Journal of Banking and Finance 161 (2024) 107112

Contents lists available at ScienceDirect

Journal of Banking and Finance

journal homepage: www.elsevier.com/locate/jbf

Cash holdings in pension funds

Sidita Hasa, Carolina Salva *

Institute of Financial Analysis, University of Neuchatel, 2000 Neuchatel, Switzerland

ARTICLE INFO

Keywords:
Pension funds
Cash holdings
Performance
Governance
Asset allocation
Switzerland

ABSTRACT

Using unexplored data on Swiss pension funds, we document substantial heterogeneity in cash holdings across funds. While we identify key operational and investments needs to hold cash, they only explain a small share of the variation in cash holdings. A large share of this variation is attributable to an unobservable, time-invariant, fund-specific factor. The average fund holds excess cash and slowly deploys it for investment. Funds with excessive cash holdings keep 8.4% of total assets in excess cash. Investing this surplus in a representative portfolio, could yield an additional expected annual return of 17 to 32 basis points, ultimately benefiting pension participants. Finally, small funds have larger cash holdings that are less responsive to specific needs, suggesting greater potential for reducing cash allocations.

1. Introduction

Retirement-income systems worldwide face similar challenges as they strive to ensure sustainable and adequate retirement income at an affordable cost. Rising life expectancy means that pension funds must distribute benefits longer, and an unfavorable financial environment of low interest rates has brought lower returns on accumulated capital. As a consequence, pension funds experience slower asset growth compared to their liabilities. To ensure the sustainability of the pension system, critical aspects such as contributions, benefits, and investment management must be reassessed.[1] While regulatory policies or external factors often influence contributions and benefits, pension funds enjoy considerable discretion in making asset allocation decisions, a key determinant of investment performance. Depending on the specific pension arrangement, investment performance can have far-reaching implications, shaping the standard of living of future generations or impacting the cost of pension provision for employers and taxpayers.

Our main goal is to gain insights into how pension funds manage their cash holdings and evaluate the factors that shape their cash allocation decisions. We aim to assess the potential for reinvesting a portion of cash holdings in assets with higher expected returns to enhance performance. How pension funds set and manage their cash holdings has important implications for investment performance; however, these aspects have received relatively limited attention in existing studies.

To address our questions, we use a unique dataset including more than 1,800 pension funds registered in Switzerland. These funds collectively and professionally manage pension savings. The dataset includes extensive information for every pension fund, covering a period of over a decade. This rich dataset is ideal for studying both cross-sectional and time series factors.[2] As collective pension schemes are increasingly regarded as an improvement over more traditional pension offerings, our analysis provides valuable insights into the tradeoffs between individual versus collective pension provision.[3] Moreover, our institutional setting allows us to focus on operational and investment

* Corresponding author.
E-mail address: carolina.salva@unine.ch (C. Salva).

[1] At a broad scale, governments are engaged in debates regarding the design of pension provision to meet these challenges. For example, recent discussions in the U.S. revolve around alternative pension options to the traditional defined benefit or 401(k) plans. In the U.K., recent rulings have encouraged the adoption of alternative pension offerings like collective pension plans. Similar debates on pension design are taking place in various other countries.

[2] We provide a brief description of the institutional setting in Switzerland in Appendix A. For a more detailed analysis, see Queisser and Vittas (2000), Gerber and Weber (2007), and Bütler (2014).

[3] Collective pension schemes have gained popularity in various countries, including Canada, the Netherlands and Denmark. In other countries, like the U.S., the debate over promoting collective defined contribution schemes as a superior alternative to existing defined contribution plans is ongoing. In the U.K., the passage of a law in 2021 permitting collective pension plans is expected to stimulate the growth of such offerings. Professionally managed collective pension schemes are well positioned to leverage expertise and resources for strategic investment allocation to optimize returns, in contrast to individually managed pension plans (eg. 401(k) plans).

https://doi.org/10.1016/j.jbankfin.2024.107112
Received 18 October 2023; Accepted 10 February 2024
Available online 12 February 2024

determinants of cash holdings, as it limits the influence of other potential factors such as fund runs or leverage on cash holdings.

Our research question is rooted in the observation of substantial variation in pension fund cash holdings across individual pension funds and across countries. For instance, in Switzerland from 2006-2018, pension funds persistently held an average cash allocation of 7.0% of their investments, although significant cross-sectional differences exist within the institutional setting. Similarly, as shown in Fig. 1, pension funds in countries like Australia, Spain or Austria also exhibit considerable average cash balances. On the other hand, countries such as the U.S., Canada, and the Netherlands, with developed retirement-income systems, have lower average-to-total investments ratios closer to 2.5%.[4] While holding significant cash balances provides pension funds with extra layers of liquidity and the ability to seize investment opportunities, it comes with significant opportunity costs and direct costs, especially if interest rates turn negative. Therefore, efficient cash management and keeping only necessary cash holdings are crucial factors than can contribute to enhanced investment returns.

We document substantial heterogeneity in cash holdings across pension funds and examine the key operational and investment factors that drive the need to hold cash. Our study quantifies the extent to which these investment and operational needs shape the cross-sectional and time series variations in cash holdings. Additionally, we explore whether there is a share of cash holdings that could be reallocated to earn higher returns. Ultimately, we aim to assess the potential that pension funds may have to increase their performance given the particular institutional setting.

To begin, we develop a regression model of cash holdings considering the operational and investment requirements of pension funds. We argue that operational reasons play a crucial role in driving pension fund cash holdings. We hypothesize that pension funds with higher expected outflows resulting from their day-to-day operations should hold larger cash balances. This is to limit the need of selling assets and bear significant transaction costs, which would negatively impact performance. Additionally, pension funds with positive net cash flows are expected to hold lower levels of cash, as a portion of the outflows can be met by inflows. Hedging activities can also require cash holdings as pension funds must meet collateral requirements or provide for the settlement of hedging programs in case the value of their derivative contracts declines. Therefore, we anticipate that pension funds engaged in hedging activities will hold higher cash balances to serve as a cushion for such cash transfers. We also highlight investment reasons for holding cash. Pension funds may choose to hold cash when opportunity costs are low as a substitute for long-term bonds of similar risk. Additionally, they may keep cash to seize future investment opportunities or as a buffer against capital calls associated with investments in illiquid assets.

We provide evidence that cash holdings are responsive to the key determinants of operational and investment needs that should primarily drive cash allocation decisions. A portion of the cash is held to cushion against expected outflows arising from operating and hedging activities, as well as to meet investment requirements. Surprisingly, we find that contemporaneous inflows are not used to meet outflow needs and reduce cash holdings. On the contrary, higher regular net flows (regular net contributions) and temporary inflows (entry vested benefits) are associated with higher cash holdings. This result challenges our initial prediction of a negative relationship. We interpret this finding as pension funds passively accumulating cash flows and gradually deploying available funds for investment purposes. We also show that smaller funds consistently hold 2.1% more cash than larger ones, even after accounting for the key determinants of cash holdings. Thus, smaller funds show more potential for adjusting cash holdings and enhancing expected performance.

Next, we examine whether pension funds subject to greater discipline or organizational sophistication are more responsive to their operational and investment needs. Our analysis reveals that pension funds in a deccumulation phase, experiencing negative net cash flows, as well as larger pension funds exhibit lower cash holdings that are more responsive to the fund's requirements. In particular, we observe that large pension funds show greater sensitivities of operational and investment proxies to cash holdings, indicating that cash policies respond more to pension fund needs. This finding supports existing evidence highlighting the significance of discipline and size in efficient investment management (see, e.g., Andonov et al., 2012; Davis and De Haan, 2012). We also explore how pension funds responded to the Swiss National Bank's (SNB) decision, in January 2015, to introduce negative interest rates. We argue that this event did not trigger an increase in the opportunity costs of holding cash; instead, it introduced an explicit cost to holding cash and generated greater pressure to achieve a target return. Our results show that pension funds reduced their cash holdings by 1.2% in response to this decision, and this reduction largely persisted even three years later. This finding indicates that pension funds are not likely trading off the various benefits of holdings cash with the consequent opportunity costs and, possibly, holding more cash than was needed.

An implication of our analysis is that the average pension fund tends to delay the investment of a portion of their cash flows, hoarding cash and gradually deploying available funds for investment. To assess the speed at which pension funds adjust to their target cash holdings, we explore the dynamics of cash holdings and perform several tests. Our findings indicate that when pension funds experience temporary increases or decreases in cash holdings, they take time to revert to average or target values. They exhibit a gradual convergence towards long-term averages or predicted targets.

Additional analysis reveals that the operational and investment determinants we identified for cash holdings only account for a small share, about 8%, of the explained variation in cash holdings. In contrast, an unobservable, time-invariant, pension fund-specific component plays a critical role in explaining cash holdings, accounting for 92% of the explained variation (which itself represents 67% of the total variation). These unobserved factors may stem from differences in technologies, managerial behavior or preferences, financial competence and/or organizational structures. Therefore, even within a context of institutional and professional investors, investor characteristics hold significant importance. This finding provides an important research avenue for future work. We take a step in this direction and perform some exploratory analysis. This analysis reveals that pension fund cash holdings may be influenced by sponsor preferences or pension fund governance.

Finally, we evaluate how much cash is held in excess of what operational and investment needs would justify. To estimate the amount of excess cash, we construct three different measures. Our findings indicate that pension funds with excessive cash holdings, on average, hold 8.6% to 8.9% of their total assets as excess cash. This reveals that in certain instances, the amount of excess cash can be substantial, subsequently impacting the performance of pension funds. We estimate that pension funds holding excess cash bear forgone expect returns of between 17 and 32 basis points.

Our study contributes to the literature exploring the factors that shape pension fund asset allocations. While existing studies mostly examine the choice between bonds and risky assets, we are the first, to our knowledge, to study the determinants of cash holdings. Because holding too much cash has significant embedded costs, keeping only necessary cash balances can improve pension fund performance.

[4] Cash refers to both cash holdings and cash equivalents. Cash allocations are computed using aggregated data provided by the OECD, Funded Pension Statistics. The 2.5% refers to average cash over total investments held by pension funds located in the Netherlands, Canada, and the U.S. High cash holdings in Switzerland is not an isolated case. There are other countries holding high levels of cash such as Australia, Austria or Spain (see, e.g. OECD, 2019). Fig. 1 shows the evolution of aggregate % of cash holdings for various countries.

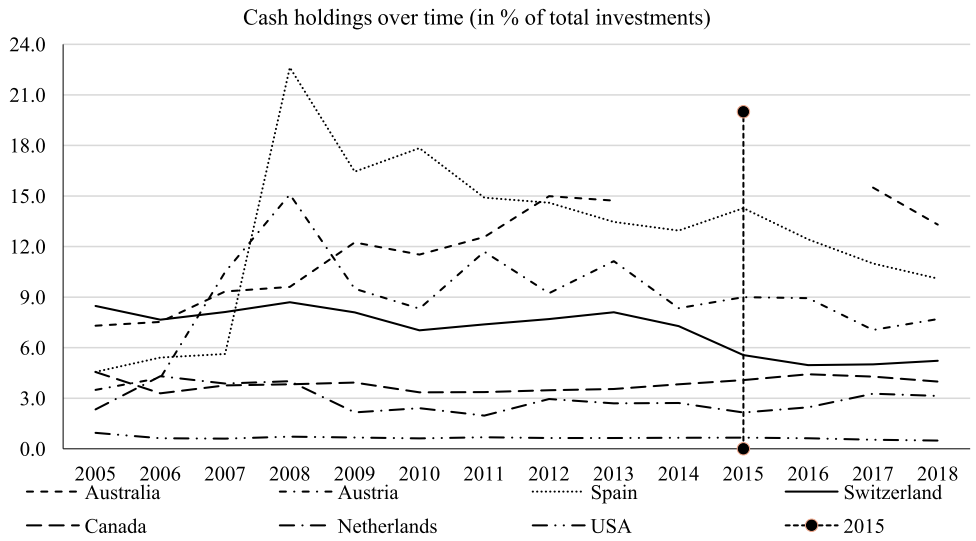

Fig. 1. Cash holdings by country This Fig. presents cash holdings of pension funds in Australia, Austria, Spain, Switzerland, Canada, Netherlands, and United States over the period 2005-2018. The data is retrieved from the database of the Organization of Economic Co-operation and Development (OECD) and refers to aggregate allocations on cash and cash equivalents as a percentage of aggregate total investments.

We further contribute to ongoing discussion on how pension funds can enhance performance when managing retirement savings. In the current landscape, where collective pension schemes are increasingly regarded as an improvement over traditional plans like defined contribution (DC) plans, it becomes important to understand the extent to which collective and professional management of pensions savings do offer better outcomes. Cash holdings, which constitute a significant portion of assets in some cases, have received comparatively less attention from certain pension funds, as they have consistently maintained significant cash balances on their balance sheets. By understanding the determinants of cash holdings, pension funds can gain valuable insights into optimizing their cash allocation, achieving a balance between liquidity needs and performance.

Finally, after adapting our models to the unique characteristics of each institutional environment, we believe that similar analysis can be extended to other jurisdictions. For instance, countries like Australia, Austria or Spain, where pension funds hold substantial investment assets in cash (see, e.g. OECD, 2019), may benefit from such analysis. Given the global demographic and economic trends, pension funds around the world face the necessity to optimize their investment management practices to mitigate the adverse effects on performance and funding capacity. Our study suggests that evaluating liquidity needs and optimizing cash policies is already a step towards that goal.

This paper is organized as follows: Section 2 outlines the theoretical rational behind pension fund cash holdings. Section 3 describes the characteristics of the dataset and describes the relationship between pension funds' cash flows and cash holdings. Section 4 presents the model used along with the results of univariate tests on the association between cash and pension funds' operational and investment needs. Sections 5 and 6 explores the dynamics and persistence of cash holdings. Section 7 defines and estimates the extent of cash held beyond operational and investment reasons. Section 8 analyses the performance implications of holding excessive cash. Finally, Section 9 presents a discussion on the robustness of our findings and Section 10 briefly concludes by summarizing our findings.

2. Related literature and hypotheses development

The main goal is to understand how pension funds manage their cash holdings, what drives cash holdings and to evaluate whether there is room to enhance performance. To date, the empirical literature on pension fund asset allocation focuses on the interplay between bonds and risky investments and identifies pension fund-specific, institutional, and sponsoring firm-specific factors to be associated with such allocations. The most common view in the literature is that pension fund asset allocation should, first, reflect the riskiness of pension liabilities and their exposure to interest rate and inflation risk (see, e.g., Hoevenaars et al., 2008; Jondeau and Rockinger, 2014) and, second, be in accordance with pension fund risk capacity and its funding status (see, e.g., Sundaresan and Zapatero, 1997; Lucas and Zeldes, 2006, 2009; Rauh, 2009; Weller and Wenger, 2009). However, institutional frictions that allow for a higher discretion in setting liability discount rates (see, e.g., Pennacchi and Rastad, 2011; Mohan and Zhang, 2014; Andonov et al., 2017), that are related to the sponsoring firms having control over pension assets (see, e.g., Cocco and Volpin, 2007; Phan and Hedge, 2013) or that encourage risk-taking in a low interest rate environment (Kroencke and Salva, 2022), weaken the view that asset allocation reflects liabilities risk and pension fund risk-capacity. Our aim is to go beyond bonds and risky assets and to study the role of cash holdings in pension funds' asset allocation and performance.

Current studies provide a limited understanding of the role of cash holdings in pension fund asset management and, at most, only include some basic statistics on how much cash pension funds hold (see, e.g., Petersen, 1995; Gerber and Weber, 2007; Mohan and Zhang, 2014; Andonov and Rauh, 2022; Boubaker et al., 2018). This is probably due to theoretical predictions that cash has a limited role as an investment asset in long-term portfolio choice. According to Campbell and Viceira (2002), asset-only long-term investing implies that long-term bonds or inflation-indexed bonds, in the presence of inflation risk, dominate the choice of holding cash due to the reinvestment risk inherent in cash. In the context of asset-liability investing, Jondeau and Rockinger (2014) explain that a liability-hedging portfolio should hold no cash if pension fund asset allocation is driven by the riskiness of pension liabilities due to the low and negative correlation of cash with the growth of pension fund liabilities. However, these studies do not consider the benefits that cash brings as a liquidity provider. Broeders et al. (2020) propose that pension funds should also consider liquidity requirements. They argue that pension funds need to hold sufficient liquidity to fulfill short-term payment obligations. The more immediate these payments are, the higher the need for liquidity and, therefore, the higher the amount of cash holdings. This renders operational needs the main driver of pension funds' cash holding behavior, suggesting a role for holding cash.

In this study, we reconcile theoretical predictions with the empirical observation that pension funds do hold, in some cases, substantial

amounts of cash.[5] We aim to understand why pension funds hold cash and whether some could be reinvested in assets with higher expected investment returns. To this end, we investigate the reasons that justify cash holdings and we estimate whether there is any surplus that could be reinvested to enhance performance. The study of these questions contributes to the limited, virtually absent, empirical studies on pension fund cash holdings. An exception is Bregnard and Salva (2022) who show that well-governed pension funds that have comprehensive investment policies in place tend to hold lower levels of cash. Our study provides a more comprehensive analysis of the true forces shaping cash holdings to better understand what actually matters for a pension fund in the decision to hold cash.

To approach these questions, we borrow from the literature on corporate and mutual fund liquidity. Although firms and mutual funds have different incentives to hold cash compared to pension funds, there are still some similarities. Keynes (1936) and Opler et al. (1999) show that firms keep cash to meet operating needs when raising external funds is costly. Similarly, Yan (2006) and Simutin (2014) suggest that mutual funds hold cash to adhere to their operational and investment needs when transaction costs from liquidating assets are high. Following the same line of reasoning, we view operational needs as the main reason for pension funds to hold cash. These needs entail meeting on-going pension payments, such as regular and lump-sum benefits, administrative, management and insurance expenses as well as accumulated savings when employees leave the fund. If cash is insufficient to cover these outflows, pension funds need to sell a fraction of their assets. Selling assets can be costly for two reasons. First, pension funds may be forced to sell at depressed prices if market conditions are unfavorable and second, they may incur significant transaction costs if other liquid assets are not sufficient. Further, pension funds may not be able to sell immediately, for example, because the sale must first be approved by the board of trustees in their scheduled meeting. Such delays in the process of asset liquidation can put a significant burden on the capacity to make payments when they become due and amplify the role of cash. As pension funds with larger expected outflows are likely to fall into larger cash shortages, they potentially face higher costs. To mitigate these costs, we argue that pension funds with large expected outflows should hold more cash.

However, a share of outflows can be offset by pension funds' inflows. Inflows include contributions, accumulated savings from new employees joining the pension fund and investment income.[6] As using inflows to cover outflows reduces the amount of cash needed, if pension funds apply such netting, we would expect that the anticipation of large and positive net cash flows leads to lower cash holdings. Following this reasoning, we propose our first hypothesis:

H1: The higher (lower) the expected net cash flows (outflows), the lower the amount of cash holdings, all else equal.

Pension funds may also hold more cash as a buffer if they are subject to greater cash flow variability. By holding more cash, they can ensure they have an adequate liquidity cushion to navigate periods of greater outflows (or lower inflows). We articulate this notion in our second hypothesis:

H2: The greater the variability in cash flows, the higher the cash holdings.

Pension funds also need to ensure sufficient liquidity to adhere to their hedging commitments as suggested by Broeders et al. (2020). If pension funds experience adverse movements against their positions in derivative contracts, they need to settle hedging programs with cash.[7] To provide a back up for such cash transfers, we expect funds with on-going derivative contracts to hold more cash than those with no hedging activity.[8] We, therefore, propose the following hypothesis:

H3: Pension funds that use derivative contracts for hedging purposes will hold more cash, all else equal.

So far, we consider operational needs and their underlying variability as the main factors driving the need for cash. This is consistent with the prescription of the Swiss law that pension funds need to keep sufficient liquidity to comply with on-going operations. Yet, we identify some investment reasons for holding cash. First, cash can be viewed as an investment asset when the foregone returns associated with holding cash are low or even absent. That is, when yield curves are flat or downward-sloping, cash can be considered a substitute for long-term high-credit-quality bonds. In contrast, with upward-sloping yield curves, the choice of long-term assets with similar credit quality that entail lower reinvestment risk should dominate holding cash. This leads us to a fourth hypothesis:

H4: If cash is held as a substitute for long-term high-credit quality bonds, the steeper the yield curve, the lower the amount of cash holdings.

Finally, pension funds may also hold cash if the goal is to pursue anticipated investments or to seize investment opportunities. When a pension fund invests in private investments that can potentially call for capital, it is exposed to a potential drawdown of liquidity and, therefore, may rationally retain more cash. Alternatively, pension funds may retain more cash if they intend to profit from market downturns and compressed prices. This motivates the following additional hypothesis:

H5: If cash is held in view of future investments (meeting capital calls in private investments or profit from market downturns at compressed prices), we should observe an increase in investments made with cash (rather than investments made with inflows). Further, if cash is held to meet capital calls, pension funds will hold more cash the higher is the share invested in private assets.

3. Data and descriptive statistics

To start with, we obtain data from the Swiss Federal Statistical Office (FSO) for the complete universe of pension funds founded in Switzerland. This data has been largely unexplored in academic research. The FSO database provides a detailed overview of pension fund income statements and balance sheets as well as structural, administrative, and financial characteristics. Since pension funds are mandated to report to the FSO, this data is unbiased. Having this unique dataset at hand allows us to obtain a large amount of information for every pension fund over a decade and to have a large cross-section of institutions, so we can study the questions proposed while controlling for potential confounding effects.

[5] For example, in Switzerland, while pension funds in the lowest decile hold 1.7% of total assets in cash, those in the highest hold 16.7%.

[6] These cash flows refer to the Swiss institutional and legal environment and may be different in other institutional settings.

[7] Depending on the jurisdiction, margining requirements on derivative contracts can also be met with other assets, e.g. highly liquid government bonds. If this is the case, it is likely that the use of derivative contracts has a more mitigated impact on the amount of cash held by a pension fund. In Switzerland, margining requirements have to be met with cash.

[8] Cash could also be justified when there is a need to hedge against inflation (see, e.g., Hoevenaars et al., 2008; Jondeau and Rockinger, 2014). However, given the low levels of inflation in Switzerland and the non-mandatory pension indexation, we argue that inflation-hedging is unlikely to drive pension fund cash holdings.

For this study, we use individual variables related to regular activities, asset allocations, cash holdings, and idiosyncratic characteristics for the period 2005-2018. To hold the legal environment constant in our analysis, we exclude pension funds that offer only super-obligatory benefits, as they are not subject to the same legal rules. We also exclude pension funds that reinsure all risks (actuarial and investment risks) with insurance companies and do not manage pension assets themselves. Finally, we drop pension funds when they are in the process of full liquidation and/or in the year when they first enter the sample, because in these cases, asset allocations do not reflect pension funds' fundamentals. Our final dataset includes an average of 1523 pension funds across years and 21,326 pension fund-year observations. Appendix B, Table B.1 details the construction of our sample.

To complement pension fund data, we also collect monthly yields for Swiss government bonds of different maturities from Thomson Reuters. In addition, we use expected equity premiums in Dimson et al. (2011-2018) estimated from a long history of world equity returns relative to U.S long-term bonds and treasury bills. Finally, we follow Andonov and Rauh (2022) and use institutional investors' expectations of long-term excess returns for four asset classes as provided by the U.S Governmental Accounting Standards Board Statement (GASB) 67.

3.1. Brief description of the institutional background

Some key characteristics of the institutional setting are worth mentioning at this stage. For further details see Appendix A. The pension funds in our sample are occupational pension funds set up or chosen by the employer. Employee affiliation is mandatory when the salary is above a certain threshold. Pension funds are mainly funded by employer and employee mandatory contributions and pay regular benefits to pensioners. Other withdrawals are generally not possible except for home ownership, in the case of divorce or when lump-sum payments upon retirement are chosen over annuities. As employers choose the affiliation of employees to a given pension fund, employees only switch pension funds when they change jobs. In that case, they transfer vested benefits into a new pension institution.

Most pension plans (about 95%), are DC plans with pooling of investments and longevity risk and professional management. These pension funds also offer minimum mandatory guarantees and provide a lifetime retirement income (annuities); they are commonly known as cash balance plans.[9] Given the structure of these funds, any increase in performance accrues to beneficiaries. However, any shortfall can potentially impact them negatively, for example, requiring catch up contributions or zero investment return. The rest are defined benefit (DB) plans. In all cases, pension institutions are legal entities separate from the employer. Investment decisions are made by the pension fund board that is characterized by equal representation of both the employer and beneficiaries. We also note that there is no mandatory indexation of pension benefits, thus holding cash as a means to hedge inflation risk (reference) is less relevant in our context.

3.2. Sample description

Panel A, Table 1 displays some general aggregated characteristics of our final sample. As of 2018, pension funds collectively manage CHF 848 billion in total assets for 3.8 million members. According to Panel B, Table 1, the number of pension funds has shrunk over the sample period, reaching 1,220 in 2018. Out of these pension funds, 1,150 (94%) are private, 825 (68%) are multi-employer, and 1'144 (94%) provide DC plans.[10] The fraction of pension funds belonging to each administrative type has remained quite stable over the previous years.[11] Note though that the share of DB plans has decreased significantly overtime. Appendix B, Table B.2 provides a description of all variables used in this study.

Panel A, Table 2 provides a pooled description of our dataset and shows that it is largely dominated by small pension funds, while there are also a few large ones. The average pension fund manages CHF 430 million of total assets for more than 2,000 beneficiaries. We also observe that the pooled average of annual total contributions, at CHF 24 million, surpasses that of total benefits, which is at CHF 17 million. This aligns with the 3.6% compound annual growth rate (CAGR) in total assets since 2005. Although total contributions (in CHF mio) exceed total benefits, contributions are growing at a slower pace with a CAGR of 2%, compared to the 6% CAGR of benefits. This is due to the number of pensioners growing faster than that of active employees as baby-boomers reach retirement. Furthermore, pension funds are, on average, adequately funded with a funding ratio of 111%. In Panel B, Table 2, 76% (72%) of pension fund-year observations show total contributions (inflows) covering benefits (outflows). More cash (9.6%) is held when contributions exceed benefits, and less (7.1%) when benefits exceed contributions, contrary to our first hypothesis. However, pension funds are also affected by other cash flows, such as investment income and general expenses, which can influence cash holdings. When total outflows exceed inflows, pension funds hold more cash (9.2%) than when the reverse occurs (8.8%), but the difference is small. Subsequent sections further explore this analysis in a conditional setting.

The upper graph of Fig. 2 illustrates how the asset allocation of Swiss pension funds has evolved over time. We observe that since 2008, pension funds have increased the risk of their portfolio by investing more in equities and real estate and less in cash and bonds, possibly triggered by decreasing interest rates after the financial crisis. The decrease in cash is more pronounced since 2015 coinciding with the introduction of negative interest rates in Switzerland. As shown in the lower graph of Fig. 2, this event triggered a decrease in the cross-sectional variation of cash and, also, a systematic decline in cash holdings. Pension funds jointly adjusted their cash holdings downward. In exchange, they increased their investments in alternative assets and real estate. Panel A, Table 3 documents substantial heterogeneity in cash holdings across pension funds with an average of 9% of total assets held in cash and a standard deviation of 10%.[12] Pension funds in our sample also allocate on average, 35% on bonds, 28% on stocks, 18% on real estate and 4% on alternative investments and are largely within the legal investment limits.[13,14] The correlations among different asset classes in Panel B, Table 3 indicate that cash is seen as a substitute for the other

[9] These plans differ from the so-called cash balance plans in the US in the allocation of risk.

[10] Appendix A provides a detailed description of the different organizational forms of Swiss pension funds. Note that DC plans are considered like "cash balance plans" as they have embedded minimum mandatory guarantees.

[11] These statistics are different from FSO statistics as of 2018, due to the way we select our sample.

[12] Egan, Mackay and Yang (2022) also document substantial heterogeneity in cash holdings in 401(k) plans in the US. Their average plan holds 11% in cash and the standard deviation is 13%. While we study the decision of institutional investors to hold cash, holdings in 401 (k) plans are the outcome of individual investor decisions.

[13] These proportions do not add up to 100% because we scale by total assets which, apart from pension fund investments, include other accrual and receivable accounts. The average proportion of total assets held in cash by pension funds in our sample is also different from the average proportion estimated with the annual data retrieved from the OECD database (9% vs 7%) for two reasons. First, OECD data refers to annual aggregate amounts and not averages, and second, cash holdings calculated with OECD data are scaled by total investments and not by total assets.

[14] Statutory requirements limit the share of assets that can be invested in certain asset classes. See Appendix A for more details.

Table 1
Sample general characteristics This table presents general and administrative characteristics of Swiss pension funds for the period 2005-2018. Panel A shows the evolution of general characteristics over time. All variables are aggregated across pension funds each year. Number of PFs is the number of pension funds. Total assets is the total assets held excluding insurance assets. Contributions is the aggregate amount of total contributions received and Benefits is the aggregate amount of total benefits paid by pension funds. Beneficiaries is the number of active employees and retirees. Employees is the number of contributing active employees and Retirees is the number of retirees. Panel B provides information on pension funds' legal and administrative form. Public equals one if the pension fund is founded by a public institution and zero, otherwise (=Private). Single-employer equals one for single-employer funds and zero, otherwise (=Multi-employer). DB, DC and Mixed DB, DC are indicator variables for the plan type and equal one for defined-benefit, defined-contributions and mixed plans, respectively, and zero, otherwise.

Panel A: General sample characteristics

Year	Number of PFs	Total assets (CHF mio)	Contributions (CHF mio)	Benefits (CHF mio)	Beneficiaries	Employees	Retirees
2005	1,825	513,492	25,495	20,104	2,655,445	2,245,566	409,879
2006	1,753	549,264	27,113	21,468	2,775,853	2,346,962	428,891
2007	1,741	578,758	32,490	22,936	2,960,514	2,509,338	451,176
2008	1,718	514,368	32,952	24,015	3,107,972	2,634,725	473,247
2009	1,692	573,085	33,958	24,915	3,138,530	2,645,883	492,647
2010	1,648	595,464	35,924	25,687	3,194,992	2,683,249	511,743
2011	1,584	602,136	36,102	26,414	3,290,785	2,757,731	533,054
2012	1,509	645,009	36,406	27,427	3,324,150	2,772,378	551,772
2013	1,436	650,352	37,046	25,885	3,199,420	2,672,647	526,773
2014	1,365	707,135	40,717	26,740	3,277,618	2,726,678	550,940
2015	1,325	759,421	43,261	29,168	3,518,377	2,905,096	613,281
2016	1,282	792,595	43,371	29,893	3,565,295	2,935,658	629,637
2017	1,228	860,848	44,775	31,028	3,683,244	3,031,650	651,594
2018	1,220	847,976	46,883	32,303	3,809,494	3,133,948	675,546

Panel B: Number of pension funds by administrative type by year

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total number of PFs	1,825	1,753	1,741	1,718	1,692	1,648	1,584	1,509	1,436	1,365	1,325	1,282	1,228	1,220
Public	97	93	92	93	91	88	88	86	76	71	72	72	70	70
Private	1,728	1,660	1,649	1,625	1,601	1,560	1,496	1,423	1,360	1,294	1,253	1,210	1,158	1,150
Single-employer	783	728	705	682	677	637	588	546	499	461	441	408	387	395
Multi-employer	1,042	1,025	1,036	1,036	1,015	1,011	996	963	937	904	884	874	841	825
DC	1,410	1,391	1,410	1,405	1,396	1,405	1,362	1,307	1,265	1,232	1,213	1,181	1,140	1,144
DB	238	216	192	172	162	138	122	102	84	61	51	43	37	30
Mix (DC, DB)	31	31	33	33	35	42	38	39	37	30	26	23	23	22

Table 2
Descriptive statistics Panel A reports pooled summary statistics of key variables of our sample for the period 2005-2018. *Total assets* (*investments*) is the total assets (investments) held by the pension fund (in CHF mio). *Retirement savings* is the savings capital accumulated by the pension fund for active employees and pensioners (in CHF mio). *Total contributions (CHF mio)* is the amount of total contributions received by the pension fund. *Total benefits (CHF mio)* is the amount of total benefits paid by the pension fund. *Beneficiaries* is the number of active employees and retirees. *Employees* is the number of active employees contributing to the pension fund and *Retirees* is the number of retirees. *Beneficiaries ratio* equals active employees over retirees and is equal to zero if the number of active employees is zero and equal to its max when the number of retirees is zero. *Funding ratio* refers to pension assets over pension liabilities as reported by the pension fund and is expressed in percentage. *Total assets (total contributions, total benefits) CAGR* is the cumulative average growth rate of total assets (total contributions, total benefits) from the first year each pension fund appears in our sample to the last and is expressed in percentage. Panel B presents pension fund-year observations with more (less) total contributions than total benefits and more (less) inflows than outflows. It also shows the number of pension funds meeting these criteria in each group at least once over the sample period. Additionally, it shows the percentage of total assets these pension funds hold in cash in each case. *Inflows* includes total contributions, entry vested benefits and investment income and O*utflows* includes total benefits, exit vested benefits, investment, administrative and insurance expenses.

Panel A: Summary statistics

	PF-year Obs.	Mean	St.Dev	p5	p25	Median	p75	p95
Total assets (CHF mio)	21,326	430.92	1,797.95	4.25	22.42	62.36	190.14	1,630.47
Total investments (CHF mio)	21,326	406.86	1,709.41	3.32	20.34	58.83	181.48	1,511.79
Retirement savings (CHF mio)	21,326	391.30	1,658.58	3.22	17.63	51.59	160.49	1,466.01
Total contributions (CHF mio)	21,326	24.22	92.46	0.24	1.26	3.49	11.13	99.48
Total benefits (CHF mio)	21,326	17.26	80.34	0.04	0.61	1.97	6.51	61.21
Beneficiaries	21,326	2,133.63	8,404.84	25.00	128.00	321.00	957.00	8,539.00
Employees	21,326	1,781.93	7,276.76	21.00	107.00	266.00	794.00	7,157.00
Retirees	21,326	351.69	1,598.72	0.00	10.00	38.00	141.00	1,246.00
Beneficiaries ratio	21,326	152.46	573.79	1.50	3.47	7.20	18.43	2,569.00
Funding ratio (%)	21,326	111.18	23.14	91.70	103.00	109.60	117.00	133.60
Total assets CAGR (%)	21,326	3.65	5.14	−3.09	1.15	3.26	5.94	10.82
Total contributions CAGR (%)	21,326	2.44	7.83	−6.59	−0.03	2.75	5.44	10.85
Total benefits CAGR (%)	20,524	6.15	13.04	−5.26	1.37	4.47	9.04	24.63

Panel B: Pension fund-years and pension funds in accumulation and deccumulation phase

	PF-year Obs.	Number of PFs	Cash (in %)
Total contributions > Total benefits	16,221	1,847	9.55
Total contributions <= Total benefits	5,105	1,053	7.06
Inflows > Outflows	15,397	1,971	8.84
Inflows <= Outflows	5,929	1,834	9.24

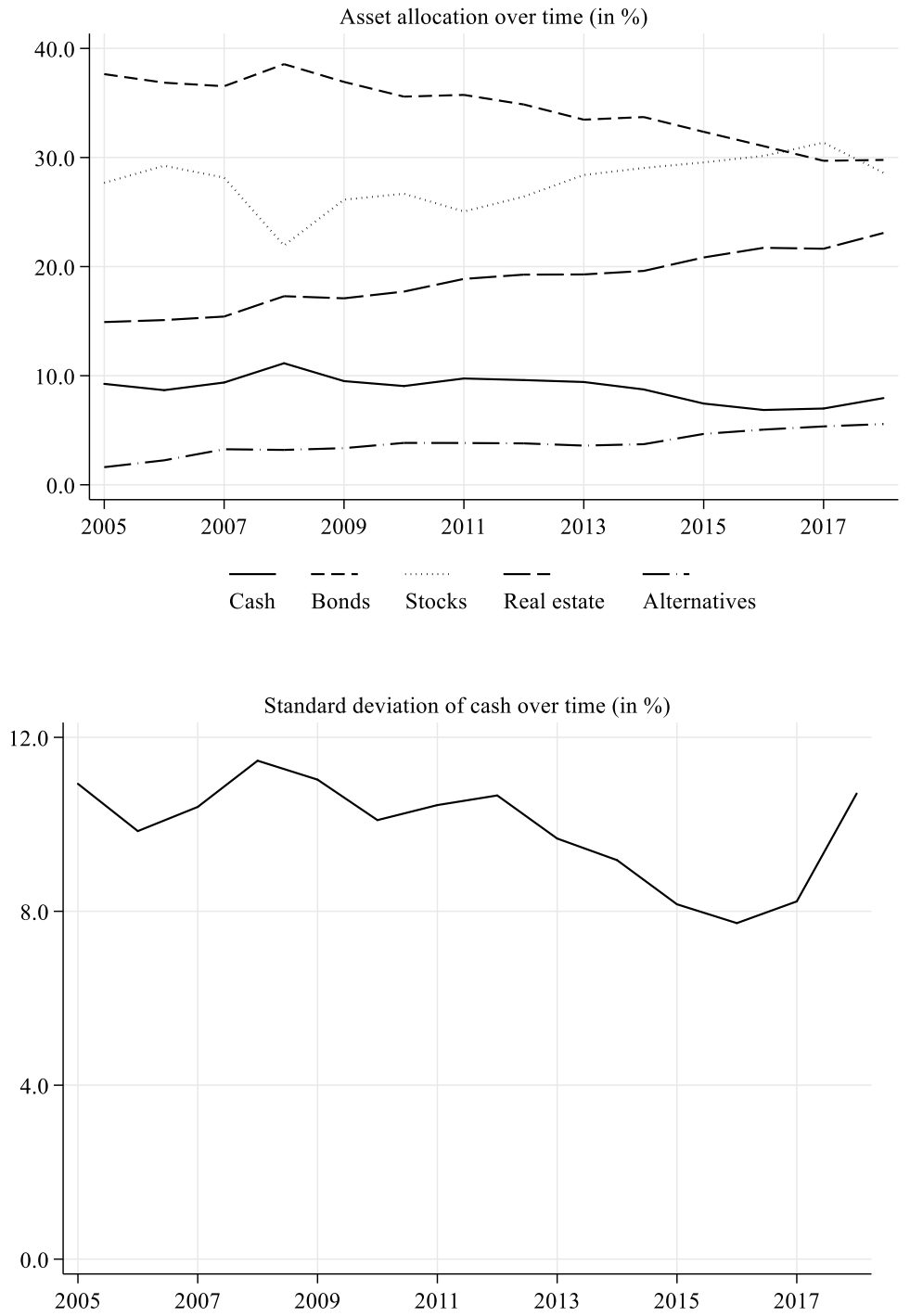

Fig. 2. Asset allocation and cross-sectional variation over time The upper graph of this figure shows average asset allocations over time. Cash refers to cash and cash equivalents (CHF and foreign currency). Bonds is the total investments in Swiss and foreign bonds as well as in foreign currency bonds. Stocks is the total investments in Swiss and foreign stocks. Real estate is the total investments in Swiss and foreign direct and indirect real estate. Alternatives is investments in hedge funds, private equity, commodities, infrastructures, insurance-linked securities and others. The lower graph presents the cross-sectional variation of cash over time. This is computed as the cross-sectional standard deviation of cash holdings each year. All variables are computed in % of total assets and are expressed in percentage. Total assets do not include assets managed by insurance companies.

asset classes, but mainly for bonds and stocks. Finally, Fig. 3 reports the evolution of cash holdings in pension funds of varying sizes. We divide the sample into small and large pension funds based on median total assets. We also track cash holdings for the largest pension funds (top quartile). Small funds consistently hold over 3% (of total assets) more cash than large ones. In Section 4, we delve into potential reasons.

3.3. Descriptive statistics of pension fund cash flows and different measures of cash

In Table 4, we examine the distribution of pension fund cash flows and their relationship with cash. In terms of magnitude, total contributions are the most important cash flows as they represent 6.5% of total assets. Contributions regularly received from employees and employers are 5.6% of total assets. This is followed by exit vested benefits (5.0%),

Table 3
Pension fund asset allocation This table presents information on pension fund asset allocation for the period 2005-2018. Panel A provides descriptive statistics of asset allocations. Cash refers to cash and cash equivalents (CHF and foreign currency). Bonds is the total investments in Swiss and foreign bonds as well as in foreign currency bonds. Stocks is the total investments in Swiss and foreign stocks. Real estate is the total investments in Swiss and foreign direct and indirect real estate. Alternatives is investments in hedge funds, private equity, commodities, infrastructures, insurance-linked securities and others. All variables are computed in % of total assets and are expressed in percentage. Total assets do not include assets managed by insurance companies. Panel B provides pair-wise correlations of the different asset classes using Bonferroni correction.

Panel A: Summary statistics of asset allocation

	Obs.	Mean	St.Dev	p5	p25	Median	p75	p95
Cash	21,326	8.95	10.12	1.10	3.33	6.15	10.75	25.66
Bonds	21,326	34.84	14.85	7.18	25.50	35.61	45.23	57.51
Stocks	21,326	27.57	10.45	8.50	21.95	27.90	33.69	44.01
Real estate	21,326	18.38	13.21	0.00	9.28	16.77	25.50	42.47
Alternatives	21,326	3.66	5.68	0.00	0.00	1.30	5.61	13.73

Panel B: Correlation between asset allocations

	Cash	Bonds	Stocks	Real estate	Alternatives
Cash	1.00				
Bonds	−0.30*	1.00			
Stocks	−0.29*	0.05*	1.00		
Real estate	−0.16*	−0.49*	−0.23*	1.00	
Alternatives	−0.08*	−0.15*	−0.02*	−0.06*	1.00

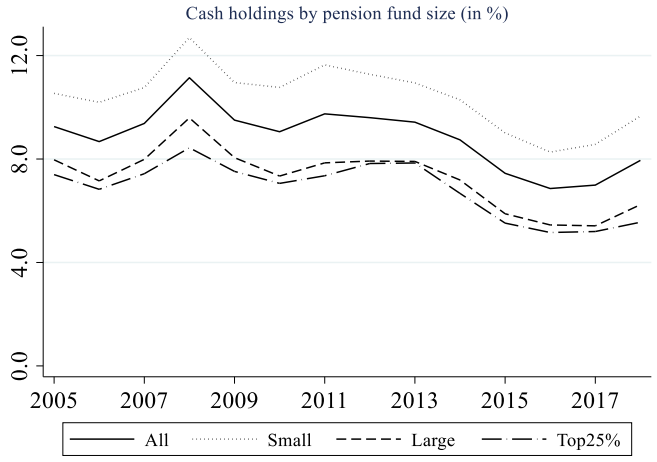

Fig. 3. Cash holdings by pension fund size over time This figure presents cash holdings for groups of pension funds of different sizes over the period 2005-2018. Cash refers to cash and cash equivalents (CHF and foreign currency) scaled by total assets and expressed in %. Total assets do not include assets managed by insurance companies. All refers to the average cash holdings of all sample. Small (Large) includes funds with total assets lower (higher) than the sample median. Top25% includes funds with total assets in the top quartile.

total benefits (3.5%), entry vested benefits (3.3%), and investment income (3.1%). We note that investment income is the only non-pure cash flow variable as it includes unrealized investment gains and losses. Given that we cannot separate realized investment income from valuation adjustments, we specially track this variable and perform various robustness tests on our analysis.

In aggregate, pension funds' inflows amount to an average of 12.9% of total assets whereas outflows equal 9.9%.[15] Given that pension funds can use inflows to cover outflows, we estimate net cash flows by activity. We observe that net cash flows from pension funds' regular activities, that of receiving employee and employer contributions and paying annuity benefits (regular net contributions), represent 3.3% of total assets. Thus, the average pension fund has positive net cash flows from its regular activities. However, in the 5th percentile, employee and employer contributions are insufficient to cover annuity benefits. Net cash flows from vesting activities are on average negative, which indicates that employees leaving the pension fund are barely replaced or are replaced by younger ones. Netting at a more aggregate level shows that pension funds' total net cash flows represent 3.0% of total assets. Excluding investment income, though, reduces total net cash flows to -0.01%.[16]

In terms of relevance, the last column of Table 4 shows that, contemporaneously, most cash flows display a significant association with the cash-to-total assets allocation. Apart from annuity benefits and investment income, all other types of inflows and outflows are positively correlated with cash. Netting similar cash flows shows that the association of regular net contributions with cash is particularly relevant while that of total net cash flows with cash is economically less important. Aggregating at a higher level assumes that all cash flows are equally important in pension funds' decision to hold cash; however, the size and significance of their association with cash indicates that this is not likely to be the case.

To sum up, this preliminary analysis shows that regular net contributions are a significant driver of cash holdings, both statistically and economically. While individual outflows are positively related with cash as expected, the relation of cash holdings with regular net contributions and individual inflows contradicts our predictions as pension funds with higher values hold more cash.

After exploring the relation of pension funds' cash flows with cash, we build different measures to better understand the relative size of cash holdings with respect to cash flows. Table 5 summarizes the results for the years 2005 and 2018 and shows that cash holdings have decreased over time. For example, as of 2005, pension funds held on average 9.2% of total assets in cash. With the cash at hand, without considering further inflows, pension funds could cover 89 months of benefits and 17 months of total outflows. Considering net contributions (contributions-benefits), pension funds in a deccumulation phase (benefits are higher than contributions) could cover 185 months of residual benefits. In 2018, pension funds decreased cash holdings to an average of 8.0% of total assets. With the cash at hand, without further inflows, pension funds could cover 49 months of benefits and 13 months of total outflows. Then considering net contributions, pension funds in a deccumulation phase could cover 183 months of residual benefits. This analysis shows that

[15] Total inflows include total contributions, entry vested benefits, and investment income. Total outflows include total benefits, exit vested benefits, and total expenses (administrative, investment and insurance expenses).

[16] We exclude investment income because first, it includes unrealized gains and losses that do not correspond to cash flows and second, it is usually directly reinvested according to discussions we had with different pension providers.

Table 4
Descriptive statistics of pension fund cash flows This table provides summary statistics for pension fund cash flows and their association with cash. Total contributions includes employee, employer and other contributions received by the pension fund. Regular contributions includes employee and employer contributions. Irregular contributions is total contributions less regular contributions. Total benefits includes benefits paid in the form of annuities and lump-sums to benefit recipients. Annuities is benefits paid in the form of annuities every year and Lump-sums is benefits paid in the form of capital. Entry vested benefits includes termination benefits transferred by new employees joining the fund and any premiums paid to recover retirement assets from home ownership or divorce withdrawals. Exit vested benefits is termination benefits and early withdrawals for home ownership and divorce. Investment income is income from investments and includes realized and unrealized gains and losses. Total expenses refers to the sum of investment, administrative and insurance expenses. Investment (Administrative) expenses includes expenses related to the investment management (administration) of the pension fund. Insurance expenses is insurance premiums paid to the Guarantee Fund and to insurance companies if the pension fund has some reinsurance. Inflows includes total contributions, entry vested benefits and investment income. Inflows (ex. inv.inc) is inflows less investment income. Outflows includes total benefits, exit vested benefits, investment, administrative and insurance expenses. Net contributions is total contributions minus total benefits. Regular net contributions is regular contributions minus annuities. Net vested benefits (Net cash flows) is entry vested benefits (inflows) minus exit vested benefits (outflows). Net cash flows (ex. inv.inc) is inflows less investment income minus outflows. All variables are computed in % of total assets and are expressed in percentage. Total assets do not include assets managed by insurance companies. In the last column, β represents the slope estimate of an OLS univariate regression of cash on the respective variable. *** and ** indicate statistical significance at the 1% and 5% level.

	Obs.	Mean	St.Dev	p5	p25	Median	p75	p95	β
Total contributions (a)	21,326	6.51	3.87	2.22	4.13	5.74	8.02	13.05	0.45***
Regular contributions (b)	21,326	5.59	3.00	1.88	3.67	5.04	6.99	10.80	0.59***
Irregular contributions	21,326	0.92	2.11	0.00	0.07	0.31	0.92	3.62	0.32***
Total benefits (c)	21,326	3.54	3.33	0.45	2.06	3.19	4.39	7.25	−0.17***
Annuities (d)	21,326	2.28	1.64	0.20	1.12	2.00	3.17	5.08	−1.03***
Lump-sums	21,326	1.26	3.09	0.00	0.05	0.55	1.41	4.65	0.09***
Entry vested benefits (e)	21,326	3.29	4.74	0.08	1.05	2.14	3.99	9.49	0.22***
Exit vested benefits (f)	21,326	5.00	7.36	0.41	1.89	3.39	5.94	13.98	0.13***
Investment income (g)	21,326	3.13	6.56	−11.08	1.01	4.13	7.17	10.67	−0.11***
Total expenses (h)	21,326	1.41	1.29	0.22	0.54	1.10	1.93	3.47	1.53***
Investment expenses	21,326	0.38	0.55	0.01	0.15	0.31	0.52	0.93	−0.13
Admin. expenses	21,326	0.27	0.32	0.02	0.11	0.19	0.33	0.72	4.98***
Insurance expenses	21,326	0.76	0.97	0.00	0.02	0.43	1.20	2.51	2.20***
Inflows (i=a+e+g)	21,326	12.93	9.26	−0.53	8.59	12.87	17.10	25.78	0.08***
Inflows (ex. inv.inc) (j=a+e)	21,326	9.80	7.20	3.01	5.76	8.25	11.97	20.93	0.23***
Outflows (k=c+f+h)	21,326	9.95	8.60	4.09	6.24	8.12	11.26	21.03	0.10***
Net contributions (a-b)	21,326	2.97	5.32	−3.21	0.11	2.46	5.34	11.12	0.31***
Regular net contributions (b-d)	21,326	3.32	3.93	−2.28	0.68	3.04	5.59	9.85	0.53***
Net vested benefits (e-f)	21,326	−1.71	7.37	−9.12	−2.64	−0.87	0.13	3.26	−0.03***
Net cash flows (i-k)	21,326	2.98	10.81	−13.77	−0.68	4.09	8.20	14.67	−0.00
Net cash flows (ex. inv.inc) (j-k)	21,326	−0.1	8.84	−9.11	−2.62	−0.01	2.69	8.79	0.05***

Table 5
Description of cash holdings This table presents descriptive statistics for different definitions of cash holdings for 2005 in Panel A and for 2018 in Panel B. Cash/Total assets (Cash/Total investments) is cash and cash equivalents over total assets (investments) and is expressed in percentage. Total assets do not include assets managed by insurance companies. Cash/Total benefits*12 (Cash/Outflows*12) is cash and cash equivalents over total benefits (outflows) times 12, which represents how many months of benefits (outflows) the pension fund can cover with its cash. Outflows includes total benefits, exit vested benefits, investment, administrative and insurance expenses. Cash/Net contributions*12 is cash and cash equivalents over net contributions times 12 if net contributions are negative. It represents how many months of residual benefits the pension fund can cover with its cash. Net contributions is total contributions minus total benefits. Cash/Net cash flows*12 is cash and cash equivalents over total net cash flows times 12 if total net cash flows are negative. This represents how many months of residual outflows the pension fund can cover with its cash. Net cash flows (ex. inv.inc) is total contributions and entry vested benefits minus total benefits, exit vested benefits and investment, administrative and insurance expenses.

Panel A: Cash in 2005

	Obs.	Mean	St.Dev	p5	p25	Median	p75	p95
Cash/Total assets	1,825	9.25	10.93	1.06	3.38	6.02	10.54	28.23
Cash/Total investments	1,820	10.62	13.07	1.27	3.79	6.69	11.86	33.86
Cash/Total benefits*12	1,737	89.19	305.08	2.96	11.67	25.10	57.87	325.83
Cash/Outflows*12	1,825	16.91	37.80	1.27	4.58	8.66	17.24	54.89
Net contributions < 0								
Cash/Net contributions*12	410	185.33	681.36	0.67	13.06	33.79	110.57	589.42
Net cash flows < 0								
Cash/Net cash flows (ex.inv.inc)*12	410	93.60	976.74	0.22	5.65	15.41	36.42	148.48

Panel B: Cash in 2018

	Obs.	Mean	St.Dev	p5	p25	Median	p75	p95
Cash/Total assets	1,220	7.95	10.71	0.87	2.47	5.06	9.32	23.92
Cash/Total investments	1,219	8.92	12.88	0.93	2.66	5.33	9.92	28.47
Cash/ Total benefits*12	1,211	49.43	202.78	2.74	8.04	18.31	39.19	146.96
Cash/Outflows*12	1,220	13.11	26.97	1.27	3.66	7.01	13.81	40.09
Net contributions < 0								
Cash/Net contributions*12	283	183.59	644.85	2.79	12.38	34.85	121.93	553.19
Net cash flows < 0								
Cash/ Net cash flows (ex.inv.inc)*12	283	44.41	138.05	1.50	5.50	14.31	34.32	149.50

while cash is lower in 2018 than it was in 2005, it still covers operational payments foreseen over substantial periods of time.

4. Determinants of cash holdings

This section, describes the methodology we follow to test our hypotheses on how operational and investment needs relate to pension fund cash holdings, and details the results we obtain.

4.1. Base model

To evaluate hypotheses H1 to H5, we regress cash as a percentage of total assets on variables that proxy for operational and investment reasons to hold cash. We therefore propose the following baseline model:

$$Cash_{i,t} = \beta_0 + \beta_1 NetCF_{i,t+1} + \beta_2 EntryVB_{i,t+1} + \beta_3 (ExitVB + LumpSums)_{i,t+1} + \beta_4 Totalexp_{i,t+1} + \beta_5 Vol_i + \beta_6 Derivatives_{i,t} + \beta_7 NewInv_{i,t+1} + \beta_8 YC_t + \Gamma' X_{i,t} + \eta_t + \varepsilon_{i,t} \quad (1)$$

where, subscripts refer to pension fund i and year t, respectively. *Cash* refers to holdings of cash and cash equivalents scaled by total assets and includes bank deposits and investments in money market securities. In our data, total assets excludes assets managed by insurance companies.

To test H1, we include a set of variables all scaled by total assets. Specifically, we include *NetCF* that refers to employee and employer contributions minus benefits in the form of annuities. We choose net cash flows from pension funds' regular activity because our previous analysis shows that aggregating net cash flows at a higher level weakens the relation with cash holdings, so we allow various flows to have different sensitivities in the model. We further include *EntryVB* that refers to entry vested benefits and represents retirement savings from new employees joining the fund, and any premiums paid by the beneficiary to recover retirement assets from home ownership or divorce withdrawals. *ExitVB* is exit vested benefits and includes termination benefits, home ownership and divorce withdrawals, and *LumpSums* are benefits paid in the form of lump-sums. We also add *Totalexp* that refers to the sum of administration and investment expenses as well as insurance premiums. We include all these cash flows separately rather than netting them out because, as indicated in the Section 3.2, pension funds appear to pay more attention to the sign of these cash flows rather than to the net amounts. With our specification, we allow pension funds to place different weights on distinct cash flows depending on their sign and regularity of occurrence. Subscript $t+1$ indicates expected cash flows in a period ahead that are scaled by total assets at t to eliminate the effect of changes in asset valuations. To proxy for expected cash flows we use realized cash flows at $t+1$.[17] Our pension funds evolve in a system designed to minimize surprises and anticipate future flows with reasonable certainty. Thus, most cash flows are highly predictable. Cash flows from regular activities (contributions minus benefits) depend on the firm's growth, recruitment policy, age group of employees and mortality rates. Flows related to vested benefits depend also on the employee turnover ratio and occur months after the employee's actual engagement or departure from the firm. Pension funds set directly the maximum amount that can be retrieved as a lump-sum as well as the deadlines for requesting a lump-sum that can be up to three years. Thus, using realized values to proxy for expected values seems relevant in our context.

Under H1, we expect β_1 and β_2 coefficients to be negative as pension funds with positive and large regular net cash flows and higher entry vested benefits need less cash. Also, our hypothesis predicts that β_3 and β_4 coefficients are positive as pension funds with large outflows should hold more cash. To test H2, we use the volatility of net contributions, *Vol*, computed as the standard deviation of net contributions over our sample period scaled by the mean of total assets. We would expect β_5 to be positive, consistent with pension funds subject to more variability holding more cash.[18] For H3, we use *Derivatives* as a proxy for liquidity needs from hedging commitments. This is a dummy variable that takes the value of 1 if the pension fund has derivative contracts and zero, otherwise. If those who hedge need more cash, we expect the coefficient β_6 to be positive. To examine H4 and H5, we use the last set of variables that proxy for investment reasons to hold cash. *NewInv* proxies for next-year investments made with current cash. It is defined as the overall change in pension funds' investments from t to $t+1$ less the investments made with total net cash flows received at $t+1$. More precisely, *NewInv* is the residual of regressing the change in pension funds' investments from t to $t+1$ on total net cash flows at $t+1$. If cash is held to pursue anticipated investment opportunities, H5 predicts a positive sign for β_7 coefficient. A positive coefficient is also consistent with delayed investment. *Alternatives* proxies for private investments that may require capital calls. *YC* proxies for the slope of the yield curve and is the spread between 1-year and 30-year Swiss government bonds. According to H4, β_8 should be negative.

To ensure that pension funds are truly comparable, we further include X, a set of control variables capturing pension fund-level characteristics. We consider *LnTA*, the natural logarithm of total assets to control for the size effect. We expect larger funds to hold less cash either because they are considered to be more sophisticated investors (see, e.g., Andonov et al., 2012; Davis and De Haan, 2012), or because they are more likely to benefit from economies of scale and face lower liquidity needs. We also consider *Coverage,* the coverage ratio, also called funding ratio (assets over liabilities). Underfunded funds are required by law to undertake specific measures to resolve underfunding, which includes following more conservative investment policies.

We also add calendar year fixed effects η to isolate the across pension fund variation and account for economic trends driving cash allocations. Finally, given the panel structure of the sample and to account for persistence in both cash holdings and our variables of interest, we use clustered standard errors at the pension fund level.[19]

4.2. Univariate tests

Having defined the variables of interest that proxy for operational and investment needs, we first perform univariate analysis. This preliminary step helps us better grasp the economic significance of each variable in isolation as well as eases the interpretation of the subsequent regression results. Table 6 evaluates cash holdings for pension funds with low and high operational and investment needs and provides univariate tests. For each variable, we split pension funds into two groups. One group includes pension funds with the variable of interest, proxying for operational or investment needs lower than the median, and the other group includes the rest. To proxy for operational needs, we use pension fund next-year cash flows and whether they use derivative

[17] In a similar fashion, Fama and French (1998) also use realized values to proxy for expected values.

[18] Using the volatility of outflows shows similar results.

[19] The results are virtually the same if we cluster standard errors also by time.

Table 6
Univariate tests of cash holdings This table provides univariate tests of cash holdings for pension funds with low vs high ranking of variables that measure operational and investment needs. Each year, we rank pension funds based on the median of the following variables. Regular net contributions is regular contributions minus annuities. EntryVB include termination benefits transferred by new employees joining the fund and any premiums paid to recover retirement assets from home ownership or divorce withdrawals. ExitVB & Lump-sums is the sum of lump-sum and exit vested benefits and Total expenses is the sum of investment, administrative and insurance expenses. These variables are computed in % of total assets and are expressed in percentage. Total assets do not include assets managed by insurance companies. With the subscript t+1, we refer to next-year cash flows scaled by total assets at year t. Vol. net contributions is the standard deviation of net contributions over time scaled by the mean of total assets over time. New investments is the residual of regressing the change in investments from t to t+1 on net cash flows at t+1 and represents investments made with cash in t over t+1. 30y-1y is the yield spread between the 1-year and 30-year Swiss government bonds. Alternatives is investments in hedge funds, private equity, commodities, infrastructures, insurance-linked securities and others. Derivatives is a dummy equal to 1 if the pension fund has derivative contracts and zero, otherwise. We provide descriptive statistics of cash holdings for each group, expressed in percentage, and then we test whether there are significant differences between the two groups using a t-test.

	Flow variable < Median Low ranking		Flow variable ≥ Median High ranking		(Low-High)	
	Obs.	Mean cash	Obs.	Mean cash	Difference	t-stat
Anticipated operating activity						
Regular net contributions$_{t+1}$	11,276	7.42	10,050	10.67	−3.25	−23.70
EntryVB $_{t+1}$	11,276	8.45	10,050	9.52	−1.07	−7.75
ExitVB & Lump-sums $_{t+1}$	11,276	7.95	10,050	10.07	−2.12	−15.35
Total expenses $_{t+1}$	11,276	7.29	10,050	10.82	−3.54	−25.90
Current operating activity						
Regular net contributions	10,660	7.22	10,666	10.68	−3.46	−25.30
EntryVB	10,666	8.21	10,660	9.70	−1.49	−10.80
ExitVB & Lump-sums	10,666	8.21	10,660	9.70	−1.49	−10.80
Total expenses	10,666	7.07	10,660	10.84	−3.77	−27.70
Vol. net contributions	10,666	7.43	10,666	10.47	−3.04	−22.25
Investment activity						
New investments	11,276	7.75	10,050	10.3	−2.56	−18.55
30y-1y	10,815	9.06	10,511	8.84	0.22	1.60
Alternatives	10,663	9.86	10,663	8.04	1.81	13.17
	Variable: No		Variable: Yes		(No-Yes)	
	Obs.	Mean cash	Obs.	Mean cash	Difference	t-stat
Derivatives	18,392	9.10	2,934	8.05	1.05	5.20

contracts. Pension funds that anticipate higher regular net contributions and entry vested benefits appear to hold more cash (10.7% vs 7.4% and 9.5% vs 8.5%). They also hold more cash when exposed to higher lump-sum and exit vested benefits as well as higher total expenses in the coming year (10.1% vs 7.9% and 10.8% vs 7.3%). Similarly, pension funds subject to greater volatility in the core of their business (net contributions) also hold more cash (10.5% vs 7.4%). However, those with derivative contracts tend to keep lower cash (8.1% vs 9.1%). We further observe that current operating activity associates closely with cash in a similar way that future activity does. Univariate t-tests show that all these differences are statistically significant. For investments needs, our analysis shows that pension funds hold more cash when they plan to invest over the next year (10.3% vs 7.8%), when the yield spread is lower (9.1% vs 8.8%) and when they hold a lower share of private assets (9.9% vs 8%). Taken together, the univariate analysis suggests that pension funds tend to hold more cash the higher their cash flows, the greater their volatility, the lower the share invested in private assets and the larger the investment needs.

4.3. Regression results

Table 7 reports coefficients, standard errors and significance tests for time fixed-effects regressions of cash on variables representing operational and investment needs. In column (1), we examine whether pension funds hold cash in anticipation of next-year activity. We observe that higher expected lump-sum benefits, exit vested benefits, and total expenses are associated with higher cash holdings. Consistent with our hypothesis, this indicates that pension funds keep liquidity to meet next period outflows. Also, in line with our predictions, they hold less cash when entry vested benefits are expected to be large. The positive coefficient on expected regular net contributions, though, suggests that pension funds tend to hoard cash even if they expect positive net cash flows from their regular activity. Cash balances do not fully mirror operational needs but may partially result from a passive accumulation of cash flows from current operations or delayed investment. To examine this conjecture, in column (2), we analyse how cash balances respond to contemporaneous cash flows.

Contemporaneous lump-sums, exit and entry vested benefits are not highly correlated with their expected values (correlation ranges from 0.37 to 0.6). Appendix B, Table B.3 reports correlations among all variables used in our tests. We incorporate these cash flows, which display a more transitory nature rather than a permanent one, into the base model. In contrast, contemporaneous and expected regular net contributions are highly correlated (correlation of 0.91) and reflect the demographics of the pension fund that are rather stable. We thus replace the expected by the contemporaneous values.[20]

Column (2) shows that contemporaneous entry vested benefits is associated with higher cash holdings and as well as regular net contributions. Finding that large transitory inflows correlate with higher cash holdings suggests that pension funds accumulate and slowly deploy available funds for investment at least in the short run. We provide a more detailed analysis of cash dynamics in the next section. In specification (3), we add controls and results remain largely unchanged, except

[20] We use contemporaneous regular net contributions, instead of expected values, in the remaining specifications in Table VII. We avoid using both variables due to their high correlation. The use of expected values would theoretically be more relevant if funds were to reduce cash when they expect high regular net contributions in the future. However, specification (1) shows that pension funds do not exhibit such behavior. The positive coefficient indicates a preference for hoarding or accumulating cash. In a cash hoarding model, the relevant variable to retain is the contemporaneous one because cash balances reflect the passive accumulation of cash flows from current operations. Alternatively, in unreported tests, we use expected values and, unsurprisingly, results remain qualitatively similar.

Table 7
What drives pension fund cash holdings? This table presents pooled regressions where *Cash* is regressed on variables that proxy for pension fund operational and investment needs and a set of control variables. *Cash* is the percentage of total assets held in cash and equivalents. *Regular net contributions* is regular contributions minus annuities. *EntryVB* include termination benefits transferred by new employees joining the fund and any premiums paid to recover retirement assets from home ownership or divorce withdrawals. *ExitVB & Lump-sums* is the sum of lump-sum and exit vested benefits and *Total expenses* is the sum of investment, administrative and insurance expenses. *Investment income* is income from investments and includes realized and unrealized gains and losses. These variables are computed in % of total assets. Total assets do not include assets managed by insurance companies. With the subscript *t+1*, we refer to next-year cash flows scaled by total assets at year *t*. *Derivatives* is a dummy equal to 1 if the pension fund has derivative contracts and zero, otherwise. *Vol. net contributions* is the standard deviation of net contributions over time scaled by the mean of total assets over time. *New investments* is the residual of regressing the change in investments from *t* to *t+1* on net cash flows at *t+1* and represents investments made with cash over *t+1*. *Alternatives* is investments in hedge funds, private equity, commodities, infrastructures, insurance-linked securities and others. *30y-1y* is the yield spread between 1-year and 30-year Swiss government bonds. Regressions (3)-(6) include a set of control variables. *Total assets (ln)* is the natural logarithm of total assets held by the pension fund and *Funding ratio* refers to pension assets over pension liabilities as report by the pension fund. All estimations include year fixed effects except regression (6). We report robust standard errors clustered at the pension fund level in (.). ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	(1) Cash	(2) Cash	(3) Cash	(4) Cash	(5) Cash	(6) Cash	(7) Cash
Regular net contributions $_{t+1}$	0.200***						
	(0.059)						
Regular net contributions		0.299***	0.278***	0.244***	0.230***	0.239***	0.248***
		(0.053)	(0.049)	(0.047)	(0.049)	(0.049)	(0.049)
EntryVB $_{t+1}$	−0.059**	−0.072***	−0.048***	−0.044***	−0.028*	−0.030*	−0.033**
	(0.026)	(0.017)	(0.016)	(0.016)	(0.015)	(0.016)	(0.016)
EntryVB		0.057**	0.082***	0.072***	0.053**	0.050*	0.051*
		(0.028)	(0.027)	(0.027)	(0.026)	(0.026)	(0.026)
ExitVB & Lump-sums $_{t+1}$	0.070**	0.062**	0.072***	0.088***	0.089***	0.088***	0.090***
	(0.033)	(0.030)	(0.027)	(0.025)	(0.024)	(0.024)	(0.024)
ExitVB & Lump-sums		−0.016	−0.019	−0.021	−0.014	−0.014	−0.012
		(0.021)	(0.022)	(0.022)	(0.021)	(0.021)	(0.021)
Total expenses $_{t+1}$	0.601***	0.551***	0.113	0.240	0.372**	0.396**	0.371**
	(0.165)	(0.169)	(0.163)	(0.161)	(0.168)	(0.170)	(0.170)
Derivatives	−0.002	−0.002	0.011***	0.011***	0.011***	0.013***	0.014***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Vol. net contributions	0.364***	0.348***	0.237**	0.223**	0.234**	0.24**	0.23**
	(0.104)	(0.103)	(0.098)	(0.097)	(0.097)	(0.097)	(0.096)
Investment income $_{t+1}$				−0.248***			
				(0.034)			
New investments					0.161***	0.161***	0.161***
					(0.011)	(0.011)	(0.011)
Alternatives						−0.093***	−0.095***
						(0.023)	(0.023)
30y-1y							−0.003***
							(0.001)
Total assets (ln)			−0.009***	−0.008***	−0.009***	−0.009***	−0.009***
			(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Funding ratio			−0.009*	−0.009*	−0.010**	−0.011**	−0.016***
			(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
_cons	0.062***	0.060***	0.173***	0.181***	0.174***	0.169***	0.189***
	(0.004)	(0.004)	(0.021)	(0.021)	(0.022)	(0.022)	(0.022)
Obs.	20106	20106	20106	20106	20106	20106	20106
R-squared	0.063	0.068	0.083	0.089	0.119	0.122	0.117
Year FE	YES	YES	YES	YES	YES	YES	NO

for liquidity needs from pension funds' hedging activities that becomes economically and statistically significant. Pension funds with derivative contracts hold an additional 1.1% of total assets in cash compared to those without derivatives. Across specifications, we also observe that pension funds subject to greater cash flow variability hold more cash.

So far, we have excluded investment income from the analysis of pension fund operating needs because it includes unrealized gains and losses and is frequently directly reinvested within the same asset class that generates it. Adding investment income in column (4) shows that pension funds expecting higher investment income hold less cash. However, this result should be viewed with caution because realized investment income may be a poor proxy for expected investment income. Further, this result may be affected by reverse causality. Investment income may be higher due to lower cash holdings to begin with. To avoid potential biases in our estimates, we exclude investment income from our subsequent analysis. Including it, though, does not alter our results.

With regards to investment reasons to hold cash, in column (5), we observe a positive and statistically significant coefficient on new investment. Pension funds keep cash balances, or delay investing their cash to the next year. This interpretation may mask two effects. Pension funds may delay investment either because they expect investment opportunities to arise or because they need some time to invest available cash flows. In column (6), we investigate whether investment opportunities have a bearing on explaining cash. For example, if cash is held to meet capital calls, we should observe higher cash holdings the larger is

Table 8
The role of discipline and sophistication Columns (1)-(4) present pooled regressions of sample splits where Cash is regressed on variables that proxy for pension fund operational and investment needs and a set of control variables. Cash is the percentage of total assets held in cash and equivalents. In column (1) and (2), we split to pension funds in accumulation and deccumulation phase and in column (3) and (4), to small and large pension funds based on median size. Column (5), includes only the largest pension funds in the sample (top quartile). In Column (6), we add year dummies from 2015 and on to the whole sample. Regular net contributions is regular contributions minus annuities. EntryVB include termination benefits transferred by new employees joining the fund and any premiums paid to recover retirement assets from home ownership or divorce withdrawals. ExitVB & Lump-sums is the sum of lump-sum and exit vested benefits and Total expenses is the sum of investment, administrative and insurance expenses. These variables are computed in % of total assets. Total assets do not include assets managed by insurance companies. With the subscript t+1, we refer to next-year cash flows scaled by total assets at year t. Derivatives is a dummy equal to 1 if the pension fund has derivative contracts and zero, otherwise. Vol. net contributions is the standard deviation of net contributions over time scaled by the mean of total assets over time. New investments is the residual of regressing the change in investments from t to t+1 on net cash flows at t+1 and represents investments made with cash over t+1. Alternatives is investments in hedge funds, private equity, commodities, infrastructures, insurance-linked securities and others. 2015 (2016, 2017) is a dummy that equals to one for the year 2015 (2016, 2017) and zero, otherwise. Total assets (ln) is the natural logarithm of total assets held by the pension fund and Funding ratio refers to pension assets over pension liabilities as report by the pension fund. All estimations include year fixed effects except specification (5). We report robust standard errors clustered at the pension fund level in (.). ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	(1) Accumulation phase	(2) Deccumulation phase	(3) Small funds	(4) Large funds	(5) Large funds Top quartile	(6) Cash
Regular net contributions	0.279***	0.172	0.362***	0.123**	−0.006	0.240***
	(0.071)	(0.125)	(0.080)	(0.052)	(0.09)	(0.049)
EntryVB $_{t+1}$	−0.025	−0.143*	−0.038**	−0.049	−0.108	−0.032**
	(0.016)	(0.079)	(0.017)	(0.039)	(0.067)	(0.015)
EntryVB	0.054**	−0.056	0.052	0.033	0.008	0.054**
	(0.027)	(0.128)	(0.033)	(0.040)	(0.074)	(0.026)
ExitVB & Lump-sums $_{t+1}$	0.077***	0.243***	0.053**	0.151***	0.203**	0.088***
	(0.025)	(0.074)	(0.026)	(0.048)	(0.088)	(0.024)
ExitVB & Lump-sums	−0.015	−0.030	−0.034	0.015	0.186*	−0.012
	(0.025)	(0.024)	(0.027)	(0.022)	(0.110)	(0.021)
Total expenses $_{t+1}$	0.312*	0.870	0.405**	0.888***	1.436**	0.377**
	(0.179)	(0.546)	(0.193)	(0.267)	(0.699)	(0.170)
Derivatives	0.012***	0.015***	0.005	0.007**	0.004	0.013***
	(0.004)	(0.005)	(0.007)	(0.003)	(0.005)	(0.003)
Vol. net contributions	0.228**	0.313*	0.459***	0.085	0.025	0.236**
	(0.105)	(0.172)	(0.141)	(0.092)	(0.207)	(0.096)
New investments	0.156***	0.182***	0.133***	0.264***	0.343***	0.161***
	(0.012)	(0.029)	(0.012)	(0.027)	(0.057)	(0.011)
Alternatives	−0.102***	−0.056*	−0.152***	−0.066*	−0.084	−0.086***
	(0.027)	(0.032)	(0.028)	(0.034)	(0.054)	(0.023)
2015						−0.012***
						(0.002)
2016						−0.014***
						(0.002)
2017						−0.009***
						(0.002)
Total assets (ln)	−0.009***	−0.007***				−0.009***
	(0.002)	(0.002)				(0.002)
Funding ratio	−0.019**	−0.001	−0.007	0.015	0.003	−0.015***
	(0.009)	(0.005)	(0.006)	(0.013)	(0.017)	(0.006)
_cons	0.185***	0.13***	0.068***	0.034**	0.039*	0.181***
	(0.028)	(0.034)	(0.009)	(0.015)	(0.021)	(0.022)
Obs.	16351	3755	10056	10050	4890	20106
R-squared	0.108	0.139	0.095	0.116	0.136	0.119
Year FE	YES	YES	YES	YES	YES	NO

the share invested in private assets. Specifically, we examine if higher investments in alternative assets correlate with higher cash holdings in anticipation of capital calls. Surprisingly, the coefficient on *Alternatives* is negative and statistically significant and, thus, inconsistent with our hypothesis.[21] The evidence is more consistent with pension funds needing time to invest incoming cash flows. In the next section, we further examine how long it takes for transitory increases of cash to be reinvested. Finally, in column (7), we add the yield curve as a determinant of cash while we exclude time fixed effects. We see that pension funds hold less cash when the opportunity cost is high and the term spread widens.

It is also worth noting that fund size continues to play a role, even after accounting for the key determinants of cash holdings. Smaller funds consistently hold more cash across all specifications. To ease the interpretation of the coefficient, in an unreported analysis of specification (6), we substitute the logarithm of total assets with a dummy variable. This dummy variable equals one if the pension fund has total assets larger than the median. The estimated coefficient for the size dummy is -0.021, and it is statistically significant (t-stat = -5.55). Smaller funds hold 2.1% more cash than larger ones. Thus, smaller funds show more potential for adjusting cash holdings and enhancing expected performance.

Summing up, we provide evidence that cash holdings respond to the key determinants of operational and investment needs that should

[21] Unreported tests, show that the higher the share of illiquid assets (measured as the share of investments in alternatives and real estate), the lower the cash holdings. Cash holdings are not held either as a balance to compensate for highly illiquid investments. This is consistent with the view that cash is not the only liquid asset and other assets with high liquidity such as government bonds, should dominate cash holdings when the goal is to balance for illiquid investments.

mainly drive cash holdings in our setting.[22] We also find that the higher are regular net flows (regular net contributions) and temporary inflows (entry vested benefits), the higher are cash holdings. This result is more surprising as we had predicted a negative relationship. We interpret this finding as pension funds passively accumulating cash flows and slowly deploying available funds for investment.

4.4. Regression results: the role of discipline and sophistication

When do cash holdings conform more to operational and investment needs? Pension funds will hold cash balances that respond more closely to their needs when they are subject to greater discipline or to greater organizational sophistication. Pension funds subject to greater outflows, facing large demands for liquidity, may track cash holdings more closely. This is also the case of large pension funds that likely enjoy more developed organizational set ups. In Table 8, we evaluate whether cash policies depend on particular circumstances. In the first two columns, we use specification (6) of Table 7 and we split our sample into pension funds in an accumulation phase (positive regular net contributions) and in a deccumulation phase (negative regular net contributions), respectively. Column (2) shows that, in contrast to their counterparts in column (1), pension funds in a deccumulation phase show greater sensitivities of key operational outflows to cash holdings. A Wald test (p-value=0.03) confirms that these pension funds hold significantly larger cash balances when anticipating larger exit vested benefits and lumpsums. Also, the coefficient on regular net contributions indicates these pension funds subject to regular net outflows hold significantly lower levels of cash (p-value=0.00).

In the two subsequent columns of Table 8, we split our sample into small and large pension funds based on the median size (total assets) as a rough proxy for more efficient processes or management capacity. Column (5) reports results for the largest pension funds in the sample (top quartile). We observe that large pension funds show greater sensitivities of operational and investment proxies to cash holdings, indicating that cash policies respond more to pension fund needs. Interestingly, the association between regular net contributions and cash holdings weakens and becomes insignificant for the largest funds. Large pension funds hoard less cash and seem more reactive investing net contributions than small funds who display a significantly larger coefficient (p-value=0.002). Large pension funds also cushion more against high expected outflows. For example, they show a significantly larger coefficient (p-value=0.06) on total expenses. The variable *New investments* loads significantly higher (p-value=0.00) for large pension funds indicating that these funds reinvest cash at a faster rate. These findings are consistent with the evidence of size being indicative of superior sophistication (see, e.g., Andonov et al., 2012; Davis and De Haan, 2012).

Lastly, we evaluate how pension funds reacted to the decision of the SNB, in January 2015, to introduce negative interest rates. A priori, this event did not trigger an increase in the opportunity costs of holding cash; instead, it introduced an explicit cost to holding cash and generated greater pressure to achieve a target return.[23] Column (6) shows that in 2015, pension funds decreased their cash holdings by 1.2% and this reduction largely persists three years later. This indicates that pension funds are not likely trading off the various benefits of holdings cash with the consequent opportunity costs and, possibly, holding more cash than was needed.

In sum, we find that pension funds subject to greater discipline and sophistication invest available cash timelier and respond more closely to key operational and financial needs. Regressions for these funds show higher adjusted R-squares (about 14% vs 10%), consistent with greater responsiveness of cash holdings to needs. However, R-squares from regressions using identified determinants of cash holdings remain generally low and only explain a small share of the variation in cash holdings.

5. Dynamics of cash holdings

An implication of our analysis is that the average pension fund does not invest a share of their cash flows in a timely manner, it hoards cash and slowly deploys available funds for investment. Pension funds tend to consider cash holdings as part of their strategic asset allocation and define a target level with quite flexible bands. The actual cash levels can therefore fluctuate overtime. If pension funds experience a temporary increase (decrease) in cash holdings, we want to evaluate how quickly they revert to average values. Next, we evaluate the dynamic behavior of cash holdings using an autoregressive analysis to understand how long it takes for transitory increases of cash to be reinvested.

We implement two sets of tests. First, we regress the change in cash holdings on its lagged change to evaluate the extent of mean reversion as follows:

$$\Delta Cash_{i,t} = a + \beta \Delta Cash_{i,t-1} + \varepsilon_{i,t} \quad (2)$$

where subscripts refer to pension fund *i* and year *t*, respectively. $\Delta Cash$ is the first difference operator. The coefficient β indicates the rate of adjustment towards a long-term mean. The results of this analysis are reported in Table 9, specifications (1) to (3). Across specifications, the coefficient β is negative and of similar magnitude (from 0.27 to 0.32) indicating that cash holdings are mean reverting consistent with pension funds adhering to targets for cash holdings. The size of the coefficient indicates that responses to transitory changes in cash are delayed; that is, cash holdings adjust towards the mean but at a relative slow pace. Specification (4) introduces additional lags of the change in cash and shows how long it takes for transitory increases of cash to be deployed. We find that it takes up to four years to revert to mean values.

Another direct way to quantify the deployment of cash flows is to examine the speed at which pension funds adjust their cash holdings towards a target level. We estimate the speed of adjustment (SOA) using the following autoregressive model of cash holdings:

$$\Delta Cash_{i,t} = a + \lambda\left(\widehat{Cash}_{i,t} - Cash_{i,t-1}\right) + \varepsilon_{i,t} \quad (3)$$

where $\widehat{Cash}$ is the predicted target level of cash estimated using Eq. (1).[24] The parameter λ is the speed of adjustment and measures the fraction of the gap between target cash in *t* and cash in *t-1* that pension funds close each year. The results of this second analysis are reported in Table 9, specifications (5) to (7). Specifications (5) and (6) show that pension funds tend to close 26% of this gap every year and they slowly approach predicted target cash holdings. The adjusted R-squared is between 16% and 19%. Controlling for factors that proxy for operational and investment needs in specification (6) has a negligible effect on the speed of adjustment. Including pension fund fixed effects in specification (7) increases the speed of adjustment to 0.68 and the adjusted R-squared to 44%. This is consistent with the importance of time-invariant pension fund specific effects for explaining cash holding targets. This points to the existence of a significant missing factor that is pension specific and different from the factors we have identified as key determinants of cash

[22] We could argue that other factors should also shape cash holdings, for example, the likelihood of fund runs or the use of leverage. These two potential determinants of cash holdings are not relevant in out setting. Pension funds in Switzerland cannot use leverage and there are mechanisms in place to limit fund runs.

[23] The introduction of negative interest rates reduced risk free rates and flattened the yield curve. There is no reason for expected risk premiums to be affected, see (Kroencke and Salva, 2023). This implies that the opportunity cost of holding cash is unlikely to than increase around this event.

[24] Alternatively, we examine a model where the target is the average cash holdings over the sample period. Pension funds adjust faster to the average cash holdings and slower to predicted target cash holdings.

Table 9
Dynamics of cash holdings Columns (1)-(4) in Panel A present regressions of the change in cash holdings on its lagged change to evaluate the extent of mean reversion. ΔCash is the change in the percentage of cash and equivalents to total assets. Total assets do not include assets managed by insurance companies. Columns (5) to (7) run regressions to estimate the speed of adjustment of cash holdings to a target level. The target is the predicted target level of cash holdings estimated using Eq. (1). All specifications include year fixed effects. Specifications (3), (4) and (7) include also pension fund fixed effects. Controls refers to all variables included in specification (6) of Table 7. That is, variables that proxy for pension fund operational and investment needs as well as the natural logarithm of total assets held by the pension fund and its funding ratio. Panel B presents the transition matrix for pension funds in the highest quartile of cash. Each year, pension funds are divided to quartiles of cash. Pension funds that every year appear for the first time in the highest quartile of cash are followed for the five subsequent years. The first two columns show the year and the number of these pension funds. The columns that follow provide the proportion of these pension funds that remain in the highest quartile of cash in the five subsequent years.

Panel A: Cash accumulation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	ΔCash	ΔCash	ΔCash	ΔCash	ΔCash	ΔCash	ΔCash
$\Delta Cash_{t-1}$	−0.276***	−0.267***	−0.315***	−0.478***			
	(0.017)	(0.014)	(0.013)	(0.021)			
$\Delta Cash_{t-2}$				−0.362***			
				(0.017)			
$\Delta Cash_{t-3}$				−0.253***			
				(0.015)			
$\Delta Cash_{t-4}$				−0.175***			
				(0.013)			
target					0.257***	0.262***	0.680***
					(0.021)	(0.023)	(0.020)
Observations	17366	16150	16086	12449	18085	18085	18004
R-squared	0.083	0.125	0.212	0.310	0.155	0.185	0.442
Controls	NO	YES	YES	YES	NO	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES
Fund FE	NO	NO	YES	YES	NO	NO	YES

Panel B: Transition matrix for pension funds in the highest quartile of cash

	Number of PFs with first time high cash	Year 1	Year 2	Year 3	Year 4	Year 5
2006	156	46%	21%	13%	12%	9%
2007	134	44%	25%	18%	13%	9%
2008	121	36%	22%	13%	13%	8%
2009	95	37%	26%	19%	13%	7%
2010	70	46%	24%	14%	10%	9%
2011	55	25%	18%	16%	7%	7%
2012	59	46%	27%	20%	12%	12%
2013	46	35%	15%	11%	4%	4%
2014	34	29%	18%	15%	12%	
2015	39	46%	26%	23%		
2016	32	50%	31%			
2017	24	46%				

Table 10
The persistence of cash holdings Panel A presents pooled regressions where Cash is regressed on Initial cash and variables that proxy for pension fund operational and investment needs. Cash is the percentage of total assets held in cash and equivalents. Initial cash is cash held during the first year a pension fund appears in the sample. We drop the first observation for each pension fund to avoid an identity specification. Regular net contributions is regular contributions minus annuities. EntryVB include termination benefits transferred by new employees joining the fund and any premiums paid to recover retirement assets from home ownership or divorce withdrawals. ExitVB & Lump-sums is the sum of lump-sum and exit vested benefits and Total expenses is the sum of investment, administrative and insurance expenses. These variables are computed in % of total assets. Total assets do not include assets managed by insurance companies. With the subscript t+1, we refer to next-year cash flows scaled by total assets at year t. Derivatives is a dummy equal to 1 if the pension fund has derivative contracts and zero, otherwise. Vol. net contributions is the standard deviation of net contributions over time scaled by the mean of total assets over time. New investments is the residual of regressing the change in investments from t to t+1 on net cash flows at t+1 and represents investments made with cash over t+1. Alternatives is investments in hedge funds, private equity, commodities, infrastructures, insurance-linked securities and others. 30y-1y is the yield spread between 1-year and 30-year Swiss government bonds. Panel B shows a variance decomposition for different models used to determine pension fund cash holdings as well as their R-squared in the last row. We compute Type III partial sum of squares for each factor used in the respective model. We normalize each column to sum to one by dividing the total sum of squares of the all the factors included in the model. Pension fund FE (Year FE) are pension fund (calendar year) fixed effects.

Panel A: The impact of initial cash on current cash holdings

	(1)	(2)	(3)
	cash	cash	cash
Initial cash	0.470***	0.447***	0.445***
	(0.041)	(0.043)	(0.043)
Regular net contributions		0.064	0.079*
		(0.044)	(0.044)
EntryVB $_{t+1}$		−0.032**	−0.039***
		(0.014)	(0.014)
EntryVB		0.043	0.044
		(0.029)	(0.029)
ExitVB & Lump-sums $_{t+1}$		0.074***	0.077***
		(0.022)	(0.022)
ExitVB & Lump-sums		−0.021	−0.018
		(0.021)	(0.021)
Total expenses $_{t+1}$		0.281*	0.257
		(0.156)	(0.156)
Derivatives		0.013***	0.014***
		(0.003)	(0.003)
Vol. net contributions		0.119	0.104
		(0.084)	(0.085)
New investments		0.140***	0.141***
		(0.010)	(0.010)
Alternatives		−0.090***	−0.097***
		(0.023)	(0.022)
30y-1y			−0.004***
			(0.001)
Total assets (ln)		−0.007***	−0.008***
		(0.001)	(0.001)
Funding ratio		−0.003	−0.010*
		(0.005)	(0.005)
_cons	0.046***	0.113***	0.139***
	(0.003)	(0.017)	(0.017)
Obs.	19321	18101	18101
R-squared	0.244	0.332	0.326
Year FE	NO	YES	NO

Panel B: Variance decomposition of pension fund cash holdings

Variable	(1)	(2)	(3)	(4)	(5)
Pension fund FE	1.000		0.987		0.924
Year FE		1.000	0.013	0.099	0.010
Regular net contributions				0.083	0.000
EntryVB				0.001	0.002
EntryVB$_{t+1}$				0.014	0.000
ExitVB & Lump-sums				0.001	0.000
ExitVB & Lump-sums $_{t+1}$				0.040	0.003

Table 10 (*continued*)

Panel A: The impact of initial cash on current cash holdings

	(1)		(2)		(3)
Total expenses $_{t+1}$				0.104	0.001
Derivatives				0.001	0.000
Vol. net contributions				0.105	
New investments				0.479	0.058
Alternatives				0.073	0.002
R-squared	0.589	0.012	0.598	0.106	0.674

holdings.

In sum, pension funds take time to deploy increases in cash holdings and only gradually converge to long term averages or predicted targets. There are situations when accumulating cash flows and retaining cash is not necessarily problematic. For example, if a pension fund receives a large one-off inflow from a large wave of new employees joining the pension fund, it may reasonably decide to smooth out the investment of this inflow over time, especially if market prices are high. To explore how pension funds react when they experience sudden increases in cash, we divide them into quartiles based on their cash holdings. We only focus on pension funds that enter the highest quartile in a given year and we provide the fraction of these funds that remain in the top quartile for the five subsequent years. Panel B, Table 9 shows that more than 50% of the pension funds that enter the highest quartile of cash do not remain there after one year. This indicates that a majority of pension funds invest large transitory inflows already in the year after. However, some funds entering the highest quartile remain there for quite some time; others spread investment over at least two years. For some pension funds, high cash holdings are the result of delayed action.

6. Persistence of cash holdings

The fact that pension funds with high regular net contributions hold more cash, that increases in cash holdings are gradually deployed and revert slowly to their mean hint to the presence of persistence. To investigate persistence, we start with the analysis of the role that initial cash holdings play in the level of future cash. Then we perform a variance decomposition to quantify the explanatory power of identified factors that shape operating and investing needs and test for the presence of an unobserved pension fund specific component.

To investigate the role of initial cash holdings on current holdings, we regress current cash holdings on initial cash. Initial cash is cash held during the first-year a pension fund appears in our sample.[25] Specification (1) in Panel A, Table 10 shows that pension funds with high initial cash holdings continue to show high cash holdings in the future. The R-squared of 24% indicates that approximately a quarter of the variation in cash holdings can be attributed to initial cash balances alone. In subsequent columns, we add time-varying operational and investment variables; the factors we identify should be key determinants of cash holdings. Their coefficients are consistent with our previous evidence. The introduction of these variables further increases R-squared to 33% but leaves the coefficient of initial cash largely unchanged in terms of magnitude and significance, suggesting that historical levels of cash are an important driver of future cash holdings. These results reveal that a permanent pension fund-specific component is critical in explaining cash holdings, compared to the time-varying operational and investment determinants.

We now turn to quantify the impact of this permanent component. To estimate how much of the variation in cash is attributable to each factor, we perform an analysis of covariance. Panel B, Table 10 displays the

[25] To avoid estimating an identity specification, we exclude the first observation for each pension fund.

results of variance decompositions for different specifications using Type III partial sum of squares. We normalize each column to sum to one by dividing the partial sum of squares of each factor by the total sum of squares of the factors included in each model. The last row of the table displays the R-squared of each model.

In the first two columns, pension fund and time fixed effects explain 100% of the fraction in the sum of squares, respectively, as they are the only factors included in each model. Pension fund fixed effects capture 59% of the variation in cash holdings (column (1)) as opposed to the time fixed effects that capture only 1.2% (column (2)). Thus, variation in cash holdings are largely due to permanent pension fund-specific factors. This is further confirmed in the third column, where our model includes both pension fund and time fixed effects. Column (4) reports a similar specification to the one presented in specification (6), Table 7, where we include all factors describing operational and investment needs with year fixed effects. This specification yields an R-squared of about 11%. This is far smaller compared to the explanatory power of pension fund fixed effects alone (R-squared = 59% in column (1)). The factors we identify as key determinants of cash holdings are, thus, relatively weak in explaining variation in cash holdings when compared to time-invariant pension fund specific factors. Looking at what factors matter most, operating needs related to pension funds' regular activity (regular net contributions), variability of cash flows, and total expenses as well as investment needs (new investments) and year fixed effects account for most of the explanatory power of this model. Lump-sums, entry and exit vested benefits, have a smaller explanatory power. This is surprising as these cash flows are an important dimension along which institutional environments differ and could explain to a large extent why Swiss pension funds hold more cash compared to those in other countries. In the last column (5), we add pension fund fixed effects to the model of column (4). This last specification explains 67% of the variation in cash holdings. The observable factors we identify as key determinants of cash holdings explain about 8% and an unobservable time-invariant pension fund specific component is responsible for 92% of the explained variation.

In this section we show that the factors we identify as key determinants in our institutional setting explain only a small share of the variation in cash holdings. An unobservable time-invariant pension fund specific component unrelated to operational and investment needs is a critical determinant of cash holdings and explains a large share of the variation. This permanent component is not related to the demographics and operational needs of the pension funds. This unobservable component could be, for example, attributed to differences in technologies, managerial behavior or preferences, competence in financial matters, and/or organizational set ups. Identifying these factors would require additional analysis that is beyond the scope of this study.

7. Excessive cash holdings

If we expect that the operational and investment factors we characterize in Section two are the key determinants of cash holdings, any portion of cash holdings unrelated to these factors should be considered excessive. The question we aim to answer at this point is whether pension funds hold excessive cash beyond what would be predicted by operational and investment needs and, if they do, how much?

Our tests point to the presence of excessive cash holdings. We have shown that pension funds subject to greater discipline, sophistication or greater pressure to achieve a target return have lower cash holdings. Next, we quantify excessive cash holdings. To this end, we follow Opler et al. (1999), Dittmar and Mahrt-Smith (2007), and Fresard and Salva (2010) and we define excess cash as the difference between the amount of cash actually held by a pension fund and the predicted normal amount of cash:

$$XCash_{i,t} = Cash_{i,t} - \widehat{Cash}_{i,t} \quad (4)$$

where subscripts refer to pension fund *i* and year *t*, respectively. *XCash* is the excess cash as a proportion of total assets. *Cash* is the actual cash over total assets. $\widehat{Cash}$ is the predicted level of cash and refers to the amount of cash a pension fund should hold if the goal was only to cover operational and investment needs. To predict that amount of cash and eventually estimate excess cash, we follow different approaches.

First, we estimate the model in regression (6), Table 7. Then to predict cash we consider only those coefficients that are consistent with our hypotheses and we exclude fixed effects. Because we are interested in estimating the normal level of cash justified by operational and investment needs, we do not account for coefficients that may capture other reasons why pension funds hold cash. Then we define excess cash as in Eq. (4).

Our second approach defines excess cash as the residual of the same regression with pension fund fixed effects. According to our previous analysis, there is a time invariant unobservable pension fund-specific effect and ignoring it may bias regression coefficients. Again, we then estimate the normal level of cash using regression coefficients that are in line with our predictions but excluding fixed effects.

Finally, we provide a model-free definition of excess cash. According to Panel B, Table 5, almost 25% of the pension funds in our sample hold approximately 2% of total assets in cash with which they can cover up to three months of total outflows. We use these funds as a benchmark and assume that 2% is closer to the amount of cash that pension funds should hold to meet their operational needs. We therefore compute the normal level of cash for each pension as the amount of cash needed to cover three months of forthcoming outflows. To this amount, we add 1% for pension funds that have derivative contracts to meet possible outflows that may arise from these contracts. This is in line with our base model estimations in column (6), Table 7, where pension funds that have derivative contracts appear to hold almost 1% more cash. This amount is further increased by 1% to account for investment purposes to hold cash. Excess cash is, then, computed as the difference of actual cash and this normal level of cash.

Table 11 presents our estimates of excess cash as well as their distribution and that of the elements used for their computation according to Eq. (4). For our model-based measures, we report only excess cash estimates for pension funds having positive excess cash. Pension funds with positive excess cash have on average 8.6%-8.9% of excessive cash holdings. The estimate is 7.6% for our model-free estimate. We note that model-based estimates implicitly assume that, on average, no excess cash is held in the population of pension funds. If we think that reasonable levels of cash are below the population averages, then we are likely underestimating the amount of excess cash held by some pension funds. All our measures lead to similar estimates, are highly correlated (almost 99%), and display a right-skewed distribution indicating that there are pension funds holding significant amounts of excess cash. In unreported tests, we estimate excess cash with alternative models and assumptions and all lead to very similar conclusions.

8. The cost of excessive cash holdings

In this section, we evaluate the performance that pension funds forego by keeping cash in excess of their operational and investment needs. To do so, we assume that excess cash is, instead, invested in a combination of bonds and equities, or in a combination of bonds, equities, and real estate. First, we hypothesize a standard allocation of 60/40 bonds/equities. For pension funds with positive excess cash, we apply these weights on the proportion of total assets held as excess cash and on expected equity and bond excess return benchmarks. Our first benchmark relies on Dimson et al. (2011-2018) and uses long-term geometric averages, in real terms, of equity and bond returns in excess of treasury bills. We focus on average estimates over 100 years as they provide superior estimators of expected returns. As a second benchmark, we use institutional investors' expectations on returns of four asset classes as

Table 11
How much of the cash held is excess? This table presents summary statistics of our three definitions of excess cash over the period 2005-2018. Actual cash is the actual cash held. Estimated normal cash 1 is the cash estimated using specification (5), Table 7 considering only coefficients in line with our predictions. Estimated normal cash 2 is the cash estimated using specification (5), Table 7, including pension fund fixed effects and considering only coefficients in line with our predictions. Model-free normal cash is computed as 3/12 times next-year outflows plus 1% (to account for cash needed for investments) plus 1% only for pension funds that have derivative contracts running. Excess cash is then the difference of actual cash and the estimated or model-free normal cash. These variables are computed in % of total assets and are expressed in percentage. Total assets do not include assets managed by insurance companies.

	Obs.	Mean	St.Dev	p5	p25	Median	p75	p95
Actual cash	7,912	16.45	12.57	6.93	9.36	12.50	18.51	40.52
Estimated normal cash 1	7,912	7.94	3.21	4.42	6.78	7.83	9.27	12.48
Excess cash 1	7,912	8.51	11.73	0.32	1.81	4.54	10.27	30.90
Actual cash	7,634	16.89	12.62	7.55	9.83	12.86	18.81	41.44
Estimated normal cash 2	7,634	7.92	3.51	3.35	7.34	8.22	9.26	11.68
Excess cash 2	7,634	8.97	12.09	0.34	1.91	4.82	11.00	31.69
Actual cash	14,287	11.13	10.33	3.38	5.36	8.04	12.90	28.89
Model-free normal cash	14,287	3.52	1.36	2.07	2.67	3.23	4.00	5.93
Excess cash 3	14,287	7.61	10.11	0.37	1.98	4.47	9.17	24.83

Table 12
The cost of holding excess cash Panel A depicts the expected excess return benchmarks we use to compute the cost of excess cash. We use world equity and long-term bond expected excess returns over treasury bills by Dimson et al. (2011-2018) estimated as an average over 100 years. Alternatively, we use institutional investors' expected returns for bonds, domestic and international equities and real estate provided by the U.S Governmental Accounting Standards Board Statement (GASB) 67. Panel B presents summary statistics for the cost of holding excessive cash over the period 2005-2018. We apply hypothetical weights (60/40 bonds/equities and 40/20/20/20 bonds/domestic equities/international equities/real estate) on the estimated excess cash and on expected excess return benchmarks to estimate the additional performance pension funds could have attained if excess cash was invested in a combination of other assets. Cost of excess cash 1-3 corresponds to each of our three definitions of excess cash. Benchmark returns and the cost of excessive cash are expressed in percentage.

Panel A: Expected excess returns by Dimson et al. *(2011-2018) and GASB No. 67*

	Equity excess return over bills	Bond excess return over bills
Dimson et al. (2011-2018)		
2005	4.2	0.8
2006	4.2	0.8
2007	4.2	0.8
2008	4.2	0.8
2009	4.4	0.7
2010	4.5	0.7
2011	4.4	0.9
2012	4.1	0.8
2013	4.3	0.9
2014	4.3	1.0
2015	4.2	1.0
2016	4.2	1.0
2017	4.3	1.1
GASB No. 67		
Domestic equity	5.4	
International equity	5.5	
Fixed income	1.3	
Real estate	4.5	
Cash	0	

Panel B: The cost of excess cash

	N	Mean	St.Dev	p5	p25	Median	p75	p95
Dimson et al. *(2011-2018), historical starting from 1900*								
60% Bonds/40% Equities								
Cost of excess cash 1	7, 912	0.19	0.26	0.01	0.04	0.10	0.23	0.68
Cost of excess cash 2	7, 634	0.20	0.27	0.01	0.04	0.11	0.24	0.71
Cost of excess cash 3	14, 287	0.17	0.22	0.01	0.04	0.10	0.20	0.55
GASB No. 67								
40% Bonds/20% Domestic equities/20% International equities/20% Real estate								
Cost of excess cash 1	7, 912	0.31	0.42	0.01	0.07	0.16	0.37	1.11
Cost of excess cash 2	7, 634	0.32	0.44	0.01	0.07	0.17	0.40	1.14
Cost of excess cash 3	14, 287	0.27	0.36	0.01	0.07	0.16	0.33	0.89

Table 13

Cash holdings and sponsor characteristics Panel A presents pooled regressions where *Cash* is regressed on variables that proxy for characteristics of the sponsor company. *Cash* is the percentage of pension fund total assets held in cash and equivalents. Total assets do not include assets managed by insurance companies. *Book leverage* is the ratio of total debt to total debt plus book value of equity. *Market leverage* is the ratio of total debt to total debt plus market capitalization. *Net debt_book* and *Net debt_market* uses instead net debt (total debt minus cash). *Sponsor cash* refers to cash divided by total assets held by the sponsor company. Panel B includes two control variables. *Total assets (ln)* is the natural logarithm of total assets held by the pension fund. *Funding ratio* refers to pension assets over pension liabilities as reported by the pension fund. All estimations include year and industry fixed effects. We report robust standard errors clustered at the pension fund level. ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Panel A: The association of cash holdings with sponsor characteristics

	(1) Cash	(2) Cash	(3) Cash	(4) Cash	(5) Cash
Book leverage	−0.396**				
	(0.164)				
Market leverage		−0.264*			
		(0.131)			
Net debt_book			−0.315**		
			(0.121)		
Net debt_market				−0.237**	
				(0.105)	
Sponsor cash					0.452***
					(0.147)
_cons	0.173***	0.152***	0.115***	0.118***	0.058**
	(0.043)	(0.040)	(0.024)	(0.027)	(0.025)
Observations	164	143	148	138	151
Pension funds	24	19	21	19	23
Adj R^2	0.202	0.201	0.217	0.178	0.173
Industry FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES

Panel B: With pension fund level controls

	(1) Cash	(2) Cash	(3) Cash	(4) Cash	(5) Cash
Book leverage	−0.073*				
	(0.037)				
Market leverage		−0.039			
		(0.047)			
Net debt_book			−0.142***		
			(0.024)		
Net debt_market				−0.100***	
				(0.022)	
Sponsor cash					0.235**
					(0.087)
Total assets (ln)	0.000	0.011**	−0.001	0.010***	0.002
	(0.003)	(0.003)	(0.002)	(0.002)	(0.004)
Funding ratio	−0.538***	−0.454***	−0.603***	−0.512***	−0.567***
	(0.107)	(0.088)	(0.063)	(0.052)	(0.083)
_cons	0.655***	0.400***	0.747***	0.470***	0.624***
	(0.115)	(0.118)	(0.078)	(0.077)	(0.114)
Observations	81	65	68	60	68
Pension funds	12	9	10	9	10
Adj R^2	0.601	0.708	0.707	0.766	0.632
Industry FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES

provided by U.S GASB 67. We assume that the excess cash is invested in four asset classes, namely bonds, domestic and international equities and real estate, rather than in a combination of bonds and equities only. We assume a 40% investment in bonds and 20% in each of the other assets. We apply these weights on the proportion of excess cash and on the expected returns of these four assets in excess of the return on cash and cash equivalents (which according to GASB 67 is zero).

Panel A, Table 12 presents the return benchmarks we use for this analysis. In Panel B, Table 12 we present descriptive statistics for the forgone performance that pension funds experience by keeping excess cash instead of investing it in more profitable assets. On average, pension funds with excess cash could expect to earn between 17 and 32 basis points, depending on the definition of excess cash, the weights on asset classes, and the benchmark used for expected excess returns. Note that the forgone performance is higher under a richer diversification that allows for investments in real estate and both international and domestic equities.[26] We can interpret these foregone gains as minimum values since they could be higher if excess cash is also invested in alternatives or only in higher yielding assets, to the extent this is compatible with pension funds' risk capacity.[27]

Our results suggest that pension funds could cut excessive cash holdings, enhance expected performance, without compromising the goal of keeping sufficient liquidity to meet the various obligations.

9. Discussion

9.1. What lies behind the permanent, pension fund specific component?

Why do some funds with low operational and investment needs have high cash holdings while others with high operational and investment needs hold less cash? What is the economic mechanism behind the unobservable, time-invariant, fund-specific component? Identifying the factors behind this permanent component is beyond the scope of this paper due to data limitations. However, we take an exploratory step toward this goal through additional analysis.

We investigate the hypothesis that cash holdings are associated with the characteristics of the sponsor company. In theory, the governance structure should limit the influence of the employer on cash allocation decisions. Pension funds operate as separate legal entities, distinct from their sponsor companies. Their boards comprise equal representation from both the employer and employee representatives who are jointly responsible for setting the investment policy and cash holding targets. The balanced governance structure should mitigate any potential incentives from the sponsor company to influence cash allocation. Yet, it remains possible that the sponsor preferences may find their way into cash allocation decisions.

To examine the relationship between cash holdings and sponsor characteristics, we manually collect data on single-employer pension funds along with corresponding employer characteristics. We obtain data for 24 pension fund-employer pairs. For the pension funds, we gather information on cash holdings, total assets, and, in some cases, the coverage ratio for the period 2010-2018. Regarding the sponsor companies, we collect data on debt, book equity, market capitalization, cash holdings, industry affiliation, and compute various capital structure ratios. These ratios provide insights into sponsor preferences and risk aversion. Subsequently, we run regressions of pension fund cash holdings on these ratios. Results are reported in Table 13.

Panel A shows a negative (positive) and statistically significant relation between sponsor leverage (cash holdings) and pension fund cash holdings. These results underscore that employers with more conservative capital structure policies tend to be associated with pension funds that maintain higher cash balances. Panel B introduces fund size and coverage ratio as control variables. Although our sample size decreases significantly, the results remain qualitatively similar. While these findings should be interpreted with caution, they suggest pension fund cash holdings may be influenced by sponsor preferences.

9.2. Are there any other potential justifications for holding cash?

We have argued that cash holdings should mainly respond to the fund-level operational and investment needs highlighted in Section 2. An alternative view is that the role of cash holdings is also to limit the threats of potential fund runs. Thus, an additional layer of cash holdings is held to meet unexpected investor withdrawals and avoid fire sales during time of stress.

Below, we elaborate on how the design of the pension system mitigates the risk of fund runs within our sample funds. The system incorporates specific rules and limitations that govern the size and timing of withdrawals. Our pension funds operate as "closed-end" funds, meaning pension beneficiaries do not have the freedom to opt out of the pension fund voluntarily. Withdrawals from pension funds are only possible under specific circumstances, such as for housing, employment changes, retirement lump-sums, or partial liquidation events.[28] Pension funds have the authority to establish withdrawal rules, including parameters like minimum notice periods and maximum lump-sum amounts.[29] Additionally, during times of financial stress, pension funds may implement temporary withdrawal restrictions to manage liquidity and safeguard the fund's long-term viability. With tools available to address extraordinary cash needs, it is unlikely that funds need to maintain significant additional liquidity to handle potential fund runs. Thus, the design of the system shields pension funds in our sample from possible runs and enables us to focus on other fund-level drivers of cash holdings.

Finally, pension funds may hold cash to meet their rebalancing needs.[30] Rebalancing involves adjusting the asset allocation of the fund to maintain the desired investment strategy and risk profile. Cash holdings provide the flexibility for funds to rebalance portfolios in response to market conditions. However, rebalancing with cash is not a costless activity as it involves foregoing potential expected returns. Furthermore, rebalancing is not obligatory, for example during periods of market stress, and it does not pose an immediate threat to the fund's sustainability. Alternative liquid assets like government bonds or highly liquid securities can be used for rebalancing, and they should be preferred over cash in an optimal portfolio (Campbell and Viceira, 2002; Jondeau and Rockinger, 2014). However, using cash for rebalancing purposes may result in lower transaction costs. In conclusion, the decision to employ cash for rebalancing purposes involves trade-offs (eg. foregone return vs lower transaction costs) and should be evaluated based on specific circumstances and associated transaction costs.

[26] According to the annual survey of Swisscanto, Dändliker et al. (2020), an additional return of 60 basis points, on average, could secure pensions and compensate for the reduction of conversion rates under discussion in political circles. The estimated additional performance pension funds could have gained by investing their excess cash is, therefore, of significance for the system.

[27] Given the positive skewness of the cost of excess cash, we also evaluate pension funds belonging to the highest quartile. In unreported results, we find that the average cost of excess cash for these pension funds reaches 44 to 87 basis points.

[28] A partial liquidation event happens when a significant reduction in the number of affiliated employees, a restructuring or a cancelation of an affiliation contract.

[29] For example, lump-sum calls are knows few months (sometimes even up to three years) before they are due and they are limited to a share of retirement income.

[30] Swiss regulation restricts the use of leverage by pension funds. Thus, leverage does not justify higher cash balances in our setting.

10. Conclusion

We investigate the factors that explain pension fund cash holdings in a setting where the need to hold cash for reasons like potential fund runs is limited and where any additional returns from investing excess cash would benefit pension participants. We document significant heterogeneity in cash holdings across funds. While we identify key operational and investments needs to justify holding cash, they explain only a small share of the variation in cash holdings. A large share of this variation is attributable to an unobservable, time-invariant, fund-specific factor. We also find that pension funds subject to greater discipline or organizational sophistication engage in more efficient cash management. Some pension funds hold more cash than necessary and exhibit slower cash deployment for investment. These excessive cash balances constituting to 8.4% of total assets hinder performance. Reallocating the surplus to a representative portfolio could yield an additional expected annual return of 17 to 32 basis points, ultimately benefiting pension participants.

While our study focuses on the Swiss context, we believe our analysis can be extended to pension funds in other countries with collective management of pension savings. Our models can be adapted to other institutional environments.

Our study leaves some questions under researched due to data limitations. For instance, why do certain funds with low operational needs maintain high cash holdings, while others with high operational needs hold less cash? What is the economic mechanism underlying the unobservable time-invariant fund-specific component? Answering these questions is beyond the scope of this paper and are left for future research.

CRediT authorship contribution statement

Sidita Hasa: Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft. **Carolina Salva:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

Appendix A

Institutional background: The Swiss occupational pension system

We provide additional details of the Swiss occupational pension fund system and emphasize the elements that are most relevant to cash management and asset allocation policies.[31] Pension plan participation is mandatory for all employees with a salary above a certain threshold, but it is the employer who chooses the pension institution. The Swiss pension market is highly fragmented and shielded from competition.

The majority of employees are covered by defined contribution (DC) plans which provide benefits based on contributions. DC plans are in fact, hybrid plans, with embedded minimum income guarantees that pool and professionally manage retirement assets. Defined benefit (DB) plans are also offered but, consistent with global trends, many DB plans have been converted into DC plans in the past years and few of them remain. In DB plans, benefits amount to a percentage, often around 60%, of the employee's previous salary (final pay or average over a period of time). Given the stringent regulation and income guarantees, upfront, the difference between DB and DC plans is small.[32] The main difference between DC and DB plans lies on who bears investment risk. In defined benefit plans, it is the employer. In DC plans, the risk is partially shifted to the employees.

Regardless of the type of plan, pension funds are financed with contributions paid by both employees and employers. Minimum contribution rates are set by the law and increase with the age of the employee. Although the amount of contributions is decided by the pension fund, employers are obliged to pay an amount that is at least equal to the sum of contributions paid by the employees. The pension provider is responsible for the accumulation of retirement savings and their withdrawal as annuities or lump-sums. Upon retirement, in DC plans when benefits are paid in the form of an annuity, the accumulated capital is converted into a regular pension using a conversion rate. Retirement benefits are usually paid in the form of a pension, but it is also possible to withdraw at least 25% of benefits in the form of a lump-sum payment. The share of benefits that can be retrieved as a lump-sum as well as the time limit for notice (after which lump-sum are no longer possible) are set at the discretion of the pension fund. Pension benefits are not automatically inflation indexed; it is the pension fund that also decides about any potential inflation adjustments. Withdrawals of accumulated pension capital are allowed for housing, self-employment or a permanent departure from Switzerland. If the employee changes jobs within Switzerland, the accumulated pension capital is transferred directly to the pension fund of the new employer or to a vested benefits account.

Pension contributions have a mandatory and a super-mandatory part. The mandatory contribution is a percentage, that varies with the age of the employee, of the insured salary over a certain threshold (CHF 21,060) and below and upper threshold (CHF 82,080). The mandatory contribution is subject to stringent regulation and minimum guarantees (minimum interest accrued annually on pension savings and a minimum conversion rate to define pension benefits upon retirement). In addition, there can be super-mandatory contributions that cover an additional share of salary, that over the upper threshold (CHF 82,080). The super-mandatory savings are lightly regulated and not subject to the same minimum guarantees. Swiss law allows for mandatory and super-mandatory savings to be managed into separate accounts but, most often, both the mandatory and super-mandatory pension savings are pooled into the same account. Accounts that pool mandatory and super-mandatory contributions may credit interest lower than the legal minimum and may be subject to lower than legally established conversion rates.

The pension provider is organized as an external entity independent from the employer. The board of trustees is the superior governing body and it is composed of an equal number of employer and employee representatives. It is responsible for the administration and the investment strategy of the fund, though asset allocation must be done respecting certain legal limits. Swiss law puts constraints on how much pension funds can allocate to the different asset classes. It sets upper investment limits for certain asset categories such 50% for equities, 30% real estate, 15% alternative investments and 30% for unhedged foreign. It also bans the use of leverage or any form of credit. Finally, the board of trustees may externalize the administration

[31] The Swiss occupational pension system is regulated by the Swiss Federal Law on Occupational Retirement, Survivors' and Disability Pension Plans (BVG/LPP).

[32] See, e.g., Bütler (2014), Bütler and Ruesch (2007), Gerber and Weber (2007), Queisser and Vittas (2000).

and the investment management of the pension fund by hiring external administrators, experts and asset managers.

Swiss pension funds are required to remain sufficiently funded and ensure they have the capacity to meet liabilities at any time. The funding ratio measures the pension fund capacity to cover its commitments. It is approximately calculated as the ratio of pension assets over expected liabilities discounted at the technical interest rate. Technical rates can differ among pension funds but should not exceed the national reference rate set by the Swiss Chamber of Pension Actuaries. Reference rates are computed annually based on the 10-year Swiss government bond yield and the 20-year past performance of a pension fund index. All pension funds must be fully funded with a funding ratio of at least 100%. An exception to this rule are public pension funds with state guarantees that may fall under a special regime of partial capitalization and be underfunded. A pension fund with a funding ratio under 100% needs to present a restructuring plan that can include, for example, catch up contributions (not credited on individual accounts), zero interest, or lower conversion rates to compute annuities. Pension funds with significant surpluses can provide individuals with greater interest on saving accounts and/or greater pension benefits (ex. compensation for inflation).

Finally, pension funds in Switzerland can take several organizational forms. Depending on whether the pension fund is founded by a firm or a public authority, it can be private or public. Pension funds that are set up by one employer are single-employer funds, whereas pension funds that serve multiple employers through affiliation contracts are multi-employer funds. Multi-employer funds can be either collective or common. Collective pension funds maintain separate accounts and rules for the pension plans of their affiliated employers while common ones run one scheme that maintains similar accounts and rules. Lastly, pension funds differ on the insurance coverage they use. Autonomous pension funds bear the financial and actuarial risks themselves. Autonomous pension funds with a stop-loss cover all risks but are supported by "stop-loss" or "excess-of-loss" contracts with insurance companies to mitigate against potential losses due to market and economic conditions as well as actuarial events. Semi-autonomous pension funds insure some actuarial risks (e.g. disability, death or old age) but not financial risks. Finally, fully reinsured pension funds transfer all risks to insurance companies and act as intermediaries between beneficiaries and insurance companies. We note that those are excluded from our sample.

Appendix B

Table B.1
Sample construction.

	All in	Less only super-obligatory funds	Less fully reinsured funds	Less last year before liquidation	Less years of liquidation process	Less first year of entering	Less 2018 if entering on 2017
Total obs.	29,820	24,669	22,689	21,814	21,528	21,330	21,326
Total PFs	3,006	2,361	2,118	2,042	2,023	2,009	2,005
Number of PFs per year							
2005	2,770	2,193	1,937	1,864	1,825	1,825	1,825
2006	2,669	2,140	1,917	1,844	1,811	1,753	1,753
2007	2,543	2,061	1,864	1,795	1,767	1,741	1,741
2008	2,435	1,996	1,823	1,773	1,744	1,718	1,718
2009	2,351	1,950	1,793	1,739	1,714	1,692	1,692
2010	2,265	1,897	1,754	1,688	1,665	1,648	1,648
2011	2,191	1,835	1,703	1,616	1,600	1,584	1,584
2012	2,073	1,743	1,619	1,530	1,512	1,509	1,509
2013	1,957	1,648	1,536	1,457	1,442	1,436	1,436
2014	1,866	1,569	1,463	1,386	1,374	1,365	1,365
2015	1,782	1,493	1,391	1,343	1,330	1,325	1,325
2016	1,713	1,440	1,346	1,296	1,285	1,282	1,282
2017	1,643	1,386	1,300	1,240	1,232	1,228	1,228
2018	1,562	1,318	1,243	1,243	1,227	1,224	1,220

Table B.2
Variable definition.

Variable	Definition
Total assets	Total assets in pension funds' balance sheet less insurance assets
Total investments	Total investments as reported in pension fund's balance sheet
Cash	Cash and cash equivalents over total assets. It includes bank deposits and investments in money market securities in Swiss franc and foreign currency
Bonds	Investments in domestic and foreign bonds as well as in foreign currency bonds over total assets
Stocks	Investments in domestic and foreign stocks over total assets
Real estate	Investments in direct and indirect, domestic and foreign real estate over total assets
Alternatives	Sum of private equity, hedge funds, commodities, infrastructures, insurance-linked securities and other alternatives over total assets
Retirement savings	The retirement capital of active employees and retirees
Total contributions	Total contributions received by the pension fund over total assets
Regular contributions	Employee and employer contributions
Irregular contributions	Total contributions minus regular contributions
Total benefits	Total benefits paid over total assets
Annuities	Benefits paid as annuities for retirement, death and invalidity over total assets
Lump-sums	Benefits paid as lump-sums for retirement, death and invalidity over total assets
Entry vested benefits	Entry vested benefits which include termination benefits that refer to the transfer of the new employees' retirement savings within the fund and any premiums paid by the beneficiary to recover the retirement assets from home ownership or divorce withdrawals over total assets
Exit vested benefits	Exit vested benefits which include termination benefits and early withdrawals for home ownership and divorce over total assets. Termination benefits refer to the transfer of the retirement savings of the insured employees to the new employer or to a vested benefits account if employment

(*continued on next page*)

Table B.2 (*continued*)

Variable	Definition
	is terminated. Early withdrawals include the withdrawal of retirement assets to finance principal house ownership or to repay a mortgage and, in the case of divorce, the withdrawal of half of the vested benefits accrued by the divorced member to transfer them to the entitled spouse's pension fund or vested benefits account
Investment income	Income from investments over total assets. It includes income and realized and unrealized gains and losses
Total expenses	The sum of investment, administrative and insurance expenses over total assets
Investment expenses	Expenses related to the investment management over total assets
Administrative expenses	Expenses related to the administration of the pension fund over total assets
Insurance expenses	Insurance premiums paid to the Guarantee Fund, which is obligatory for all Swiss pension funds, and premiums paid to the insurance company if the fund is insured over total assets
Inflows	Total contributions plus entry vested benefits plus investment income over total assets
Inflows (ex. inv.inc.)	Inflows excluding investment income
Outflows	Total benefits plus exit vested benefits plus total expenses over total assets
Net contributions	Total contributions minus total benefits
Regular net contributions	Regular contributions minus annuities
Net vested benefits	Entry vested benefits minus exit vested benefits
Net cash flows	Inflows minus outflows
Net cash flows (ex. inv.inc)	Inflows excluding investment income minus outflows
Cash/Total assets	Cash and cash equivalents over total assets
Cash/Total investments	Cash and cash equivalents over total investments
Cash/Total benefits*12	Cash and cash equivalents over total benefits times 12
Cash/Outflows*12	Cash and cash equivalents over outflows times 12
Cash/Net contributions*12	Cash and cash equivalents over total net contributions times 12
Cash/Net cash flows (ex. inv. inc)*12	Cash and cash equivalents over net cash flows, excluding investment income, times 12
Assets CAGR (%)	Cumulative average growth rate of total assets
Contributions CAGR (%)	Cumulative average growth rate of total contributions
Benefits CAGR (%)	Cumulative average growth rate of total benefits
EntryVB	Entry vested benefits
ExitVB & Lump-sums	The sum of lump-sum and exit vested benefits
Derivatives	A dummy equal to 1 if the pension fund has derivative contracts and zero, otherwise
Vol. net contributions	The standard deviation of total contributions minus total assets over time scaled by the mean of total assets over time.
New investments	The residual of regressing the change in investments from t to $t+1$ on net cash flows at $t+1$ and represents investments made with cash over $t+1$
30y-1y	The yield spread between the 1-year and 30-year Swiss government bonds
Initial cash	Cash held during the first year a pension fund appears in the sample. We drop the first observation for each pension fund to avoid an identity specification.
Actual cash	The actual cash held by the pension fund
Estimated normal cash 1	Cash estimated using specification (5), Table 7 considering only coefficients in line with our predictions
Estimated normal cash 2	Cash estimated using specification (5), Table 7, including pension fund fixed effects and considering only coefficients in line with our predictions
Model-free normal cash	Computed as 3/12 times next-year outflows plus 1% (to account for cash needed for investments) plus 1% only for pension funds that have derivative contracts running
Excess cash 1	The difference of actual cash and estimated normal cash 1
Excess cash 2	The difference of actual cash and estimated normal cash 2
Excess cash 3	The difference of actual cash and model-free normal cash
Cost of excess cash	Hypothetical weights applied on the proportion of excess cash and on benchmark expected excess returns
Public	A dummy equal to 1 if the pension fund is founded by a public institution and zero, otherwise
Private	A dummy equal to 1 if the pension fund is founded by a private institution and zero, otherwise
Single-employer	A dummy equal to 1 for pension fund with only one affiliated employer and zero, otherwise.
Multi-employer	A dummy equal to 1 for pension fund with multiple affiliated employers and zero, otherwise
DC	A dummy equal to 1 if the pension fund runs defined-contributions plans and zero, otherwise
DB	A dummy equal to 1 if the pension fund runs defined-benefits plans and zero, otherwise.
Mix (DC, DB)	A dummy equal to 1 if the pension fund runs a mix of defined-contributions and defined-benefits plans and zero, otherwise
Beneficiaries	Number of active employees and retirees
Employees	Number of active employees
Retirees	Number of retirees
Beneficiaries ratio	Ratio of active employees to retirees. It is equal to zero if the number of active employees is zero and equal to the overall maximum if the number of retirees is zero
Funding ratio	The funding ratio as reported by the pension fund
Total assets (ln)	Natural logarithm of total assets

Table B.3
Correlation matrix The table presents the correlation matrix for all dependent and independent variables we use. All variables are defined in Appendix B, Table B.2.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) Cash	1.00															
(2) Regular net contributions $_{t+1}$	0.19*	1.00														
(3) Regular net contributions	0.20*	0.91*	1.00													
(4) EntryVB $_{t+1}$	0.07*	0.45*	0.35*	1.00												
(5) EntryVB	0.10*	0.44*	0.41*	0.58*	1.00											
(6) ExitVB & Lump-sums $_{t+1}$	0.15*	0.50*	0.45*	0.41*	0.39*	1.00										
(7) ExitVB & Lump-sums	0.09*	0.30*	0.36*	0.20*	0.30*	0.37*	1.00									
(8) Total expenses $_{t+1}$	0.19*	0.65*	0.57*	0.38*	0.36*	0.43*	0.27*	1.00								
(9) Derivatives	−0.04*	−0.08*	−0.09*	−0.03*	−0.03*	−0.06*	−0.06*	−0.11*	1.00							
(10) Vol. net contributions	0.14*	0.51*	0.50*	0.39*	0.39*	0.40*	0.31*	0.47*	−0.04*	1.00						
(11) Investment income $_{t+1}$	−0.02*	0.06*	−0.01	0.03*	0.01	0.06*	−0.01	0.07*	0.01	−0.01	1.00					
(12) New investments	0.16*	−0.14*	−0.05*	−0.09*	−0.02*	−0.11*	−0.06*	−0.18*	0.03*	−0.03*	−0.07*	1.00				
(13) 30y-1y	−0.02*	−0.02*	−0.02*	0.00	−0.04*	−0.01	−0.02*	−0.02*	0.01	0.00	0.19*	0.01	1.00			
(14) Alternatives	−0.08*	0.01	0.00	0.00	0.00	−0.01	−0.02	−0.03*	0.23*	0.03*	−0.01	0.01	0.00	1.00		
(15) Total assets (ln)	−0.21*	−0.25*	−0.28*	−0.04*	−0.05*	−0.15*	−0.15*	−0.45*	0.35*	−0.17*	0.03*	0.11*	0.02*	0.24*	1.00	
(16) Funding ratio	−0.02*	−0.07*	−0.07*	−0.05*	−0.08*	−0.08*	−0.02*	−0.02*	−0.06*	−0.06*	−0.11*	0.01	0.01	−0.09*	−0.17*	1.00

*** p<0.01, ** p<0.05, * p<0.1

References

Andonov, A., Rauh, J.D., 2022. The return expectations of public pension funds. Rev. Financial Studies 35 (8), 3777–3822.

Andonov, A., Bauer, R.M., Cremers, M.K., 2012. Can large pension funds beat the market? Asset allocation, market timing, security selection and the limits of liquidity. Working Paper.

Andonov, A., Bauer, R.M., Cremers, M.K., 2017. Pension fund asset allocation and liability discount rates. Rev. Financ. Stud. 30 (8), 2555–2595.

Boubaker, S., Gounopoulos, D., Nguyen, D.K., Paltalidis, N., 2018. Reprint of: Assessing the effects of unconventional monetary policy and low interest rates on pension fund risk incentives. J. Bank. Finance 92, 340–357.

Bregnard, N., Salva, C., 2022. Pension fund board governance and asset allocation: Evidence from Switzerland. J. Pension Econ. Finance. *Forthcoming*.

Broeders, D., Jansen, K., Werker, B.J., 2020. Pension fund's illiquid asset allocation under liquidity and capital constraints. J. Pension Econ. Finance 20 (1), 1–23.

Bütler, M., 2016. Insights from Switzerland's pension system. In: Mitchell, O., Shea, R. (Eds.), Reimagining pensions: The next 40 Years. Oxford University Press.

Bütler, M., Ruesch, M., 2007. Annuities in Switzerland. World Bank Policy Res. Working Papers 4438.

Campbell, J.Y., Viceira, L.M., 2002. Strategic Asset allocation: Portfolio choice For Long-Term Investors. ſ'Oxford University Press.

Cocco, J.F., Volpin, P.F., 2007. Corporate governance of pension plans: The U.K. evidence. Financ. Analysts J. 63 (1), 70–83.

Dändliker, H., Deplazes, I., Konrad, H., 2020. Swiss Pension Fund Study 2020. Swisscanto Pensions Ltd, Zürich.

Davis, P.E., De Haan, L., 2012. Pension fund finance and sponsoring companies. J. Pension Econ. Finance 11 (3), 439–463.

Dimson, E., Marsh, P., Staunton, M., 2018. Credit Suisse global Investments Returns Yearbooks 2011-2018. Credit Suisse Research Institute, Zurich.

Dittmar, A., Mahrt-Smith, J., 2007. Corporate governance and the value of cash holdings. J. Financ. Econ. 83 (3), 599–634.

Fama, E.F., French, K.R., 1998. Taxes, financing decisions, and firm value. J. Finance 53 (4), 819–843.

Fresard, F., Salva, C., 2010. The value of excess cash and corporate governance: Evidence from US cross-listings. J. financ. econ. 98 (2), 359–384.

Gerber, D.S., Weber, R., 2007. Demography and investment behavior of pension funds: Evidence for Switzerland. J. Pension Econ. Finance 6 (3), 313–337.

Hoevenaars, R.P., Molenaar, R.D., Schotman, P.C., Steenkamp, T.B., 2008. Strategic asset allocation with liabilities: Beyond stocks and bonds. J. Econ. Dyn. Control 32 (9), 2939–2970.

Jondeau, E., Rockinger, M., 2014. Optimal long-term allocation with pension fund liabilities. Swiss Finance Institute Res. N 14-58.

Keynes, J.M., 1936. The General Theory of Employment, Interest and Money. Macmillan Cambridge University Press, for Royal Economic Society.

Kroencke, T.A., Salva, C., 2023. Delegated Risk-taking. *Working paper*. University of Neuchâtel.

Lucas, D.J., Zeldes, S.P., 2006. Valuing and hedging defined benefit pension obligations: The role of stocks revisited. Working Paper.

Lucas, D.J., Zeldes, S.P., 2009. How should public pension plans invest? Am. Econ. Rev. 99 (2), 527–532.

Mohan, N., Zhang, T., 2014. An analysis of risk-taking behavior for public defined benefit pension plans. J. Bank. Financ. 40, 403–419.

OECD, 2019. Pension Markets in Focus. Retrieved from. http://www.oecd.org/daf/fin/private-pensions/pensionmarketsinfocus.htm.

Opler, T., Pinkowitz, L., Stulz, R., Williamson, R., 1999. The determinants and implications of corporate cash holdings. J. Financ. Econ. 52 (1), 3–46.

Pennacchi, G., Rastad, M., 2011. Portfolio allocation for public pension funds. J. Pension Econ. Finance 10 (2), 221–245.

Petersen, M.A., 1995. Allocating assets and discounting cash flows: Pension plan finance. Working Paper.

Phan, H.V., Hegde, S.P., 2013. Corporate governance and risk taking in pension plans: Evidence from defined benefit asset allocations. J. Financ. Quant. Anal. 48 (3), 919–946.

Queisser, M., Vittas, D., 2000. The Swiss multi-pillar pension system: triumph of common sense. Working Paper. The World Bank.

Rauh, J.D., 2009. Risk shifting versus risk management: investment policy in corporate pension plans. Rev. Financ. Stud. 22 (7), 2687–2733.

Simutin, M., 2014. Cash holdings and mutual fund performance. Rev. Financ. 18 (4), 1425–1464.

Sundaresan, S., Zapatero, F., 1997. Valuation, optimal asset allocation and retirement incentives of pension plans. Rev. Financ. Stud. 10 (3), 631–660.

Weller, C., Wenger, J., 2009. Prudent investors: the asset allocation of public pension plans. J.Pension Econ. Finance 8 (4), 501–525.

Yan, X., 2006. The determinants and implications of mutual fund cash holdings: Theory and evidence. Financ. Manage 35 (2), 67–91.