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Riskiness and Procyclicality in Pension Asset Allocation

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Does Regulation Matter? Riskiness and Procyclicality in Pension Asset Allocation

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Abstract

We investigate the influence of investment regulations on the riskiness and procyclicality of defined-benefit (DB) pension funds' asset allocations. We provide a global comparison of the regulatory framework for public, corporate and industry pension funds in the US, Canada and the Netherlands. Derived from panel data analysis of a unique set of close to 600 detailed funds' asset allocations, our results highlight that regulatory factors are vitally important – more so than the funds' individual and institutional characteristics, in shaping these asset allocations. In particular, risk-based capital requirements, balance sheet recognition of unfunded liabilities, lower liability discount rates, and shorter recovery periods lead pension funds to decrease their asset allocation to risky assets. Risk-based capital requirements reduce overall risky asset allocation by as much as 5%, mainly through alternatives. Our empirical results do not corroborate the theoretical predictions that risk-based capital requirements encourage procyclical investment.

JEL codes: G11, G28, H55
Keywords: Solvency, Pension funds, Defined Benefit, Liability discount rate, Valuation requirements, Financial stability, Regulation

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1. Introduction

Regulation of financial institutions is a highly topical issue. Regulators are concerned not only with effective protection of the institutions' stakeholders but also with the potential unintended consequences of regulation. Mechanisms to prevent institutions from insolvency could become an obstacle for long-term or risky investments, subsequently adversely affecting their capacity to finance the real economy.[1] The prolonged deliberation process for regulatory revisions in banking, insurance and pension provision institutions (i.e., Basel II and III, Solvency II, and IORP II, respectively) underscores the difficulty of achieving the objectives of regulation while minimizing the perverse effects.

It is a theoretically established fact that regulatory constraints can shape investors' behavior, often in an unexpected and undesirable manner. Basak and Shapiro (2001) demonstrate that Value-at-Risk (VaR) constraint lead to larger losses in the worst states of the economy because agents behaving optimally would not insure against these states. Similarly, capital requirements based on 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). Moreover, risk-based capital requirements are accused of generating procyclical investment behavior (Pennacchi, 2005; Gordy and Howells, 2006; Bec and Gollier, 2009; Repullo and Suarez, 2013; Papaioannou et al., 2013), especially when solvency buffers are calibrated using risk models estimated on a short history.[2] Apart from VaR, mark-to-market valuation is another regulatory requirement that is believed to distort financial institutions' portfolio choice (Allen and Carletti, 2008), limit investors' ability to take risk (Severinson and Yermo, 2012) and instigate procyclical investment behavior (Novoa, Scarlata and Solé, 2009).

Unfortunately, despite a lively theoretical debate, there is scant empirical evidence about the practical effects of regulation on financial institutions' investments.[3] In this regard, pension funds

[1] This question has been raised for example by the Green Paper from the European Commission on long-term financing of the European economy: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52013DC0150
[2] Furthermore, repeated use of a short-term VaR constraint for a long investment horizon can generate substantial economic costs (Shi and Werker, 2012)
[3] There are a few exceptions. Ellul et al. (2011) show that regulatory constraints induce insurance companies to sell downgraded corporate bonds.

are a rewarding and instructive field of investigation because in contrast to banking and insurance, there is much less regulatory harmonization across countries. This diversity in the regulatory setup permits the analysis of a wider range of requirements. Until recently, pension funds in many countries, including the US, Canada, many European states and emerging economies, were regulated on the basis of strict investment constraints. Now, however, all these investment rules are being eased and replaced by solvency requirements. Moreover, in 2007 the Netherlands introduced risk-based regulations requiring a solvency capital buffer, similar to the buffers applicable to banks and insurers under Basel III and Solvency II, respectively. In Europe, there are on-going discussions about applying such a framework to all European pension funds (EIOPA, 2012). As a result, and in contrast to the situation in the banking and insurance industries, pension fund regulation is far from being harmonized. The North American and Dutch pension industries are particularly interesting to investigate because they offer a wide variety of regulatory choices. They also underwent notable regulatory changes, such as the Pension Protection Act in 2006 in the US, and the Financial Assessment Framework (FTK) in 2007 in the Netherlands.

In this paper, we seek to determine whether regulation has an impact on pension funds' asset allocation choices. Asset allocation decisions have been shown to be an important source of performance and thus income[4] 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 two important dimensions that have been widely theoretically debated: the extent of risky asset exposure and the procyclicality of investment. In particular, we aim to gauge the economic magnitude of regulatory factors in explaining fund allocation choices, compared with other factors identified so far as the main drivers of pension fund's asset allocation: individual and institutional characteristics of the plans (Chemla, 2005; Rauh, 2009; Dyck and Pomorski, 2011; Crossley and Jametti, 2013, etc.). With a sizeable database on individual defined-benefit (DB) pension funds' asset allocation in the US, Canada and the Netherlands over a long period (1990-2011), we have a unique opportunity to investigate whether regulatory changes had an impact on their asset allocation choices.

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

To carry out this investigation, we build a global comparison of the pension regulatory environment of our three countries under study over seven different dimensions. We chronologically map each country's regulatory dimensions by category of funds (i.e., public, corporate and industry). We then test individual, institutional and regulatory determinants of the historical asset allocations of US, Canadian and Dutch pension funds, using the CEM Benchmarking database, which provides detailed information on a large sample of DB funds from these three countries. While there are previous studies that separately examine individual and institutional factors explaining the 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 taken by different countries. Moreover, while many papers examine Dutch, US, and to a lesser extent, Canadian pension funds individually, few compare them on a transatlantic basis (e.g., Bikker et al., 2012; Andonov et al., 2013). Our unique database enables us to make such a comparison.

Two sets of results emerge from our analysis. First, we show that regulatory factors play a much larger role than individual and institutional factors in explaining the pension funds' allocation to risky assets. Among the regulatory factors, risk-based capital requirements have the largest impact, followed by balance sheet recognition of unfunded liabilities. The former decrease the funds' equity exposures by 5.5% on average, while the latter by 5.1%. Risk-based capital requirements do not have a uniform impact on all risky assets. Real estate, private equity, infrastructure and mortgages are penalized, while commodities are favored. Our results confirm that pension funds' individual and institutional characteristics have a statistically significant impact on their asset allocations (Dyck and Pomorski, 2011; Rauh, 2009; Bikker et al., 2011) but less so than regulatory factors. Funds with younger participants and a higher value of assets under management invest more in risky assets. The presence of a guaranteeing institution, such as the Pension Benefit Guaranty Corporation (PBGC) in the US, leads to more risky asset allocations.

Second, we build an original measure of investment procyclicality, finding mild evidence that pension funds' investments are procyclical during normal times, but much stronger evidence of procyclicality during turbulence (confirming the pension funds' "bad habits" documented by Ang et al., 2014). But contrary to theoretical predictions, we discover that regulation has little impact on the procyclicality of asset allocations. Risk-based capital requirements and mark-to-market valuation of assets do not make investment more procyclical. This last, counter-intuitive result may be explained, at least partially, by the fact that the only country in our database with risk-based regulation, the Netherlands, slackened the requirements in response to the subprime crisis, allowing funds to keep or even increase their risky asset exposure.

There is a large literature trying to assess the determinants of pension funds' allocation choices. Bodie (1987) shows that for a DB fund with only guaranteed nominal benefits, pure accrued liability hedging would 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. In practice, DB pension funds invest a substantial proportion of their wealth in risky assets, especially equities, and, to a lesser extent in alternatives and risky fixed income securities. Part of this risky asset investment may be explained by the positive correlation of risky assets, especially stocks, to wage growth (Sundaresan and Zapatero, 1997; Peskin, 2001; Lucas and Zeldes, 2006). However, the fact that pension funds' risky asset allocation depends on their characteristics (e.g., public or private), and that it changes dramatically over time,[5] suggests that hedging wage growth is not the only explanation. Funds' individual 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.

The institutional characteristics of the plans, such as the presence of a guarantee mechanism, may also have an influence on the fund's risk-taking behavior. Most corporate DB funds in the US, as well as Canadian pension funds in Ontario, are insured by a pension benefit guarantee

[5] For example, US public funds' risky asset allocations rose from 56% to 73% between 1994 and 2011, whereas for Dutch funds they decreased from 69% to 42% over the same period.

fund.[6] This insurance, which partly covers funding shortfalls for the pension plans of bankrupt firms, provides a put option that reduces the negative impact of pension liabilities on the firm's value to shareholders. Sharpe (1976), Treynor (1977) and Bodie (1990) demonstrate that underfunding and allocating investments to risky assets can maximize the value of this option. There is some evidence that funds do behave as if they are maximizing the value of the put option (Nielson and Chan, 2007; Crossley and Jametti, 2013).[7]

Finally, in addition to individual characteristics and the institutional setup, the regulatory environment may also influence the willingness of funds to invest in risky assets. Very few academic papers have dealt with this dimension 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 way pension liabilities should be valued. Public pension funds are subject to the actuarial approach of the Government Accounting Standard 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 were also those choosing riskier portfolios. Andonov et al. (2013) add to this by comparing the asset allocations and liability discount rate of public funds in the US with private funds in the US, and with public and private funds in Canada and Europe. They provide empirical evidence that US public funds increased their allocation to riskier investment strategies in order to maintain high discount rates and present lower liabilities, especially those funds with a higher proportion of retired members. But other dimensions of pension regulation, such as funding constraints, mark-to-market valuation of assets, and risk-based capital requirements, may potentially have an impact on pension fund investments as well. Our results expand previous empirical investigation by providing the first comprehensive empirical evidence on the theoretically debated questions of regulatory impact on pension funds'

[6] The Pension Benefit Guaranty Corporation (PBGC) in the US and the Pension Benefits Guarantee Fund (PBGF) in Canada ensure the payment of pension benefits if a sponsor becomes insolvent. The PBGC, for instance, collects an annual insurance premium per plan participant, plus a variable rate premium for underfunded plans.

[7] Love et al. (2011) show that the particular form of pension insurance (where the insurance premium is underpriced and is a function of the pension plan's underfunding) often pushes firms towards one of two extremes—either maximizing the risk in the pension promise by reducing contributions and mismatching assets and liabilities, or minimizing the risk in the pension promise by fully funding future benefits and investing in assets designed to match the liabilities as closely as possible. Incentives for moral hazard may be nevertheless offset by a few factors: for instance, companies with strongly performing business lines would prefer to remain solvent and fund their pension plans.

asset allocation. It shows that regulatory choices matter in shaping the investment decisions of pension plans. We hope that our insights can contribute to the academic discussion on the optimal design of pension regulation and assist regulators and practitioners in their efforts to develop a framework for a sound 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 methodology, Section 4 discusses our empirical results on the major drivers of pension investment asset allocation (riskiness and procyclicality), Section 5 concludes.

2. Overview of Pension Regulatory Environment

Unlike insurance companies and banks, pension funds are not subject to harmonized prudential regulation but are governed by highly heterogeneous rules that differ not only between countries but also within them. We focus on two sets of regulations that influence pension fund investments: the budgeting and funding rules of the fund, and the financial reporting standards of the sponsor (i.e., accounting rules). For US private, Canadian and Dutch pension plans, these two sets of regulations are distinct and determined by separate regulatory authorities. 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 private pension funds are not regulated under the same rules or by the same regulatory authority. 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[8] 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

[8] 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.

Rastad (2011), and Andonov et al. (2013), 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 under current accounting standards, 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).[9] 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.[10] 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 valued with, at most, a two-year average of 90-110% of fair value[11] (compared with the previous five-year average of 90-120%).

[9] 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.

[10] 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.

[11] 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.

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),[12] this fair value does not have to be reported on their balance sheet. Only when accumulated benefit obligation (ABO)[13] exceeds 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

[12] 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.
[13] 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.

balance sheet.[14] 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 private and public 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.[15]

Canadian private pension plans and their sponsors prepare their financial statements in accordance with standards set by the Accounting Standards Board of Canada (AcSB).[16] 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

[14] Sponsors of multi-employer plan are required only to report their respective contribution to the plan.
[15] 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.
[16] Since 2011, these standards have been grouped in Part IV, Section 4600 of the Canadian Institute of Chartered Accountants Handbook.

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.[17] 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 similar to those that will apply in Europe for insurance companies, and that 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.

[17] 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.

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.[18] Because of the stand-alone[19] 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 below 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-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

[18] 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.

[19] 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).

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 the interest rates on corporate bonds (US private funds), government bonds (Canada) or even swaps (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 and Methodology

3.1 Data Description

Our data is sourced 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. We carry out our analysis on an unbalanced panel of 589 funds: 377 in the US, 174 in Canada and 38 in the Netherlands, over the

1991-2011 period.[20] The value of assets under management of these funds amount to 35% of all DB funds in the US, 32% in Canada, and 30% in the Netherlands in 2011.[21] There is no evidence of self-reporting bias in our database (Dyck and Pomorsky, 2011),[22] as the data are anonymous.

Table 2 presents summary statistics on the database by country and type, in 1996[23] and 2011, for funds' individual characteristics: size (measured by 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 present the percentage allocated to risky assets: equities, risky fixed income (mortgages and high yield) and alternatives (tactical asset allocation,[24] commodities, natural resources, infrastructure, real estate,[25] other real assets, hedge funds, private equity[26]).

Insert Table 2 about here

The size (measured by the value of assets under management) of US and Canadian public funds in the database more than doubled in 17 years. The 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.

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[20] 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.
[21] 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).
[22] 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.
[23] 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.
[24] Fully funded long-only segregated asset pool dedicated to tactical asset allocation.
[25] REITs and real estate ex-REITs.
[26] Venture capital, leveraged buyout, diversified private equity, and other private equity.

Asset allocation showed diverging trends. Whereas US and Canadian public funds, as well as US multiemployer funds, increased their risky asset allocation between 1996 and 2011 (by 14.7%, 9% and 11.7% respectively), there were no significant changes for Canadian corporate and industry funds (small deductions of 3% and 2.1%), but there was a decrease for US private funds (by 8.3%) and an even larger decline for Dutch corporate and industry funds (by 22.4% and 16.3%). 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.

3.2 Variable Construction

There are various ways to measure the riskiness of the asset allocation, the most direct method being to measure the volatility of the funds' portfolios. Unfortunately, with only annual data on pension funds' returns, we are unable to assess the dynamics of risk. We thus measure the riskiness of the asset allocation as the percentage of the global portfolio dedicated to risky assets, overall and in three sub-categories: equities, risky fixed income and alternatives.

Various definitions of procyclicality coexist in the literature. The Financial Stability Forum (FSF, 2009) refers to it as the "dynamic interactions (positive feedback mechanism) between the financial and the real sectors of the economy". The European Commission defines rules as procyclical if they "unnecessarily amplify swings in underlying economic cycles or contribute to excessive market movements".[27] Bec and Gollier (2009) consider a financial or economic variable to be procyclical if it tends to increase when the overall level of the economy

[27] Solvency II: Frequently Asked Questions (FAQs) – European Commission Internal Market and Services Directorate General

also rises or the global financial market cycle is on the upswing.[28] We follow this definition and consider that investors are procyclical if they are buying risky assets when market prices rise and selling them when they fall, thus potentially exaggerating market movements.

We define an original measure of procyclicality of pension fund investment that compares the sign of a fund's net purchase of buying in risky asset *j* with that of the market return that year. Our procyclicality measure for asset class *j*, PC_{it}^{j} is set to one if the sign of net buying in asset class *j* during year *t* is similar to that of the market return that year, and zero otherwise.

$$PC_{it}^{j} = \begin{cases} 1 \text{ if } \mathrm{sign}(netpurch_{it}^{j}) = \mathrm{sign}(r_t^{Mkt}) \\ 0 \quad \text{otherwise} \end{cases} \tag{1}$$

$$netpurch_{it}^{j} = w_{it}^{j} - w_{it-1}^{j} \frac{1 + r_{it}^{j}}{1 + r_{it}^{T}} \tag{2}$$

w_{it}^{j} is fund $i's$ allocation in a risky asset (sub-)class *j* at time *t*, r_{it}^{T} is the total return of fund *i* at time *t*, r_{it}^{j} is the return of the risky asset class *j* in the portfolio of fund *i* at time *t*,[29] r_t^{Mkt} is the market return at time *t*, approximated by the return on the MSCI World.[30] Net purchase, $netpurch_{it}^{j}$, of fund *i* in asset class *j* is measured as the difference between the actual weights of the funds and the funds' estimated would-be risky asset weights if the past year's weights were allowed to drift along with market performance (a no-rebalancing or asset-drift strategy).

The reasoning behind the definition of PC is best illustrated with an example. Suppose that the market return at time *t* is positive, $r_t^{Mkt}>0$. If a fund *i*'s actual weight in asset class *j*, w_{it}^{j} is higher than the asset drift weights, then it suggests that there is an inflow of investment to that asset class. This is procyclical investment behavior according to our definition. The reasoning

[28] For institutional investors, Papaioannou al. (2013) define procyclicality as momentum behavior.
[29] Since much of the data on the asset class breakdown of individual pension funds' returns is missing, we recompose the risky asset portfolio return of each fund by using the weighted average performance of selected benchmarks, the weights being equal to those reported by the fund. For equities, we used the following geographical benchmarks from MSCI: US, Canada, Netherlands, Australia, UK, World ex-Australia and World ex-US, ACWI ex-US. Risky fixed income benchmarks are the Barclays US Corporate High Yield bond index and BofA US Mortgage. For alternatives, we used S&P GSCI, NAREIT index, UBS global infrastructure, NCREIF property, timberland and farmland indices, and HFRIWI for hedge funds.
[30] We conducted robustness checks with alternative definitions of market returns (equally weighted set of indices corresponding to the asset subcategories in the database), with similar results.

behind adverse asset price movements is similar. Figure 1 plots PC (average over funds) by fund type. At each point in time, the curves indicate the percentage of funds in our database that behave procyclically.

Insert Figure 1 about here

Procyclicality varies over time. The average procyclicality level, defined as the percentage of funds being procyclical per year, is 38%. All funds demonstrate additional procyclicality in the immediate aftermath of financial crises, as shown by the peaks of our procyclicality measure in 2003 (following the dot.com, Enron and WorldCom crises) and 2008. However, Dutch funds showed less procyclicality than their US and Canadian counterparts in 2009 and 2010. This empirical evidence is in line with the separate findings reported by DNB (2011), which show countercyclical behavior by Dutch pension funds during the crisis, and by Papaioannou et al. (2013), who report procyclical behavior by US funds during the same period.

We consider three types of explanatory factors: regulatory variables, funds' individual characteristics, and institutional characteristics.[31] Table 3 describes the explanatory variable construction, and presents the expected effects inferred from economic theory on the riskiness and procyclicality of asset allocations.

Insert Table 3 about here

We define our quantitative restriction variable (*QIR)* as the sum over all restricted assets of (1- asset weight restriction).[32] Tighter limits or a higher number of restricted assets yield a higher *QIR*. Quantitative investment restrictions, if binding, would naturally lead to lower allocations in the asset classes concerned. Since they are stated as a fixed percentage of the asset value, these

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[31] Despite being one of the most comprehensive sources of international pension fund data, the CEM Benchmarking database does not contain funding status. In addition to the anonymity of the participating funds in the database, this critical information cannot be recovered and is thus omitted in the analysis,

[32] Before 2010, Canada imposed separate restriction on both natural resources and Canadian natural resources. As our data does not permit the distinction between Canadian natural resources from overall natural resources, we consider only the 25% limit on real estate and natural resources.

restrictions – if binding – are also likely to encourage countercyclical investment behavior among funds when prices go up (forced selling during bullish times).

We consider three types of valuation requirements. We define the asset valuation variable (*AssetVal)* as 1, 0.5, or 0, depending on whether fair valuation is strictly imposed, smoothing is allowed, or further discretion is permitted, for both the funding and accounting requirements. As both regulations may have an impact on the funds' behavior, we take the average of the two measures. Mark-to-market valuation limits investors' ability to take risk (Severinson and Yermo, 2012), amplifies funds' sensitivity to short-term changes in financial returns; , and encourages procyclical investment behavior (Novoa, Scarlata and Solé, 2009). Second, we consider the liability discount rate (*LDR*) disclosed by the funds. If funds are allowed to apply a rate that is dependent on the riskiness of their investments, they may be encouraged to invest more heavily in risky assets (Pennachi and Rastad, 2011; Andonov et al., 2013). Third, we define a variable accounting for the recognition of the funded status of the fund in the sponsor's (or government's) balance sheet. *LiabRecog* 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. The gradient reflects the level of the liabilities recognition requirement. Sponsors 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). This incentive is likely to be stronger in stressed markets, so the recognition requirement may also induce procyclicality.

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). This implies that when the funding requirement becomes more stringent, more funds are likely to be underfunded, and hence, risky asset exposure might decline on average. In all cases, fixed requirements could lead funds to cut their risky asset exposure when markets go down, leading to procyclicality, especially when mark-to-market valuation is adopted. The presence of risk-based capital requirements (*RBCR)* is accounted for through a dummy variable equal to one when risk-based capital buffers are mandatory. The requirement to hold higher capital buffers for risky assets is expected to make investment in risky assets less attractive. It could cause funds to be more sensitive to market cycles, and hence to invest procyclically (Adrian and Shin, 2008; Bec and Gollier, 2009). Finally, we take into account the length of the recovery period (in years) allowed in case of underfunding (*Recovery*). If granted a longer period, plans would be able to invest more in risky assets and have fewer incentives to behave procyclically.

The effects of funds' individual characteristics on their investments are well known. We thus control for plans' heterogeneous characteristics, namely the different maturities of the funds (*Maturity*), defined as the percentage of retired members; the presence of varying inflation indexation mechanisms (*Inf Indx* is the 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 a higher allocation to alternative assets (Dyck and Pomorski, 2011). Finally, as an institutional characteristic, we take into account the presence of a collective insurance mechanism provided by a guarantee fund. Our *Guarantee* variable is defined as a dummy variable equal to one if there is a collective guarantee. The existence of a safety net that partly covers funding shortfalls for the plans operated by bankrupt firms may tempt pension plans to take greater investment risks (Nielson and Chan, 2007; Crossley and Jametti, 2013).

3.3 Methodology

We seek to explain funds' risk-taking by means of regulatory factors and fund characteristics using an unbalanced panel of fund level data over time. Our regression model is specified as such:

$$\begin{aligned} w_{it} = \alpha &+ \beta_1 QIR_{it} + \beta_2 AssetVal_{it} + \beta_3 LDR_{it} + \beta_4 LiabRecog_{it} \\ &+ \beta_5 Funding_{it} + \beta_6 RBCR_{it} + \beta_7 Recovery_{it} \\ &+ \beta_8 Maturity_{it} + \beta_9 Inf\ Indx_{it} + \beta_{10} Size_{it} + \varepsilon_{it} \end{aligned} \quad (3)$$

w_{it} is the percentage invested in risky assets (globally or on each subcategory: equities, risky fixed income, alternative investments) by fund i in year t, QIR_{it} is the index measuring strictness of quantitative investment restrictions, $AssetVal_{it}$ is the asset valuation method for funding requirements, LDR_{it} is the self-reported liability discount rate, $LiabRecog_{it}$ is the requirement to recognize liabilities in excess of the PBO or equivalent, and $Funding_{it}$ is the minimum funding requirements. $RBCR_{it}$ is the risk-based capital requirements and $Recovery_{it}$ is the recovery period. $Maturity_{it}$ refers to the percentage of retired members, $Inf\ Indx_{it}$ is the percentage of members' benefits contractually indexed to inflation, $Size_{it}$ is the value in billions of US dollars of funds' assets under management.

We postulate that the error term ε_{it} in (3) consists of the fixed effects of Fund and Year. Fund level fixed effects mitigate all possible biases due to fund heterogeneity that is constant over time. Year-specific effects, such as systemic global financial market fluctuations that affect all the funds considered, are taken into account by Year fixed effects. As the data is unbalanced, Year fixed effects also mitigate the irregular number of plans each year. The Hausman test supports our choice for fixed rather than random effects.

With the data structured along multi-levels, e.g., country, type (public, private, industry) and fund, there are numerous possible assumptions for the fixed effects that could be included in the specification. We start by presenting the fixed effects on the lowest granularity possible, i.e., Fund and Year. We introduce a robustness check by replacing the Fund fixed effect by the Type fixed effects. Unfortunately, all of these specifications preclude us from investigating what impact a guaranteeing institution would have. Therefore, we also test the baseline specification of a pooled regression with no fixed effects, and another with only Year fixed effects.[33] We present errors that are clustered by year.[34] Estimated Fund, Type, Country, and Year fixed effects are not reported.

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[33] These specifications with coarser granularity for fixed-effect levels permit the addition of an indicator variable, $Guarantee_{it}$, that is one for fund types in countries where a collective guarantee fund exists. We present these results for overall risky assets only.

[34] 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.

We investigate funds' procyclical investment behavior using a generalized linear logit model, as in (4).[35] Our specification choice is the logit analogy of the specification (3), with Year, Country and Type fixed effects.[36]

$$P[PC_{it}^{j} = 1] = \mathrm{F}_L(\alpha + \beta_1 QIR_{it} + \beta_2 AssetVal_{it} + \beta_3 LDR_{it} + \beta_4 LiabRecog_{it} + \beta_5 Funding_{it} + \beta_6 RBCR_{it} + \beta_7 Recovery_{it} + \beta_8 Maturity_{it} + \beta_9 Inf\ Indx_{it} + \beta_{10} Size_{it} + \varepsilon_{it} \quad (4)$$

PC_{it}^{j} is the procyclicality measure for asset class j, F_L is the cumulative distribution function of a logistic distribution, $F_L(z) = \frac{1}{1+e^{-z}}$. The coefficients are estimated by maximum likelihood. Errors are clustered by year. Year, Country and Type fixed effects estimates are not reported.

4. Major Drivers of Pension Investment Behavior

4.1 Allocation to risky assets

Table 4 presents the results of the regressions of the percentage allocated to risky assets on regulatory variables, and on the individual and institutional characteristics of the funds. The first four columns detail the results for the global risky asset allocation and its subclasses (i.e., equities, risky fixed income and alternatives), with Fund and Year fixed effects. The last three columns present the results of the specifications with various combinations of fixed effects (i.e., none; Year; Year, Country and Type), for global risky assets only. Tables 5 and 6 present refined results based on sub-asset class decomposition in the alternatives (commodities, infrastructures,

[35] A logit model is chosen in our case because the link function g(x) = ln(1/(1-x)) is canonical. It implicitly assumes a direct connection between the explanatory variables and the probability that a fund is procyclical.

[36] We omit the Fund level fixed effects because it would entail estimation of every Fund and Year fixed effects – close to 600 parameters. Within transformation cannot be applied to the logit model. An alternative to preserve specification with Fund and Year fixed effects is the linear mixed effect logit model, whereby the fixed effects are assumed to be random, i.e., $\alpha_i \sim N(0, \sigma_{Fund}^2)$, for all i; $\eta_t \sim N(0, \sigma_{Year}^2)$. Results from the estimation of this model do not yield material changes to our conclusion and thus are not presented here.

real estate, private equity, hedge funds) and the risky fixed income (high yield and mortgages) space respectively, under the specification with Fund and Year fixed effects.[37]

Insert Table 4 about here

Insert Table 5 about here

Insert Table 6 about here

We find that regardless of the specification used for the regression, regulatory variables have a highly significant impact on asset allocation choices, ranging (in absolute terms) from 0.03% to 5.5% respectively when we adopt the specification with Fund and Year fixed effects. We consistently find across all regressions that the impact of regulatory variables is at least similar in amplitude, and in many instances even higher, than the impact of funds' individual and institutional characteristics.

Risk-based capital requirements, unique to the Netherlands since 2007 among all the countries in our dataset, yield a 5.5% reduction in the overall allocation to risky assets on average. This is the regulatory factor with the largest economic impact. While the effect of risk-based capital requirements is negative on overall risky asset exposure (Table 4), it is non-significant for equities, but economically and statistically important for alternatives (-3.1%). Surprisingly, it is associated with an increase in commodities (+1.1%, see Table 5). The contrasting implications of this regulatory requirement may be linked to the relative capital charges of these different asset classes under the Dutch FTK, by risk modules. While these capital charges are 25% for risks associated with listed equities in mature markets (35% for those in emerging markets), they are 30% for commodities.[38] As risks stemming from equities and commodities face comparable capital charges, if expected returns are identical or even higher for commodities, this would explain the preference for commodities.

Recognizing unfunded liabilities on the sponsor's balance sheet has the next highest impact on pension funds' asset allocation, yielding a 5.1% decrease in the funds' risky asset allocation,

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[37] Only the specifications without fixed effects, or with year fixed effects, allow us to investigate the influence of the collective guarantee scheme on the risky asset allocation.

[38] Under the proposed IORP II Directive revision, the analogous capital charge by risk modules is 33% for EEA and OECD equities, 43% for all other equities, and 25% for property risk.

almost equally spread between equities (-2.7%) and alternatives (-2.3%).[39] The requirement to recognize unfunded liabilities in excess of PBO increases the volatility of the sponsor's balance sheet, inducing funds to shift their asset allocation to safer, less volatile assets. Minimum funding requirements have little economic impact on risky asset allocations. Increasing the minimum funding requirement by a standard deviation (i.e., 40.5%), yields a reduction of $0.03 \times 40.5 = 1.2\%$ in the allocation to risky assets. This is consistent with the reasoning that because underfunded funds tend to invest less in risky assets, a higher funding requirement could only increase the number of underfunded funds, thus yielding an overall negative impact on risky asset allocation. Additionally, imposing a shorter recovery period significantly reduces the funds' risky asset allocation. A standard deviation decrease in the recovery period (corresponding to 12 years) yields on average a reduction of $0.12 \times 12 = 1.44\%$ in risky asset allocation.

Funds with higher liability discount rates allocate more to risky assets. A standard deviation increase in the discount rate premium (corresponding to 1.3%) leads to a $0.49 \times 1.3 = 0.6\%$ increase in the weights assigned to risky assets (especially private equity). Our results confirm the findings of Andonov et al. (2013) and emphasize the importance of the choice of liability discount rate in the pension fund's allocation. Public funds in the US, which are now much less constrained than domestic corporate funds but also than other funds in the rest of the world, tend to allocate more to risky assets. But it is also interesting to put this result into perspective. The choice of the discount rate, although important, is not the regulatory dimension with the largest economic impact on funds' actual asset allocation.

Lower quantitative restrictions are estimated to yield higher overall investments into risky assets, especially risky fixed income and alternatives. These restrictions were imposed in Canada in the 1990s on two particular alternative asset classes: real estate and natural resources, as well as foreign assets.[40] In Table 5, we observe that investment restrictions have a significantly negative impact on infrastructure,[41] and no significant impact on real estate or commodities.[42] The positive global impact of investment restrictions on the overall risky asset allocation is

[39] Especially infrastructure, real estate and private equity.
[40] Exposure to these asset classes could be gained through equities, infrastructures, commodities and real estate.
[41] Natural resources could be partly included in that category.
[42] This last result is consistent with the fact that the restrictions were probably non-binding on these asset classes over our sample, since funds allocate significantly less in practice than the stated constraint.

driven by the significant positive impact of restrictions on non-restricted risky assets (high yield bonds, private equity and hedge funds). This supports the idea that funds, being restricted to invest in some risky asset classes, reallocate to other risky assets due to the constraint.

Among individual characteristics, fund size has the largest statistically significant impact on the risky asset allocation. A standard deviation increase in the value of assets under management, corresponding to \$20 billion, is associated with an allocation that is 2.1% larger for risky assets overall, and in particular, 1.6% larger for alternatives (infrastructure, real estate and private equity) and 0.36% for risky fixed income (especially mortgages). The size of the pension fund has a substantially larger influence on the allocation to alternatives than to any other asset sub-class. This confirms the fact that larger funds are also the most sophisticated and have more resources to hire competent professionals with expertise in monitoring complicated assets such as hedge funds, infrastructure or private equity. A standard deviation increase in the percentage of retired members (corresponding to 18%) is estimated to entail a $0.09 \times 18 = 1.6\%$ decrease in risky asset allocation, particularly equities. Our results are consistent with those of Bikker et al. (2011), who demonstrate that maturity differences are an important factor explaining the variability of asset allocation among plans. Fund size and maturity have a fairly consistent influence on overall risky asset allocation regardless of the specification. We also find that funds with one standard deviation higher inflation-indexed contracts allocate as much as $41 \times 0.01 = 0.41\%$ more to alternatives, and $41 \times 0.005 = 0.21\%$ to real estate. This is consistent with the fact that funds tend to use alternative assets to hedge inflation (Amenc et al., 2009). Despite empirical evidence supporting the inflation-hedging potential of equities over a long investment horizon (Boudoukh and Richardson, 1993; Schotman and Schweizer, 2000), we find no conclusive results on funds' tendencies to allocate more to equities when they offer more inflation indexing.

The presence of a guarantee fund tends to have a positive and significant impact on the riskiness of the asset allocation. This result is in line with the theoretical results of Sharpe (1976) and Treynor (1977) and also with recent empirical evidence (Nielson and Chan, 2007; Crossley and Jametti, 2013) showing that funds tend to tolerate more underfunding, and thus allocate more to risky assets, when an insurance mechanism is present.[43] The global explanatory power of the regression specifications is commendable, ranging from 4-10% under the Fund and Year fixed effects with within-transformation and 19-27% under the Country, Type and Year fixed effects.

4.2 Procyclicality

Table 7 presents the results of the logit regressions with Year, Country and Type fixed effects on our procyclicality measure PC_{it}^{j}, with j representing overall risky assets or their subclasses: equities, risky fixed income and alternatives. Funds having quantitative investment restrictions display greater procyclical behavior in their risky asset investments, especially equities. A 5% increase in restrictions implies a 22% higher probability of being procyclical. Larger funds tend to be more procyclical in risky fixed income. But the effect is rather small. A standard deviation increase in fund size (i.e., by 20 billion USD) yields an increase of less than 0.01 in the probability of being procyclical.

Perhaps most surprising is the fact that imposing risk-based capital requirements is not associated with greater procyclicality across all risky asset investments. This result contradicts theoretical predictions (Adrian and Shin, 2008; Bec and Gollier, 2009) that using risk models estimated on a short history to calibrate solvency buffers (as introduced in the Netherlands in 2007) generates procyclical investment behavior.

Insert Table 7 about here

The lack of convincing evidence of any procyclical behavior among Dutch pension funds could be attributed to regulatory slackening in the Netherlands in response to the subprime crisis. The Dutch pension supervisory authority, De Nederlandsche Bank (DNB), announced numerous waivers to the standing regulation in order to help pension funds recover. These alternative

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[43] Whether a fund's participation in a guarantee fund (e.g., PBGC in the US or PBGF in Ontario, Canada) influences its exposure to financial risk cannot be fully investigated in our setup due to the lack of information on the sponsor and funds' liabilities. Viewing the PBGC guarantee as a put option, its value would depend on the price of this option, the estimation of which would require information on the amount guaranteed, premium, and assumptions on the sponsor's probability of default, value of liabilities, etc. (Binsbergen, Novy-Marx and Rauh, 2013).

actions, along with the greater flexibility granted to Dutch pension administrator to hike contribution rates, probably helped smooth pension plans' arduous path to full solvency. Besides, about 90 large corporations, including Royal Dutch Shell and ING, made one-off contributions of up to EUR 2 billion to restore their pension plans' funding ratio (Høj, 2011). Therefore, even if risk-based capital requirements alone would have yielded procyclical investment behavior, various permissible responses to the crisis may have produced a mitigated effect in terms of investment procyclicality. Our results complement and expand on the rather scarce empirical evidence on the procyclical behavior of institutional investors. OECD (2010) and Papaioannou et al. (2013) show that US and Canadian public pension funds were net sellers of equities during the subprime crisis. Alternative empirical evidence (DNB, 2011) shows Dutch pension funds were indeed countercyclical during the same period. Our results offer a comprehensive explanation of these mixed empirical findings by showing how the different regulatory choices made by the three countries under study may explain funds' different behaviors during the crisis.

5. Conclusion

Amidst ongoing discussions about applying a framework similar to Solvency II in Europe to occupational pensions, an intense debate is underway on how regulatory changes might change institutional investors' asset allocations. Although various theoretical papers discuss the potential impact of mark-to-market valuation and risk-based capital requirements on financial institutions' ability to take risk and on the procyclicality of their investments, there is scant empirical evidence at present. Our paper attempts to fill this gap by means of a detailed analysis of pension funds' allocations, based on a sizeable database of DB funds in three countries: the United States, Canada and the Netherlands. These countries are particularly interesting because they are diverse in their regulatory approaches and also 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 focused on two types of regulatory measures in the mid-2000s: valuation requirements (mark-to-market, both for solvency and accounting reasons) and funding requirements. The countries not only implemented valuation and funding requirements at different dates but also imposed different degrees of strictness. 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 have kept only traditional funding requirements.

Our empirical results highlight that regulation has at least as much, and in many instances even more influence on asset allocation choices as do pension funds' individual characteristics (maturity, size, inflation indexation) and institutional characteristics (presence of a guaranteeing mechanism). Among the different regulatory options, we find that risk-based capital requirements and recognition of unfunded liabilities on the sponsor's balance sheet have the largest impact, the two measures together reduce the share allocated to risky assets by more than 10%. Interestingly, quantitative risk-based capital requirements lead to a decrease in real estate, mortgages, and private equity, but an increase in commodities. In our opinion, this result is particularly important for regulators. They seem to have imposed constraints that make certain alternative investments more attractive, and others less so. Lastly, risk-based capital requirements are not found to have a statistically significant link to procyclicality, in contrast to the belief conveyed by theoretical studies, possibly because of coincident slackening of other regulatory standards.

Annual data frequency limits our analysis of procyclicality. Furthermore, data availability issues restrict our study to only three countries. A more thorough look at European countries, while challenging, would be a highly interesting refinement.

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Table 1: Comparison of the regulatory environment of US, Canadian and Dutch pension plans (change since 1990)

This table presents a comparison of US public, private (corporate and industry), Canadian public and private, as well as Dutch corporate and industry pension funds in their respective regulations since 1990.

	US public	US private (corporate)	US private (industry)	Canada public and private (corporate and industry)	Dutch private (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 157 refined the definition	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 private (corporate)	US private (industry)	Canada public and private (corporate and industry)	Dutch private (corporate and industry)
		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.
Balance Sheet Asset or Obligation	Between 1986 and 1994: GASB No. 5 Disclosure but no recognition	Before 2006: FAS 87 Only unfunded liabilities in excess of ABO are recognized on the balance	Since 1986: ERISA Participating sponsors merely report contributions	Up till 2011: CICA 3460 and 3461 Surplus/ insufficiency of funding relative to pension	Since 2005: IAS 19 The following amount is recognized: Present value of ABO less

	US public	US private (corporate)	US private (industry)	Canada public and private (corporate and industry)	Dutch private (corporate and industry)
	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.	sheet. Since 2006: FAS 158 All over/underfunded liabilities in excess of PBO are recognized on the sponsor's balance sheet.	on their financial statements but not the plan's long-term financial risks.	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	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 capital requirements	None	None	None	None	Since 2007: FTK Regulatory capital requirement computed by applying fixed

	US public	US private (corporate)	US private (industry)	Canada public and private (corporate and industry)	Dutch private (corporate and industry)
					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 summary statistics for pension funds' returns, asset allocation and characteristics, by country and by type in the US. 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 assets 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 provides the list of variables used in the regression specifications. Brief explanations on the variables' definition and expected effect on both riskiness and procyclicality of asset allocation are given.

Variable	Definition	Expected Effect	Riskiness	Procyclicality
Regulatory factors				
Investment requirements				
Quantitative investment restrictions *(QIR)*	Sum of (1-Investment Limit over all restricted asset classes) [IV]	Stricter *QIR* yields lower allocation to restricted assets Imposing fixed weights (if the constraint is binding) should lead to more countercyclical asset allocation when markets are up	-	-
Valuation requirements				
Asset valuation (*AssetVal*)	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 should induce more procyclicality	-	+
Liability discount rate (*LDR*)	Discount rate level for funding purposes disclosed by the fund.[V]	Higher risky asset allocation when higher discount rates reported	+	≈
Recognition of funded status on the sponsor's/ government balance sheet *(LiabRecog)*	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, especially during bad times (more procyclicality)	-	+
Funding requirements				
Minimum funding requirement (*Funding*)	Level of funding requirement[VIII]	Overall reduction in risky asset allocation as more funds become underfunded. Fixed funding requirements should lead funds to cut exposure to risky assets when things go wrong, leading to more procyclicality	-	+
Risk-based	Dummy: 1 on the	Imposing the use of quantitative	-	+

Variable	Definition	Expected Effect	Riskiness	Procyclicality
capital requirements (*RBCR*)	existence of mandatory quantitative risk requirements[IX]	risk measures based on past historical returns should lead to more procyclicality		
Recovery period (*Recovery*)	Average recovery period in years	Longer recovery period allows higher allocation to risky assets and less need to adopt a procyclical behavior	+	-
Individual characteristics				
Maturity (*Maturity*)	Percentage of retired members	More mature funds would allocate less to risky assets	-	≈
Inflation indexation (*Inf Indx*)	Percentage of member's benefits contractually indexed to inflation	Funds providing more inflation indexation would allocate more to risky assets	+	≈
Size (*Size*)	Market value of Assets under Management in billions of USD	Funds with larger AUM are likely to adopt more sophisticated strategies, thus invest more in alternatives	+ (for alternatives)	≈
Institutional characteristic				
Guarantee (*Guarantee*)	Dummy: 1 if pension benefits are collectively insured by a guarantee fund	The presence of an insurance fund allows 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: Determinants of Riskiness of Asset Allocation

This table presents the regression investigating the impact of regulatory variables and individual characteristics on pension funds' allocation to risky assets and its subclasses, with Fund and Year fixed effects. Explanatory variables are regulatory choices and funds' individual and institutional characteristics. Coefficients are estimated by least squares on the within-transformed data. The first three columns concern the allocation to risky assets, equities, risky fixed income and alternatives. The last three columns concern the allocation to overall risky assets with different sets of fixed effects (i.e., none; Year; Year, Type and Country). Standard errors in parentheses are heteroskedasticity robust and clustered by year.

	Dependent variable:						
	Percentage Allocation to						
	Risky Assets	*Equities*	*Risky FI*	*Alt*	*Risky Assets*		
Quantitative Investment Restrictions	0.027*** (0.008)	-0.012* (0.007)	0.014*** (0.002)	0.025*** (0.009)	-0.019** (0.007)	0.050*** (0.009)	0.039*** (0.009)
Asset Valuation	1.580 (1.260)	1.970 (1.400)	1.250** (0.489)	-1.630 (1.580)	-1.220 (1.490)	9.570*** (1.590)	6.550** (2.100)
Liability Discount Rate	0.486*** (0.124)	-0.038 (0.181)	0.015 (0.033)	0.509*** (0.132)	-0.063 (0.157)	0.781*** (0.171)	0.765*** (0.171)
Recognition of Unfunded Liabilities	-5.070*** (0.898)	-2.640** (1.250)	-0.134 (0.114)	-2.290** (1.010)	0.828 (0.773)	-3.340*** (0.775)	-6.00*** (0.935)
Minimum Funding Requirements	-0.025** (0.011)	0.014 (0.015)	-0.019* (0.011)	-0.020** (0.010)	0.029* (0.016)	-0.091*** (0.017)	-0.011 (0.012)
Risk-based Capital Requirements	-5.530*** (1.640)	-1.610 (1.280)	-0.873 (0.546)	-3.050*** (0.758)	-10.800*** (1.620)	-10.30*** (1.370)	-11.0*** (1.860)
Recovery Period	0.121*** (0.026)	0.213*** (0.056)	0.002 (0.011)	-0.094** (0.047)	0.240*** (0.043)	0.176*** (0.041)	0.128** (0.047)
Maturity	-0.087*** (0.018)	-0.092*** (0.019)	-0.001 (0.004)	0.006 (0.015)	-0.072*** (0.010)	-0.085*** (0.009)	-0.091*** (0.009)
Inflation Indexation	0.007 (0.006)	-0.005 (0.007)	0.003 (0.003)	0.010** (0.004)	0.012*** (0.004)	0.007 (0.004)	0.012** (0.004)
Size	0.106*** (0.026)	0.007 (0.022)	0.018*** (0.003)	0.081*** (0.017)	0.068*** (0.006)	0.052*** (0.008)	0.055*** (0.006)
Guarantee					2.300** (1.010)	10.600*** (1.110)	
Year FE	Yes	Yes	Yes	Yes	No	Yes	Yes
Country and Type FE	No	No	No	No	No	No	Yes
Fund FE	Yes	Yes	Yes	Yes	No	No	No
R^2	0.095	0.051	0.031	0.040	0.192	0.259	0.266
Adjusted-R^2	0.081	0.043	0.026	0.030	0.190	0.253	0.260
Nobs.	4059	4059	4059	4059	4059	4059	4059

Significance: *0.1, **0.05,***0.01

Table 5: Determinants of Allocation to Alternative Sub-classes

This table presents the panel regression investigating the impact of regulatory variables and individual characteristics on pension funds' allocation to alternative sub-classes, with fund and year fixed effects. Explanatory variables are regulatory choices and funds' individual characteristics. Coefficients are estimated by least squares on the within-transformed data. The five columns from left to right represent the result concerning all commodities, infrastructure, real estate, private equity, and hedge fund. Standard errors in parentheses are heteroskedasticity robust and clustered by year.

	Dependent variable:				
	Percentage Allocation to				
	Commodities	*Infrastructure*	*Real Estate*	*Private Equity*	*Hedge Fund*
Quantitative Investment Restrictions	0.002	-0.006***	0.002	0.012***	0.020***
	(0.001)	(0.002)	(0.002)	(0.004)	(0.003)
Asset Valuation	-0.090	0.094	0.395	-0.294	0.296
	(0.149)	(0.212)	(0.349)	(0.739)	(0.612)
Liability Discount Rate	0.018	0.004	-0.002	0.099***	0.099
	(0.011)	(0.011)	(0.043)	(0.033)	(0.073)
Recognition of Unfunded Liabilities	-0.146*	-0.426**	-0.993***	-0.665**	-0.385
	(0.088)	(0.210)	(0.265)	(0.261)	(0.481)
Minimum Funding Requirements	0.000	-0.002	-0.008	-0.020***	0.005
	(0.002)	(0.001)	(0.005)	(0.006)	(0.005)
Risk-based Capital Requirements	1.070***	-0.161**	-2.870***	-0.556**	-0.530*
	(0.301)	(0.080)	(0.695)	(0.235)	(0.271)
Recovery Period	-0.011**	-0.003	0.020*	-0.036**	-0.060
	(0.005)	(0.010)	(0.011)	(0.014)	(0.023)
Maturity	0.000	-0.002**	-0.004	0.012**	0.008
	(0.001)	(0.001)	(0.004)	(0.005)	(0.007)
Inflation Indexation	-0.001**	0.001*	0.005***	0.000	0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)
Size	0.005**	0.015***	0.025***	0.044***	-0.007**
	(0.002)	(0.003)	(0.008)	(0.009)	(0.003)
R^2	0.036	0.069	0.053	0.067	0.038
Adjusted-R^2	0.031	0.059	0.045	0.056	0.032
Nobs.	4059	4059	4059	4059	4059

Significance: *0.1, **0.05,***0.01

Table 6: Determinants of Allocation to Risky FI Sub-classes

This table presents the panel regression investigating the impact of regulatory variables and individual characteristics on pension funds' allocation to risky fixed income, with Fund and Year fixed effects. Explanatory variables are regulatory choices and funds' individual characteristics. Coefficients are estimated by least squares on the within-transformed data. The two columns from left to right show the results for all high yield bonds and mortgages. Standard errors in parentheses are heteroskedasticity robust and clustered by year.

	Dependent variable:	
	Percentage Allocation to	
	High Yield	*Mortgages*
Quantitative Investment Restrictions	0.020***	-0.003*
	(0.003)	(0.002)
Asset Valuation	0.296	-0.676***
	(0.612)	(0.261)
Liability Discount Rate	0.099	-0.056**
	(0.073)	(0.025)
Recognition of Unfunded Liabilities	-0.385	-0.046
	(0.481)	(0.153)
Minimum Funding Requirements	0.005	-0.018
	(0.005)	(0.013)
Risk-based Capital Requirements	-0.530*	-2.250***
	(0.271)	(0.848)
Recovery Period	-0.060***	0.009
	(0.023)	(0.013)
Maturity	0.008	0.000
	(0.007)	(0.001)
Inflation Indexation	0.000	0.001
	(0.002)	(0.001)
Size	-0.007**	0.017***
	(0.003)	(0.003)
R^2	0.051	0.058
Adjusted-R^2	0.043	0.069
Nobs.	4059	4059

Significance: *0.1, **0.05, ***0.01

Table 7: Determinants of Procyclical Asset Allocation –PC

This table presents the logit regression investigating the impact of regulatory variables, individual and institutional characteristics on pension funds' procyclicality in investment, with Year, Type and Country fixed effects. The procyclicality measure is as defined in (1). Explanatory variables are regulatory mechanisms and funds' individual characteristics. The four columns from left to right represent the result concerning all risky asset allocations, as well as their subcomponents: equities, risky fixed income (mortgage and high yield bonds) and alternatives (real estate, private equity, hedge funds, commodities, natural resources, infrastructure, and venture capital). Standard errors in parentheses are heteroskedasticity robust and clustered by year. McFadden's (1974) pseudo-R^2 is presented.[VIII]

	Dependent variable:			
	PC			
	Risky Assets	*Equities*	*Risky Fixed Income*	*Alternatives*
Quantitative Investment Restrictions	0.014***	0.019***	0.003	-0.002
	(0.003)	(0.003)	(0.004)	(0.002)
Asset Valuation	0.138	0.720	-0.784	-1.230**
	(0.546)	(0.698)	(0.704)	(0.501)
Liability Discount Rate	-0.146***	-0.096*	-0.160***	-0.029
	(0.050)	(0.058)	(0.053)	(0.043)
Recognition of Unfunded Liabilities	-0.056	0.181	-0.353	-0.245
	(0.247)	(0.326)	(0.284)	(0.235)
Minimum Funding Requirements	0.001	0.000	0.007*	0.007**
	(0.003)	(0.004)	(0.004)	(0.003)
Risk-based Capital Requirements	-0.660	-2.010**	-0.835*	-0.706*
	(0.560)	(0.828)	(0.454)	(0.408)
Recovery Period	0.028**	0.027*	0.021	-0.002
	(0.012)	(0.015)	(0.013)	(0.011)
Maturity	-0.002	-0.003	-0.001	-0.006***
	(0.002)	(0.003)	(0.003)	(0.002)
Inflation Indexation	-0.001	-0.001	0.003*	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
Size	0.000	0.000	0.011***	0.003*
	(0.002)	(0.003)	(0.002)	(0.002)
Pseudo-R^2	0.154	0.143	0.198	0.108
Nobs.	4059	4059	4059	4059

Significance: *0.1, **0.05, ***0.01

[VIII] This is $1-\frac{L_1}{L_0}$, L_1 is the log likelihood of the estimated model. L_0 is the log likelihood of the null model with only the constant term.

Figure 1: Time Series of Asset Drift Procyclicality Measure By Countries

Figure 1 shows the average of the procyclicality measure, $PC^{All\ Risky\ Assets}$, over funds in each year. The higher the measure, the more the funds in a particular country exhibit procyclical behavior.