Does Regulation Matter? Effects on Pension Funds' Risk Taking

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Abstract

We investigate the influence of investment, valuation and funding regulation on the riskiness of defined-benefit (DB) pension funds' asset allocations. We compare the regulatory frameworks of public, corporate and industry pension funds in the United States, Canada and the Netherlands in 1991-2011. Derived from panel data analysis of a unique set of close to 600 detailed funds' asset allocations, our results highlight that regulatory factors are more economically significant than fund characteristics in shaping their asset allocation. In particular, risk-based capital requirements is associated to about 7% less risky asset exposure, whereas a 9% lower investment in risky assets is attributed to mark-to-market valuation imposed in conjunction with balance sheet recognition of unfunded liabilities. Equities constitute most of the decline in investment risk-taking.

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1. Introduction

The regulation of financial institutions is a highly topical issue. Over the past couple of years, with the objective to protect stakeholders and to promote financial stability, regulators instituted mechanisms to prevent financial institutions' insolvency by essentially limiting their funding risk. This evolution in the regulatory environment (see Basel II and III, Solvency II, and IORP II) led to a critical debate as it was rapidly recognized that regulation, while restraining excessive risk-taking, could unfairly penalize some investment opportunities and affect the expected financial performance of these institutions. Furthermore, the diversion of financial institutions' investments away from long-term projects may eventually hinder economic growth (European Commission, 2014; OECD, 2014). In the case of pension funds, the balance between regulating risk without overly constraining investments is particularly pertinent today. Due to the structural increase in liabilities coming from longer life expectancy, in addition to historically low interest rates, pension plans' sustainability are under threat. An appropriate level of risk-taking in the funds' investments could lift some of the pressure on the rising costs of retirement income provision. Therefore, we quantify the impact of pension regulatory requirements on the plans' investment risk-taking.

It is a theoretically established fact that regulatory constraints can shape the investment behavior of financial institutions, often in an unexpected and undesirable manner. While fixed solvency ratios (which are portfolio insurance type of constraints) reduce the regulated institutions' capacity to invest in risky assets in all unfavorable states of the world (Bec and Gollier, 2009), the same does not hold true for Value-at-Risk (VaR) limits. Basak and Shapiro (2001) demonstrate that a Value-at-Risk (VaR) constraint leads to larger losses in the worst states of the economy because agents behaving optimally would not insure against these states. The failure of a VaR constraint to limit risk when losses are worst is not only surprising, but also worrying. Other known flaws of a VaR limit is that it leads to sizeable economic costs when there is a mismatch of the investor's investment horizon, and the horizon on which the VaR is defined (Shi and Werker, 2012). Furthermore, capital requirements based on the VaR assessment induce well-capitalized banks to reduce risk but when in financial distress, banks would switch to a high-risk portfolio (Calem and Rob, 1999; Dangl and Lehar, 2004).

Pension fund regulation is heterogeneous across countries so both fixed solvency ratios and VaR-based constraints exist globally. Anglo-Saxon countries (e.g., Canada and the US) adopted fixed solvency ratios, whereas continental Europe is moving towards VaR constraints (e.g., solvency capital requirement). Although VaR-based constraints are already widely used for banks around the world (e.g., Basel III), and now insurance companies in Europe (e.g., Solvency II), only a handful of countries such as the Netherlands currently impose solvency capital requirements on pension funds, but there is keen interest at the European Commission to extend the regulation Europe-wide (EIOPA, 2012). If solvency constraints are at the heart of regulation, they are usually accompanied by numerous other regulatory constraints (e.g., mark-to-market valuation, recovery periods, etc.) that can also influence funds' investment behavior. For example, mark-to-market valuation is claimed to distort financial institutions' portfolio choice (Allen and Carletti, 2008; Plantin, Sapra and Shin, 2008) and limit investors' ability to take risk (Severinson and Yermo, 2012).

Despite a lively theoretical debate, there is scant empirical evidence about the practical effects of regulation on financial institutions' investments.[1] In this regard, pension funds are a rewarding and instructive field of investigation because in contrast to the banking and insurance industries, there is much less regulatory harmonization across countries. This diversity in the regulatory setup permits the analysis of a wide range of regulation. Until recently, pension funds in many countries, including the US, Canada, many European states and emerging economies were regulated on the basis of rigid investment constraints such as portfolio limits. Now, however, all these investment rules are being eased and replaced by solvency requirements, either fixed solvency ratios or risk-based capital requirements. The North American and Dutch pension industries are particularly interesting to investigate because they not only have distinctive regulatory structures, but also underwent notable regulatory changes, such as the Pension Protection Act (PPA) in 2006 in the US, and the Financial Assessment Framework (FTK) in 2007 in the Netherlands.

[1] There are a few exceptions. Ellul et al. (2011) show that regulatory constraints induce insurance companies to sell downgraded corporate bonds.

In this paper, we seek to determine the extent that regulation influences pension funds' asset allocation. Asset allocation has been shown to be an important source of performance and thus income[2] for pension funds (Brinson et al., 1986, 1991; Munnell and Soto, 2007; Bikker et al., 2011; Aglietta et al., 2012; Andonov et al., 2012; Chambers et al., 2012). We focus on a dimension that has been widely analyzed in theory: the extent of risky asset exposure. In particular, we assess the economic magnitude of regulatory factors in explaining funds' investment allocation, relative to individual characteristics of the plans - identified so far as a key driver of pension funds' asset allocation (Chemla, 2005; Rauh, 2009; Dyck and Pomorski, 2011). With a representative database of defined-benefit (DB) pension fund asset allocation in the US, Canada and the Netherlands over twenty-two years (1990-2011), we have a unique opportunity to investigate the extent that funds' asset allocation is shaped by their regulatory environment.

To carry out this investigation, we document and compare the pension regulatory environments of the US, Canada and the Netherlands over seven different dimensions. We chronologically map each country's regulatory requirements by type of funds (i.e., public, corporate and industry). We then analyze the importance of individual and regulatory factors as determinants of the historical asset allocations of US, Canadian and Dutch pension funds, using a set of panel data regression models. While there are previous studies that separately examine whether select individual and institutional factors explain pension funds' asset allocations, we are not aware of any study that quantifies the relative importance of these factors, or that examines in as much detail, the wide variety of regulatory options. Furthermore, many papers examine Dutch, US, and to a lesser extent, Canadian pension funds in isolation, yet few compare them on a transatlantic basis (apart from Bikker et al., 2012; Andonov et al., 2014). Our international database enables us to make such a comparison.

Over a wide range of assumptions on the unobserved effects (i.e., random, correlated random and fixed effects), we consistently find that regulatory requirements not only statistically significantly affect funds' exposure to risky assets, but are also more economically significant than the plans' characteristics. Among the regulatory factors, risk-based capital requirements and mark-to-market valuation have notable impact. They both decrease the funds' equity exposures

[2] Up to 60% of benefits in US public funds is expected to be funded by investment earnings (NASRA, 2014).

by around 7% on average. When imposed in combination with the requirement that plan sponsors recognize unfunded liabilities on their balance sheet, mark-to-market valuation's influence is magnified to a 9% reduction of exposure to overall risky assets. Additionally, on asset classes that have a small weight - often zero - in the fund' portfolio, risk-based capital requirements are among the most economically significant regulatory mechanism as well. For instance, censored regression estimates suggest that risk-based capital requirements are associated to 2.5% and 1% lower allocation in mortgages and real assets respectively.

There is a large literature that attempts to identify the determinants of pension funds' allocation. Bodie (1987) shows that for a DB fund with only guaranteed nominal benefits, pure accrued liability hedging could be accomplished by investing the fund's wealth entirely in nominal bonds. However, the dynamic nature of the funds' obligations requires taking into account not just the accrued liabilities but also the obligations associated with expected future accruals, which are related to wage growth. This might explain the significant portion of DB funds' investment that is dedicated to risky assets, especially equities, which have a positive correlation to wage growth (Sundaresan and Zapatero, 1997; Peskin, 2001; Lucas and Zeldes, 2006). Funds' characteristics, notably their size and the structure of their liabilities (maturity, inflation indexing), have been stressed as major determinants of the riskiness of pension plan asset allocations. Chemla (2005) and Dyck and Pomorski (2011) find that larger plans have higher allocations to alternative investments, whereas Rauh (2009) and Bikker et al. (2011) find a positive and significant relationship between risk-taking and the share of active employees in the plan.

Few academic papers have dealt with the broad pension regulatory environment of so far, and those that have tend to focus on how the choice of the liability discount rate affects funds' asset allocations. In the US, there is disagreement on the valuation of pension liabilities. Public pension funds are subject to the actuarial approach of the Governmental Accounting Standards Board (GASB) and therefore discount future retirement payments with the expected rate of return on the plan assets, whereas private funds use a market rate. Pennachi and Rastad (2011) point out that among US public funds, those selecting higher discount rates are also those choosing riskier portfolios. Andonov et al. (2014) add to this by comparing the asset allocation and liability discount rate of public and private funds in the US, Canada and Europe. They provide evidence that US public funds adopt riskier investment portfolios in order to maintain high discount rates and present lower liabilities. Yet, other dimensions of pension regulation, such as funding constraints, mark-to-market valuation of assets, and risk-based capital requirements, are likely to have an impact on pension investments as well. We provide the first comprehensive study on the influence of regulation on pension funds' asset allocation. Our insights contribute to the academic discussion on the optimal design of pension regulation and may assist regulators and pension professionals in their efforts to develop a sound framework for the pension industry.

The paper is organized as follows. Section 2 presents a comparison of the changes in the pension regulatory environment in the US, Canada and the Netherlands since 1990, Section 3 describes our data and Section 4 outlines the methodology. In Section 5, we discuss our empirical results on the major drivers of pension asset allocation, Section 6 concludes.

2. Overview of Pension Regulatory Environment

Unlike insurance companies and banks, pension funds are not subject to harmonized regulation but are governed by highly heterogeneous rules that differ not only between countries but also within them. We focus on three sets of regulations that influence pension fund investments: the investment limits, funding and solvency requirements of the fund, and the financial reporting standards of the sponsor. For US corporate, Canadian and Dutch pension plans, the sponsors' accounting regulations are distinct from the other three sets of regulations and determined by a separate regulatory authority. In contrast, US public funds are bound solely by regulations on reporting and by lax funding regulation.

2.1 United States

In the US, public and corporate pension funds are regulated by different regulatory authorities. For public funds, the standards for both accounting and funding were set in 1984 in Governmental Accounting Standards Board (GASB) Statement 25 and in Actuarial Standards of

Practice (ASOP) 27. The GASB standard allows an actuarial valuation of funds' assets[3] and discounting of their liabilities using the expected rate of return on pension plan assets. As pointed out by Brown and Wilcox (2009), Novy-Marx and Rauh (2009), Pennacchi and Rastad (2011), and Andonov et al. (2014), this valuation provision is inconsistent with basic economic theory and creates moral hazard incentives in the form of "accounting arbitrage". In other words, public plans have incentives to invest in risky assets in order to justify a higher discount rate that would reduce the value of their liabilities. Novy-Marx (2013) shows that public plans in the US can improve their funding status by reducing holdings of cash and bonds while keeping all other asset holdings constant. In addition to the GASB standard, many public pension funds are subject to quantitative asset restrictions that are an intrinsic part of their investment mandate.

US private plans are either single (corporate funds) or multi-employer (industry funds, also known as Taft-Hartley plans).[4] Single-employer funds are subject to far more stringent rules as compared with their public counterparts, both for pension plans' budgeting and sponsors' accounting. On the one hand, plan budgeting rules impose minimum standards for funding levels, sponsor contributions, recovery periods, and so on. They are set federally under the 1974 Employee Retirement Income Security Act (ERISA), and its many subsequent amendments. Among the latter, the 2006 Pension Protection Act (PPA) introduced major reforms that came into effect in 2008. For single-employer corporate plans, PPA requires pension plans to target full funding by 2011 (compared with 90% before that date, and a gradual increase from 90% to 100% between 2008 and 2011) on a market-related basis, with liabilities discounted at corporate bond rates.[5] PPA also requires quicker remediation of shortfalls. Any deficit has to be covered to attain a 100% funding level over a 7-year period (compared with 30 years previously). Assets are

[3] Actuarial valuation recognizes realized and/or unrealized gains and losses in the market value versus book value, typically over a five-year period, rather than immediately.

[4] Single-employer plans are retirement plans that are administered by one employer only. Multi-employer plans are collectively bargained plans maintained by labor unions and more than one employer. A board of trustees with equal representation of employers and labor manages them. This type of arrangement is common in industries that are typically unionized and characterized by frequent job switching, such as construction, entertainment, trucking, and mining.

[5] Under PPA, the discount rate for single-employer plans is a two-year average of investment-grade corporate bonds (i.e., AAA, AA and A). The rates are three-tiered (i.e., 5, 5-15, and more than 15 years) to match the duration of plans' liabilities. PPA shortened the averaging period of the discount rate from four to two years.

valued with, at most, a two-year average of 90-110% of fair value[6] (compared with the previous five-year average of 90-120%).

US multi-employer funds, in comparison with single-employer types, have seemingly more lenient requirements despite being regulated under the same federal acts. Historically, multi-employer plans have broad discretion on the valuation assumptions for plan assets and liabilities, as well as on funding methods. PPA preserves and even extends these flexibilities. For the purpose of determining annual funding, the only condition on the discount rate is that it has to be *actuarially reasonable*. Employer and employee contribution rates are decided through a collective bargaining process every three to five years. Due to the lengthy nature of the process, the PPA provides a period of fifteen years (previously thirty) for amortization of shortfalls. It requires multiemployer plans that are under 80% funded to submit a plan for achieving a one-third improvement in the funded level every ten years. On the accounting side, participating sponsors of multi-employer funds merely have to report the required contributions each year on their financial statements.

The accounting statements of incorporated companies in the US have to be aligned with the rules set by the Financial Accounting Standards Board (FASB). Over the past decades, the FASB has changed the items that sponsors have to disclose or recognize, as well as the permissible recognition method. Three pertinent standards were in force between 1991 and 2011, namely FAS 87, 132 and 158. Under FAS 87 (effective 1986), single-employer fund sponsors have to recognize the cost of providing pensions on their income statement, and to disclose the fair value of pension assets and the present value of pension obligations in the notes to the financial statements. While employers are required to compute their plans' funded status, defined as the fair value of assets less projected benefit obligation (PBO),[7] this fair value does not have to be reported on their balance sheet. Only when accumulated benefit obligation (ABO)[8] exceeds

[6] Fair value requires the assessment of the price that is fair between two specific parties, taking into account the respective advantages or disadvantages that each will gain from the transaction. Market value may meet this criteria, but this is not necessarily be the case. In practice, fair value estimation may be based on market prices if they are available and considered reliable. Otherwise, it can be based on an estimate, with different methodologies allowed.
[7] PBO is the actuarial present value of future pension benefits accrued from past service years. Future events such as compensation increases, turnover and mortality are taken into consideration.
[8] In contrast to PBO, ABO is an estimate of a company's pension liability under the view that the plan is terminated on the date the calculation is performed.

accrued pension costs must firms recognize the unfunded ABO as an additional minimum liability. Amir and Benartzi (1998) find that firms on the borderline between disclosure and recognition modify their funds' asset allocation to reduce the probability of facing a pension deficit, and they do so by investing in more bonds than stocks. FAS 158 became effective on December 15, 2006, making it mandatory to always recognize the plans' funded status on the balance sheet.[9] The requirement to report any unfunded liabilities, with liabilities determined as PBO, is stricter than the ABO standard under FAS 87.

2.2 Canada

In Canada, there is much less regulatory distinction between public and corporate pension funds. All registered pension plans (RPPs) are regulated under both federal and provincial pension standards. Maximum levels of funding and types of benefits are outlined under federal income tax rules. With the exception of employees of banks, communications companies etc., who are included under the 1985 Federal Pension Benefits Standards Act, minimum standards for funding and other issues are set at provincial level (Van Riesen, 2009). Ontario was the first to enact provincial pension legislation, in 1965, and most of the other provinces have since followed suit. Additionally, the Canadian Association of Pension Supervisory Authorities (CAPSA) has been set up to harmonize federal and provincial pension law. Due to CAPSA's close relations with the Canadian Institute of Actuaries (CIA), pension legislation remains fairly consistent across the country (Pugh, 2006). The CIA Standard of Practice Section 3400 advocates a funding requirement of 100%, as determined using actuarially acceptable assumptions (e.g., market value of assets, accrued liability discounted using Government of Canada bonds) and considering accrued liabilities only. Until 2005, Canadian funds were also subject to quantitative investment restrictions, and until 2010 were prohibited from investing more than 25% of their portfolio in real estate, and 15% in Canadian resource properties.[10]

[9] Sponsors of multi-employer plan are required only to report their respective contribution to the plan.
[10] Private pension plans in Canada are also subject to information requirements by the Office of the Superintendent of Financial Institutions (OSFI). A series of risk-based indicators should be provided to the supervisory authority through plan regulatory filings.

Canadian private pension plans and their sponsors prepare their financial statements in accordance with standards set by the Accounting Standards Board of Canada (AcSB).[11] Between December 1986 and 1999, the effective rules for sponsors were set out in CICA 3460, but many of the key assumptions, such as the liability discount rate, were left to the plan administrator's discretion. Effective January 1st 2000, CICA 3461 revoked some of that discretion, but on issues such as valuation of assets, funds can still choose between market and market-related value. The items to recognize on the balance sheet–surplus or deficiency of assets relative to pension expense–also remain the same. In January 2006, the AcSB announced its decision to converge to International Financial Reporting Standards (IFRS) for all Canadian enterprises. A five-year transition period was allowed, with an effective move to International Accounting Standard (IAS) 19 on January 1st 2011. Canadian public pension plans' sponsors followed the same set of CICA accounting standards up to 2012, when the plan sponsors transitioned to the Public Sector Accounting Board PS 4000 standards.

2.3 The Netherlands

Unlike the US, the Netherlands makes no regulatory distinction between funds covering public or private sector workers; and unlike Canada, it has no provincial regulatory boundaries. The Financial Assessment Framework (Financieel Toetsingskader, FTK) for Dutch pensions was introduced in January 2007 (with voluntary adoption since 2005) to lay down pension funds' financial requirements.[12] The FTK outlines regulations concerning the liability discount rate (i.e., swap rate), confirms the requirement for mark-to market asset valuation (as was already the case under the predecessor to the FTK) and sets capital buffers to ensure, with a 97.5% confidence level, that funds' assets will not be less than the level of liabilities within a year. If funds fail to meet this condition, they are granted a three-year timeframe to meet the minimum solvency requirements and up to fifteen years to recoup the buffer requirements. Among the three countries under study, the Netherlands is the only one to have put in place risk-based capital requirements

[11] Since 2011, these standards have been grouped in Part IV, Section 4600 of the Canadian Institute of Chartered Accountants Handbook.

[12] FTK falls under the broader 2006 Pensions Act, which replaced the Pensioen- en spaarfondsenwet (PSW) introduced in 1952. PSW permitted several funding methods. For example, the (65-x) method allowed salary or other pension increases on past service benefits to be funded over the remaining years until retirement age, typically 65. This method allowed deferral of pension costs. In 1999, the Dutch legislator prescribed the spread of pension accruals over the total number of years of service. PSW required a 100% funding ratio for funds.

that are similar to those that will apply in Europe for insurance companies, and are under discussion for pension plans.

Companies listed on a market in the European Union (EU) are required to abide by IAS 19 since January 1st, 2005. While IAS 19 applies to listed companies in the EU, the Dutch government approved a bill in 2005 to encourage unlisted companies to follow the same standard. IAS 19 requires balance sheet recognition of the present value of estimated total retirement benefits, including future compensation net of the fair value of pension assets, discounted using the interest rate on high quality corporate debt. Plan assets are measured at fair market value with no permissible smoothing. Before IAS 19's adoption, the Dutch accounting regulation, Raad voor de Jaarverslaggeving RJ 271 (2002 edition) required the previous year's pension contribution premium to be recognized in the income statement as an operating expense and the previous year's premium adjustment paid for salary increments to be shown on the balance sheet.[13] Because of the stand-alone[14] nature of Dutch occupational pensions, the employer's pension liabilities are not easily determined. Additionally, Dutch pension plans often include policy mechanisms that make it possible to adjust the benefits promised, such as conditional indexing. The sponsors of industry funds treat industry plans as DC funds from an accounting perspective, and recognize only the promised contribution due each year on their balance sheet. On the contrary, corporations with their own pension funds have to recognize unfunded pension liabilities on their balance sheets.

2.4 Comparing Regulations

Table 1 summarizes the main differences between the regulations governing US, Canadian and Dutch funds since 1990. The different forms of regulation can be classified under three dimensions: (1) investment restrictions, e.g., quantitative limits on certain categories of investment (usually risky assets); (2) valuation requirements, both for assets (e.g., mark-to-

[13] More precisely, the discrepancy between the premium payment due and paid, the deficit provision, if any, and the recognition of asset from advance payments or any surplus. RJ 271 (2002) accounting requirements were thought to provide little transparency on funds' asset and liabilities. See Swinkels (2011) for more discussion on the implication of IAS 19 for Dutch pension fund sponsors.

[14] Dutch occupational pension funds are independent trusts. Since the governing board comprises equal representation of employers and unions, the employer does not have exclusive power on decision-making, and is not solely responsible for any underfunding (Bovenberg and Nijman, 2009).

market valuation, with or without smoothing, actuarial valuation) and for liabilities (discount rate allowed, recognition of unfunded liabilities in the State's or sponsor's balance sheet); and (3) funding requirements, e.g., rules requiring a minimum level of funding requirements, risk-based capital requirements, allowance of a recovery period in case of underfunding.

Insert Table 1 about here

The overall picture shows that quantitative investment restrictions are still in place in some US states, were eliminated by 2010 in Canada, and never existed in the Netherlands. Market valuation of assets and liabilities (for funding or accounting reasons) was mandatory in the Netherlands over the full sample period, whereas it was introduced later in Canada (2000 for the valuation of liabilities, 2011 for assets) and in the US (2006 for liabilities and still no requirement for assets, as fair value smoothing is allowed). The discount rate used to evaluate a fund's liabilities varies substantially across countries: from "expected returns of assets" for US public funds to corporate bonds rates (US private funds), government bonds (Canada) or even swaps rates (the Netherlands). Minimum funding requirements exist in all three countries, with the exception of US public funds. They gradually increased over time for private funds. They are complemented with a recovery period varying from three years (the Netherlands) to ten years (Canada). In general, this recovery period had a tendency to decline as a result of regulatory revision. As for the balance sheet recognition obligation, funds in Canada and the Netherlands have been held to similar standards since the mid-2000s due to the convergence of global accounting standards, notably IAS 19. US corporate plans have a similar yet more stringent requirement since 2006. US public funds will not adopt the recognition requirement until 2015. Finally, the Netherlands is the only country in our panel to have introduced quantitative risk-based capital requirements.

3. Data Description and Exploratory Analysis

Our data is from CEM Benchmarking, a Toronto-based provider of performance benchmarking services to leading pension funds around the globe. To our knowledge, this is the broadest database on pension fund asset allocation worldwide. It comprises 978 funds from seven countries (i.e., Australia, Canada, Netherlands, New Zealand, Sweden, United Kingdom and the United States). Funds are predominantly from the US and Canada (59% and 25% of all funds, respectively), and to a lesser extent, the Netherlands (12% of all funds). The database provides yearly information on funds' asset allocations and characteristics over the period 1990-2011.

We focus on three countries in the database that are well represented: the US, Canada and the Netherlands. Our sample is an unbalanced panel of 589 funds (i.e., 377 in the US, 174 in Canada and 38 in the Netherlands).[15] As a percentage of DB assets of each country in 2011, the value of assets under management of the funds in our analysis is 35% in the US, 32% in Canada, and 30% in the Netherlands. [16] Thus, the database is a representative sample of DB funds in these countries.

We build a yearly measure of the riskiness of the funds' asset allocation by taking the value of the funds' investment holding in risky assets that year, as a percentage of the total value of asset under management. There are three major risky asset classes: (1) equities, (2) risky fixed income, (mortgages and high yield) and (3) alternatives, that we grouped in three sub-classes: real assets (commodities, natural resources, infrastructure, real estate,[17] other real assets), private equity (venture capital, leveraged buyout, diversified private equity, and other private equity) and active funds (hedge funds and tactical asset allocation)[18]. Table 2 presents summary statistics on the database by country and type, in 1996[19] and 2011, for funds' individual characteristics: size (i.e., assets under management in billions of US dollars), percentage of retired members, percentage of members' benefits contractually indexed to inflation, average total fund returns that year, and self-reported liability discount rate. We also show the percentage allocated to risky assets: equities, risky fixed income and alternatives.

Insert Table 2 about here

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[15] Pension funds in the database are classified into three categories: public, private, and other (mainly composed of multi-employer funds, also known as "union" or "Taft-Hartley" funds in the US, and "industry" funds in the Netherlands). Preserving only the funds with all required information, and at least two observations over the time period (i.e., in order to apply within transformation in panel regression), we analyze 60% of the funds in the database.
[16] This proportion is derived from comparison of pension assets in 2011 (Towers Watson Global Pension Asset Study 2012). Funds using CEM's benchmarking service tend to be large (Bikker et al., 2012).
[17] REITs and real estate ex-REITs.
[18] Fully funded long-only segregated asset pool dedicated to tactical asset allocation.
[19] This is the first year when there is at least one observation for each type of fund in every country. Dutch funds are less numerous compared with US or Canadian funds in the first half of 1990s.

The size of US and Canadian public funds in the database more than doubled in 17 years. Maturity, measured by the percentage of retired members, increased on average by 37% across all categories of funds, reflecting population ageing. The percentage of inflation-indexed pension contracts decreased for all but US public funds and Canadian corporate funds. In both 1996 and 2011, North American funds adopt liability discount rates that are twice as high on average as those of Dutch funds. There is significant dispersion of returns across countries and types of funds. Dutch funds outperformed all other funds on average in 2011, but in 1996, their Canadian counterparts achieved higher returns.

Asset allocation shows diverging trends, as seen from Figure 1. Whereas US and Canadian public funds, as well as US industry funds, increased their overall risky asset allocation (by 14.7%, 9% and 11.7% respectively, between 1996 and 2011), there were no significant changes for Canadian corporate and industry funds (small deductions of 3% and 2.1%). We observe that US corporate funds reduce their average allocation to risky assets by 8.3%, half the reduction for Dutch corporate and industry funds, which decreased their risky assets share on average by 22.4% and 16.3%. Therefore, funds not only demonstrate differences in average risky asset allocation across countries, but also between types of funds within a country.

Insert Figure 1 about here

The breakdown in Table 2 also indicates that there is a general trend across North American funds to increase the allocation to alternative assets and risky fixed income over the sample period, whereas that of Dutch funds remains fairly constant. US and Canadian public funds have a noticeably higher allocation to risky assets relative to Dutch funds in 2011. The stark contrast between Dutch and North American pension funds can be seen in the former's lower allocation to equities. These different choices may explain Dutch pension funds' resilience in weathering the financial crisis, as evidenced by their highest average total return in 2011.

As shown in Figure 1, asset allocation patterns are unique by countries and types of funds. In Canada, the country where regulation is harmonized across funds, there is higher resemblance in the asset allocation trends between different types of funds. In the US, where regulatory requirements are more demanding for corporate relative to public funds, there is wider dispersion in asset allocation across fund types. We note the striking divergence around 2007 Dutch pension funds' asset allocations to risky assets. Even though both Dutch industry and corporate funds are subject to the same framework for pension fund oversight (i.e., FTK), corporate fund sponsors face more rigorous accounting requirements on balance sheet recognition than industry fund sponsors. As the accounting regulation IAS 19 placed more emphasis on market valuation of both assets and liabilities, corporate fund sponsors conceivably were in more distress due to sunken risky asset values during the financial crisis.

4. Empirical Strategy

We devise an empirical strategy to identify the relationship between regulation and pension funds' asset allocations. We first define the explanatory variables, then present the econometric specifications.

4.1 Explanatory Variable Construction

We consider two categories of explanatory factors: regulatory variables and fund characteristics. Table 3 describes the explanatory variable construction, and presents the expected effects inferred from economic theory on the riskiness of asset allocations.

Insert Table 3 about here

We define the *Quantitative Investment Restriction* variable as the sum of (1- asset weight restriction) over all restricted assets.[20] Tighter limits or a higher number of restricted assets yield a higher level of restriction. If binding, these restrictions would naturally lead to lower allocations in the asset classes concerned.

[20] Before 2010, Canada imposed separate restrictions on natural resources and Canadian natural resources. As our data do not contain information on the geographical location of natural resource investments, we consider only the 25% limit on real estate and natural resources.

We define three variables related valuation requirements. The first, *Mark-to-Market Asset Valuation,* takes three levels, determined by whether mark-to-market valuation is strictly imposed (1), smoothing is allowed (0.5), or further discretion is permitted (0). This classification is carried out on valuation requirements for both funding and accounting, and the variable is defined to be the average of the two classifications. Second, we consider the *Liability Discount Rate* disclosed by the funds. We consider the level of the liability discount rate relative to the ten-year government bond yield of each country, to account for different interest rate levels in the countries. As extensively discussed by Pennachi and Rastad (2011) and Andonov et al. (2014), funds that are allowed to apply a rate that is dependent on the riskiness of their investments, may be encouraged to invest more in risky assets. Finally, we consider the *Recognition of Unfunded Liabilities* on the sponsor's balance sheet. It is defined as 1 if the liabilities to be recognized include expected increases in accrued benefits, 0.5 if only accrued benefits are taken into account, and 0 otherwise. This scale reflects the level of the liabilities recognition requirement. Sponsors who are required to recognize underfunded liabilities on their balance sheet may be compelled to reduce risky asset allocation in order to minimize balance sheet volatility (Amir et al., 2010).

Three types of funding requirements are considered. *Funding* is the minimum funding requirement in percentage. A higher funding requirement is likely to decrease the funds' risky asset exposure. There is abundant empirical evidence showing that underfunded plans tend to take less investment risk, whereas well-funded ones invest more in risky assets (e.g., Rauh, 2009; de Dreu and Bikker, 2012; Bikker et al. 2012). For a higher funding requirement, more funds are likely to be underfunded, and hence, we postulate an inverse relationship between risky asset exposure and funding requirement. The presence of *Risk-based Capital Requirements* is accounted for through a dummy variable equal to one when risk-based capital buffers are in force. The requirement to hold higher capital buffers for risky assets is expected to make investment in risky assets less attractive. Finally, we take into account the length of the *Recovery Period* (in years) allowed in case of underfunding. A longer period is regarded as less stringent; hence plans may be able to invest more in risky assets.

The effects of funds' characteristics on their investments are known, hence necessary to be controlled for. These characteristics include the percentage of retired members (*Maturity*), the presence of varying *Inflation Indexation* mechanisms (percentage of indexed benefits), and the *Size* of the funds (assets under management in billions of US dollars). More mature funds, and funds that do not index pensions on inflation have incentives to take less risk in their asset allocation (Lucas and Zeldes, 2006; Rauh, 2009; Bikker et al., 2011). Since larger funds are able to hire specialists with expertise in more complex asset classes, they are also likelier to have higher allocation to alternative assets (Dyck and Pomorski, 2011). Besides that, we also consider the funds' investment return in the previous year (*Past Investment Return*) , as funds having higher past return were shown to invest more in risky assets (Rauh, 2011). [21]

4.2 Methodology

To investigate the relation between regulation and risky asset holdings, we estimate a set of regression models that imposes assumptions on the unobserved heterogeneity. Part of the dispersion in allocation in risky assets may be due to regulation and to differences in individual characteristics of the funds, but it may also be attributable to unobserved heterogeneity such as attitude toward risk. Regression estimates that do not control for unobserved heterogeneity can incorporate significant biases. Therefore, we make three sets of assumptions on the unobserved heterogeneity, namely by treating them as random effects, correlated random effects, and fixed effects.[22] We rely on adequate variation in the longitudinal dimension, but not a balanced panel.[23] Next, we separately analyze risky fixed income and alternatives under a censored regression model because up to 76% and 19% of observations, respectively, are zero for these two asset classes.

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[21] CEM Benchmarking did not provide funding status of the funds. In addition to the anonymity of the participating funds in the database, this critical information cannot be recovered and is thus grouped along with other unobserved heterogeneity.

[22] Note that another alternative to mitigate omitted variables is to apply instrumental variable estimation. However, identifying valid instruments that are correlated with regulatory requirements but not risky asset allocation is a difficult task.

[23] However, there is no particular reason to suspect that funds that join and exit and sample early or late would react in a systematically different way to the regulation. This assumption is further supported by the fact that our anonymous data does not show any evidence of self-reporting bias (Dyck and Pomorsky, 2011). The difference between the performance of plans that skip reporting for one year and that of plans that continue reporting is small and not statistically different from zero.

The underlying specification is the following:

$$w_{it} = \boldsymbol{x_{it}}\beta + \boldsymbol{z_{it}}\gamma + c_i + u_{it} \quad (1)$$

The observed portfolio share in risky assets (or its subclass) is w_{it} , $\boldsymbol{x_{it}}$ is the vector of regulatory requirements. $\boldsymbol{z_{it}}$ is the vector of fund characteristics that control for observable heterogeneity, whereas c_i is the unobserved, time-invariant, fund-specific effect, and u_{it} is the idiosyncratic error. We exclude year effects because we assume that events such as financial market shocks – the main argument for including year effects - are adequately accounted for through the funds' past return, which in $\boldsymbol{z_{it}}$.

We begin by estimating a random effect model:

$$c_i | \boldsymbol{x_{it}}, \boldsymbol{z_{it}}, \delta_t \sim \mathcal{N}(0, \sigma_c^2) \quad (2)$$

$\mathcal{N}$ is the Normal distribution. This specification is particularly relevant if the funds that participate in the survey are seen as a random sample of the population of funds.

Under a random effect model, consistency of our estimates is only assured when c_i and δ_t are uncorrelated with all elements in the vector $\boldsymbol{x_{it}}$ and $\boldsymbol{z_{it}}$, which is unlikely to be the case for c_i. The unobserved parameters such as risk preference and investment deliberation process are likely to be correlated with observable fund characteristics such as type, size and maturity. In order to mitigate the omitted variables problem, we adopt the correlated random effects (CRE) model, which systematically accounts for the correlation between the observed variables and unobserved ones. The CRE specification assumes that the unobserved heterogeneity is linearly related to the observable characteristics (i.e., maturity, indexation, size), and the means of the time-varying variables. More specifically, we follow Mundlak (1978) and assume that individual specific effect is equally correlated to $\boldsymbol{x_{it}}$ and $\boldsymbol{z_{it}}$ of all time periods.[24] This is reasonable considering that

[24] Chamberlain's (1984) introduces an approach with the less stringent assumption that c_i is correlated to the time-varying $\boldsymbol{x_{it}}$ and $\boldsymbol{z_{it}}$. Mundlak's (1978) approach has an added advantage as it economizes on the degrees of freedom.

the median number of participating years for the funds is four years. Therefore, the unobserved constant is assumed to be:

$$c_i = \Psi + \bar{\boldsymbol{x}}_i\lambda + \bar{\boldsymbol{z}}_i\kappa + a_i,\ a_i|\boldsymbol{x_{it}}, \boldsymbol{z_{it}}, \delta_t \sim \mathcal{N}(0, \sigma_a^2) \quad (3)$$

whereby $\bar{\boldsymbol{x}}_i = \frac{1}{T}\sum_{t=1}^{T}\boldsymbol{x_{it}}$ and $\bar{\boldsymbol{z}}_i = \frac{1}{T}\sum_{t=1}^{T}\boldsymbol{z_{it}}$, Ψ is a constant, a_i is the independent portion of the unobserved effect, and $\mathcal{N}$ is the Normal distribution.

If the CRE specification indicates that there is statistically significant association between a funds' regulatory environment and its assets holdings' riskiness, then we would have more compelling evidence of the causal relation between regulatory requirements and DB pension asset allocation. Yet, apart from the assumption of a linear relation between the unobserved and observed heterogeneity, the CRE also assumes that the conditional variance of the unobserved effect is constant, which may not hold. In the final step of handling unobserved heterogeneity, we estimate the fixed effects of equation (1) by *within* estimation, and present standard errors that are clustered by Year.[25] While the fixed effects specification grants us the most confidence in mitigating unobserved heterogeneity, it has the drawback of being less suited in handling variables that are fairly constant over time. We highlight this because for any particular type of funds within a country, there are at most a handful of regulatory changes over the span of time considered. Thus, there is merit to consider the random effects and correlated random effects model, even if these models rely on more stringent assumptions on the unobserved effects.

For alternatives and risky fixed income, due to the fairly large proportion of funds that hold none of risky fixed income and alternatives (76% and 19% of observations, respectively), estimates by RE, CRE and FE may understate the effect of regulation on these asset classes as they ignore changes along the intensive margin. Ordinary Least Squares estimates would not only be biased, but also inconsistent. Thus, we follow the vast literature on individual portfolio holdings where data censoring at zero is common.[26] We separately investigate the intensive

[25] Year clustering allows residuals to be correlated across funds in each year. We cluster only by year because the data's cross-sectional size is considerably larger than the time dimension. When clustering, we adopt the guideline in Thomson (2011), i.e., we cluster along the dimension with fewer observations.
[26] The literature analyzing individual portfolio holdings typically relies on censored regression model such as the Tobit model, e.g., Poterba and Samwick, 2003; Rosen and Wu, 2004.

margin of investing in risky fixed income, alternatives, and their composing assets with a one-sided censored regression model.[27]

The censored regression model specified as such:

$$w_{it}^{*} = \boldsymbol{x_{it}}\beta + \boldsymbol{z_{it}}\gamma + c_i + u_{it} \quad (4)$$
$$w_{it} = max\{0, w_{it}^{*}\}$$

w_{it}^{*} is interpretable as the desired risky portfolio share. To obtain a consistent estimate of the censored regression model with fixed effects, we apply Honoré's (1992) least absolute deviation estimator for one-sided censored variables.[28] We also present the average marginal effects calculated as per Honoré's (2008) to facilitate the economic interpretation of the estimates,.

5. Major Drivers of Pension Allocation to Risky Assets

5.1 Overall Risky Assets and Sub-classes

For each specification, we present a pair of result tables, one for the major asset classes (i.e., overall risky assets, equities, risky fixed income, and alternatives), and another for the sub-asset classes (i.e., high yield, mortgages, real assets, private equity, and active funds). Tables 4 and 5 are for the Random Effects (RE) model, Tables 6 and 7 for the Correlated Random Effects (CRE) specification, and Tables 8 and 9 for the Fixed Effects (FE) model.

We find that for all RE, CRE and FE specifications, select fund characteristics and regulatory variables consistently have statistically significant influence on the funds' asset allocation. The economic impact, however, are much higher for certain regulatory variables relative to that of fund characteristics. In the following, we mostly cite the estimates by the FE model, which is unbiased for unobserved heterogeneity under the most restrictive assumption. Unless highlighted

[27] We deem that only the censoring at zero is pertinent even though the share of any asset class is also in theory censored at 100%. However, this is never binding for risky fixed income and only true for one observation for alternatives.
[28] As the upper bound of 100% is almost never binding, we consider only one-sided censorship. Honoré's (1992) program is available at http://www.princeton.edu/~honore/stata/.

in the text, the estimates for the RE and CRE models are almost always in the vicinity of the FE estimates.

Insert Table 8 about here

Insert Table 9 about here

Risk-based Capital Requirements, unique to the Netherlands since 2007 among all the countries in our dataset, are consistently estimated to yield 7% reduction in the overall allocation to risky assets. Equities compose the bulk of the decrease in exposure to risky assets (6.5% by the FE estimates). The estimates also suggest that marginally higher allocation to high yield and active funds and a slightly lower allocation to mortgages coincide with the introduction of risk-based capital requirements.

As the implementation of the risk-based capital requirements is coincident with the onset of the global financial crisis, we are concerned that the reduction in investments in risky assets is due to the financial crisis, and not the introduction of risk-based capital requirements. To eliminate any doubt, we need a counterfactual – How would Dutch pension plans behave during the financial crisis if there were no risk-based capital requirements? Our data, however, only allow us to shed light on the cross-sectional difference, namely, to compare the behavior of plans that are and are not subject to risk-based capital requirements over the financial crisis. To this end, we define a *Crisis* variable that is an indicator for the years 2008-2009. We perform the RE, CRE and FE regressions, this time by introducing our *Crisis* dummy and an interaction term, *Risk-based Capital Requirements* × *Crisis*. Estimates of this interaction model (Table 10) imply that during the years 2008-09, funds that are subject to risk-based capital requirements decrease risky assets investments by 7.5%, much more than the decrease (0.1%) in overall risky assets by the funds that are not subject to risk-based capital requirements over the same period. Therefore, we have more conviction that risk-based capital requirements are associated to a marked decrease in risky asset allocation, independently from the crisis.[29]

[29] Note that we were also concerned by the fact that risk-based capital requirements could be voluntarily adopted before the official regulatory change, from 2005 onwards. We re-define the *Risk-based Capital Requirements* variable to be equal to one for Dutch funds since 2005, then repeat the regressions with RE, CRE and FE. Estimates (not reported) provide similar implication as with the previous estimates with the variable defined on the official adoption date of the regulation. i.e., risk-based capital requirement is associated to about 5% lower overall allocation to risky assets, and equities account for most of this decrease.

Insert Table 10 about here

Mark-to-market asset valuation follows closely behind risk-based capital requirements in its economic significance in asset allocation decisions. The closer a fund has to adhere to mark-to-market asset valuation, the less it, on average, invests in risky assets. Our estimates suggest that if a fund were previously subject to more discretion than fair market valuation with smoothing, and is now required to use mark-to-market valuation (i.e., a 0 to 1 move on the scale of the variable *Mark-to-market Asset Valuation*), it would decrease its allocation to risky assets by about 6% on average. Equities once again constitute almost all of that reduction in risky asset exposure. Furthermore, investments in active funds and mortgages are also lowered, but at a much smaller magnitude (i.e., 1.3 and 0.7% respectively under FE specifications). As mark-to-market asset valuation is a more volatile measure relative to other asset valuation alternatives (e.g., book value, fair value with smoothing, etc.), it may be a greater inhibition of taking on investment risks to pension sponsors who are required to recognize unfunded liabilities on their balance sheet. To investigate this hypothesis, we include an interaction term, *Mark-to-market Asset Valuation* × *Recognition of Unfunded Liabilities.* Results (Table 11) imply that neither of the two regulatory requirements, when imposed in isolation, has a statistically significant impact on the funds' asset allocations. It is the interaction of the two that induces funds to reduce their risky asset allocation. A fund that has to value assets by their market value, and has a sponsor that has to recognize unfunded liabilities on its balance sheet invests about 9.3% less in overall risky assets.

Insert Table 11 about here

Our estimates concerning the *Liability Discount Rate* are consistent with the hypothesis that when funds are allowed to set a higher discount rate, they tend to invest more in risky assets. However, the less than 1.2% impact on overall risky asset allocation induced by a one standard deviation (i.e., 130 bps) increase in the liability discount rate [30] is small relative to the effect of risk-based capital requirements and mark-to-market asset valuation. Therefore, despite the attention that has been granted to the discretion that US public pension funds have on setting their

[30] By FE estimates, 1.3% × 0.878% = 1.14%

liability discount rate and its consequence (Munnell et al., 2010; Pennachi and Rastad, 2011; Novy-Marx, 2013; Andonov et al., 2014), we show that the choice of the liability discount rate has a relatively smaller effect on funds' asset allocation than other regulatory requirements, such as the imposition of risk-based capital requirements or mark-to market valuation. Therefore, in the perspective of the broader regulatory framework, the liability discount rate is less economically significant than other existing regulatory mechanisms in influencing pension plans' asset allocation.

The remaining regulatory requirements have a relatively small impact and comparable economic significance to the funds' characteristics. If the *Recovery Period* of an underfunded plan is prolonged by one more year, our estimates suggest that the fund would invest around 0.2% more in overall risky assets. The effect of *Quantitative Investment Restrictions* is also comparatively modest. The most affected asset class is alternatives, which is precisely the restricted asset class in our database. A 10% stricter investment limit would lead to a 3.1% lower allocation in alternatives by the FE estimates. *Minimum Funding Requirement* is estimated to be statistically significant under RE and CRE, but not with FEs. This could be because funding status is not included as an explanatory variable.[31] A fund's response to the minimum funding requirement clearly depends on its funding status - a fund that barely meets the funding requirement would undoubtedly be more responsive to any marginal change in funding requirement.

Size, Maturity, Inflation Indexation and Past Investment Returns have statistically significant relation to the share invested in risky assets, but are economically less significant. For example, $1 billion higher asset under the management is associated to only 0.2% higher exposure to risky assets, especially alternatives (i.e., 0.16% by estimation with FE). This confirms the fact that larger funds are likely to adopt more sophisticated investment strategies and have more resources to hire competent professionals with expertise in monitoring complex asset classes such as hedge funds, infrastructure or private equity. Besides that, a 10% higher investment return in the

[31] Rauh (2010) estimates that controlling for fund fixed effects, funds in the best decile of funding status invests as much as 10% more in equities relative to funds in the worst decile of funding status. As funding status is not provided by CEM Benchmarking, and not retrievable by our own due to anonymity of the funds, we can only consider it as an unobserved effect.

previous year is synonymous with a 3.1% higher allocation to overall risky assets (by FE estimates). This is close to the estimate of Rauh (2010), who finds that funds invest about 2.2% less in safe assets (i.e., government debt, cash and insurance) if investment return in the preceding year is 10% higher. Additionally, every 10% increase in retired members is associated to less than 1% reduction in allocation to equities. Our estimate is slightly higher than Rauh's (2010) estimate of a 0.4% decrease in equity investment for the same percentage increase in fund maturity. The extent of members' benefit that is inflation indexed is consistently estimated to yield 0.2% higher allocation to alternatives, especially real assets. We find no conclusive results across RE, CRE and FE specifications on funds' tendencies to allocate more to equities when they offer more inflation indexing, a result which is consistent with the mixed empirical evidence supporting the inflation-hedging potential of equities (Ang et al., 2012; Boudoukh and Richardson, 1993; Schotman and Schweizer, 2000).

5.2 Intensive Margin of Investments in Alternatives and Risky Fixed Income

Results from our analysis of the intensive margin of investments in alternatives and risky fixed income are presented in Tables 12-14. We compare the estimates from the censored regression model to the FE model, which we know to be similar to those obtained under the RE and CRE specifications. A larger set of coefficient estimates for risky fixed income is statistically significant relative to the estimates under the FE model. This is consistent with our expectation because risky fixed income has a proportionally larger number of observations (76%) that are censored at zero. As a similar set of variables for alternatives are estimated to be statistically significant under the FE and censored regression specifications, we are reassured that censoring is not as pertinent an issue to alternatives, as this asset class has only 19% of observations censored at zero.

Insert Table 12 about here

Insert Table 13 about here

Insert Table 14 about here

Table 14 shows that risk-based capital requirements are estimated to reduce allocation to risky fixed income by 60 bps, whereas by the FE estimates, the coefficient associated to this regulation is barely statistically significant. We also find that recognition of unfunded liabilities inexplicably leads to marginally (48 bps) higher investments in risky fixed income. As for alternatives, a 1% higher liability discount rate is associated to 39 bps more allocation, while the same regulatory requirement is not statistically significantly related to the liability discount rate under the FE model.

The censored regression estimates concerning risk-based capital requirement suggest that the regulation has a larger effect on high yield, mortgages, real assets and active funds than the FE estimates imply. This requirement is associated to 2.5% lower allocation to mortgages, and 0.9% less investment in real assets. It, however, is linked to 1.6% and 1% higher allocation to high yield and active funds, both of which were not statistically significant under the FE estimates. Therefore, the censored regression results highlight the effect of risk-based capital requirement which were overlooked under the RE, CRE and FE specifications.

6. Conclusion

Regulatory revisions for pension funds are underway in many countries. The effect of regulatory measures on the plans' investments lies at the core of discussions with regulators, especially since pension funds holdings are as large, if not larger than the country's economy. Although numerous theoretical papers discuss the potential impact of mark-to-market valuation and risk-based capital requirements on financial institutions' ability to invest in risky assets, there is scant empirical evidence on the topic. Our paper attempts to fill this gap with a detailed analysis of pension funds' allocations on a sizeable database of DB funds in three countries: the United States, Canada and the Netherlands. These countries are diverse in their regulatory approaches, and undertook pension reforms at different points in time. The US and Canada did not abandon quantitative investment restrictions until the early 2000s, whereas the Dutch never implemented them in the first place. All three countries focus on two types of regulatory measures in the mid-2000s: valuation requirements (i.e., mark-to-market, both for solvency and accounting purposes) and funding requirements (i.e., minimum funding, solvency capital and recovery period). The countries not only imposed valuation and funding requirements on different dates but also imposed them at varying levels of strictness. Moreover, in 2007, the Netherlands took the lead in imposing risk-based capital requirements on pension funds – a regulatory initiative that European pension regulators seem keen to implement across the entire continent. Meanwhile, the US and Canada retain conventional funding requirements.

Our empirical results highlight that regulation has at least as much, and in many instances much more influence on asset allocation choices as do pension funds' individual characteristics (maturity, size, inflation indexation). This finding of a relationship between allocation to risky assets and the regulatory mechanisms persists after taking into account the unobserved heterogeneity across pension plans. Among the regulatory options considered, risk-based capital requirements is associated to 7% reduction in risky asset allocation, even after disentangling the coincident effect of the 2008-2009 financial crisis. Mark-to-market asset valuation, when implemented with the requirement to recognize unfunded liabilities on the sponsor's balance sheet, reduce the share allocated to risky assets by about 9%. Equities predominantly account for the estimated decline in risky investments. Using a censored regression approach, we also show that risk-based capital requirements reduce investments in mortgages (2.5%) and real assets (0.9%).

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Table 1: Comparison of the Regulatory Environment of US, Canadian and Dutch Defined Benefit Pension Plans (evolution since 1990)

This table compares the regulation of US public, corporate and industry, Canadian public and corporate, as well as Dutch corporate and industry Defined Benefit pension funds since 1990.

	US Public	US Corporate	US Industry	Canada Corporate and Industry	Dutch Corporate and Industry
Investment restrictions					
Quantitative Investment Restrictions	No unified regulation.[I]	None	None	Prior to 2005: 30% limit on foreign assets Prior to 2010: 15% limit on resource property, 25% limit on real estate and Canadian natural resource property.	None
Valuation requirements					
Asset Valuation	GASB: Actuarial valuation allowing five years smoothing of gains and losses.	*For funding:* Before 2006: ERISA Fair value with smoothing After 2006: PPA (effective in 2009) Fair value. Option to smooth up to 24 months under PPA. Smoothed value has to be bounded between 90% and 110% of the asset's current market value. *For sponsors' accounting:* Since 1986: FAS 87 Market value or market-related value (e.g., 5-year moving average) permitted). In 2006, FAS	Since 1986: ERISA Reasonable actuarial assumptions.	*For funding:* [II] CICA 4600: Fair value of assets *For sponsors' accounting:* Up till 2011: CICA 3460 and 3461 Market value or market-related value (e.g., 5-year moving average permitted) Since 2011: IAS 19 Market value	*For funding:* Before 2007: PSW Market value After 2007: FTK Market value *For sponsors' accounting:* Before 2005: RJ 271 edition 2002 and 2003 2002 ed. did not require the recognition of the value of investment assets. 2003 ed. adopted many of the principles in IAS 19 After 2005: IAS 19 Market value

	US Public	US Corporate	US Industry	Canada Corporate and Industry	Dutch Corporate and Industry
		157 refined the definition of market value.			
Liability Discount Rate	GASB: Expected return of assets.	*For funding:* Before 2004: ERISA and subsequent amendments A corridor around the 4-year weighted average[III] of the 30Y T bond. The permissible range above and below the weighted average varied over time. 2004-06: PFEA Market rate (corporate bonds), 4-year average. Since 2006: PPA Market rate (corporate bonds), with 2-year smoothing allowed. *For sponsors' accounting:* FAS 87 Market rate (corporate bonds). 4-year average prior to 2006, 2-year average after.	*Since 1986: ERISA* Discount rate has to be *actuarially reasonable*	*For funding:* Government bond yield (7Y) plus an additional factor (e.g., 0.9%) for the first 10 years, extrapolated after 10 years. Same rule for indexed pension based on Government real yield. *For sponsors' accounting:* Before 2000: CICA 3460 Management's "best estimate" of the long-term rate of return on assets. After 2000: CICA 3461 Market interest rate at the measurement date on high-quality debt instruments (e.g., AA corporate bonds) with cash flow that matches the timing and amount of the expected benefit payments, or interest rate inherent in the amount at which the accrued benefit obligation could be settled. When corporate bond rates do not extend far enough into the future, government bond rates can be used.	*For funding:* Before 2007: PSW Fixed actuarial interest rate with a prescribed maximum. If no indexation is provided, then >4% is allowed, otherwise lower than 4%. Since 2007: FTK Yield curve that is based on the euro swap curve as set by the DNB. *For sponsors' accounting:* Since 2005: IAS 19 High quality corporate bond yield only for listed corporate sponsors.
Recognition of Liabilities on the Sponsor's	Between 1986 and 1994: GASB No. 5 Disclosure but no	Before 2006: FAS 87 Only unfunded liabilities in excess of ABO are	Since 1986: ERISA Participating sponsors merely	Up till 2011: CICA 3460 and 3461 Surplus/ insufficiency of	Since 2005: IAS 19 The following amount is recognized:

	US Public	US Corporate	US Industry	Canada Corporate and Industry	Dutch Corporate and Industry
Balance Sheet	recognition Since 1994: GASB No. 27 Recognition of Net Pension Obligation, which is the shortfall in the annually required contribution, as a liability From 2015 onwards: The difference between the market value of pension fund assets and benefit obligations, an amount called the Net Pension Liability will have to be recognized on the balance sheet.	recognized on the balance sheet. Since 2006: FAS 158 All over/underfunded liabilities in excess of PBO are recognized on the sponsor's balance sheet.	report contributions on their financial statements but not the plan's long-term financial risks.	funding relative to pension expense recognized. Since 2011: IAS 19 The following amount is recognized: Present value of ABO less unrecognized past service costs, ± actuarial gains / losses not recognized less fair value of plan assets	Present value of ABO less unrecognized past service costs, ± actuarial gains / losses not recognized less fair value of plan assets
			Funding requirements		
Minimum Funding Requirements	No min (0%)	Since 1994: Retirement Protection Act Min funding of 90% Since 2006: PPA 100% funding target but phased in over three years beginning 2008, at the rate of 92% (2008), 94% (2009), 96% (2010), 100% after.	100%	100%	Before 1999: PSW "65-x" funding standard, 65 is the assumed normal retirement age and "x" is the plan member's current age. Since 1999: PSW Assets must cover the present value of the accrued pensions (i.e. 100%) Since 2007: FTK 100%
Risk-based	None	None	None	None	Since 2007: FTK

	US Public	US Corporate	US Industry	Canada Corporate and Industry	Dutch Corporate and Industry
Capital Requirements					Regulatory capital requirement computed by applying fixed shocks onto the various risks exposure that correspond to 105% at confidence level of 97.5% with a year horizon. For a stylized pension fund with equal investment in equity and bonds, this is approximately 130% funding ratio.
Recovery Period	None	Before 2006: 30Y Since 2006: PPA 7Y	Before 2006: ERISA No provision. Since 2006: PPA 10 years, 15 years for seriously endangered plans.	Federal plans and provincial plans in Alberta and Ontario have a maximum amortization period of 10 years since 2009, previously 5 years. Other provinces typically set it at 5 years (with a possibility of extension with the consent of plan members).	Between 1999 and 2007: PSW 10 year transition to attain the new minimum funding requirement of 100% Since 2007: FTK 3 years for solvency margin, up to 15 years for buffer depending on continuity analysis

[I] US federal public pension plans are mandated to invest in government securities. US state and local plans set policy investment limits for certain asset classes. For instance, Mitchell and Useem (2000) report that in 1993, about 30% of their sample of public funds had investment restrictions (e.g., Kansas outlawed holdings of bank stocks, South Carolina prohibited equity investments, etc.). Due to the anonymity of the data, we do not take these self-imposed limits into account, and treat them as an intrinsic part of the funds' allocation strategy. However, quantitative investment restrictions are set by the state, so we could not identify them in our anonymous sample.

[II] These regulations concern federally regulated plans only. Rates for provincially regulated plans may differ.

[III] Average yield over 48 months with rates for the most recent 12 months weighted by 4, the second most recent 12 months weighted by 3, the third most recent 12 months weighted by 2, and the fourth weighted by 1.

CICA: Canadian Institute of Chartered Accountants
DNB: De Nederlandsche Bank (Central Bank of the Netherlands)
ERISA: Employee Retirement Income Security Act
FAS: Financial Accounting Standards
FTK: Financieel Toetsingskader (Financial Assessment Framework)
PBGC: Pension Benefit Guaranty Corporation
PFEA: Pension Funding Equity Act
PPA: Pension Protection Act
PSW: Pensioen- en spaarfondsenwet (Pensions and Savings Fund Act)

Table 2: Summary Statistics

This table provides the summary statistics for pension funds' returns, asset allocation and characteristics, by country and by type. The total number of funds and observations is presented in Panel A. Panels B and C present the following data for 1996 and 2011 respectively: mean (and standard deviations in parenthesis) of the size in billions USD, maturity (i.e., the % of retired members), the extent to which members benefits are indexed to inflation, liability discount rate used, total annual return, % allocated to risky assets and its subcategories (i.e., equities, risky fixed income and alternative assets).

	US			Canada			Netherlands	
	Public	Private		Public	Private		Private	
		Corporate	Industry		Corporate	Industry	Corporate	Industry
Panel A: Total number of pension funds and observations								
No. of Funds	121	232	24	44	105	25	9	29
No. of Obs	921	1439	127	407	825	188	50	102
Panel B: Summary Statistics in 1996								
No. of Obs	27	62	5	16	39	5	1	2
Size (billions, USD)	15.2 (23.6)	4.5 (8.9)	2.6 (3)	5.5 (11.4)	1.3 (1.5)	2.7 (4.4)	3 (NA)	8 (1.7)
Retired members (%)	30.7 (6.8)	37 (15.8)	32.6 (22.5)	39.5 (25.5)	37.4 (15)	19.4 (8.5)	41.1 (NA)	34.4 (16.2)
Inflation indexation (%)	50.1 (47.9)	8.1 (26.5)	0 (0)	58.75 (43.5)	31 (36.6)	75 (43.3)	0 (NA)	45 (63.6)
Total return (%)	13.2 (2.8)	15 (2.6)	13.4 (1.2)	18.3 (1.6)	18.4 (1.9)	18.7 (1.2)	13.6 (NA)	14.55 (0.2)
Liabilities discount rate (%)	7.7 (0.9)	8.2 (0.7)	7.87 (0.4)	7.7 (0.8)	7.6 (0.5)	7.7 (1.1)	4 (NA)	4 (0)
Asset Allocation (%)								
Risky Assets	60 (15.2)	71.2 (8.7)	63.2 (11.4)	55.6 (10.3)	60.2 (7.3)	66.2 (7.1)	70.8 (NA)	63.4 (5.5)
Equities	53.8 (15)	63.3 (10.6)	60.3 (10.8)	52 (9.6)	56.7 (7.2)	61.9 (8.2)	29.7 (NA)	25.9 (5.4)
Risky Fixed Income	0 (0)	0 (0)	0 (0)	0 (0)	0.1 (0.6)	1 (2.3)	27.5 (NA)	21.5 (3.2)
Alternatives	6.2 (6.1)	7.9 (7.3)	2.9 (1.9)	3.7 (4.9)	3.4 (4.8)	3.2 (3.3)	13.6 (NA)	16.1 (3.3)
Panel C: Summary Statistics in 2011								
No. of Obs	50	102	8	20	32	10	3	19
Size (billions, USD)	31.1 (43.1)	8.2 (12.8)	6.3 (7.4)	14.5 (26.3)	2.9 (3.8)	1.3 (1)	11.7 (5.8)	13.3 (24.2)
Retired members (%)	38.3 (8.3)	57.8 (22.4)	47 (12)	46.3 (21)	54.6 (23.7)	32.8 (13.6)	59.6 (22)	41.9 (20.5)
Inflation idexation (%)	53.4 (48.1)	4.9 (19.8)	25 (46.3)	59 (42.7)	42.2 (45.3)	54 (48.8)	33.3 (57.7)	20 (40)
Total return (%)	1.5 (1.9)	5.6 (4.7)	3.4 (2.8)	2.9 (3.6)	3.8 (3.7)	2.8 (2.6)	6.3 (1)	9.5 (4.6)
Liabilities discount rate (%)	7.3 (1.3)	5 (0.5)	6.8 (1.1)	6.2 (0.5)	5.4 (0.9)	6.1 (0.6)	2.7 (0)	2.8 (0.9)
Asset Allocation (%)								
Risky Assets	74.7 (8.6)	62.9 (13.7)	74.9 (11.5)	64.6 (10.1)	57.2 (11.4)	64.1 (4)	48.4 (14.6)	47.1 (12.8)
Equities	50.5 (11.2)	44.7 (15.9)	48.1 (11.8)	49.9 (9.8)	53.1 (11.2)	53.3 (9)	31.4 (14.2)	28.8 (9.3)
Risky Fixed Income	2.7 (4.1)	1.4 (2.4)	1.9 (2.9)	1.2 (3.2)	0.1 (0.4)	0.6 (0.9)	5.3 (2.5)	3.9 (4.8)
Alternatives	21.5 (12.8)	16.8 (15.8)	24.9 (20.3)	13.5 (12.3)	4 (5.1)	10.2 (7.6)	11.8 (5.9)	14.5 (8.5)

Table 3: Variable Definition and Expected Impact on Risky Asset Allocation

This table describes the list of variables used in our analysis. Brief explanation on the variables' definition and the expected effect on the riskiness of asset allocation are given.

Variable	Definition	Details	Expected Effect
Regulatory Factors			
Investment Requirements			
Quantitative Investment Restrictions	Sum of (1-Investment Limit over all restricted asset classes) [IV]	Lower limits may yield lower allocation to restricted assets, if the limits are binding.	-
Valuation Requirements			
Mark-to-market Asset Valuation	Dummy: 1 if market or fair valuation is imposed, 0.5 if smoothing is allowed, 0 in the case of further discretion than smoothing. Because accounting and funding regulation can slightly differ, we consider the average of the two dummy variables.	Mark-to-market valuation may induce more volatility to the funding ratio, and on the sponsor's balance sheet thus lead to less investment in risky assets.	-
Recognition of Unfunded Liabilities (on the sponsor's balance sheet)	Dummy: 1 if unfunded liabilities (as measured by PBO[VI] or equivalent) are recognized on the balance sheet, 0.5 if recognition of excess/ deficit relative to liabilities as measured by ABO[VII] or equivalent is necessary, 0 otherwise.	Lower allocation to risky assets to reduce volatility in the sponsor's balance sheet.	-
Liability Discount Rate	The spread between the discount rate level for funding purposes disclosed by the fund[V] and the domestic 10-year government bond.	Higher risky asset allocation when higher discount rates reported	+
Funding Requirements			
Minimum Funding Requirement	Level of funding requirement[VIII]	Overall reduction in risky asset allocation as funds are more likely to be underfunded.	-
Risk-based Capital Requirements	Dummy: 1 on the existence of mandatory quantitative risk requirements[IX]	Discourage investment risk-taking as capital requirements add to the cost of bearing financial risks.	-
Recovery Period	Recovery period in years	Longer recovery period allows higher allocation to risky assets.	+
Individual Factors			
Maturity	Percentage of retired members	More mature funds would allocate less to risky assets	-
Inflation Indexation	Percentage of member's benefits contractually indexed to inflation	Funds providing more inflation indexation would allocate more to risky assets	+
Size	Market value of Assets under Management (AUM) in billions	Funds with larger AUM are likely to adopt more sophisticated	+

	of USD	strategies, thus invest more in alternatives	(for alternatives)
Past Investment Return	Total investment return in the previous year	Higher return precedes higher allocation to risky assets.	+

IV As the data does not permit the distinction between Canadian natural resources from overall natural resources, we consider only the 25% restriction on real estate and natural resources.

V The rates for accounting purposes are also available for 50% of the funds in the database. Since US public funds have only one set of regulations that governs funding and reporting (GASB), the disclosed liability discount rate and expected rate of return are identical for 93% of the funds.

VI Projected Benefit Obligation.

VII Accumulated Benefit Obligation.

VIII Dutch funds' "65-x" funding requirement is estimated using $\min\{\frac{Maturity}{65} \times 100, 100\}$, with $Maturity$ as the percentage of retired members.

XI As voluntary adoption of the FTK among Dutch funds has been permitted since 2005, we also vary the definition of RBCR to begin in 2004 to 2006, obtaining similar results. Results presented in the tables adopt the official date of FTK implementation in 2007.

Table 4: Random Effects – Major Asset Classes

This table presents the estimates of the random effects specification (Eqs. (1) and (2)) for the overall risky asset investment (column (1)), and its composing sub asset classes. Risky fixed income consists of high yield and mortgages. Alternatives include the following: real assets (commodities, natural resources, infrastructure, real estate, other real assets), private equity (venture capital, leveraged buyout, diversified private equity, and other private equity) and active funds (hedge funds and tactical asset allocation). Standard errors are in parentheses.

	Dependent variable:			
	All	Equities	Risky Fixed Income	Alternatives
	(1)	(2)	(3)	(4)
Quantitative Investment Restrictions	-0.026*** (0.006)	0.029*** (0.006)	-0.003** (0.001)	-0.048*** (0.005)
Mark-to-market Asset Valuation	-5.911*** (1.199)	-3.776*** (1.369)	0.609** (0.308)	-2.490** (1.049)
Recognition of Unfunded Liabilities	-0.281 (0.587)	-1.560** (0.673)	0.434*** (0.150)	0.850* (0.508)
Liability Discount Rate	0.959*** (0.111)	0.562*** (0.128)	0.085*** (0.029)	0.319*** (0.096)
Minimum Funding Requirement	0.049*** (0.011)	0.065*** (0.012)	-0.005* (0.003)	-0.012 (0.010)
Risk-based Capital Requirements	-6.799*** (1.323)	-9.686*** (1.510)	0.580* (0.340)	1.936* (1.158)
Recovery Period	0.197*** (0.028)	0.433*** (0.032)	-0.013* (0.007)	-0.226*** (0.024)
Maturity	-0.044*** (0.013)	-0.088*** (0.015)	0.009*** (0.003)	0.038*** (0.012)
Inflation Indexation	0.004 (0.006)	-0.013** (0.007)	0.001 (0.002)	0.017*** (0.005)
Size	0.140*** (0.014)	-0.024 (0.016)	0.025*** (0.004)	0.141*** (0.013)
Past Investment Return	0.032*** (0.009)	0.066*** (0.011)	-0.007*** (0.002)	-0.026*** (0.008)
Constant	59.450*** (1.428)	46.562*** (1.624)	0.715* (0.367)	11.974*** (1.261)
Observations	3,687	3,687	3,687	3,687
R^2	0.488	0.414	0.056	0.164
Adjusted R^2	0.487	0.413	0.056	0.164
F Statistic (df = 11; 3675)	318.903***	235.881***	19.991***	65.618***
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 5: Random Effects – Sub Asset Classes

This table presents the estimates of the random effects specification (Eqs. (1) and (2)) for the asset classes that compose Risky Fixed Income (i.e., High Yield and Mortgages) and Alternatives (i.e., Real Assets, Private Equity, Active Funds). Real Assets aggregates commodities, natural resources, infrastructure, real estate, other real assets; Private Equity includes venture capital, leveraged buyout, diversified private equity, and other private equity; whereas Active Funds consist of hedge funds and tactical asset allocation. Standard errors are in parentheses.

	Dependent variable:				
	High Yield	Mortgages	Real Assets	Private Equity	Active Funds
	(1)	(2)	(3)	(4)	(5)
Quantitative Investment Restrictions	-0.002 (0.001)	-0.002** (0.001)	-0.021*** (0.002)	-0.007*** (0.002)	-0.018*** (0.003)
Mark-to-market Asset Valuation	-0.374 (0.249)	0.984*** (0.189)	1.473*** (0.416)	-0.651* (0.348)	-3.400*** (0.706)
Recognition of Unfunded Liabilities	0.620*** (0.123)	-0.193** (0.092)	-0.903*** (0.197)	0.441*** (0.164)	1.315*** (0.347)
Liability Discount Rate	0.132*** (0.023)	-0.050*** (0.018)	0.014 (0.037)	0.124*** (0.031)	0.174*** (0.066)
Minimum Funding Requirement	-0.0003 (0.002)	-0.004** (0.002)	-0.011*** (0.004)	-0.013*** (0.003)	0.011* (0.006)
Risk-based Capital Requirements	1.757*** (0.274)	-1.110*** (0.208)	0.676 (0.460)	0.104 (0.384)	0.864 (0.779)
Recovery Period	-0.007 (0.006)	-0.006 (0.004)	-0.065*** (0.009)	-0.068*** (0.008)	-0.086*** (0.016)
Maturity	0.008*** (0.003)	0.001 (0.002)	0.005 (0.005)	0.025*** (0.004)	0.011 (0.008)
Inflation Indexation	0.001 (0.001)	0.0001 (0.001)	0.012*** (0.002)	0.0002 (0.002)	0.006 (0.004)
Size	0.012*** (0.003)	0.012*** (0.002)	0.062*** (0.005)	0.064*** (0.004)	0.015* (0.008)
Past Investment Return	-0.006*** (0.002)	-0.001 (0.001)	-0.020*** (0.003)	-0.012*** (0.003)	0.006 (0.006)
Constant	0.119 (0.294)	0.651*** (0.224)	5.897*** (0.515)	2.935*** (0.431)	2.786*** (0.837)
Observations	3,687	3,687	3,687	3,687	3,687
R^2	0.072	0.026	0.135	0.182	0.062
Adjusted R^2	0.071	0.026	0.135	0.181	0.062
F Statistic (df = 11; 3675)	25.783***	8.861***	52.115***	74.086***	22.214***
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 6: Correlated Random Effects - Major Asset Classes

This table presents the estimates of the correlated random effects specification (Eqs. (1) and (3)) for the overall risky asset investment (column (1)), and its composing sub asset classes. Risky fixed income consists of high yield and mortgages. Alternatives include the following: real assets (commodities, natural resources, infrastructure, real estate, other real assets), private equity (venture capital, leveraged buyout, diversified private equity, and other private equity) and active funds (hedge funds and tactical asset allocation). Standard errors are in parentheses.

	Dependent variable:			
	All	Equities	Risky Fixed Income	Alternatives
	(1)	(2)	(3)	(4)
Quantitative Investment Restrictions	-0.025*** (0.006)	0.027*** (0.006)	-0.003* (0.001)	-0.047*** (0.005)
Mark-to-market Asset Valuation	-5.947*** (1.206)	-3.880*** (1.375)	0.554* (0.309)	-2.337** (1.054)
Recognition of Unfunded Liabilities	-0.359 (0.585)	-1.606** (0.672)	0.446*** (0.150)	0.818 (0.506)
Liability Discount Rate	0.951*** (0.111)	0.554*** (0.128)	0.088*** (0.028)	0.320*** (0.096)
Minimum Funding Requirement	0.047*** (0.011)	0.065*** (0.012)	-0.005* (0.003)	-0.013 (0.010)
Risk-based Capital Requirements	-6.791*** (1.331)	-9.487*** (1.517)	0.481 (0.341)	1.788 (1.164)
Recovery Period	0.194*** (0.028)	0.433*** (0.032)	-0.012* (0.007)	-0.229*** (0.024)
Maturity	-0.041*** (0.013)	-0.088*** (0.015)	0.010*** (0.003)	0.040*** (0.012)
Inflation Indexation	0.004 (0.006)	-0.014** (0.007)	0.001 (0.002)	0.018*** (0.005)
Size	0.146*** (0.014)	-0.023 (0.016)	0.026*** (0.004)	0.143*** (0.013)
Past Investment Return	0.032*** (0.009)	0.066*** (0.011)	-0.007*** (0.002)	-0.026*** (0.008)
Constant	59.552*** (1.447)	46.702*** (1.639)	0.681* (0.372)	11.906*** (1.277)
Observations	3,687	3,687	3,687	3,687
Log Likelihood	-12,663.930	-13,165.930	-7,659.741	-12,148.450
Akaike Inf. Crit.	25,355.870	26,359.860	15,347.480	24,324.890
Bayesian Inf. Crit.	25,442.840	26,446.840	15,434.460	24,411.870
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 7: Correlated Random Effects - Sub Asset Classes

This table presents the estimates of the correlated random effects specification (Eqs. (1) and (3)) for the asset classes that constitute Risky Fixed Income (i.e., High Yield and Mortgages) and Alternatives (i.e., Real Assets, Private Equity, Active Funds). Real Assets aggregates commodities, natural resources, infrastructure, real estate, other real assets; Private Equity includes venture capital, leveraged buyout, diversified private equity, and other private equity; whereas Active Funds consist of hedge funds and tactical asset allocation. Standard errors are in parentheses.

	Dependent variable:				
	High Yield	Mortgages	Real Assets	Private Equity	Active Funds
	(1)	(2)	(3)	(4)	(5)
Quantitative Investment Restrictions	-0.001 (0.001)	-0.002** (0.001)	-0.021*** (0.002)	-0.007*** (0.002)	-0.017*** (0.003)
Mark-to-market Asset Valuation	-0.347 (0.250)	0.914*** (0.189)	1.425*** (0.417)	-0.548 (0.349)	-3.235*** (0.711)
Recognition of Unfunded Liabilities	0.620*** (0.123)	-0.182** (0.092)	-0.889*** (0.196)	0.406** (0.163)	1.292*** (0.346)
Liability Discount Rate	0.133*** (0.023)	-0.049*** (0.017)	0.015 (0.037)	0.123*** (0.031)	0.174*** (0.066)
Minimum Funding Requirement	-0.0004 (0.002)	-0.004** (0.002)	-0.011*** (0.004)	-0.013*** (0.004)	0.010 (0.006)
Risk-based Capital Requirements	1.742*** (0.276)	-1.174*** (0.209)	0.568 (0.461)	0.114 (0.385)	0.851 (0.785)
Recovery Period	-0.007 (0.006)	-0.005 (0.004)	-0.065*** (0.009)	-0.070*** (0.008)	-0.088*** (0.016)
Maturity	0.008*** (0.003)	0.001 (0.002)	0.006 (0.005)	0.026*** (0.004)	0.012 (0.008)
Inflation Indexation	0.001 (0.001)	0.0001 (0.001)	0.012*** (0.002)	0.0003 (0.002)	0.006* (0.004)
Size	0.013*** (0.003)	0.012*** (0.002)	0.063*** (0.005)	0.064*** (0.004)	0.017** (0.009)
Past Investment Return	-0.006*** (0.002)	-0.001 (0.001)	-0.020*** (0.003)	-0.012*** (0.003)	0.006 (0.006)
Constant	0.088 (0.297)	0.647*** (0.226)	5.853*** (0.521)	2.945*** (0.438)	2.759*** (0.851)
Observations	3,687	3,687	3,687	3,687	3,687
Log Likelihood	-6,913.046	-5,872.605	-8,707.326	-8,042.172	-10,732.670
Akaike Inf. Crit.	13,854.090	11,773.210	17,442.650	16,112.340	21,493.330
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 8: Fixed Effects - Major Asset Classes

This table presents the estimates of the fixed effect specification (Eqs. (1)) for the overall risky asset investment (column (1)), and its composing sub asset classes. Risky fixed income consists of high yield and mortgages. Alternatives include the following: real assets (commodities, natural resources, infrastructure, real estate, other real assets), private equity (venture capital, leveraged buyout, diversified private equity, and other private equity) and active funds (hedge funds and tactical asset allocation). Standard errors (in parentheses) are clustered by Year.

	Dependent variable:			
	All	Equities	Risky Fixed Income	Alternatives
	(1)	(2)	(3)	(4)
Quantitative Investment Restrictions	-0.023*** (0.009)	0.010 (0.016)	-0.002 (0.002)	-0.031*** (0.010)
Mark-to-market Asset Valuation	-6.627*** (1.711)	-6.040** (2.919)	-0.351 (0.377)	-0.236 (1.611)
Recognition of Unfunded Liabilities	-1.030 (1.083)	-1.918 (1.755)	0.560** (0.229)	0.328 (1.736)
Liability Discount Rate	0.878*** (0.178)	0.432 (0.275)	0.110** (0.052)	0.336 (0.218)
Minimum Funding Requirement	-0.013 (0.018)	0.009 (0.025)	-0.016 (0.013)	-0.006 (0.016)
Risk-based Capital Requirements	-7.075*** (1.918)	-6.474*** (1.988)	-0.860* (0.512)	0.259 (0.588)
Recovery Period	0.170*** (0.041)	0.437*** (0.079)	-0.010 (0.011)	-0.258*** (0.078)
Maturity	-0.020 (0.023)	-0.096*** (0.035)	0.014*** (0.005)	0.062*** (0.019)
Inflation Indexation	0.007 (0.007)	-0.018** (0.008)	0.003 (0.003)	0.022*** (0.005)
Size	0.205*** (0.021)	0.003 (0.038)	0.038*** (0.004)	0.164*** (0.026)
Past Investment Return	0.031** (0.016)	0.065* (0.033)	-0.007 (0.005)	-0.027 (0.025)
Observations	3,687	3,687	3,687	3,687
R^2	0.120	0.186	0.072	0.163
Adjusted R^2	0.103	0.160	0.062	0.140
F Statistic (df = 11; 3171)	39.229***	65.884***	22.291***	56.111***
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 9: Fixed Effects - Sub Asset Classes

This table presents the estimates of the fixed effects specification (Eqs. (1)) for the asset classes that compose Risky Fixed Income (i.e., High Yield and Mortgages) and Alternatives (i.e., Real Assets, Private Equity, Active Funds). Real Assets aggregates commodities, natural resources, infrastructure, real estate, other real assets; Private Equity includes venture capital, leveraged buyout, diversified private equity, and other private equity; whereas Active Funds consist of hedge funds and tactical asset allocation. Standard errors (in parentheses) are clustered by Year.

	Dependent variable:				
	High Yield	Mortgages	Real Assets	Private Equity	Active Funds
	(1)	(2)	(3)	(4)	(5)
Quantitative Investment Restrictions	0.003* (0.001)	-0.005*** (0.001)	-0.021*** (0.006)	-0.001 (0.002)	-0.008** (0.003)
Mark-to-market Asset Valuation	0.309 (0.307)	-0.660*** (0.120)	0.635 (0.963)	0.446 (0.332)	-1.299** (0.525)
Recognition of Unfunded Liabilities	0.530** (0.246)	0.030 (0.148)	-0.724 (0.745)	0.121 (0.291)	0.960 (0.706)
Liability Discount Rate	0.146*** (0.053)	-0.036** (0.015)	0.024 (0.075)	0.122*** (0.043)	0.185 (0.116)
Minimum Funding Requirement	0.004 (0.003)	-0.020 (0.014)	-0.008 (0.006)	-0.014** (0.007)	0.016* (0.010)
Risk-based Capital Requirements	1.648*** (0.477)	-2.508*** (0.839)	-0.908** (0.439)	0.271 (0.331)	0.978*** (0.360)
Recovery Period	-0.014 (0.009)	0.004 (0.009)	-0.056 (0.036)	-0.085*** (0.014)	-0.109*** (0.031)
Maturity	0.014*** (0.004)	0.0001 (0.001)	0.008 (0.005)	0.035*** (0.007)	0.019* (0.010)
Inflation Indexation	0.001 (0.003)	0.001 (0.001)	0.011*** (0.002)	0.002 (0.001)	0.010*** (0.003)
Size	0.019*** (0.003)	0.019*** (0.003)	0.070*** (0.011)	0.067*** (0.013)	0.025*** (0.004)
Past Investment Return	-0.006 (0.005)	-0.0004 (0.001)	-0.020** (0.009)	-0.012 (0.008)	0.005 (0.010)
Observations	3,687	3,687	3,687	3,687	3,687
R^2	0.084	0.067	0.122	0.200	0.065
Adjusted R^2	0.072	0.058	0.105	0.172	0.056
F Statistic (df = 11; 3171)	26.280***	20.785***	39.997***	71.961***	19.997***
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 10: Interaction Models – Risk-based Capital Requirement – All Risky Assets

This table presents the estimates from the specification with the interacted term *Risk-based Capital Requirements* × *Crisis* (Risk × Crisis), for the random effects (RE, column (1)), correlated random effects (CRE, column (2)), and fixed effects (FE, column (3)) specifications. The dependent variable is the overall percentage of the value of a fund's asset that is allocated to risky assets. Standard Errors are in parentheses, and those the FE model are clustered by Year.

	Specification:		
	RE	CRE	FE
	(1)	(2)	(3)
Quantitative Investment Restrictions	-0.026*** (0.006)	-0.025*** (0.006)	-0.024*** (0.009)
Mark-to-market Asset Valuation	-5.940*** (1.216)	-5.987*** (1.223)	-6.840*** (1.781)
Liability Discount Rate	-0.276 (0.587)	-0.354 (0.585)	-1.021 (1.088)
Recognition of Unfunded Liabilities	0.968*** (0.113)	0.961*** (0.112)	0.894*** (0.177)
Minimum Funding Requirement	0.049*** (0.011)	0.047*** (0.011)	-0.015 (0.018)
Risk-based Capital Requirements	-6.225*** (1.509)	-6.254*** (1.512)	-6.899*** (2.319)
Crisis	-0.094 (0.433)	-0.112 (0.429)	-0.370 (0.797)
Recovery Period	0.195*** (0.029)	0.192*** (0.029)	0.162*** (0.039)
Maturity	-0.044*** (0.013)	-0.041*** (0.013)	-0.021 (0.022)
Inflation Indexation	0.004 (0.006)	0.004 (0.006)	0.008 (0.006)
Size	0.139*** (0.014)	0.145*** (0.015)	0.205*** (0.021)
Past Investment Return	0.031*** (0.011)	0.030*** (0.011)	0.027 (0.020)
Risk x Crisis	-1.278 (1.700)	-1.186 (1.686)	-0.289 (1.708)
Observations	3,687	3,687	3,687
Log Likelihood		-12,662.110	
Akaike Inf. Crit.		25,356.220	
R^2	0.489		0.120
Adjusted R^2	0.487		0.103
F Statistic (df = 12; 3170)	269.908***		33.246***
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 11: Interaction Models –Mark-to-market Asset Valuation – All Risky Assets

This table presents the estimates from the specification with the interacted term *Mark-to-market Asset Valuation* × *Recognition of Unfunded Liabilities* (MktVal × LiabRecog), for the random effects (RE, column (1)), correlated random effects (CRE, column (2)), and fixed effects (FE, column (3)) specifications. The dependent variable is the overall percentage of the value of a fund's asset that is allocated to risky assets. Standard Errors are in parentheses, and those for the FE model are clustered by Year.

	Specification:		
	RE	CRE	FE
	(1)	(2)	(3)
Quantitative Investment Restrictions	-0.024*** (0.006)	-0.024*** (0.006)	-0.022** (0.009)
Mark-to-market Asset Valuation	-1.250 (1.478)	-1.290 (1.485)	-1.864 (1.913)
Recognition of Unfunded Liabilities	3.260*** (0.882)	3.143*** (0.878)	2.082 (1.653)
Liability Discount Rate	0.968*** (0.111)	0.958*** (0.110)	0.871*** (0.176)
Minimum Funding Requirement	0.058*** (0.011)	0.056*** (0.011)	-0.002 (0.018)
Risk-based Capital Requirements	-4.715*** (1.374)	-4.683*** (1.383)	-4.560** (2.261)
Recovery Period	0.222*** (0.028)	0.219*** (0.028)	0.191*** (0.040)
Maturity	-0.044*** (0.013)	-0.041*** (0.013)	-0.020 (0.023)
Inflation Indexation	0.006 (0.006)	0.005 (0.006)	0.008 (0.006)
Size	0.136*** (0.014)	0.142*** (0.014)	0.199*** (0.019)
Past Investment Return	0.034*** (0.009)	0.034*** (0.009)	0.033** (0.015)
MktVal × LiabRecog	-11.374*** (2.122)	-11.248*** (2.110)	-10.125*** (2.971)
Observations	3,687	3,687	3,687
Log Likelihood		-12,648.110	
Akaike Inf. Crit.		25,326.220	
R^2	0.084		0.126
Adjusted R^2	0.072		0.108
F Statistic (df = 12; 3170)	24.122***		37.954***
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 12: Risky Fixed Income and Its Subclasses: Intensive Margin by Censored Regression

This table presents the estimates from the Censored Regression Model (Eq. (4)) for the Risky Fixed Income asset class (Column (1)) and its composing sub-asset classes – High Yield (Column (2)), and Mortgages (Column (3)). The estimates are obtained by the method introduced by Honoré (1992). The corresponding average marginal effects are provided in Table 14.

	Dependent variable:		
	Risky Fixed Income	High Yield	Mortgages
	(1)	(2)	(3)
Quantitative Investment Restrictions	-0.0291* (0.0174)	-0.0354 (0.0411)	-0.0399** (0.0168)
Mark-to-market Asset Valuation	-3.088 (2.586)	21.75 (13.49)	-4.388** (1.896)
Recognition of Unfunded Liabilities	0.588*** (0.163)	2.156** (0.881)	-1.603 (2.808)
Liability Discount Rate	1.446*** (0.385)	0.730*** (0.178)	0.0809 (0.236)
Minimum Funding Requirement	-0.343*** (0.0727)	-0.013 (0.0336)	-0.594*** (0.147)
Risk-based Capital Requirements	-2.351** (0.949)	0.873 (0.698)	-7.418*** (1.186)
Recovery Period	-0.0861*** (0.0258)	0.0116 (0.0199)	-0.339** (0.134)
Maturity	0.0685** (0.0285)	0.0663* (0.0349)	0.0167 (0.0333)
Inflation Indexation	0.0119 (0.0141)	0.0083 (0.0161)	0.0178 (0.0264)
Size	0.120*** (0.0375)	0.135*** (0.0469)	0.0789*** (0.0159)
Past Investment Return	-0.0233*** (0.00821)	-0.0316*** (0.0087)	-0.0137 (0.015)
Observations	3,687	3,687	3,687
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 13: Alternatives and Its Subclasses: Intensive Margin by Censored Regression

This table presents the estimates from the Censored Regression Model (Eq. (4)) for the Alternatives asset class (Column (1)) and its composing sub-asset classes – Real Assets (Column (2)), Private Equity (Column (3)) and Active Funds (Column (4)). The estimates are obtained by the method introduced by Honoré (1992). The corresponding average marginal effects are provided in Table 14.

	Dependent variable:			
	Alternatives	Real Assets	Private Equity	Active Funds
	(1)	(2)	(3)	(4)
Quantitative Investment Restrictions	-0.0553***(0.0196)	-0.0383***(0.0083)	-0.0169* (0.00933)	-0.0511 (0.0448)
Mark-to-market Asset Valuation	-1.886(2.33)	-0.011(0.922)	0.291 (1.072)	-9.401 (6.487)
Liability Discount Rate	0.477**(0.241)	0.0213(0.089)	0.340*** (0.103)	1.048** (0.497)
Recognition of Unfunded Liabilities	1.449(1.309)	-0.651(0.553)	0.767 (0.466)	4.125* (2.363)
Minimum Funding Requirement	-0.00237(0.0203)	-0.00802(0.0101)	-0.0187 (0.0162)	0.0929** (0.0394)
Risk-based Capital Requirements	-0.755(1.353)	-1.067(1.232)	0.174 (1.566)	-0.35 (1.033)
Recovery Period	-0.301***(0.0473)	-0.0655**(0.0257)	-0.124*** (0.0164)	-0.219*** (0.0663)
Maturity	0.107**(0.0482)	0.0156(0.0147)	0.0665*** (0.0257)	0.0425 (0.065)
Inflation Indexation	0.0294**(0.0134)	0.0133**(0.00528)	0.00172 (0.00839)	0.0392* (0.0227)
Size	0.166**(0.0724)	0.0682*(0.0389)	0.0628*** (0.0146)	0.0591 (0.0666)
Past Investment Return	-0.0339***(0.00944)	-0.0273***(0.0049)	-0.0233*** (0.00435)	0.0162 (0.0161)
Observations	3,687	3,687	3,687	3,687
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 14: Risky Fixed Income and Alternatives: Average Marginal Effect Implied by the Censored Regression

This table presents the average marginal effects implied by the censored regression model, corresponding to estimates in the Tables 12 and 13. We follow Honoré (2008) by multiplying the coefficient estimates with the proportion of the observations that is not censored. The values displayed here allow us to directly interpret the average economic effect of the censored regression model. For example, if the value of asset under management increases by $1 billion, we estimate that the fund would increase its investment into private equity by on average 3.5 bps (column (6)).

	Risky Fixed Income	Alternatives	High Yield	Mortgages	Real Assets	Private Equity	Active Funds
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Quantitative Investment Restrictions	-0.007*	-0.045***	-0.007	-0.004**	-0.028***	-0.009*	-0.014
Mark-to-market Asset Valuation	-0.772	-1.547	4.35	-0.395**	-0.008	0.163	-2.632
Recognition of Unfunded Liabilities	0.479***	1.188	0.431**	-0.144	-0.482	0.43	1.155*
Liability Discount Rate	0.147***	0.391**	0.146***	0.007	0.016	0.19***	0.293**
Minimum Funding Requirement	-0.086***	-0.002	-0.003	-0.053***	-0.006	-0.01	0.026**
Risk-based Capital Requirements	-0.588**	-0.619	0.175	-0.668***	-0.79	0.097	-0.098
Recovery Period	-0.022***	-0.247***	0.002	-0.031**	-0.048**	-0.069***	-0.061***
Maturity	0.017***	0.088**	0.013*	0.002	0.012	0.037***	0.012
Inflation Indexation	0.003	0.024**	0.002	0.002	0.01**	0.001	0.011*
Size	0.03***	0.136**	0.027***	0.007***	0.05*	0.035***	0.017
Past Investment Return	-0.006***	-0.028***	-0.006***	-0.001	-0.02***	-0.013***	0.005
Observations	3,687	3,687	3,687	3,687	3,687	3,687	3,687
Proportion Uncensored	0.25	0.82	0.2	0.09	0.73	0.56	0.28
Note:						*p<0.1; **p<0.05; ***p<0.01	

Figure 1: Time Series of Mean Allocation to Risky Assets By Country and Type of Fund

Figure 1 displays the mean allocation to overall risky assets over time, by country and types of funds. Dutch funds stand out in having an overall downward trend on exposure to risky assets throughout the time period considered whereas Canadian and US funds typically only reduce allocation to risky assets in the mid to late 2000s. Within the US, discrepancy in the risky asset investments among the different types of funds is wider than that among Canadian funds.