APPENDIX TO:

COST SAVING AND THE FREEZING OF CORPORATE PENSION PLANS*

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Appendix A: Additional supporting tables and figures

Table A.1 Example of age-service matrix

This is an example of an age-service (and compensation) matrix, collected from the paper attachments to Form 5500, year 2001.

Attained age	Years of service									
	<1	1–4	5–9	10–14	15–19	20–24	25–29	30–34	35–39	40+
<25	157	297	38							
	$37,272	$47,783	$46,381							
25–29	290	1,877	1,113	28						
	$45,609	$62,874	$64,188	$64,280						
30–34	268	2,037	2,704	678	69					
	$48,594	$70,739	$71,797	$73,889	$70,838					
35–39	221	1,367	2,094	1,437	1,369	70				
	$49,442	$74,445	$75,538	$82,468	$83,476	$77,843				
40–44	205	1,047	1,624	1,049	2,007	2,373	355			
	$53,620	$75,557	$77,173	$85,723	$90,267	$85,715	$78,478			
45–49	145	638	1,092	690	1,289	3,410	1,999	406		
	$49,954	$71,965	$75,501	$83,525	$91,437	$90,855	$87,143	$86,384		
50–54	103	428	651	432	806	1,060	1,224	1,696	114	
	$51,393	$72,208	$73,844	$80,177	$87,100	$89,129	$91,712	$93,062	$88,210	
55–59	45	248	351	239	286	271	281	564	312	21
	$51,026	$71,141	$77,044	$75,080	$82,843	$87,265	$91,771	$93,768	$91,462	$93,106
60–64	13	76	120	66	50	54	52	73	96	36
		$66,371	$73,213	$68,061	$77,637	$70,217	$66,673	$87,677	$86,666	$86,447
65–69	3	12	15	5	4	3	3	7	5	14
70+		1	1	6		1		2	1	2

Plan
Name: Xerox Corporation Retirement Income Guarantee Plan
EIN: 16-468020
PN: 333

Table A.2: Sample freezes

This table describes the sample selection of defined benefit (DB) plans subject to a hard freeze during our sample period. A hard freeze implies closure of the plan to new participants and the discontinuation of all benefit accruals. Although hard freezes are reported in Form 5500, often the disclosure is delayed. We proceed by manually searching the news and the attachments to Form 5500 to correctly identify the year of the freeze. In Column 1, we report the plans that froze during our sample period and the year of the freeze. In Column 2, we report the plans for which we could identify at least one attachment to Form 5500 prior to the freeze. In Columns 3 and 4, we report the availability of the age-service matrix for regular freezes, while in Columns 5 to 7 we report the availability of the age-service matrix for cash balance (CB) plans. CB plans are DB plans for accounting and funding purposes. However, the benefit accrual is calculated based on a different rule.

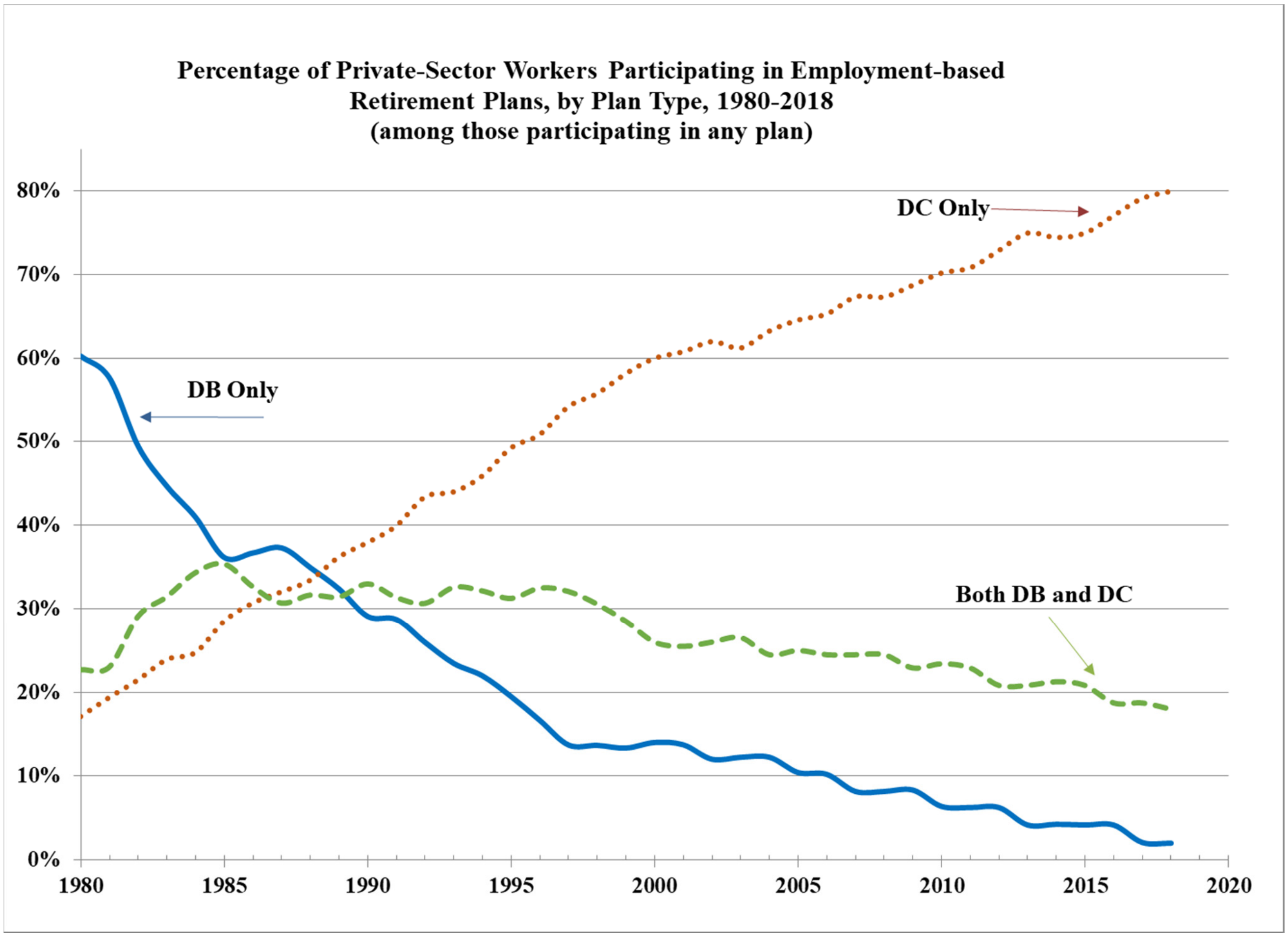
Fiscal year	Freeze year hand-collected	Freezes with PDF attachments before freeze	DB plans w/ participants table	DB plans w/ salary table	CB plans w/ participants table	CB plans w/ salary table	CB plans w/ account balance table
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
2000	2						
2001	7						
2002	14	2	2	1			
2003	25	15	12	12	3	2	
2004	25	22	15	10	7	5	5
2005	21	18	13	13	5	4	2
2006	33	33	23	21	10	9	9
2007	27	26	21	18	5	2	2
2008	21	21	14	12	7	7	6
2009	31	31	19	17	12	11	10
2010	5	5	2	1	3	3	3
2011	2	2	2	2			
Total	213	175	123	107	52	43	37

Table A.3: Probability of plan freeze as a function of defined benefit accruals (alternative)

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. δt,t+1 /MV is the estimated benefit accrual for regular plans, normalized by the market value of the sponsor's assets. 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
$\delta_{t,t+1}$ / MV	3.613***	3.248***	2.499	3.775***	3.686***	3.578***	3.453***	3.469***
	(0.002)	(0.007)	(0.270)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
ABO (log)	-0.005***	-0.005***	-0.005*	-0.005***	-0.004***	-0.005***	-0.004***	-0.004***
	(0.000)	(0.000)	(0.066)	(0.001)	(0.002)	(0.000)	(0.001)	(0.001)
PLAN FUNDING	-0.026**	-0.029***	-0.030***	-0.022***	-0.021***	-0.031***	-0.025**	-0.025**
	(0.013)	(0.002)	(0.009)	(0.009)	(0.010)	(0.001)	(0.010)	(0.010)
EBITDA/ SALES	-0.007	-0.006	-0.004	-0.009	-0.006	-0.010	-0.007	-0.007
	(0.405)	(0.453)	(0.552)	(0.334)	(0.432)	(0.339)	(0.421)	(0.392)
INTEREST COVERAGE	-0.007***	-0.007***	-0.006	-0.007***	-0.007***	-0.007***	-0.008***	-0.008***
	(0.002)	(0.002)	(0.107)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)
UNIONIZED	-0.009**	-0.008**	-0.010*	-0.009**	-0.007	-0.006	-0.008**	-0.008**
	(0.021)	(0.049)	(0.079)	(0.015)	(0.102)	(0.123)	(0.036)	(0.050)
LABOR MKT				0.017	-0.003***	0.020***	0.277*	0.384**
				(0.120)	(0.005)	(0.006)	(0.088)	(0.046)
Constant	0.290***	0.288***	-0.025	0.458***	0.470***	0.290***	0.266***	0.263***
	(0.000)	(0.000)	(0.802)	(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	4,406	4,406	4,406	4,281	4,283	4,406	4,303	4,303
R-squared	0.05	0.061	0.349	0.062	0.063	0.054	0.043	0.043

Figure A.1: Participation in retirement plans



Source: 1980-1999 data are from authors calculations based on Table E4 of the Department of Labor's Abstract of 1999 Form 5500 Annual Reports https://www.dol.gov/sites/dolgov/files/EBSA/researchers/statistics/retirement-bulletins/private-pension-plan-bulletins-abstract-1999.pdf; 1999-2018 data are from EBRI https://www.ebri.org/docs/default-source/fast-facts/ff-344-retplans-23jan20.pdf which is based on Bureau of Labor Statistics, Current Population Survey, and U.S. Department of Labor data.

Figure A.2 Employer cost in a defined benefit plan as a percent of salary ($\delta_{t,t+1}/Y_t$)

The figure shows the expected annual cost as a percentage of salary based on different combinations of age and service. The figure is based on calculations 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%.

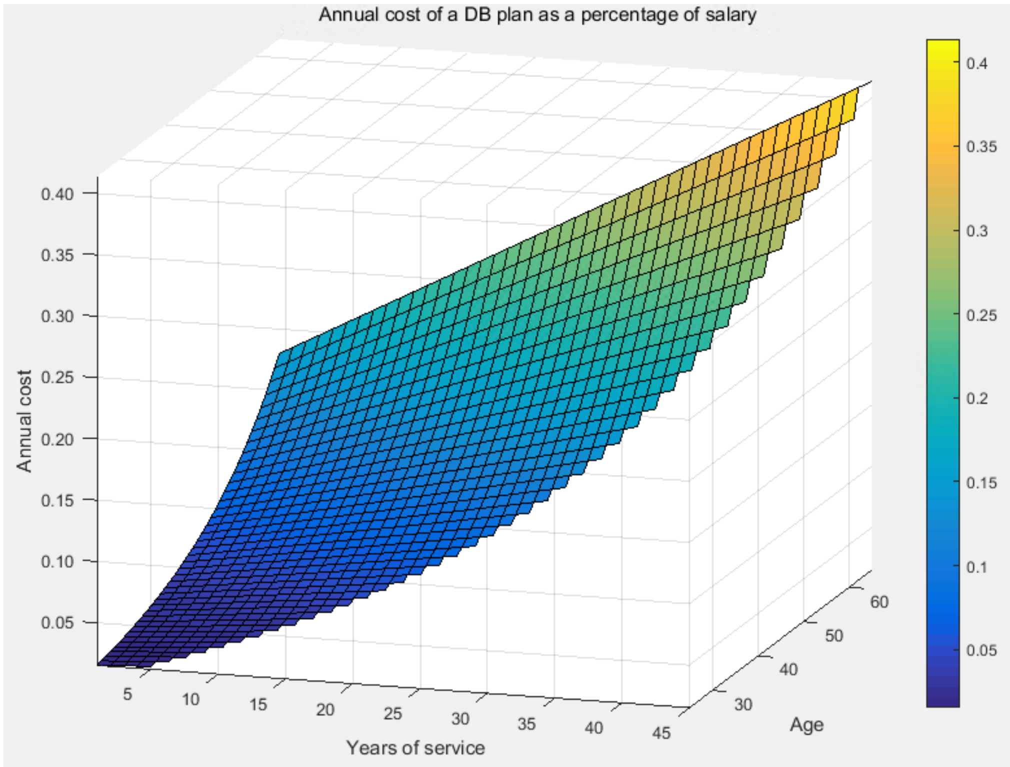
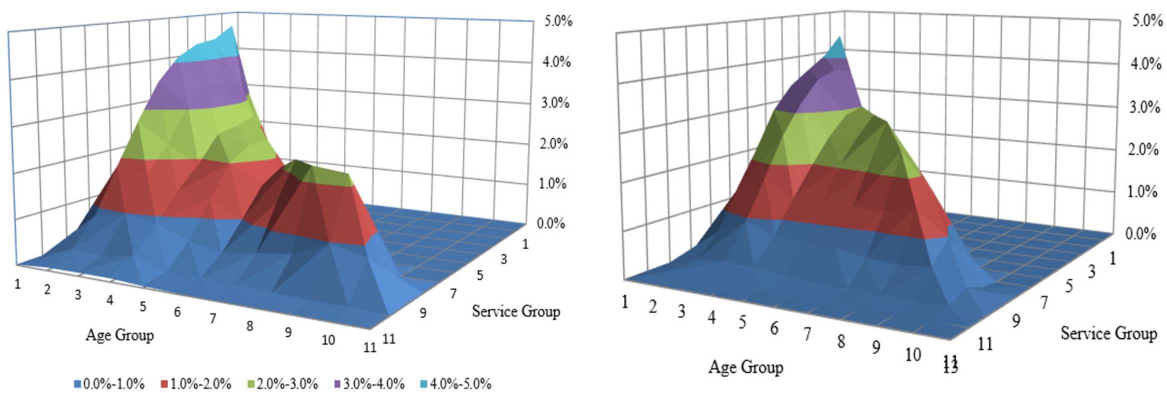


Figure A.3: Age-Service Distributions

The figure shows the age-service distribution for freeze (Panel A, left) and nonfreeze plans Panel A, right). Panel B shows the plot of the difference between the age-service distribution of freeze and non-freeze plans. We include all plan years preceding the freeze.

Panel A: Age-service distribution (freezes)



Age Group	1	2	3	4	5	6	7	8	9	10	11	12	13
Age	<20	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75<
Service Group	1	2	3	4	5	6	7	8	9	10	11	12	
Service	<1	1-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40	45	50	

Panel C: Difference in age-service distributions (freezes and non-freezes)

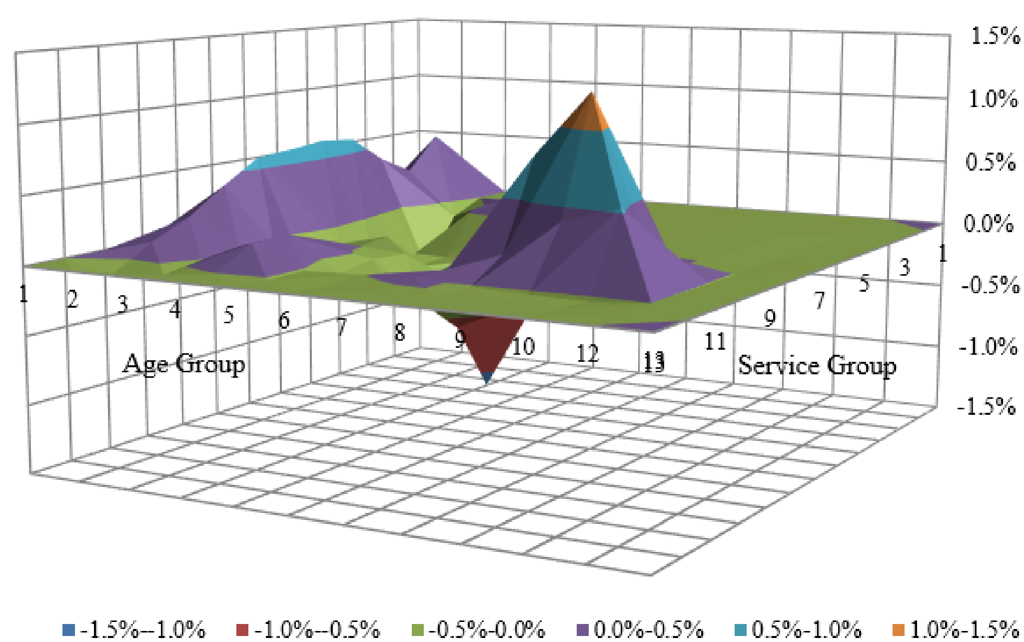
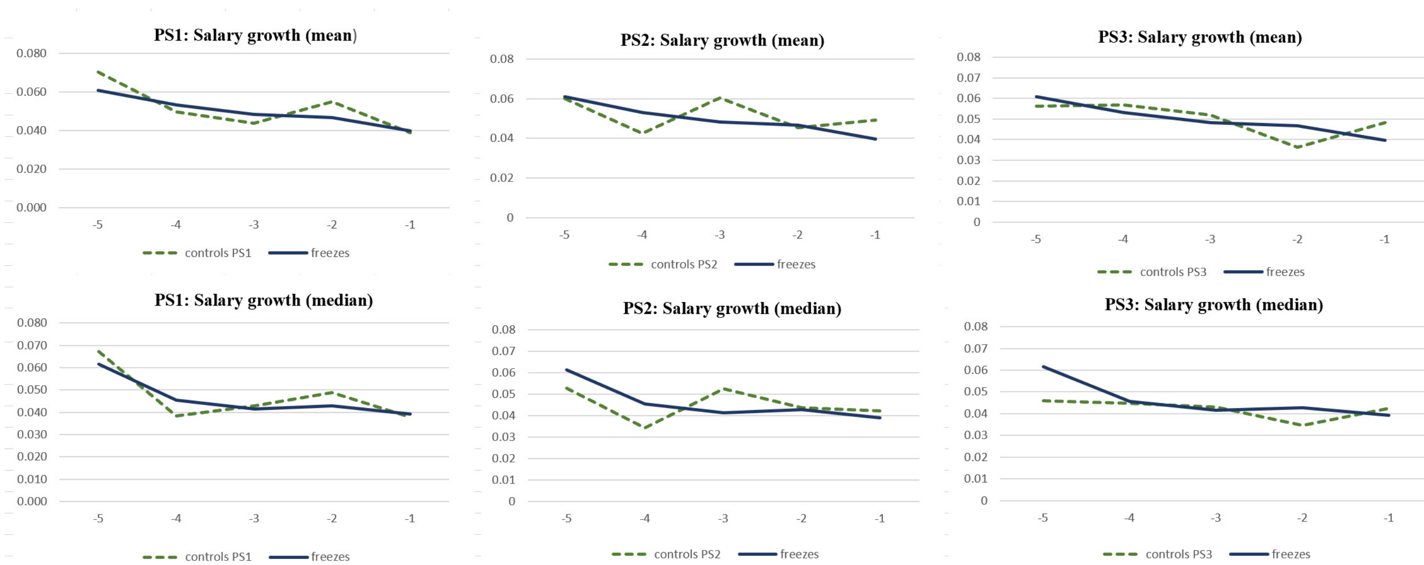
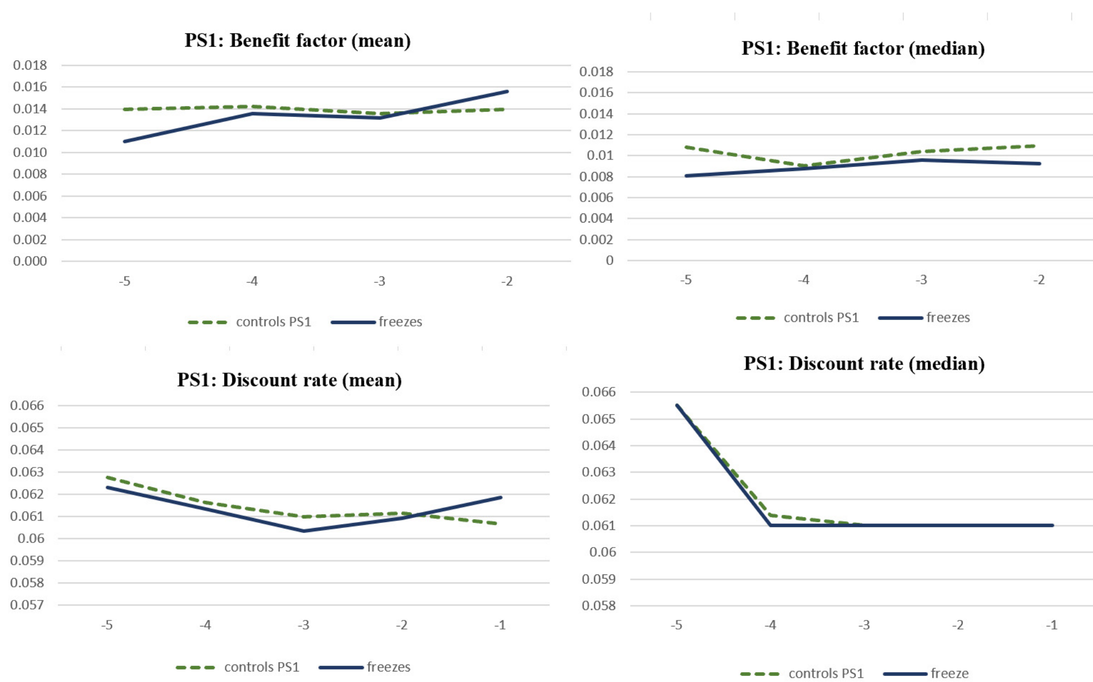


Figure A.4 Pre-Freeze Trends

Panel A: Salary growth before pension freezes for all propensity matches



Panel B: Other variables before pension freeze (PS1)



Appendix B: Additional discussions

How do firms typically switch from a DB to a DC plan?

One way for a firm to switch from a DB to a DC plan is to terminate the DB plan. However, the termination of a DB plan is often costly and, in many cases, impossible. Underfunded pension plans can be taken over by PBGC only when the sponsor has filed for bankruptcy. Under normal business conditions, plans can only be terminated if they are fully funded. In this case, a 50% excise tax is applied to any excess assets reverted to the employer, followed by another layer of corporate income taxes. However, if participants in a terminating plan are provided with a replacement plan, the excise tax is reduced to 20%.[1] Sponsors must pay off beneficiaries by purchasing annuities. Most of these "standard terminations" have been implemented for small single-employer plans.[2] The number of "distress terminations" is also small, but the large ones have been highly publicized (for example, United Airlines).

The most common strategy for ending new accruals is a pension freeze. Although there are several types of freezes, all involve the reduction or cessation of new accruals. As mentioned in the introduction, a hard freeze eliminates all future accruals, so nominal benefits will not grow from the level they had reached at the time of the freeze. A soft freeze eliminates new accruals for a subset of employees, typically new employees. Most often, sponsoring companies compensate workers by allowing them to participate in either an existing or a new 401(k) plan. Many large companies sponsor more than one pension plan, and firms frequently decide to freeze plans on a selective basis.

As an alternative or predecessor to freezing, some companies have undertaken conversions of their existing DB plans to CB plans. Having replaced DB accruals with the CB accruals, the sponsor still has the option to freeze the CB accruals at a later date. If the sponsor freezes the CB plan, the CB accruals are then typically replaced with contributions to a DC plan.

Can pension freezes save costs?

A freeze of DB pension accruals can be thought of as having three sets of effects. First, the freeze in isolation with no offsets would be a cut in the employee's current and future compensation. Second, the firm may need to compensate employees affected by the freeze. The firm could do so by

[1] For this reduction to take effect, the employer must demonstrate that it amended the plan prior to termination to provide immediate pro-rated benefit increases, and that it transferred 25% of the terminating plan's excess assets directly to the replacement plan before any amount was reverted.

[2] According to Belt (2005), during the 1986–1994 period, 99,000 of the 101,000 single-employer plan terminations fell into the category of a standard termination, with only 2,000 being distress terminations.

raising salaries or contributions to other benefit plans, including DC pension arrangements. Third, workers could respond to the changed compensation package by pursuing outside options. If the total compensation of some workers relative to their outside options has decreased, then turnover for those workers would be expected to increase.

In a perfectly competitive frictionless labor market in which employees and employers valued all pension benefits identically, the change in other compensation (including salary, DC contributions, and other benefits) should exactly offset the reduction in DB pension benefit accruals. In this world, there would be no cost savings from a DB pension freeze; all potential cost savings for the firm would be offset, and relative total compensation among young and old workers would be the same as before the freeze.

The possibility of cost savings arises from several possible violations of the assumptions in the above framework. First, if workers value the DB pension benefits at an amount less than the cost to the employer of providing those benefits, freezing the pension plan could generate a surplus over which employers and employees could bargain, potentially both saving firms on compensation costs and making workers better off. Second, labor markets may not be frictionless. To take one example, there could be nominal wage rigidities. If nominal wage cuts are either not possible or very costly to firms, and if workers were compensated more than their marginal products before the freeze, firms could be able to lower total compensation (and thus save costs) via a pension freeze. In this example, cutting non-wage benefits is a way of bypassing or overcoming nominal wage rigidities.

Third, cost savings from a pension freeze could also arise in a model with firm-specific human capital. As we saw earlier, DB pension accruals as a percentage of salary are increasing in both years of service and age, whereas DC contributions as a percentage of salary are typically independent of age and years of service. One possible model that would explain this accrual structure is the following. Suppose that employees accumulate firm-specific human capital, so that the marginal product of labor at the firm is greater than the outside wage option for the worker, and the gap between the two increases with seniority. The firm thus has increasing monopoly power over the worker as the worker becomes more senior. The higher future pension accruals that are built into the pension formula provide workers some commitment that the firm will not exploit this monopoly power, at least over any individual worker. A DB pension freeze coupled with a flat percentage increase in DC contributions would reduce the compensation of older and longer-tenured workers relative to younger and newly hired workers, and it would correspond to a reneging of the prior implicit contract of higher future compensation for these workers. As a result, the freeze would generate cost saving for firms and lower welfare of the more senior workers.

Determinants of defined benefit plan freezes

If (and only if) cost savings are possible due to frictions in labor markets, higher accruals would be expected to increase the likelihood that a firm will freeze its DB plan. In addition, a set of corporate finance factors also would be expected to affect the likelihood that a firm will freeze its DB plans. 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.[3] Furthermore, the burden of sponsoring a DB plan could be related to the extent to which pension liabilities are funded. Sponsors of worse-funded plans have greater incentives to freeze plans for corporate financial purposes. Finally, freezing is probably less costly for firms that do not have strong employee representation in the form of unions, as collective bargaining would be expected to allow 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.

[3] DB plans could in theory be funded with riskless assets, but in practice they are not. Riskless funding implies a stream of contributions that is higher in expected value but has the same present-value cost, because funding with risky assets requires higher contributions in the most expensive states of the world (Novy-Marx and Rauh, 2011). If firms are financially constrained, then risky funding becomes even more costly for the firm, as it could have to forgo capital investment opportunities to fund pensions (Rauh, 2006a).

Appendix C: Additional details on methodology, sample and estimation of variables

Measuring pension accruals for DB plans

Substituting and rearranging Eq. 5, we get

$$\lambda_{t,s} = kZ_{s,R}[N_s Y_s - N_t Y_t] = kZ_{s,R}[(N_s - N_t)Y_t + (Y_s - Y_t)N_s] , \tag{C.1}$$

which implies

$$\lambda_{t,s} = kZ_{s,R}Y_t \left[(N_s - N_t) + \left(\frac{Y_s - Y_t}{Y_t}\right) N_s\right] = kZ_{s,R}Y_t[(N_s - N_t) + g_{t,s}\, N_s] , \tag{C.2}$$

in which $g_{t,s}$ is the total nominal salary growth between *t,* and the minimum of *s* and the last year of employment. Recalling that $\lambda_{t,s}$ is a random variable as of time *t*, we define $\delta_{t,s}$ as the expected present value (as of time t) of $\lambda_{t,s}$:

$$\delta_{t,s} = E_t\, \{\lambda_{t,s}\, (1 + i)^{-(s-t)}\} = E_t\, \{k\, Z_{s,R}(1 + i)^{-(s-t)}\, Y_t[(N_s - N_t) + g_{t,s}\, N_s]\}, \tag{C.3}$$

in which 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. To the extent that the evolution of future salary and years worked is positively correlated with asset pricing factors, the appropriate discount rate is likely higher than the one appropriate for discounting a deferred annuity stream.[4] Nevertheless, for simplicity we ignore this distinction. We assume that $Z_{t,R} = E\{Z_{s,R}(1 + i)^{-(s-t)}\}$, and that the evolution of salary and work is independent of the evolution of these annuity factors. The latter assumption allows us to use the same discount rate for the entire expression, as would be appropriate for discounting $Z_{s,R}$ alone. With these assumptions, we can simplify this expression to

$$\delta_{t,s} = kZ_{t,R}\, Y_t E_t\, \{\, (N_s - N_t)\, + g_{t,s}\, N_s\, \}. \tag{C.4}$$

Theory suggests that the probability of a firm freezing today (time *t*) should be positively related to $\delta_{t,s}$, the expected extra costs of waiting *s-t* periods to freeze rather than freezing today.[5] In our empirical work in subsequent sections, we construct estimates of $\delta_{t,s}$ and test this prediction.

[4] For a discussion of the correlation of wages and stock returns over different horizons, see Benzoni, Collin-Dufresne, and Goldstein (2007). See Lucas and Zeldes (2006) and Geanakoplos and Zeldes (2010, 2018) for a derivation of the term structure of discount rates in the presence of wage risk.

[5] We note that this calculation for $s>t+1$ ignores the option value of freezing or not in the periods between t and *s*.

For illustrative purposes, assume for the moment that years of service are non-stochastic and always increase by one per year in the absence of a freeze. In this case, the one year expected accrual difference of one participant is

$$\delta_{t,t+1} = kZ_t Y_t[1 + (N_t + 1) \cdot E_t\ (g_{t,t+1})]\ , \tag{C.5}$$

in which $E_t(g_{t,t+1})$ is the expected growth in nominal salary between t and $t+1$. If $s=t+5$ and the worker is assumed to stay with the firm for five full years with certainty, then the expected five-year accrual difference for one participant is

$$\delta_{t,t+5} = kZ_t Y_t[5 + (N_t + 5)\ E_t(g_{t,t+5})]. \tag{C.6}$$

<u>Measuring pension accruals for CB plans</u>

We assume that the crediting interest rate i_c for the CB plan equals the appropriate market valuation discount rate i in equation (10), 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. Under this assumption, the potential cost saving from freezing the plan today relative to one year in the future reduces to:

$$\delta_{t,t+1}^{CB} = \frac{[CB_t(1+i_c)+hY_t - CB_t(1+i_c)\mathrm{t}]}{1+i} = \frac{hY_t}{1+i} \tag{C.7}$$

which implies that $\frac{\delta_{t,t+1}^{CB}}{Y_t} = \frac{h}{1+i}$, i.e. one-year accruals as a percentage of salary will approximately equal the pay credit rate.

If the crediting rate i_c differs from the discount rate i, the accrual formula becomes more complicated. If the crediting rate is higher than the discount rate, an extra $1 of cash balance today would be worth more in present value than $1, because the cash balance will grow at the crediting rate and be discounted back to the present at the (lower) market rate. This would raise the estimates of $\delta_{t,s}^{CB}$, and the increase would be greater for younger workers who are many years from retirement. In this case, the annual accrual cost as a percent of salary shown in Fig. 1 would be downward sloping with respect to age, as in earlier years the employer is promising to pay the employee an above-market return for a longer period of time. If the crediting rate is instead lower than the market rate, the line would be upward sloping.

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 the subset of 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. 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. Under the current IRS rules, subsidiaries that are at least 80% owned by the parent could elect to file consolidated income tax returns. But they can also choose to file taxes separately while still remaining consolidated with the parent company for financial purposes. In this case, the EIN and sponsor name reported in Form 5500 will differ from the parent's. To overcome this problems, we manually collect the names of all subsidiaries reported by all sponsors in the 10-k filings (Exhibit 21 in the form). We identify potential sponsors in Compustat based on the availability of aggregate pension information such as pension assets and liabilities.

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. In principle, we can identify the year the plan was frozen by examining when the box on Form 5500 was first checked. Of course, this procedure would only be appropriate starting in 2004, the second year that the question was included on the form. We found, and fixed, a number of inaccuracies, including a number of plans that first report a freeze on Form 5500 years after the freeze actually took place.

Entry and Exit

New participants are generally disclosed in the first column of the age-service matrix (participants with less than one year of service). Exits (or separations) are estimated from snapshots of the age-service matrices at time t and t+5. The matrix at t+5 allows us to observe a complete shift of the remaining participants on the diagonal. For example, all participants in the cell corresponding to the 30–34 age group and 1–4 years of service group are transitioning into a diagonal cell corresponding to the 35–39 age group and 5–9 years of service, unless they leave the firm. This structure helps us estimate the separating probability at t+5 at the age-service group level (on a rolling window). Once we calculate the proportion of participants that stay with the firm in 5 years, we estimate the separation probability for all years between time t and t+5 by using a geometric average. In the absence of an insufficient time series of matrices at the plan level, we use industry averages, calculated separately for freeze and non-freeze plans, for all years before the freeze.

Estimating missing salary information

Most of the tables include both the number of participants and the average salary per participant, within each age-service group. However, for confidentiality reasons, the salary information is only disclosed for age-service groups with more than 20 participants. We therefore estimate the average salary in these age-service groups (in which the number of participants is available) by using information on disclosed salaries for the other age-service groups for that plan year and in the plan time series. The imputation relies on the following estimation, using the time series information on all available plans, at the age-service group level:

$$Log(Salary_{wpt}) = \alpha_1 + \alpha_2 Age_{wt} + \alpha_3 Age_{wt}{}^2 + \alpha_4 Service_{wt} + \alpha_5 Service_{wt}{}^2 + \varepsilon_p + \vartheta_t + \delta_{wpt},$$

in which $Salary_{wpt}$ is the salary for participant w in plan p at time t, Age_{wt} and $Service_{wt}$ are the age and the service groups for participant w at time t, ε_p is the plan fixed effect, ϑ_t is the time fixed effect, and δ_{wpt} is the residual term. We run the regressions separately for CB plans and for traditional DB plans, allowing the possibility that the salaries of participants in CB plans follow a different path. We use the regression estimates and age-service data to compute predicted salaries for missing age-service groups.

Benefit factors

As described in the text, back out the plan-level benefit factor k from two separate estimates of service costs. The first measure is reported in line 1d(2)(b) on Schedule B of Form 5500 as the "Expected Increase in Current Liability," defined as "the amount by which the 'RPA '94' current liability is expected to increase due to benefits accruing during the plan year on account of credited service and/or salary changes for the current year." This variable, also known as "service cost," corresponds to our projected accrual variable ($\delta_{t,s}$) over a one-year horizon—i.e., $\delta_{t,t+1}$. We refer to this first estimate as $\widehat{SC_t^1}$.[6]

For the second measure, we start by estimating this service cost for each bracketed age-service cell group *w* (in which *w* represents a cell group of workers rather than an individual worker):

$$SC_{w,t} = k \cdot Z_{t,R} \left[N_{w,t+1}Y_{w,t+1} - N_{w,t}Y_{w,t}\right],$$

in which $SC_{w,t}$ is the service cost for participant group *w* in the plan in year *t*, *k* is the plan-level benefit factor, $N_{w,t}$ is the number of years of service of employee group *w* as of time *t*, $Y_{w,t}$ is the time *t* salary of employee group *w*, and $Z_{t,R}$ is the discounted annuity factor defined earlier but using the plan-level statutory discount rate (i_p), as reported in Form 5500 (which, recall, could differ from the discount rate that the firm should use when deciding whether to freeze).[7] We compute a weighted sum across age (*a*) and service (*s*) groups (using the number of participants in each group as weights) to obtain

$$\widehat{SC_t^2} = \sum_a \sum_s SC_{w,t} = k_t \sum_a \sum_s Z_{t,R} \left[N_{w,t+1}Y_{w,t+1} - N_{w,t}Y_{w,t}\right]$$

as a function of k. We then compute the estimated benefit factor k_t, which we allow to vary across both plans and time as the level of *k* such that $\widehat{SC_t^1} = \widehat{SC_t^2}$; i.e.,

$$\widehat{k_t} = \frac{\widehat{SC_t^1}}{\sum_a \sum_s Z_{t,R}\left[N_{w,t+1}Y_{w,t+1} - N_{w,t}Y_{w,t}\right]}.$$

[6] Our annual projected accrual calculation allows us to estimate future benefits by age and tenure groups, at any point in time. Most importantly, it allows us to estimate the counterfactual that is what the future benefits would have been for all frozen plans in the absence of the freeze.

[7] We use the statutory discount rate here because we are attempting to match the service cost as reported on Form 5500 (which is based on this statutory discount rate).