Fiscal Implications of Pension Underfunding*

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Abstract

This paper analyzes the extent to which occupational pension systems in North America and Europe are likely to create financial stress for their sponsoring corporations and government entities. Across the five countries studied (U.S., Canada, Netherlands, U.K., and Germany), in most of the plans examined, benefit growth rates will have to decline or contribution growth rates will have to increase relative to the past decade if the level of unfunded liabilities is to be stabilized. U.S. occupational pension systems in general pose considerably greater financial risks to their sponsors than systems in the other countries, due to large gaps between contribution inflows and benefit outflows. This in turn stems from a high reliance on assumed investment returns as a funding strategy, an approach that would threaten to have similar adverse effects to the extent that it is implemented by non-U.S. plans.

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Introduction

Occupational defined benefit pension systems in North America and Europe currently provide trillions of dollars of investment capital for financial markets and support the retirements of hundreds of millions of individuals. These systems are characterized by pledges of streams of cash flows to current and future retirees, whose payout amounts depend on inputs such as years worked and salaries during the working career. Most systems fund these promises using portfolios of assets invested in securities whose values rise and fall with equity markets. While some systems devote part of the portfolio to asset-liability matching strategies to gain exposure to fixed income assets whose payout profiles will mirror that of the payouts, in most cases there is a substantial mismatch between the risk-return profile of the assets and the liabilities.

The mismatch between assets and liabilities at a large scale invites the question of whether underfunded pension systems pose a systemic risk to the global financial system or macroeconomy. The European Central Bank (2009) defines systemic risk as "risk of financial instability so widespread that it impairs the functioning of a financial system to the point where economic growth and welfare suffer materially." Beetsma and Vos (2016) argue that under this definition, there is no need in Europe to treat pension funds as systemically important institutions, citing stress tests by the European regulator EIOPA. Such stress tests (see EIOPA (2015, 2017)) examine the impact of a set of "one-off instantaneous shocks to asset prices and yields" to both national and market-consistent common balance sheets. These tests focus on the possibility that pension systems — which are in their current construction entities that leverage financial risk by promising fixed liabilities and funding them with risky assets — might amplify financial shocks and transmit them to the real economy.

Yet the nature of the risk that pension systems might pose for public finances and the economy are fundamentally longer-term in nature. The systemic question in the pension context is therefore not so much whether a financial shock could spark a financial crisis through the pension system but whether pension plans are sustainable in the absence of additional support or bailouts by the central government through either fiscal policy or central bank involvement in asset markets such as those for sub-national government paper. While systemic implications of banking and insurance may be best reflected through a comprehensive stress test analysis that examines robustness to asset market shocks, systemic implications of pension underfunding arise primarily through a much slower-moving fiscal channel.

This paper analyzes the evolution of market-value funding ratios over the past two decades in an initial sample of occupational pension systems in the U.S., Canada, U.K., Netherlands, and Germany. The sample consists of both corporate and public occupational systems. In addition to past and current funding status, simulations of system evolution under a range of different scenarios over the coming decade demonstrate the extent of risks that systems might pose to sponsors and the governments that serve as fiscal backstops. The scenarios begin from a baseline under which benefits and contributions both continue to grow at the rate at which they have grown over the past 10 years, and then consider a range of investment return scenarios including a risk-neutral expected return based on risk-free yields and an expected rate of return based on the historically estimated market loading of each system's investment returns.

The analysis focuses on the space of occupational pension systems that are not directly administered by a country's central or federal government. This includes pension systems sponsored by subnational governments, independent or semi-independent foundations, and companies.[1] I analyze the burden that occupational pension systems in North America and Europe are likely to place on their sponsoring corporations and governments, and discuss the possibility of whether extreme financial stress will have fiscal implications for central governments.

By placing international systems into a single, comparable framework, the analysis shows that U.S. pension plans, and particularly those in the public sector, pose unique fiscal threats and will place the greatest burden on sponsor solvency. However, across the five countries studied (U.S., Canada, Netherlands, U.K., and Germany), in most of the plans studied, benefit growth rates will have to decline or contribution growth rates will have to increase relative to the past decades if the level of unfunded liabilities to be stabilized. This raises the question of whether defined benefit pension system in some of the other countries studied (notably Canada and the U.K.) also pose longer-term challenges for their government and corporate sponsors if such measures are not taken.

1. What Type of Risk?

The European Central Bank (2009) defines systemic risk as "risk of financial instability so widespread that it impairs the functioning of a financial system to the point where economic

[1] The Canada Pension Plan is also included, even though it is administered by Employment and Social Development Canada (ESDC) a department of the government of Canada.

growth and welfare suffer materially." Such definitions of systemic risk undergird the financial stability and crisis prevention responsibility of the European Insurance and Occupational Pensions Authority (EIOPA). In the United States and United Kingdom, less attention has been paid to the notion that pensions would fit into this framework of systemic risk assessment. In the United States, the regulation of corporate occupational defined benefit plans is centered on compliance with the Employee Retirement Income Security Act (ERISA) and ensuring that corporations fund their defined benefit promises sufficiently so as to protect the financial position of the federal Pension Benefit Guaranty Corporation (PBGC). Similarly, the UK Pensions Regulator's primary statutory objectives are to protect the benefits of pension scheme members and to reduce the risk of calls on the Pension Protection Fund (PPF). The U.S. system of state and local pension systems that cover some 30 million current and future retirees is essentially outside the purview of federal government regulation.

Pension funds that are not fully funded or do not engage in full matching of investment assets to the cash flow profile of liabilities are fundamentally leveraged entities and therefore subject to financial risk. Consider first a pension fund that holds assets A_t and has accumulated liabilities whose present value L_t, measured by discounting promised benefits at a rate that appropriately reflects the fixed-income like nature of the benefit promise.[2] If $A_t = L_t$ and the assets are held in fixed-income securities whose income streams match those of the promised liability cash flows (or at least invested in duration-matched fixed income portfolios), then there is a perfect hedge and there is no financial risk. If $A_t < L_t$, but if the assets are still matched to a liabilities, then the system faces interest rate risk. To a first-order approximation the unfunded liability ($L_t – A_t$) increases by the same percentage as the liability L_t itself as interest rate rise or fall.

The more typical situation is one in which $A_t < L_t$, but there is a mismatch between assets and liabilities. If financial assets include stocks or stakes in private investments funds, their values will likely vary inversely with interest rates but not to exactly the same extent as the liabilities. Under a broader, more encompassing definition of liabilities, such as a projected benefit obligation whose present value is more closely linked to the evolution of wages in the economy, the equity component of financial assets may to some extend hedge against changes in liabilities caused by changes in real wages (Lucas and Zeldes (2006), Benzoni, Collin-Dufresne, and Goldstein (2007)). Nonetheless, given the share of projected liabilities in a typical pension plan that are already

[2] Accumulated benefits here is meant in the sense of an accumulated benefit obligation.

accumulated based on past service, there remains considerable asset-liability mismatch in pension systems with heavy risk loadings in equity markets.[3] In some settings, such as US public employee pension systems, this arrangement is in part justified by measuring liabilities using an expected rate of return in the risk assets in the pension fund instead of an appropriate fixed-income yield curve, making the reported value of liabilities greater than L_t and closer to the value of A_t (Novy-Marx and Rauh (2011a)).

Funding trillions of dollars of promised pension benefits with non-fixed-income assets is tantamount to taking large-scale leveraged investments in risk assets. This provides a suitable motivation to examine the risks that such a structure might pose for financial markets and the macroeconomy. There are several types of risk that it is important to examine.

Asset valuations: systems around the world invest in stocks, private equity, hedge funds, real estate, commodities and other risky asset classes, as well as both investment grade and speculative-grade fixed income securities. EIOPA has focused on stress-testing funding ratios in response to a sharp decline in the value of these assets. A longer-term consideration is whether the assets will deliver sufficient returns to pay the liabilities without extensive additional support from sponsors beyond current burdens.

Interest rate risk in liability valuations: The cost of providing a given stream of promised benefits is a function of the yield curves that determine the cost of annuities. If interest rates fall, the value of pension benefit promises increases. If interest rates rise, the value of these promises decreases. To the extent that assets are invested in matching fixed-income investments, these risks may be partially hedged. The accounting of most systems around the world recognizes this interest rate risk, although U.S. public systems rely heavily on the expected return on assets in stating the value of their liabilities as well as their annual pension costs (Novy-Marx and Rauh (2011a), Andonov, Bauer, and Cremers (2017)).

Correlations between assets and liabilities: The correlation between stock valuations and fixed income valuations has at times been positive and at times negative. During the financial crisis, stocks crashed and rates fell, so that a negative correlation between stock returns and bond returns turned into the "perfect storm" for pension funds. But after the financial crisis, stocks

[3] van Binsbergen, Brandt, and Koijen (2008) study the additional considerations arise when a centralized decision-maker such as a Chief Investment Officer employs multiple asset managers to implement and execute investment strategies in separate asset classes in the presence of ALM objectives.

recovered and rates fell further, so that the stocks at least served as a partial hedge for pension funds as rates dropped, a period over which the stock market return was positively correlated with the bond market. Pension funds are at greater risk if the correlation between bond returns and stock returns turns negative.

Evolution of liability: Defined benefit pension liabilities generally are determined as a product of a benefit factor (b), the number of years worked (N_t), and a final-average or career-average salary (Y_t). The evolution of the liability is therefore linked to a number of factors, including how long employees work in their benefits-eligible position at a given employer, how their salaries develop, and the evolution of benefit factors over time. Furthermore, correlations among these factors, asset valuations, and interest rate risk are important. The correlation of salaries with the value of equity assets gives equity assets some hedging properties. The question is whether this hedge is quantitatively strong over the relevant horizon, and for the relevant workers in defined benefit plans. Those in public sector occupations may have labor income that processes are more shielded from market movements even over moderately long horizons.

Too-big-to fail risks through insurance industry: In some markets, sponsors have bought themselves out of the obligation to pay pensions by entering into pension risk transfer (PRT) contracts with insurance companies. The International Monetary Fund (IMF) has expressed the concern that this might add to systemic risks surrounding too-big-to-fail insurance firms in the U.S. (IMF (2015)).

The approach of EIOPA to incorporate all of these risks is to examine funding ratios across the occupational pension schemes of European countries. EIOPA studies a current baseline as well as a “double hit” scenario in which risk assets decline in value by 20% and the 10-year risk-free yield returns to around 0%. That is, EIOPA is studying relatively short-term hits to asset valuations and interest rates and stress-testing the systems’ funding ratios. The main assessment of EIOPA is that the “IORP [Institutions for Occupational Retirement Provision] sector does not seem to exert direct financial stability effects in the same way and to the same extent as banking or insurance” (EIOPA (2015)).

In light of the possibility of short-run systemic liquidity risk across a range of non-bank institutions, the Financial Stability Board (FSB) which had been created by the G-20 began in 2015 a process to identify non-bank globally systemically important financial institutions that due to their size and interconnectedness could pose a threat to global financial stability. EIOPA’s stress tests seem to suggest that European pension systems are unlikely to spark or amplify a financial crisis. Other evidence in favor of this conclusion that pension funds do not pose this type of systemic risk is summarized by Beetsma and Vos (2016). Broeders et al (2016) find strong evidence that Dutch pension funds rebalance their asset allocations in the short run, thus exerting a stabilizing as opposed to amplifying influence on financial markets. If there is a chance that market declines might be amplified by pension funding arrangements, Beetsma and Vos (2016) argue that risk-based solvency requirements (which arise in part due to regulators' treatment of pensions as potentially systemically important) would be in part to blame.

Looking at pensions with the lens of a longer horizon, however, it becomes clear that while pension systems are unlikely to catalyze a short-run liquidity crunch or financial crisis, some do pose solvency and fiscal threats to their sponsors and the governments that either implicitly or explicitly backstop those sponsors. In the European context, EIOPA (2017) discusses sources of potential "support" for the funding ratio in the event of adverse movements in asset and rate markets. The two sources of support through which funding gaps are addressed are (i) sponsor support, when the sponsor is under the plan's rules or relevant statutes contractually obligated to increase contributions; and (ii) benefit reductions, when the plan has some built in stabilizers. These reflect what will happen under current laws and regulations. In addition, laws can change to both increase contributions and benefit reductions, although different legal regimes may permit such changes to a lesser or greater extent.

If sponsors such as governments and corporations are required to make up for large unfunded pension promises ("sponsor support"), there will likely be larger economic impacts, as shown increasingly in evidence from the US.[4] For example, Rauh (2006) demonstrates the impact of pension funding requirements on corporations in the US on corporate investment. Eide (2015) provides evidence that rising retirement benefit costs have caused California localities to underfund basic infrastructure maintenance needs at the state and local level. Nation (2017) shows that as pension funding amounts have increased, governments have reduced social, welfare and educational services, as well as spending on libraries, recreation, and community services.

Most recently, Mennis, Banta, and Draine (2018) provide a stress-test analysis of the fiscal risk of distress for U.S. public pensions in 10 states by considering how funding and burdens on

[4] From 1993 to 2007, GM spent $103 billion to fund legacy pensions and retiree health care (Lowenstein (2008)). Total earnings before interest and taxes (EBIT) over this time period was

state governments would evolve under a 5% investment return scenario and under an “asset shock” scenario in which there is a 20% investment loss followed by a recovery period of 10% annualized returns for three years, followed by a return to the 5% investment return scenario. Funding is simulated under two different budgetary settings – one in which government contributions are fixed as a share of projected future state revenue and one which would more closely adhere to states’ written contribution policies. The authors conclude that states with low funded levels that have already increased contributions may struggle to improve funding levels and reduce costs if target investment returns are not met, while states with funding policies that are not designed to respond to market downturns are also at risk of fiscal distress.

In the most burdensome cases, pensions contribute to sponsor insolvency. Lowenstein (2008) documents central the role that unfunded pension liabilities played in the bankruptcy of General Motors (GM), which filed for Chapter 11 protection in 2009. Lowenstein (2008) cites the fact that from 1993 to 2007, GM spent $103 billion to fund legacy pensions and retiree health care. Total earnings before interest and taxes (EBIT) for GM over this period was $139 billion, and net income was negative. Other major corporate bankruptcies in the US in which unfunded pension obligations were a significant share of total debts and unfunded obligations include United Airlines (2005), Delphi (2009), and Bethlehem Steel (2003).

Pensions also played a key role in the municipal bankruptcy of the City of Detroit, which filed for Chapter 9 protection in 2013. According to the city’s filings (US Bankruptcy Court Eastern District of Michigan (2013)), it had amassed $18.3 billion in debts, including $3.5 billion in unfunded pension obligations using actuarial discount rates. On a Treasury yield curve basis, however, Novy-Marx and Rauh (2011b) calculated Detroit’s accumulated unfunded liabilities at $6.4 billion, which would bring the total to $21.2 billion. Also included in the $18.3 billion were an additional $1.4 billion of pension-related debt certificates that had been issued in 2005 and 2006, and an additional $6.4 billion unfunded liability due to other post-employment retirement benefits (OPEBs). Pensions and post-retirement benefit obligations therefore comprised around two-thirds of Detroit’s total obligations at the time of its bankruptcy filing. Other recent municipal bankruptcies in which pensions were a significant share of total debts and unfunded obligations include Stockton (CA), San Bernardino (CA), and Jefferson County (AL).

Even though pension promises were one of the primary causes of the bankruptcies of both Detroit and General Motors, the protections offered to pensions through the legal processes invoked, combined with the political realities of renegotiation, led to these pension promises largely being preserved through the bankruptcies of both entities. The reorganized entities that emerged carried most of the pre-bankruptcy obligations. In the special circumstances surrounding the prepackaged bankruptcy of General Motors, the requirement to pay pensions was retained by the company, so the pension promise was not diminished. In typical U.S. corporate bankruptcies, the responsibility to pay pensions is transferred to the PBGC, along with the assets and liabilities of the plans, although pension payouts from the PBGC are subject to caps depending on the age of the recipient and the type of benefit. Currently this maximum stands at $64,432 per year for a single straight-life annuity. Even this usually covers the majority of pension payouts, so that in the language of EIOPA, most of the unfunded liability must be covered by either "sponsor support" or as an unfunded obligation of the U.S. federal government. In the municipal cases, pensions have been preserved almost in their entirety.

Cities and states are not part of the legal framework that entitles corporate pension claimants to the federal government support through PBGC. However, the state constitutions and status of many city and state entities in the U.S. severally limit the degree to which pensions can be reduced, even via technical adjustments such as an increase in the retirement age, unless limited to new hires after the date of the change. The strongest provisions are from states whose constitutions contain non-impairment clauses, such as Illinois and Michigan, but overall the examples are very few where a state or city has changed benefits for current employees in a meaningful way. Even after the unusual step of a sponsor bankruptcy, Detroit members saw a total of a 4.5% cut to base benefits and a reduction in cost of living adjustments. Thus, it is also the case that most of the unfunded liability in municipal cases has, at least up till now, been covered through the mechanism "sponsor support".

The U.S. Commonwealth of Puerto Rico provides another interesting example. Puerto Rico sought protection from creditors under federal U.S. laws in 2017 for $123 billion of debt and unfunded liabilities, of which $49 billion is unfunded pension obligations. This compares to 2017 estimated total general fund gross revenues of $10 billion.[5] While clearly the island has suffered from shocks due to population outflow and natural disasters, obligations to pay public employee pensions are now a large part of the financial challenge that Puerto Rico faces in emerging from its fiscal crisis. Puerto Rico's essentially unfunded retirement systems now have around 338,000

[5] See Puerto Rico Economic Indicators, Government of Puerto Rico.

members in total, which means that over 10% of the island's population is relying on a pension from one of the systems.

The above examples show that the combination of strong pension rights for beneficiaries in underfunded systems and heavy reliance by sponsors on risky assets has led to a large economic burden when sponsor support is the required remedy. At the other extreme, some systems have the equivalent of built in stabilizers through risk-sharing. As of 2006, the typical pension in the Netherlands consisted of an average-earnings defined benefit pension in which a nominal benefit was guaranteed, with indexation to prices or wages conditional on asset performance (Bikker and Vlaar (2007)). In that sense, to the extent that unfunded liabilities emerge, they are at least in part contractually redressed by benefit reductions, as reflected in EIOPA's assessment of the Dutch pension system.[6] Furthermore, the system of conditional indexation itself emerged in part as renegotiation of the pension contract after the market declines of 2000-2002 (Bikker and Vlaar (2007)), and that system now is likely to be renegotiated in the context of recent Dutch legislation establishing a transition of defined benefit assets and liabilities into a new defined contribution system.

Thus, when the pension rights of beneficiaries are weak as they are in the Netherlands, pension funding ratios are supported by benefit reductions. This contrasts with the U.S. public sector situation described above in which beneficiary pension rights are strong and measures that could introduce risk-sharing with beneficiaries have been almost completely limited to contribution increases and the introduction of new pension tiers for new hires. Many state and local governments have introduced new tiers of defined benefits with less generous benefit parameters for new employees. In 2017, both Michigan and Pennsylvania passed pension reform bills that introduced a 401(k) plan option for a large group of public employees. Neither state, however, went as far with these reforms as to close defined benefit elements entirely to new workers, as Michigan itself did for newly hired employees of its State Employee Retirement System (SERS) in 1997. Alaska also closed the DB plans in its Public Employee Retirement System (PERS) and its Teachers Retirement System (TRS) in 2006, putting all new employees onto 401(k) plans, and the City of San Diego undertook similar action in 2012 for its newly hired non-public-safety workers. These are the only major governmental entities in the U.S. that have

[6] EIOPA's assessment of the Dutch pension system found a funding ratio of 74% in the market-consistent adverse scenario, with almost all of the difference being compensated by benefit reductions (25 of the 26 percentage points).

moved even new employees to pure defined contribution plans, and courts have generally blocked more aggressive attempts to alter even prospective benefits for existing employees the U.S. public sector.

The laws governing the provision of retirement benefits by U.S. corporations in general are viewed to permit reductions to prospective benefits but not accumulated benefits. That is, if an employee's pension has a benefit factor b, and as of time t the employee has worked for N_t years at a final average salary of Y_t, the accumulated benefit obligation at time t is simply the present value of an annuity $b*N_t*Y_t$ beginning at retirement date $R = t+s$. This is in contrast to a projected benefit obligation in which the annuity that would be valued would be $E_t[b*N_{t+s}*Y_{t+s}]$ beginning at retirement date $R = t+s$. Firms under the ERISA framework must honor the accumulated benefit, including any promised cost of living adjustments, but may change future benefit accruals, including by freezing future pension accruals entirely. As of 2017, 24% of firms in the U.S. Fortune 500 had closed their defined benefit plan to new workers, while 42% had frozen pension accruals entirely, and 7% had terminated through risk transfer to insurance firms or via lump sums, leaving only 27% with open defined benefit plans (McFarland (2018)). Rauh, Stefanescu, and Zeldes (2017) find that freezing a defined benefit plan saves U.S. firms on average 3 percent of total payroll in the first year and the equivalent of 13.5 percent of the long-horizon payroll of current employees, net of increases to defined contribution pension packages. Freezing and defined benefit plans therefore may result in reductions to the value of pension benefits promised to employees, while alleviating financial pressure on the sponsor.

Looking forward, ultimately the risk to sponsors and governments backstopping them will depend on the joint evolution of three parameters: benefit growth rates, contribution growth rates, and asset returns. Specifically, in systems where benefits are growing rapidly and asset returns are modest, the sponsor will have to continue to increase contributions in order to maintain the solvency of the pension plan. The key risk is not one of panic that would lead to a freezing up of asset markets or a run, but rather the burden that paying pension promises over a long period of time will have on sponsors and governments. To the extent that this could be exacerbated by run-like behavior, it would be more likely to be on the side of participants choosing to withdraw from systems and take early retirement in large numbers if they sense a system is failing, as happened with the Dallas Police and Fire Pension System in Texas in 2016.

2. Assessment of Aggregate Pension Fund Solvency

Table 1 shows a compilation of assessments of aggregate occupational defined benefit pension fund solvency across four of the five countries examined in this study: the U.S., Netherlands, U.K., and Germany. The U.S. and Canada were selected to cover North America for the purpose of this study, but aggregated Canadian data were not available at the time of the study and hence Canada is not included in the table. The European countries were chosen as the EU countries with the largest occupational pension plan liabilities according to EIOPA (2018).[7]

The table provides extensive detail on the sources of each of these figures. The U.S. is divided into three sectors: public, corporate, and union (more formally known as multiemployer). The U.S. public sector calculations are from Rauh (2017). The U.S. corporate and union calculations are new calculations that I performed using the U.S. Department of Labor data files for the IRS 5500 filings, which are required filings for corporate single-employer and multiemployer occupational pension plans in the United States. In the U.K., Netherlands, and Germany, total actuarial liabilities are from the EIOPA (2018) market development report, while all the funding ratios presented for these countries are from the EIOPA (2017) IORP stress test report.[8]

Across all of these countries, but most of all in the U.S. and U.K., there are major differences between funding ratios as stated in national or corporate accounts ("actuarial") and market-consistent funding ratios. Market-consistent liabilities are described by EIOPA (2017) as "using market (risk-free) curves for the valuation of liabilities," which EIOPA is able to calculate by requesting that systems report projected cash flows underlying unconditional benefits. The U.K. occupational pension system has a 90% funding ratio using its own standards, but this drops to 64% when the appropriate risk-free market rate is applied. Novy-Marx and Rauh (2011a) and Rauh (2017) perform similar analysis on U.S. public pension plans. The pension reports of these governments themselves generally use expected rates of return on assets of around 7.5% per year to discount expected benefit cash flows.[9] These benefit cash flows are unconditional on investment

[7] Switzerland, however, had substantially larger occupational pension liabilities than Germany at CHF 707.9 billion as of 2014 (Bundesamt für Statistik (2016)), compared to €171 billion in Germany but below €1.257 trillion in the Netherlands.

[8] The market-consistent liability value can be inferred from these reported statistics, since EIOPA (2017) reports both stated and market-consistent funding ratios and EIOPA (2018) the stated value of liabilities.

[9] More specifically, traditional governmental accounting rules that applied to U.S. public sector plans encourage state and local governments to consider pension promises fully funded, assuming that the expected return on pension fund assets is met. This was somewhat modified by Governmental Accounting Standards Board (GASB) Statement 67

performance, but often are projected benefit obligations in the sense that they partially incorporate actuarial projections of how long employees will work and what future salaries will be.[10] Novy-Marx and Rauh (2011a) provide a methodology for converting these public sector disclosures to accumulated benefit obligations, and Rauh (2017) updates these calculations.

The calculations performed in Table 1 for U.S. corporate and union plans involve summing the actuarial liability across all plans to derive the total actuarial liability,[11] and summing the so-called current liability across all plans to derive the total market liability. Since the current liability uses rates that are still above what would be the weighted-average rate from a market yield curve, it is not exactly the market-consistent liability, but is substantially closer to it than the actuarial liability would be.

A number of authors have analyzed the question of the appropriate discount rate for pension cash flows. For a sponsor who wants to measure the present value of already promised benefits, the value of a replicating portfolio that would defease the liability would yield this measure. A number of authors have emphasized the usefulness of applying default-free yield curves to measure the present value of the accumulated benefit obligation liability (Bulow (1982), Brown and Wilcox (2009)). Novy-Marx and Rauh (2011) approximate this market-consistent default-free yield curve in valuing U.S. public pension liabilities using Treasury yield curves. They note that a pension promise is nowhere near as liquid as a Treasury, a factor that would point towards an appropriate valuation yield curve for pensions being above a Treasury yield curve. However, around 40% of public employee pension promises in the U.S. are directly linked to inflation (and more partially linked) a factor that would point towards an appropriate market-consistent valuation yield curve for pensions being below a Treasury yield curve. Even higher yields such as the yields on state or local government bonds would be appropriate only for a valuation of the accumulated benefits that credited state and local governments for their ability to default on these accumulated pension obligations, despite the restrictions against such actions discussed above. Overall therefore, the analysis of the literature is in harmony with the market-consistent liability approach by EIOPA (2017).

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which requires plans that foresee a point of exhaustion of assets to use a somewhat lower rate that blends the expected return with a high-grade municipal bond rate.

[10] This is done using an actuarial "entry age normal" method in which new liabilities accrue as a fixed percentage of worker salary throughout the career.

[11] More specifically, the stated liability is the actuarial funding target for single-employer plans and the actuarial valuation liability for multiemployer plans.

The table shows that U.S. public sector pension liabilities amount to \$4.97 trillion on the basis under which they are stated in governmental reports but \$7.44 trillion on a market-consistent basis. The funding ratio of these liabilities is 72% on a "GASB 67" actuarial basis[12] but only 48% on a market consistent basis. The U.S. corporate liabilities total \$1.88 trillion on an actuarial basis but \$3.08 trillion on a (near) market-consistent current liability basis, corresponding to funding ratios of 112% and 68% respectively. Note that U.S. corporate pension funds that present financial statements under FASB provide accounts under yet another method that discounts the liabilities using a high-grade corporate yield curve and would result in an aggregate valuation between the market valuation and stated valuation in Table 1.[13] U.S. multiemployer liabilities total \$0.614 trillion on an actuarial basis and \$1.212 on a (near) market-consistent current liability basis, corresponding to funding ratios of 78% and 39% respectively. The funding ratios of U.S. systems on a market consistent basis certainly present a picture of considerably lower funding ratios than on an actuarial basis.

These differences exist but are not nearly as pronounced for the Netherlands and Germany. In the Netherlands, the difference between actuarial and market consistent liabilities for occupational plans maps into a difference between a 98% funding ratio and a 92% funding ratio. For Germany, the funding ratio on an actuarial basis would be 107% and on a market-consistent basis 87%. The U.K. occupational pension sector resembles in some ways the U.S. corporate sector. The aggregate U.K. funding ratio is 90% of the stated £1.825 trillion in liabilities, but only 64% of the market-consistent £2.566 trillion.

Finally, Table 1 also presents the market-consistent funding ratio after an "adverse" market event according to EIOPA (2017). Funding ratios would be only 45% in the U.K., 74% in the Netherlands, and 71% in Germany after a 20% decline in asset values and a sharp downward shift of the valuation yield curve. EIOPA (2017) notes however, that in the case of the Netherlands most of this difference would be compensated for by benefit reductions, given the built-in stabilizers in the conditional indexation provisions in those plans. In the other countries sponsor support would play a larger role, and thus unfunded liabilities would stress the financial position of the sponsor.

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[12] GASB is the U.S. Governmental Accounting Standards Board.

[13] Discounting the corporate pension liabilities using the corporate bond yield treats the pension obligations as dischargeable in the same states of the world as other unsecured claims on the firm, which is perhaps accurate from the perspective of shareholders in the firm given the option to put the pension liabilities to the PBGC.

Total market-consistent liabilities for occupational plans in these four countries sum to \$11.7 trillion in the U.S., plus £2.6 trillion in the U.K., plus €1.5 trillion in Germany and the Netherlands. At end-of-year 2016 exchange rates, the overall total liabilities represented in the table amounts to \$16.5 trillion in U.S. dollars. Unfunded liabilities using a similar calculation are \$5.6 trillion in the U.S. plus \$1.1 trillion in the U.K. (£0.9 trillion) and an additional \$0.14 trillion (€0.13) in the two EU countries studied, for a total of \$6.8 trillion in unfunded liabilities.

3. Historical and Current Funding Ratios in International Sample

Within the countries selected based on the conditions explained in Section 2, the following criteria were used to select the sample of individual occupational plans analyzed in the main analysis. The five largest corporate plans were identified in each country, and the five largest public plans or multiemployer plans were identified in each country. Data were obtained from the annual reports and actuarial reports of the pension plans and their sponsoring employers for contributions (employer, employee and additional government), benefit payments (including withdrawals), the market value of assets, the stated value of liabilities, the discount rate used in the reports for the stated value of liabilities, and the level of investment income (or realized percentage return on assets).

The requirement for inclusion was at least 10 years of historical data (2007-2016) on these key components. In some cases, data were unavailable on key components (such as liabilities) and so the plans were omitted, e.g. German public sector plans. In the cases of U.S. states, the sample was enlarged by (i) collecting additional major plans sponsored by the same state (e.g. Texas Teachers Retirement System was one of the largest five public occupational plans, so Texas Employees Retirement System data were collected as well as a separate plan); and (ii) a sample of large, distressed, U.S. plans were included: Puerto Rico, New Jersey, Illinois Teachers, Central States, and Chicago Police. Overall, there were 55 plans for which at least 10 years of historical data could be collected. Data on membership for the plans is incomplete but overall the plans across the five countries studied are estimated to cover around 50 million workers.

In addition, data on market interest rates was collected from a variety of sources. Assuming that the duration of pension liabilities is 15 years, a 15-year zero coupon bond will be a single market yield that closely approximates the correct yield to measure stated liabilities on a default-free basis. Appendix 1 details the construction of these 15-year zero coupon yields from public sources. To calculate the market value of liabilities, a simple discount rate correct was applied to the stated value: $(1 + R)^{15}/(1 + r_{15,ZC})$, where R is the reported rate used by the system and $r_{15,ZC}$ is the 15-year zero-coupon calculated as described in Appendix 1. To derive an estimate of the historical beta for each system, the historical series of annual investment returns for each system is regressed on the return on the value-weighted stock market index (VWRETD) from CRSP.

The top section of Table 2 presents summary statistics as of 2016 for the assets and liabilities of each of the systems in the sample. The mean level of assets in the systems studied is \$59.6 billion, with average liabilities at \$86.1 billion under the stated measures and \$140.9 billion under the market-consistent measure. While the U.S. public, U.S. Non-Public, and Non-US plans have roughly the same average asset values, the U.S. plans have considerably larger liabilities. The average stated funding ratio is 74.7% across all 55 plans in the sample, but non-US funds are considerably better funded with 94.1%. Stated funding ratios in the U.S. plans average only 48.0%, much lower than the 72% documented in Table 1, due to the inclusion of the distressed plans in the sample and the fact that these plans are generally required by GASB 67 to use rates that are considerably below the expected returns due to projected asset exhaustion. On a market basis, the funding ratios fall to an average 25.8% for U.S. public plans and 75.2% for non-US plans, with the US non-public plans (corporations and union plans) in between.[14]

Table 2 also presents summary statistics on the historical levels of contributions relative to benefits. In the 10 years to 2016, contributions are 77% of benefit payouts across plans. For U.S. public plans they average only 54.1%, and for U.S. corporate and union plans they average 27.8%, whereas for non-US plans this ratio is over 1. This shows the extent to which U.S. public plans are relying on investment returns to maintain their asset levels, whereas in contrast the contributions paid into and the benefits paid out of plans are relatively balanced. In recent years, however, contributions have on average been lower than benefits even in the non-US plans, as shown by the row *Contributions [3yr] / Benefits*, which is the average of the contributions of years 2014-2016 scaled by 2016 benefits. Averaged across all plans in the sample, contributions have grown faster than benefits over the past 10 years (4.5% versus 4.0%), which is driven by increases in contributions by U.S. plans. The non-U.S. plans have seen benefit growth outpacing contribution growth on average.

[14] Note that the 2016 valuation date implies a 15-year zero coupon yield of 1.94%. As of June 2018, these rates were 150 basis points higher.

Finally, the bottom panel summarizes the discount rates used across plans in the calculation of the stated liabilities and the market liabilities. The stated liability discount rate is collected directly from the comprehensive annual financial reports. The market liability discount rate is the country-specific and reporting-date-specific 15-year zero-coupon yield ($r_{15,ZC}$). Discount rates for reporting purposes (R) average 4.1% across all plans in the sample, 5.9% in U.S. public plans, and 3.2% in non-US plans.[15] The 5.9% is an average of the non-distress and distress U.S. sample, as plans in Puerto Rico and New Jersey are using municipal bond rates consistent with GASB 67 reporting requirements. Estimated betas for U.S. public plan assets are 0.52, compared to 0.46 for non-public and 0.34 for non-US plans.[16]

Figure 1 shows the evolution of the average stated funding ratio and average market-consistent funding ratio in two balanced panels: one over the years 2007-2016 for which all 55 plans in the sample are included, and one over the years 1999-2016 for which complete data were only available for 30 of the plans. The 1999 panel series are shown on the left axis and the 2007 panel series are shown on the right axis. The dashed lines show the liability on a stated basis using system-chosen discount rates. The solid lines show the liability on a market basis using country-specific 15-year zero-coupon yields. The level of the funding ratio in the longer panel is lower, but the patterns over time are very similar. Funding ratios fell sharply over 1999-2001, recovered somewhat during 2002-2007, fell steadily again over 2008-2012, and then recovered marginally over 2013-2016.

In Figure 2, the sample is divided into U.S. and non-U.S. plans. The graphs show that the recovery in funding ratios in 2002-2007 was much stronger in non-U.S. plans compared to U.S. plans, and that the decline since 2007 has been much steeper for U.S. plans compared to non-U.S. plans. The graphs also demonstrate a steady downward deterioration in funding ratios for U.S. plans over the entire period, as opposed to a sharp decline due to one market crash. Funding for U.S. plans in particular seems to decline during periods of equity market decline, but not to rise during periods of equity market recovery. This pattern is seen to a lesser extent in the non-U.S. plans, particularly in the most recent time period of strong equity market returns.

[15] For the U.S. corporate plans the stated discount rate (R) is the current liability rate as opposed to the actuarial rate, which was referred to in Table 1 as the "near" market rate.

[16] Since these are betas based on annual data, they may be held down by slowness in marking illiquid assets to market.

Funding ratios are fundamentally driven by several components. On the asset side, the key drivers are contribution payments (positively), benefit payments (negatively), and investment returns (positively). On the liability side, the key determinants are the valuation discount rate, the rate of new service accruals, benefit payouts, and the plans' actuarial assumptions and modeling decisions. Figure 3 depicts the evolution of the ratio of contributions to benefits for U.S. and non-U.S. plans. In the U.S., over the past 10 years the ratio of contributions paid-in to benefits paid-out has been stable at around 0.5. Outside the U.S., there is evidence that this ratio has declined from over 1.0 to the range of 0.7-0.8 more recently. The fact that the ratio of contributions to benefits is relatively low and has not increased in the U.S., while it has decreased from somewhat higher levels outside of the U.S., contributes to explaining why the funding ratio in the U.S. has slowly deteriorated and why the funding ratio outside the U.S. has not strongly recovered since the financial crisis of 2008. The history of investment returns themselves is shown in Figure 4.

Another way to visualize these factors is to examine the return that would have been necessary in each year to keep assets stable, and the return that would have been necessary each year to keep funding ratios stable under a fixed discount rate assumption. Each panel in Figure 5 shows the history of two calculations of necessary returns to achieve (i) a stable asset level given contribution inflows and benefit outflows; and (ii) stable funding level (in dollar terms) given contribution inflows, benefit outflows, and a fixed 2.5% liability discount rate. Formally, the solid lines show the within-year median value of the quantity $(B_t - C_t)/A_{t-1}$ where B_t represents benefits, C_t represents contributions, and A_{t-1} represents lagged assets. The dashed lines shows the within-year median value of the quantity $(B_t - C_t + \Delta L_{t,t-1})/A_{t-1}$ where $\Delta L_{t,t-1}$ is the change in liabilities that would have been reported under a fixed 2.5% discount rate.

The top graph in Figure 5 shows these quantities in the U.S. public plan sample. The return required to keep assets stable given the difference between benefits and contributions has risen from around 3% in 2005 to 5% in 2016. The return required to keep the funding level stable in dollar terms is substantially higher at around 11% in 2016 and fluctuating well above 10% during the entire period under study. This difference reflects the fact that liabilities are increasing due to any of several factors: a growing workforce, an aging workforce, the granting of benefit increases; plan choices to recognize benefit promises that were previously unrecognized; actuarial losses in which factors such as longevity deviated assumptions; or changes in assumptions going forward about inputs into the cost of providing pensions.

The middle graph of Figure 5 shows a different pattern for U.S. corporate and union pension plans. Here the level of investment returns required to keep assets stable has been around 5% over the entire time period, and the level of investment returns required to keep unfunded liabilities stable in dollar terms has fluctuated around a much lower level than in the U.S. public setting, ending at around 2.5% per year in 2016. This is presumably due to the fact that corporations in the U.S. have undertaken many measures to slow, stop, or reverse the growth of pension liabilities, through soft pension freezes, hard pension freezes, and pension risk transfers respectively.

The bottom graph of Figure 5 illustrates that for non-U.S. systems, the asset returns needed to keep the level of assets stable was around zero for much of the time period studied, and has recently increased to around 1.3% as benefit increases have outstripped contribution increases. The asset return needed to keep the level of unfunded liabilities stable declined from around 10% during the first decade of the 2000s to around 5% in the post-crisis era and below 4% in 2016. Liability growth outside the U.S. plans has therefore not been as controlled as liability growth in the U.S. corporate plans, but not as high as liability growth in the U.S. public plans.

Overall then, what explains the deterioration of the funding status of U.S. public pension plans? Benefit payouts have grown strongly, investment returns have been volatile, and interest rates have declined. To maintain the funding ratio, U.S. public plans would therefore have had to increase contributions even more than the 5.5% annualized growth in contributions over the past 10 years, and/or to have managed to restrain liability growth as U.S. corporations and some non-U.S. pension systems have done.

4. Forward Simulation of Funding Ratios

In this section, I present the results of a forward-simulation of funding ratios under the modeling assumption that benefits and contributions each continue to grow over the coming 10 years as they have over the preceding 10 years for each system. Specifically, beginning with A_t at the 2016 level of assets, B_t at the 2016 level of payouts, and C_t at the average of level contributions over 2014-2016, I assume that assets evolve according to the following equation of motion:

$$A_{t+1} = A_t * (1 + r) - B_t * (1 + g_b) + C_t(1 + g_c).$$

The results from four asset return scenarios are analyzed: (i) a baseline in which $r = r_{15,ZC}$; (ii) $r = 0$; (iii) $r = -2\%$; and (iv) $r = r_{15,ZC} + \beta * MRP$, where the market risk premium (MRP) is set to 5%. Liabilities are assumed to grow at the rate $r_{15,ZC}$ each year. Contribution growth (gc) is censored at zero for the purposes of the simulation. That is, if contributions have contracted over the ten years to 2016, g_c is set to zero for the purposes of the simulation.

Figure 6 illustrates the results of these simulations for each sample plan with more than $1 billion in liabilities in the sample and for which no data points were missing (a total of 40 plans). The results are ordered in ascending order of the plan's 2016 market-consistent funding ratio. The 2027 funding ratios are presented on the linear scale and are censored at –20% (–0.2) at the bottom and 80% (+0.8) at the top. A funding ratio of below zero indicates that asset exhaustion has occurred and that additional resources have been required to pay benefits.[17] The markers on the scales represent the 2027 simulated market-consistent funding ratio under the four different asset return scenarios.

On average, the market-consistent funding ratio declines for the plans in this sample from 56.8% in 2016 to a projected 34.2% in 2027. The worst-funded systems in as of 2016 include the Puerto Rico systems (one of which was already depleted of assets) and the systems in the distress sample of U.S. funds: the Chicago Police, Illinois Teachers, New Jersey pension funds, and Central States. The systems whose funding positions are expected to deteriorate the most are those with the weakest levels of contributions relative to benefits, including several U.S. corporate plans, the Central States union plan, the pension systems of Puerto Rico and the State of New Jersey, and teachers retirement systems in which contribution rules are not closely linked to actuarial assessments (such as CalSTRS).

This approach of course builds in a continuation of very rapid contribution increases in some systems. For example, the 10-year contribution growth rates of four systems were over 10% per year over the past 10 years (General Motors, Illinois Teachers, British Airways APS, and Daimler - Germany), and the simulation assumes contributions continue to grow at these rates. Sensitivity analysis that caps contribution growth rates at 2% per year indicates that average projected 2027 funding ratios are on average approximately 5 percentage points lower than they would otherwise have been, driven heavily however by systems with these very high recent growth rates of contributions.

[17] For example, a funding ratio of -20% indicates that additional assets have been drawn on the sponsor in the amount of 20% of the projected 2027 liability.

Remarkably, only 7 out of the 40 systems would see improvements in funding ratios over the coming 10 years under the baseline assumptions, despite the assumption of continued contribution growth: Canada Pension Plan, Illinois Teachers, the Dutch Plans PFZW and Metaal en Technik, General Motors, and the Daimler plans, the latter two of which are among those in which the rapid contribution growth rates of the last 10 years will be the least plausible to sustain. Under the market return assumption with historical betas, this figure rises to 16 plans.

5. Conclusion

The results in this paper demonstrate that most occupational pension systems in the countries studied will have to increase contribution growth rates and/or decrease benefit growth rates if they wish to stabilize funding ratios over the coming decade. Solvency analysis should therefore focus on the long-term and ask whether the "sponsor support" (requirement for increased contributions) that is built into some systems will be feasible for the sponsor without creating substantial fiscal hardship. In the U.S., the unfunded liability across all non-federal occupational pension systems (state, local, corporate and union) of $5.63 trillion has risen to 30% of U.S. GDP, despite substantial contribution increases and a long-running bull market. In the U.K. the unfunded liability implied by EIOPA's 64% market-consistent funding ratio across all occupational pension plans would be £0.924 or 47% of U.K. 2016 GDP. If "sponsor support" is the legally required remedy, this will place a non-trivial burden on the sponsors.

In other areas, such as the Netherlands, these issues have largely been dealt with via a system of flexible benefit arrangements, which could otherwise be called weak pension rights. The introduction of conditional indexation in the Netherlands in the last decade, and the foreseen conversion of many plans to a collective DC scheme, allows the growth rate of benefits to be managed. The U.S. corporate sector is also one of comparatively weak pension rights, since pensions can be frozen at the will of the company. This is in contrast to the public sector pension landscape in the U.S. where pension rights are quite strong and there are substantial legal restrictions to undertaking actions that will slow the growth of benefits.

Systems in this study who have seen the largest growth of unfunded liabilities are the ones that are contributing considerably less than the benefit outflow and relying on assumed investment returns to make up the difference. If there is one clear lesson from the multi-decade history of pension systems here, it is that this practice imposes substantial risks on either sponsors or beneficiaries or both.

These findings raise a number of important questions. From an investor perspective, what disclosures should investors require when investing in the securities issued by entities that also sponsor pension promises? European and Asian banks and investors have taken an increased interest in U.S. taxable municipal bonds, for example. Underlying current statements of funding ratios is a wide range of technical assumptions, and different regimes very clearly allow different degrees of changes to pension benefits. At a minimum, an understanding of the degree to which unfunded liabilities will be redressed through benefit cuts versus contribution increases ("sponsor support" in the language of EIOPA) is important for understanding sponsor risk.

The largest question from a regulatory (if not macroprudential) standpoint is: what is the appropriate regulatory regime to restore solvency to the U.S. state and local systems, and to prevent systems in the U.K. and Canada from potentially following the same path? Lucas (2017) advocates systems that delink disclosure and funding requirements, as the question of appropriate measurement of pension liabilities is considerably less controversial than the question of optimal funding levels of funding strategies. The market-consistent measurement basis using yield-curves that approximate the relative risk or safety of pension promises is well-understood, so requiring disclosures on this basis should not be controversial. However, that leaves the question of what funding regulations are necessary to prevent defined benefit pension systems from taking excessive risks in their funding strategies that could harm taxpayers, shareholders, and/or pension beneficiaries. This becomes a particularly important question when there can be externalities from unfunded liabilities beyond the systems and their sponsors. The existence of the PBGC in the US, the PPF in the UK, and the possibility of even a partial, implicit federal guarantee for sub-national unfunded public pension liabilities in the event of a crisis, raise the stakes for national regulators. Governments must consider the negative impact that pension failures could have on national taxpayers if a bailout of "too-big-to-fail" sub-national states or companies with large unfunded pension liabilities cannot be prevented.

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Table 1: Compilation of Assessments of Aggregate Pension Fund Solvency

	Total liabilities (Actuarial)	Total liabilities (Market)	Funding Ratio		
			Stated	Market Consistent	Market Consistent Adverse Scenario
US - Public (2015)	$4.967	$7.435	72%	48%	
US - Corporate (2016)	$1.878	$3.075	112%	68%	
US - Union (2015)	$0.614	$1.212	78%	39%	
UK - (2016)	£1.825	£2.566	90%	64%	45%
Netherlands - (2016)	€ 1.257	€ 1.339	98%	92%	74%
Germany - (2016)	€ 0.171	€ 0.210	107%	87%	71%

Note and Sources:

US - Public is from Rauh (2017). Total actuarial liabilities are on a GASB 67 basis, which are entry age normal liabilities using for the most part expected rates of return on plan assets (liability-weighted average discount rate 7.39%). The stated funding ratio uses the actuarial liability and the reported market value of assets. Market liabilities are calculations by Rauh (2017) as an accumulated benefit obligation (ABO) assuming a 10-year duration and using the 10-year point on the zero-coupon yield curve.[18]

US - Corporate are author's calculations based on the US Employee Benefits Security Administration's public data of IRS 5500 Schedule SB filings for the 2016 plan year. Actuarial liabilities are the so-called funding target from IRS 5500 filings (liability-weighted average discount rate 6.06%). The stated funding ratio uses the actuarial liability and the reported market value of assets. Market liabilities are calculated assuming a 15-year duration and using the 15-year point on the zero-coupon Treasury yield curve.

US - Union are author's calculations based on the US Employee Benefits Security Administration's public data of IRS 5500 Schedule MB filings for the 2015 plan year. Actuarial liabilities are the valuation liability (average discount rate 7.37%) and market liabilities use points on the yield curve corresponding to approximate durations of active and retired employees provided by the Pension Benefit Guaranty Corporation (PBGC).

UK, Netherlands and Germany - Total actuarial liabilities are from EIOPA (2018) and funding ratios on a stated, market consistent, and market consistent adverse scenario basis are from EIOPA (2017). The adverse scenario foresees a 20% decline in asset values and downward shift in the yield curve in which the 10-year risk-free yield drops to close to 0%. Total market liabilities do not appear in the EIOPA (2018) report but can be inferred from the EIOPA (2018) stated liabilities and the stated and market-consistent funding ratios which do appear in EIOPA (2017).

[18] GASB 67 disclosures that reveal the sensitivity of the net pension liability to a 1% change in discount rates suggest a duration of public pension liabilities around the GASB 67 discount rate of approximately 11 years.

Table 2: Summary Statistics as of 2016

This table shows means and standard deviations as of 2016 for all of the 55 pension systems in this study. Assets and Liabilities are in billions of US dollars, converted using market exchange rates as of the date of the system's comprehensive annual financial report. Liabilities on a stated basis are GASB 67 liabilities for U.S. public plans, the FASB liability for US corporate plans, and the technical provision for non-US plans. The zero-coupon yield is the estimated yield on a country-specific 15-year coupon default-free security as of the date of the report from which the liability figures are collected (see Appendix Table 1). Beta is calculated by regressing the investment return within a system on the return on the value-weighted stock market index (VWRETD) from CRSP.

	All N=55	US Public N=20	US Non-Public N=7	Non-US N=28
Assets ($ billion)	59.6	60.2	58.4	59.5
	(78.8)	(83.3)	(23.2)	(86.2)
Liabilities ($ billion, stated)	86.1	91.3	76.9	84.6
	(140.6)	(111.1)	(14.4)	(175.5)
Liabilities ($ billion, market)	140.9	185.5	87.9	122.6
	(262.9)	(257.9)	(17.5)	(300.7)
Funding ratio (stated)	0.747	0.480	0.734	0.941
	(0.346)	(0.325)	(0.223)	(0.249)
Funding ratio (market)	0.556	0.258	0.640	0.752
	(0.322)	(0.166)	(0.188)	(0.272)
Contributions [10yr] / Benefits [10yr]	0.770	0.541	0.278	1.056
	(0.526)	(0.157)	(0.160)	(0.571)
Contributions [3yr] / Benefits	0.662	0.552	0.209	0.853
	(0.497)	(0.148)	(0.126)	(0.603)
Benefit growth 10yr (g_b)	0.040	0.046	0.009	0.044
	(0.063)	(0.065)	(0.027)	(0.069)
Contribution growth 10yr (g_c)	0.045	0.055	0.038	0.039
	(0.042)	(0.032)	(0.056)	(0.045)
Discount rate (R)	0.041	0.059	0.039	0.032
	(0.020)	(0.017)	(0.003)	(0.017)
Zero coupon yield ($r_{15,ZC}$)	0.019	0.020	0.030	0.015
	(0.007)	(0.002)	(0.000)	(0.007)
Beta (β)	0.423	0.524	0.460	0.340
	(0.208)	(0.216)	(0.105)	(0.193)

Figure 1: Evolution of Average Funding Ratio in Balanced Panels (International)

This figure shows the average funding ratios on both a stated and market basis in balanced panels. One balanced panel begins in 1999, and the other begins in 2007. The 1999 panel series are shown on the left axis and the 2007 panel series are shown on the right axis. The dashed lines show the liability on a stated basis using system-chosen discount rates. The solid lines show the liability on a market basis using country-specific 15-year zero-coupon yields.

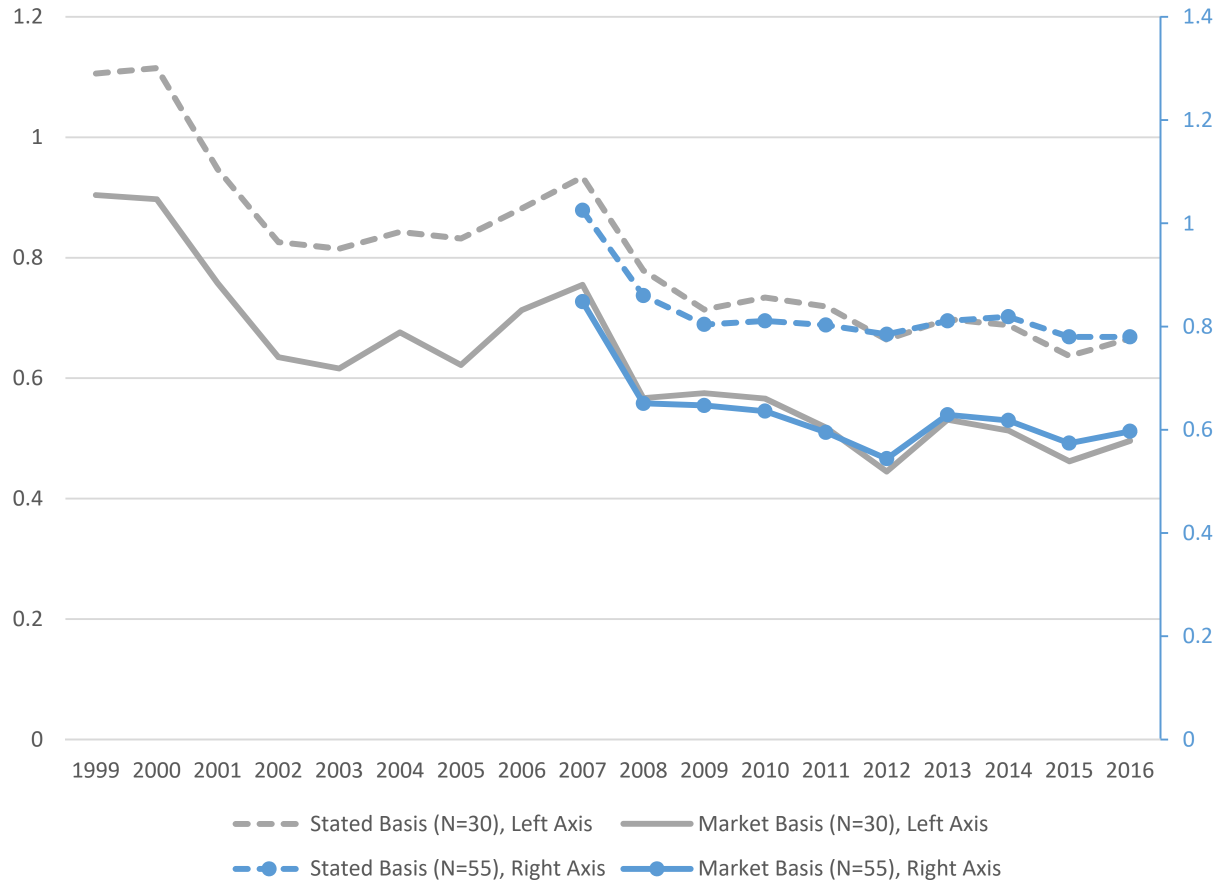
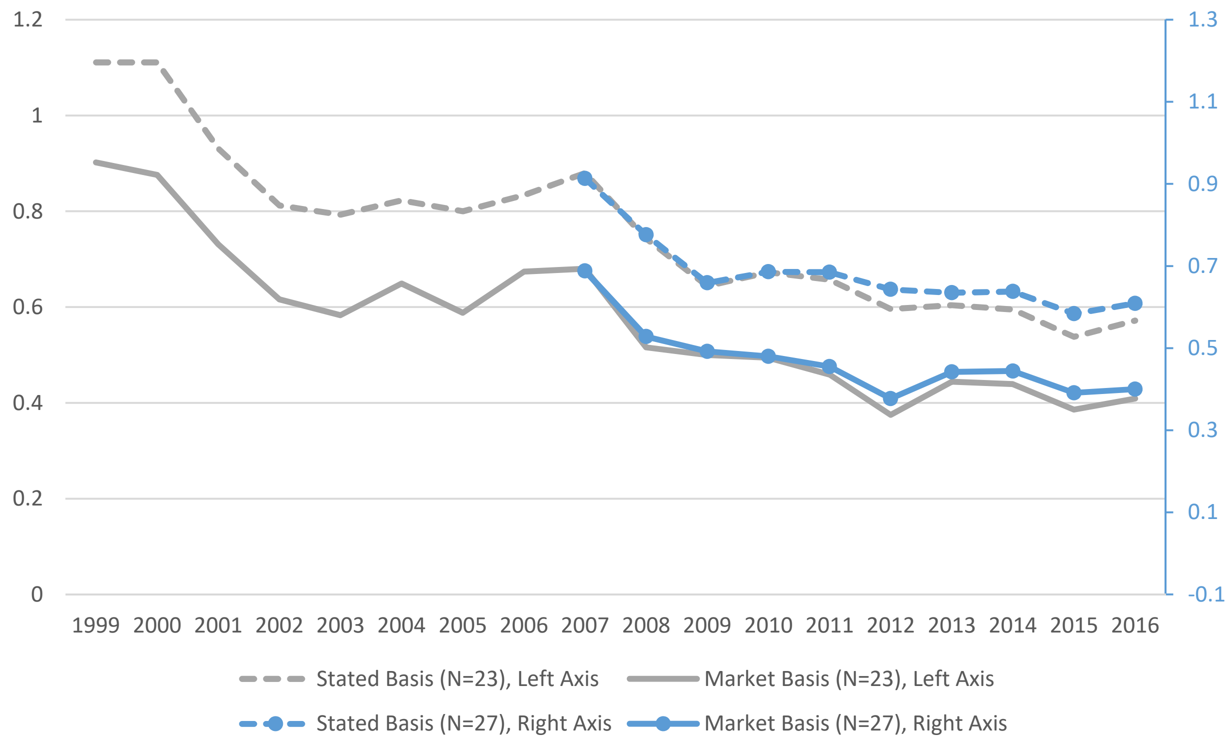


Figure 2: Evolution of Average Funding Ratio in Balanced Panels (US and Non-US)

These figures repeat Figure 1 in US only (Panel A) and non-US only (Panel B) subsamples.

Panel A: US Only



Panel B: Non-US Only

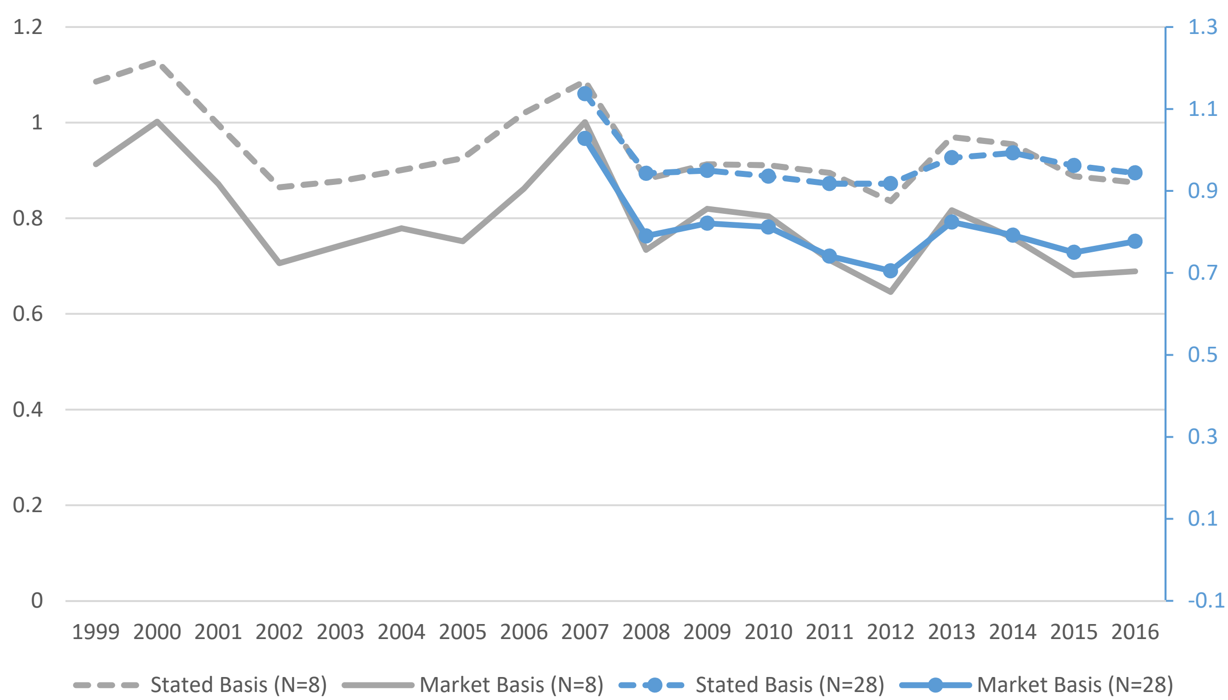
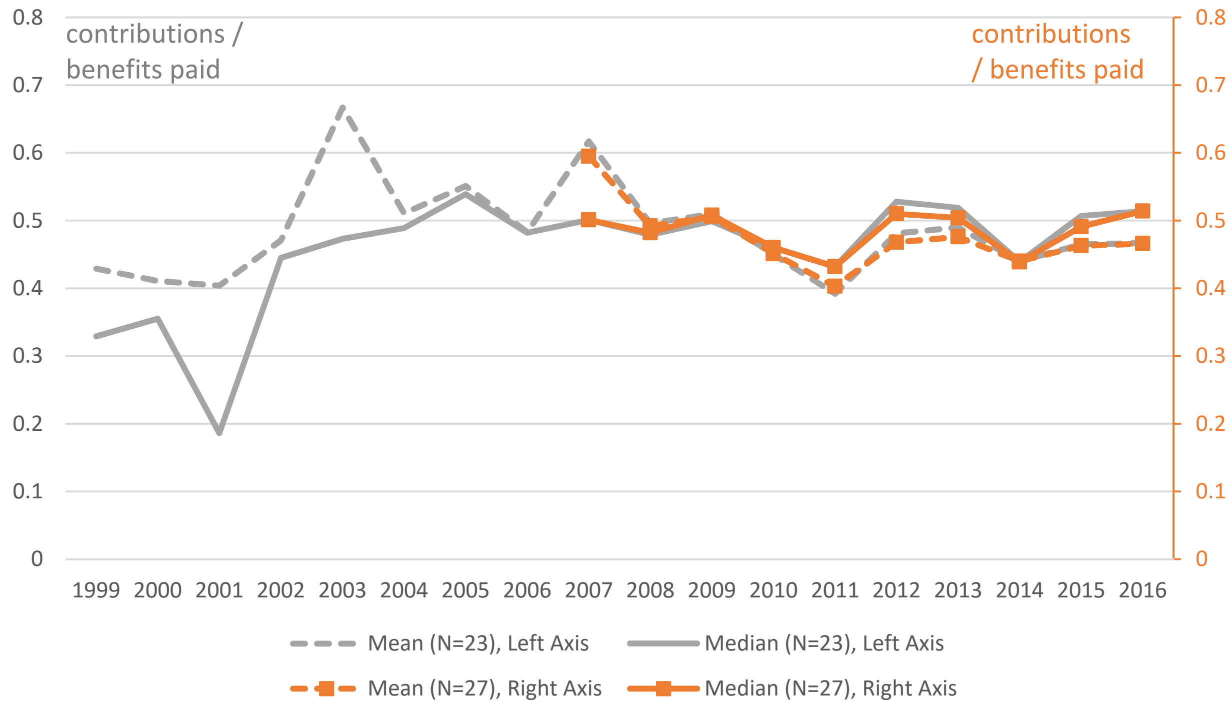


Figure 3: Evolution of Average Ratio of Contributions to Benefits (US and Non-US)

This figure shows the evolution of the ratio of contributions to benefits paid for US systems (Panel A) and Non-US systems (Panel B) in balanced panels.

Panel A: US Only



Panel B: Non-US Only

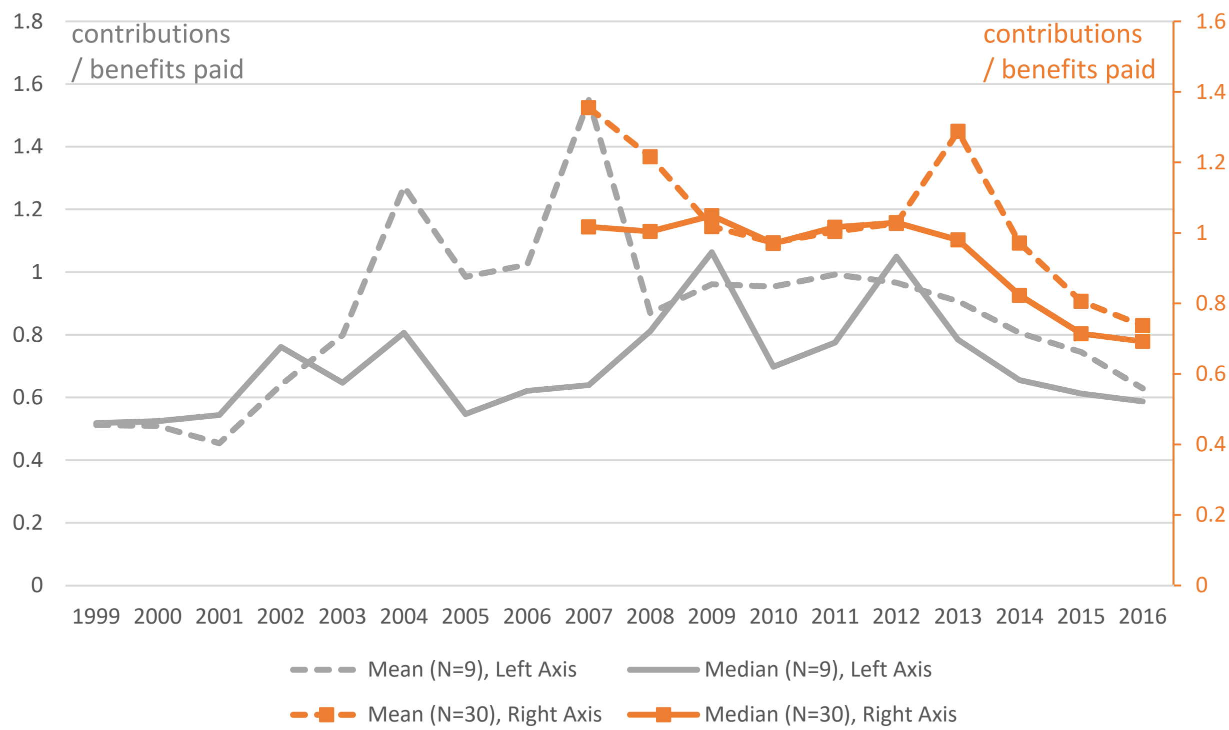
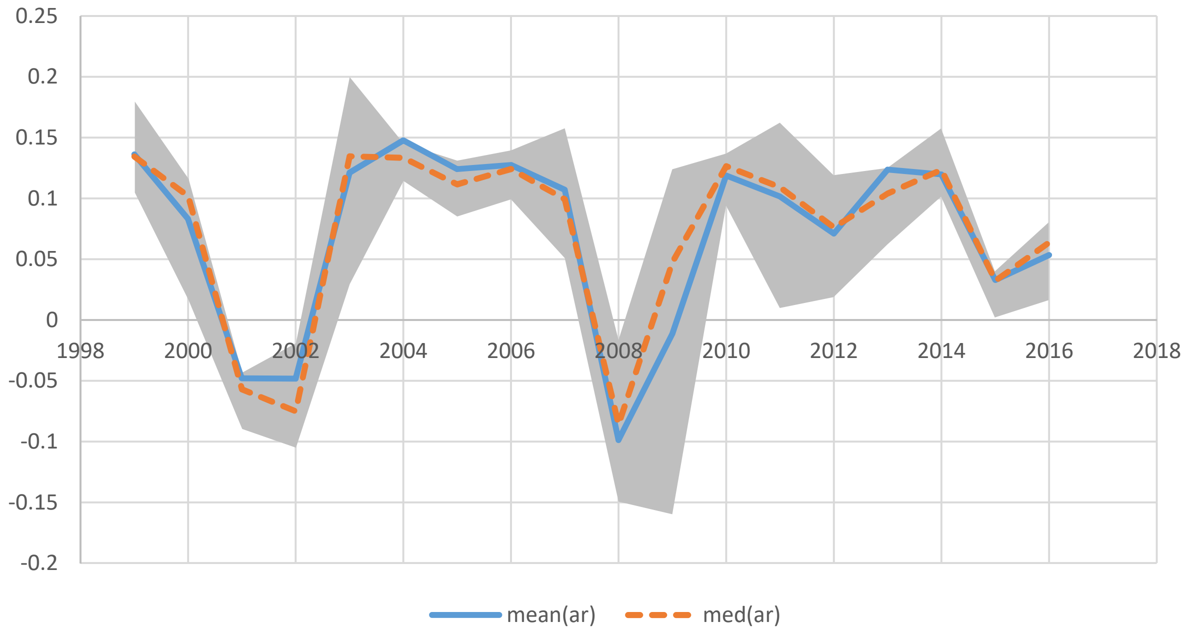


Figure 4: Realized Pension Fund Returns in Balanced Panels

This figure shows average and median one-year investment returns in balanced panels. The gray shaded area shows the interquartile range.

Panel A: Balanced Panel, 1999-2016 (N = 30)



Panel B: Balanced Panel, 2007-2016 (N = 47)

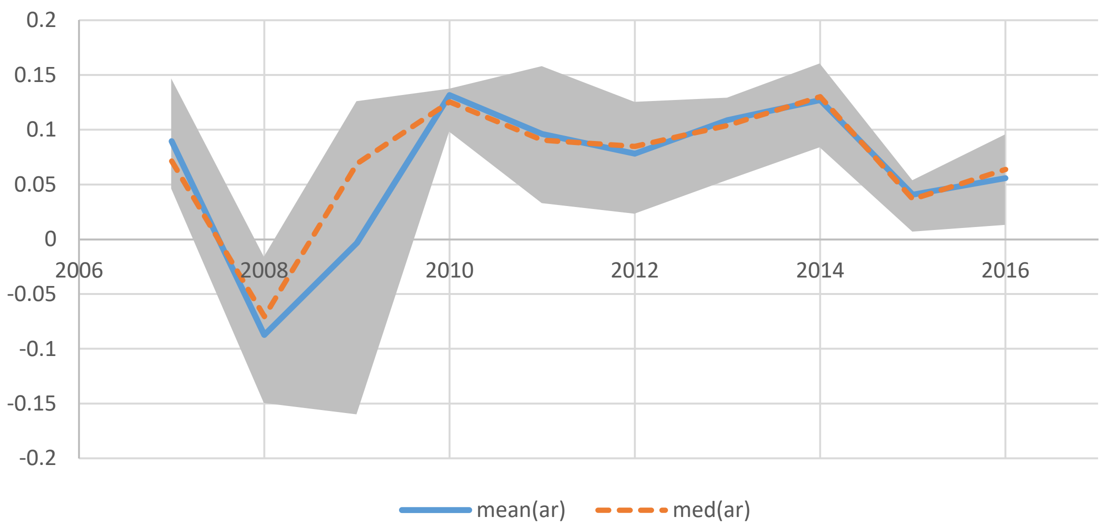


Figure 5: Returns Necessary for Stable Asset Levels and Funding

Each figure shows two calculations of necessary returns to achieve (i) a stable asset level given contribution inflows and benefit outflows (solid line); and (ii) stable funding level given contribution inflows, benefit outflows, and a fixed 2.5% liability discount rate (dashed line). The figures show the median of these values across plans in the three subsamples. Specifically, the necessary return to keep asset levels stable is given by calculating the cash flow shortfall (benefits minus contributions) and scaling by lagged assets. The calculation for a stable funding level does the same but also requires the asset return to pay for any increases in liability not due to changes in discount rates. That is, the two calculations are equal only if liabilties do not change from year to year.

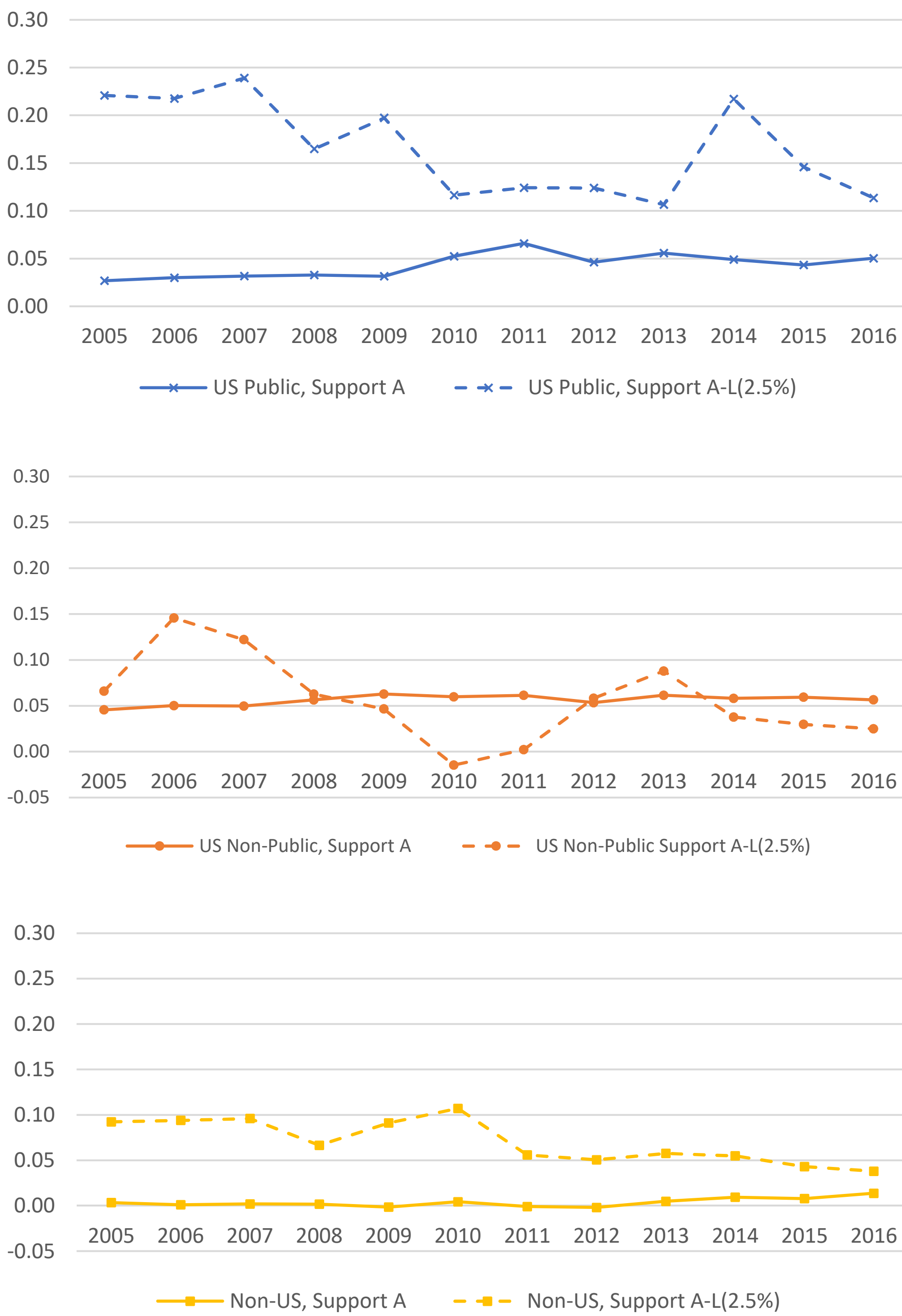
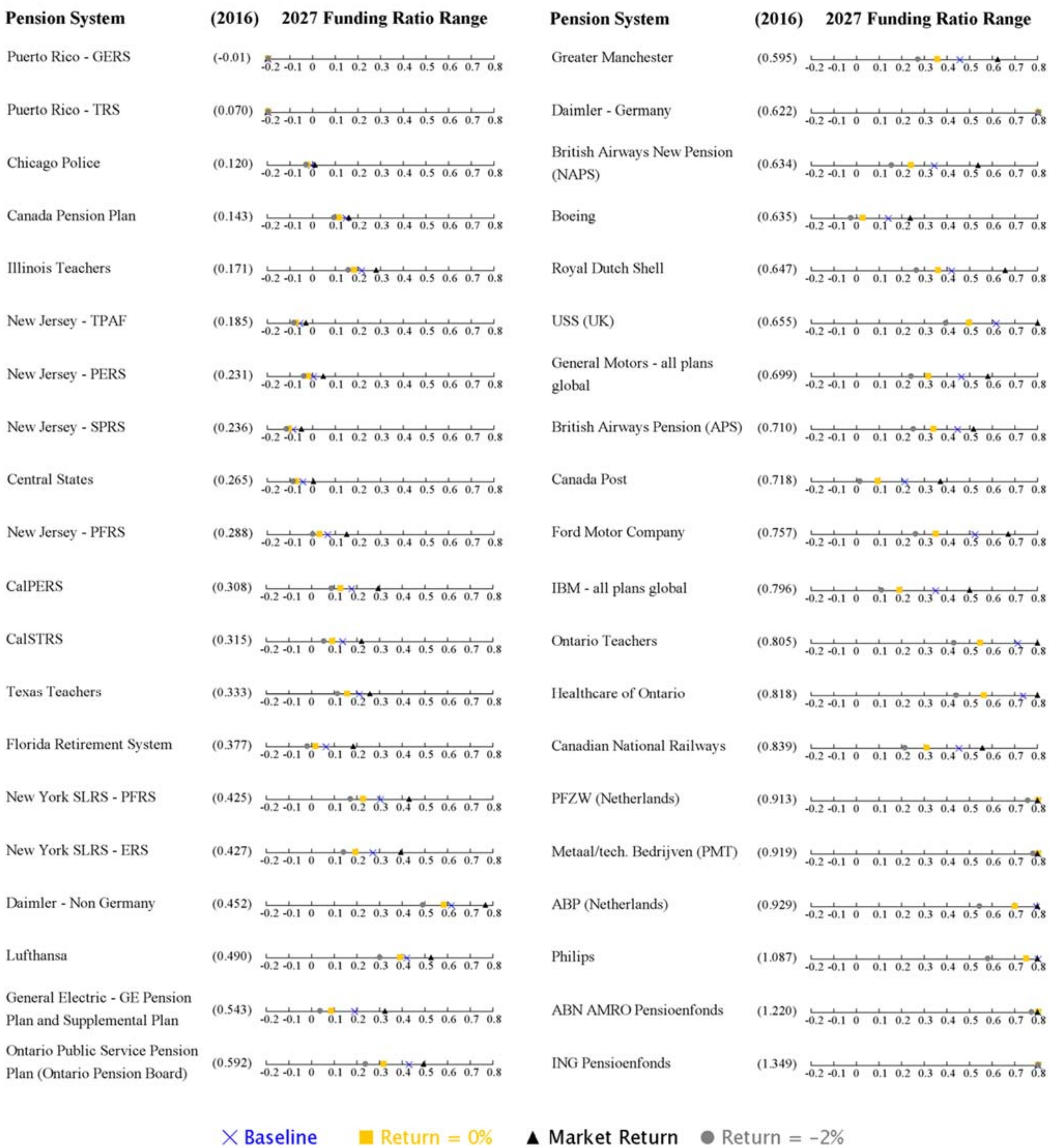


Figure 6: Market-Consistent Funding Ratios Simulated to 2027 with Comparison to 2016

This figure shows the 2016 market-consistent funding ratio for all sample plans with more than $1 billion in liabilities, and the results of a simulation that projects a continuation of benefit growth and contribution growth from the previous decade. Four funding ratio points are calculated for 2027: the "baseline" which assumes that the asset return will be the zero-coupon yield; a zero-return scenario; a –2% annualized return scenario, and a scenario under which returns equal the zero-coupon yield plus each systems measured beta times a market risk premium of 5%. 2027 funding ratios are censored at -0.2 at the bottom and +0.8 at the top.



Appendix 1

This appendix details the sources for zero-coupon yields in the five countries examined in this study.

Canada: The source is the Bank of Canada's interest rates and bond yield curves, series ZC1500YR, the 15-year zero coupon yield.

Germany: Deutsche Bundesbank series BBK01.WZ3439, providing the yield on a zero-coupon security with a residual yield of 15 years.

Netherlands: The 15-year point from the De Nederlandsche Bank (DNB) in the nominal interest rate term structure for pension funds (zero-coupon) is used.

United States: The Federal Reserve's FRED database contains series DGS10 and DGS20, which are the 10-year Treasury and 20-year Treasury constant maturity rates as calculated by the Federal Reserve and published in its Selected Interest Rates (H.15) statistical release. These the yields on coupon-bearing bonds of 10- and 20-year maturities. I assume that the average of these represents the approximate yield on a 15-year coupon bond, and raise that yield by the spread between the 10-year zero coupon bond (given by THREEFY10) and the 10-year coupon bond. The 10-year zero coupon bond (THREEFY10) is based on methodology from Kim and Wright (2005).

United Kingdom: The source is the Bank of England, which provides series IUQMNZC and IUQLNZC as 10-year and 20-year nominal zero coupon yields. A simple average of these two is used as the 15-year zero coupon yield.