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Swiss pension funds: funding ratio, discount rate, and asset allocation

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Abstract

The funding ratio is a financial indicator to measure the viability of pension funds. The paper analyzes how Swiss occupational pension funds' technical discount rate and asset allocation are related to the funding ratio. The paper shows that funds with weaker funding ratios apply higher rates to discount future pension liabilities what points toward euphemistic discounting. Further, weaker funded pension funds invest less in equities—with the exception of pension funds below the regulatory minimum threshold. The latter invest more in equities than funds above the threshold, which points to gambling for resurrection. The findings question the funding ratio as a transparent measure for pensions' sustainability and unfold the regulatory environment's disincentives.

Keywords: Pension funds, Non-Bank Financial Institutions, Funding ratio

JEL Classification: D81, G11, G18, G23, H55, J32, L51

1 Introduction

Over the past few decades, the pension systems of most developed countries have been faced with a constant decline in interest rates and a constant increase in life expectancy. In Switzerland, the nominal 10-year yield on Swiss government bonds was 4% at the end of the 1980s. Since then, it constantly declined, eventually reaching −0.5% in 2020 (SNB, 2020). At the same time, between 1980 and 2018, the average life expectancy of a Swiss female at 65 increased from around 18 to 23 years, and the average life expectancy of a Swiss male at 65 increased from around 14 to 20 years; other OECD countries show similar increases (OECD, 2020). Low interest rates together with an ageing population are a challenging environment for pension funds. With higher life expectancy, pension funds' pension liability increases, while the low interest rates make it more difficult for funds to finance these higher debt burdens with returns from low-risk assets. In many economies—including Switzerland—this challenge has stimulated discussions about the financial viability of pension systems. It also raised awareness about financing gaps that potentially must be financed by the younger generations. Further, it stimulated discussions about the need for reforms, and the need for transparent and comparable measures to assess a fund's viability.[1]

The viability of Swiss occupational pension funds is measured by the funding ratio (*Deckungsgrad*). This ratio is defined as the market value of a fund's assets divided by the expected net present value of pension liabilities. By regulation, funds must maintain full funding and meet the regulatory minimum requirement of a funding ratio of 100%. That is, pension liabilities should not exceed assets. Otherwise, funds have a funding shortfall (funding ratio below 100%). Such underfunded funds are required to take recovering actions to achieve full coverage of liabilities.

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[1] see, e.g., NZZ (2019; 2020) for examples of coverages in the popular press.

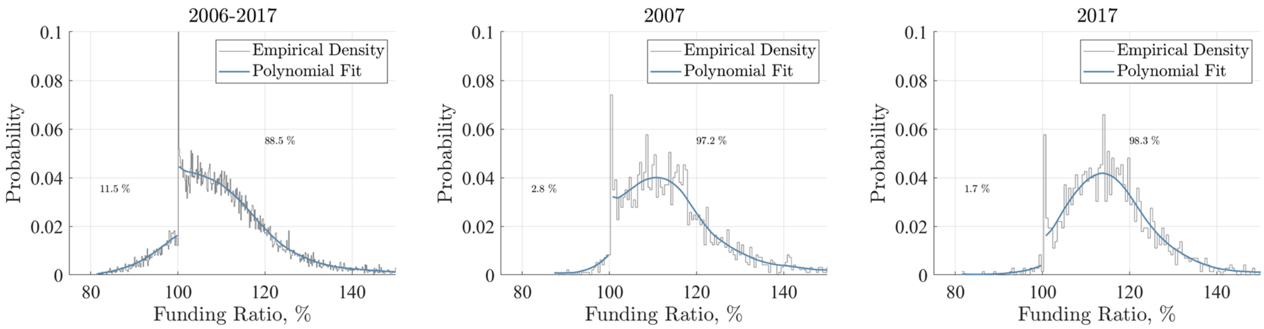

Fig. 1 Distribution of Funding Ratios. Distributions of the funding ratios of pension funds pooled across all years 2006–2017, in 2007 , and in 2017. The solid line shows the smoothed fit using a local 4th-order polynomial kernel regression to the left and to the right of 100%. Binwidth of histogram and bandwidth of triangular kernel are based on the procedure by McCrary (2008). Bin at 100% omitted for polynomial fit. Figure shows spike exactly at the regulatory minimum (100%). The corresponding McCrary test for discontinuity between left and right of 100% (omitting the 100% bin) is positive and significant. The sample includes only private and public funds without state guarantees and only includes funds with a funding ratio between 81.5 and 152.3% (0.5th–95th percentile range)

This paper is a descriptive analysis of the comprehensive data set of the Swiss Occupational Pension Funds Statistics collected by the Swiss Federal Statistical Office (*Bundesamt für Statistik, BFS*). As shown in Fig. 1, the distribution of funding ratios is heavily discontinuous at the 100% threshold, with more mass to the right. This indicates that most pension funds can manage adequate funding—at least in terms of the reported funding ratio—and avoid falling below the regulatory minimum.

Pension funds have little influence on exogenous factors that affect their funding stability, such as the demographics of its insurants or the returns of financial markets. However, the Swiss regulatory environment enables some flexibility on some parameters that can fundamentally affect their funding stability, such as future pension promises or the asset allocation affecting profits. Further, a fund can decide how much of their earnings to retain and how much to pay out as interest on insurants' savings. But regulatory environment also allows some discretion concerning parameters that only influence *the calculation* of the funding ratio, such as the conservatism of the assumptions about future demographic developments or of the discount rate.

This paper analyzes how far a fund's choices of these parameters of discretion are statistically related to a fund's funding ratio (or vice versa). The paper focuses on the technical discount rate and the share of assets pension funds invest in equities. For this analysis, I estimate the local averages of the technical discount rate, and the share of equity assets conditional on the funding ratio using local linear regressions and global polynomial fits.

The application of higher technical discount rates allows funds to under-report the value of pension liabilities and report euphemistic funding ratios. The paper compares the average discount rates of funds grouped by similar funding ratios using local linear regressions. The results indicate that funds with lower funding ratios apply higher technical discount rates. In 2017, only 1.8% of funds had a funding ratio below 100% when evaluated with the funds' own choice of technical discount rates. In contrast, in the same year, a counterfactual share of 28.2% of funds was insufficiently funded when approximating the value of pension liabilities at risk-free market interest rates. The resulting approximated valuation difference aggregated across all funds amounted to 15% of total reported pension liabilities, in 2017.

Euphemistic reporting of pension liabilities enables funds to hide their true funding gap and thereby helps to postpone necessary structural reforms that would fundamentally improve funding. Given the low (and negative) yields on risk-free assets and the parallel increase in life expectancy, such reforms would include the reduction in pension benefits by reducing conversion rates see, e.g., (Kupper Staub and Eggenberger, 2017), or a portfolio re-allocation investing more into riskier assets [see e.g., (Seiler Zimmermann and Zimmermann, 2017)]. Given the suggestion to allow pension funds to invest more into riskier assets, the paper further analyzes pension funds asset allocation. I look at funds share of assets invested in equities, which is an approximation for the risk choice of funds asset allocation. The results show that weaker funded funds invest a lower share of equities than funds with better funding ratios. Interestingly, this relationship is only valid for funds that satisfy the regulatory minimum requirement. At the threshold of a funding ratio of 100%, the relationship is discontinuous and non-monotonous. Funds below 100% invest 3–5% more than funds above 100%. It is not possible to certainly conclude from the analysis whether better funded funds have a higher risk capacity and thus dare more to invest a higher amount into equities or whether it is the success of their higher equity allocation that allows them to accumulate earnings and build-up capital. Under the assumption that the first was true, one needs to be aware that the requirement to satisfy full funding may constrain funds in increasing their risk appetite, too much.

This paper contributes to the discussion about the future viability of pensions, e.g., (Rajan, 2006; Reinhart et al., 2012; 2006), especially with its focus on Switzerland, and related calls for reforms of the current system (e.g., Amman and Bühler 2017; Greber and Moor, 2017 ; Kupper Staub and Eggenberger, 2017; Seiler Zimmermann and Zimmermann, 2017; Spuhler 2017 ,and many more). The paper is, to the best of my knowledge, one of the first of its kind analyzing the distribution of Swiss pension funds' funding ratio, using a comprehensive data set of the Swiss Federal Statistical Office (Bundesamt für Statistik, BFS).

Concerning pension funds applying favorable discount rates, the paper relates to Stalebrink and Donatella (2020) who find evidence for an increased likelihood of opportunistic accounting choices for US public pension funds in shortfall. Our paper contributes to the literature suggesting similar evidence for Switzerland.

The paper further contributes to evidence on how pension funds' (and firms') asset allocation is related to their viability. In this respect, the results are partly in contrast with the empirical analysis by Rauh (2009), who finds that weakly funded defined benefit pension plans allocate a larger share of their investment to safer securities. A related aspect is investigated by An et al. (2013). The authors investigate the risk-taking of corporate pension funds depending on the viability of the sponsor (employer), finding that sponsors with low-funded pension promises and with high default risks avoid risk, and only funds on the verge of bankruptcy take higher risks in their pension funds. More generally, the paper is related to the issue of risk-shifting, gambling for resurrection, or search for yield, as mentioned, for example, in Jensen and Meckling (1979), or Rajan 2006. Dewatripont and Tirole 2012 provide a theoretical framework exploring the possible incentives for banks to gamble for resurrection.

Further, the paper is also related to the general literature on investment policies, especially pension fund payouts and dividend policies, the quality and credibility of accounting variables (e.g., Dechow et al., 2010; Healy and Wahlen, 1999), regulatory arbitrage and favorable reporting (e.g., Behn et al., 2016), or cross-subsidization between generations.

The remainder of the paper is organized as follows: Sect. 2 provides background on the Swiss occupational pension system. Section 2.1 discusses how pension funds can affect the funding ratio fundamentally by cutting pension promises or re-allocating assets to increase returns form investment, and how they can affect the ratio with accounting tricks by applying favorable technical discount rates. Section 3 describes the empirical methodology of the analysis. The results are presented and discussed in Section 4. Section 5 presents final remarks.

2 The Swiss occupational pension system

The Swiss pension system is a three-pillar system. The first pillar is the state pension fund—the federal *old-age and survivors' insurance* (*AHV*); the second pillar is the occupational pension funds, provided by employers (*Berufliche Vorsorge, BVG*); the third pillar is private—partly tax-deductible (*Pillar 3a*)—savings.

There exist around 1500 occupational pension funds in Switzerland. They hold aggregate assets of a total of CHF 875 bn. (USD 860 bn. BFS, 2019). According to OECD (2019), they account to one of the world's largest markets for pension assets.

The legal framework for the occupational pension system is defined in the *Federal Law on Occupational Retirement, Survivors' and Disability Pension Plans (BVG/LLP)*, and the *Ordinance on Retirement, Survivors' and Disability Pension Plans (BVV2/OBB2)*. The supervisory authority is the *Occupational Pension Supervisory Commission (Oberaufsichtskommission Berufliche Vorsorge, OAK-BV)* and cantonal or regional authorities.

Each employer is mandated to provide an occupational pension fund to its employees. The funds save for employees' retirement but also provide disability and death insurance to employees (and their relatives). The majority of funds offer defined-contribution (DC) pension plans which are funded by contributions (savings) of the employer and the employees.[2] When employees join another employer, their accumulated savings are transferred to the new employer's pension fund. Contributions are proportional to an employee's salary and increase with age. With some restrictions, employees are allowed to withdraw some savings as collateral for mortgages already before retirement. They can also contribute and save more than the regular contributions with additional lump sum payments to the fund. When employees retire at the age of 64 (women) or 65 (men), the total annual pension payments are determined by multiplying

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[2] Between 2010 and 2019, the number of pension funds offering defined benefit (DB) pension plans declined from 157 (6.9% of all funds) in 2010 to only 33 (2.2%) in 2019 (BFS, 2021). Like DC plans, DB plans are financed by contributions from employees and the employer, but benefits are determined as a proportion of an employee's insured salary rather than as a proportion of accumulated savings.

the retiree's savings times the conversion rate (*Umwandlungssatz*), which is defined by the pension plan.[3]

$$\textit{Annual Pension} = \textit{Conversion Rate} \times \textit{Savings at Retirement}$$

The annual pension is generally fixed and paid up until the end of the insurant's (and their partner's) lifetime. Based on a study by Swisscanto (2019), the average conversion rate in 2019 was 5.7% (2010: 6.7%).

Each fund has a board of directors, or a pension commission, equally composed of employer and employee representatives. The board's (or commission's) responsibilities include the annual decision how much interest will be paid on employed insurants' savings.

The Swiss pension scheme distinguishes between *obligatory* and *over-obligatory* pension benefits. Obligatory pension benefits are the minimum pension benefits funds need to provide, which is to insure salaries up to the amount of CHF 85'320 (BSV, 2019b). If pension funds also insure salaries above that threshold, the benefits based on the exceeding amount are called over-obligatory benefits. The law defines requirements only for the obligatory benefits. For example, the minimum conversion ratio for obligatory benefits is currently 6.8% (BSV, 2019c), and the minimum interest rate that has to be paid on savings is determined by the federal council and is currently at 1% (BSV, 2019a).[4] Most pension plans that insure salaries higher than the obligatory maximum do not distinguish between obligatory and over-obligatory benefits. Thereby, interest paid on savings, as well as the conversion rate of the plan, can be lower than the minimum requirements when determined based on total benefits. However, a fund needs to guarantee that the minimum requirements for the obligatory part of benefits are fulfilled.[5]

From a regulatory perspective, the (technical) funding ratio is the most relevant financial indicator to determine the viability of a pension fund. Following, Art. 44, App. 1, BVV2/OBB2, the funding ratio is defined as the pension fund's assets at market value (less debt and other liabilities) divided by the pension liabilities (including what is owed to retired insurants and the savings of active insurants, without reserves not attributable to the insurants).[6] Pension liabilities are determined as the net present value of expected future pension payments. The present value of expected future pension obligations depends on the pension fund's assumptions about life expectancies. The value also depends on the technical discount rate (*technischer Zinssatz*) to discount expected future pension payments.

According to Art. 65d, BVG/LLP, pension funds that become insufficiently funded need to achieve full funding within appropriate time (which is generally 5–7 years). Funds have to take recovering actions if the funding gap is not only temporary and funds cannot overcome the gap without further measures in appropriate time. Such recovering action may include the adjustment of plans to re-achieve full funding (Peter, 2009). Only if these measures are insufficient, can they ask for one-time contributions from employed insurants and the employer to recover. Theoretically, retired insurants can also be required to contribute in case of a necessary recovery—though only with strict limitations.[7,8] As a further recovery measure, a fund is allowed to pay exceptional interest rates on the obligatory benefits lower than the minimum interest rate (though not for longer than 5 years and not more than 0.5 percentage points less than the minimum requirement).[9]

The orange part of the bars in Fig. 2 shows the number of Swiss pension funds with a funding ratio below 100%. A clear observation is that market turbulence following the global financial crisis of 2008 yielded a sharp increase in the number of insufficiently capitalized funds.

An employer can run a pension funds for their employees on their own. Alternatively, they can join a collective fund (*Sammeleinrichtung*) or a joint fund (*Gemeinschaftseinrichtung*). Collective and joint funds pool administration, investment, as well as pension, disability, and death risk of multiple employers. The forms in which these risks are pooled are manifold. Joint funds often offer a single pension plan for all joined employers. Collective funds consist of multiple sub-funds for each employer and

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[3] At retirement, pensioners also have the option to withdraw up to 50 % of their savings. In this case, the annual pension is determined with the conversion rate on the remaining savings. Given the high conversion rates, the withdrawing option is nowadays in most cases not lucrative.

[4] The federal council (one of the two Swiss parliament's councils) recently decided a reform lowering the conversion rate applied to obligatory minimum pension benefits to 6.0% (Bundesversammlung, 2021).

[5] While these minimum requirements may result in subsidization of savings in the obligatory benefits by savings realized from over-obligatory benefits, Seiler Zimmermann and Zimmermann (2018) find no evidence that such subsidization took place between 2002 and 2015.

[6] If not explicitly stated otherwise, we refer to the technical funding ratio simply as 'funding ratio.'

[7] Actually, according to Art. 65d, Sec 3, a. the BVG/LLP would allow financing funding gaps for insufficiently funded funds, by cutting current retired insurants' benefits, though only with limitations on over-obligatory benefits and only if foreseen in the fund's policy.

[8] In 2017, the Swiss Federal Tribunal rejected a complaint by the pension fund of PriceWaterhouseCoopers. The fund wanted to implement a pension plan model which foresaw preventive pension deductions even when not being in a shortfall. This model was not accepted by the pension and trust supervisory authority of the Canton of Zurich, the local supervisory authority (Bundesgericht, 2017; NZZ, 2017).

[9] According to Art. 65d-65e, BVG/LLP.

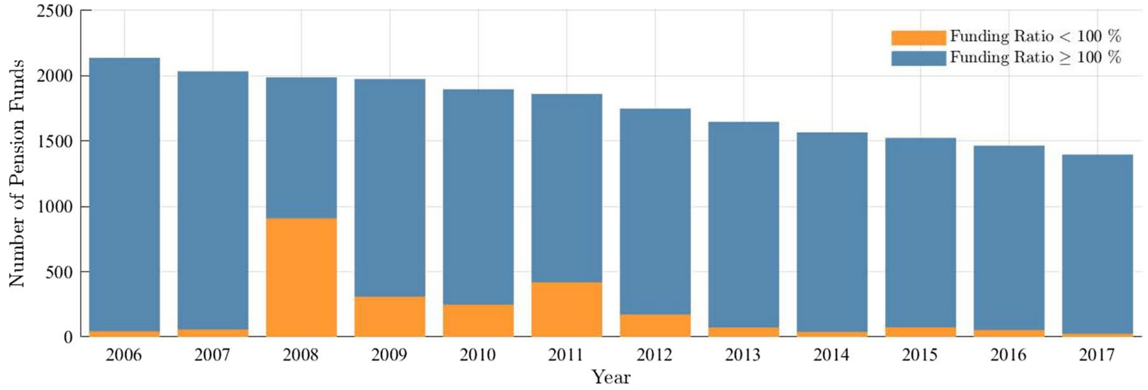

Fig. 2 Number of Swiss Pension Funds. Total number of Swiss occupational pension funds (consolidated level) between 2006 and 2017. Blue bars show total number, the yellow shading indicates number of funds in a shortfall. Between 2006 and 2017, the total number declined from 2138 to 1396 funds. The number of funds in a shortfall (funding ratio < 100%) increased in 2008, following the financial crisis. The sample only includes private and public funds without state guarantee, and only includes funds with a funding ratio between 81.5 and 152.3% (0.5th–95th percentile range)

allow employer-specific plans. Banks and insurance companies often act as collective funds and provide pension fund services for other companies. Over the years, most employers have ceased offering own funds and joined a collective or joint fund. This has resulted in a decline in the total number of pension funds as visible in Fig. 2.

Pension funds can be further divided between private and public funds. The latter are funds of public employers, such as agencies, public administration, or state-owned companies. Historically, the pension liabilities of public funds were explicitly guaranteed by a state guarantee provided by the (in most case cantonal) governments. In the past, public funds with an explicit state guarantee were not required to be fully funded. Only since 2012 they are required to maintain a funding ratio level of at least 80% and need to achieve 100% by 2052 (PPCmetrics, 2020). Given the different minimum requirement that apply, public pension funds with state guarantees need to be evaluated separately and are discarded from the analysis of this paper.

2.1 Managerial discretion

Funds have several options to control the funding ratio. To illustrate the most obvious strategies, consider the stylized formulation of the funding ratio FR_t as the ratio of relevant assets divided by the net present value of pension liabilities. Assets can be re-written as the cumulative sum the of past years net profits $\pi(\sigma, i)$, including return on assets (which depends on the risk allocation σ), contributions from employers and employees, pension payments, the interest paid on savings (i) and other expenses. Liabilities can be re-written as the sum of expected future pension payments $E[P]$ discounted using the discount rate r)

$$FR_t = \frac{Assets_t}{Pension\ Liabilites_t} = \sum_{s=-\infty}^{t} \pi_s(\sigma_s, i_s) \Bigg/ \sum_{d=t}^{\infty} \frac{E_t[P_{t+d}]}{(1+r)^d} \tag{1}$$

Lower pension benefits P_{t+d} would increase the funding ratio. More conservative discount rates (r) would lower the ratio. Furthermore, by changing its choice of asset allocation (and risk σ_s), a pension fund can affect (future) profits what affects the funding ratio. The following discusses these options in more detail.[10]

Future pension promises (P_{t+d}). A pension fund can improve its funding by lowering future pension promises P_d. Currently, almost every Swiss occupational pension fund provides funded and DC pension plans. Hence, upon retirement, an insurant gets an annual pension, which is proportional to the savings (contributions plus interest) they accumulated during their working life. The proportion which determines the annual total pension payments is the conversion rate. A lower conversion rate positively affects the funding ratio. For the conversion rate, the regulation only requires that the BVG minimal rate of 6.8% is guaranteed for the obligatory benefits. The

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[10] From an accounting perspective, a pension fund could further influence the calculation of the funding ratio by the degree of conservatism concerning the demographic assumptions about expected life-expectancy (affecting $E[.]$). They could also accumulate earnings and improve funding with a more prudent payout policy, that is, by paying lower interest rates on active insurants savings (lowering i).

pension determined at retirement is in general fixed and cannot be reduced. However, pension funds can provide, for example, inflation compensations.

Technical discount rate (***r***) The technical discount rate is the rate at which pension funds discount future pension liabilities. The regulatory framework allows some discretion concerning the choice of the discount rate. While a external independent pension fund expert must provide recommendations about the appropriate discount rate, the final decision is set by the pension fund's board. In cases where the expert deems the decision inappropriate, he/she is required to notify the supervisor OAK-BV. A lower discount rate would lower the funding ratio as it increases pension liabilities owed to retirees. However, applying higher discount rates improves the ratio only from an accounting perspective but does not improve funding fundamentally.

Asset allocation ($\pi(\sigma_s)$) A fund can decide to investing more riskier assets to potentially earn a higher return (Seiler Zimmermann and Zimmermann,2017). Rauh (2009) discusses different theories about incentives for funds' risk choices. On one hand, taking too much risk can threat a fund's financial situation if markets turn south; on the other hand, by taking more risk, a fund could *gamble for resurrection* by betting on positive market outcomes. A simple measure of fund's risk choice is the share of assets invested in equities. The regulatory framework given by BVV2/OBB2 lays out some investment limits for different asset classes. The maximum share of assets that is allowed to be invested in equities is limited to 50%. Funds can only deviate from these limits with good reasoning (e.g., deviations caused by losses or profits); otherwise, the pension fund expert is also mandated to notify the supervisor OAK-BV.

In an environment with lower interest rates and higher life expectancy, the fundamentally meaningful and sustainable strategy for pension funds to improve funding is to align the conversion ratio (Kupper Staub and Eggenberger, 2017) with returns on assets (Seiler Zimmermann and Zimmermann, 2017). Otherwise, a pension fund will sustain structural losses. Figure 3 illustrates this point. The figure plots for different conversion rates and market returns how long it takes until a retired insurants own savings are depleted. Suppose two different pension plans: plan A with a conversion rate of 5%, and plan B with a conversion rate of 6%. If the average market returns were 2.5%, a pensioner's savings would last for about 28 years under plan A, while it would only last for 22 years under plan B. If market returns were only 1%, the savings would last for about 22 years, in plan A but only 18 years in the plan B. Hence, if the average retired insurants lived longer than the savings last, the financial gap would need to be financed by other insurants' savings. The alternative strategy to apply favorable discount rates improves a funds funding only from an accounting perspective. If funds choose this strategy only to postpone necessary reforms, they will burden the cost to overcome the disguised structural funding gaps on later generations.

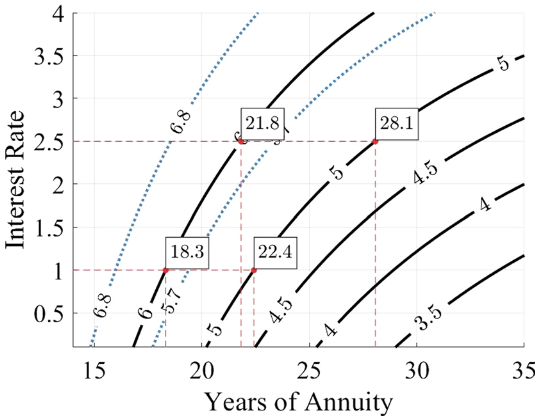

Fig. 3 Examplary conversion rates. Figure shows for different conversion factors (iso-curves), and interest rates (y-axis) how long pension payments last until a retired insurants own savings are depleted (x-axis). Pension payments assumed as annuities, with constant interest rates and annual pension payments in the amount of the respective conversion rate as a percentage of a retired insurants savings at the time of retirement. Source: Own calculations

The paper focuses on the technical discount rate, and the share of assets invested in equities. While it would have been especially interesting to look at funds' conversion ratio, the available dataset does not include information about this variable.[11]

3 Data and empirical methodology

3.1 Data

The data were provided by the BFS in pseudo-anonymized form. The BFS collects the data in an annual mandatory survey. The data most comprehensively cover the Swiss pension fund landscape. The provided dataset covers approximately 2000 pension funds with approximately 25,000 pension fund-year observations. The data cover the period from 2005 to 2017 and consist of annual, end-of-year (reporting) data. They include observations at the consolidated level but provide no information about sub-funds within collective or joint pension funds.

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[11] An analysis of the interest rates pension funds pay on savings was omitted in the final version of this paper but can be found in earlier drafts. Also, an analysis of the demographic assumptions was omitted. Data on the actuarial tables funds use have only been available since 2014, and the corresponding results show only a weak statistical relation to the funding ratio. This made me decide not to analyse the aspect of actuarial tables in this paper.

Table 1 Summary statistics of pension funds' key variables

Variable	Obs.	Mean	S.E.	Perc. 10	Median	Perc. 90
Total assets, CHF bn	21,239	368.65	1701.55	4.55	50.55	592.36
Log total assets, log CHF 1000	21,239	10.85	1.86	8.42	10.83	13.29
Retiree Pension Liabilities (techn.), CHF bn	21,239	149.23	621.34	0.84	23.35	252.35
Active Insurants' Savings, CHF bn	21,239	111.13	617.61	0.00	7.85	158.27
Number of joined employers	21,239	190.53	1663.40	1	2	40
Number of active insurants[a]	13,104	1968.66	10,845.97	23	232	2484
Number of retired insurants	21,239	276.18	1364.69	0	28	402.6
Number of active per retired insurant	11,710	13.56	41.46	1.81	5.80	25.67
Share of equity assets, %	18,974	26.51	10.95	11.77	27.03	39.05
Technical discount rate, %	17,182	3.20	0.65	2.25	3.50	4.00
Interest paid on savings (obligatory), %	18,178	2.42	1.28	1.25	2.25	4.00
Interest paid on savings (over-obligatory), %	16,831	2.35	1.00	1.50	2.00	3.50
Funding ratio (techn.)[b] , %	21,239	110.42	11.12	99.05	108.86	125.00
Economic funding ratio[c] , %	19,399	106.42	16.68	89.20	104.22	124.56
Share of obligatory savings[d] , %	16,860	53.12	22.50	28.26	52.22	76.05
Public fund = 1 [e]	21,239	0.02	0.128			
Collective fund = 1 [e]	21,239	0.05	0.228			
Joint fund = 1 [e]	21,239	0.06	0.236			

Summary statistics pooled for all years (2006–2017). Sample only includes private and public pension funds without state guarantees, and only includes funds with a (techn.) funding ratio between 81.5 and 152.3% (0.5th–95th percentile range)

[a] Excluding active insurants with risk insurance only and no retirement insurance.

[b] Technical funding ratio, according to Art. 44 BVV2/OBB2, evaluating pension liabilities with funds own technical discount rate and own choice of actuarial table.

[c] Funding ratio evaluating retiree pension liabilities with risk-free market interest rates and generation table as actuarial table.

[d] Share of active insurants' obligatory savings (BVG minimum) to their total savings.

[e] Dummy variable = 1 for public, collective, or joint funds and = 0 otherwise.

The available variables include information on pension funds' assets, where the distinction of asset types is relatively high-level. The variables include total fixed-income, equity, mortgage, real estate, cash, and other assets. Further, the data provide information on total (net present) pension liabilities owed to its insurants, separated by how much is owed to retired insurants and how much to working employees (active insurants); it also includes information about reserves and provisions. Furthermore, the data set includes the applied technical discount rate, and the funding ratio. The provided variables allow replicating reported (technical) funding ratios. However, I am not completely able to exactly match all observations' reported funding ratio with the funding ratio replicated from funds' liabilities and assets. Thus, pension fund observations, where the deviation of the reported and the replicated funding ratio is larger than 2 percentage points, are eliminated from the analysis. This elimination affects 7.1% of observations, corresponding only to 2.6% of aggregated total assets, and only to 1.8% of aggregated number of insurants. Additionally, since 2005 was a testing year for the survey, data from 2005 are not considered in the analysis.

For each fund, the data set additionally provides information about the number of active and retired insurants, the number of employers, and the type (private, public with state-guarantee, public without state-guarantee, collective, etc.). Apart from the distinction between retirees and active insured people, we have no further direct information about a fund's age distribution of insurants.

Finally, we conduct our analysis considering only pension funds with funding ratios between 81.3% and 152.3%, which are the 0.5th and 95th-percentiles of the funds' funding ratios for all years. Table 1 provides the summary statistics of the key variables.

3.2 Methodology

We are interested in the average level of a fund's technical discount rate, and the share of equity assets, conditional on a fund's funding ratio. The technical discount rate and the share of equity assets as dependent variable are denoted as y_i. A fund's funding ratio is denoted as FR_i. To estimate the conditional average $E[y_i|FR_i = FR_j]$ we run a sequence of local linear regressions at different points FR_j

$$\min_{\alpha,\beta} \sum_{i=1}^{N} K\left(\frac{FR_i - FR_j}{h(j)}\right)\left(y_i - \alpha - \beta(FR_i - FR_j)\right)^2 \tag{2}$$

The bandwidth $h(j)$ varies, where $h(j)$ is determined as the maximum Euclidian distance of FR_j to the nearest 20% of all values of FR_i. For the kernel weights, I use the tricube kernel $K(u) = (70/81)(1 - |u|^3)^3$ for $|u| \leq 1$ and $K(u) = 0$, otherwise.[12]

The local linear regression for the share of equity assets shows a smooth downward spike at the 100% funding ratio threshold. Hence, for the analysis of the share of equity assets, I perform local linear regressions as above but separately for the sample with funding ratios below 100% and the sample with funding ratios above 100%. Given the weak stability of the local linear regression for funds below 100%, I further fit a global polynomial regression. The polynomial regression allows for a different number of polynomial terms to the left (p) and right (q) of the 100% funding ratio threshold. The global polynomial regression considers all observations in the sample instead of performing the regressions only locally. One can specify the left and right polynomial regressions as one regression by including an interaction term with a dummy for the observations with a funding ratio above $c = 100\%$. Further, values are centered at the cutoff c. This specification allows to easily interpret the coefficient of the interaction between the intercept and the dummy as the average difference in the share of equity assets between funded funds and funds in shortfall.

$$\begin{aligned} y_i = &\alpha + 1\{FR_i < c\} : (\beta_1(FR_i - c) - \ldots - \beta_p(FR_i - c)^p) \\ &+ 1\{FR_i \geq c\} : (\tau + \gamma_1(FR_i - c) - \ldots - \gamma_q(FR_i - c)^q) + \varepsilon_i \end{aligned} \tag{3}$$

The order of polynomials to the left (p) and right (q) of the cutoff (c) are selected based on the model with the lowest Bayesian Information Criterion (BIC) (Hausman and Rapson, 2018) while checking all combinations with 1 to 7 polynomials.

4 Results

4.1 Empirical distribution of funding ratios

We first establish the discontinuity in the distribution of funding ratios at the 100% threshold and conclude that most funds are successfully able to maintain a ratio above 100%. Figure 1 (shown in the introduction) plots the distribution of the funding ratios of pension funds for 2006, 2017 as well as overall from 2006 to 2017. The individual years are shown in Fig. 9. The depiction of the empirical distribution such as the choice of binwidths and the fitted density (red line) follows the procedure by McCrary 2008). The fitted density is estimated from a 4-order polynomial fitted to the left and right of 100%, while omitting the bin including the observations with exactly 100%. The distribution shows a heavy discontinuity at the 100% threshold already from visual inspection. The significance of the discontinuity is confirmed by the Mc Crary test described in more detail in Appendix 8 and with results reported in Table 6. Following the financial crisis of 2008, many funds fell below the 100% threshold; however, the discontinuity remains significant. Although most pension funds do indeed manage to be above 100%, 11.5% of all fund-year observations are below this threshold. This result is a clear indication that pension funds avoid falling below the minimum threshold and that pension funds are able to largely control their funding ratio. However, they cannot or do not do so entirely, since there are some funds below the 100% threshold.

4.2 Technical discount rate

The next sections analyze the relationship between funds funding ratio and their choice of the technical discount and their asset allocation. We begin with the technical discount rate and look at the average discount rate of funds grouped by similar funding ratios. This allows to get an indication of whether the excess mass in Fig. 1 is the result of funds choosing different technical discount rates. Especially, to see whether funds just above 100% choose favorable (and high) discount rates since they would fall below 100% if they applied a lower, counterfactual discount rate. In Fig. 10, the solid line plots the average technical discount rate (y-axis) that pension funds apply to discount future pension liabilities given a pension fund's funding ratio (x-axis). In all years, the general pattern is that funds with lower funding apply higher discount rates than funds with better funding. However, although worse-funded funds use higher rates, one can nevertheless observe a decline in the level of the fitted line over the past decade. While the overall average discount rate was 3.72% in 2006, the average declined by 160 bps to 2.12%. In 2006, funds with a funding ratio of 115% applied on average a discount rate of 3.70% (95% confidence interval [3.66, 3.75]), while funds with a 105% ratio applied a higher rate of 3.78% ([3.74, 3.82]). In 2017, the funds with a 115% ratio used a more conservative rate of 2.10% ([2.04, 2.17]), while the funds with a 105% ratio used a rate of 2.30% ([2.07, 2.19]). For funds with a ratio

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[12] All computations are done using MATLAB 2020a (Matlab, 2020) local regressions build on adjustments and corrections to Cao (2008); Duarte(2012) and make use of Lansey (2013); Schäublin (2020a; b)

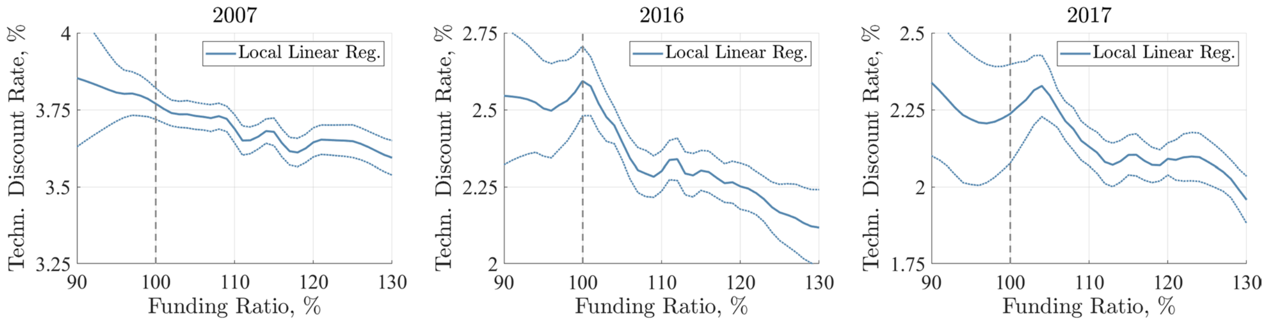

Fig. 4 Average Technical Discount Rate—Local Linear Regression Figures show the weighted average discount rate (y-axis) used to discount pension liabilities of insurants, conditional on the funding ratio of the funds (x-axis). Blue solid lines are averages estimated by a local linear regression using a tricube kernel with varying bandwidths, considering the closest 20% of observations. Dotted blue lines show the 95% confidence band from bootstrapped standard errors (500 iterations). The average discount interest rate decreases the better a fund's funding ratio. The sample includes only private and public funds without state guarantees, and only includes funds with a funding ratio between 81.5 and 152.3% (0.5th–95th percentile range)

of only 90%, the average discount rate was 4.00% ([3.87, 4.14]) in 2006, and 2.34% ([2.09, 2.58]) in 2017 (Fig. 4).[13]

4.2.1 Discussion

The negative statistical relationship between funding ratios and the applied discount rate indicates that funds with lower funding ratios do apply higher discount rates. If the weaker funded funds with high discount rates applied lower, more conservative rates (as their peers do which are located in the figure to their right), their funding ratio would be even worse. This result is in line with the perception that funds do not align the discount rate to declining market rates if this would threaten an already weak funding ratio.[14]

4.2.2 Market-based discount rates

An alternative to a valuation of pension liabilities based on a discretely chosen discount rate is to evaluate pension liabilities based on market interest rates. Under a market-based valuation, the value of pension liabilities would correspond to the cost of a replicating portfolio that matches the size, the maturity, and the risk of the expected cash (out-) flows in terms of future pension payments. For a sufficiently large population of insurants, the uncertainty of these expected cash flows converged to zero. Hence, a corresponding replicating portfolio to finance these cash flows was composed of risk-free securities of matching maturities.[15] If a fund applies higher discount rates that include a (risk) premium, this would imply that the pension obligations would be funded with a risky replicating portfolio. Indeed, most pension funds finance pension obligations by investing their assets not exclusively in federal bonds but also in risky assets. But generally, the (financial) risk of such a portfolio would not exactly match the (demographic) risk of the expected pension obligations. The valuation with non-risk-free interest rates would neglect (and hide) the risk transformation implied by the mismatch between the risk of assets and liabilities.

Compared to the technical funding ratio that uses discretionary technical discount rates, the alternative *economic funding ratio* uses *market-based* discount rates. While some pension funds report the ratio explicitly, it is not a regulatory requirement. As the technical funding ratio, the economic funding ratio is the ratio of a funds' assets divided by a funds' pension liabilities. However, pension liabilities owed to retirees are discounted with risk-free market interest rates of Swiss government bonds' term structure (PPCmetrics, 2017; PPCmetrics, 2020).[16]

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[13] Other selected point estimates, other years, including confidence bands, as well as the specific bandwidths are given in Table 3 in Appendix.

[14] Indeed, as was mentioned in discussions with practitioners, in their experience, funds implement reforms that tackle the discount rate in favorable years when the funding ratio is comfortable.

[15] If the expected cash flows was less certain than the distribution of a funds' insurants life expectancy, the corresponding replicating portfolio would consists of securities matching the exact distribution of the life-expectancy, and resulting cash-flows, that is the securities would pay-off (do not pay-off) in the same states as the liability is due (is not due).

[16] This definition of the economic funding ratio determines the pension liabilities owed to active insurants simply as the amount of their savings (active insurants' savings). Additionally, future liabilities are determined using the generation table. More sophisticated definitions of economic funding ratio take into the expected pension entitlement owed to active insurants becoming retirees, or account for the fund's recovery capacity (PPCmetrics, 2017, p. 9

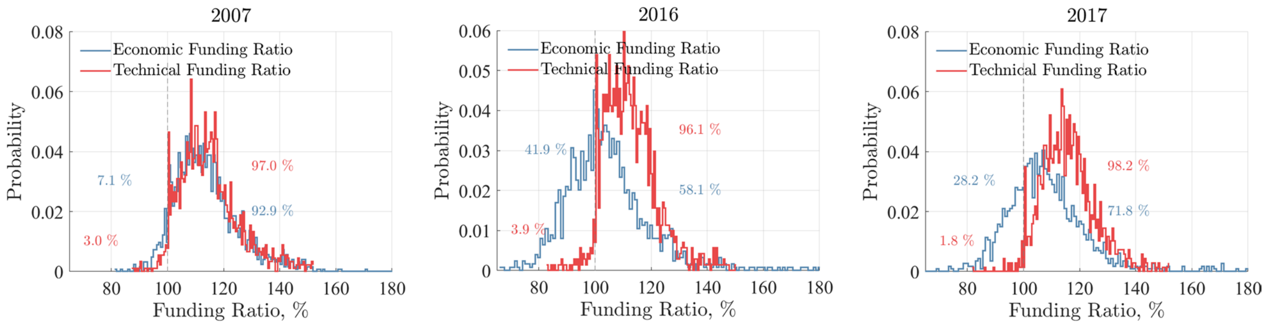

Fig. 5 Distribution of Funding Ratios. Histogram of pension funds' technical and economic funding ratios in 2007, 2016 and 2017. Economic funding ratios-based retiree pension liabilites evaluated at market interest approximated with conversion factors retrieved from PPCmetrics, (2020). The sample includes only private and public funds without state guarantees, and only includes funds with a funding ratio between 81.5 and 152.3% (0.5th–95th percentile range of the overall sample)

Thus, the economic funding ratio allows determining a fund's funding eliminating the effect of technical discount rates exceeding the level of risk-free market rates. This size of the effect is quantified as the difference in the valuation of retiree pension liabilities using market rates versus using technical discount rates. Given the available data, the most practical approach to approximate funds' market value of retiree pension liabilities (and the economic funding ratio), is to use the conversion factors provided by PPCmetrics, (2020). The factors allow to easily approximate the market value by multiplying the reported retiree pension liabilities with the corresponding conversion factor. The factors depend on a fund's applied technical discount rate and the actuarial table a fund uses.[17] The conversion factors are determined by PPCmetrics assuming a representative demographic structure of insurants (PPCmetrics, 2017p. 133).

Figure 5 compares the distribution of funds' economic and technical funding ratios of 2007, 2016, and 2017. For 2016 and 2017, the distribution of economic funding ratios shows a smoother pattern and no spike at the 100% threshold, in contrast to the distribution of the technical funding ratios.[18] While 98% of funds have a technical funding ratio above 100%, almost every fourth of these funds is insufficiently funded given a valuation of pension liabilities with market interest rates. In 2007, the two distributions are almost overlapping. This observations matches the flatter slope of the average technical discount rate in Fig. 10 for 2007. It is a further indication, that one factor why the mass of pension funds above slightly above 100 is able to maintain full funding is that they apply higher discount rates.

Focussing on 2017, Fig. 6 reports the total annual gross excess funding and shortfall in CHF aggregated across all funds. The red and blue bars show the total short fall and total excess funding of all funds based on a technical discount rate valuation. In 2017, excess funding, amounted to CHF 79.1 bn. The black and blue solid lines show the total excess funding based on a market discount rate valuation. In 2017, excess funding was only CHF 33.5 bn if pension liabilities, while the corresponding the net excess funding (excess funding less shortfall) was only CHF +4.2 bn (dashed line).

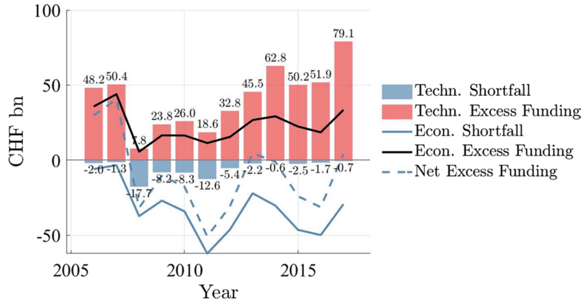

Fig. 6 Aggregated Gross Excess Funding and Shortfall.Aggregated gross and net excess funding and shortfall, based on technical pension liabilities (Technical) and pension liabilities determined at market rates (Econonomic). Economic funding shortfall and excess based on retiree pension liabilites evaluated at market interest rates approximated with conversion factors retrieved from PPCmetrics, (2020). The sample includes only private and public funds without state guarantees, and only includes funds with a funding ratio between 81.5 and 152.3% (0.5th–95th percentile range of the overall sample)

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[17] For the years before 2014, when the BFS data do not include information about funds' actuarial tables, we assumed that all funds applied the more widespread periodic table.

[18] Note, compared to the histogram for 2017 in Fig. 9, the sample size for both histograms in Fig. 5 is slightly reduced, dropping funds with incomplete data to determine the economic funding ratio.

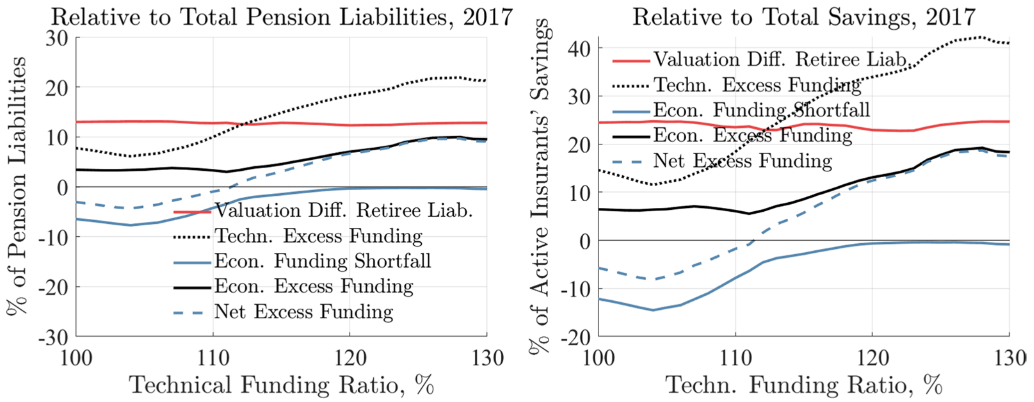

Fig. 7 Relative Valuation Difference, Excess Funding and Shortfall, 2017. Figure shows relative aggregated valuation difference and excess funding and shortfall for funds within same band width of funding ratios (x-axis) and as a share of total pension liabilities (left panel) and active insurants' savings (right panel). The aggregation is the total sum in CHF of all funds neighboring observations within band width including closet 20% of observations and weighted by tricube kernel weights. The left panel shows shares as percent of total reported pension liabilities, the right panel as percent of active insurants' savings. Economic funding ratios, and corresponding retiree pension liabilites evaluated at market interest rates are approximated using the conversion factors retrieved from PPCmetrics (2020). The sample includes only private and public funds without state guarantees, and only includes funds with a funding ratio between 81.5 and 152.3% (0.5th–95th percentile range of the overall sample)

The left panel of Fig. 7 shows (in blue) the local valuation difference between market-based and reported pension liabilities owed to retirees relative to the local total reported pension liabilities in 2017. The relative valuation difference is determined as the aggregated sum of the valuation difference divided by the aggregated sum of total pension liabilities. The sums are aggregated locally including funds with a funding ratio closest to 20% of all funds and weighted with tricube kernel weights. The figure illustrates the impact of the inherent premium of discount rates when compared to a valuation with risk-free interest rates. Independent of the technical discount rate, the valuation difference amounts to 15% of funds' pension liabilities. Further, the figure shows the corresponding aggregated relative excess funding and shortfall under the two different valuation approaches. The large valuation difference implies that even funds with a technical funding ratio of 110% have factually a shortfall in funding under the market-based valuation.

The right panle of Fig. 7 reports the local valuation difference and excess funding and shortfall relative to local active insurants' savings. The figure highlights the implications of the funding gap measured with risk-free market rates. For example, for funds with a technical funding ratio of 100%, the factual economic funding shortfall (red line) amounts to about 20% of active insurants' savings. If this shortfall is financed from active insurants' savings. It implies that an employee would have to contribute 25 cents of every saved franc toward the recovery of the financing gap, should it materialize. The financing gap will less likely materialize, if funds are able to earn a return above the risk-free market interest rates. This would require that funds would invest more of their assets in riskier assets but with higher average expected return. However, as we show in the next section, the weaker funded funds invest in general a lower share of assets in equities.

4.3 Asset allocation

Compared to applying euphemistic discount rates, a reallocation of low-risk assets to riskier assets with higher returns is a potentially more sustainable strategy to maintain long-term funding of pension liabilities. To investigate which funds follow riskier investment strategies, I perform an additional analysis, looking a pension funds share of assets invested in equities.

Figure 8 shows the funds' average share of assets invested in equities (y-axis) conditional on the funds' funding ratio (x-axis) in 2007, 2016, and 2017. Compared to the preceding figures, the local linear regression estimates (blue line) separate the samples to the left and the right of the 100% threshold. Additionally, the red line shows the estimates from the global linear regression. Both methods indicate a higher share of assets for funds below the 100% threshold (left) compared to funds above the 100% threshold (except for 2008, where many more funds fell into a shortfall).

Figure 8 shows the funds' average share of equity assets for all years. In most years, for funds to the right the share of assets invested in equities is positively related to a fund's funding ratio. Table 2 confirms this observation.

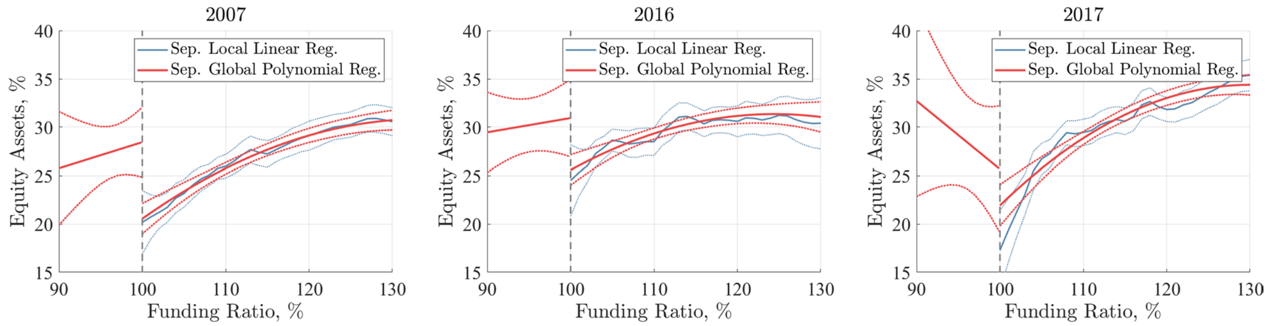

Fig. 8 Average Share of Equity Assets—Separate Local Linear and Global Polynomial Regression. Figures show weighted average share of assets invested in equities (y-axis), conditional on the funding ratio of the funds (x-axis). Estimates considering as sample only funds in a shortfall (below 100%), and sufficiently funded funds (equal and above 100%), respectively. Solid blue line shows averages estimated by a local linear regression using a tricube kernel with varying bandwidths, considering the closest 20% of observations. Solid red line shows averages from global polynomial regressions, with different numbers of polynomial terms to the left and right of 100%. Dotted lines show 95% confidence bands from bootstrapped standard errors (500 iterations). To the right of 100% the average equity share increases concavely in almost all years. The average equity share for funds in a shortfall (left) is discontinuously higher than the share invested by funded funds (right). The sample includes only private and public funds without state guarantees, and only includes funds with a funding ratio between 81.5 and 152.3% (0.5th–95th percentile range). Local linear regression estimates are not shown where the number of observations for regression does not exceed 10

The columns in the table report the estimated intercept, the coefficient τ (measuring the difference between the funds above and below 100%) as well as the coefficient for the respective first two polynomial terms (the slopes). The last column shows the number of polynomial terms selected for the left and right, based on the BIC selection criterion. The table reports the results from yearly regressions as well as for a pooled regression considering all years. The intercepts in Table 2 indicate that funds to the left have an average equity share of roughly 25–30% of their total assets. The slope to the right of 100% is significantly positive for most years. The estimates for τ indicate that funds above the threshold have an equity share, which is 3–5 percentage points lower.[19].

The positive slope on the right of 100% indicates that funds closer to the threshold are more cautious than better-funded funds further to the right. This is in line with the findings of An et al. (2013) and Rauh (2009)—who conclude that the weakly funded funds do not want to threaten further their funding by taking too much risk. Clearly, the results do not allow to any conclusion about causality. Is it that funds with better funding invest more since they have a higher capacity to invest, or are they better funded since the riskier investment strategy was more successful and allowed them to build up reserves and improve funding?

The result that funds below the 100% threshold have a higher share of equity assets and hence have riskier portfolios is similar to the results discussed in (An et al., 2013). An interpretation of the result could be that funds below the threshold *gamble for resurrection*. They run riskier strategies hoping for high returns to get back above the threshold. An alternative, second, explanation could be that funds with a high share of equities are below the threshold since they took more risks. For example, following the financial crisis in 2008, Figure 11 shows that the number of insufficiently funded funds increased, likely due to losses on the asset side (though not necessarily only from equity investments). However, there are three arguments that do not speak in favor of the second explanation. First, note that funds that fell below the cut-off, still have higher equity shares despite their losses – given the second explanation the losses should have reduced their equity investment. Second, a partly reversed picture would be observed in the good financial years, if the second explanation was true (e.g., 2006, 2009, 2012–2014). Third, it would also be less likely that a discontinuity would be observed. The latter is because not all ’high risk’ funds that had losses would fall below the threshold. Some of them would still have sufficient funding. This would imply that the funding ratios post-losses were more smoothly distributed across the threshold, reducing the discontinuity. However, such a case is observed only in 2008 but not generally.

Finally, note that the above analysis does not show that funds take more risk, as soon as they cross the threshold from above. The analysis is only

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[19] Point-estimates for the local linear and global polynomial regression are shown in Table 4 and Table 5

Table 2 Global Polynomial Regression Coefficients: Share of Equity Assets related to the Funding Ratio

Year	Intercept, α	Difference, τ	Slope left, β_1	Slope right, γ_1	*n*	Polynomial	R^2
2006	24.74***	− 5.29*	− 0.25	0.79***	1838	1, 2	0.08
	(2.31)	(2.54)	(0.36)	(0.10)			
2007	28.45***	− 7.9***	0.27	0.61***	1777	1, 2	0.06
	(1.74)	(1.89)	(0.37)	(0.09)			
2008	20.11***	− 0.88	− 0.46***	− 0.28*	1769	1, 2	0.09
	(0.50)	(0.80)	(0.06)	(0.12)			
2009	26.56***	− 4.15***	− 0.23	0.69***	1768	1, 3	0.02
	(0.89)	(1.21)	(0.20)	(0.20)			
2010	27.94***	− 2.08*	0.01	− 0.02	1688	1, 1	0.01
	(0.87)	(0.97)	(0.17)	(0.03)			
2011	26.91***	− 3.02***	0.05	− 0.05	1669	1, 1	0.02
	(0.68)	(0.78)	(0.14)	(0.03)			
2012	28.49***	− 3.22*	0.1	0.01	1558	1, 1	0.01
	(1.27)	(1.30)	(0.25)	(0.04)			
2013	25.71***	− 3.32	− 0.97***	1.02***	1485	1, 3	0.04
	(1.55)	(1.82)	(0.25)	(0.21)			
2014	28.13***	− 5.12*	− 0.18	0.53***	1411	1, 2	0.04
	(1.94)	(2.23)	(0.36)	(0.11)			
2015	30.57***	− 5.98***	− 0.27	0.47***	1388	1, 2	0.03
	(1.34)	(1.54)	(0.35)	(0.10)			
2016	30.94***	− 5.37*	0.15	0.47***	1344	1, 2	0.03
	(2.04)	(2.23)	(0.28)	(0.10)			
2017	25.66***	− 3.73	− 0.71	0.83***	1279	1, 2	0.09
	(3.15)	(3.32)	(0.60)	(0.12)			
2006–2017	25.54***	− 3.46***	− 0.09	0.65***	18,974	1, 3	0.03
	(0.32)	(0.41)	(0.05)	(0.05)			

Coefficients for global polynomial regression for share of total assets invested in equities (in %), depending on funding ratio (in %) and polynomial terms. Table columns only show the estimates for the intercept (α), for the difference left and right of the cut-off (τ), and slopes (first polynomial terms, β_1, and γ_1). Estimates from global polynomial regressions with separate polynomials to the left and right of a funding ratio of 100%. Selected number of polynomials based on the BIC selection criterion. Bootstrapped standard errors in parentheses (500 iterations). The last three columns show the number of observations (n), the number of selected polynomial terms (left, *p*, and right, *q*), and the R^2. Significance levels at 0.05 *, 0.01 ** and 0.001 ***. Estimates for τ show a negative and significant difference between unfunded and funded funds in almost all years (excluding 2008, 2013, 2017). In the pooled regression (last row), the difference is 3.46 percentage points. For sufficiently funded funds, the share of equity assets is positively related to the funding ratio ($\gamma_1 > 0$) in almost all years (excl. 2010–2012). The samples include only private and public funds without state guarantees, and includes only funds with a funding ratio between 81.5 and 152.3% (0.5th–95th percentile range)

cross-sectional and does not consider funds over time. While attempted, the results for an analysis of funds over years were not clear, which can be explained by the following: first, the dataset, unfortunately, does not allow us to infer whether a fund's difference in portfolio allocations across time is due to a conscious decision to re-allocate or gains and losses on different allocations (i.e., no portfolio re-balancing). Furthermore, funds' may not react immediately when the fall below 100%. The time it takes for a fund to react and implement a riskier strategy may differ across funds. Both reasons make it more challenging to credibly investigate gambling for resurrection across time with a difference in difference approach.

5 Conclusion

The aging of the population and lower interest rates threaten the viability of pensions across developed economies worldwide. Understanding the tools and strategies used by pension funds to sustainably guarantee full funding of future pension promises is essential. In this context, it is important to understand the shortcomings of the funding ratio as an indicator to measure the level of pension funds funding.

This paper aims to analyze the funding ratio of Swiss occupational pension funds. The results show that the worse a fund's funding ratio, the higher—and hence more euphemistic—the applied technical discount rate to discount future pension liability. The higher discount rate result in a biased valuation of pension liabilities when compared to a valuation with market-based discount rates. This valuation bias amounted to about 15% of total pension liabilities, in 2017.

Further, this paper identifies a positive relationship between funding ratios and the share of assets invested in equity for funds that meet the regulatory requirement. An potential explanation for this observation is that the strict regulatory requirement to maintain full funding constraints funds risk appetite (and capacity). Additionally, funds below the regulatory minimum appear to gamble for resurrection, which can be interpreted from the discontinuously higher equity shares of funds in a shortfall vs. sufficiently funded funds.

The validity of the paper's descriptive analysis is limited to the extent that it only analyzes the difference cross-sectionally. The analysis does not allow to infer whether individual funds change their variables of choice as they become better or worse funded. Furthermore, the available dataset does not provide information about the funds' conversion rates or more sophisticated demographic characteristics. To guarantee future pension payments pension funds could also lower conversion rates and reduce pension promises. Knowledge about the demography of a fund's insurants would facilitate controlling for further pension fund characteristics that essentially determine a fund's ability to meet future pension promises. The analysis in this paper is descriptive; drawing sharper conclusion would require further and deeper investigations. However, it may serve for a better understanding of pension funds' decision on how to react to the challenges of an aging population and lower returns, as well as provide an empirical basis for further theoretical and empirical research on pension funds.

Discounting pension liabilities with euphemistic discount rates may enable funds to meet the regulatory minimum requirement. However, it allows funds to conceal their (economic) funding shortfall and structural financing gaps. This allows them to postpone reforms to align pension promises with market returns. The costs thereof are paid by the non-retired insurants once these financing gaps materialize. Necessary reforms would include (i) a change in the investment strategy to reallocate assets and increase returns, or (ii) a reduction in pension promises by lowering the conversion rate. However, one should take into account that having a weak funding ratio makes funds to be more reluctant to choose riskier investment strategies (measured as the share of equity assets to total assets).

As long as conversion rates and a funds returns are not aligned, this creates disincentives. For example, employees close to retirement are incentivized to buy into the fund in order to benefit from the high conversion rates. This creates an even higher burden to be financed by the younger employees. Moreover, younger employees are disincentivizes to save more within the second pillar. As they can expect that their pension plans will need to be adjusted in the future, they may be incentivized to save rather on their own, than to make one-time lump sum contributions to the pension fund.

Appendix

Additional figures

See Figs. 9, 10, 11 and 12.

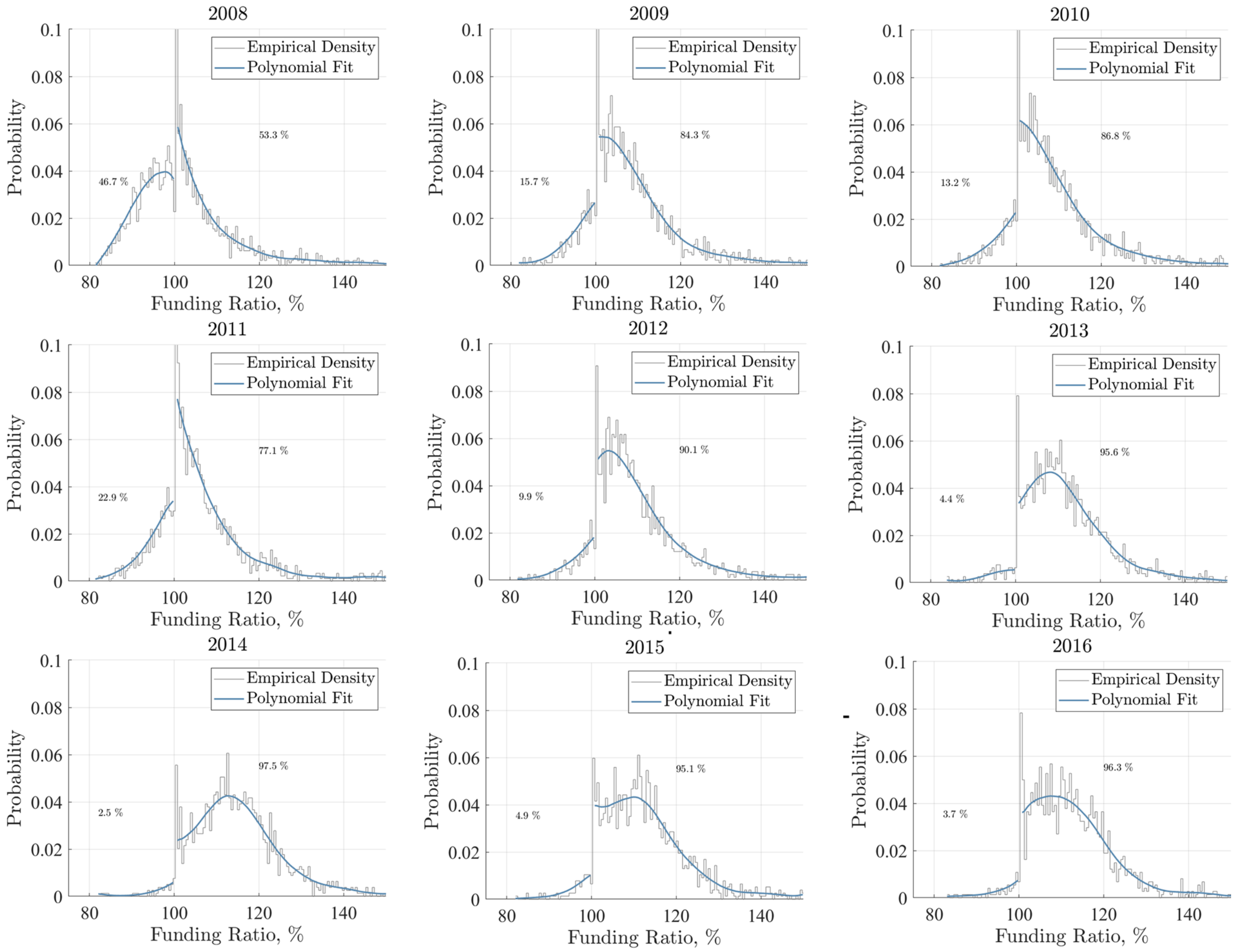

Fig. 9 Distribution of Funding Ratios. Annual distributions of the funding ratios of pension funds, 2008–2016 (years 2007 and 2017 in the main text). Figure at bottom right shows pooled distribution including all pension fund observations for all years. The solid line shows the smoothed fit using a local 4th order polynomial kernel regression to the left and to the right of 100%. Binwidth of histogram and bandwidth of triangular kernel are based on the procedure by McCrary (2008). Bin at 100% omitted for polynomial fit. Figure shows spike exactly at the regulatory minimum (100%). The corresponding McCrary test for discontinuity between left and right of 100% (omitting the 100% bin) is positive and significant. The sample includes only private and public funds without state guarantees, and only includes funds with a funding ratio between 81.5 and 152.3% (0.5th–95th percentile range).

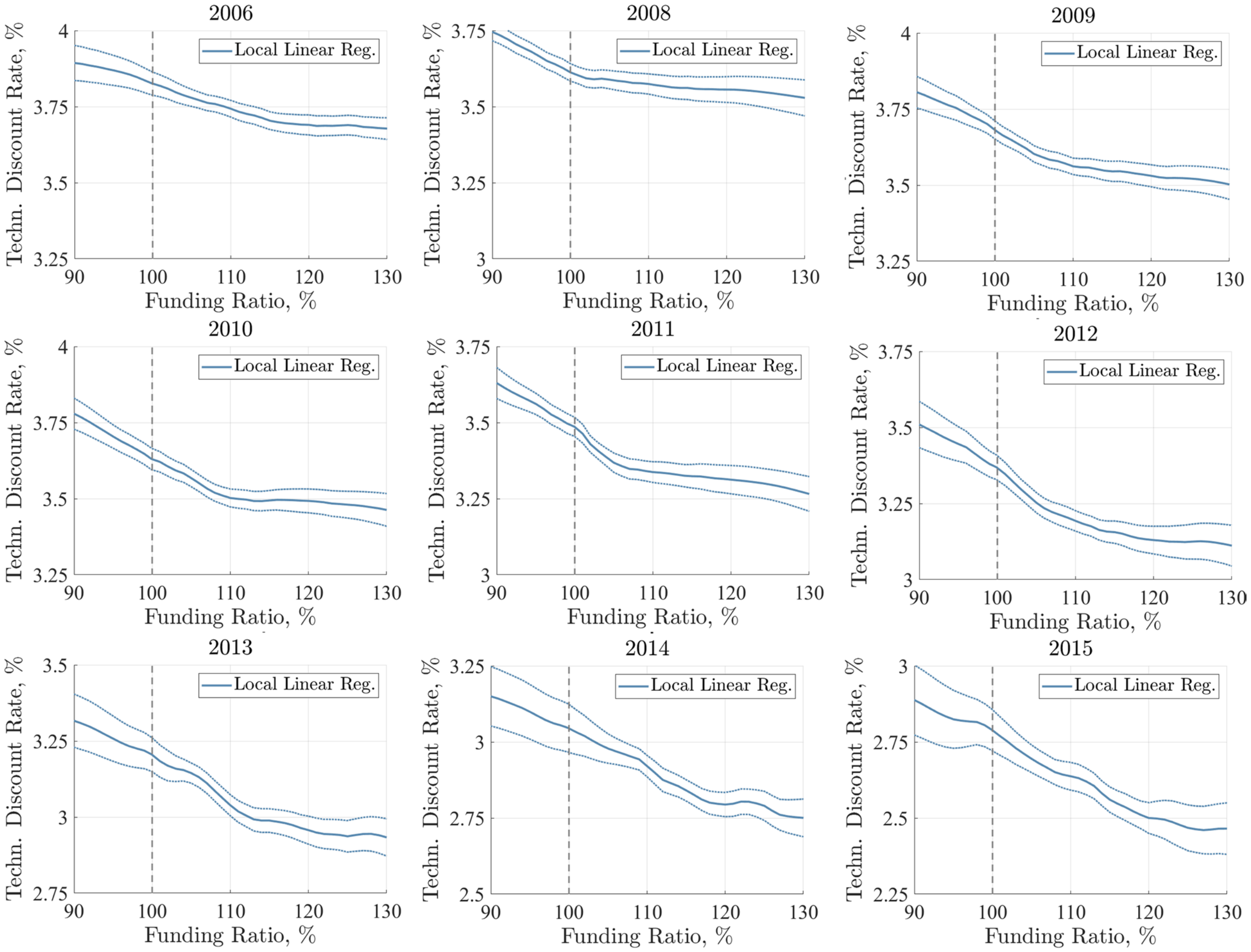

Fig. 10 Average Technical Discount Rate - Local Linear Regression. Figures show the weighted average discount rate (y-axis) used to discount pension liabilities of insurants, conditional on the funding ratio of the funds (x-axis). Blue solid lines are averages estimated by a local linear regression using a tricube kernel with varying bandwidths, considering the closest 20% of observations. Dotted blue lines show the 95% confidence band from bootstrapped standard errors (500 iterations). The average discount interest rate decreases the better a fund's funding ratio. The sample includes only private and public funds without state guarantees, and only includes funds with a funding ratio between 81.5 and 152.3% (0.5th–95th percentile range). Years, 2007, 2016, and 2017 in the main text

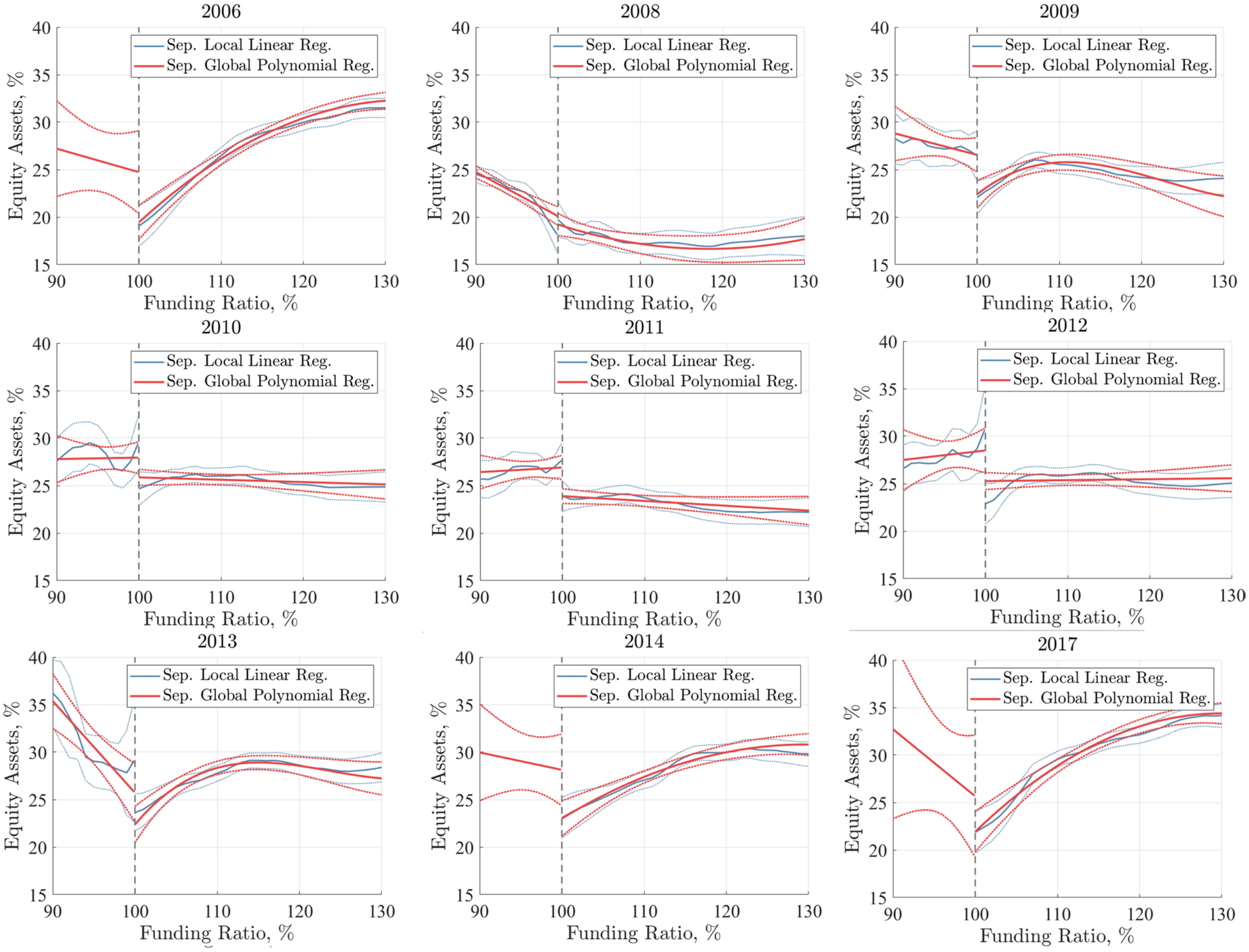

Fig. 11 Average Share of Equity Assets - Separate Local Linear and Global Polynomial Regression. Figures show weighted average share of assets invested in equities (y-axis), conditional on the funding ratio of the funds (x-axis). Estimates considering as sample only funds in a shortfall (below 100%), and sufficiently funded funds (equal and above 100%), respectively. Solid blue line shows averages estimated by a local linear regression using a tricube kernel with varying bandwidths, considering the closest 20% of observations. Solid red line shows averages from global polynomial regressions, with different numbers of polynomial terms to the left and right of 100%. Dotted lines show 95% confidence bands from bootstrapped standard errors (500 iterations). To the right of 100% the average equity share increases concavely in almost all years. The average equity share for funds in a shortfall (left) is discontinuously higher than the share invested by funded funds (right). The sample includes only private and public funds without state guarantees, and only includes funds with a funding ratio between 81.5 and 152.3% (0.5th–95th percentile range). Local linear regression estimates are not shown where the number of observations for regression does not exceed 10. Years, 2007, 2016, and 2017 in the main text

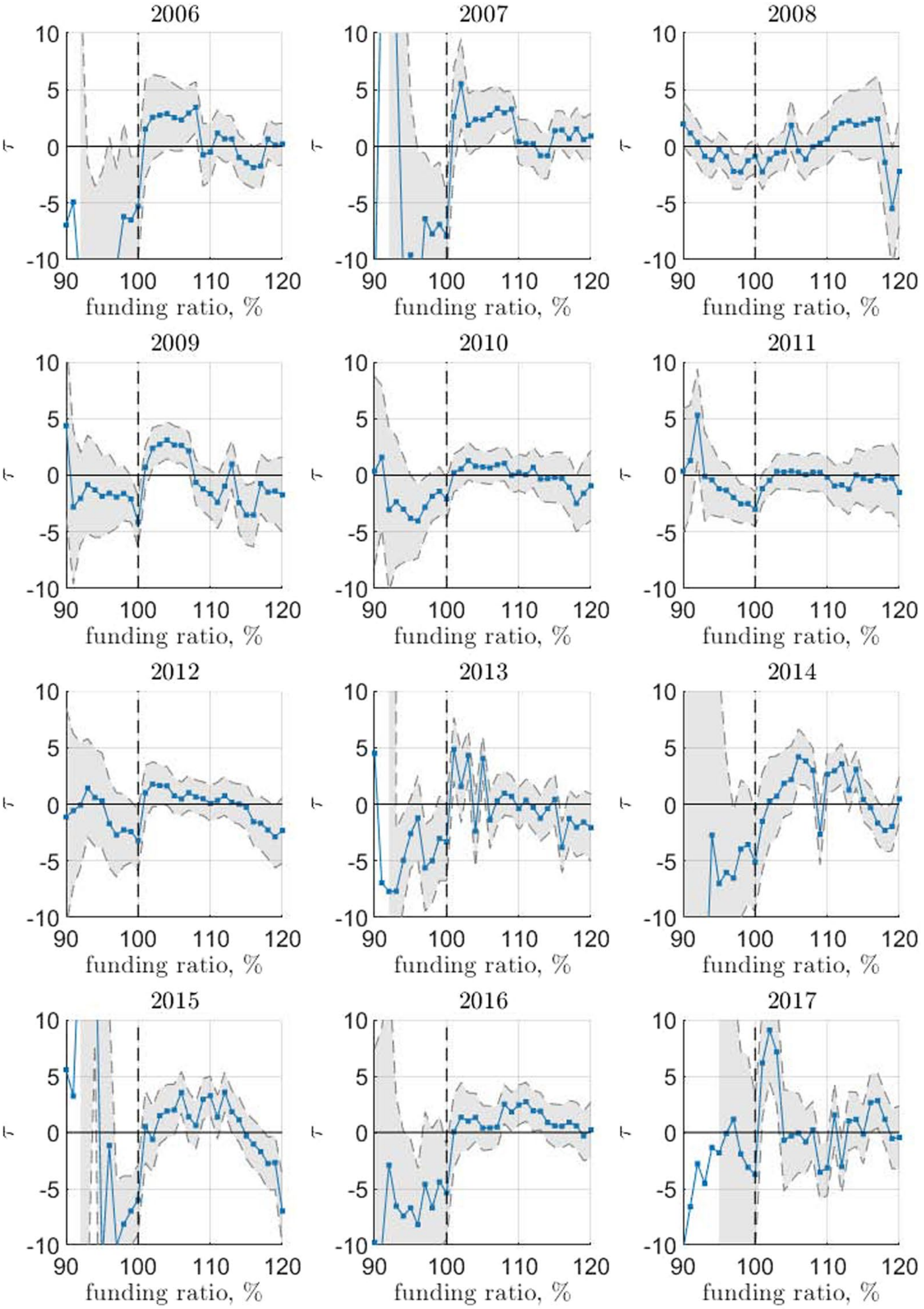

Fig. 12 Estimates for τ at Alternative Cut-offs. Figure shows the coefficients for τ estimated for varying alternative cut-offs c, using the global polynomial regression specification. The gray area indicates the 95% confidence bands from bootstrapped standard errors (500 iterations). Confidence bands are below zero, mostly only at $c = 100\%$. Compared to alternative cut-offs, the specification with $c = 100\%$appears to yield the estimate that is most significantly different from zero in almost all years. The sample includes only private and public funds without state guarantees, and includes only funds with a funding ratio between 81.5 and 152.3% (0.5th–95th percentile range)

Additional Tables

See Tables 3, 4 and 5.

Table 3 Local linear regression: Technical Discount Rate Related to the Funding Ratio

Year		f(85)	f(90)	f(95)	f(100)	f(105)	f(110)	f(115)
2006	*f*(*x*)	4.10	4.00	3.91	3.83	3.78	3.74	3.70
	C.I.	[3.89; 4.31]	[3.87; 4.14]	[3.82; 4.00]	[3.78; 3.88]	[3.74; 3.82]	[3.71; 3.78]	[3.66; 3.75]
	h(*x*)	22.84	17.84	12.84	7.97	4.00	2.45	2.50
2007	*f*(*x*)	3.89	3.85	3.81	3.77	3.73	3.69	3.68
	C.I.	[3.50; 4.28]	[3.62; 4.08]	[3.71; 3.90]	[3.72; 3.82]	[3.69; 3.77]	[3.64; 3.73]	[3.63; 3.72]
	h(*x*)	20.97	15.97	10.97	6.27	3.03	2.34	2.24
2008	*f*(*x*)	3.77	3.75	3.67	3.59	3.56	3.58	3.56
	C.I.	[3.70; 3.84]	[3.70; 3.79]	[3.63; 3.71]	[3.55; 3.64]	[3.52; 3.61]	[3.53; 3.63]	[3.51; 3.62]
	h(*x*)	7.47	3.41	2.23	1.73	3.51	6.52	10.24
2009	*f*(*x*)	3.79	3.79	3.76	3.68	3.62	3.58	3.55
	C.I.	[3.68; 3.90]	[3.72; 3.87]	[3.71; 3.81]	[3.63; 3.72]	[3.57; 3.66]	[3.53; 3.62]	[3.50; 3.60]
	h(*x*)	15.17	10.17	5.36	2.51	1.74	2.56	4.64
2010	*f*(*x*)	3.87	3.78	3.71	3.65	3.60	3.48	3.50
	C.I.	[3.75; 3.99]	[3.71;3.85]	[3.66; 3.76]	[3.60; 3.70]	[3.56; 3.65]	[3.43; 3.53]	[3.45; 3.55]
	h(*x*)	15.74	10.74	6.02	2.47	1.76	2.64	4.65
2011	*f*(*x*)	3.64	3.63	3.56	3.48	3.36	3.33	3.33
	C.I.	[3.52; 3.76]	[3.56; 3.70]	[3.50; 3.61]	[3.43; 3.53]	[3.32; 3.41]	[3.28; 3.38]	[3.27; 3.39]
	h(*x*)	13.44	8.45	4.36	1.54	1.95	3.63	6.38
2012	*f*(*x*)	3.48	3.50	3.44	3.38	3.26	3.21	3.15
	C.I.	[3.27; 3.70]	[3.38; 3.62]	[3.36; 3.52]	[3.32; 3.44]	[3.21; 3.31]	[3.15; 3.27]	[3.09; 3.20]
	h(*x*)	16.88	11.88	7.05	2.94	1.65	2.37	4.19
2013	*f*(*x*)	3.16	3.23	3.30	3.16	3.18	3.07	2.97
	C.I.	[2.86; 3.46]	[3.04; 3.42]	[3.19; 3.41]	[3.06; 3.27]	[3.12; 3.23]	[3.02; 3.12]	[2.92; 3.03]
	h(*x*)	19.25	14.25	9.31	4.65	2.24	1.97	3.03
2014	*f*(*x*)	3.06	3.08	3.13	3.04	2.99	2.91	2.83
	C.I.	[2.82; 3.30]	[2.88; 3.29]	[2.91; 3.35]	[2.93; 3.15]	[2.92; 3.05]	[2.86; 2.97]	[2.77; 2.89]
	h(*x*)	22.04	17.04	12.04	7.07	3.65	2.27	2.37
2015	*f*(*x*)	2.71	2.79	2.88	2.78	2.67	2.61	2.56
	C.I.	[2.22; 3.20]	[2.51; 3.07]	[2.77; 3.00]	[2.69; 2.87]	[2.60; 2.74]	[2.55; 2.68]	[2.50; 2.62]
	h(*x*)	19.11	14.11	9.15	4.55	2.55	2.07	2.47
2016	*f*(*x*)	2.57	2.55	2.50	2.59	2.39	2.30	2.30
	C.I.	[2.24; 2.90]	[2.32; 2.77]	[2.35; 2.66]	[2.49; 2.70]	[2.33; 2.45]	[2.24; 2.36]	[2.24; 2.37]
	h(*x*)	19.25	14.25	9.34	4.63	2.23	2.16	2.62
2017	*f*(*x*)	2.45	2.34	2.22	2.24	2.30	2.13	2.10
	C.I.	[2.12; 2.78]	[2.09; 2.58]	[2.02; 2.42]	[2.09; 2.39]	[2.21; 2.39]	[2.07; 2.19]	[2.04; 2.17]
	h(*x*)	22.70	17.70	12.70	7.72	3.75	2.46	2.14

Point estimates (*f*(*x*)) for local average technical discount rate (in percent), for different funding ratios (in percent). Estimates from local linear regressions with varying local bandwidths *h*(*x*) covering the closest 20% of observations and using a tricube kernel. Confidence band (C.I.) in square brackets is from bootstrapped standard errors (500 iterations). The sample includes only private and public funds without state guarantees, and includes only funds with a funding ratio between 81.5 and 152.3% (0.5th–95th percentile range)

Table 4 Local linear regression: Share of Equity Assets Related to the Funding Ratio

Year		f(85)	f(90)	f(95)	f(100)	f(105)	f(110)	f(115)
2006	*f*(*x*)	–	–	–	18.0	22.9	26.6	29.6
	C.I.	–	–	–	[14.3; 21.8]	[21.4; 24.4]	[25.2; 27.9]	[28.3; 31.0]
	h(*x*)	–	–	–	8.0	3.9	2.5	2.5
2007	*f*(*x*)	–	–	–	20.2	23.2	26.0	27.2
	C.I.	–	–	–	[17.0; 23.4]	[21.7; 24.6]	[24.6; 27.3]	[26.0; 28.5]
	h(*x*)	–	–	–	6.4	3.0	2.3	2.2
2008	*f*(*x*)	26.8	24.1	21.9	17.9	19.0	16.1	17.7
	C.I.	[25.0; 28.5]	[22.8; 25.4]	[20.7; 23.1]	[15.6; 20.2]	[16.8; 21.1]	[14.5; 17.8]	[15.8; 19.6]
	h(*x*)	4.9	2.0	1.1	1.1	1.7	3.4	5.4
2009	*f*(*x*)	30.7	28.4	27.6	22.5	25.3	25.7	25.5
	C.I.	[22.7; 38.7]	[25.2; 31.6]	[24.7; 30.5]	[20.1; 25.0]	[24.0; 26.7]	[24.1; 27.3]	[23.9; 27.1]
	h(*x*)	8.1	3.8	1.3	3.2	1.5	2.1	3.8
2010	*f*(*x*)	25.7	28.5	30.9	24.8	26.2	25.8	26.5
	C.I.	[19.5; 32.0]	[23.8; 33.1]	[27.2; 34.6]	[22.3; 27.4]	[24.9; 27.5]	[24.4; 27.1]	[25.0; 28.0]
	h(*x*)	7.4	3.6	1.2	2.9	1.5	2.3	4.0
2011	*f*(*x*)	27.7	25.0	26.3	23.9	23.9	24.4	22.5
	C.I.	[23.1; 32.3]	[21.7; 28.2]	[24.1; 28.5]	[21.6; 26.1]	[22.5; 25.2]	[23.0; 25.8]	[20.8; 24.1]
	h(*x*)	7.2	3.2	1.3	1.6	1.5	2.8	5.2
2012	*f*(*x*)	28.1	28.7	29.1	21.9	26.4	25.5	26.5
	C.I.	[19.0; 37.2]	[25.5; 31.9]	[26.9; 31.4]	[18.6; 25.2]	[25.0; 27.7]	[24.0; 27.1]	[25.2; 27.9]
	h(*x*)	7.8	3.5	1.5	3.5	1.6	2.2	3.7
2013	*f*(*x*)	42.1	37.5	30.4	21.6	26.3	27.4	29.8
	C.I.	[30.5; 53.8]	[26.1; 49.0]	[25.3; 35.5]	[18.6; 24.6]	[24.8; 27.9]	[26.2; 28.7]	[28.6; 31.0]
	h(*x*)	7.9	3.6	0.9	5.1	2.2	1.9	2.9
2014	*f*(*x*)	33.0	40.5	32.3	23.2	25.1	26.4	30.3
	C.I.	[− 37.0; 102.9]	[− 19.1; 100.1]	[19.8; 44.9]	[18.7; 27.7]	[23.6; 26.7]	[24.9; 27.8]	[29.2; 31.5]
	h(*x*)	8.9	5.8	1.4	7.7	3.7	2.3	2.3
2015	*f*(*x*)	33.9	30.2	46.7	24.4	26.8	27.7	30.8
	C.I.	[20.6; 47.2]	[22.6; 37.9]	[32.0; 61.5]	[20.8; 28.1]	[25.5; 28.1]	[26.3; 29.0]	[29.4; 32.3]
	h(*x*)	9.7	5.2	1.6	5.3	2.5	2.0	2.4
2016	*f*(*x*)	–	–	–	24.5	28.7	28.5	30.8
	C.I.	–	–	–	[20.7; 28.3]	[27.5; 29.8]	[27.1; 29.9]	[29.5; 32.1]
	h(*x*)	–	–	–	5.0	2.2	2.2	2.5
2017	*f*(*x*)	–	–	–	17.3	26.7	29.5	30.6
	C.I.	–	–	–	[13.0; 21.5]	[25.0; 28.5]	[28.2; 30.7]	[29.2; 32.1]
	h(*x*)	–	–	–	8.2	3.8	2.4	2.1

Point estimates (*f*(*x*)) for localaverage share of assets invested in equities (in percent), for different funding ratios (in percent). Estimates from local linear regressions with varying local bandwidths *h*(*x*) covering the closest 33.3% of observations and using a tricube kernel. Confidence band (C.I.) in square brackets is from bootstrapped standard errors (500 iterations). The sample includes only private and public funds without state guarantees, and includes only funds with a funding ratio between 81.5 and 152.3% (0.5th–95th percentile range). Local linear regression estimates are not shown where the number of observations for regression does not exceed 10

Table 5 Global polynomial regression: Share of Equity Assets Related to the Funding Ratio

Year		f(85)	f(90)	f(95)	f(100)	f(105)	f(110)	f(115)
2006	*f*(*x*)	28.4	27.2	26.0	19.4	23.1	26.1	28.6
	C.I.	[20.0; 36.9]	[21.8; 32.6]	[22.4; 29.5]	[17.6; 21.2]	[22.0; 24.2]	[25.5; 26.8]	[28.0; 29.2]
2007	*f*(*x*)	24.4	25.7	27.1	20.5	23.4	25.7	27.7
	C.I.	[15.4; 33.4]	[20.1; 31.4]	[24.1; 30.1]	[19.1; 22.0]	[22.5; 24.2]	[25.2; 26.3]	[27.0; 28.3]
2008	*f*(*x*)	27.1	24.8	22.4	19.2	18.0	17.2	16.7
	C.I.	[25.9; 28.2]	[24.1; 25.4]	[21.9; 23.0]	[18.0; 20.4]	[17.3; 18.8]	[16.2; 18.2]	[15.4; 18.1]
2009	*f*(*x*)	29.9	28.8	27.7	22.4	24.9	25.8	25.5
	C.I.	[25.3; 34.6]	[26.0; 31.6]	[26.5; 28.9]	[20.9; 23.9]	[24.2; 25.6]	[25.0; 26.5]	[24.6; 26.4]
2010	*f*(*x*)	27.7	27.8	27.9	25.9	25.7	25.6	25.5
	C.I.	[23.8; 31.6]	[25.4; 30.2]	[26.6; 29.1]	[25.0; 26.7]	[25.1; 26.4]	[25.1; 26.2]	[24.8; 26.2]
2011	*f*(*x*)	26.2	26.4	26.7	23.9	23.6	23.4	23.1
	C.I.	[23.1; 29.2]	[24.6; 28.3]	[25.8; 27.6]	[23.1; 24.7]	[23.1; 24.2]	[22.8; 23.9]	[22.4; 23.8]
2012	*f*(*x*)	27.0	27.5	28.0	25.3	25.3	25.4	25.4
	C.I.	[21.5; 32.5]	[24.3; 30.7]	[26.5; 29.5]	[24.4; 26.2]	[24.6; 26.0]	[24.8; 25.9]	[24.8; 26.1]
2013	*f*(*x*)	40.2	35.4	30.5	22.4	26.3	28.3	28.9
	C.I.	[35.1; 45.3]	[32.4; 38.3]	[28.8; 32.3]	[20.4; 24.3]	[25.6; 27.1]	[27.7; 29.0]	[28.2; 29.6]
2014	*f*(*x*)	30.9	30.0	29.0	23.0	25.4	27.4	28.9
	C.I.	[22.1; 39.7]	[24.4; 35.5]	[25.9; 32.2]	[21.0; 25.0]	[24.3; 26.6]	[26.7; 28.1]	[28.3; 29.6]
2015	*f*(*x*)	34.6	33.2	31.9	24.6	26.7	28.4	29.7
	C.I.	[25.5; 43.7]	[27.4; 39.1]	[29.0; 34.8]	[23.0; 26.2]	[25.8; 27.6]	[27.8; 29.1]	[28.9; 30.4]
2016	*f*(*x*)	28.7	29.5	30.2	25.6	27.7	29.3	30.5
	C.I.	[22.6; 34.9]	[25.6; 33.4]	[27.4; 33.0]	[24.1; 27.1]	[26.9; 28.5]	[28.8; 29.9]	[29.8; 31.2]
2017	*f*(*x*)	36.2	32.7	29.2	21.9	25.7	28.9	31.3
	C.I.	[21.9; 50.6]	[23.8; 41.6]	[24.3; 34.1]	[19.7; 24.1]	[24.5; 27.0]	[28.2; 29.6]	[30.6; 31.9]

Point estimates (*f*(*x*)) for local average share of assets invested in equities (in percent), for different funding ratios (in percent). Estimates from global polynomial regression with separate number of polynomials for funds with a funding ratio of below, and above 100%, respectively. Confidence band (C.I.) in square brackets is from bootstrapped standard errors (500 iterations). The sample includes only private and public funds without state guarantees, and includes only funds with a funding ratio between 81.5 and 152.3% (0.5th–95th percentile range)

Table 6 Mc-Crary Test for Discontinuity in pension funds funding ratio at 100 percent

Year(s)	θ	SE	Obs.	Binwidth (b)	Bandwidth (h)
2006	**1.234*****	(0.266)	2138	0.486	6.4
2007	**1.352*****	(0.224)	2034	0.479	7.1
2008	**0.583*****	(0.123)	1988	0.497	7.1
2009	**0.685*****	(0.124)	1975	0.460	8.8
2010	**0.978*****	(0.123)	1897	0.471	9.9
2011	**0.880*****	(0.124)	1861	0.497	7.0
2012	**0.972*****	(0.144)	1749	0.475	9.9
2013	**1.754*****	(0.292)	1647	0.485	7.4
2014	**1.331*****	(0.298)	1566	0.505	7.2
2015	**1.345*****	(0.221)	1524	0.506	7.8
2016	**1.492*****	(0.266)	1464	0.507	7.4
2017	**1.307*****	(0.374)	1396	0.521	7.8
2006–2017	**1.012*****	(0.054)	21,239	0.154	6.5

Table reports the estimated jump in the distribution of funding ratios following the testing procedure of McCrary (2008). θ measures the log-difference in the polynomials fitted to the left and right of the cutoff of 100%. Standard errors in parentheses. Obs. indicates the number of observations per period, bin width the bin size of the first stage histogram, band width of the triangular kernel to determine the discontinuity at the cutoff. Significance levels at 0.05 *, 0.01 ** and 0.001 ***. The sample includes only private and public funds without state guarantees, and only includes funds with a funding ratio between 81.5 and 152.3% (0.5th–95th percentile range)

Mc Crary test

To estimate the discontinuous jump in the distribution of funding ratios (denoted as FR) and for Figs. 1, and 9, we follow the procedure proposed by McCrary (2008). The bin size $\hat{b}$ of the (gray) histogram in Fig. 9 is determined using $\hat{b} = 2\hat{\sigma} n^{-1/2}$ where n is the total number of observations, and $\hat{\sigma}$ the sample standard deviation of funding ratios. The red line is the density estimate $\hat{f}(FR)$ and smooths the histogram separately to the left and right of the cut-off 100%. The smoothing estimates a local regression fitting a 4th order polynomial of the bin-midpoints to the number of observations per bin. The local linear regression uses a triangle kernel with bandwidth $\hat{h}$. The bandwidth is selected following the procedure proposed by McCrary (2008).

The parameter to measure the jump in the distribution is the log difference in the height of the density function $f(FR)$ at the cut-off $c = 100\%$ and can be roughly interpreted as the relative change.

$$\theta_c = \ln\left(\lim_{FR\downarrow c} f(FR)\right) - \ln\left(\lim_{FR\uparrow c} f(FR)\right) := \ln(f^{+}) - \ln(f^{-})$$

with an approximate standard error

$$\hat{\sigma}_\theta = \sqrt{\frac{1}{nh}\frac{24}{5}\left(\frac{1}{\hat{f}^{+}}+\frac{1}{\hat{f}^{-}}\right)}$$

(McCrary, 2008), p. 703, 705. For the analysis, pension fund observations that reported a funding ratio of exact 100% are omitted, in order to prevent the measured discontinuity from being driven by the large value at 100% (following the idea of Barreca et al., 2011). Table 6 reports the corresponding estimates for the individual and aggregated years 2006–2017.

Abbreviations

AHV: Old-Age and Survivors' Insurance (Alters- und Hinterbliebenen Versicherung); BFS: Swiss Federal Statistical Office (Bundesamt für Statistik); BIC: Bayesian Information Criterion; bn: Billion; BSV: Federal Social Insurance Office (Bundesamt für Sozialversicherungen); BVG/LLP: Federal Law on Occupational Retirement, Survivors' and Disability Pension Plans (Bundesgesetz über die berufliche Alters-, Hinterlassenen- und Invalidenvorsorge/Loi fédérale sur la prévoyance professionnelle vieillesse, survivants et invalidité); BVV2/OBB2: Ordinance on Retirement, Survivors' and Disability Pension Plans (Verordnung über die berufliche Alters-, Hinterlassenen- und Invalidenvorsorge/Ordonnance sur la prévoyance professionnelle vieillesse, survivants et invalidité); CHF: Swiss Franc; DB: Defined benefit; DC: Defined contribution; OAK-BV: Occupational Pension Supervisory Commission (Oberausichtskommission Berufliche Vorsorge); Obs: Observation; OECD: Organisation for Economic Cooperation; Perc: Percentile; S.E: Standard error; SNB: Swiss National Bank; techn: Technical; USD: United States Dollar.

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Competing interests

The authors declare that they have no competing interests.

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