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Cost saving and the freezing of corporate pension plans☆

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ABSTRACT

Companies that freeze defined benefit pension plans save the equivalent of 13.5% of the long-horizon payroll of current employees. Furthermore, firms with higher prospective accruals are more likely to freeze their plans. Cost savings would not be possible in a benchmark model in which i) all workers receive compensation equal to their marginal product and ii) workers value equally all identical-cost forms of pension benefits. We find evidence consistent both with firms' reneging on implicit contracts that would have provided workers with high pension accruals later in their careers and with shifts in employee valuation of different forms of retirement benefits.

1. Introduction

The role of defined benefit pensions in the labor market has been characterized in the economics literature by two distinct approaches. Under the "legal contracts" framework, there is a frictionless, competitive equilibrium in the spot market for labor, with no other economic benefits to deferring compensation (Rosen, 1974; Sharpe, 1976; Bulow, 1982). As a result, workers' total periodic compensation would have to equal their marginal product of labor. The alternative "implicit contracts" framework (Ippolito, 1985) incorporates economic factors that cause a worker's compensation to deviate from marginal product, such as the desire to discourage worker shirking (Lazear (1979)), the offering of efficiency wages to encourage effort (Shapiro and Stiglitz, 1984), or the use of DB pensions to incentivize efficient employment, effort, and retirement decisions (e.g. Lazear, 1983).

The shift from defined benefit (DB) to defined contribution (DC) pensions in the U.S. corporate sector over the past several decades provides

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an opportunity to study these different views of pensions and contracts in the labor market. Under the legal contracts view, if a firm were to freeze or terminate its DB pension plan, it would have to adjust other dimensions of compensation so that there would be no change in costs. Under the implicit contracts hypothesis, firms that freeze or terminate their plans would be able to save costs in part through reneging on implicit contracts, and firms might decide to time such decisions to minimize the option value to workers of continued benefit accruals.[1] Alternatively, firms could see cost savings when they freeze or terminate DB plans if worker preferences or other characteristics have shifted so that financial frictions lead workers to value a DB plan less than an equal-cost DC plan. In this last scenario, employers and employees would potentially both be made better off with a DB freeze coupled with a new or enhanced DC plan.

In this paper, we study the extent to which firms save costs through DB pension freezes and the role of this cost saving in explaining which firms freeze their plans, and we interpret these results in the context of the above hypotheses about pensions in labor markets. In 1998, 58% of today's Fortune 500 employers offered a DB plan to new hires, but by 2017 only 16% did so (see Willis Towers Watson (2018)). Most commonly, newer firms, such as those that are in the Fortune 500 today but were not 20 years ago have favored DC arrangements for new employees. However, freezes are the main channel through which the shift has occurred for today's long-lived firms. Of the above 42 percentage point drop, 25 percentage points came from a plan hard freeze in which benefit accruals are stopped for all workers; 15 percentage points came from closing the DB plans to new employees in what is called a soft freeze, stopping accruals for new workers but leaving those already employed unaffected; and the remaining 2 percentage points came from plan terminations, which generally occur when firms that sponsor DB plans enter bankruptcy and transfer unfunded liabilities to the Pension Benefit Guaranty Corporation.

Measuring the extent to which firms save costs in DB pension freezes requires measuring the prospective DB accruals that they avoid by freezing as well as incorporating the increases in current contributions to the DC plans that replace them. We use rich administrative data on the demographics of individual DB pension plans as well as pension plan finances to obtain these measures. To measure forgone accruals, we consider two counterfactuals. First, we compare implementing a hard freeze today to waiting and implementing a hard freeze *s* years in the future. Second, we compare implementing a hard freeze today to implementing a soft freeze today by closing the DB plan only to new workers. In both cases we incorporate actual increases in contributions to 401(k) plans that happen after the freezes. Under the first counterfactual, we conclude that firms save 3% of payroll over the first year and 8% of the present value of payroll over 10 years, which amounts to 3.4% of the firm's total assets. Under the second counterfactual, we estimate the present value of long-term (45-year) cost savings on workers employed at the time of the freeze to be over 5% of total current book assets or 13.5% of the expected future payroll of those workers. As we find no evidence of compensating salary increases, we conclude that workers would have to value the structure, choice, flexibility, and/or portability of DC plans (relative to DB plans) by at least this much to experience welfare gains from freezes.

One identification concern is that freezing could be correlated with other factors that would have led to cost savings even in the absence of the freeze. We make the assumptions that had freeze firms not frozen, i) they would have had similar entry and exit patterns as before they froze, and ii) 401(k) contributions as a percent of salary would have remained the same as before the freeze.

To examine whether the decision to freeze is related to prospective accruals, we use propensity score-matched control samples, and we also estimate a linear probability model that incorporates a number of controls. In order to address the possibility that firms with higher accruals may be more likely to freeze for other reasons, we control for labor market factors including labor market tightness and average industry tenure. Our identifying assumption is that at least in the presence of these controls, prospective accruals are uncorrelated with omitted factors that could be leading a firm to freeze. We find that firms that froze would have (had they not frozen) faced, on average, about 50% higher accruals as a share of firm assets than comparable firms that did not freeze, and that the probability that a firm freezes a pension plan is positively related to the value of prospective accruals as a share of firm assets.

The evidence therefore suggests that higher accruals play a significant role in driving the freeze decision. Decomposing the accrual differences for freeze and non-freeze firms, we find that much of the difference in prospective accruals between the freeze and matched non-freeze firms is driven by the size of the labor force relative to firm assets, and some is also due to differences in benefit factors.

Our finding that employers can achieve substantial cost savings by changing pension arrangements is evidence against the benchmark model described above and in favor of at least one of the two possible alternatives. Either the compensation of some or all workers is not always equal to marginal product; or employees value DB pension benefits less than they value an equal-cost DC plan so that a freeze coupled with supplemental DC benefits creates a surplus that can be split between the firm and its workers. While we cannot conclusively say to what extent the results are explained by reneging on implicit contracts versus differences in worker valuation, we find suggestive evidence that both factors are at play.

One way we address this question is to examine whether there is heterogeneity in cost saving across employee characteristics, in particular age. In a DB plan, annual accruals as a percent of salary increase substantially with age. Consistent with this, we find that realized short-horizon cost savings per worker as a percentage of salary are in fact largest for workers aged 50 to 65 and smallest for workers aged 20 to 34. This age pattern could be explained by a preference for DC relative to DB that is increasing with age and/or bargaining power of workers that is decreasing in age (making it easier for firms to renege on implicit contracts for older workers).

It seems implausible that older workers would undervalue a dollar of DB benefits relative to a dollar of DC benefits substantially more than younger workers. If anything, younger workers would likely value the investment flexibility (e.g. the ability to choose across a set of stock and bond funds) and portability of a dollar of DC benefits relatively more than older workers. On the other hand, there are good reasons to believe that the bargaining power of older workers is less than that of younger workers. This suggests that at least part of the cost saving is arising from reneging on implicit contracts for seasoned workers.

To shed further light on this question, we supplement our analysis of traditional DB freezes with an analogous examination of cash balance (CB) plan freezes. CB plans are a hybrid of DB and DC, having some properties of each. Like DC plans, CB plan benefits are expressed as an account balance that grows due to contributions and a rate of return. Also, CB plans have annual accruals as a percentage of salary that are rou equal (or only very modestly rising) across age, making them much more similar in this respect to DC plans than DB plans. However, like traditional DB plans, CB plan sponsors control all investment decisions and bear all investment risks, leaving workers with no choice on asset allocation. In addition, CB plan vesting occurs over a number of years so, like traditional DB plans, workers have less portability than they typically do in DC plans. Thus, if an employer freezes a CB plan and provides a DC plan in its place, the employee receives a plan that has a very similar accrual structure, with the main differences being portability and the ability of the employee to set the desired investment strategy and level of risk. If, by freezing a CB plan, employers can save

[1] As emphasized by Lazear and Moore (1988) and Stock and Wise (1990), under the implicit contracts view, the option to continue to earn benefits under a DB plan is valuable to workers in addition to the accrued defined benefits. The option is particularly valuable if vesting periods are long. As such, the decisions of pension plan participants about when to retire should also be a function of this option value.

money even on young employees with substantial presumed bargaining power, this suggests that at least some employees are willing to forego dollars of employer contributions in order to get the added choice and portability of DC plans.

We find that cost savings from CB plan freezes net of new contributions to DC plans are also substantial and equal about 72% of the savings from freezes of traditional DB plans over a 10-year horizon. We therefore conclude that not all of the cost savings in pension freezes are coming from reneging on implicit contracts for seasoned workers, and that some employees value the benefit features common to DB and CB plans less than those of a DC plan.

Our results have implications for a variety of public policy issues. First, as described above, we examine whether workers receive compensation equal to their marginal product, which is an important input to numerous policy questions including optimal capital and labor taxation (see, e.g. Piketty et al., 2014). Second, recent research in public economics suggests that individuals value annuities less than the amount implied by rational life-cycle models (Brown et al. (2019), Fitzpatrick (2015)), and some papers have presented evidence that workers may not fully understand their pension plans (Gustman and Steinmeier (2014), Dolls et al. (2018)). Our results add to this literature by suggesting that workers may not value DB benefits at their financial present value. Third, our results have implications for the PBGC government insurance program. Our finding that pension freezes reduce overall labor costs suggests that freezes could help firms better meet already-accrued pension benefit promises, and therefore indirectly improve the financial health of the PBGC. Fourth, current law (ERISA) protects private-sector accrued nominal benefits but not future accruals. In contrast, many state and local governments also protect by law some future accruals of DB plans, with protections varying widely across states and localities (Munnell and Quinby, 2012). Our results on freezes highlight the potential tension between employee protection and the flexibility of firms to improve their financial condition by reducing employee compensation. Similar to Pontiff et al. (1990), which analyzes settings in which firms could extract value from pension plans by acquiring other firms, our paper shows how firms operate within existing rules to increase cash flow by freezing pensions.

This paper proceeds as follows. Section 2 describes the conceptual framework, landscape, and existing literature. Section 3 gives a simple model and describes the theoretical issues related to pension freezes and cost savings. Section 4 describes the data and the methodology used in our empirical tests. Section 5 presents the results. Section 6 concludes.

2. Pension structures and background

2.1. The labor market and defined benefit versus defined contribution pension structures

DB plan sponsors promise retirement income to their employees, with employers bearing all the investment and longevity risk to meet the pension liability. The risk borne by the employee under a DB plan is limited to risk of job change, risk that future benefit accruals will be reduced or eliminated (as in a freeze), salary risk (as the pension is a function of late-career salary), inflation risk (after separation or a plan freeze, because at that point benefits are typically fixed in nominal terms), and risk that benefits will be reduced if their employer becomes financially insolvent.

A DC plan has a simpler structure. It is a retirement savings program under which the employer provides certain contributions to the participant's account during employment but there is no guaranteed retirement benefit. The participant has control over the investment allocations and can withdraw all or part of the accumulated account balance during retirement. DC plans typically give most or all responsibility to the employee for setting contributions, allocating assets, and making withdrawals, and the employee bears the investment risk (Bodie et al. (1988); Samwick and Skinner (2004); and Poterba et al. (2007)). The sponsor's financial responsibility in a DC plan arrangement essentially ends after its share of the contribution is made.

A CB plan is a hybrid form of pension that combines features of DB and DC plans. Contributions are set as a percent of salary (either a fixed percent or one that increases with age and/or years of service), and the rate of return on balances is determined the crediting rate of interest set in plan rules.[2] Employer contributions are pooled and invested by the sponsor. As in a traditional DB plan, benefits do not depend on the plan's investment performance, so the employer bears the full investment risk. A CB plan is therefore like a DB plan along the dimensions of risk and choice/control, but is closer to a DC plan along the dimension of accruals.

As noted above, the legal contracts view of pensions assumes that there is a frictionless, competitive equilibrium in spot markets for labor and that there are no other economic benefits (other than tax-deferral) to deferring compensation. If workers are rational, they will only forgo wages in any given period equal to the accrual value of new benefits they have earned (Rosen, 1974; Sharpe, 1976; Bulow, 1982). As a result, a worker's total periodic compensation, including cash wages, pension accruals, and other benefits, must equal his or her marginal product of labor, and a firm can then freeze or terminate its plan at any time without affecting total costs.

The implicit contracts view (Ippolito, 1985) takes into account frictions that could cause a worker's compensation to deviate from marginal product. For example, efficiency wages could be paid to encourage effort (Shapiro and Stiglitz, 1984), or downward wage rigidity could prevent firms from lowering wages in the presence of negative unanticipated shocks to worker productivity (for a review, see Bewley, 1999). Under the implicit contracts view, workers typically receive compensation (including DB pension accruals) that is less than their marginal product when young and more than their marginal product when old, as a way to efficiently incentivize workers' effort, tenure, and retirement decisions. One such implicit contract (discussed further in the conclusion) arises when workers accumulate firm-specific human capital. The high expected future DB accruals encourage workers to join and stay with the firm and reduce the potential for firms to exploit the increasing bargaining power they have over workers during their careers. The decision to freeze a DB plan could be driven by changing demographic and economic forces that make existing DB contract less efficient, giving the firm the opportunity to achieve a one-time gain by reneging on these implicit contracts for current workers.

Previous papers on the role of DB plans in corporations have focused on work incentives (Ippolito, 1985; Lazear, 1983; Mitchell and Fields, 1984), tax benefits (Black, 1980; Tepper, 1981; Petersen, 1992; Shivdasani and Stefanescu, 2010), earnings manipulation (Bergstresser et al., 2006) and financial slack (Ballester et al., 2002). Corporate pension plans have a significant effect on the investment policy of the company (Rauh, 2006a). Firm equity betas reflect the size of pension liabilities and pension asset risk (Jin et al., 2006).

Other work considers the incentives that DB sponsorship provides in the context of mergers and acquisitions. Pontiff et al. (1990) demonstrate that during a time largely before excise taxes on the extraction of overfunded assets, around 13% of the takeover premium can be explained by the option to terminate overfunded DB plans, highlighting another mechanism by which value is extracted from DB pension plans potentially at the expense of employees. By 1990, Congress had imposed excise taxes of up to 50% on overfunded assets, dulling these incentives, although our results suggest that there may well still be the possibility for acquirers to extract value from DB sponsors by changing pension policy after an acquisition, e.g. through pension freezes. Other work shows that firms with DB plans are less likely to be targeted in an acquisition (Cocco and Volpin, 2013). In some pension systems, significant agency conflicts can exist between the insider trustees and plan members (Cocco and Volpin, 2007). Cocco (2014) provides a

[2] The interest credit in a cash balance plan can be fixed-rate or variable-rate (e.g. an interest rate benchmark plus a basis point spread).

comprehensive review of the literature on corporate finance and DB pension plans (see also Chen et al. (2011); Klasa et al. (2009); Matsa (2010); Matsa and Agrawal (2013); and Simintzi et al. (2015)).

2.2. The pension transformation and pension freezes

Encouraged by the tax deductibility of pension contributions in times when corporate tax rates reached historical highs after World War II, employers viewed DB plans as a tool to build and retain human capital. In 1980, of all private-sector wage and salary workers participating in a pension plan in their current job, 60% were participating only in a DB plan, 17% were participating only in a DC plan, and the remaining 23% were participating in both types of plans. By 2018, of those participating in a plan, merely 2% were solely in a DB plan, 80% were solely in a DC plan, and the remaining 18% were in both (see Appendix Fig. A.1). Many other countries in the world have also undergone a significant shift from DB to DC pensions (Holzmann, 2013).

The relative decline of DB pensions has been well documented (Clark and McDermed (1990); Gustman and Steinmeier (1992)). At first, this shift occurred primarily through new firms adopting DC rather than DB plans (Kruse, 1995; Ippolito and Thompson, 2000). Starting in the early 2000's, however, the hybrid conversions and pension freezes of very large employers became more common (VanDerhei (2006), Government Accountability Office (2008), and Willis Towers Watson (2018)). In 2005, for example, IBM, Hewlett-Packard, Sears Holding, Verizon, and many other firms announced pension freezes.

Why has this shift toward DC occurred? Explanations fit broadly into three categories. Some of these explanations are consistent with a model in which all workers are at least as well off after the shift from DB to DC, while others imply that some or all workers are worse off.

The first relates to institutional and legal changes that fostered the shift to DC plans, generally thought to go back to the Revenue Act of 1978, which changed the U.S. Internal Revenue Code to allow salary reductions to be used for retirement plan contributions. Following this legislation, large firms began to establish 401(k) plans. Over time, the costs and risks of DB pensions relative to DC plans became more apparent to employers. Although interest rate risk, mortality risk, and investment risk could all in principle be hedged through the appropriate choice of plan assets (e.g., asset liability matching), in practice they are not, whether because of a lack of suitable hedging instruments, a lack of desire to do so, or both.[3] Furthermore, pension shortfalls that arise in the face of unhedged shocks can compete for cash within the firm and thus have liquidity implications, potentially negatively affecting capital investment decisions (Rauh, 2006a). The economic environment of the early 2000s, with volatile equity markets and generally falling interest rates, highlighted these risks, as did new accounting standards that moved more unfunded pension liabilities onto firms' balance sheets.

Second, changes in the economic environment could have driven changes in the pension landscape. Life expectancy has increased over the past 40 years, raising projected costs. The large decrease in inflation that occurred in the 1980s raised the real projected costs of accruing fixed nominal pensions, as has the multi-decade decline in interest rates. Labor mobility increased, induced by declines in the value of existing jobs relative to new jobs, lowering the attractiveness of DB plans to workers (Friedberg and Owyang, 2004). Other factors include changes in labor characteristics and preferences (Aaronson and Coronado, 2005), and reduced search costs (Friedberg et al., 2006). Increased global competition could have led to lower equilibrium compensation for U.S. workers. In the presence of downward nominal wage rigidity, employers might have found it easier to cut pension benefits through a shift of pension design than to cut wages.[4] Also, the demographic changes associated with the post–World War II baby boom led to an increased concentration of the workforce in age groups that had the highest projected DB accruals (see Butrica et al., 2009).

Third, changes in consumer preferences, such as an increased desire for flexibility and control over retirement wealth investment and spending decisions, might have driven pension changes. A DB plan requires participants to take a mostly riskless benefit, essentially by buying deferred annuities with the pension contributions made on their behalf. A DC plan allows participants to choose their asset allocation and make their own tradeoffs regarding risk and return.[5] Even within DB pensions, there has been an increase in the fraction of people taking lump sum distributions instead of a lifetime income (annuity) stream, which could potentially represent an increased preference for flexibility and control (see, e.g., Beshears et al., 2014).[6]

The literature on the determinants of DB plan freezes is relatively sparse. Munnell and Soto (2007) find that plan characteristics (such as underfunding level, size, and large credit balances), bargaining power, and the financial health of the company play a role in the firm decision to freeze. Beaudoin et al. (2010) find that the less-profitable sponsors are more likely to freeze DB plans. In addition, they show that the balance sheet effect of SFAS 158 is associated with the decision to freeze, a finding related to Yu (2014) who finds that freezes are related to the difference between accumulated liabilities and projected liabilities under U.S. GAAP disclosure rules.[7] Other papers have considered the effect of DB plan freezes on firms' financial and capital budgeting decisions (Phan and Hegde (2012), Choy et al. (2014)). The results of Petersen (1994) suggest that moving away from DB arrangements could create financial flexibility on operating leverage. Copeland and VanDerhei (2010) examine the effect of (soft) pension freezes coupled with increases in DC contributions on projected retirement income and argue that at least without risk adjustment the new workers who are put into the DC plan are no worse off.[8]

Several papers have attempted to use equity market event studies to examine whether DB plan freezes enhance shareholder value, with rather mixed conclusions.[9] Because our paper considers the cost effects on the firm from a cash flow and accrual standpoint, it is complementary to this event-study strand of literature.[10]

[3] Capital markets appear to price these risks (Jin et al., 2006). Furthermore, Love et al. (2011) find that firms' optimal funding and investment decisions depend on the nature of government pension insurance, the degree of insurance pricing, the amount of guaranteed benefits, the stringency of minimum funding requirements, and the costs of financial distress, among other factors.

[4] For a survey see Howitt (2002).

[5] Although in theory a worker could borrow against his or her future pension to invest in the desired portfolio of financial assets, in practice this is generally thought to be infeasible. Note also that participants are constrained by the menu of investment options offered through the 401(k) plan and are likely affected by the choice of options presented to them (Brown et al., 2007). Several studies have found evidence of agency problems in the setting of the investment menu or fund selection; e.g., that service-providers favor their own funds (Pool et al., 2016), that trustee families overinvest in the sponsor's stock (Cohen and Schmidt, 2009), or that firms induce employees to own company stock in 401(k) plans as a takeover defense (Rauh, 2006b).

[6] We include an additional discussion on how firms typically switch from a DB to a DC plan and whether pension freezes can save costs in Appendix B.

[7] Under U.S. GAAP, liabilities are disclosed as a projected benefit obligation (PBO) that accounts for future salary increases but not future years of service.

[8] Their method credits the full historical equity premium to the average DC benefits of future workers, so their results cannot be interpreted as a measure of the true economic losses to workers (or the cost saving to firms) from pension freezes.

[9] Phan and Hegde (2012) find evidence of positive short-run abnormal returns but no evidence of long-term abnormal returns. Rubin (2007) finds that pension freezes enhance firm market value with a lag. Milevsky and Song (2010) find a positive effect of DB freezing on company value of around 3.8%, though of marginal statistical significance. McFarland et al. (2009) instead find that the value of small firms declines in some specifications. They argue that 401(k) enhancements and declines in employee productivity could offset any potential cost savings, or alternatively that freezes are simply a reflection of financial challenges at the firm.

[10] Although some literature suggests that share prices fully reflect the value of unfunded pension liabilities (Feldstein and Seligman, 1981), other papers find that markets do not fully see through pension accounting and could overvalue firms with underfunded pension plans (Franzoni and Marin, 2006) or respond excessively to pension assumptions (Coronado and Sharpe, 2003).

3. Pension accruals and freezes

3.1. Measuring pension accruals

How much does it cost a firm on an annual basis to offer a retirement benefit to its workers? For a DC plan, answering this question is relatively straightforward, but it is more complicated for a DB plan, because the plan incurs future liabilities that are not generally equal to the current contributions that the firm makes to the plan's pension fund.

3.1.1. Defined contribution plans

The annual cost to a firm of offering a DC plan is equal to the contributions that the firm makes, either in the form of an outright contribution or as a matching contribution. Typically these are set as a percentage of each worker's current salary up to a ceiling. The costs of providing a DC plan will only vary with an employee's tenure and salary if participation and contribution rates also vary along those dimensions. There is evidence that, in 401(k) plans without auto-enrollment, participation rates rise with tenure over the first several years of employment (Choi et al. (2004)). However, we would expect contribution rates in DC plans that are offered to workers as a replacement for DB plans to start at a level closer to a steady state.

3.1.2. Defined benefit plans

Most traditional DB plans promise to pay a fixed nominal income stream in retirement of a magnitude that depends on years of service, a salary measure, and a benefit factor. The formula is usually multiplicative. We capture this with the following benefit formula:

$$B_R = k \cdot N_Q \cdot Y_Q, \tag{1}$$

in which B_R is the nominal benefit paid in year R and beyond; k is the benefit factor, typically in the range of 1.5 to 2.0%; N_Q is the number of years that the employee was covered by the plan before separating from the firm (by quitting, retiring, or being fired) in year Q; and Y_Q is the nominal salary in the final year that the worker was employed and covered by the plan.[11] The employee receives the benefit in the form of an annuity that pays out the same annual B_R every year, beginning at a specified retirement age (e.g., age 65) and continuing for as long as the recipient lives.[12] For example, a worker with 40 years of service with a benefit factor of 1.5 would receive an annual nominal pension benefit equal to 60% of his or her final salary.

Because DB pensions are based on a formula that defines retirement income and DC pensions are based on a formula that defines contributions as a percent of salary, it is not easy to compare the costs and payouts of the two types of pensions. We therefore develop a metric to compare plans: the expected present value of annual accruals as a percent of annual salary. For a DC plan, this metric is simply the employer contribution as a percent of salary. In what follows, we describe how we construct the comparable measure for DB plans.

At any point in time t, a firm has the option of terminating the plan or freezing benefits. Under a typical termination or freeze, the pension plan must pay the worker the future annual benefit determined by formula (1), with N_Q and Y_Q "frozen" at their current levels, N_t and Y_t, so that $B_R = k \cdot N_t \cdot Y_t$. We refer to this term as the time R retirement benefit accrued as of time t.

Following standard practice, we define the accumulated benefit obligation (ABO) as the present value as of time t of the future stream of these accrued benefits:

$$ABO_t = k \cdot N_t \cdot Y_t \cdot Z_{t,R} \tag{2}$$

The annuity factor, $Z_{t,R}$, is defined as the cost at time t of buying a deferred nominal annuity stream of \$1 that begins at year R (if the beneficiary is still alive) and continues as long as the recipient lives.[13] The appropriate discount rate for a true present value from the perspective of the shareholders of the firm would reflect the fact that accrued benefits are bond-like promises on which firms can default only in the event of bankruptcy and termination by the PBGC. A corporate bond yield of the firm's own credit quality with maturity equal to the duration of the pension promise would have similar characteristics. The statutory discount rates that firms must use to comply with regulatory rules differ in some respects. Historically, statutory funding rates for deficit reduction contributions were based on U.S. Treasury yields, but since the early 2000s they have been based on smoothed corporate yield curves. Note that pension benefits received during retirement are tied to salary at separation or freeze, and thus are fixed in nominal terms once separation or a freeze has occurred. Thus, the appropriate discount rate is a nominal one, which, in turn, depends on expectations of inflation and any inflation risk premium.

We define annual accruals as the difference (in today's dollars) between next year's ABO if the plan continues running and next year's ABO if the plan were instead terminated or frozen today. These annual costs are uncertain, as there is uncertainty about future salaries, separations, and mortality. This cost measure can be defined over a horizon of any length of time. The ABO liability for one worker at time $s > t$ if the plan is not frozen prior to s is

$$ABO_{s|[\text{no freeze prior to } s]} = k \cdot N_s \cdot Y_s \cdot Z_{s,R}, \tag{3}$$

in which Y_s is the nominal salary at time $s > t$ (if the participant is still employed) or the last salary the participant received (if separated).

If, instead, the freeze is implemented at time t, the number of years of service and the salary will remain frozen at their current levels, N_t and Y_t. Therefore, the ABO will be

$$ABO_{s|[\text{freeze at } t]} = k \cdot N_t \cdot Y_t \cdot Z_{s,R}. \tag{4}$$

We define $\lambda_{t,s}$ as the difference as of time s between these two measures:

$$\lambda_{t,s} = ABO_{s|[\text{no freeze prior to } s]} - ABO_{s|[\text{freeze at } t]}. \tag{5}$$

We next define $\delta_{t,\,s}$ as the expected present value (as of time t) of $\lambda_{t,s}$, and derive its value as follows:[14]

$$\begin{aligned}\delta_{t,s} &= E_t\left\{\lambda_{t,s}\,(1+i)^{-(s-t)}\right\}\\ &= E_t\left\{k\,Z_{s,R}(1+i)^{-(s-t)}\,Y_t\left[(N_s - N_t) + g_{t,s}N_s\right]\right\},\end{aligned} \tag{6}$$

where $g_{t,s}$ is the total nominal salary growth between t and the minimum of s and the last year of employment. The appropriate discount rate i should reflect the riskiness of the future accruals, which depend on the evolution of the worker's future salary and years worked. Assuming that the evolution of salary and work is

[11] Final pay is most commonly used in the benefit formula. In some cases, the benefit formula is based on the final or highest *few* years or on career average pay or includes an adjustment to integrate with Social Security benefits.

[12] The worker can usually alter the features and corresponding amount of the annuity received, and some workers also have the option of receiving a single lump-sum payment instead.

[13] This assumes that a worker who dies prior to retirement age receives no retirement benefit. If a spousal or other survivor benefit would be paid, then the formula would have to be adjusted accordingly.

[14] We include some additional details of the derivation in Appendix C.

independent of aggregate asset pricing factors and future annuity factors, and that $Z_{t,\,R} = E\{Z_{s,\,R}(1+i)^{-(s-t)}\}$, we can simplify this expression to[15]

$$\delta_{t,s} = kZ_{t,R}\, Y_t E_t\ \{(N_s - N_t) + g_{t,s} N_s\ \}. \tag{7}$$

We divide $\delta_{t,\,t+1}$ by current salary, Y_t, to yield the annual cost of a DB plan as a percent of current salary. As mentioned earlier, this measure is directly comparable to a common cost measure for DC plans: current contributions and matches as a percent of current salary. Fig. 1 plots $\delta_{t,\,t+1}/Y_t$ against age, based on our parameter assumptions and assuming that years of service rise one for one with age. We include in this figure the annual DC costs as a percent of salary for a worker who participates in the plan and contributes enough to get the full match in every year. The DC costs are a constant percentage of salary, i.e. a flat line in the graph, equal to the sum of the employer outright contribution and matching rate (for exposition purposes only, we calibrate it to the data). Finally, Fig. 1 also includes the annual costs of CB plans.

There are stark differences in the accrual/cost patterns of DB and DC plans. DC accruals as a percent of salary are constant. In contrast, the cost of annual DB accruals is about 2% of salary for a new 25 year-old worker and rises to over 25% of annual salary for a 60 year-old worker with 35 years of experience. These differences in accruals are crucial to our framework, as freezing a DB plan and replacing it with a DC plan involves replacing a convex accrual structure that rewards older and more senior workers more heavily (as a percent of salary) with a flat one in which accruals are constant with age and tenure. Demographic differences across firms will generate differences in the potential cost savings from freezing a DB pension plan. These differences in accrual patterns could also yield different incentive effects on workers to remain with the firm.[16]

3.1.3. Cash balance plans

As described in the introduction, a CB plan, while legally governed by the rules of DB plans, is a hybrid plan that has some features of a DB plan and some that more closely resemble a DC plan. The latter include that contributions are equal to a percentage of salary and earn a rate of return over time, and that the lump sum available at retirement is equal to the accumulated balance in the account. For some CB plans, the contributions are set as a fixed percent of salary, while for others, the percent of salary increases modestly with age and/or years of service.

Under a CB plan, each worker has an "account" that is credited each year with an interest credit (equal to the starting balance multiplied by an interest rate, typically either a fixed rate or a floating rate tied to a Treasury rate), and a pay credit (a percentage of salary):

$$CB_{t+1|[no\ freeze\ at\ time\ t]} = CB_t(1+i_c) + h{\cdot}Y_t \tag{9}$$

in which CB_t is the balance accumulated at the beginning of period t, CB_{t+1} is the balance accumulated at the beginning of period t + 1, Y_t is salary in period t, i_c is the interest credit rate and h is the pay credit rate.[17] At retirement, cash balance plans are required to offer employees a life annuity (converted based on the accumulated balance CB_R), and many also offer employees the option to take the accumulated balance as a lump sum.[18]

If the CB plan is frozen, no further salary credits are earned, but balances typically continue to earn interest credits until retirement:

$$CB_{t+1|[freeze\ at\ time\ t]} = CB_t(1+i_c) \tag{10}$$

We define $\delta^{CB}_{t,s}$ parallel to the DB definition above: the difference between the present value of the future retirement obligation if the plan is frozen at s and the obligation if the plan is frozen at t:

$$\delta^{CB}_{t,s} = \mathrm{E}_t\left\{\left(CB_{R[\text{freeze at s}]} - CB_{R|[freeze\ at\ t]}\ \right)(1+i)^{-(R-t)}\right\}. \tag{11}$$

We assume that the crediting interest rate i_c for the CB plan equals the appropriate market valuation discount rate i in Eq. (11), which implies that $CB_{R[freeze\ at\ t]}\,(1+i)^{-(R-t)} = CB_t$, i.e. the cash balance at time t represents the present value of the future retirement obligation. In Fig. 1 we compare $\delta^{CB}_{t,\,t+1}$ scaled by salary to the comparable cost measures for DB and DC plans. We plot the accrual patterns for two sets of CB plans: those that set h to be a constant and that set h to rise with age and/or years of service.[19] If h is a constant, accruals as a percent of salary is a flat line, as it was for the DC accruals. For those plans where h increases with age and/or years of service, we see a modest increase in $\delta^{CB}_{t,\,t+1}$scaled by salary, rising from about 3.2% of pay to about 8.5% of pay as age increases.

Multi-year accruals can be computed by iterating Eqs. (9) and (10) forward and substituting into Eq. (11). $\delta^{CB}_{t,s}$ is then equal to the present value of the stream of $h_{t+j}Y_{t+j}$ between t and s. If h is constant, this equals h times the present value of income between t and s.[20]

4. Empirical tests: data and methodology

4.1. Sample selection

Our primary source of information on DB pensions is Form 5500, filed annually by plan administrators with the Department of Labor (DOL) and the IRS. We begin by extracting information on all DB plans filing Form 5500 between 1999 and 2010. Next, we restrict the sample to plans that can be reliably linked to sponsors covered by Compustat. The reported sponsor name and its employer identification number (EIN) serve as the primary identifiers.[21] Table 1 illustrates the sample selection criteria. The result is a sample of 40,637 plan-years from the IRS 5500 filings matched to Compustat.

Our accrual estimates are based on age-service tables, reported in the attachments to Form 5500, that list, for various age and service categories, the number of workers covered by the plan and the average salary of these workers. Our sample is further restricted by the availability of these tables at the plan level. Under the current disclosure rules, only plans with >1000 active participants are required to disclose this information. We therefore restrict the sample to plans that report 1000 active participants for at least one year during our sample period, which

15 Geanakoplos and Zeldes (2010, 2018) argue that future wages are positively correlated with stock prices and that the appropriate discount rate on wage-linked cash flows should be higher to reflect this. We assume away any such effect here.

16 Appendix Fig. A.2 plots $\delta_{t,\,t+1}/Y_t$ against both age and service. Costs as a percent of salary increase both with years of service (assuming $g > 0$) and with age (assuming $i > 0$). Note also that the degree to which accruals increase with tenure depends on nominal salary growth, so that the patterns of DB accruals as a percent of salary are affected both by real salary growth and by the average inflation rate. Changes in inflation can thus alter both the level and shape of the accrual graph and the corresponding incentives for workers to remain with the firm and for firm to freeze the plan. We thank Stan Panis for highlighting this point.

17 When a DB plan is converted to a CB plan, the starting cash balance is typically set equal to the present value of the cash flows the worker would have received under the DB arrangement if there were no future accruals.

18 We assume that the annuity stream offered has present value at time R equal to the lump sum CB_R.

19 The CB lines in Fig. 1 are based on an average of a subsample of frozen and matched CB plans.

20 We further develop the discussion on crediting rates in Appendix C.

21 Although these variables allow us to generate a first link to Compustat sponsors, in many instances Form 5500 reports the name and EIN of one of the parent sponsor's subsidiaries. To overcome this problem, we manually collect the names of all subsidiaries reported by all sponsors in the 10-k filings (Exhibit 21). We identify potential sponsors in Compustat based on the availability of aggregate pension information such as pension assets and liabilities. This process allows us to obtain a very close match between sponsors and plans.

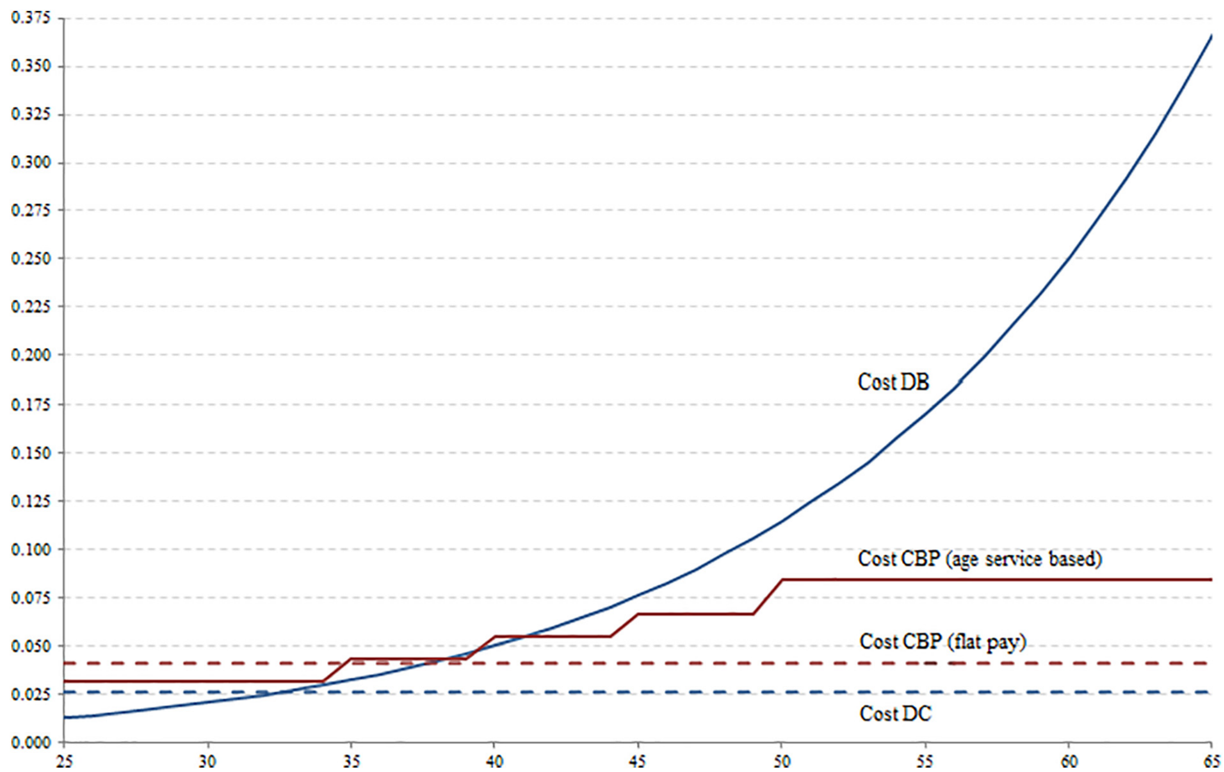


Fig. 1. Annual employer cost as a percent of salary ($\delta_{t,\ t+1}/Y_t$) in defined contribution, defined benefit, and cash balance plans. The figure shows the expected annual cost, as a percentage of salary, to the sponsor over time for one worker hired at age 25 and remaining with the firm until age 65. We calibrated the graph to averages that we estimate from our data. The salary growth is 4.5% per year, the discount rate is 6.1%, and the benefit factor is 1.3%. The employer contribution to the DC plan is set at 2.6% per year. The CBP flat pay rate is 4.1%.

limits the sample to 14,315 plan-year observations.[22] An example of this age-service table is reported in Appendix Table A.1. Age-service tables were available for 8551 plan-years.[23] Among these, there are 2049 plan-years of forms that are filed by CB plans. Where available, we also collect the cash balance table, which reports individual account balances by age-service groups.

To pursue our analysis, we require an accurate list of which pension plans were frozen and when the freezing took place. Since 2003, there has been a question (check box) on the form that asks whether the pension plan is (hard) frozen. Once the plan is reported as frozen, all subsequent filings should have this annotation. Of course, for plans that checked the box already in 2003, it is not immediately clear whether they froze in 2003 itself, or in a prior year. To deal with plans that checked the box in the first year, and as a check on the accuracy of the information reported in the check box, we searched for information about plan freezes in the news, annual reports, and in the history of the plan as reported in the attachments to Form 5500, correcting any inaccuracies manually. Appendix Table A.2 shows the development of this sample of pension freezes. Our procedure identifies 213 plans that were frozen during our sample period.[24]

4.2. Estimating cost savings from pension freezes

We have defined $\delta_{t,s}$ as the expected value of the benefit accruals that would occur over the period between t and $t+s$ in the absence of a pension freeze. Recall that for a given individual, $\delta_{t,\ s} = kZ_{t,\ R}\, Y_t E_t\{\,(N_s - N_t) + g_{t,\ s}N_s\,\}$.

For each plan as a whole, we compute two measures of δ. The first includes accruals by all future workers, including both current workers and new workers that join the firm between t and s.[25] We compute this measure for s from 1 to 10 years. This captures how much a firm could potentially save by freezing its plan today (time t) rather than at time $t+s$ in the future. However, because it measures a cross-section of accruals for all workers rather than tracking workers throughout their careers, this measure will miss an important piece of the one-time cost savings that arise from cutting the future accruals of then older and more senior workers.[26] To capture the full transitional cost savings, we estimate a second, cohort-based, measure that restricts the population to include only current workers (i.e., it excludes accruals of workers who will be hired by the firm in the future), but tracks the current workers forward for a longer period of their future tenure at the firm (up to 45 years) and sums the present value of all of the corresponding

[22] The age-service tables are not in a standardized form or collected electronically. The DOL made scanned Form 5500 attachments publicly available during the summer of 2011 for all years between 2003 and 2011. Data were manually entered from these age-service matrices into spreadsheets, and we subsequently standardized them for a uniform definition of age and service groups.

[23] The results are not sensitive to the inclusion or exclusion of the roughly 100 observations obtainable for 1999 to 2002. We requested this subset of paper attachments based on a pilot of sample-plan freezes that we identified from public news announcements.

[24] Because of other data requirements, we only use 175 of these for our sample (see later sections). Prior to the announcement, 52 of the 175 plans have a cash balance feature.

[25] This measure is sometimes referred to as the "open group" measure because it assumes the plan is open to future workers.

[26] For example, consider a steady state with a similar number of workers at each age. If pensions represent implicit contracts for higher future compensation, the cost savings from freezing now could be very similar to the cost savings from freezing 10 years from now, leading the differential between the two to be small, even though there would be large "transition" savings from the freeze (either now or in 10 years).

Table 1
Sample selection of defined benefit plans.
This table describes our sample selection process. First, we identify all defined benefit (DB) plans filing Form 5500 with the Internal Revenue Service and the Department of Labor (Column 1). Second, we extract the subset of plans sponsored by companies covered by Compustat (Column 2). Our methodology requires the disclosure of the age-service matrix, which is only mandated for plans with >1000 active participants. We therefore restrict the sample based on whether the plan reported >1000 active participants for at least one year during our sample period (Column 3). The age-service matrix is disclosed in the attachments to Form 5500. We screen our sample for the availability of such attachments (Column 4). We manually search these filings for the age-service matrices that contain participants and salary information. We report the number of plans for which participant information is available in Column 5. For confidentiality purposes, the salary information is only disclosed for cells with >20 participants. We report the number of plans for which salary information exists in Column 6. As a first screen test, we identify hard freezes based on the plan disclosure from Form 5500 (Column 7). Separately, we identify all DB plans that disclose a cash balance feature (Column 8). When these plans disclose a cash balance plan (CB) table in the attachments, we report it in Column 9.

Fiscal year	Universe	Linked to Compustat	w/ at least 1000 active	w/ attachments	w/ participants table	w/ salary table	w/ hard freeze code	w/ CB code	w/ cash balance table
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1999	27,733	3335	1061	45	45	35	0	5	0
2000	39,270	4311	1386	22	17	15	0	5	0
2001	40,984	4284	1413	42	28	22	0	6	0
2002	40,904	4065	1380	51	51	43	3	10	0
2003	41,171	3912	1373	1228	1205	925	53	271	214
2004	41,285	3729	1333	1296	1274	988	73	291	260
2005	41,981	3745	1342	1322	1307	991	100	313	270
2006	42,413	3604	1321	1238	1197	862	126	284	251
2007	42,609	3429	1286	1175	1137	780	159	292	255
2008	47,376	3092	1197	935	906	614	167	233	211
2009	36,639	2605	1055	1044	1035	705	189	307	265
2010	17,208	526	168	153	147	88	27	32	27
2011	13								
Total	459,586	40,637	14,315	8551	8349	6068	897	2049	1753

accruals.[27] The 45-year version of this measure is equal to the present value of all accruals that would be avoided by implementing a hard freeze today instead of a soft freeze today.

Our calculations of cost savings make the identifying assumption that in the absence of the freeze there would have been no changes in plan parameters or in worker entry and exit. In addition, when we compare these foregone DB accruals to 401(k) contribution increases, the identifying assumption is that contributions to defined contribution plans would have, in the absence of the freeze, remained the same as a percent of salary as they were before the freeze.

4.3. Measurement of accruals

We estimate $\delta_{t,s}$ for both freeze and non-freeze firms over various horizons. Estimating $\delta_{t,s}$ requires information on projected future salaries and years of service, as well as benefit parameters and discount rates. To obtain these estimates, we use a combination of i) plan-level summary information and ii) worker-level data from the plan's age-service-salary matrices. We summarize our methodology in the following sections, with some additional details provided in Appendix C.

We first estimate future salaries and salary growth, and do so separately for traditional and cash balance plans using the salary information in the age-service-salary matrices in the years preceding the freeze. Our presumption is that salary growth is persistent at the plan level and does not change significantly from year to year. Thus, in the absence of a freeze, salaries are expected to grow at the same rate as in the past. We further apply the estimated plan level salary growth to individual participants' salaries in each age-service cell of the matrix to estimate their level in future years. Missing salary levels for some age-service groups were estimated from regressions on available data.

Next, we measure years of service. If no workers transitioned in or out of employment with the firm, then the number of years of service of each worker would simply increase by one per year. In practice, of course, entries and exits do occur, and we therefore need to incorporate these into our analysis. We use repeated snapshots of the age-service matrices to estimate the entries and exits (separations) as a percentage of total participants by age groups each year, at the plan and industry level. Entry is easily identified in the first column of the matrix each year, and exit is estimated from matrix snapshots at five-year intervals on a rolling window.

Next, measuring the change in accrued benefits over any given horizon requires estimates, at the plan level, of the benefit factor (k), the rate of salary growth, and the discount rate.

(a) The benefit factor (k). In the absence of direct information on the benefit factor, k, we impute an estimate of k from two different accrual measures: a plan-level service cost measure from Form 5500, and a plan-level measure that we compute up to an unknown scalar k by aggregating information based on age, salary, and years of service. We then compute the value of k that equalizes these two service costs. Note that because we model simplified plans, the benefit factors we estimate reflect a range of plan features that affect accrual rates, not just the benefit factors themselves. These might include different COLAs, retirement ages, and vesting provisions.

(b) Discount rates (i). Regulations require firms to use market-based discount rates in calculating their current liability for the IRS Form 5500 filing. We assume that this regulatory discount rate is the same as the market rate for discounting future liabilities and accruals.[28]

[27] This measure is sometimes referred to as the "closed group" measure because it assumes the plan is closed to future workers. For both measures, we incorporate estimates of exit / separation rates from the workforce. The separating probability from the plan is integrated for all future years and for all age-service groups. Our estimation is not able to differentiate participants who retire from those who leave the firm. However, the exit probability for older and longer-tenured employees is most likely due to retirement. For DC costs, we use the same assumptions about future entry into and future exit from the workforce as we use to compute the corresponding DB accruals. We are thereby implicitly assuming that the future worker entry and exit rates are unaffected by the freeze.

[28] To the extent that a pension promise from the perspective of the firm is equivalent to a defaultable corporate bond, a corporate bond rate is the appropriate discount rate concept. Existing rules allow however for some flexibility in firms' selection of rates that may or may not be related to underlying risk factors. For 2002 to 2003, the current liability discount rate could not be >20% above or 10% below the weighted average of interest rates (set by the U.S. Department of the Treasury) on the rates of interest on 30-year Treasury securities during the past four years. For 2004 to 2006, the current liability discount rate could not be >10% above or below the weighted average of interest rates on long-term investment-grade corporate bonds during the previous four years. For 2007 to 2010, pursuant to the Pension Protection Act, a procedure was phased in whereby the funding standard liability would be calculated using a three-segment high-quality corporate bond yield curve published by the Treasury Department. In the period after our sample, these rules were relaxed considerably by MAP-21 legislation in 2012.

(c) The pay credit (h) is hand-collected from the paper attachments to IRS Form 5500, for a subsample of CBP freeze and CBP non-freeze plans (182 plans). We find that in 40% of cases it is a flat percentage of salary, in 13% of cases depends on age, in 20% of cases depends on service and in 28% of cases it depends both on age and service.

Finally, our cost savings analysis requires an estimate of the difference between future 401(k) contributions made by the sponsor after the freeze and what those 401(k) contributions would have been in the absence of a freeze. Because we obviously cannot observe contributions under this counterfactual, we estimate them by assuming that in the absence of a freeze, future 401(k) contributions as a percent of salary would remain constant.[29] We estimate current and actual future DC contributions by aggregating (using Form 5500 Schedule H) all actual contributions made by the sponsor to all of its 401(k) plans for each relevant year. Any difference between the actual reported employer contribution and the projected employer contribution is then attributed to the accounts of the DB participants now included in these DC plans. We translate the incremental 401(k) contributions that we calculate into a present value by using the formula of a growing annuity (over 1 to 10 years) and assuming constant salary growth, to be consistent with the measurement of the DB accruals.[30]

4.4. Summary statistics on freeze and non-freeze plans

Table 2 shows that the freeze and non-freeze plans in our sample differ on a variety of observable dimensions. The columns labeled freezes are based on only pre-freeze data. Panel A examines traditional DB plans, i.e. excluding CB plans, while panel B examines CB plans.

Firms that freeze pension plans are smaller; they have an average of \$22.5 billion in book assets (from Compustat) compared with \$36.9 billion for non-freeze firms. They are also more leveraged, have lower interest coverage, and have smaller operating margins. The plans of firms that freeze are also smaller - before the freeze they have both fewer total participants (a difference of 4288 at the mean), fewer total liabilities (by \$316 million at the mean), and lower total payroll by \$101 million. Payroll as a percent of total assets is significantly higher for plans that freeze: 7.8% vs 4.8% at the mean. This fact suggests that labor costs are more important for firms that freeze than for firms that do not.

Freeze plans also appear to be in worse financial condition than those that do not freeze, as they have funding ratios that are on average 9% lower than non-freeze firms before the freeze. Freeze plans have a higher ratio of active participants to total participants by 5.5%, suggesting that relatively more of the liability is coming from promises to active employees. However, freeze plans use slightly lower pension discount rates, which is interesting in light of the fact that freeze plans have a higher share of active workers than non-freeze plans, and thus would in theory support higher average discount rates. One possibility is that sponsors make plans look more underfunded before the freeze to negotiate with participants (see for example Comprix and Muller (2011)).

According to the plans' own reporting, service costs (accruals) for freeze plans are somewhat lower as a share of payroll, by around 0.9% at the mean. However, these service costs are higher as a percentage of total sponsor assets, reflecting the fact that total assets are smaller. The differences presented in the table suggest that the expected growth rate of the total liability and cost as a percentage of corporate assets are higher for firms that are about to be frozen than firms that are not. Indeed, based on estimates described in the previous section, freeze firms have benefit factors that are 9 basis points greater than firms that do not freeze.

Looking at Panel B of Table 2 (CB plans), we observe broadly similar patterns. CB plans that ultimately freeze have worse funding and a higher ratio of active participants. In contrast to the relation between freeze and non-freeze traditional DB plans, there is some evidence that the CB plans that ultimately freeze are, at the mean, somewhat larger than those that do not. Finally, as was the case with traditional DB plans, the CB plans that ultimately freeze have lower service costs as a share of payroll but higher service costs as a fraction of corporate assets.

4.5. The freeze decision and matched control samples

To examine whether the decision to freeze is in part driven by prospective accruals, we use propensity score–matched control samples, and we also estimate a linear probability model. Our identifying assumption is that prospective accruals are uncorrelated with omitted factors that could be leading firms to freeze.

The goal of using our control samples is to eliminate the confounding factors of unobserved industry-level trends, year-level correlations such as changes in regulation following the Pension Protection Act of 2006, and other potential covariates. We construct five control samples for this analysis: 1) *Non-freezes*, the entire universe of plans that did not freeze during our sample period for which age-service tables were available; 2) *Ind Controls,* the subsample of the non-freezes within the same two-digit SIC code and year; 3) *PS Match1,* the subsample of the non-freezes group matched on propensity scores calculated based on two-digit SIC, ABO, and year; 4) *PS Match2*, the subsample of the non-freezes group matched on propensity scores calculated based on two-digit SIC, ABO funding ratio, and year; and 5) *PS Match3*, the subsample of the non-freezes group matched on propensity scores based on two-digit SIC, ABO, funding ratio, and year. The propensity score is the conditional probability of treatment assignment given ex ante variables (Rosenbaum and Rubin (1983, 1985); Heckman and Vytlacil (2007)). We follow a similar matching procedure to identify matched plans for CB plans freezes from a large sample of CB plans that did not freeze, among observations for which the pay credit is available.

The final treatment sample includes 116 traditional pension freezes and 40 cash balance freezes. Our control groups have 4896 plans, 1634 industry control plans, and 116 PS Matched plans. Similarly, we identify 1641 non-freeze CB plans and 40 PS Matched CB plans.

The purpose of developing these control groups is to assess the extent to which higher accruals in fact influence a firm's decision to freeze their DB or CB plan. This hypothesis contrasts with two main alternatives. First, sponsor financing constraints may make the sponsorship of DB plans costly – given the typical equity-heavy pension fund portfolio, firms face the risk of having to contribute more to DB plans during times when they have profitable investment opportunities. Second, it is possible that firms freeze DB plans and introduce DC plans in response to changes over time in the value that employees place on having a DB pension, whose value to the employee rises convexly with the number of years the employee works at the firm.

The construction of PS Match2 and PS Match3 are specifically created to address the possibility that higher accruals could be correlated with greater financing constraints, since large plans with high levels of unfunded liabilities are more likely to create financial hardship for the sponsor in coming years. Regarding the second alternative hypothesis, while firms with higher accruals could in theory be the same firms where workers value the DB plan less, in practice, this seems very unlikely. If freeze firm employees valued the DB less than employees at control firms, then why would they have ended up at a point where they have higher accruals than employees control firms? We also address this question more directly, as we include an industry level mobility control in our linear probability model.

[29] Because there is no salary information in Form 5500 for DC plans, we assume that the rate of salary growth for existing participants in the 401(k) plan is the same as the rate of salary growth for participants in the DB plans.

[30] We use the same discount rate that we used for DB accruals earlier (again ignoring any adjustment for salary risk).

Table 2
Sample statistics: Freeze plans versus non-frozen plans.
The table presents the characteristics of plans that have been frozen (for all years preceding the freeze) relative to all plans that have not been frozen. In Panel A, we report the average characteristics for freeze and non-freeze defined benefit (DB) plans (excluding cash balance (CB) plans), while in Panel B we focus on DB plans with a CB feature. *Funding (%)* is defined as plan assets minus plan liabilities divided by plan liabilities. Both plan assets and plan liabilities are collected from Form 5500. The pension liability disclosed in Form 5500 is commonly referred to as the accumulated benefit obligation (ABO) and represents the present value of all accrued benefits. *Active participants (%)* is the ratio between the number of active participants and the number of total participants, as reported in Form 5500. *Salary per active participant* is calculated based on the age-service salary information. *Service cost* is the reported expected increase of pension benefits during the year, as reported in Form 5500. *Payroll* is the sum of all participants' salaries, as reported in the age-service tables. *Discount rate* is the rate used to discount future expected pension benefits, as reported in Form 5500. The *benefit factor* and *salary growth* are both estimated based on the collected age-service tables.

	Panel A: DB excluding CB						Panel B: CB only					
	N	Freezes	N	Non-freezes	Diff		N	Freezes	N	Non-freezes	Diff	
Sponsor level												
Total assets (sponsor) ($mil)	399	22,545	4897	36,932	−14,387	***	184	42,355	1625	61,860	−19,505	*
Market leverage	366	0.34	4329	0.3	0.04	**	156	0.37	1502	0.33	0.04	
Interest coverage	356	7.64	4313	10.23	−2.59	**	151	5.92	1475	8.57	−2.65	**
EBITDA/Sales	391	0.15	4614	0.17	−0.02	***	172	0.18	1571	0.2	−0.02	
Plan level												
ABO ($mil)	409	397	4981	713	−316	***	181	2058	1624	1182	876	*
ABO/Total assets (sponsor)	399	10.60%	4622	8.10%	0.02	***	181	11.10%	1624	8.30%	0.028	*
ABO/Payroll	409	179.70%	4977	232.80%	−53.0%	***	176	241.60%	1624	295.30%	−53.7%	
Payroll ($mil)	411	232	5023	333	−101	***	184	868.26	1625	607.4	260.9	
Payroll/Total assets (sponsor)	397	7.80%	4634	4.80%	3.00%	***	184	7.60%	1625	4.50%	3.10%	***
Salary per active participant	411	51,904	5022	58,578	−6673	***	181	54,775	1619	62,213	−7438	
Active participants (%)	407	55.70%	4973	50.20%	5.50%	***	181	61.80%	1620	54.60%	7.20%	***
Total participants	409	9522	4988	13,810	−4288	***	181	33,890	1624	23,149	10,741	*
Funding (%)	409	−6.20%	4977	2.90%	−9.10%	***	181	−1.34%	1624	2.46%	−3.80%	*
Service Cost/Payroll	409	5.67%	4978	6.57%	−0.90%	**	176	5.60%	1624	7.90%	−2.30%	
Service Cost/Total assets	409	0.60%	4974	0.40%	0.20%	***	181	0.78%	1624	0.41%	0.40%	***
Discount rate (%)	411	6.15%	5022	6.26%	−0.11%	***	171	6.10%	1625	6.30%	−0.10%	**
Salary growth (%)	411	4.45%	5022	4.36%	0.09%		171	4.80%	1625	4.30%	0.50%	*

5. Results

5.1. Accrual comparisons

In this section, we first document that the projected future DB accruals of freeze plans (conditional on not freezing) are larger than those of non-freeze plans. Then, using propensity control samples, we show that the savings achieved through the plan freeze are not due to other observable factors that could have led to cost savings even in the absence of freezing. Finally, we test the hypothesis that the higher accruals cause firms to freeze by using a linear probability model, and we include additional controls to capture possible confounding factors correlated with high accruals.

Table 3 shows the results of our accrual estimations. Panel A includes summary statistics for inputs to the accrual calculation including the salary growth, discount rate, benefit factor, and employee entry and

Table 3
Projected defined benefit plan accruals for plans in absence of freeze (plan level).
In Panel A, we report summary statistics of various components used in the estimation of benefit accruals. *Entry Ratio* is calculated as the ratio of participants with less than one year of service and total participants in the previous year. *Exit Ratio* is calculated based on the exit probability that we describe in the text, calculated first at the cell level and then value-weighted using the number of total participants in the previous year. *Salary Growth* is a plan level variable, calculated at the plan level based on the growth of salary and the number of participants at the cell level. *Discount Rate* comes from IRS Form 5500. *Benefit Factor* calculation is described in the text. In Panel B we report the estimated accruals for freeze relative to non-freeze plans. For freezes, the table shows the estimated accrual based on the age-service table for the year preceding the freeze. $\delta_{t,s}$ is the estimated benefit accrual for regular plans. *Non-freezes* refer to the group of plans that have not been frozen during the sample period. *Ind Controls* constrains the non-freezes group based on the two-digit SIC code and year. *PS Match1* selects a matched nonfreezes group based on propensity scores calculated based on two-digit SIC, ABO, and year. *PS Match2* selects a matched non-freezes group based on propensity scores calculated based on two-digit SIC, year, and the funding ratio. *PS Match3* selects a matched non-freezes group based on propensity scores calculated based on two-digit SIC, ABO, year, and the funding ratio.***, **, * indicate the statistical significance of 0.01, 0.05, and 0.1, respectively, of the difference between the estimated benefit accruals of freezes relative to the control group for the first year following the freeze.

Panel A: components of the DB accrual calculation (excluding CB)

	Freezes					PS Match1				
	Entry ratio	Exit ratio	Salary growth	Discount rate	Benefit factor	Entry ratio	Exit ratio	Salary growth	Discount rate	Benefit factor
Min	0.01%	6.14%	−1.21%	4.59%	0.01%	0.01%	4.41%	0.36%	4.59%	0.07%
Mean	5.89%	10.82%	4.49%	6.15%	1.32%	5.78%	8.99%	4.44%	6.26%	1.26%
Median	4.80%	8.90%	4.40%	6.10%	1.10%	5.31%	8.35%	4.47%	6.10%	1.09%
Max	46.10%	72.24%	11.18%	8.26%	4.00%	22.90%	38.17%	11.18%	8.50%	4.00%
N	116	116	116	116	116	116	116	116	116	116

Panel B: $\delta_{t,s}$ / total assets, freeze plans versus non-frozen plans (excluding CB)

		Savings from current and future workers			Savings from current workers only	
	No. sponsors	Year +1	Year +5	Year +10	Year +10	Year +45
Freezes	116	0.0041	0.0181	0.0321	0.0312	0.0514
Non-freezes	4896	0.0026***	0.0119***	0.0217***	0.0200***	0.0326***
Ind Controls	1634	0.0026***	0.0119***	0.0219***	0.0199***	0.0330***
PS Match1	116	0.0022***	0.0103***	0.0192***	0.0173***	0.0287***
PS Match2	116	0.0023***	0.0108***	0.0198***	0.0181***	0.0300***
PS Match3	116	0.0022***	0.0102***	0.0188***	0.0173***	0.0289***

Table 4
Projected cash balance plan accruals for plans in absence of freeze (plan level).
In Panel A, we report summary statistics of various components used in the estimation of benefit accruals for CB plans. *Entry Ratio* is calculated as the ratio of participants with less than one year of service and total participants in the previous year. *Exit Ratio* is calculated based on the exit probability that we describe in the text, calculated first at the cell level and then value-weighted using the number of total participants in the previous year. *Salary Growth* is a plan level variable, calculated at the plan level based on the growth of salary and the number of participants at the cell level. *Discount Rate* and *Pay Credit* come from IRS Form 5500. In Panel B we report the estimated accruals for CB freeze relative to CB non-freeze plans. $\delta_{t,s}$ is the estimated benefit accrual for regular plans. $\delta_{t,s}^{CB}$ is the estimated benefit accrual for CB plans. *PS Match1* selects a matched nonfreezes group based on propensity scores calculated based on two-digit SIC, ABO, and year. *PS Match2* selects a matched non-freezes group based on propensity scores calculated based on two-digit SIC, year, and the funding ratio. *PS Match3* selects a matched non-freezes group based on propensity scores calculated based on two-digit SIC, ABO, year, and the funding ratio.***, **, * indicate the statistical significance of 0.01, 0.05, and 0.1, respectively, of the difference between the estimated benefit accruals of freezes relative to the control group for the first year following the freeze.

Panel A: components of the CB accrual calculation

	CBP Freezes					CBP PS Match1				
	Entry ratio	Exit ratio	Salary growth	Discount rate	Pay credit	Entry ratio	Exit ratio	Salary growth	Discount rate	Pay credit
Min	0.04%	5.01%	−0.66%	4.98%	2.00%	0.01%	4.33%	−2.67%	4.98%	2.00%
Mean	7.00%	9.10%	4.35%	6.02%	4.80%	7.00%	9.18%	4.32%	6.20%	4.26%
Median	7.01%	9.21%	4.19%	6.01%	4.97%	6.26%	8.66%	4.35%	6.10%	4.05%
Max	30.80%	14.02%	8.65%	8.25%	10.29%	30.54%	17.04%	11.79%	8.25%	7.80%
N	40	40	40	40	40	40	40	40	40	40

Panel B: $\delta_{t,s}^{CB}$ / total assets, freeze plans versus non-frozen plans (CB only)

	No. plans	Savings from current and future workers			Savings from current workers only	
	Obs	Year +1	Year +5	Year +10	Year +10	Year +45
Freezes	40	0.0027	0.0119	0.0190	0.0176	0.0242
PS Match1	40	0.0019*	0.0081*	0.0128*	0.0122*	0.0166*
PS Match2	40	0.0016***	0.0070**	0.0117**	0.0105**	0.0150**
PS Match3	40	0.0011***	0.0050***	0.0084***	0.0076***	0.0105***

exit rates (see Table for descriptions). Panel B presents $\delta_{t,\ s}$, our measure of the reduction in accruals that would occur by freezing today (t) rather than freezing *s* years in the future. We scale accruals by total firm assets, under the assumption that the firm cares about the cost savings of the freeze compared with the total value of the firm.

As discussed earlier, we compute two measures of accruals: one that includes accruals by all current *and future* workers and one that includes only current workers. The first measure, presented on the left of panel B, captures how much a firm could potentially save by freezing its plan today rather than in the future and measures a cross-section of accruals for all workers rather than tracking workers throughout their careers. The second measure, presented on the right of panel B, captures the full transitional cost savings of all current workers through the end of their career, when accruals are relatively higher. This distinction allows us to differentiate between savings coming from current and future employees, whereby we do not attempt to estimate long-horizon savings from future employees given the uncertainty about future entry rates.

Accruals for current and future workers are estimated for 1, 5, and 10 years. The first row contains the $\delta_{t,s}$ for plans that froze. We estimate that in the absence of the freeze, projected 1-year accruals would have been 0.41% of assets and 10-year accruals would have been 3.2% of current firm assets. The second row presents comparable data on plans that were not frozen. The projected one-year accruals for these plans were 0.26% of assets. The absolute difference between counterfactual freeze and projected non-freeze plan accruals amounts to 0.15% (=0.0041–0.0026) of assets at a 1-year horizon and 1.04% (=0.0321–0.0217) of assets at a 10-year horizon (these differences are statistically significant at the 1% level). Thus, had the freeze plans not frozen, their subsequent one-year accruals would have been 57% higher (0.41% of assets compared with 0.26% of assets) and their 10-year accruals 48% higher than comparable accruals for non-freeze plans. Restricting the control sample to the plans that are in the same two-digit SIC industry and year as the freeze plans yields very similar results. Thus, plans that freeze have greater potential cost savings from halting accruals than plans that do not freeze.

As we saw in the comparison of means in Table 2, plans that freeze differ in meaningful ways from plans that do not freeze. Most critically, they are smaller in terms of total liabilities, and they also have lower funding ratios.[31] The PS Match lines in Table 3 show the counterfactual freeze plan accruals relative to the projected accruals of propensity score–matched firms that do not freeze. The accruals of the propensity score–matched samples are in almost all cases slightly lower than the accruals of the larger and more general control samples. Overall, comparing the estimated counterfactual accruals of the freeze plans with the estimated accruals of the PS Matched control plans yields very similar results to the differences we find when we use the larger and more general control samples.[32]

The right panel of Table 3 shows analogous accruals calculations for current workers only. The estimated forgone accruals on a 10-year horizon for current workers are only marginally smaller than those estimated in the left panel for current and future workers, which is a reflection of relatively small accruals for new hires over the first 10 years, as well as relatively low entry rates. For the 45-year measures, we find that the present value of future accruals for current workers is 5.1% of current firm assets, or 65% higher than the 10-year measure. In both the 10-year and 45-year calculations, we find that counterfactual accruals for freeze firms are around 56% higher than for non-freezes, and even larger relative to the PS matched samples.

Table 4 shows that future accruals are also larger CB plan freezes compared to a set of similarly constructed controls. Pay credit is calculated as a participant-weighted average across different age-service groups. We find that mean entry and exit ratios, salary growth, and discount rates are similar across freeze and non-freeze plans, while mean pay credit is somewhat higher for freeze than for non-freeze plans. In Panel B of Table 4 we show accrual calculations for the freeze and control samples of CB plans. As with traditional DB, we find that plans

[31] Other inputs, such as mean salary growth, entry rates, discount rates, and benefit factors are similar for freeze and the non-freeze PS matched firms (see Table 3 panel A for statistics on the PS1 sample, as an example).

[32] In separate analyses, we also examine whether freeze and non-freeze firms share common trends before freezes occur. Our results, as shown in Appendix Fig. A.4, show no significant differentials, suggesting that firms are not flattening out their benefit structures before the freeze.

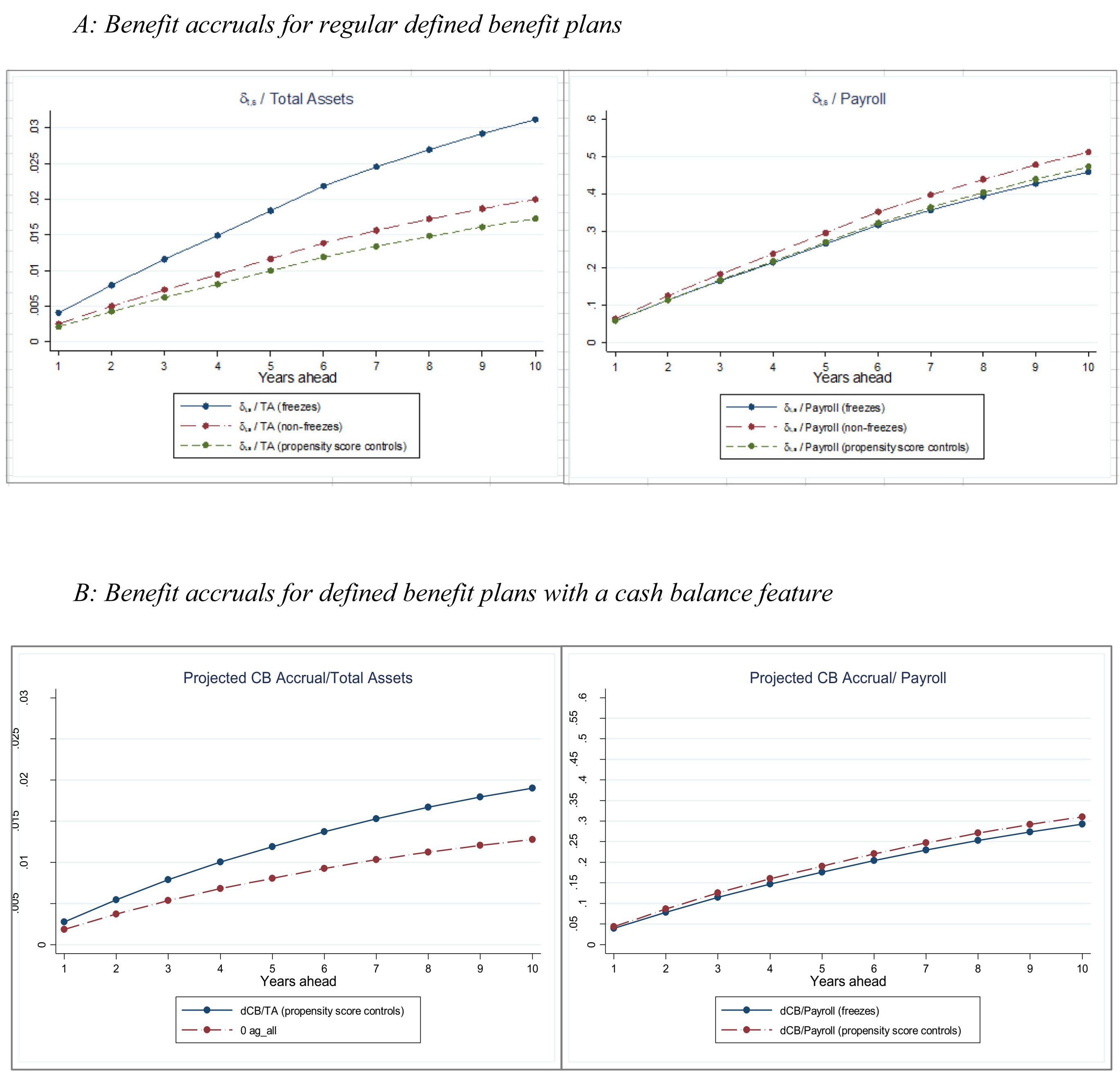


Fig. 2. Projected benefit accruals for freezes and controls. The table shows projected benefit accruals as a percentage of the payroll and of total sponsor assets for traditional defined benefit plans (Panel A) and cash balance plans (Panel B). Each graph includes estimates for three different groups: freezes, non-freezes, and propensity control plans. Panel A: Benefit accruals for regular defined benefit plans. Panel B: Benefit accruals for defined benefit plans with a cash balance feature.

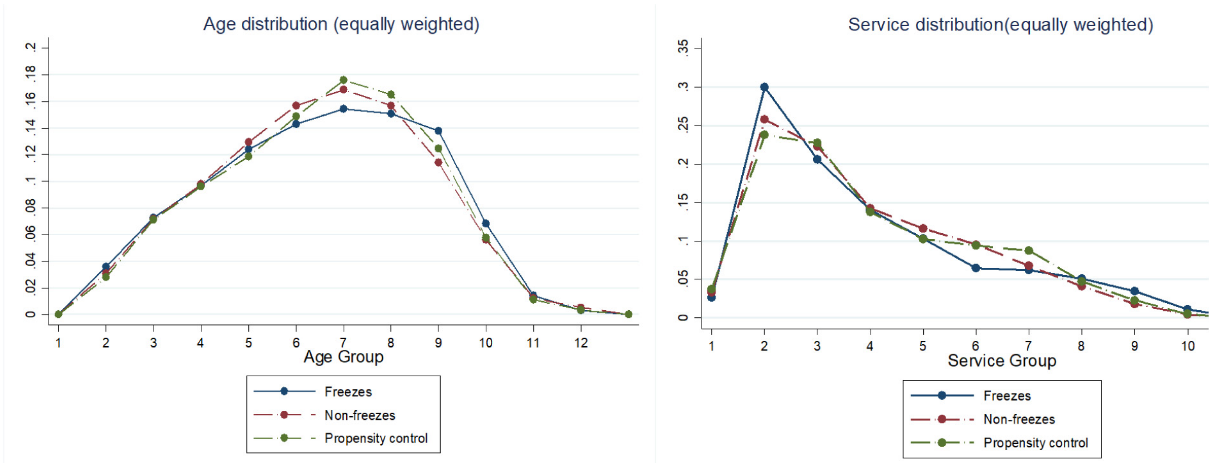
that froze had higher projected accruals than comparable plans that did not freeze. For example, for PS1, the difference amounts to 0.08% (= 0.0027–0.0019) of assets at a 1-year horizon and 0.62% (=0.0190–0.0128) of assets at a 10-year horizon.[33]

Fig. 2 illustrates these patterns graphically, where the most relevant comparison is the accruals of the freeze sample (solid line) to the accruals of the matched controls (dotted line). The upper-left graph shows the accruals scaled by total assets. The lower-left graph does the same for CB plans. These graphs correspond directly to the rows in panel B Tables 3 and 4, respectively.

We also examine the relations in panel B of Tables 3 and 4 and in Fig. 2 for an alternative scaling measure: accruals as a share of payroll (see the right side of Fig. 2 for the comparable graphs). Under this scaling, the differences are not significant. The graphs show that when scaling by total payroll, both the unmatched and the matched sample of non-freeze firms have larger accruals as a share of payroll than the freeze firms, but again these differences are insignificant. These results reflect the fact that non-freeze firms have much higher assets but similar payroll to freeze firms, i.e. that freeze firms have a much higher ratio of payroll to assets (see Table 2). The difference in accruals as a share of total assets is therefore in part because freeze firms have relatively larger payrolls relative to assets, and in part to the different age-service distributions and plan parameters (higher benefit factors and salary growth) of freeze firms.

Fig. 3 examines one potential explanation for why freeze and non-freeze plans could differ in their accruals: specifically, the age and service distribution of the workforce. The left graph shows the age

[33] The results for CB plans differ across control groups more than they did for the DB plans. This may be due to the smaller sample sizes.



Age Group	1	2	3	4	5	6	7	8	9	10
Age	<20	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
Differences										
Freeze - All Controls		0.005*	0.001	-0.001	-0.005	-0.014*	-0.015***	-0.006***	0.024**	0.012
Freeze - PS Match		0.008*	0.001	0.001	0.005	-0.006	-0.021*	-0.014**	0.013	0.010

Service Group	1	2	3	4	5	6	7	8	9	10
Service	<1	1-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44
Differences										
Freeze - All Controls	-0.007	0.042***	-0.017*	-0.003	-0.013***	-0.030***	-0.006***	0.010***	0.017***	0.006
Freeze - PS Match	-0.012*	0.062***	-0.021	0.002	0.001	-0.029**	-0.025*	0.004	0.012	0.006

Fig. 3. Age distributions and service distributions for freeze and control firms. The figure shows the age distribution and the service distribution for freeze firms, non-freeze firms, and propensity score matched controls. ***, **, * indicate the statistical significance of 0.01, 0.05, and 0.1, respectively, of these differences.

distribution of freeze and non-freeze plans, and the right graph shows the service distributions.[34] Below the graphs we show tests of statistical significance for differences at each point. Freeze firms have more workers aged 55 to 64 and fewer workers aged 40 to 54 than comparable firms that do not freeze. Specifically, around 1.5% less of the workforce is 40 to 44 years old, around 1.5% less of the workforce is 45 to 49 years old, around 2.5% more of the workforce is 55 to 59, and around 1% more of the workforce is 60 to 64. Service patterns are similar but more extreme. Freeze plans have a higher share of very long-tenured employees with 30 years or more service, and a correspondingly lower share of workers with 5 to 29 years of service.

To further isolate the *relative* importance of various accrual factors that explain the observed accrual differences between freeze and non-freeze firms presented in Table 3, we undertake in Table 5 a more precise decomposition of these differences based on benefit-related parameters, demographic factors, and the size of the labor force relative to firm assets.[35] In each panel, the starting point is the counterfactual prospective DB accruals (including current and future workers) relative to assets for freeze firms. The characteristics of each firm are then replaced with those of the propensity score–matched controls sequentially and cumulatively, and the prospective DB accruals are recalculated.

In all cases, adjusting for both the total sponsor assets and the total number of participants has a substantial effect on accruals. For example, in PS Match1, the combined effect decreases accruals from 0.0041 to 0.0031—about half of the differential accruals between the freeze plans and their matched sample.[36] This fact suggests that labor is more important in the firm production function for sponsors that freeze their plans than for those that do not. The plan age-service distribution of participants (demographics) and salaries (human capital) have a further effect of decreasing the difference in accruals by about 21% (that is, (0.0031–0.0027)/(0.0041–0.0022)). The remaining difference of about 26% is attributed to the combined effect of plan-level assumptions on the benefit formulas (the benefit factor, salary growth, and the discount factor).

To further examine whether the decision to freeze is related to prospective accruals, we estimate a linear probability model for the probability of a freeze. This analysis follows from the identification concern that firms with higher accruals may be more likely to freeze for other reasons. We therefore include in the estimation a number of controls, such as firm level financial constraints, plan health, and labor market characteristics.

For instance, firms in a weak financial position, as reflected by profitability and interest coverage ratios, might freeze plans to avoid the liquidity or cash-flow problems associated with having to fund DB plans. Sponsors of worse-funded plans have greater incentives to freeze plans for corporate financial purposes. Finally, firms with strong employee representation (such as unions) may be expected to help employees to recuperate more of the losses from the foregone accruals through salary increases or greater contributions to the DC plans that will replace DB accruals.

Table 6 shows the results of our linear probability model that examines the impact of one-year accruals on the probability of freezing.[37] Plan-year observations after the plan has been frozen are excluded, and all standard errors are clustered at the firm level. The first column shows that firms with higher estimated accruals as a share of total firm assets ($\delta_{t,t+1}$ /*TA*) in the year following the freeze are more likely

[34] For the freeze plans, the graphs are based only on observations in years before the freeze.

[35] Our exploration is motivated, for example, by the observation that freeze firms have a more pronounced group of older and longer-tenured workers. Appendix Fig. A.3 shows the joint age-service distribution for freeze plans (Panel A), non-freeze plans (Panel B), and the difference between the two (Panel C).

[36] The results hold independent of the particular propensity score control sample used.

[37] Results are qualitatively similar using a probit model.

to freeze, controlling for the size of the plan. The marginal effect is 1.7, which implies that for each 1 percentage point increase in DB accruals scaled by total assets, there is a 1.7 percentage point higher probability of the plan freezing. One standard deviation of $\delta_{t,t+1}/TA$ is 0.4%, so a plan with one standard deviation more accruals is 0.7 (=0.4*1.7) percentage points more likely to be frozen, which compares with an unconditional sample freeze probability of 2.2%.[38]

The next two columns explore further whether the effect comes from within-industry variation or from within-firm variation. Column (2) includes industry fixed effects. It reveals that within industries, firms with larger savings are more likely to freeze, suggesting that competitive effects are likely important determinants of freeze decisions. Column (3), which includes firm fixed effects, addresses a different question, which is the timing of the freeze for firms that choose to freeze, as there is no variation over time in the dependent variable for a given non-freeze firm. The results show that the timing of the freeze is driven by sponsor and plan financial characteristics, such as lower profitability and interest coverage and worsening funding status. As the DB accruals themselves do not vary substantially for a given firm across time, the accruals are not a statistically significant predictor of when a given freeze will occur.

The remaining columns explore the impact of industry-level labor market characteristics, such as labor tightness, labor mobility, and average tenure. Across industries, freezes are more likely to occur where jobs are more likely to be available and job-to-job transitions are high. However, changes of these industry level variables over time do not appear to have a significant impact on pension freezes.[39] We conclude that while the decision to freeze is a combined result of industry and firm level pressures, cost savings remain an important element of this decision.

5.2. Realized cost savings

In this section, we analyze the degree to which the drop in DB costs due to a freeze is offset by an increase in DC costs. If the employer increases DC contributions by as much as (or more than) the DB accruals would have been in the absence of the freeze, then the firm does not save any costs. For this exercise, we are interested in the absolute amount of ex-post cost savings of firms that froze, rather than the amount relative to those that did not freeze.[40] We make the identifying assumption that had they not frozen, freeze firms' 401(k) contributions as a percent of payroll would have stayed the same. We also assume that there are no other offsets to the employees, such as improvements in non-pension fringe benefits or compensating salary changes (we address the latter in the next section).

Table 7 shows counterfactual DB accruals and estimated actual increases in 401(k) contributions for both firms that freeze traditional DB plans and those that freeze CB plans, at the sponsor-firm level.[41] Given that 401 k contributions are more naturally presented as a percentage of salary, the table reports savings also as a percentage of payroll.

The left side of the table estimates the cost savings for all workers from freezing the plan today instead of freezing 1, 5, and 10 years in the future. The right side of the table shows the cost savings from current workers only, over 10 years (for comparison) and 45 years (at which point all current workers will have separated from the firm).

Table 5
Decomposition of accrual differences between freeze and non-freeze firms.
This table decomposes the differences between freeze firms and propensity score–matched control plans into benefit-related parameters, demographic factors, and the size of the labor force relative to firm assets. In each panel, the starting point is the counterfactual prospective defined benefit (DB) accruals for freeze plans. The characteristics of each plan are then replaced with those of the propensity score–matched controls sequentially and cumulatively, and the prospective DB accruals are re-calculated.

	$\delta_{t,s}/TA$ (Year +1)	$\delta_{t,s}/TA$ (Year +5)	$\delta_{t,s}/TA$ (Year +10)
Freezes	0.0041	0.0181	0.0321
Sequential changes in characteristics to PS Match1			
Plan-level scaling			
Sponsor assets	0.0057	0.0275	0.0537
Total participants	0.0031	0.0151	0.0312
Plan-age-service distribution			
Cell participants	0.0026	0.0133	0.0282
Cell salaries	0.0027	0.0131	0.0261
Plan-level assumptions			
g (salary growth)	0.0026	0.0125	0.0247
i (discount rate)	0.0025	0.0123	0.0241
k (accrual factor)	0.0022	0.0103	0.0192
Sequential changes in characteristics to PS Match2			
Plan-level scaling			
Sponsor assets	0.0036	0.0174	0.0331
Total participants	0.0033	0.0157	0.0302
Plan-age-service distribution			
Cell participants	0.0027	0.0136	0.0270
Cell salaries	0.0028	0.0137	0.0276
Plan-level assumptions			
g (salary growth)	0.0028	0.0137	0.0286
i (discount rate)	0.0028	0.0143	0.0305
k (accrual factor)	0.0023	0.0108	0.0198
Sequential changes in characteristics to PS Match3			
Plan-level scaling			
Sponsor assets	0.0047	0.0215	0.0410
Total participants	0.0030	0.0143	0.0281
Plan-age-service distribution			
Cell participants	0.0026	0.0130	0.0259
Cell salaries	0.0028	0.0137	0.0272
Plan-level assumptions			
g (salary growth)	0.0028	0.0135	0.0270
i (discount rate)	0.0028	0.0135	0.0271
k (accrual factor)	0.0022	0.0102	0.0188

For each side of the table, we include three sets of rows, corresponding to three scaling measures: current payroll, current firm assets, and the present value of future payroll (of all workers in the left panel and of current workers only in the right panel). For all of these combinations, we present the projected accruals that would have occurred if the firm had not frozen the plan, the estimated increases in 401(k) contributions that occurred as a result of the freeze, and the difference between the two, which we refer to as realized cost savings.

Consider first the savings from both current and future workers. Compared with a one-year counterfactual DB accrual of 6.1% of payroll, firms increase contributions to DC plans by 2.6% of payroll in the first year after the freeze, a difference of 3.5% of payroll. Over 10 years, compared with counterfactual DB accruals of 49.6% of current payroll, we estimate that firms will contribute to 401(k) plans an extra amount equal in present value to 10.4% of current payroll, a difference of 39.2% of current payroll.[42] The next rows show that firms save 3.1% of current assets over 10 years net of the increase in

[38] As a robustness check, we re-ran Table 6 using the market value of assets rather than book value. The results (presented in the Appendix, Table A.3) are qualitatively similar, but the coefficients on accruals are larger and the p-values are smaller.

[39] We also ran a specification that included a dummy for whether the firm had been taken over in the previous 3 years. The coefficient on the dummy was not significant and other coefficients were similar to those in our baseline.

[40] Moreover, even if we were interested in a relative measure, we have no way of knowing the counterfactual of what 401(k) contributions would have been for the non-freeze firms had they chosen to freeze.

[41] The number of observations is smaller because a few sponsors freeze multiple plans.

[42] These estimates are close to those reported by Towers Watson (2009). Although their data sources and analysis are very different from ours, they find that "sponsors that transitioned from DB to DC-only coverage increased their DC benefits values by an average of 27 percentage points (of payroll), but the enhancement covered only about half of the DB value lost by closing or freezing pension plans."

Table 6
Probability of plan freeze as a function of defined benefit accruals.
This table shows the linear probability estimation of a plan freeze. The dependent variable is 1 if the plan is frozen next year and 0 otherwise. Plan-year observations after the plan has been frozen are excluded. $\delta_{t,t+1}$ */TA* is the estimated benefit accrual for regular plans, normalized by the total assets (*TA*) of the sponsor. *ABO* is the accumulated benefit obligation. *Plan Funding (%)* is defined as plan assets (PA) minus plan liabilities (or ABO) divided by plan liabilities. Both plan assets and plan liabilities are collected from Form 5500. *Unionized* is a categorical variable equal to 1 if the plan is represented by a union and 0 otherwise. *EBITDA/Sales* refers to earnings before interest, taxes, and depreciation and amortization expenses, normalized by total sales. *Interest coverage* is the ratio between EBIT and the interest payments on debt. *Labor Tightness* is defined as the ratio of number of vacancies and unemployment (2-digit NAICS code by year), as reported by BLS. *Tenure* is the average numbers of years with the company, from Consumer Population Survey (2-digit NAIC code by year). *Mobility Separations* and *Mobility Hires* are job to job separations and hire divided by the beginning of the year employment (Census data). *P*-values are reported in parentheses. * denotes significance at the 0.10 level, ** at the 0.05 level, and *** at the 0.01 level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Labor market variable				Labor Tightness	Tenure	Tenure<5	Mobility Separations	Mobility Hires
$\delta_{t,t+1}$ / TA	1.725**	1.287*	1.075	1.928***	1.799***	1.717**	1.556**	1.571**
	(0.011)	(0.092)	(0.432)	(0.005)	(0.009)	(0.011)	(0.019)	(0.018)
ABO (log)	−0.005***	−0.005***	−0.005	−0.005***	−0.004***	−0.005***	−0.004***	−0.004***
	(0.000)	(0.000)	(0.108)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Plan funding	−0.028***	−0.032***	−0.031***	−0.024***	−0.022***	−0.033***	−0.028***	−0.028***
	(0.010)	(0.001)	(0.008)	(0.006)	(0.007)	(0.001)	(0.008)	(0.008)
EBITDA/ sales	−0.003	−0.002	−0.003	−0.008	−0.005	−0.006	−0.005	−0.006
	(0.679)	(0.772)	(0.596)	(0.369)	(0.542)	(0.491)	(0.545)	(0.503)
Interest coverage	−0.009***	−0.008***	−0.007*	−0.009***	−0.009***	−0.008***	−0.009***	−0.009***
	(0.001)	(0.002)	(0.066)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)
Unionized	−0.012***	−0.011***	−0.013**	−0.012***	−0.010**	−0.010**	−0.012***	−0.011***
	(0.001)	(0.004)	(0.031)	(0.001)	(0.014)	(0.011)	(0.002)	(0.003)
Labor MKT				0.020*	−0.003***	0.022***	0.337*	0.416**
				(0.075)	(0.001)	(0.002)	(0.056)	(0.035)
Constant	0.341***	0.336***	−0.036	0.550***	0.561***	0.339***	0.325***	0.323***
	(0.000)	(0.000)	(0.714)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	No	Yes	No	No	No	No	No	No
Firm FE	No	No	Yes	No	No	No	No	No
Observations	4712	4712	4712	4581	4587	4712	4607	4607
R-squared	0.050	0.061	0.349	0.062	0.063	0.054	0.043	0.043

401(k) contributions. The third set of rows shows that over 10 years, freeze firms save 8.1% of the present value of future payroll of all current and future workers.

The estimates on the right side of the table on current workers only suggest that virtually all of the accruals and cost savings over the 10-year period come from current workers. Savings over 10 years from

Table 7
Estimated cost savings as a share of payroll at the sponsor level.
The table presents the estimated cost savings that emerge from pension plan freezes at the sponsor level. Panel A focuses on regular freezes, while Panel B focuses on CB plan freezes. *Current Payroll* is the sum of all participants' salaries for the year preceding the freeze. *PV Future Payroll* is the present value of all current and future participants' future salaries. *TA* denotes the total book assets of the sponsoring firm. $\delta_{t,s}$ is the estimated benefit accrual for regular plans, aggregated at the sponsor level. $\delta_{t,s}^{CB}$ is the estimated benefit accrual for CB plans, aggregated at the sponsor level. *d401k* is the increase in the 401(k) contribution following the freeze. *Difference* is the difference between the $\delta_{t,s}$ and d401(k) lines.

Panel A: defined benefit plan freezes

	No. sponsors	Savings from current and future workers			Savings from current workers only	
		Year +1	Year +5	Year +10	Year +10	Year +45
$\delta_{t,s}$ /Current payroll [counterfactual]	113	0.0612	0.2755	0.4959	0.4758	0.7910
d401k /Current payroll [estimated actual]	113	0.0263	0.0863	0.1039	0.0983	0.1659
Difference	113	0.0349	0.1892	0.3920	0.3775	0.6250
$\delta_{t,s}$ /TA [counterfactual]	113	0.0043	0.0191	0.0338	0.0329	0.0542
d401k /TA [estimated actual]	113	0.0006	0.0021	0.0026	0.0025	0.0034
Difference	113	0.0037	0.0171	0.0312	0.0304	0.0508
$\delta_{t,s,}$ / PV Future payroll [counterfactual]	113	0.0610	0.0764	0.1085	0.1112	0.1634
d401k / PV Future payroll [estimated actual]	113	0.0279	0.0279	0.0279	0.0279	0.0279
Difference	113	0.0331	0.0485	0.0806	0.0833	0.1354

Panel B: cash balance plan freezes

	No. sponsors	Savings from current and future workers			Savings from current workers only	
		Year +1	Year +5	Year +10	Year +10	Year +45
	39	0.0406	0.1826	0.3050	0.2729	0.4011
d401k/ payroll [estimated actual]	39	0.0119	0.0488	0.0673	0.0561	0.0631
Difference	39	0.0287	0.1338	0.2377	0.2169	0.3380
$\delta_{t,s}^{CB}$ / TA [counterfactual]	39	0.0030	0.0129	0.0207	0.0193	0.0268
d401k/ TA [estimated actual]	39	0.0005	0.0021	0.0028	0.0025	0.0029
Difference	39	0.0024	0.0108	0.0179	0.0168	0.0238
$\delta_{t,s}^{CB}$ / future payroll [counterfactual]	39	0.0431	0.0530	0.0708	0.0637	0.0823
d401k/ future payroll [estimated actual]	39	0.0124	0.0124	0.0124	0.0124	0.0124
Difference	39	0.0307	0.0406	0.0584	0.0513	0.0699

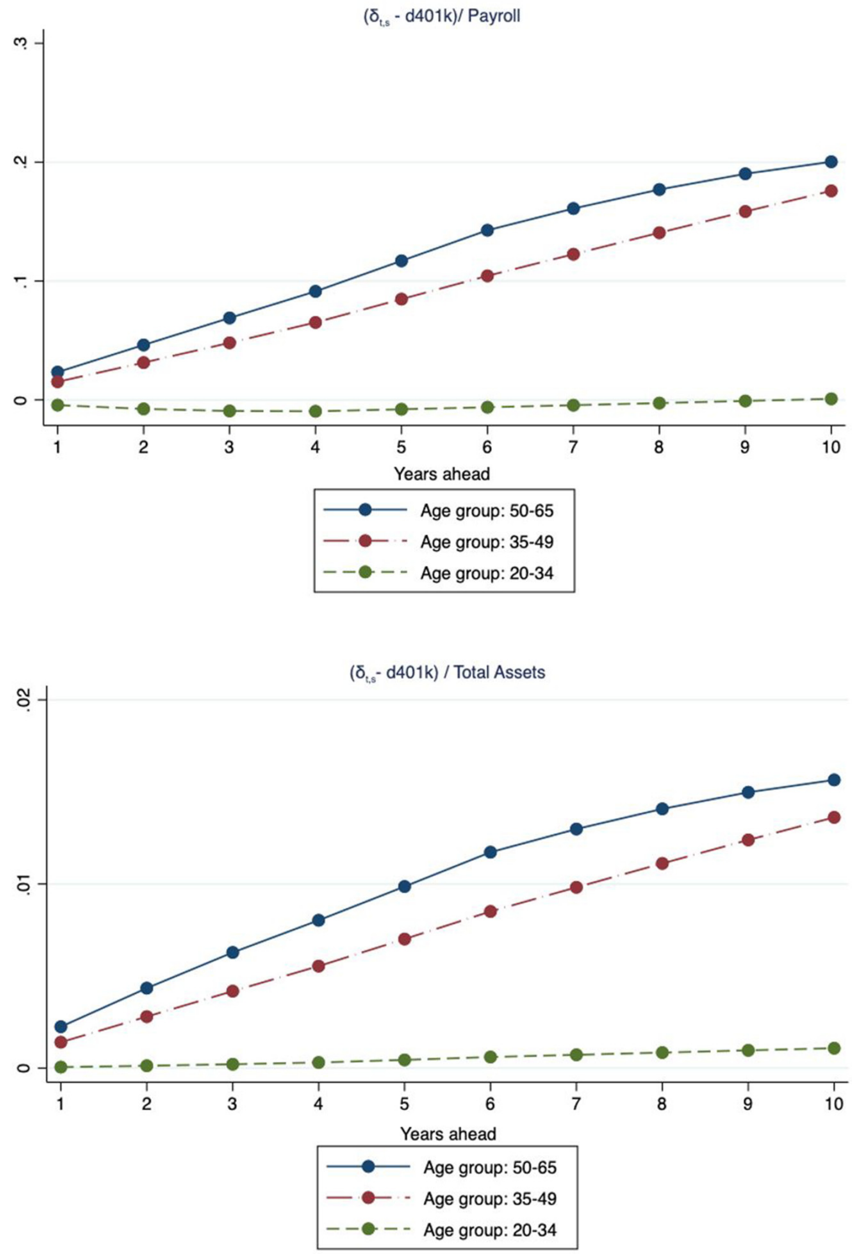


Fig. 4. Estimated cost savings by age groups. The figure shows the estimated cost savings projected 10 years into the future, for three age clusters, including current and future workers: a) 20 to 34 years old, b) 35 to 49 years old, and c) 50 to 65 years old. The cost savings are calculated as the difference between the counterfactual accrual benefits and the actual change in 401(k) contribution, relative to the current plan level payroll and sponsor total assets.

current workers alone amount to 37.8% of current payroll, 3.0% of current assets, and 8.3% of the present value of future payroll, compared to 39.2%, 3.1%, and 8.1% for the open group.[43] The 45-year estimates show substantially more cost-saving than the 10 year estimates, equal to 62.5% of current payroll, 5.1% of current firm assets, and 13.5% of the present value of the corresponding future payroll. Thus current workers are estimated to lose 13.5% of their entire future payroll at the firm as a result of the pension freeze. This substantial number arises due to the high DB accruals that would have been earned by current workers later in their careers had the pension freeze not occurred.

Panel B of Table 7 shows that for CB plans, both the counterfactual accruals and the estimated 401(k) increases are significantly smaller. Nevertheless, the net cost savings from the perspective of the firm are still substantial. Specifically, freezing of the CB plans is estimated to have saved firms 5.8% of future payroll over a 10-year (open group) horizon, or around 72% of the 10-year savings realized in DB freezes.

In Fig. 4, we investigate the extent to which the cost savings is greater for certain age groups. The upper graph shows the accruals for the freeze plans by age group, minus the increases in 401(k) contributions, scaled by total current aggregate payroll. Because the estimates are scaled by plan-level payroll rather than payroll of the age group, the estimates reflect both differences across age groups in accrual rates as a percentage of own salary and differences in the number of workers in each age group. Relative to the projected increase in 401(k) contributions for these

[43] It is possible (as in the third set) for the savings from current workers only to be higher than the savings from all current and future workers, as the freeze could increase 10-year costs for future hires. This could occur if in the absence of the freeze their DB accruals when starting out would have been less than the 401(k) contributions they now receive instead.

Table 8
Ex post salary growth.
The table presents the actual salary growth before and after the freeze for freeze plans and their controls. *Previous years* refers to all years before the freeze, and *Year + 1* refers to the first year after the freeze was implemented. *Ind Controls* constrains the non-freezes group based on the two-digit SIC code and year. *PS Match1* selects a matched non-freezes group based on propensity scores calculated based on two-digit SIC, ABO, and year. *PS Match3* selects a matched non-freezes group based on propensity scores calculated based on two-digit SIC, ABO, year, and the funding ratio.

	N	Previous years (mean)	Previous years (median)	Year+1 (mean)	Year+1 (median)
Freezes	72	4.35%	4.40%	2.56%	3.14%
Ind controls	1150	4.41%	4.41%	4.86%	3.78%
PS Match1	72	4.44%	4.53%	5.72%	4.91%
PS Match2	72	4.12%	3.87%	3.68%	3.40%
PS Match3	72	4.07%	4.26%	5.31%	3.90%

plans, the figure shows that for the youngest employees (ages 20 to 34), the increased 401(k) contributions mostly offset the lost DB accruals.[44] The most saving is achieved at the expense of the workers in the oldest age group (ages 50 to 65), followed by those in the middle group (ages 35 to 49). For example, over 10 years, there is a difference of approximately 18% of payroll for employees aged 35 to 49, and there is a difference of 21% of payroll for employees aged 50 to 65. The total cost savings for firms (39% of payroll, as reported in Table 7) is therefore achieved because the increase in DC contributions is small relative to the forgone DB accruals for workers in the 35–65 age range. The lower graph shows the same accruals scaled by plan assets, where the patterns are broadly similar.

These findings suggest that at least older employees are made worse-off by the change. Suppose that workers value a dollar of DC accruals at cost, but mark down a dollar of DB accruals by a fraction φ_a that varies with age a. For all workers to value new DC benefits the same as their prior DB benefits, the markdown factor φ_a would have to be increasing with age as well. This seems implausible – if anything it seems more likely that φ_a would be higher for *younger* workers, as these are the workers who would potentially be most bothered by the lack of choice, control, and transparency inherent in DB plans. In addition, it seems implausible that the markdown ratios for older workers would be high enough to make them indifferent to the DB freeze.[45]

5.3. Compensating salary growth

In Table 8, we examine whether there is a compensating differential through salary increases after freezes. In fact, we find the opposite. There are 72 plan-year freeze observations for which salary data exist in at least one year before the freeze and one year after the freeze. Before the freeze, employees in these plans see average salary growth of 4.35%, but the year after the freeze their salary only grows by an average of 2.56%. Furthermore, control firms see comparable salary growth in years before the freeze and substantially *higher* salary growth in the year after the freeze. To the extent that the observed variables, including a low pension funding ratio, capture a sponsor's weak financial condition, these results suggest that salary growth would not have been substantially lower in the absence of the freeze, and that the cost savings from freezing are not being offset by higher salaries. The observed salary decreases for freeze firms may arise as part of the same cost-saving pressures that cause freezes.

[44] As expected, savings are in fact slightly negative in the near future for the youngest cohorts, as their projected accruals as a percent of current salary tend to be small. Note that the smaller magnitudes in the graph reflect the cumulative net savings per groups at the plan level and therefore the fact that the younger cohorts have a smaller number of participants.

[45] It would be interesting to know how freezes affected new hiring after the freeze. The data necessary to investigate this are unfortunately not available at the plan level. Noiser plan *sponsor* level data on employment do not indicate any consistent differences between the subsequent employment growth of freeze and control firms.

6. Conclusion

In this paper, we show that the decision to freeze corporate DB plans is positively related to prospective cost savings resulting from the freeze. Our results imply either that workers do not value DB pensions as much as equal-cost DC benefits; or that labor market frictions exist that result in some or all workers being compensated more than their outside option or marginal product, so that firms can save costs by cutting prospective pension accruals; or both.

Additional evidence on the differential impact on different demographic groups suggests that both factors lead to cost savings. In the absence of compensating wage changes, freezes that replace accrual structures that increase with age and tenure with flat ones cut the compensation of older, longer-tenured workers more than that of younger, shorter-tenured workers. Since it is implausible that older workers would particularly value DC over DB benefits, these findings imply that at least part of the cost savings come from reducing the welfare of older workers. One possible model consistent with this evidence is one in which workers accumulate firm-specific human capital that creates a growing wedge between their marginal product to the firm and their outside option. The implicit promise of the DB pension to provide higher accruals to more senior workers could represent one (imperfect) way of committing the firm to not exploit its growing monopoly power over the worker. The freezing of DB plans would represent a reneging on such an implicit contract.

However, the finding that firms achieve substantial cost savings by freezing cash balance plans, in which accrual profiles have the same or similar shapes as DC contributions, suggests that compensation cuts that primarily reduce the welfare of more senior workers are not the only source of cost savings. Some cost savings from a pension freeze therefore likely arise because workers undervalue DB benefits and perceive themselves as no worse-off with a lower-cost DC plan.

The fact that the pace of freezes has accelerated is suggestive of the idea that some of the factors that we have identified have become more important over time. While we do not provide evidence of long-term changes in potential cost saving, the long-term decline in nominal interest rates certainly increases accruals under fixed benefit contracts, and the timing of firms' reneging on implicit contracts may reflect their increasing market power in the labor markets they face.

Appendix A. Online Appendices A, B, and C

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpubeco.2020.104211.

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