative coefficients.

We lagged all the explanatory variables by one year, as their values need to be known by the employer at the time of the freeze decision. To control for economic and legislative changes, we included firm and fixed-year effects, and because the dependent variable is binary, we use probit regression.

6B. The Effects of a Hard Freeze on Employer Risk

We use market data to measure risk, rather than accounting data, as it is less prone to judgements, manipulation and rule changes. Employer risk is measured in five different ways - total risk (*TR*), equity beta (β_E), unsystematic risk (*UR*), asset beta including the pension scheme (β_{A+P}), and credit risk (*CR*). We measure total employer risk as the natural log of the annualised standard deviation of daily excess returns, equity betas were downloaded from Bloomberg, unsystematic risk was computed as the natural log of (total risk minus the equity beta multiplied by the of the standard deviation of daily excess returns on the FTSE 100). Credit ratings were from Fitch Rating and, following Choy et al. (2014), we converted them into numbers, with the smallest number representing the highest credit rating. We computed the asset betas, allowing for the pension scheme in this calculation (Ji, et al. 2006), as:-

$$\beta_{A+P} = \beta_E + [\beta_P(\text{Pension Benefit Obligation}) - \beta_A(\text{Pension Assets})]/\text{Operating Assets} \qquad (4)$$

where β_P is the pension liability beta, and β_A is the pension asset beta. Following An et al (2013), Jin et al. (2006) and Li and Henry (forthcoming), we computed β_P by assuming it is equal to the employer's debt beta (β_D), which we estimated using the regression:-

$$R_D = R_F - \beta_D(R_M - R_F)(1\text{-}t) \qquad (5)$$

where R_D is the return on debt, R_F is the risk-free rate, R_M is the return on the market, and t is the effective corporate tax rate. Following An et al (2013), and Li and Henry (forthcoming), β_A is the weighted average of the betas of the scheme's asset classes using the beta values in Table 4 of Jin et al. (2006). A freeze will affect the employer in both the year of the freeze and later years, so we include all the post-freeze observations in our regressions when studying the effects of a freeze. Therefore $Freeze_t$ is redefined as zero in all the years before a freeze, and one in the freeze and subsequent years.

Freezing a DB scheme affects the risks of both the scheme and the employer. In section 3.A it was argued that a hard freeze can lead to a rise in systematic risk, while total and unsystematic risk both fall. Previous empirical findings of the effect of a freeze on the five measures of risk are mixed. There is agreement that unsystematic risk drops, and systematic and asset risk both rise; but conflicting findings for unsystematic risk, credit risk, and total risk. To investigate this, we employ five different measures of risk – total risk (TR), unsystematic risk (UR), credit risk (CR), systematic risk (β_e) and the asset beta (β_{A+P}). Equation (6) regresses these five measures of risk on the 14 explanatory variables used to explain the freeze decision, plus the hard freeze dummy variable. We use ordinary least squares with year and firm fixed effects.

$$(TR, \beta_E, UR, \beta_{A+P}, \text{or } CR)_t = \alpha + \beta_0 Freeze_t + \beta_1 FR_t + \beta_2 Size_t + \beta_3 OCF_t + \beta_4 Loss_t + \beta_5 ED_t + \beta_6 Union_t + \beta_7 LEV_t + \beta_8 SFreeze_t + \beta_9 Equity_t + \beta_{10} \Delta CEO_t + \beta_{11} \Delta Sales_t + \beta_{12} \Delta DIV_t + \beta_{13} \Delta R\&D_t + \beta_{14} \Delta CAPEX_t + \varepsilon_t \quad (6)$$

7. Empirical Results

First, we investigate the reasons for a hard freeze, and then we consider the effects of a hard freeze on five measures of employer risk.

7A. Reasons for a Hard Freeze

Table 5 shows the regression results for equation (3) and the causes of a hard freeze. In line with expectations based on the US evidence, we find that large employers with a small operating cash flow and a highly unionized workforce are less likely to hard freeze their scheme; while those who have previously soft frozen their scheme are more likely to freeze their scheme. The funding ratio, a loss making employer, a more mature scheme, employer leverage, equity percentage of the pension fund and changes of CEO, dividends, R&D and CAPEX have no effect. These results indicate that in both the US and UK *Size, OCF* and *Union* increase the chances of a hard freeze. However, unlike the US, *FR, Loss, ED, ΔCEO, ΔSales, ΔDiv* were not significant for the UK.

[TABLE 5 near here]

They also show that hard freezes are not motivated by financial pressures. A low funding ratio, loss making employer, highly levered employer, mature scheme, and decreases in discretionary expenditure (dividends, R&D, CAPEX) have no effect on the probability of a freeze. If financial pressure is an important motivation for hard freezes, some or all of these variables might be expected to be significant. In addition, the variables that are significant do not support a financial pressure motivation. The significant negative effects of a unionised workforce and being a large employer are independent of the financial status of the employer. A previous soft freeze may not have been due to financial pressure, and since schemes are soft frozen on average eight years before a hard freeze, the financial status of the employer may have changed since the soft freeze decision. A rise in the employer's operating cash flow suggests a reduction in financial pressure, and the significant negative sign reduces the probability of a hard freeze. Therefore, there is little evidence that schemes are hard frozen in response to financial pressure on the employer.

7B. Effects of a Hard Freeze on Risk

Table 6 contains the results of regressing our five measures of risk (*TR*, β_E, *UR*, β_{A+P} and *CR*) on the 14 explanatory variables used to explain the freeze decision, plus the hard freeze dummy.

[TABLE 6 near here]

The key finding is that, after controlling for the other 14 variables, a hard freeze leads to a reduction in *TR, UR* and *CR*, but a rise in β_E and β_{A+P}.[12] This is consistent with the earlier suggestion in Section 3A that the initial direct effects of a freeze have a negative effect on total and unsystematic risk, but can have a positive effect on the employer's equity beta. A freeze reduces DB scheme risk, which reduces the total, unsystematic and credit risk of the employer. By 2016 80% of the largest UK DB schemes were frozen. If most employers have frozen DB schemes, when an employer freezes their scheme, this increases the correlation between their returns and those of the market Index, which can raise their equity and asset betas. These results for total risk are consistent with Choy et al. (2014) and Silverstein (2021) for the US, but contradict the results of Li and Kara (2022) for the UK. They agree with Atanasova and Hrazdil (2010) for the US and Li and Kara (2022) for the UK that credit risk is reduced, but not with Choy et al (2014) who found an increase in US credit risk. They agree with Champagne et al (2017) who found that US systematic risk increases, and Choy et al (2014) that US asset risk increases; but disagree with Champagne et al (2017) who showed that US unsystematic risk reduces when the scheme is frozen.

Table 6 also shows that for the UK the funding ratio, employer size, operating cash flow, and leverage have a negative relationship with employer risk, and an employer loss has a positive relationship. While the negative relationships for the funding ratio, employer size and operating cash flow are consistent with expectations, the negative relationship for leverage is less expected. Effective duration, unionization, soft freeze, equity percentage, and changes in R&D and CAPEX have both a positive and negative relationship with the various measures of employer risk. For the US Champagne et al. (2017) showed that leverage has a negative relationship with both systematic and unsystematic risk, while employer size has no relationship. We find that leverage has a negative effect only for unsystematic risk, and that the funding ratio has a negative relationship for both systematic and unsystematic risk.

8. Robustness Check

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[12] If the smallest set of 709 observations is used to re-estimate all the regressions in Table 6 our conclusions are unchanged.

To investigate whether the risk response to a freeze occurs at another time than the year of the freeze, following Choy et al. (2014), we included an additional ten freeze dummy variables in equation (7), making a window of 11 years around the freeze. We use the full sample, and the 11 freeze dummies are one in their chosen year, and zero otherwise.

$$(TR,\ \beta_E,\ UR,\ \beta_{A+P},\ \text{or}\ CR)_t = \alpha + \beta_{t-5}Freeze_{t-5} + \beta_{t-4}Freeze_{t-4} + \beta_{t-3}Freeze_{t-3} + \beta_{t-2}Freeze_{t-2} + \beta_{t-1}Freeze_{t-1} + \beta_0 Freeze_t + \beta_{t+1}Freeze_{t+1} + \beta_{t+2}Freeze_{t+2} + \beta_{t+3}Freeze_{t+3} + \beta_{t+4}Freeze_{t+4} + \beta_{t+5}Freeze_{t+5} + \beta_1 FR_t + \beta_2 Size_t + \beta_3 OCF_t + \beta_4 Loss_t + \beta_5 ED_t + \beta_6 Union_t + \beta_7 LEV_t + \beta_8 SFreeze_t + \beta_9 Equity_t + \beta_{10}\Delta CEO_t + \beta_{11}\Delta Sales_t + \beta_{12}\Delta DIV_t + \beta_{13}\Delta R\&D_t + \beta_{14}\Delta CAPEX_t + \varepsilon_t \quad (7)$$

[TABLE 7 near here]

All the significant freeze variables in Table 7 have the same signs as in Table 6, so our earlier findings of the effects of a freeze on the five measures of employer risk are supported. However, while a freeze has a significant effect on systematic risk, unsystematic risk and asset risk in the year of the freeze and the following year, this is not the case for total risk and credit risk. The reduction in credit risk is significant in all five of the post-freeze years, and the reduction in total risk is significant in post freeze years 4 and 5.

9. Conclusions

Employers with defined benefit (DB) pension schemes face associated risks and costs, and in recent decades they have been closing (or freezing) these schemes and replacing them with riskless and much cheaper defined contribution schemes. Using UK data on hard freezes (no new members or accruals) we investigate two related questions – what are the characteristics of employers who freeze their DB schemes, and what is the effect of freezing a DB scheme on the employer's risk. There have been many such studies using US data, but very few with UK data.

Of the thirty plus variables found to influence the probability of a freeze in the US, we tested the effect of ten on the probability of UK hard freezes. Despite being significant for the US, only three of these ten variables are significant for the UK - employer size, operating cash flow and unionization, all of which reduce this probability. This finding is consistent with unions opposing a freeze to prevent their members pensions moving from DB to DC. But it is unclear why an increase in operating cash flow should increase the probability of a freeze, nor why larger companies are less likely to freeze their DB schemes. We also tested four variables that have not been examined before, and found a strong positive effect for a soft freeze on the probability of a subsequent hard freeze. This fits with the view that a soft freeze is a step on the road to a hard freeze, with a lag of roughly eight years. We also find that hard freezes are not caused by the financial distress of the employer or scheme.

In our analysis of the effects of a freeze we concentrate on risk. Freezing a scheme can lead to a wide range of effects on the employer, which then lead to either an increase or decrease in employer risk, and so the effect on risk is an empirical issue. We measure employer risk in five different ways - total risk, systematic risk, unsystematic risk, asset risk and credit risk, and find that three of our risk measures (total, unsystematic and credit) rise, while the other two risk measures (systematic and asset) decline. These results are consistent with the direct effects of a freeze being more important than its indirect effects. A freeze reduces DB pension risk for the employer, which reduces their total, unsystematic and credit risk. Systematic and asset risk move in the opposite direction because most companies in the FTSE 100 index no longer have an open DB scheme, and so are not subject to DB pension risk. Therefore, a freeze usually increases the correlation of the employer's returns with the index, which increases their equity and asset betas. While our findings for individual risks are supported by some previous studies, they conflict with other US and UK studies.

We also reran the five regressions for the effects of a freeze on our five measures of employer risk, with 11 freeze dummy variables centered on the year of the freeze. These show that for systematic, unsystematic and asset risk, the effect on risk occurs in the year of the freeze and the following year. For credit risk the effect is in all five years after the freeze, and for total risk the effect is in years four and five after the freeze.

The evidence to date for the US and UK has found a large number (over thirty) causes of a freeze, but many of these results are contradictory, and lack any obvious logic. Our results for the UK indicate that, contrary to expectations, financial distress does not cause freezes. We also find that unionization decreases the freeze probability, and a previous soft freeze increases the probability of a subsequent hard freeze, both of which are consistent with expectations. Future research could examine the effects of a freeze on other aspects of UK employers e.g. returns, leverage, R&D, CAPEX, liquidity, innovation and labour costs. It might also examine the effect of the value of CEO accrued DB pension benefits and employer risk on the closure decision. Finally, it could consider why the total risk response to a freeze is delayed to years four and five after a freeze, while the credit risk response occurs in all of the five years after the freeze.

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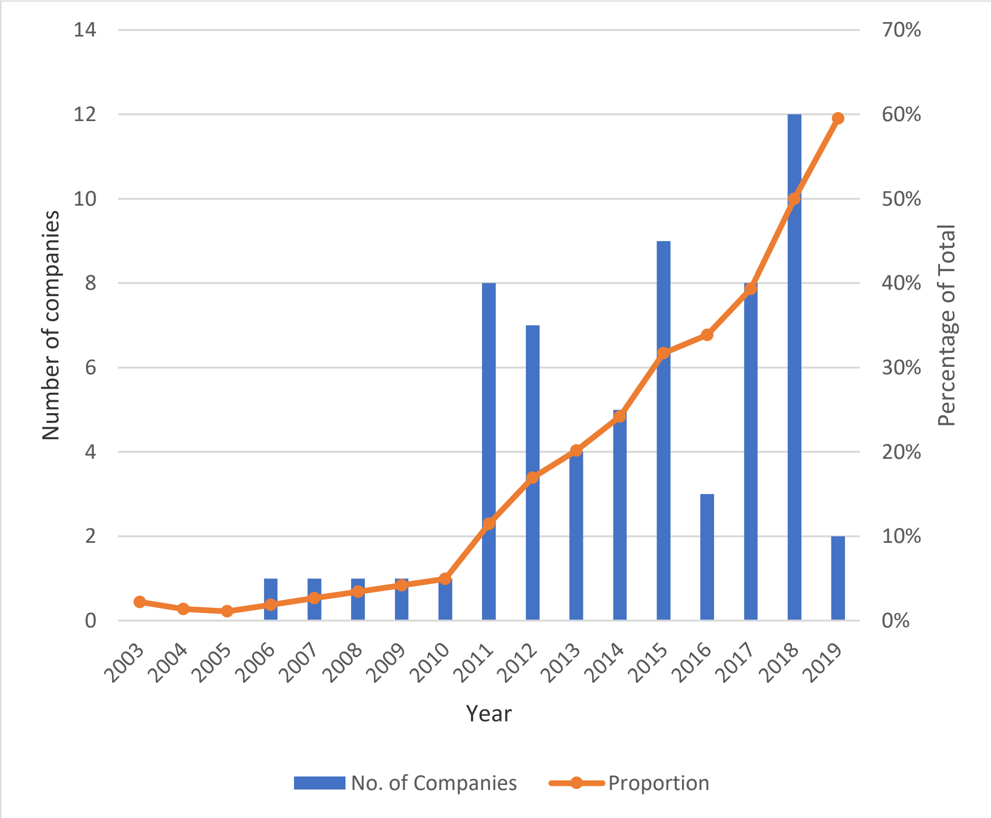

Figure 1: Distribution of DB Scheme Hard Freezes[13]

Figure 1 plots the proportion each year of companies in the sample with a hard frozen DB scheme.

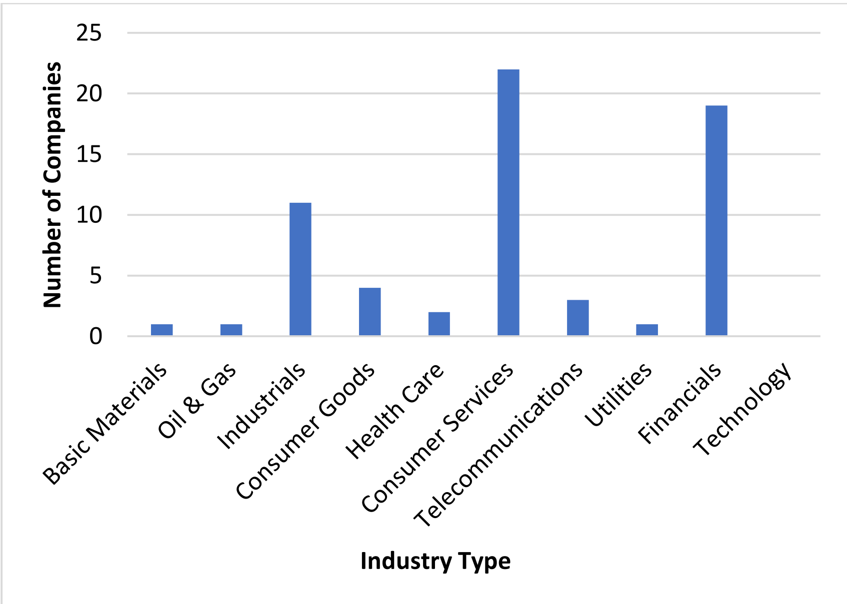

Figure 2: Hard Frozen DB Schemes by Industry

[13] Only 42 companies in our sample include data for 2019.

	Open	Soft Frozen	Hard Frozen
2006	66%	32%	2%
2007	50%	46%	3%
2008	44%	52%	4%
2009	37%	59%	4%
2010	34%	60%	5%
2011	31%	62%	6%
2012	28%	64%	8%
2013	23%	65%	12%
2014	22%	62%	15%
2015	22%	62%	16%
2016	19%	60%	20%
2017	21%	55%	24%
2018	21%	53%	25%
2019	21%	52%	27%
2020	24%	45%	30%

Table 1: Proportions of UK DB Members, Deferreds and Pensioners (Pension Protection Fund, 2020)

	Open	Soft Frozen	Hard Frozen
2003	-	-	9%
2004	-	-	12%
2005	-	-	14%
2013	64%	5%	31%

Table 2: Proportions of US DB Schemes that were Open, Soft and Hard Frozen (PBGC, 2008, 2013)

Variables	Non-Freeze				Freeze				Test statistics	
	N	Mean	Std Dev	Median	N	Mean	Std Dev	Median	t-Statistic	Wilcoxon z-statistic
FR	1509	87.8360	17.7380	89.3090	321	97.2130	17.6430	97.6610	-8.608***	-9.641***
Size	1465	9.3650	1.7880	9.0330	321	9.1690	1.5280	8.7860	1.818**	1.968**
OCF	1496	0.0890	0.0900	0.0830	320	0.0700	0.1040	0.0520	3.342***	6.721***
Loss	1497	0.1060	0.3070	0.0000	320	0.1060	0.3090	0.0000	-0.0370	-0.0370
ED	1030	18.0520	3.2070	17.8110	294	17.9070	2.9110	18.0000	0.6970	-0.0030
Union	1512	19.0950	10.2190	17.3000	321	13.3610	6.0270	12.9000	9.699***	9.118***
CEO	1515	0.1590	0.5260	0.0000	321	0.1310	0.3380	0.0000	0.9220	0.5910
SFreeze	1493	0.5680	0.4960	1.0000	321	0.9750	0.1560	1.0000	-14.561***	-13.782***
Equity	1330	41.6450	19.3290	40.7760	324	27.5790	19.9400	25.7480	11.674***	11.178***
LEV	1477	0.1660	0.1350	0.1440	321	0.1290	0.1170	0.0990	4.549***	6.286***
ΔSales	1481	0.0770	0.5720	0.0480	320	1.9260	33.0220	0.0390	-2.155**	2.148**
ΔDIV	1481	0.0440	6.5730	0.0030	320	-0.0660	4.1280	0.0000	0.2880	-0.3140
ΔR&D	1480	0.0320	0.4850	0.0000	320	0.0040	0.1840	0.0000	-1.298*	-1.1750
ΔCAPEX	1481	-0.0830	1.9170	-0.0230	320	-0.0250	1.2720	0.0000	-0.5100	-0.8000

Table 3: Descriptive Statistics

This table provides the summary statistics for our company-year observations. The comparison between freeze companies and non-freeze companies is based on data from 2003 to 2019. *FR* is the funding ratio of the DB scheme, which is calculated as the market value of pension assets divided by the total pension liability. *Size* is the natural logarithm of the employer's market capitalization (£ million). *OCF* is the employer's operating cash flow, deflated by its total assets. *Loss* is a dummy variable equal to one if the employer reported a negative net income in the previous fiscal year, and zero otherwise. *ED* is the effective duration of employer's total pension liability (years) at the end of each financial year. *Union* is the industry-average percentage the employer's labour force that is unionized at the end of each year. *CEO* is an indicator variable equal to one if there is a change of CEO, and zero otherwise. *SFreeze* is an indicator variable equal to one if the employer has soft frozen (closed to new entrants) previously. *Equity* is the equity percentage of the pension funds assets. *LEV* is the leverage ratio which is measured as consolidated long-term debt divided by the consolidated assets. *ΔSales* is $(S_t - S_{t-1})/S_{t-1}$, where S_t is total sales revenue in year t. *ΔDIV* is the change of dividend pay-out ratio (calculated as dividends paid over net income). *ΔR&D* is the change in the ratio of R&D expenses to total assets. *ΔCAPEX* represents the change in the ratio of capital expenditure to total assets. Tests of significant differences between the two groups use both parametric (t-statistics for means) and nonparametric (Wilcoxon z-statistics for the median) statistics. ***, **, or * denotes statistical significance at the 1%, 5%, or 10% level, respectively.

	Freeze	FR	Size	OCF	Loss	ED	Union	CEO	SFreeze	Equity	ΔSales	ΔDIV	ΔLEV	ΔR&D	ΔCAPEX
Freeze	1.0000														
FR	0.1974***	1.0000													
Size	-0.0430*	0.1479***	1.0000												
OCF	-0.0782***	-0.0907***	-0.1466***	1.0000											
Loss	0.0009	-0.0238	0.0093	-0.1004***	1.0000										
ED	-0.0192	0.1513***	-0.1607***	0.0617**	-0.0034	1.0000									
Union	-0.2211***	0.0414*	0.0313	-0.0043	0.0165	0.0123	1.0000								
CEO	-0.0215	-0.0225	0.0131	0.0025	0.0804***	0.0022	-0.0261	1.0000							
SFreeze	0.3237***	0.1289***	-0.0109	0.0059	-0.0106	-0.0551**	-0.3183***	0.0309	1.0000						
Equity	-0.2761***	–0.2469***	–0.1650***	0.0954***	–0.0354	0.1824***	0.1086***	–0.0568**	–0.1790***	1.0000					
ΔSales	0.0507**	-0.0204	-0.0282	-0.0354	-0.0088	0.0238	-0.0121	0.0394*	0.0149	0.0347	1.0000				
ΔDIV	-0.0068	0.0015	-0.0075	0.0046	0.1010***	-0.0024	0.0005	0.0946***	-0.0018	–0.0006	-0.0006	1.0000			
LEV	-0.1208***	-0.0560**	-0.2227***	-0.1193***	0.1568***	-0.0238	0.1087***	0.0175	-0.1397***	0.0197	-0.0315	-0.0023	1.0000		
ΔR&D	0.0306	0.0624***	-0.0288	-0.0057	0.0238	-0.0211	0.0159	-0.0069	0.0205	0.0135	0.0007	-0.0968***	-0.0728***	1.0000	
ΔCAPEX	0.0120	0.0019	-0.0038	0.0047	-0.0402*	0.0088	0.0206	0.0049	0.0011	0.0114	0.0456*	-0.0101	-0.0169	0.0125	1.0000

Table 4: Correlation Matrix for the Variables in the Hard Freeze Determinants Model

All the variables have been previously explained in Table 3. ***, **, or * denotes statistical significance at the 1%, 5%, or 10% level, respectively.

	Coefficients	Std. Error
Funding Ratio (*FR*)	0.005	0.004
Size of Employer (*Size*)	−0.125**	0.047
Operating Cash Flow (*OCF*)	−3.860***	1.258
Employer Loss (*Loss*)	-0.027	0.231
Effective Duration (*ED*)	-0.002	0.023
Unionized % (*Union*)	−0.026***	0.010
Leverage Ratio (*LEV*)	−0.064	0.638
Change in CEO (*ΔCEO*)	−0.027	0.195
Previous Soft Freeze (*SFeeze*)	0.693***	0.193
Equity % of Pension Fund (*Equity*)	0.001	0.005
Change in Sales (*ΔSales*)	0.001	0.001
Change in Dividends (*ΔDIV*)	−0.017	0.013
Change in R&D (*ΔR&D*)	0.120	0.196
Change in CAPEX (*ΔCAPEX*)	0.007	0.043
Constant	−1.809***	0.604
Firm Fixed Effects	Yes	-
Year Fixed Effects	Yes	-
Observations	1069	
Log pseudo likelihood	−115.055	
Pseudo R squared	0.128	

Table 5: Causes of a Hard Freeze

The dependent variable is *Freeze*, which is a dummy variable equal to one in the year when the employer's DB scheme is hard frozen, and zero before the hard freeze year. Observations after the freeze year are dropped. For details of the explanatory variables see Table 3. This regression includes firm- and year-fixed effects. We use probit regression, with robust standard errors clustered at the firm level. ***, **, or * denotes statistical significance of each coefficient at the 1%, 5%, or 10% level, respectively.

Dependent Variable	Total Risk		Systematic Risk		Unsystematic Risk		Asset Risk		Credit Risk	
Explanatory Variables	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Freeze	−0.395***	0.133	0.012**	0.001	−0.169**	0.085	0.061**	0.032	−0.022***	0.006
Funding Ratio (*FR*)	−0.004*	0.003	−0.008**	0.004	−0.005***	0.002	−0.004**	0.002	−0.001***	0.000
Size of Employer (*Size*)	−0.241***	0.038	−0.070*	0.040	−0.040**	0.017	−0.078	0.069	−0.031***	0.004
Operating Cash Flow (*OCF*)	−0.304***	0.070	0.200	0.200	−0.144***	0.044	−0.369	1.168	−0.102***	0.029
Employer Loss (*Loss*)	0.004	0.188	0.438	0.439	0.468***	0.070	−0.039	1.228	0.038***	0.011
Effective Duration (*ED*)	−0.121***	0.022	−0.100**	0.045	0.009	0.009	0.018*	0.009	0.001	0.000
Unionized % (*Union*)	−0.033***	0.005	−0.020**	0.009	0.012***	0.004	−0.011	0.010	0.001	0.001
Leverage Ratio (*LEV*)	−0.518***	0.045	0.765	1.138	−0.597***	0.195	0.120	0.798	−0.074***	0.020
Change in CEO (*ΔCEO*)	−0.108	0.121	−0.168	0.251	0.060	0.077	−0.277	0.211	−0.007	0.007
Previous Soft Freeze (*SFeeze*)	−0.502***	0.127	0.008**	0.003	−0.104*	0.055	0.357*	0.193	0.033	0.021
Equity % of Pension Fund (*Equity*)	0.008**	0.004	0.008	0.008	−0.005***	0.001	−0.004	0.004	−0.001**	0.001
Change in Sales (*ΔSales*)	0.000	0.000	0.000	0.000	−0.000***	0.000	0.000	0.000	0.000	0.000
Change in Dividends (*ΔDIV*)	−0.002	0.041	0.055	0.110	−0.022	0.020	0.011	0.069	−0.000	0.002
Change in R&D (*ΔR&D*)	−0.055	0.040	−0.012	0.122	−0.095***	0.020	0.038	0.062	0.007**	0.004
Change in CAPEX (*ΔCAPEX*)	0.041***	0.012	−0.055	0.040	0.008	0.008	−0.015	0.020	−0.001*	0.001
Constant	7.985***	1.521	5.160	5.168	2.985***	0.851	4.918	1.992	1.628	0.911
Firm Fixed Effects	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-
Year Fixed Effects	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-
Observations	1292		1283		1197		1283		709	
Adjusted R squared	0.211		0.118		0.287		0.123		0.618	

Table 6: Effect of a Hard Pension Freeze on Five Measures of Employer Risk

The dependent variables are total risk, which is the natural log of the standard deviation of excess returns on the employer, systematic risk which is the employer's equity beta, unsystematic risk which is the natural log of the difference between (total risk and systematic risk times the standard deviation of excess returns on the FTSE 100), asset risk which is the asset beta including the pension scheme, and credit risk which is based on their Fitch credit ratings. For details of the 14 control variables see Table 3. Table 7 does not show the estimated coefficients for the 14 explanatory variables as these are broadly similar to those in Table 6, and are not the subject of current concern. We use ordinary least squares regression, with year and firm fixed effects. ***, **, or * denotes statistical significance of each coefficient at the 1%, 5%, or 10% level, respectively

Dependent Variable	Total Risk		Systematic Risk		Unsystematic Risk		Asset Risk		Credit Risk	
Explanatory Variables	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Pre Freeze −5	0.688	0.675	1.171	0.788	2.765	2.230	0.588	0.430	−0.004	0.012
Pre Freeze −4	0.650	0.520	1.102	0.737	2.188	2.150	0.172	0.418	−0.010	0.012
Pre Freeze −3	0.694	0.688	0.315	0.747	1.604	2.110	0.610	0.398	−0.009	0.013
Pre Freeze −2	0.415	0.315	1.009	0.693	1.961	2.007	0.400	0.387	−0.007	0.012
Pre Freeze −1	0.444	0.521	0.670	0.666	1.952	2.035	0.434	0.367	−0.012	0.011
Freeze Year 0	0.250	0.250	1.509**	0.662	−3.498*	2.060	0.878**	0.375	−0.012	0.011
Post Freeze +1	0.250	0.257	1.632**	0.777	−3.857*	2.061	1.137***	0.407	−0.022*	0.011
Post Freeze +2	−0.032	0.270	0.065	0.775	−2.005	2.120	−0.091	0.433	−0.039***	0.014
Post Freeze +3	−0.221	0.288	0.233	0.803	−2.009	2.130	0.388	0.401	−0.049***	0.015
Post Freeze +4	−0.501**	0.252	−0.947	0.888	2.087	2.133	−0.594	0.520	−0.051***	0.017
Post Freeze +5	−0.380*	0.230	−0.857	0.952	2.030	2.158	−0.437	0.550	−0.034*	0.017
14 Control Variables	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-
Firm Fixed Effects	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-
Year Fixed Effects	Yes	-	Yes	-	Yes	-	Yes	-	Yes	-
Observations	1292		1283		1197		1283		709	
Adjusted R squared	0.220		0.122		0.285		0.119		0.713	

Table 7: Effects of a Hard Freeze on Employer Risk for the Eleven Years around the Freeze

The dependent variables are total risk, which is the natural log of the standard deviation of excess returns on the employer, systematic risk which is the employer's equity beta, unsystematic risk which is the natural log of the difference between (total risk and systematic risk times the standard deviation of excess returns on the FTSE 100), asset risk which is the asset beta including the pension scheme, and credit risk which is based on their Fitch credit ratings. For details of the 14 control variables see Table 3. Table 7 does not show the estimated coefficients for the 14 explanatory variables as these are broadly similar to those in Table 6, and are not the subject of current concern. We use ordinary least squares regression, with year and firm fixed effects. ***, **, or * denotes statistical significance of each coefficient at the 1%, 5%, or 10% level, respectively.