Adequacy of Bond Supply and Cost of Pension Benefits: A Financial Economics Perspective

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Abstract

Despite a large literature studying the link between population aging and financial market returns and some limited studies on the market implications of the pension reform, little has been done to quantify the actuarial impact of an asset allocation shift by pension funds. The latter has become particularly important for plan sponsors who view pension obligations through a financial economics lens. Financial economics points to the importance of matching assets and liabilities in reducing the risk of pension funds. In this context, pension funds may undertake a shift from equities to long-term bonds. Depending on the supply of bonds and other macroeconomic factors, bond prices and yields may or may not be affected, which has implications for the cost of providing pension benefits. The paper attempts to fill the gap in the literature by empirically assessing the adequacy of the supply of bonds, quantifying the price impact, gauging the actuarial cost, and proposing appropriate government policy measures. We find that the supply of long-term bonds is far from sufficient to meet the growing demand by pension funds. The inadequate supply may result in a statistically and economically significant impact on bond yields and an actuarially significant impact on the cost of providing pension benefits. The ramifications should not hold back the shift to bonds by pension funds. Instead, governments should take effective measures to spur bond supply.

Keywords: Pension cost; Financial economics; Demand and supply; Long-term bonds; Asset allocation; Pension funds

1. Introduction

The recent focus on a financial economics approach to pension plans and accompanying reforms may prompt pension funds to change their investment allocation strategies. Plan sponsors who view pension obligations through financial economics lens would choose to weight their portfolios towards fixed income assets. The financial economics perspective has also spurred increasing momentum towards new regulatory and accounting rules, which would compel pension funds to employ asset liability management (ALM) as their investment strategies, resulting in more allocation to fixed income securities.

The shift in allocation strategies may raise important questions concerning the impact on bond yields and resulting effects on the cost of providing benefits for the pension fund universe. Whether the shift to bonds from equities could affect bond prices will depend on, among other things, the balance between bond demand and supply. If bond supply falls short of demand, bond prices may go up and bond yields may go down. The adequacy of bond supply may have significant actuarial implications as the imbalance may not only increase the cost of purchasing an immunized portfolio, but also hike pension liabilities.

Despite a large literature studying the link between population aging and financial market returns and some limited studies on the market implications of the pension reform, little has been done to quantify the actuarial impact of such a potential move of pension assets from a financial economics perspective. Goldman Sachs (2004) and Morgan Stanley (2004) offer mixed evidence on the market impact of the pension reform. However, in talking about the so-called yield curve conundrum, the Federal Reserve Chairman Ben Bernanke in one of his speeches said that "Changes in the management of and accounting for pension funds are a third possible source of a declining term premium." Bank of England also acknowledged the impact of the imbalance in pushing down long-dated gilt yields.

The paper attempts to fill the gap in the literature by empirically assessing the adequacy of the supply of bonds, quantifying the price impact, gauging the actuarial cost, and proposing appropriate government policy measures. We start off by discussing the investment strategies of pension funds under the new regulatory landscape based on the financial economics theory. We then investigate the current asset allocation in pension funds. Using a combination of databases, we compile demand and supply data for long-term government bonds and high quality corporate bonds by pension funds in twenty advanced economies: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States. We then compare the supply with the projected demand of bonds based on investment strategies of pension funds. Moreover, we apply econometric techniques to quantify the impact of the imbalance on bond yields by controlling for various fundamental macroeconomic factors such as growth, inflation, fiscal policy, and monetary

policy. We further translate the impact on yields into cost effects on pension benefits. In the end, we examine the role of governments in developing markets for long-term bonds and real-return bonds and suggest policy measures to increase bond supply.

We find that the bond supply may be far from adequate and the substantial inadequacy may lead to statistically, economically, and actuarially significant implications. In particular, we illustrate that with the rapid developments of pension funds and relatively moderate increase of bond supply, the inadequate supply could be substantial. Pension assets are more than five times the sum of corporate and government bonds, although there are large variations across countries, types of instruments, and maturity segments. In addition, we demonstrate that the impact of stepping up purchases of long-term government bonds and high quality corporate bonds on reducing bond yields is statistically and economically significant. A one percentage point increase of pension flows lowers corporate yields by at least 28 basis points and Treasury yields by 20 basis points. We further show that the yield reduction would in turn raise the cost of pension markedly. Our most conservative estimates reveal that the bond shortage would increase pension liabilities by at least 4 percent and normal cost by at least 8 percent in one year.

The paper contributes to the literature in several ways. To our knowledge, we are the first to examine this important issue with a large cross section of countries, cover both corporate bonds and government bonds including inflation-indexed bonds, and employ econometric analyses. Although OECD (2005) and IMF (2004) have also looked at the adequacy issue, they cover fewer countries and focus only on government bonds while we assess the adequacy using data of government and high quality corporate bonds from G-20 advanced countries, which more accurately reflect the investment profiles of pension funds in reality. Though Goldman Sachs (2004) and Morgan Stanley (2004) measure the yield impact of pension reforms, the impact concerns only 10-year treasuries while we examine 30-year treasuries and high quality corporate bonds in addition to 10-year treasuries. Neither of the studies addresses the actuarial implications while we dig deeper to translate the impact of long bond yield changes to pension cost. Finally, none of the studies present an econometric framework as we do in the paper.

The rest of the paper is organized as follows. Section 2 describes the potential change of investment allocations under the new approach and new regulatory landscape. Section 3 reviews the current asset allocation pattern in pension funds across G-20 countries. Section 4 illustrates demand and supply of both government and corporate bonds in G-20 markets. Section 5 estimates the yield impact of bond purchases. Section 6 quantifies the actuarial cost of providing benefits. Section 7 discusses governments' role and makes some proposals. Section 8 concludes.

2. What investment strategies should pension funds take from a financial economics perspective?

Financial economics theories have important implications for pension funding, accounting, and investment. The differences between traditional actuarial and financial economics approaches have been discussed by Bader and Gold (2003), Day (2004), Hardy (2005), and Joint AAA/SOA (2006). From a financial economics perspective, plan sponsors should invest predominately in fixed income securities. Putting theory into practice, the Boots Company has invested a vast majority of its pension assets into bonds [1]. In this section, we elaborate on the rationale.

Several arguments have been floated in support of the bond allocation[2]. First, pension benefits resemble bonds and thus bond investments by pension funds could match liabilities and reduce the interest rate risk. Second, investing in bonds could take advantage of the tax benefits of bonds for corporate plans. Third, with plan assets invested in a matching bond portfolio, capital markets would be more transparent and more efficient as actuarial assumptions would be less affected by judgment. Fourth, an equity-to-bond shift in pension funds adds value for shareholders and local taxpayers in a transparent financial environment.

Financial economics theories regarding pension plans have driven the global reform of pension regulations and accounting standards. An example is the new pension funding rules in the U.S.— the 2006 Pension Protection Act (PPA). PPA imposes stricter funding requirements and reduces a great deal of smoothing for measuring assets and liabilities, resulting in high volatilities of funded status and contribution requirements[3]. Similarly, other advanced countries such as Denmark, Japan, the Netherlands, Sweden, and the United Kingdom have also reformed their pension funding rules by moving towards market-based valuations of pension liabilities. On the accounting side, the recent Financial Accounting Standards Boards (FASB) No. 158 statement requires U.S. companies to report the funded status of pension plans in their financial statements, leading to wild fluctuations in their balance sheets. The next phase of FASB project will focus on the measurement of pension expense and income, which is reflected on an employer's income statement. The U.S. accounting standards will converge with those of the International Accounting Standards Board, a move in line with the global trend as most advanced countries have gradually implemented the international accounting standards. The accounting reform is expected to increase the transparency of pension accounting standards, which should result in a significant equity-to-bond shift in pension assets in the near future. Many surveys of plan

[1] Back in 2001, Boots even adopted an all-bond strategy. For details, see Ralfe, Speed, and Palin (2004). Due to the difficulty of matching ultra-long pension liabilities with the bond maturities available, it has since then raised the proportion of its assets invested in equities to 10 percent (Financial Times, October 9, 2005).

[2] See Bader (2003), Bader and Gold (2007), Moriarty (2006), and Ruloff (2004).

[3] For various proposals for pension funding reform, refer to Siegel and Genno (2005).

sponsors indicated that the new accounting and regulatory changes could lead them to increase bond allocations and extend the portfolio duration. Consequently, plan sponsors could stabilize their funded status and contribution requirements[4].

In response to the new climate, characterized by higher funding targets, greater contribution requirements, more transparent pension accounting, and volatile stock markets, more and more plan sponsors have employed ALM as their pension investment strategies. Instead of an asset-only focus, plan sponsors are designing investment policies that better incorporate liability structure of plans. As an important part of the ALM, many pension funds have adopted strategies based on liability-driven investment (LDI). The liability-driven approach is achieved by shifting a higher percentage of plan assets into longer duration fixed income securities, or by adding derivatives to extend the portfolio duration. Despite the merit of not having to own the underlying security while using derivatives, there is evidence that the implementation of LDI using derivatives is slowing because of the current credit crisis and the counterparty risk. Therefore, LDI strategies will mostly be accomplished by shifting more plan assets to fixed income securities.

3. What is the current asset allocation pattern in pension funds?

Do the current investment strategies of pension funds reflect the financial economics approach? We examine in this section the current asset allocation pattern in pension funds across twenty developed economies: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States. We focus on developed economies since asset allocations and pension funds in emerging markets are quite different from those in advanced economies (Xiao, 2007). Although pension funds tend to invest in many asset classes other than bonds and equities, we focus below on the two categories only as they represent the bulk of their investments.

To facilitate comparison, Figure 1 shows the investments of pension funds in bills and bonds in G-20 developed economies using data from OECD Global Pension Statistics[5]. Large variations exist among different countries. Countries such as Demark, Norway, Spain, and Sweden invest more than half of their assets in bills and bonds. However, countries such as Belgium invest less than five percent of its assets in bills and bonds. On average, pension funds in G-20 advanced economies allocate slightly more than one third of assets in bills and bonds. Figure 2 shows the investments of pension funds in equities[6] in G-20 developed

[4] See Archer and Gulliver (2005).

[5] Fixed income securities in mutual funds are not included since the allocation of equities and bonds in mutual funds is not specified.

[6] For the same reason as described in footnote 5, equities in mutual funds are not included.

economies. Similar to allocations in bills and bonds, different countries exhibit large variances. Equity allocations range from 5 percent in Greece to 66 percent in Ireland. With the exception of Ireland, the United Kingdom, and Australia, all countries invest less than half of their assets in equities. Comparing allocations in bills and bonds with those in equities for each country, pension funds in Australia, Belgium, Canada, Germany, Ireland, Japan, the United Kingdom, and the United States invest less in bills and bonds than in equities.

Since the OECD data do not differentiate defined benefit plans and defined contribution plans, we rely on data from the Federal Reserve Flow of Funds for asset allocations in defined benefit plans. In the United States, the Federal Reserve Flow of Funds[7] (2008) shows that corporate defined benefit plans invested in fixed income securities in the amount of $598 billion at the end of 2007, representing less than 23 percent of the total pension fund assets. However, more than 53 percent of the total pension fund assets are held in equities. For state and local pension funds, pension plan asset invested in fixed income securities were $800 billion as of the end of 2007, representing 25 percent of total pension fund assets. Equity holdings were $1987 billion, representing almost 63 percent of the total pension fund assets.

The dominance of equities is not surprising given that plan sponsors had been steadily increasing equity allocations until recently. Bull markets during the 90s encouraged pension plan sponsors to step up their exposure to equities. Over the long term, equities have been shown to provide higher return than bonds, which would lead to lower contributions or better benefits. Equities also provide good protection against inflation in the long run. However, the equity risk premium may not be sufficient to compensate for the risk that increases over time. With the global move towards fair value accounting that limits actuarial smoothing, plan sponsors are forced to reduce equity exposure.

There is already some evidence showing this trend. According to the survey of the largest DB plans conducted by Pyramis (2008), corporate plans reduced their equity allocation by about 6 percent while increasing fixed income allocation by 4 percent during 2006-2008. LDI usage was more than doubled from the 2006 level to 36 percent in 2008. Looking into the future, about 40 percent of plan sponsors, compared to less than 30 percent of plan sponsors two years ago, anticipate increasing their exposure to fixed income investments. The big change from equity to fixed income represents, among plan sponsors, a shift in

[7] In the Flow of Funds, corporate bonds and foreign bonds are grouped together and there is no way to separate the two. However, foreign bonds are likely to be of very minor importance and can be ignored. For example, the Public Fund Survey (2008) shows that foreign bonds make up only 0.8 percent of pension assets in 2007. Moreover, for the same reason in footnote 5 and 6, fixed income securities and equity holdings from the Flow of Funds exclude those in the mutual funds category throughout the paper.

thinking to a liability-driven investment strategy for their pension plans seeking to curb the future volatility of their funded status.

Demand for long-term fixed income securities is poised to grow further. A rapidly aging population in most advanced economies has driven stricter matching regulations governing pension funds in the Netherlands, United Kingdom, France, and other jurisdictions. As mentioned in section 2, changes in regulatory standards and the adoption of new international reporting standards have increased the focus on LDI by pension funds. New international accounting standards such as fair value accounting expose more clearly the interest rate risk on the liability side of the balance sheet, thereby reinforcing the need to match pension funds' assets and long-term liabilities. This is leading to a reallocation of the assets of many pension funds toward long bonds. Long-term bonds provide a natural hedge against interest rate risks and offer attractive convexity characteristics.

In this section, we show that the current asset allocation of pension funds are largely equity dominated. However, global demand for long-term fixed income securities is widely expected to rise for reasons we already discussed including new risk-based regulations, new international accounting standards, asset-liability matching techniques, and projections of rapidly aging and longer-living populations. Then the next question is whether there is sufficient supply of instruments to meet the ever increasing demand, which is the focus of our next section.

4. How does demand stack up against supply?

One simple and intuitive measure of potential excess demand can be obtained by comparing the size of pension fund balance sheets with the amounts of outstanding long-term bonds with a residual maturity of 10 years or more. Such a measure could be indicative to highlight the potential excess demand assuming that all pension funds consider long-term bonds as the only suitable investments and that they attempt to shift all of their assets into such instruments.

Reflecting potential demand, Table 1 shows the size of pension funds in G-20 developed economies during 2001-2007 using data from OECD Global Pension Statistics. With the exception of Japan, all the countries demonstrate impressive growth. In particular, pension funds in Australia, Austria, France, Spain, and Sweden more than triple in size in seven years. Figure 3 plots the importance of pension funds relative to national economy in 2007. It varies greatly by countries ranging from little importance in Greece to great importance in Denmark. In particular, pension funds in Australia, Canada, Denmark, the Netherlands, Switzerland, and the United States are larger than the national economy measured by nominal GDP. On average, pension funds in G-20 advanced economies amount to half of the size of national economies.

As a partial indication of bond supply, Table 2 shows the size of government bond markets in G-20 advanced economies during 2001-2007 using data from OECD Central Government Debt Statistics. Although modest compared to the rapid development in pension funds, all the countries have seen a marked growth in government bond markets with substantial variations ranging from a 16 percent to a 172 percent growth rate. Bond markets in Austria, France, Germany, Greece, Ireland, Norway, Portugal, Switzerland, and the United Kingdom experienced more than 100 percent growth. Figure 4 plots the importance of the government bond market relative to the national economy in 2007. It varies greatly by countries ranging from 5 percent in Australia to 118 percent in Japan. Outstanding government bonds in Austria, Belgium, Greece, Italy, Japan, and Portugal reach more than half of the size of the national economy measured by nominal GDP. On average, outstanding government bonds in G-20 developed economies amount to 42 percent of the size of national economies.

However, not all outstanding government bonds are long-term bonds. To get a comprehensive picture of available long-term government and high quality corporate bonds, data from national authorities and Dealogic are used to obtain the total amount of government and corporate bonds, including inflation-indexed bonds, with a residual maturity of at least 10 years.

To gauge the scarcity of bonds, we construct several measures to display a complete picture. Figure 5 depicts the ratio of pension assets to long-term government bonds and high quality corporate bonds by country. The ratio varies substantially across countries, ranging from 0.1 in Greece to 49 in Finland. Figure 6 and Figure 7 show the bond supply distribution across maturity segments for government bonds and corporate bonds respectively. More than half of the government bonds have a residual maturity less than 20 years. Bonds with a maturity less than 50 years make up the bulk of the remainder with bonds with a maturity over 50 years accounting for less than 1 percent. The supply of corporate bonds displays a different maturity profile. Bonds with a maturity less than 20 years account for less than 20 percent of total supply. About 60 percent of corporate bonds mature between 20 and 50 years while bonds with a maturity over 50 years make up the remaining 20 percent. Figure 8 shows the ratios of assets and outstanding amounts across different categories and maturity segments of bonds. Pension assets are more than five times the sum of corporate and government bonds. In other words, should all pension funds attempt to achieve asset-liability-duration matching they would at most be able to immunize about a fifth of their balance sheets. This ratio rises to eight if only government bonds are included. Ratios by long bonds, very long bonds, and ultra-long bonds are quite revealing where long bonds have residual maturities between 10 and 20 years, very long bonds have residual maturities between 20 and 30 years, and ultra-long bonds have residual maturities over 30 years. Ratios are highest for very long bonds, but lowest for long bonds, indicating the relative scarcity of very long bonds.

The comparison highlights that the potential demand for high-quality long-term fixed-income instruments from pension funds may well exceed the supply of long-dated bonds, given the

large size of pension funds. Although the implicit assumption of 100 percent may appear extreme and unrealistic, an alternative assumption of a shift of just 75 percent of the total portfolio into long-term bonds, which is certainly a more realistic assumption and mirrors the current allocation of American insurance companies, would yield a similar picture as the gap appears so large that even assuming a more modest reallocation of pension portfolios into such instruments would simply not be feasible. Our findings are consistent with those of the OECD (2005) study, which uses only government bonds for G-10 countries.

How will the imbalance affect the cost of pension benefits? To tackle this issue, we first examine the impact on bond yields, a key driver of the cost, as shown in the next section. Due to data availability, the following analyses focus on U.S. only. Similar methods can be extended to other countries as well with results depending on country specific situation.

5. What is the impact of bond flows on long-term bond yields?

Whether pension inflows impact Treasury and corporate yields is an open question. Although some related studies have been done, the results are uncertain and mixed. These studies do not examine the yield impact arising from the financial economics rationale, but instead focus on the pension reform aspect. For example, Goldman Sachs (2004) uses the relationship between long-term yields and fiscal deficit suggested by a Federal Reserve staff study to conclude that the impact of the pension reform on yields is small. Morgan Stanley (2004) claims that the yield impact of the pension reform varies in the range of 35-150 basis points, but details on how these numbers are derived are not provided.

We tackle the issue directly and systematically by presenting in this section our econometric methodology and regression results. We employ a reduced form model to characterize demand and supply factors affecting bond yields, as in Warnock and Warnock (2006). In this framework, the dependent variable is the long-term bond yield driving the interest rate assumption used to discount pension benefit streams. The current and suggested practice in selecting discount rates dictates that high-quality corporate bond yields (a rating of A and above) and long-term (10-year and 30-year) government bond yields are good proxies. In particular, we pick long-term yields constructed by Moody's, Barclays, and the Treasury. These data are widely used and provide a long time series to allow regressions with a high degree of freedom. The independent variables reflect monetary and fiscal policies as well as macroeconomic conditions. Because the bond yield is a forward-looking asset price, we try to rely on variables encompassing forward-looking expectations. Specifically, we assume that bond yields are a function of pension flows, expected growth, expected inflation, volatility, and monetary and fiscal policy. The econometric formulation of the model is as follows:

$$Y_t = \alpha + \beta_1 * PF_{t-1} + \beta_2 * EG_{t-1} + \beta_3 * EI_{t-1} + \beta_4 * Vol_{t-1} + \beta_5 * MP_{t-1} + \beta_6 * FP_{t-1} + \varepsilon_t$$

where Y denotes yields;

t denotes time;

β_i : i=1,2,3,4,5,6 are coefficients to be estimated;

PF, EG, EI, Vol, MP, FP denote variables measuring pension flows, expected growth, expected inflation, volatility, and monetary and fiscal policy, which we briefly discuss below.

5.1. Data

5.1.1. Pension flows

Pension flows data are constructed by combining net purchases of fixed income securities by private pension funds, state and local pension funds, and federal pension funds, available from the Federal Reserve Flow of Funds[8]. They are then scaled by nominal GDP available from the Bureau of Economic Analysis.

5.1.2. Expected Growth and Expected Inflation

The Fisher Equation tells us that nominal long-term interest rates are governed by real interest rates and expected inflation. The higher the real rates and the higher the expected inflation, the higher the long-term nominal rates demanded by investors. Expected GDP growth helps capture factors that impact real interest rates. Higher growth expectations tend to drive up real rates, and in turn nominal rates. For expected inflation, we use both one-year-ahead expected inflation and ten-year-ahead expected inflation since long-term expectations (ten-years-ahead) evolve slowly and a short-term (one-year-ahead) one is used to capture short-term variations. Both one-year-ahead expected inflation and one-year-ahead expected GDP growth are available from Consensus Economics Survey. Ten-year-ahead expected inflation is from Philadelphia Fed's Survey of Professional Forecasters.

5.1.3. Volatility

Bonds are risky, thus investors must be compensated for bearing risk. While U.S. Treasury bonds are only subject to interest rate risk, corporate bonds carry both interest rate and default risk. As yields rise or default risk premiums increase, investors' holdings of existing bonds become less valuable. To proxy for the risk, we use the volatility of long-term interest

[8] In the Flow of Funds, corporate bonds and foreign bonds are grouped together and there is no way to separate the two. However, foreign bonds are likely to be of very minor importance and can be ignored. For example, the public fund survey (2008) shows that foreign bonds make up only 0.8 percent of pension assets in FY2007. Therefore, the sum of corporate and foreign bonds is attributed to corporate bonds throughout the paper.

rates, calculated as the rolling 36-month or 60-month standard deviation of changes in long rates, depending on the length of the time series. All of the yields data are obtained from the Federal Reserve and DataStream.

5.1.4. Monetary and Fiscal Policy

The expectations theory of the term structure shows that long rates are dictated by short rates. Current monetary policy, captured by the effective federal funds rate, has a direct impact on the short end of the yield curve. Federal funds rate are obtained from the Federal Reserve. Fiscal policy affects rates by the amount of borrowing or indebtedness. Laubach (2003) utilizes the long-dated budget projections to show that a one percentage-point increase in the deficit- to-GDP ratio increases long rates by 24 basis points. To measure the stance of fiscal policy, we use the structural budget balance expressed as a percent of potential GDP. This measure is free from business cycle conditions and available from the Congressional Budget Office (CBO).

Table 3 provides summary statistics of independent variables from 1962Q1 to 2008Q3. As can be seen, these variables vary substantially over time. The small differences between mean and median for all the variables indicate few outliers or extreme values. On average, pension flows are positive, but less than 0.5 percent of GDP. The swing between maximum and minimum reaches 2.7 percent of GDP. The effective federal funds rate ranges from as low as 1 percent to as high as 19 percent. Expected inflation varies from more than 1 percent to more than 9 percent. Structural balance and expected growth span the negative and positive territory. In contrast, the range of yield volatilities is comparatively narrower. By and large, this period is characterized by relatively high federal funds rate, relatively low expected inflation and low yield volatilities, negative structural balance, and positive expected growth.

5.2. Results

Table 4 presents regression results for nominal Aaa corporate yields estimated using quarterly data from 1962Q1 to 2008Q3 under different specifications. Nominal Aaa corporate yield data are constructed by Moody's and available from the Federal Reserve. Pension flows are scaled by nominal GDP. Column (i) of Table 4 has the most parsimonious specification of yield regression. The negative and statistically significant coefficient of pension flows indicates clearly that pension purchases of corporate bonds drive down bond yields. The positive and statistically significant coefficients of the effective federal funds rate and expected inflation imply that they drive up bond yields, consistent with theory and empirical studies. When structural balance, yield volatilities, and expected growth are controlled for in Column (ii), (iii), and (iv), results still hold. In all specifications, coefficients of pension purchases are negative and highly significant at the one percent level, suggesting that pension funds flows depress corporate yields. When macroeconomic

conditions, monetary policy, fiscal policy, and financial market conditions are controlled for as shown in Column 4, a one percentage point increase of pension flows reduces Aaa corporate yields by 48 basis points. All the control variables show the expected sign, indicating other forces also at play in influencing corporate yields. In particular, effective federal funds rates have a positive and significant impact on corporate yields in all specifications. A one percentage point of Fed tightening results in a 34 basis point increase in yields. Rising yield volatilities boost yields appreciably. A one percentage point increase in volatility hikes yields by 250 basis points. In line with the literature and economic theory, rising inflation and growth expectations and a widening of the structural fiscal deficit tend to boost yields, although the coefficient of expected growth is not statistically significant. The overall fit of the regression measured by the adjusted R-squared is 84 percent.

To cross check the impact of pension flows on bond yields, we run a somewhat different regression in Table 5. The dependent variable is real Aaa corporate yields, which is equal to nominal Aaa corporate yields minus 10-year inflation rates. Correspondingly, one of the independent variables, expected inflation, is adjusted by long-term inflation. The regression of real Aaa corporate yields shows that pension purchases also have a negative and significant impact on real yields. When macroeconomic conditions, monetary policy, fiscal policy, and financial market conditions are controlled for, a one percentage point rise of pension flows reduces Aaa corporate real yields by 55 basis points. When yields became real rates, inflation expectations become relative to long-run inflation expectations. Yield volatilities and inflation expectations continue to be drivers of yields. Although the effective federal fund rate and the structural deficit affect real yields in the same way as for nominal yields, their statistical significance level is lower. The overall fit of the regression measured by the adjusted R-squared is 87 percent.

Results by using Aa corporate yields and A corporate yields confirm the role of pension flows in reducing yields and the role of other control variables. Aa corporate yields and A corporate yields are constructed by Barclays[9] and available from Datastream from 1976Q1 to 2008Q3. When macroeconomic conditions, monetary policy, fiscal policy, and financial market conditions are controlled for, Table 6 shows that a one percentage point increase of pension flows decreases Aa corporate yields by 28 basis points and lowers A corporate yields by 33 basis points. In the case of real yields, a one percentage point increase of pension flows reduces Aa corporate yields by 39 basis points and A corporate yields by 46 basis points, as seen in Table 7.

Results from using 30-year Treasury yields and 10-year Treasury yields dovetail with those of corporate yields, although the impact of pension flows is smaller. The 30-year Treasury

[9] These data were formally constructed by Lehman Brothers, known as Lehman Aggregate Bond Index, a widely used bond index.

constant maturity series started in February 1977, was discontinued on February 18, 2002, and reintroduced on February 9, 2006. From February 18, 2002, to February 9, 2006, the U.S. Treasury published a factor for adjusting the daily nominal 20-year constant maturity in order to estimate a 30-year nominal rate. The adjusted rate is taken from the American Academy of Actuaries. For nominal 30-year rates, the most significant drivers of long-term Treasury yields are the level of the federal funds rate and expected growth. Expected inflation and the size of the structural budget deficit have the right sign, as predicated by theory, but are not significant. When macroeconomic conditions, monetary policy, fiscal policy, and financial market conditions are controlled for, Table 8 shows that a one-percentage-point increase of pension flows reduces 30-year Treasury yields by 20 basis points. When adjusting for inflation, the impact is decreased to 13 basis points as in Table 9. Results from 10-year Treasury yields are similar. Not only are the level of the federal funds rate and expected growth significant drivers, but also the structure balance becomes significant. When everything is controlled for, a one percentage point increase of pension flows reduces 10-year Treasury yields in both nominal and real terms by 20 basis points. The relatively weaker results of Treasury bonds compared to those of corporate bonds may simply reflect the depth and liquidity of U.S. Treasury markets over corporate bond markets.

Robust tests using average nominal yields and real yields present the same story and confirm the negative and significant association between pension flows and bond yields. To test for robustness of our findings, we ran a gamut of regressions as shown in Table 10-13. Instead of using yields at the end of each quarter, we use average yields that average out daily yields throughout the quarter. Similar regressions are run for Aaa corporate yields, Aa corporate yields, A corporate yields, 30-year Treasury yields, and 10-year Treasury yields in both nominal and real terms. Robust tests on corporate bonds are quantitatively similar to our main results, especially regarding the coefficients of pension flows. The coefficients of pension flows on Treasury bonds are somewhat smaller. In all specifications, pension flows have a significant and negative impact on yields. The effects range from 26 to 55 basis points for nominal/real corporate yields and from 4 to 12 basis points for nominal/real Treasury yields.

In this section, we demonstrate clearly the negative impact of bond flows on long-term bond yields. In addition, we show that the yield impact of bond purchases on corporate bonds is larger than that of Treasury bonds. For corporate bonds, the impact on nominal yields is smaller than that of real yields and the impact on yields of Aaa corporate bonds is largest. With robust quantitative results on yields at hand, we proceed to calculate the implications for pension costs, which is the focus of the next section.

6. What is the resulting impact on the cost of providing pension benefits?

As shown in section 5, when bond demand outstrips supply, price goes up and yields go down. Lower yields lead to higher pension liabilities and normal cost. Using the relation

between bond yield changes and bond purchases identified in previous econometrical analyses, we are able to quantify the impact of the bond yield changes on the cost of pension benefits. To that end, the following components need to be determined: the sensitivity of pension liabilities to yield changes, the amount of public and private sector pension liabilities, the appropriate discount rate for public and private sector pension liabilities, and the demand for Treasuries and corporate bonds.

The sensitivity of the pension liability to interest rate changes is usually measured by duration. The duration of traditional defined benefit pension liabilities is typically in the range of 12 to 15 years (a one percent change in interest rates commonly changes pension liabilities by about 12 to 15 percent) depending on the relative weights of active and retired participants. Plans with mostly young employees will have longer durations and plans with mostly retirees will have shorter durations. The higher the duration, the greater the changes in pension liabilities in response to interest rate changes. To be conservative, we assume the duration to be 12 years, corresponding to a typical plan with a 50/50 mix of actives and retirees. As duration is only the first order linear approximation of changes in pension liabilities as a result of interest rate changes, we improve the approximation by employing appropriate convexity adjustments to more accurately capture pension liability changes due to bond yield changes.

We separate out the analysis of public and private sector liabilities for several reasons. Public and private pension liabilities have distinct characteristics in terms of default risk and funding status. Moreover, private pensions are subject to more stringent regulatory and accounting rules than public pensions. Finally, public and private pension funds employ different asset allocation strategies.

As comprehensive data on pension fund liabilities are unavailable, we apply the funded ratios identified in the Public Fund Survey (2008) and Miliman pension funding study (2008) to pension fund assets in order to estimate public and private pension liabilities respectively. The Public Fund Survey of state and local retirement systems represents more than 85 percent of the 3.2 trillion of assets reported by the Federal Reserve Flow of Funds (2008). The survey points to a ratio of assets to liabilities of 86.4 percent. Assuming that the funded ratio is similar for the plans included in the survey and the plans not included, we estimate the aggregate public pension liabilities to be $3.7 trillion. The Milliman's study of the 100 U.S. public companies with the biggest defined benefit pension assets represents more than 50 percent of the $2.6 trillion of private defined benefit assets reported by the Federal Reserve Flow of Funds (2008). The study identifies a ratio of assets to liabilities to be 105 percent. Assuming the funded ratio is similar for the plans included in the survey and the plans not included, we estimate the aggregate private pension liabilities to be $2.5 trillion.

We set different discount rates for private and public pension liability cash flows. Specifically, private pension cash flows are discounted by corporate bond yields while public

pension cash flows are discounted by Treasury yields. For private pension funds, we use the yields of high-quality corporate bonds with at least a rating of A to measure liability changes, consistent with the PPA and FASB rules. For public pension funds, the convention is to use the long-term expected rate of return on assets as the discount rate in determining pension liabilities. From the financial economics perspective, pension liabilities should be valued by discount rates commensurate with bond market yields[10]. Given that governmental plans are not likely to default on their pension promise, we consider the Treasury yield as a more appropriate choice for measuring cost effects on public pension funds. Our approach is consistent with the argument put forward by Fed Vice Chairman Donald Kohn in one of his recent speeches: "...the only appropriate way to calculate the present value of a very-low-risk liability is to use a very-low-risk discount rate".

As discussed in section 2, the financial economics perspective and pension reform may induce the pension fund managers to reduce equity exposures and purchase fixed income securities. Given the share of fixed income assets in the portfolio of the U.S. insurance industry is about 75 percent, a modest estimate of the allocation for fixed income securities would be for plan sponsors to increase the fixed income securities to 50 percent of the pension fund portfolio.

With the fixed income securities representing less than 23 percent of private pension assets, the share of fixed income securities needs to be more than doubled to reach 50 percent of pension fund assets valued at 2.6 trillion. Within the fixed income securities, we assume that the proportions of Treasury securities and corporate bonds would stay the same after the asset mix shift. Over the period from the year 2000 through 2007, the allocations of treasuries and corporate bonds within fixed income securities were relatively stable. Hence, we simply take the most recent 2007 allocation of Treasuries (18 percent) and corporate bonds (43 percent) to estimate the additional bond purchases. For the fixed income securities allocation to reach 50 percent of the pension fund portfolios, Treasury securities need to increase by $124 billion and corporate bonds need to increase by $303 billion.

If state and local government pension funds adjust their pension portfolio in the same way as corporate pension plans[11], with the current fixed income securities representing 25 percent of total public pension fund assets valued at 3.2 trillion, plan sponsors need to purchase $251

[10] Most public pension funds do not use market yields to measure pension liability. In our analysis, we use Treasury yields to discount public pension cash flows based on financial economics principles. As data on the market value of liabilities are not available, we derive a rough estimate of public pension liabilities (developed from funded ratios in the Public Fund Survey) with a view to indicating only the order of magnitude for the following projected cost effects.

[11] Public plan sponsors anticipate that similar funding and accounting rules applicable to private pension funds will apply to public pensions in the not-so-distant future.

billion more of corporate bonds and $160 billion more of Treasury securities to reach the asset mix of 50/50. We take the most recent 2007 allocation of Treasuries (21 percent) and corporate bonds (32 percent) within public pension funds and use the same assumption that the proportions of Treasury securities and corporate bonds would stay the same after the asset mix shift. Combining with the purchases of corporate pension sponsors, the total inflows of corporate bonds would be $554 billion and those of Treasury securities would be $284 billion.

However, the timing and span of the asset allocation shift is uncertain. Views differ as to the pace and magnitude of such a re-allocation. Moreover, there is no useful or reliable mechanical rule to determine, on the basis of a given amount of liabilities, the extent to which assets will be invested in long bonds. Pension funds adopt very different mixes of alpha and beta strategies. As such, the shift may happen abruptly, e.g., in one year or gradually, e.g., in two or more years. Consequently, we take an agnostic approach and use one year and two years as examples and discuss them in turn for illustrative purposes.

To measure the magnitude of the cost impact, we take two measures. One is the increase in pension liabilities. The other one is the increase in the normal cost that dictates pension contributions. We estimate only the impact on the perceived cost of providing benefits as the impact on the actual cost depends on many factors, such as the rate of contributions to the plan, the actual investment return, and the extent to which the accrued liabilities have been funded, which are beyond the scope of this paper.

As shown in our econometrics analysis results, when macroeconomic conditions, monetary policy, fiscal policy, and financial market conditions are controlled for, a one-percentage-point increase of pension flows decreases Aa corporate yields by 28 basis points, lowers A corporate yields by 33 basis points, and reduces Aaa corporate yields by 48 basis points. High quality corporate bond yields could be one of A, Aa and Aaa bond yields, or could be a combination of these yields. We illustrate next with a conservative estimate of the impact using Aa corporate yields and demonstrate briefly the potential extent of the cost impact using A and Aaa yields.

If the shift happens over one year, using the corporate bonds yield changes in relation with the purchase of corporate bonds, the demand for corporate bonds of $303 billion would trigger the decline of the Aa corporate bond yield by a substantial 61 basis points, as shown in Table 14. Assuming an average duration of 12 years, the pension liability discounted at Aa corporate yields would increase by 8 percent.

Alternatively, we can quantify the impact on the normal cost as a result of bond undersupply. Using the rule of thumb[12] ─ a change of one percent in the interest rate alters the normal cost

[12] The rule has been used in several studies. Among others, see Hustead (2001).

by about 25 percent ─ the reallocation of private pension fund assets in a one year horizon would increase the normal cost by over 15 percent.

If state and local governments join the forces, the total purchase of $554 billion in corporate bonds and $284 billion in Treasury securities would have a phenomenal impact, with Aa corporate yields and Treasury yields plunging by 111 basis points and 41 basis points respectively, as shown in Table 15. To put these results in perspective, it would be interesting to compare our projection of the market effects of such Treasury purchases with the real market reaction to the recent Federal Reserve's aggressive Quantitative Easing measures on March 19. Following the Fed's announcement to buy up $300 billion in U.S. Treasuries, the 10-year Treasury yields curve flattened dramatically, falling 44 basis points, consistent with our projection of yield changes. As a result, private pension liabilities would jump by 15.3 percent and public pension liabilities would rise by 5.2 percent. Putting it all together, the total rebalancing move of pension fund portfolios in one year would increase aggregate pension liabilities by 9 percent. Alternatively, the joint rebalancing of pension funds would increase the normal cost for corporate pensions by about 28 percent and that for public pensions by over 10 percent.

If the shift occurs over two years, there would be an increase of $152 billion in corporate bonds and an increase of $62 billion in Treasury securities each year. Table 16 shows that Aa corporate yields would decrease by 30 basis points, resulting in an increase of 4 percent in private pension liabilities. If state and local governments follow suit, the increase in corporate bonds holdings would flatten the Aa corporate yield curve by 55 basis points, resulting in increasing the private pension liability by almost 7 percent as seen in Table 17. The increase in Treasury holdings would flatten the Treasury yield curve by 20 basis points, leading to an increase in public pension liabilities of 3 percent. The combined rebalancing move of pension fund portfolios over two years would increase aggregate pension liabilities by 4 percent each year, with the total impact roughly the same as what would happen under a one-year scenario. The effect on the normal cost would spread out in two years with each year costing half of what could result from a more abrupt move.

Using the same methodology, results using A and Aaa corporate yields would be much higher, as shown in Table 14-17. For example, corporate bond purchase of $303 billion in one year could reduce the Aaa corporate yield by 104 basis points, hiking the pension liability and normal cost by 14.3 percent and 26 percent, respectively. When state and local pension funds adjust their portfolio the same way as their private counterparts, the total pension liability would jump by 14 percent or about 6 percent of GDP. Correspondingly, the normal cost would rise sharply by up to 48 percent.

Our scenario analyses demonstrate that, if pension plans invest half of their pension assets in fixed income securities, the inadequate supply of bonds would have a substantial impact on the cost of providing pension benefits. In particular, our most conservative scenario, where private pension funds alone are moving to bonds in two years and Aa corporate yields are used to discount pension flows, reveals that the shortage would increase pension liabilities by

4 percent and the normal cost by 8 percent each year. Depending on the speed of the allocation shift, the choice of discount rates, and the decision of public pension sponsors, pension liabilities could rise by as much as 14 percent, or about 6 percent of GDP. Hence, pension plan sponsors would face the deterioration in funded status and significant increase in contribution requirements. This presents a challenge for plan sponsors to fulfill their benefit obligations. For plan sponsors who embrace an all-bond strategy, the massive reallocation from equities to bonds would result in a significant pension cost burden.

However, the cost impact should not stand as an obstacle for plan sponsors to shift their assets to bonds. We quantify the impact of the imbalance on yields and pension cost assuming *ceteris paribus*, i.e., all else remains unchanged. The imbalance can be corrected by appropriate policies, which can undo any potential effects. One of them is spurring bond issuances by governments or corporations, which leads to our next section on the role of government in increasing bond supply.

7. What policy measures can governments take to increase bond supply?

Governments in several OECD countries have started or re-introduced the issuance of very long and ultra-long bonds. The United States, the United Kingdom, France, Germany, Italy, and the Netherlands are among the governments that have issued very long and ultra-long bonds in recent years. For example, the US government issued 20-year inflation-protected securities in 2004 and resumed the sale of 30-year debt in 2006, after the 2001 suspension. Probably the most notable recent development was the issuance of bonds with maturities of 50 years. In February 2005, the French government issued successfully a 50-year nominal bond. Later the same year, the UK government re-introduced a 50-year gilt after a break of more than 40 years and issued the world's first 50-year inflation-linked bond. However, as illustrated in previous sections, the bond supply is far from sufficient to meet the demand of pension funds.

To spur the supply of suitable financial instruments with a view to helping pension funds to better match assets and liabilities, the discussion about the role of governments may be cast in the context of the scope of public debt management objectives. Generally speaking, the government issuance decision with respect to long-term bonds in most countries is guided by cost-risk considerations and market efficiency. Specifically, governments intend to achieve two objectives: (i) minimizing borrowing and management costs over the long term, subject to an acceptable level of risk; and (ii) supporting efficient domestic bond markets. That said, there are tradeoffs between the two objectives. Issuing sufficiently large amounts of very-long bonds and index-linked bonds might lead governments to assume greater risks and sometimes even higher debt service costs. Governments would need to balance any such costs against the benefits of increasing the market efficiency and reducing contingent fiscal liabilities, which would call for an integrated framework to weigh these considerations.

Several studies have shown that deep and efficient government bond markets would boost the development of corporate bond markets as government bonds are usually benchmarks for corporate bond issuers. To facilitate the creation of deep and efficient markets for such instruments, governments need to (i) make the term structure of the fixed-income markets more complete; and (ii) encourage secondary market developments by promoting the role of market makers and conducting regular assessments of the auction process to address possible weaknesses. Governments may also develop plans to deal with potentially volatile pension demand arising from changes in accounting standards, funding regulations, and risk management.

While inflation-indexed bonds can benefit governments through the correlation between inflation and tax revenue, the benefit of longevity-indexed bonds is less clear as higher life expectancy at old ages tends to increase public expenditure more than tax revenues. To issue longevity-indexed bonds, it would be necessary to address a number of potential market issues related to indices, types of indexation, and selling techniques. The only longevity-indexed bond issued by a private institution failed to generate enough demand[13]. Several explanations regarding pricing, design, risk and benefits have been offered to explain the failure.

Given that governments from advanced economies already have some exposure to longevity risks via public pensions and other social security arrangements, a careful analysis of the optimal level of exposure would be meaningful[14]. The government could also be selective in the type of longevity risk it underwrites, concentrating on those where market failures render the emergence of a private market least likely. For example, governments could issue securities that protect the holder against non-diversifiable "tail" risks such as greater-than-expected longevity improvements.

Governments can encourage or support the development of a private market in longevity hedging products by producing a reliable and widely accepted longevity index that is based on up-to-date mortality statistics and can be used as a benchmark for pricing these products. Alternatively, they could make the data and information necessary to produce such an index widely available through their national statistical agencies. Government issuance in the early stages of the development of the longevity hedging market would not only provide a benchmark but also stimulate interest in improving mortality tables and projections.

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[13] This longevity-indexed bond was issued by the European Investment Bank for the UK pension market only. The bond payments were linked to a specifically constructed cohort survivor index.

[14] See OECD (2007) for detailed discussions.

The ongoing crisis provides a good opportunity for governments to issue long inflation-indexed bonds. With the massive fiscal stimulus and financial rescue packages such as American Recovery and Reinvestment Act and Troubled Assets Recovery Program (TARP) in the U.S. and the European Economic Recovery Program in which governments, on average, adopt budget measures of 1-2 percent of GDP to stimulate domestic demand, investors are concerned about the oversupply of short-term government paper. Several governments, which used to be considered as the strongest and safest credits, have had difficulties in hitting their targets in bond auctions. Although short-term demand from investors has dropped (since inflation expectations amid the economic downturn are subdued) there are risks that massive packages could spark a sharp pickup in prices in the future. In fact, inflation pressures keep mounting with central banks taking even more massive measures to boost the money supply. Hence, governments should commit to building up long-dated inflation-indexed bonds. For example, the U.K saw fairly strong demand for its inflation-indexed bonds to mature in 2032.

8. Conclusions

This paper represents a first attempt to quantitatively examine the imbalance between long-term bond supply and demand and to explore the actuarial implications for pension funds. We examine the important issue across a large cross section of countries, cover both government and corporate bonds, and employ econometric analyses.

From the perspective of financial economics, plan sponsors should shift out of equities and into fixed income securities. In response to the new climate, characterized by higher funding targets, greater contribution requirements, more transparency in pension accounting, and volatile stock markets, pension fund managers are increasingly employing strategies such as asset liability management or liability driven investment, resulting in more pension assets allocated to bonds, especially bonds with longer durations. With current pension fund assets largely dominated by equities, the demand for long-term fixed income securities is expected to rise.

However, bond supply is insufficient to meet the growing demand. Using data related to demand for long term bonds by pension funds and the supply of government bonds and high quality corporate bonds for the G-20 advanced countries, we empirically assess how the demand for long-term bonds by pension funds stacks up against the supply of bonds. We find that the supply of long-term government bonds and high quality corporate bonds (including inflation-indexed bonds) is significantly inadequate to meet the demand from pension funds, although there are large variations across countries, types of instruments, and maturity segments. Specifically, the combined supply of government and corporate bonds is less than one fifth of total pension assets while the supply of government bonds is only about one eighth of total pension assets. Very long bonds are relatively scarce compared to long bonds and ultra-long bonds.

Using econometrics techniques, we demonstrate that the imbalance has an economically and statistically significant impact in lowering nominal and real bond yields. Stepping up purchases of high quality corporate bonds has a more pronounced impact on decreasing yields than purchasing long-term government bonds. For corporate bonds, when macroeconomic conditions, monetary policy, fiscal policy, and financial market conditions are controlled for, a one-percentage-point increase of pension flows reduces: Aa corporate yields by 28 basis points, A corporate yields by 33 basis points, and Aaa corporate yields by 48 basis points. The impact on real yields is even larger. In the case of Treasury bonds, the yield impact is about 20 basis points, consistent with recent market reactions to the Federal Reserve's quantitative easing measures. Robust tests using average nominal yields and real yields present the same story and confirm the negative and significant relationship between pension flows and bond yields.

With robust quantitative results on yields at hand, we further illustrate the implications for pension funds by analyzing the impact on pension liabilities and normal cost. Our results demonstrate that, if pension plans shift assets toward fixed income securities to achieve a 50/50 asset allocation with equities, the inadequate supply of bonds would have a substantial impact on the cost of pensions. In the most conservative scenario, the pension liability would jump by 4 percent and the normal cost would rise by 8 percent in one year. Depending on the speed of the allocation shift, the choice of discount rates, and the decision of public pension sponsors, pension liabilities could rise by as much as 14 percent, or about 6 percent of GDP. The bond undersupply would bring another stress to plan sponsors in meeting their pension obligations.

The solution to the problem is not to reduce exposure to bonds, but to increase bond supply. To this end, we propose several measures government can take to boost the supply of long-term bonds. In particular, we encourage governments: (i) to recast their public debt management objectives to facilitate the creation of deep and efficient markets; (ii) to make the term structure of the government fixed-income market more complete; (iii) to promote secondary market developments by promoting the role of market makers and conducting regular assessments of the auction process to address possible weaknesses; (iv) to concentrate on longevity risk markets where market failures render the emergence of a private market least likely; (v) to produce a reliable and widely accepted longevity index that is based on up-to-date mortality statistics and can be used as a benchmark for pricing these products; and (vi) to take advantage of the ongoing crisis to issue long real-return bonds.

Our paper raises some interesting issues that could be explored in future research. For example, how should DB plans increase their fixed income allocations without increasing their cost significantly? Is there a particular "glide path" that could minimize the yield impact and associated transactions costs? If bond yields fall or spreads narrow, would bond

issuers see this as an opportunity to issue more debt, which in turn could boost yields or widen spreads? What actions can corporations take to increase long-term bond supply?

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References

Archer, Michael and William B. Gulliver. 2005. A Towers Perrin Proposal for Pension Funding Reform. The Future of Pension Plan Funding and Disclosure Monograph, Society of Actuaries.

American Academy of Actuaries. 2008. Academy Alert: 2008-PEB-22: December 2008 Interest Rates. December 18.

Bader, Lawrence N. 2003. The Case Against Stock in Corporate Pension Funds. *Pension Section News*, February 2003.

Bader, Lawrence N. and Jeremy Gold. 2003. Reinventing Pension Actuarial Science. *The Pension Forum* 14(2) 1-13.

_____, 2007. The Case Against Stock in Public Pension Funds. *Financial Analysts Journal,* January/February 2007.

Bernanke, Ben. 2006. Reflections on the Yield Curve and Monetary Policy. The Economic Club of New York, New York, March 20.

Board of Governors. Federal Reserve System. 2008. *Flow of Funds Accounts of the United States*. Washington, DC: BOG.

Day, Tony. 2004. Financial Economics and Actuarial Practice. *North American Actuarial Journal* 8(3): 90–102.

Goldman, Sachs. 2004. Corporate Defined Benefit Plans: The Potential Consequences of Current Reform Initiatives. March 15.

Hardy, Mary R. 2005. We Are All "Actuaries of the Third Kind" Now. *North American Actuarial Journal* 9(2) iii-v.

Hustead, Edwin C. 2001. Determining the Cost of Public Pension Plans. In *Pensions in The Public Sector*, eds. Olivia S. Mitchell and Edwin C. Hustead, University of Pennsylvania Press, Chapter 10.

IMF. 2004. *Global Financial Stability Report*. World Economic and Financial Surveys. Washington, DC: International Monetary Fund, September.

Joint AAA/SOA Task Force on Financial Economics and the Actuarial Model. 2006. Pension Actuary's Guide to Financial Economics. Society of Actuaries and American Academy of Actuaries.

Kohn, Donald L. 2008. The Economic Outlook. Speech at the National Conference on Public Employee Retirement Systems (NCPERS) Annual Conference, New Orleans, Louisiana. May 20.

Laubach, Thomas. 2003. New Evidence on the Interest Rate Effects of Budget Deficits and Debt. Finance and Economic Discussion Paper #2003-12, Board of Governors of the Federal Reserve System.

Milliman. 2008. Milliman 2008 Pension Funding Study. April 2008.

Morgan Stanley. 2004. Pension Missiles: Is the Cure Worse than the Disease? March 25.

Moriarty, Charlene. The Actuary's New Clothes - A Canadian Perspective on the Financial Economics Debate. *Contingencies*. May/June 2006, American Academy of Actuaries.

NASRA/NCTR. 2008. Public Fund Survey FY 2007.

OECD. 2005-2008. *Financial Market Trends*. Organization for Economic Co-operation and Development. Paris.

Pyramis Global Advisors. 2008. The Global Investor's Challenge: Achieving Balance in a Volatile World.

Ralfe, John, Cliff Speed, and Jon Palin. 2004. Pensions and Capital Structure: Why Hold Equities in the Pension Fund? *North American Actuarial Journal* 8(3): 103–113.

Ruloff, Mark. 2004. Defined Benefit Plans are More Successful with Bonds. *Pension Section News*, September 2004.

Siegel, Steven and C. Ian Genno. 2005. Introduction and Overview of the Pension Plan Funding Reform Monograph. The Future of Pension Plan Funding and Disclosure Monograph, Society of Actuaries.

Tett, Gillian and Tony Tassell. 2005. A Swing into Bonds, Financial Times, October 9, 2005.

Warnock, F., and V. Warnock. International capital flows and U.S. interest rates. *Journal of International Money and Finance*. Forthcoming.

Xiao, Yingbin. 2007. What do bond holdings reveal about international funds' preferences? *Emerging Markets Review* 8, 167-180.

Table 1
Size of pension funds in G-20 developed countries, 2001-2007
(In millions of US dollars)

	2001	2002	2003	2004	2005	2006	2007
Australia	268,181	281,376	348,859	473,092	583,603	691,605	956,506
Austria	5,673	7,863	10,553	12,882	14,566	15,989	18,014
Belgium	12,771	12,429	12,154	14,353	16,541	16,769	18,152
Canada	743,347	728,506	859,706	994,537	1,156,156	1,337,087	1,475,002
Denmark	154,173	189,863	250,009	307,846	358,559	384,902	438,226
Finland	70,164	75,583	100,407	130,793	150,015	163,085	191,233
France	51,371	95,401	123,277	123,602	123,602	155,207	179,178
Germany	65,125	70,474	88,903	104,143	112,534	122,764	136,456
Greece	..	..	..	..	..	..	34
Ireland	45,791	42,234	62,656	77,433	96,811	110,093	118,633
Italy	25,092	28,234	36,794	44,154	49,496	55,952	68,686
Japan	580,519	561,645	477,322	373,380	301,994	..	..
Netherlands	411,322	374,898	545,337	659,723	769,627	843,011	1,013,357
Norway	9,389	10,596	14,565	16,939	20,266	22,875	27,385
Portugal	13,273	16,265	20,578	21,638	26,946	30,185	34,577
Spain	35,060	52,380	71,439	88,268	100,143	112,644	128,798
Sweden	72,806	85,229	102,916	141,096	165,220	218,042	260,659
Switzerland	261,357	267,554	334,829	389,496	434,746	465,425	505,425
United Kingdom	1,040,472	930,832	1,175,335	1,467,118	1,763,762	2,002,059	..
United States	11,134,455	10,422,698	12,376,945	13,584,558	14,639,870	16,115,563	17,076,891

Source: OECD Global Pension Statistics.

Table 2
Size of government bond markets in G-20 developed countries, 2001-2007
(In millions of US dollars)

	2001	2002	2003	2004	2005	2006	2007
Australia	32,528	35,409	41,230	40,983	45,878	43,902	49,444
Austria	96,627	119,254	150,453	173,886	156,844	183,051	209,880
Belgium	190,036	231,510	278,849	298,555	261,820	291,817	335,094
Canada	196,205	193,617	224,935	226,563	227,324	224,242	256,164
Denmark	76,763	91,108	105,327	113,377	86,508	86,756	88,865
Finland	43,189	49,620	64,024	69,196	62,291	66,095	70,154
France	529,526	659,648	857,633	1,002,215	922,556	1,067,222	1,239,903
Germany	562,263	723,107	918,006	1,064,772	979,998	1,154,638	1,314,171
Greece	119,492	155,641	200,153	242,406	228,885	270,725	324,454
Ireland	21,554	26,332	36,704	43,375	37,676	41,903	46,299
Italy	906,013	1,077,789	1,308,762	1,460,145	1,302,172	1,492,642	1,707,053
Japan	3,071,875	3,886,455	4,890,747	5,285,987	5,108,941	5,155,301	..
Netherlands	151,304	178,094	227,910	265,940	236,584	258,254	280,837
Norway	14,981	18,301	22,781	22,258	22,517	29,494	34,252
Portugal	46,782	63,155	76,033	81,746	82,031	101,457	116,464
Spain	231,623	281,946	334,740	371,815	331,743	366,000	399,909
Sweden	79,296	96,941	125,242	140,189	118,768	135,939	134,715
Switzerland	36,982	50,513	66,259	81,816	72,661	78,398	85,014
United Kingdom	437,604	509,319	627,572	717,144	785,247	933,211	1,027,061
United States	2,180,706	2,253,350	2,542,350	2,884,450	3,156,510	3,377,408	3,475,950

Source: OECD Central Government Debt Statistics.

Table 3
Summary statistics of independent variables

	Mean	Median	Maximum	Minimum
Pension flows	0.37	0.47	1.37	-1.31
Federal funds rate	6.17	5.45	19.10	0.98
Expected inflation	3.98	3.54	9.37	1.05
Relative inflation	-1.73	-0.34	1.80	-9.66
Structural balance	-2.03	-2.01	1.51	-4.72
Volatility	0.60	0.50	2.02	0.08
Expected growth	3.06	2.88	8.51	-2.46

This table summarizes independent variables used in regressions of bonds yields. The pension flows variable is constructed by dividing the sum of net quarterly purchases of bonds by private pension funds, state and local government retirement funds, and federal government retirement funds (available from the Federal Reserve) by quarterly nominal GDP (from the Bureau of Economic Analysis). The Fed funds rate variable is the effective federal funds rate from the Federal Reserve. The expected inflation variable is one-year-ahead inflation expectations available from the Consensus Economics Survey. Relative inflation is the difference between ten-years-ahead expected inflation (from the Philadelphia Fed's Survey of Professional Forecasters) and one-year-ahead expected inflation from Consensus Economics Survey. The expected growth variable is one-year-ahead GDP expectations available (from the Consensus Economics Survey). The structural balance variable is expressed as a percentage of potential GDP and is from the Congressional Budget Office. The volatility variable is calculated as the rolling 60-month standard deviation of changes in bond yields.

Table 4
Determinants of nominal yields of Aaa corporate bonds

	(i)	(ii)	(iii)	(iv)
Pension flows	-0.699***	-0.741***	-0.458***	-0.480***
Fed funds rate	0.476***	0.505***	0.318***	0.339***
Expected inflation	0.310**	0.194	0.178*	0.173*
Structural balance		-0.355***	-0.195*	-0.196*
Volatility			2.524***	2.483***
Expected growth				0.058
Adjusted R^2	0.69	0.73	0.84	0.84
# of Obs.	187	187	187	187

This table presents time series regression results of nominal yields of Aaa corporate bonds using quarterly data from 1962Q1 to 2008Q3. The dependent variable, nominal yields of Aaa corporate bonds is the end of quarter yields taken from the Federal Reserve. The pension flows variable is constructed by dividing the sum of net quarterly purchases of corporate bonds by private pension funds, state and local government retirement funds, and federal government retirement funds (available from the Federal Reserve) by quarterly nominal GDP (from the Bureau of Economic Analysis). The Fed funds rate variable is the effective federal funds rate from the Federal Reserve. Expected inflation and expected growth variables are one-year-ahead inflation and GDP expectations available from the Consensus Economics Survey. The structural balance variable is expressed as a percentage of potential GDP and is from the Congressional Budget Office. The volatility variable is calculated as the rolling 60-month standard deviation of changes in nominal yields of Aaa corporate bonds. The significance level is calculated based on robust standard errors adjusted for serial correlation. ***, **, and * indicate significance at the 1 percent level, 5 percent level, and 10 percent level respectively.

Table 5
Determinants of real yields of Aaa corporate bonds

	(i)	(ii)	(iii)	(iv)
Pension flows	-0.682***	-0.721***	-0.537**	-0.554**
Fed funds rate	0.150**	0.142**	0.026*	0.002*
Relative inflation	1.171***	1.163***	1.103***	1.118***
Structural balance		-0.151	-0.014	-0.012
Volatility			2.284***	2.200***
Expected growth				0.082
Adjusted R^2	0.83	0.83	0.87	0.87
# of Obs.	187	187	187	187

This table presents time series regression results of real yields of Aaa corporate bonds using quarterly data from 1962Q1 to 2008Q3. The dependent variable, real yields of Aaa corporate bonds is equal to the difference between corresponding nominal yields at the end of quarter taken (from the Federal Reserve) and ten-year-ahead expected inflation (from the Philadelphia Fed's Survey of Professional Forecasters). The pension flows variable is constructed by dividing the sum of net quarterly purchases of corporate bonds by private pension funds, state and local government retirement funds, and federal government retirement funds (available from the Federal Reserve) by quarterly nominal GDP (from the Bureau of Economic Analysis). The Fed funds rate variable is the effective federal funds rate from the Federal Reserve. Relative inflation is the difference between ten-years-ahead expected inflation (from the Philadelphia Fed's Survey of Professional Forecasters) and one-year-ahead expected inflation (from the Consensus Economics Survey). The expected growth variable is one-year-ahead GDP expectations available from the Consensus Economics Survey. The structural balance variable is expressed as a percentage of potential GDP and is from the Congressional Budget Office. The volatility variable is calculated as the rolling 60-month standard deviation of changes in real yields of Aaa corporate bonds. The significance level is calculated based on robust standard errors adjusted for serial correlation. ***, **, and * indicate significance at the 1 percent level, 5 percent level, and 10 percent level respectively.

Table 6
Determinants of nominal yields of Aa and A corporate bonds

	Aa	A
Pension flows	-0.275**	-0.334***
Fed funds rate	0.435***	0.429***
Expected inflation	0.133*	0.107
Structural balance	-0.220***	-0.244***
Volatility	1.934***	1.974***
Expected growth	0.149**	0.086
Adjusted R^2	0.89	0.88
# of Obs.	131	131

This table presents time series regression results of nominal yields of Aa and A corporate bonds using quarterly data from 1976Q1 to 2008Q3. The dependent variables, nominal yields of Aa and A corporate bonds are the end of quarter yields available from DataStream. The pension flows variable is constructed by dividing the sum of net quarterly purchases of corporate bonds by private pension funds, state and local government retirement funds, and federal government retirement funds (available from the Federal Reserve) by quarterly nominal GDP (from the Bureau of Economic Analysis). The Fed funds rate variable is the effective federal funds rate from the Federal Reserve. The expected inflation and expected growth variables are one-year-ahead inflation and GDP expectations available from the Consensus Economics Survey. The structural balance variable is expressed as a percentage of potential GDP and is from the Congressional Budget Office. Volatility variables are calculated as the rolling 36-month standard deviation of changes in nominal yields of Aa and A corporate bonds. The significance level is calculated based on robust standard errors adjusted for serial correlation. ***, **, and * indicate significance at the 1 percent level, 5 percent level, and 10 percent level respectively.

Table 7
Determinants of real yields of Aa and A corporate bonds

	Aa	A
Pension flows	-0.391*	-0.460*
Fed funds rate	0.043	0.034
Relative inflation	1.442***	1.513***
Structural balance	-0.101	-0.131
Volatility	2.063***	1.972***
Expected growth	0.245*	0.214
Adjusted R^2	0.65	0.64
# of Obs.	131	131

This table presents time series regression results of real yields of Aa and A corporate bonds using quarterly data from 1976Q1 to 2008Q3. The dependent variable, real yields of Aa and A corporate bonds are equal to the difference between corresponding nominal yields at the end of each quarter taken from DataStream and ten-years-ahead expected inflation from Philadelphia Fed's Survey of Professional Forecasters. The pension flows variable is constructed by dividing the sum of net quarterly purchases of corporate bonds by private pension funds, state and local government retirement funds, and federal government retirement funds (available from the Federal Reserve) by quarterly nominal GDP (from the Bureau of Economic Analysis). The Fed funds rate variable is the effective federal funds rate from the Federal Reserve. Relative inflation is the difference between ten-year-ahead expected inflation from the Philadelphia Fed's Survey of Professional Forecasters and one-year-ahead expected inflation from the Consensus Economics Survey. The expected growth variable is one-year-ahead GDP expectations available from Consensus Economics Survey. The structural balance variable is expressed as a percentage of potential GDP and is from the Congressional Budget Office. Volatility variables are calculated as the rolling 36-month standard deviation of changes in real yields of Aa and A corporate bonds. The significance level is calculated based on robust standard errors adjusted for serial correlation. ***, **, and * indicate significance at the 1 percent level, 5 percent level, and 10 percent level respectively.

Table 8
Determinants of nominal yields of 30-year Treasury and 10-year Treasury bonds

	30-year Treasury	10-year Treasury
Pension flows	-0.198*	-0.199*
Fed funds rate	0.128**	0.218***
Expected inflation	0.101	0.026**
Structural balance	-0.061	-0.087**
Volatility	0.315*	0.418**
Expected growth	0.141***	0.094***
Adjusted R^2	0.96	0.96
# of Obs.	115	187

This table presents time series regression results of nominal yields of 30-year Treasury bonds using quarterly data from 1980Q1 to 2008Q3 and those of 10-year Treasury bonds using quarterly data from 1962Q1 to 2008Q3. The dependent variables, nominal yields of 30-year Treasury bonds at the end of each quarter are taken from the American Academy of Actuaries while nominal yields of 10-year Treasury bonds at the end of each quarter are taken from the Federal Reserve. The pension flows variable is constructed by dividing the sum of net quarterly purchases of Treasury bonds by private pension funds, state and local government retirement funds, and federal government retirement funds (available from the Federal Reserve) by quarterly nominal GDP (from the Bureau of Economic Analysis). The Fed funds rate variable is the effective federal funds rate from the Federal Reserve. The expected inflation and expected growth variables are one-year-ahead inflation and GDP expectations available from the Consensus Economics Survey. The structural balance variable is expressed as a percentage of potential GDP and is from the Congressional Budget Office. Volatility variables are calculated as the rolling 36-month standard deviation of changes in nominal yields of 30-year Treasury bonds and the rolling 60-month standard deviation of changes in nominal yields of 10-year Treasury bonds respectively. The significance level is calculated based on robust standard errors adjusted for serial correlation. ***, **, and * indicate significance at the 1 percent level, 5 percent level, and 10 percent level respectively.

Table 9
Determinants of real yields of 30-year treasury and 10-year treasury bonds

	30-year Treasury	10-year Treasury
Pension flows	-0.133*	-0.194**
Fed funds rate	0.133***	0.083***
Relative inflation	0.295	0.247***
Structural balance	-0.033	-0.018
Volatility	0.140	0.317***
Expected growth	0.119**	0.052*
Adjusted R^2	0.82	0.97
# of Obs.	115	187

This table presents time series regression results of real yields of 30-year Treasury bonds using quarterly data from 1980Q1 to 2008Q3 and those of 10-year Treasury bonds using quarterly data from 1962Q1 to 2008Q3. The dependent variables, real yields of 30-year Treasury bonds are equal to the difference between corresponding nominal yields at the end of each quarter taken from the American Academy of Actuaries and ten-years-ahead expected inflation from Philadelphia Fed's Survey of Professional Forecasters while real yields of 10-year Treasury bonds are equal to the difference between corresponding nominal yields at the end of quarter yields taken from the Federal Reserve and ten-year-ahead expected inflation from Philadelphia Fed's Survey of Professional Forecasters. The pension flows variable is constructed by dividing the sum of net quarterly purchases of Treasury bonds by private pension funds, state and local government retirement funds, and federal government retirement funds (available from the Federal Reserve) by quarterly nominal GDP (from the Bureau of Economic Analysis). The Fed funds rate variable is the effective federal funds rate from the Federal Reserve. Relative inflation is the difference between ten-year-ahead expected inflation from the Philadelphia Fed's Survey of Professional Forecasters and one-year-ahead expected inflation from the Consensus Economics Survey. The expected growth variable is one-year-ahead GDP expectations available from the Consensus Economics Survey. The structural balance variable is expressed as a percentage of potential GDP and is from the Congressional Budget Office. Volatility variables are calculated as the rolling 36-month standard deviation of changes in real yields of 30-year Treasury bonds and the rolling 60-month standard deviation of changes in real yields of 10-year Treasury bonds respectively. The significance level is calculated based on robust standard errors adjusted for serial correlation. ***, **, and * indicate significance at the 1 percent level, 5 percent level, and 10 percent level respectively.

Table 10
Determinants of average nominal yields of Aaa, Aa, and A corporate bonds

	Aaa	Aa	A
Pension flows	-0.479***	-0.264**	-0.331***
Fed funds rate	0.323***	0.439***	0.427***
Expected inflation	0.170*	0.112	0.094
Structural balance	-0.207*	-0.248***	-0.269***
Volatility	2.557***	1.879***	1.939***
Expected growth	0.056	0.155***	0.096*
Adjusted R^2	0.83	0.89	0.88
# of Obs.	187	131	131

This table presents time series regression results of average nominal yields of Aaa, Aa, and A corporate bonds. Quarterly data from 1962Q1 to 2008Q3 are used for Aaa corporate bonds while quarterly data from 1976Q1 to 2008Q3 are used for Aa and A corporate bonds. The dependent variables, nominal yields of Aaa corporate bonds are the three month average yields calculated based on data from the Federal Reserve while nominal yields of Aa and A corporate bonds are the three month average yields calculated based on data available from DataStream. The pension flows variable is constructed by dividing the sum of net quarterly purchases of corporate bonds by private pension funds, state and local government retirement funds, and federal government retirement funds (available from the Federal Reserve) by quarterly nominal GDP (from the Bureau of Economic Analysis). The Fed funds rate variable is the effective federal funds rate from the Federal Reserve. The expected inflation and expected growth variables are one-year-ahead inflation and GDP expectations available from the Consensus Economics Survey. The structural balance variable is expressed as a percentage of potential GDP and is from the Congressional Budget Office. Volatility variables are calculated as the rolling 60-month standard deviation of changes in nominal yields in the case of Aaa corporate bonds but as the rolling 36-month standard deviation of changes in nominal yields in the case of Aa and A corporate bonds. The significance level is calculated based on robust standard errors adjusted for serial correlation. ***, **, and * indicate significance at the 1 percent level, 5 percent level, and 10 percent level respectively.

Table 11
Determinants of average real yields of Aaa, Aa, and A corporate bonds

	Aaa	Aa	A
Pension flows	-0.551**	-0.386*	-0.461*
Fed funds rate	0.015*	0.037*	0.028*
Relative inflation	1.122***	1.428***	1.491***
Structural balance	-0.023	-0.125*	-0.153
Volatility	2.267***	2.019***	1.940***
Expected growth	0.081	0.243*	0.214
Adjusted R^2	0.87	0.64	0.63
# of Obs.	187	131	131

This table presents time series regression results of average real yields of Aaa, Aa, and A corporate bonds. Quarterly data from 1962Q1 to 2008Q3 are used for Aaa corporate bonds while quarterly data from 1976Q1 to 2008Q3 are used for Aa and A corporate bonds. The dependent variables, real yields of Aaa corporate bonds are equal to the difference between corresponding nominal yields calculated based on data from the Federal Reserve and ten-years-ahead expected inflation from Philadelphia Fed's Survey of Professional Forecasters while real yields of Aa and A corporate bonds are equal to the difference between corresponding nominal yields calculated based on data from DataStream and ten-year-ahead expected inflation from Philadelphia Fed's Survey of Professional Forecasters. The pension flows variable is constructed by dividing the sum of net quarterly purchases of corporate bonds by private pension funds, state and local government retirement funds, and federal government retirement funds (available from the Federal Reserve) by quarterly nominal GDP (from the Bureau of Economic Analysis). The Fed funds rate variable is the effective federal funds rate from the Federal Reserve. Relative inflation is the difference between ten-year-ahead expected inflation from the Philadelphia Fed's Survey of Professional Forecasters and one-year-ahead expected inflation from the Consensus Economics Survey. The expected growth variable is one-year-ahead GDP expectations available from the Consensus Economics Survey. The structural balance variable is expressed as a percentage of potential GDP and is from the Congressional Budget Office. Volatility variables are calculated as the rolling 60-month standard deviation of changes in real yields in the case of Aaa corporate bonds but as the rolling 36-month standard deviation of changes in real yields in the case of Aa and A corporate bonds. The significance level is calculated based on robust standard errors adjusted for serial correlation. ***, **, and * indicate significance at the 1 percent level, 5 percent level, and 10 percent level respectively.

Table 12
Determinants of average nominal yields of 30-year Treasury and 10-year Treasury bonds

	30-year Treasury	10-year Treasury
Pension flows	-0.122*	-0.064*
Fed funds rate	0.104**	0.151***
Expected inflation	0.070	0.059**
Structural balance	-0.049	0.334**
Volatility	0.187	-0.046
Expected growth	0.109***	0.056***
Adjusted R^2	0.98	0.98
# of Obs.	115	187

This table presents time series regression results of average nominal yields of 30-year Treasury bonds using quarterly data from 1980Q1 to 2008Q3 and those of 10-year Treasury bonds using quarterly data from 1962Q1 to 2008Q3. The dependent variables, average nominal yields of 30-year Treasury bonds are the three month average yields calculated based on data taken from the American Academy of Actuaries while average nominal yields of 10-year Treasury bonds are calculated based on data taken from the Federal Reserve. The pension flows variable is constructed by dividing the sum of net quarterly purchases of Treasury bonds by private pension funds, state and local government retirement funds, and federal government retirement funds (available from the Federal Reserve) by quarterly nominal GDP (from the Bureau of Economic Analysis). The Fed funds rate variable is the effective federal funds rate from the Federal Reserve. The expected inflation and expected growth variables are one-year-ahead inflation and GDP expectations available from the Consensus Economics Survey. The structural balance variable is expressed as a percentage of potential GDP and is from the Congressional Budget Office. Volatility variables are calculated as the rolling 36-month standard deviation of changes in nominal yields in the case of 30-year Treasury bonds and the rolling 60-month standard deviation of changes in nominal yields in the case of 10-year Treasury bonds respectively. The significance level is calculated based on robust standard errors adjusted for serial correlation. ***, **, and * indicate significance at the 1 percent level, 5 percent level, and 10 percent level respectively.

Table 13
Determinants of average real yields of 30-year Treasury and 10-year Treasury bonds

	30-year Treasury	10-year Treasury
Pension flows	-0.036*	-0.068*
Fed funds rate	0.095***	0.075***
Relative inflation	0.132	0.185***
Structural balance	-0.020	-0.158*
Volatility	0.074	0.007
Expected growth	0.055	0.027
Adjusted R^2	0.89	0.98
# of Obs.	114	186

This table presents time series regression results of average real yields of 30-year Treasury bonds using quarterly data from 1980Q1 to 2008Q3 and those of 10-year Treasury bonds using quarterly data from 1962Q1 to 2008Q3. The dependent variables, average real yields of 30-year Treasury bonds are equal to the difference between corresponding nominal yields calculated based on data taken from the American Academy of Actuaries and ten-years-ahead expected inflation from the Philadelphia Fed's Survey of Professional Forecasters while average real yields of 10-year Treasury bonds are equal to the difference between corresponding nominal yields calculated based on data taken from the Federal Reserve and ten-year-ahead expected inflation from the Philadelphia Fed's Survey of Professional Forecasters. The pension flows variable is constructed by dividing the sum of net quarterly purchases of Treasury bonds by private pension funds, state and local government retirement funds, and federal government retirement funds (available from the Federal Reserve) by quarterly nominal GDP (from the Bureau of Economic Analysis). The Fed funds rate variable is the effective federal funds rate from the Federal Reserve. Relative inflation is the difference between ten-year-ahead expected inflation from the Philadelphia Fed's Survey of Professional Forecasters and one-year-ahead expected inflation from the Consensus Economics Survey. The expected growth variable is one-year-ahead GDP expectations available from the Consensus Economics Survey. The structural balance variable is expressed as a percentage of potential GDP and is from the Congressional Budget Office. Volatility variables are calculated as the rolling 36-month standard deviation of changes in real yields in the case of 30-year Treasury bonds and the rolling 60-month standard deviation of changes in real yields in the case of 10-year Treasury bonds respectively. The significance level is calculated based on robust standard errors adjusted for serial correlation. ***, **, and * indicate significance at the 1 percent level, 5 percent level, and 10 percent level respectively.

Table 14
Impact of bond purchases by private pension funds on the pension cost in a one year horizon

	Yield decrease (bp)	Liability increase (%)	Normal cost increase (%)
Aaa corporate bonds	104	14.3	26.0
Aa corporate bonds	61	8.0	15.2
A corporate bonds	71	9.5	17.9

This table presents the impact on the pension liability and the normal cost if the shift into bonds by private pension funds occurs over one year. We first use the relation between bond yields and pension flows identified in various econometric analyses to pin down the change in yields arising from the purchase of corporate bonds by private pension funds. We then translate yield changes into liability changes through appropriate duration and convexity adjustments. Specifically, liability increase (%) = duration * yield decrease (bp) /100 + convexity * (yield decrease (bp)/10000) ^2*100. We also translate the yield change into the change in the normal cost using the rule of thumb that a one percent change in yield alters the normal cost by about 25 percent. Specifically, normal cost increase (%) = yield decrease (bp) *25/100.

Table 15
Impact of bond purchases by both private and public pension funds on the pension cost in a one year horizon

	Yield decrease (bp)	Liability increase (%)	Normal cost increase (%)
Aaa corporate bonds	190	28.2	47.5
Aa corporate bonds	111	15.3	27.7
A corporate bonds	131	18.4	32.6
30-year Treasury	41	5.2	10.2
10-year Treasury	41	5.2	10.2

This table presents the impact on the pension liability and the normal cost if the shift into bonds by both private and public pension funds occurs over one year. We first use the relation between bond yields and pension flows identified in various econometric analyses to pin down the change in yields arising from the purchase of corporate bonds and Treasury securities by private and public pension funds. We then translate yield changes into liability changes through appropriate duration and convexity adjustments. Specifically, liability increase (%) = duration * yield decrease (bp) /100 + convexity * (yield decrease (bp)/10000) ^2*100. We also translate the yield change into the change in the normal cost using the rule of thumb that a one percent change in yield alters the normal cost by about 25 percent. Specifically, normal cost increase (%) = yield decrease (bp) *25/100.

Table 16

Impact of bond purchases by private pension funds on the pension cost in a two-year horizon

	Yield decrease (bp)	Liability increase (%)	Normal cost increase (%)
Aaa corporate bonds	52	6.8	13.0
Aa corporate bonds	30	3.9	7.6
A corporate bonds	36	4.6	8.9

This table presents the impact on the pension liability and the normal cost if the shift into bonds by private pension funds occurs over two years. We first use the relation between bond yields and pension flows identified in various econometric analyses to pin down the change in yields arising from the purchase of corporate bonds by private pension funds. We then translate yield changes into liability changes through appropriate duration and convexity adjustments. Specifically, liability increase (%) = duration * yield decrease (bp) /100 + convexity * (yield decrease (bp)/10000) ^2*100. We also translate the yield change into the change in the normal cost using the rule of thumb that a one percent change in yield alters the normal cost by about 25 percent. Specifically, normal cost increase (%) = yield decrease (bp) *25/100.

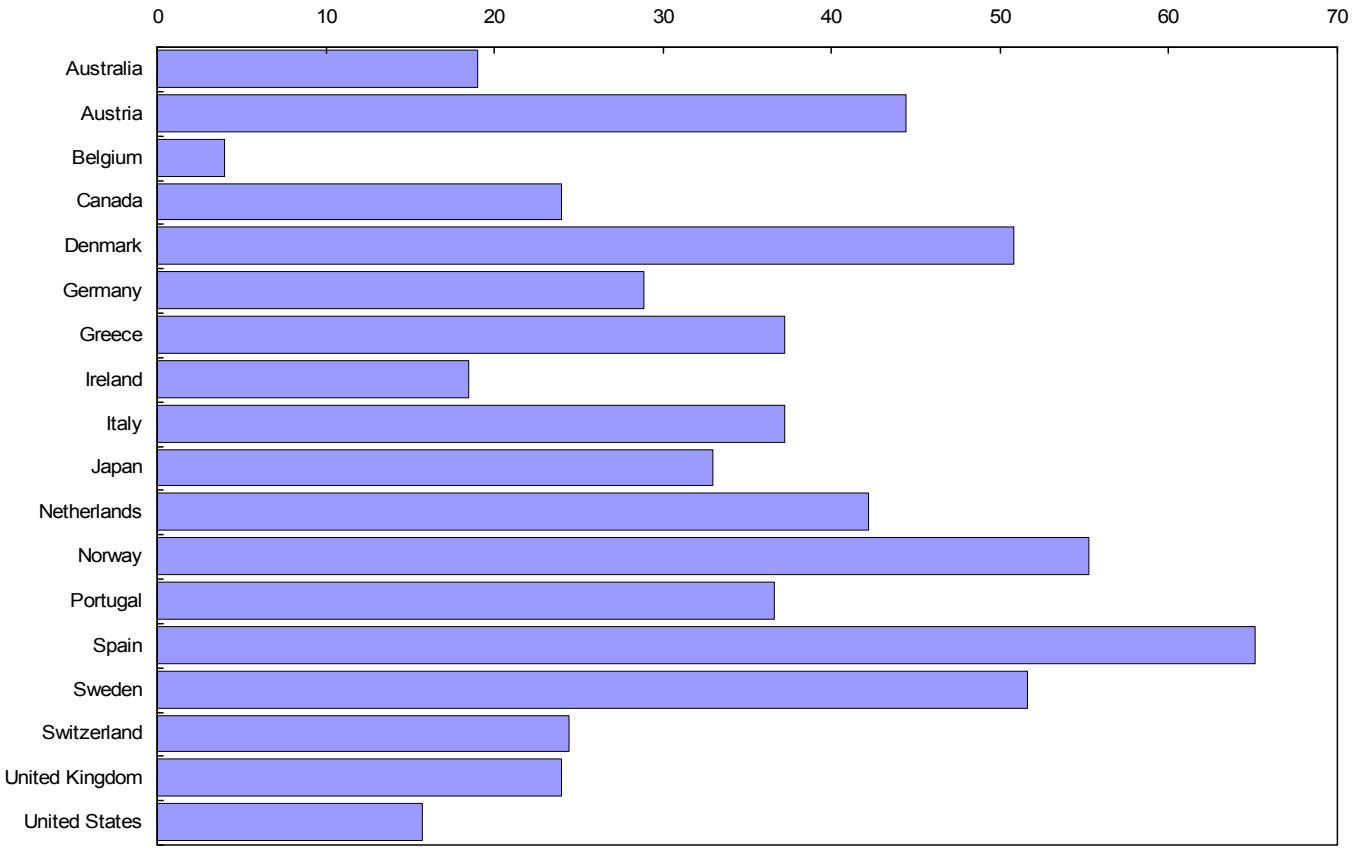
Table 17

Impact of bond purchases by both private and public pension funds on the pension cost in a two-year horizon

	Yield decrease (bp)	Liability increase (%)	Normal cost increase (%)
Aaa corporate bonds	95	12.9	23.7
Aa corporate bonds	55	7.2	13.8
A corporate bonds	65	8.6	16.3
30-year Treasury	20	2.6	5.1
10-year Treasury	20	2.6	5.1

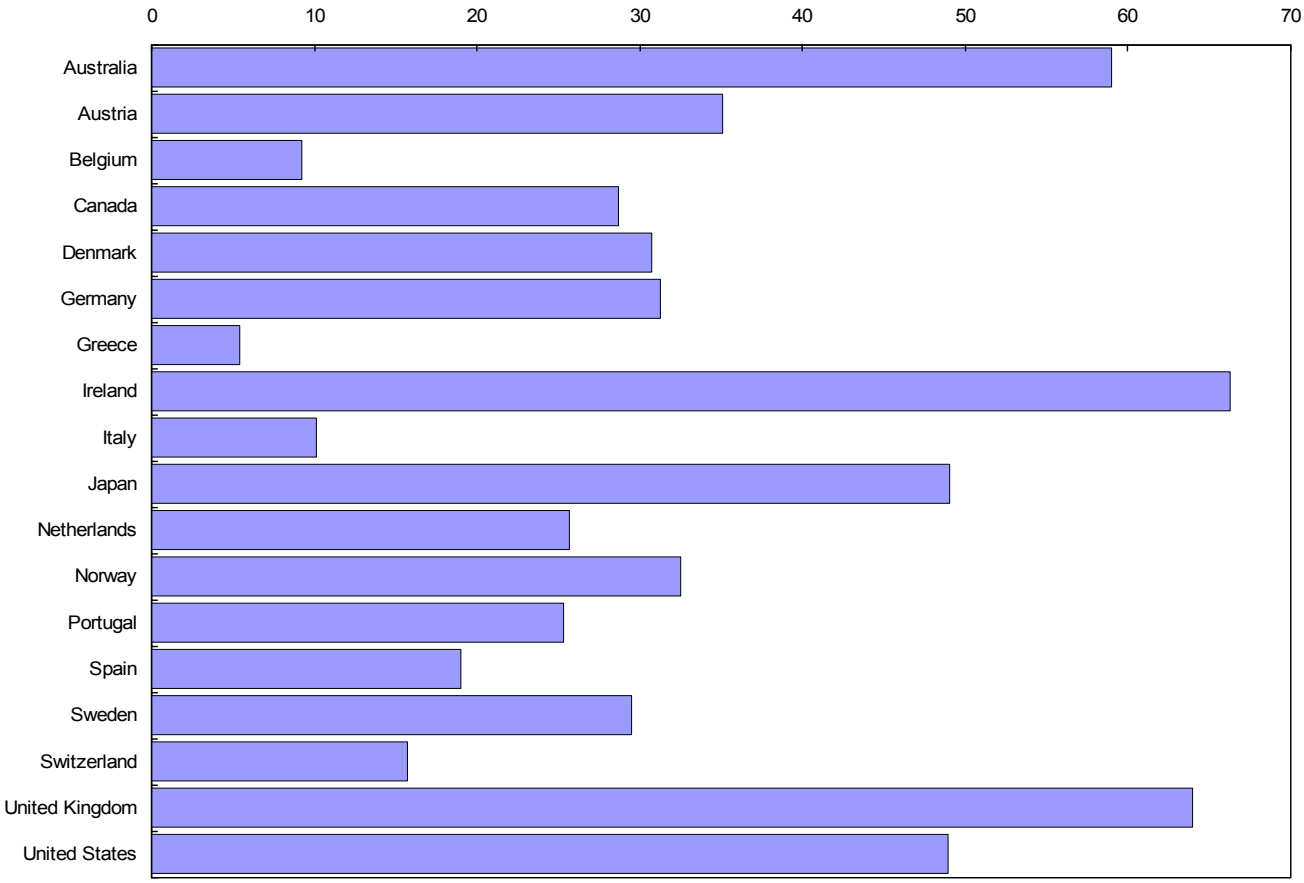
This table presents the impact on the pension liability and the normal cost if the shift into bonds by both private and public pension funds occurs over two years. We first use the relation between bond yields and pension flows identified in various econometric analyses to pin down the change in yields arising from the purchase of corporate bonds and Treasury securities by private and public pension funds. We then translate yield changes into liability changes through appropriate duration and convexity adjustments. Specifically, liability increase (%) = duration * yield decrease (bp) /100 + convexity * (yield decrease (bp)/10000) ^2*100. We also translate the yield change into the change in the normal cost using the rule of thumb that a one percent change in yield alters the normal cost by about 25 percent. Specifically, normal cost increase (%) = yield decrease (bp) *25/100.

Figure 1
Allocation of bills and bonds in pension fund assets in G-20 developed countries
(In percent of total assets)



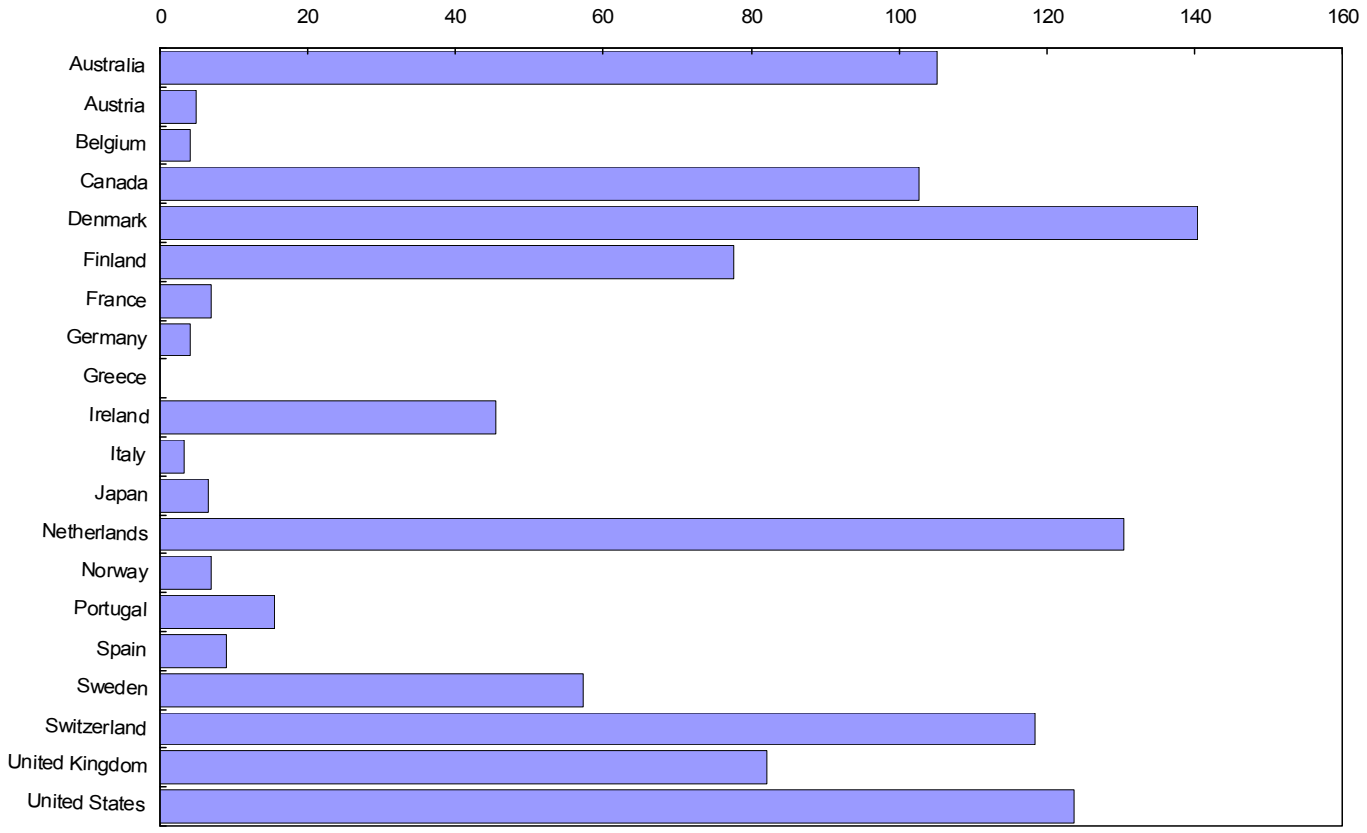
Source: OECD Global Pension Statistics.

Figure 2
Allocation of equities in pension fund assets in G-20 developed countries
(In percent of total assets)



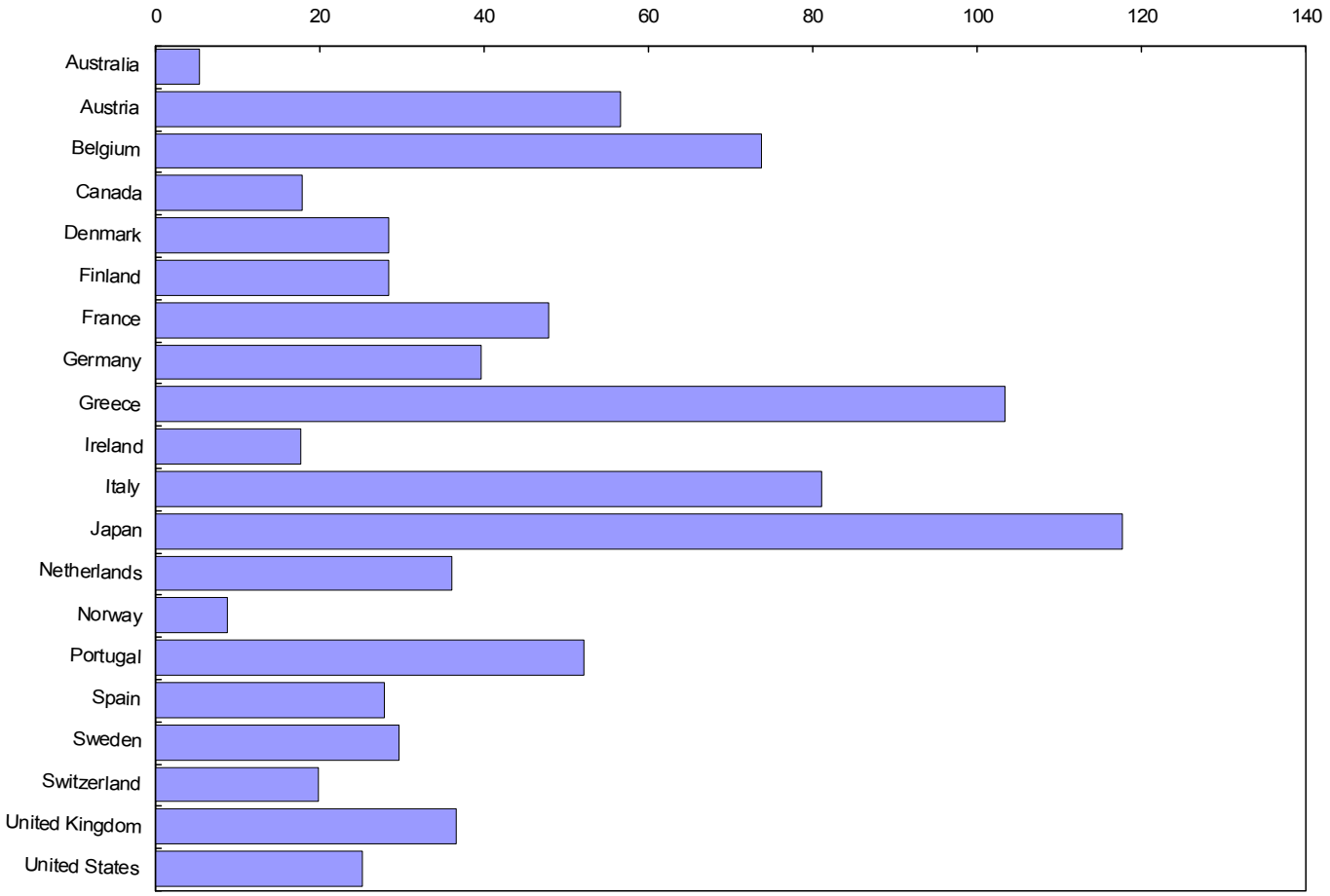
Source: OECD Global Pension Statistics.

Figure 3
Importance of pension funds relative to national economy in G-20 developed countries
(Pension fund assets in percent of GDP)



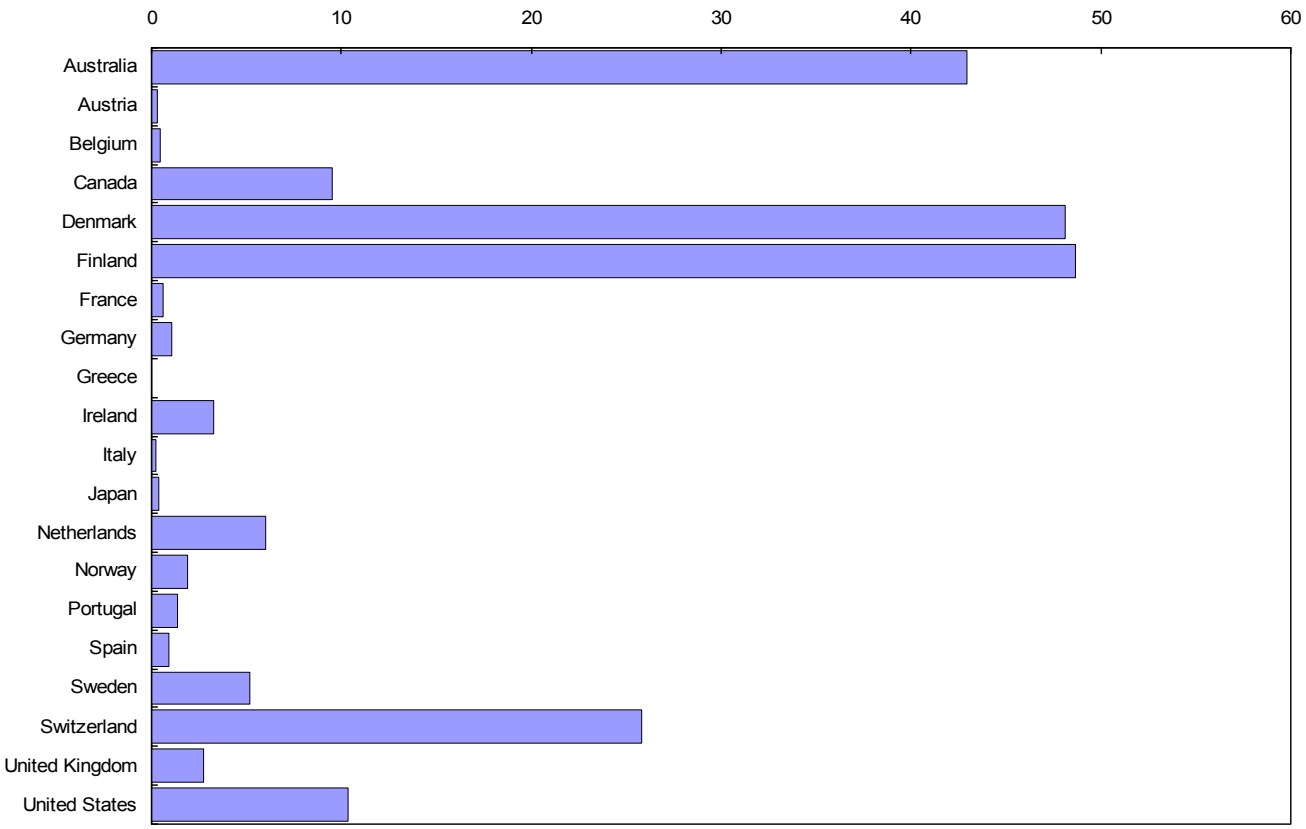
Sources: OECD Global Pension Statistics, IMF International Financial Statistics, authors' estimates.

Figure 4
Importance of government bond markets relative to national economy in G-20 developed countries
(Government bonds outstanding in percent of GDP)



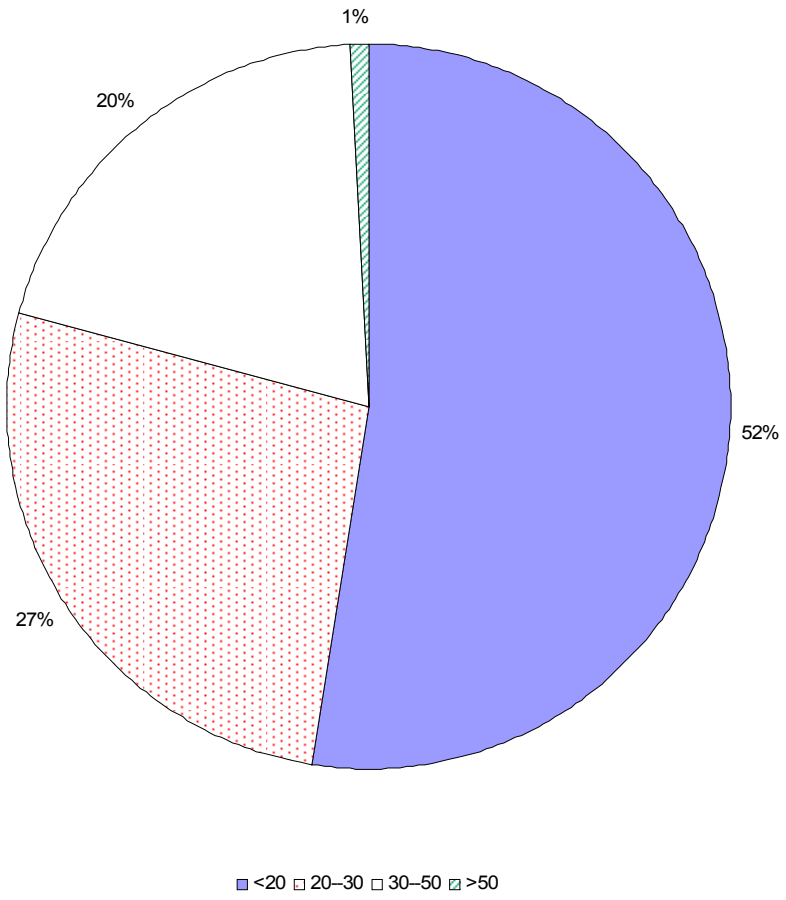
Sources: OECD Central Government Debt Statistics, IMF International Financial Statistics, authors' estimates.

Figure 5
Ratio of pension funds relative to long-term government and high quality corporate bonds outstanding in G-20 developed countries



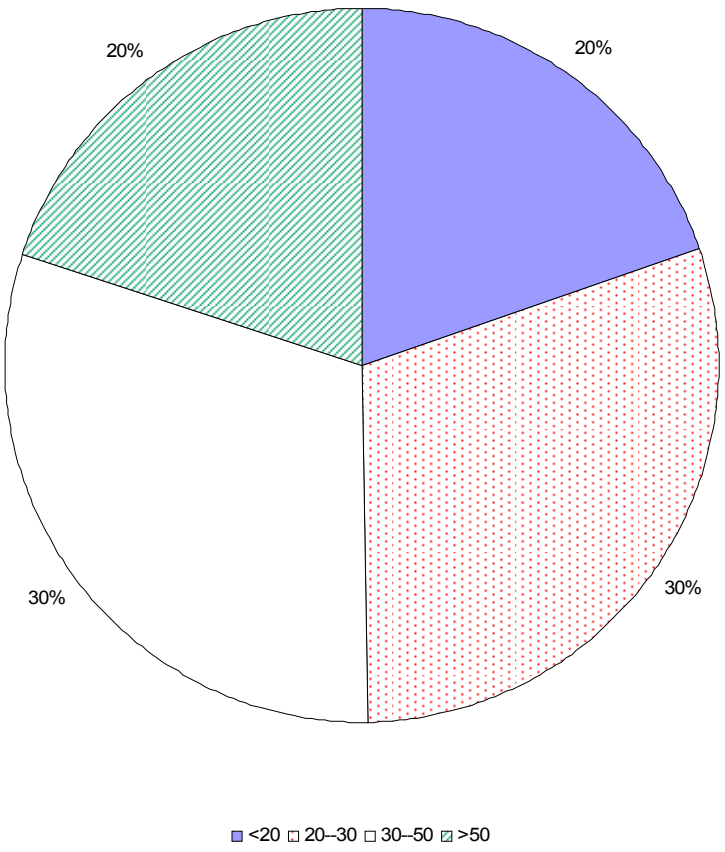
This figure displays the ratio of pension fund assets relative to long-term government and high quality corporate bonds including inflation-indexed bonds, with a residual maturity of at least 10 years outstanding as of 2007. Data on pension fund assets are from OECD Global Pension Statistics. Data on long-term government and high quality corporate bonds are from national authorities and Dealogic.

Figure 6
Maturity Profile of outstanding long-term government bonds in G-20 developed countries



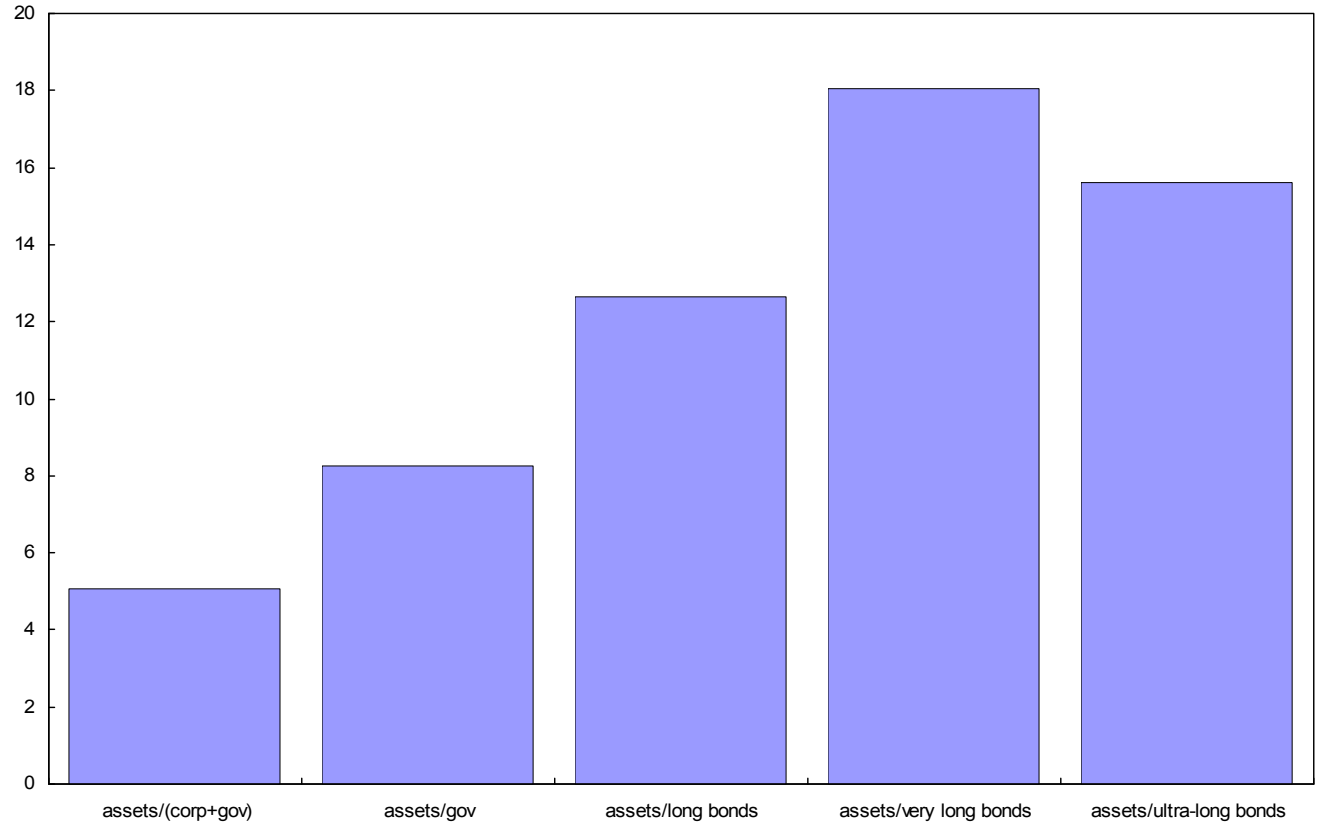
This figure illustrates the share of long-term government bonds outstanding with a residual maturity of 10 years and more as of end of 2007 by different maturity segments. Data are calculated by pooling together outstanding amounts of eligible long-term government bonds in G-20 developed countries by maturity segments. Outstanding amounts of eligible long-term government bonds are collected from national authorities and Dealogic.

Figure 7
Maturity Profile of outstanding long-term high quality corporate bonds in G-20 developed countries



This figure illustrates the share of long-term high quality corporate bonds outstanding with a residual maturity of 10 years and more as of end of 2007 by different maturity segments. Data are calculated by pooling together outstanding amounts of eligible long-term corporate bonds in G-20 developed countries by maturity segments. Outstanding amounts of eligible long-term corporate bonds are collected from Dealogic.

Figure 8
Relative scarcity of Bonds



This figure illustrates the ratios of pension funds assets to different measures of bonds outstanding with a residual maturity of 10 years or more as of end of 2007. Long bonds have residual maturities between 10 and 20 years, very long bonds have residual maturities between 20 and 30 years, and ultra-long bonds have residual maturities over 30 years. Ratios are calculated based on data from OECD Global Pension Statistics, national authorities, and Dealogic.