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Corporate Postretirement Benefit Plans and Real Investment

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Abstract. This paper shows that the real investment by nonfinancial firms is systematically related to the size of their defined-benefit plan. In particular, these plans allow research and development (R&D)-intensive firms to retain and borrow from their employees, which is attractive since they have high adjustment costs, require a stable cash flow, have less collateral, have assets that are harder to value, and have high asymmetric information and agency costs. By contrast, capital expenditures benefit from credit multiplier effects with regard to regular debt, which substitutes for postretirement obligations. As a result, firms with defined-benefit plans have 12% more R&D and 5% less capital expenditure compared with otherwise similar firms, and they vary contributions as a function of cash flow and real investment. The role of postretirement plans is attenuated in countries with available alternative funding sources. The results are robust to controlling for other dimensions of financial policy—cash holdings, debt maturity, dividends, preferred stock, convertible debt, and leverage—that also affect real investment.

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Keywords: real investment • capital expenditure • R&D • financial policy • financial flexibility • postretirement benefits • pension

1. Introduction

Real investment by nonfinancial firms is the foundation of economic growth. As a result, a number of studies have investigated the extent to which financial constraints affect corporate investment by estimating cash flow sensitivities for financially constrained/unconstrained firms. Nevertheless, the conclusions appear to differ depending on the classification scheme used to define samples of financially constrained firms (e.g., Hadlock and Pierce 2010, Cleary 1999, Kaplan and Zingales 1997, Fazzari et al. 1988). Interestingly, the literature has focused on this aspect of physical investment, whereas research and development (R&D) and dimensions of financial policy other than cash flow have enjoyed much less attention (e.g., Li 2011). In the presence of capital market imperfections, however, a number of facets of corporate financial strategy might be relevant for corporate investment (Modigliani and Miller 1958). To this end, this paper investigates the role of corporate defined-benefit postretirement plans for corporate real investment, both in the form of capital expenditures and R&D, based on a sample of more than 33,000 publicly traded nonfinancial firms from 50 countries during the period 2002–2009.[1]

Corporate defined-benefit postretirement plans have a range of features that can be important for the real investment of the sponsors of these plans, such as employee retention and financial flexibility. Historically, many plans have been set up as final salary schemes, where the promised benefit is a function of the length of service and the salary at career's end. The convexity of the payoff structure creates incentives for employees to stay with the plan sponsor. This aspect of employee retention is particularly important for firms that undertake significant research and development, where firm-specific human capital is essential. The costs of hiring and training highly skilled employees are significant, and employee turnover can lead to the loss of critical proprietary information.

Compared with firms without a defined-benefit plan, plan sponsors enjoy more financial flexibility because they defer the payment of a part of an employee's compensation to the future and thus effectively borrow from them. Moreover, although postretirement liabilities are corporate obligations that have many similarities with regular debt, they are more flexible in terms of their valuation and the level and timing of contributions (see, e.g., Ballester et al. 2002).[2] These two features of postretirement plans are particularly attractive for firms with high R&D, since they require stable investment as a result of high adjustment costs, but they tend to have lower leverage because it is more difficult for them to borrow as a result of high asymmetric information, less collateral, and more intangible assets that are harder to value. However, they can use defined-benefit plans to borrow from their employees, where agency costs and monitoring are lower compared with other creditors. By contrast, although capital expenditures are typically lumpy, larger-sized investments, they have lower adjustment costs and provide collateral for secured external borrowing. Their tangible assets benefit from credit multiplier effects with regard to regular debt, which substitutes for postretirement obligations. As a result, benefits from defined-benefit plans are smaller for capital expenditure (CapEx)–intensive firms. Although existing work on the interactions of financial policy and real investment is limited to date, Childs et al. (2005) and MacKay (2003) also motivate the idea of different types of growth options of firms and suggest that they differ in the way they are affected by financial policy. By contrast, Mauer and Triantis (1994) predict that debt financing has a negligible impact on the firm's investment and operating policies and that firms can thus determine the exercise timing decisions of their real options ignoring the effect of debt financing.

Studying the role of postretirement plans for real investment in an international context is interesting and important because defined-benefit postretirement plans are often more frequent and are economically more important outside the United States. At the same time, the United States is characterized by very developed financial markets, and there are many ways of financing real investment available to U.S. firms. The international setting also effectively provides evidence from several independent samples, which helps to establish robustness and guards against spurious relations. A larger international sample also provides more cross-sectional variation in policies and more powerful tests to better understand real investment. In an increasingly globalized world, effective policy making depends on understanding cross-country differences in important corporate activities such as real investment.

The empirical analysis demonstrates a significant relation between postretirement plans and the real investment of nonfinancial firms around the world. In particular, after controlling for other dimensions of financial policy, the results show that the relation is conditional on the type of investment opportunity: the size of the defined-benefit plan is positively related to R&D and negatively related to capital expenditures. Thus, the importance of postretirement benefit plans extends beyond capital structure to the real operations of a company, and this is an important way in which financing and investment interact. Given discretion over the timing, plan sponsors vary their plan contributions as a function of free cash flow and investment—e.g., they make smaller contributions when they invest more and have smaller cash flow. Note that companies with a lot of research and development in this study are not small start-up companies; they are large pharmaceutical and technology companies. All companies in the sample are publicly listed, and the analysis controls for many dimensions such as firm age, market-to-book, firm size, firm risk, profitability, leverage, net property, plant and equipment, industry, etc. Merck and Texas Instruments are examples of large pharmaceutical and technology companies that have large R&D programs and big postretirement benefit plans.

Effects related to postretirement plans are not only statistically significant but also economically sizable. With the obligations of the average plan totaling 11% of total assets, the typical plan sponsor has 12% more research and development and 5% less capital expenditures compared with an otherwise similar nonsponsoring firm. The relation between postretirement plans and real investment exists in many countries and industries. In line with borrowing from employees as a source of financing, the role of defined-benefit plans for real investment is attenuated in countries with available alternative sources of financing, such as venture capital and private credit. Thus, to the extent that defined-benefit plans retain human capital, reduce employee turnover, and increase financial flexibility, companies are able to undertake more R&D. Additionally, and contrary to some theoretical predictions of no or little effect of financial policy on operating policies, other dimensions of financial policy are also related to firms' real investment, such as cash, debt maturity, preferred stock, convertible debt, leverage, and corporate payout. To illustrate, cash is positively related to real investment, whereas leverage has a negative relation with real investment. These results are important because the existing knowledge on the interaction of corporate investment with financial policies in general and defined-benefit plans in particular is limited. Providing international evidence on the interactions between investment and financing policies that consider a wide range of corporate financial characteristics is thus another contribution of this paper.

The results are robust to a number of variations to methodology and data. In particular, I use a range of different estimation techniques that account for self-selection and alternative ways of adjusting standard errors such as clustering and Newey–West correction (Newey and West 1987). The results are also unaffected by limiting the sample to firms that comply with U.S. Generally Accepted Accounting Principles (GAAP) or International Accounting Standards (IAS), by employing various fixed effects (e.g., for countries, industries, accounting standards, years, firms) to control for potential differences across accounting standards and time, or by analyzing different time periods (such the subperiods before and after 2006). I manually verify the data on postretirement plans via a comparison with their recognition and disclosure in the annual reports, and I replicate the results for U.S. firms using data from the Center for Research in Security Prices (CRSP) and Compustat. Moreover, the analysis tries to avoid omitted variable biases by including large sets of control variables, but the results also hold for larger samples that result from relaxing the restrictions on data availability. Details on these and a number of other robustness tests are provided later in the paper.

Overall, the results of this paper demonstrate a significant role of postretirement plans for the asset side (i.e., real investment) of nonfinancial corporations around the world. The paper contributes to our understanding of the interrelationships between financing and operating policies. It not only documents that various dimensions of financial policy affect firms' operations in the United States and internationally but also particularly reveals a relation between postretirement benefit plans and corporate investment policies. Given the implications of real investment for economic growth and the recent challenges of the economic viability of defined-benefit postretirement plans, the result that these plans relate to the type of real investment that companies undertake is an important insight.

The rest of this paper is organized as follows. Section 2 discusses the hypotheses. Section 3 covers the sample and data. Section 4 presents the results of the empirical analysis. Section 5 concludes.

2. Hypotheses

2.1. Real Investment

Research and development and capital expenditures are important forms of corporate real investment that differ along a number of characteristics. R&D investment pertains to the direct and indirect costs related to the creation and development of new processes, techniques, applications, and products with commercial possibilities. Thus, R&D results in innovation, new knowledge, and technology that generate growth options for the firm (Reuer and Tong 2007). It is commonly carried out in a staged fashion—from fundamental research, applied research, development, and design, all the way to commercialization—that allows for sequential decision making and discretion about the future of a project along the way. R&D programs typically extend over many years but do not bring immediate payoffs. They have very limited collateral value, and successful R&D activities create mostly intangible knowledge assets, such as patents, that are hard to value and partly embedded in human capital. Risky firms must typically pledge collateral to obtain debt finance (Berger and Udell 1990), but banks and other creditors prefer physical assets to secure loans and are reluctant to lend when the project involves substantial R&D investment rather than physical investment.

Because the assets of R&D-intensive firms are highly specialized and less redeployable, they lose substantial value in the case of bankruptcy, since their value in an alternative use is much lower. As a result, problems of financial distress are particularly severe for these firms (Cornell and Shapiro 1988, Opler and Titman 1994).[3] Regular debt is also expensive for these firms because of significant agency costs resulting from moral hazard and information asymmetries between corporate insiders and outsiders with regard to the quality, progress, and success of R&D projects (e.g., Myers and Majluf 1984).[4] In fact, even the physical investment of R&D-intensive firms is more prone to moral hazard and adverse selection (Himmelberg and Petersen 1994). Moreover, servicing debt usually requires a stable source of cash flow, which is a challenge for the funding of an R&D investment program that must be sustained at a certain level in order to be productive (Hall 2002). Consequently, R&D is typically financed with internal cash flow/equity, and firms with high R&D tend to use comparatively little debt (Hall 2002).[5]

R&D requires a stable internal cash flow, and R&D-intensive firms may also hold cash to buffer shocks to their financing, thereby partially avoiding the high adjustment costs associated with altering the path of R&D investment. By its very nature, R&D is highly dependent on human capital, and most R&D investment consists of wage payments to highly trained scientists, engineers, and other skilled technology workers who often require significant firm-specific training. As a result, cuts to R&D spending typically mean dismissing workers. However, if the adjustment is only the response to a temporary funding gap, hiring and training new workers in subsequent periods entails substantial additional costs (Carpenter et al. 1994). To illustrate, the costs of hiring and training are on the order of one year of payroll costs for the average worker, and firm-specific training costs rise rapidly with the skill of the worker (Hamermesh and Pfann 1996). Moreover, firing researchers bears the risk of leaking critical proprietary information to competitors, diminishing the value of the innovation and endangering the competitive advantage of the firm. The turnover of workers can also negatively affect the research process given that research is often conducted in teams, and suspension of a research project significantly reduces its value because it prevents the resolution of technical uncertainty and increases the likelihood that the firm will not be able to finish the project before its competitors (Li 2011). Given these substantial costs of adjusting R&D, there are significant economic incentives to maintain a smooth path of R&D investment (Hall 2002).

In contrast to R&D, capital expenditures are typically used to acquire fixed assets other than those associated with acquisitions, including additions to property, plant, and equipment, as well as investments in machinery and equipment, that effectively execute growth options of the firm. They tend to be large in more mature industries, where significant past investments generate barriers to entry (Reuer and Tong 2007). Their physical nature renders the assets easily pledgeable as collateral for external borrowing. There are lower information asymmetries associated with tangible assets; they tend to be less specific to the individual firm and are more valuable to others. As a result, they are easier to value; their liquidation values are higher; and given lower agency costs of debt, firms can easily borrow against them, which is reflected in higher leverage ratios of firms with high levels of CapEx. Redeployable physical assets (such as aircraft) can also be financed via leasing.

Moreover, because capital expenditures are less determined by human capital, science, or regulation, their adjustment costs are relatively modest (Cooper and Haltiwanger 2006) and much lower compared with R&D (Brown and Petersen 2011). In particular, estimates of the adjustment costs for both R&D and physical investment typically report that the adjustment costs for R&D are substantially greater (e.g., Bernstein and Nadiri 1989). As a result of significant differences in the nature and size of the adjustment costs for CapEx and R&D, capital expenditures tend to be much more volatile than R&D investment, both in aggregate and at the firm level. By contrast, R&D is much less responsive to temporary cash flow shocks than capital expenditures (Himmelberg and Petersen 1994). Thus, R&D and CapEx clearly differ in terms of the nature of the resulting assets, the size and timing of the financing needs, their adjustment costs, and most suitable source of financing.

A number of studies investigate the relation between financing constraints and corporate real investment, mostly with a focus on capital expenditures. In a seminal paper, Fazzari et al. (1988) show that firms have high cash flow sensitivities of investment if they are financially constrained as measured by low dividend payout. Using alternative measures of financial constraints (e.g., no public debt, small size), a number of papers have subsequently presented supporting evidence to this finding. Fazzari and Petersen (1993) and Carpenter et al. (1994) show that firms absorb shocks to internal finance through changes in inventory investment and that internal finance has a stronger effect on inventory investment for small firms than for large firms.

Kaplan and Zingales (1997) call the usefulness of cash flow sensitivities into question by documenting that only a few of the firms with low dividend payout appear to be actually financially constrained based on contextual information from the firms' 10-Ks, management discussions, and public news and that these firms exhibit lower cash flow sensitivities than firms without constraints (by their classification). Similarly, Cleary (1999) shows that the investment decisions of firms with high creditworthiness are extremely sensitive to the availability of internal funds, whereas less creditworthy firms are much less sensitive to internal fund availability. More recently, Hadlock and Pierce (2010) in turn cast doubt on the validity of the Kaplan–Zingales index as a measure of financial constraints while offering mixed evidence on the validity of other common measures of constraints, suggesting that firm size and age are the most useful predictors of financial constraint levels. Related studies suggest that financial constraints may be informative for a firm's subsequent stock returns (e.g., Lamont et al. 2001).

Almeida and Campello (2002) show that more cash allows more investment, both directly and indirectly, by increasing borrowing capacity and, moreover, that this indirect effect is greater for firms that face smaller frictions. Povel and Raith (2004) show that higher cash not only allows constrained firms to invest more but also encourages them to do so. Moyen (2004) suggests that the results in Fazzari et al. (1988) are consistent with a setting where low dividends indicate financing constraints, whereas the findings in Kaplan and Zingales (1997) are in line with a setting where firms cannot raise external funds. Dasgupta and Sengupta (2007) show that more cash diminishes the extent of moral hazard and thus permits greater investment, particularly for firms with low liquidity, even though the relation between investment and liquidity is not monotonic. Alti (2003) shows that an increase in cash can lead to higher investment even in the absence of capital market frictions, because it provides additional information about the quality of a firm's investment opportunities. This information effect is stronger for low-cash firms because such firms are typically younger and have greater ex ante uncertainty about their future prospects.

Most of these studies focus on capital expenditures, whereas evidence on R&D is much more limited. To this end, Himmelberg and Petersen (1994) find significant relations between internal financing and both R&D and CapEx, but the elasticity for R&D with internal finance is less than half the elasticity for physical investment, which is consistent with high adjustment costs. Almeida and Campello (2007) show that asset tangibility positively affects the cash flow sensitivity of investment in financially constrained firms but not in unconstrained firms. Li (2011) finds that the impact of financial constraints is very severe for R&D-intensive firms.

2.2. Postretirement Benefit Plans

Defined-benefit (DB) plans for postretirement benefits have several features and characteristics that are relevant with regard to corporate real investment. In particular, the benefit calculation is typically based on the length of service and the final salary. Because salaries tend to increase with career progression, early years of service are typically revalued with higher career-end salaries. This convex payoff structure creates monetary incentives to stay in the scheme (and thus with the employer), because employees suffer wealth losses if they quit early. As a result, sponsoring firms tend to have lower employee turnover (Mitchell 1982, Schiller and Weiss 1980). In addition to postretirement benefits, other benefits are often linked to the scheme, such as invalidity and life insurance. Thus, defined-benefit plans are an important employee retention mechanism (Ippolito 1985).

Firms that sponsor a DB plan pay their employees a part of their compensation in cash and a part in the future (Gustman et al. 1994).[6] Thus, plan sponsors effectively borrow from their employees. This can be attractive for firms that have difficulty borrowing otherwise. Firms with alternative sources of funds need to consider the differences in cost and other characteristics, given that postretirement obligations (partially) substitute for regular debt. As a result, defined-benefit plans contribute to the financial flexibility of plan sponsors, i.e., their ability to respond in a timely and value-maximizing manner to unexpected changes in the firm's cash flows or investment opportunity set (Denis 2011). Employees are considered the most vulnerable of a firm's creditors, since they have not intentionally assumed the credit risk of their employer or negotiated a risk premium. Furthermore, they have no recourse and lack the information and ability to assess credit risk. Unlike other creditors, employees lose their jobs in the insolvency of their employer, in addition to salaries and benefits owed, and they can neither protect their position as easily as sophisticated creditors nor diversify the credit risk through multiple investments. Employees also exert much less effective monitoring of management than external providers of funds, especially if the claims of the former are insured, because monitoring is costly and employees may be less specialized compared with outside lenders in assessing the financial viability of the firm (Ippolito 1985).[7] At the same time, plan sponsors have to bear the investment risk associated with the plan assets, and postretirement obligations are harder to unwind than regular debt.

Although failure to meet minimum postretirement benefit plan contributions can trigger bankruptcy, the level and timing of contributions is more flexible than with payments to service regular debt. Companies can take advantage of this feature to maximize the associated tax shields by making larger contributions when marginal tax rates are high (note that this discretion is with regard to voluntary contributions, not mandatory contributions). Higher contributions will also reduce required minimum contributions in future years, build financial slack, and increase flexibility (Ballester et al. 2002, Friedman 1983). At the same time, firms may sometimes reduce or even forgo funding of a period's pension expense ("contribution holiday"), when possible, to meet competing investment or financing cash needs such as plan expansions, corporate acquisitions, debt retirement, or dividend increases. Consequently, defined-benefit plans provide plan sponsors with financial flexibility in terms of discretion with regard to the timing of making payments. They are akin to interest-only mortgages, where the size of the liability is clearly defined but the repayment schedule is flexible beyond periodic interest rate payments.[8]

Moreover, the estimates of pension and healthcare liabilities and costs rely on a number of assumptions, such as discount rates, expected long-term rate of return on plan assets, employee turnover, early retirement, salary scale (typically a function of productivity improvements, inflation, merit or promotional increases, and seniority raises), disability, family composition, mortality, retirement age, per-capita claims cost by age group, healthcare cost trend rate, medical coverage to be paid by governmental authorities and other providers of healthcare benefits, etc. Given the large size and long duration of pension obligations, small changes in the assumptions can have large effects on their valuations.[9] Although all areas of financial reporting require management to make estimates and judgments, this is particularly true of accounting for defined-benefit plans, which relies on numerous subjective assumptions given the prospective and variable nature of postretirement promises (Standard & Poor's 2006). Companies can increase or decrease the size of their postretirement obligations depending on changes in the fair value of plan assets, which tend to be driven by market movements and to a much lesser extent by changes in interest rates, because fixed income investments generally represent only a fraction of the pension asset portfolio and the maturity of those investments is typically much shorter (Revsine et al. 2005). To illustrate, it has been noted that discount rate assumptions vary significantly more widely among companies than underlying differences in interest rates and workforce demographics would justify. Similarly, there is some choice with regard to how and when to determine the fair value of the plan assets (Feldstein and Mørck 1983).[10] Companies may even use changes to postretirement plan assumptions to avoid violations on their other liabilities.[11]

These features of defined-benefit postretirement plans are particularly suitable for R&D-intensive firms, because their investment projects are risky, and information asymmetries and agency costs are high, while they have a critical need to retain firm-specific human capital, a lack of collateral, and a requirement of stable funding. Defined-benefit plans create incentives for their employees to stay with the firm, reduce employee turnover, and provide valuable financial flexibility via borrowing from their employees with a flexible repayment schedule that R&D-intensive firms otherwise do not have. These firms benefit from the flexibility of adjusting pension contributions, to buffer against shocks to cash flows and/or the costs of external equity finance, which allows them smoothing R&D investment.

Underfunding of DB plans by plan sponsors can be a way of bonding an organized work force by rendering employees equivalent to long-term unsecured bondholders. Borrowing from employees can also be optimal if employees as insiders have better information about the capabilities of the firm and the prospects of its R&D process compared to outside lenders (Ippolito 1985). To illustrate, the exercise of stock options and the participation in employee stock purchase plans have been shown to predict future stock returns and corporate patent applications (Huddart and Lang 2003, Babenko and Sen 2014). Furthermore, trades by corporate insiders, such as officers and directors, are associated with significant abnormal returns over periods of about 12 months after the trades, suggesting that they have more information about the firm (Finnerty 1976; Givoly and Palmon 1985; Seyhun 1986, 1992a, b; Lakonishok and Lee 2001).[12]

R&D-intensive firms typically have more unique or specialized products and rely on firm-specific human capital for their competitive edge. As a result, the benefits of debt-related tax shields are, at some point, outweighed by the costs of potential bankruptcy related to disruptions in the firm's relationship with its employees, customers, and suppliers; consequently, high R&D firms tend to have lower regular leverage (Titman and Wessels 1988, Butt Jaggia and Thakor 1994). At the same time, employees are the weakest creditors, and firms might be able to borrow from them even if external creditors were unwilling to provide funds, since postretirement benefits are often protected by a guarantee (Bartram 2015).[13] Moreover, R&D-intensive firms can use postretirement plan assumptions to manage earnings instead of cutting R&D expenditures to meet earnings thresholds as part of real earnings management (Eldenburg et al. 2011; Cohen et al. 2010, 2008; Roychowdhury 2006; Bushee 1998). As a result, a positive relation between the size of defined-benefit postretirement plans and R&D investment can be predicted.

By contrast, the retention of human capital is less critical for firms with capital expenditures, as the adjustment costs of physical investment are much lower compared to R&D. Moreover, these firms can borrow more easily and cheaply externally, given the tangible, redeployable nature of their assets.[14] Since pledgeable assets support more borrowing, which allows for further investment in pledgeable assets, CapEx-intensive firms benefit from a credit multiplier effect (Almeida and Campello 2007). Even though capital expenditures are volatile, cash holdings and external borrowing typically provide CapEx-intensive firms with the necessary financial flexibility, whereas DB plan obligations would limit their borrowing capacity given (partial) substitution between different forms of corporate liabilities. Thus, since the benefits of DB plans are smaller and the costs higher for CapEx-intensive firms, the relation between the size of defined-benefit postretirement plans and capital expenditures is likely negative.

The related literature motivates and supports the idea that different types of growth options relate differently to financial policy. To illustrate, in Childs et al. (2005), financial flexibility has an effect on the firm's initial debt level that depends on the characteristics of the firm's growth option. When exercising the option replaces assets-in-place with a riskier asset underlying the growth option, a firm with dynamic debt will choose a larger initial level of debt than a firm with static debt. This is because the former has the flexibility to later reduce leverage when the growth option is exercised. By contrast, when exercising the growth option expands assets-in-place, a firm with dynamic debt is less aggressive with its choice of initial leverage because it has the flexibility to increase the debt level when the growth option is exercised. Consequently, the optimal debt level is conditional on the type of growth option. By contrast, since existing theory models of financing and investment typically have simple structures of corporate assets (i.e., only assets-in-place), operating flexibility plays no role for financial policy, whereas financial flexibility typically entails lower initial debt levels as firms can increase leverage in the future (see, e.g., Titman and Tsyplakov 2007, Goldstein et al. 2001, Leland 1998). Moreover, firms with more financial flexibility are predicted to have higher levels of leverage, whereas firms with a static debt policy have lower leverage. Mauer and Triantis (1994) find that production flexibility and financial flexibility are to some extent substitutes, whereas Hackbarth and Mauer (2012) show that agency conflicts significantly decrease optimal leverage.

Tsyplakov (2008) examines the effect of investment frictions on leverage dynamics and provides evidence that small firms have more volatile investments and longer time-to-build, which may explain the observed differences in leverage dynamics across small and large firms. Morellec and Schürhoff (2011) show that asymmetric information induces firms with good prospects to speed up investment, leading to a significant erosion of the option value of waiting to invest, and Boyle and Guthrie (2003) show that the threat of future funding shortfalls lowers the value of the firm's timing options and encourages acceleration of investment. More cash reduces the need for costly external financing and thereby lowers the cost of capital. In Whited (2006), lower liquidity increases the fixed adjustment costs of changing the capital stock, causing firms with less slack to have a greater length of time between large, indivisible investment projects.

3. Sample and Data

The sample consists of all firms with data available on WorldScope and DataStream, excluding utility firms (Standard Industrial Classification (SIC) code 49) and financial firms, i.e., banks, insurance companies, etc. (SIC codes 60–64). I further impose a number of filters, because firms can have multiple share classes or listing locations. In particular, I screen on the security type, use only primary listings, exclude American depositary receipts (ADRs), and require that the currency of the stock price be a legal tender in the country of incorporation of the firm. Further, I exclude U.S. Over-the-Counter (OTC) Bulletin Board and "pink sheet" stocks, as well as firms with missing country or firm identifiers. The number of observations in Bahrain, Bermuda, Jordan, Kenya, Lithuania, Oman, Slovenia, Tunisia, the United Arab Emirates, and Zimbabwe is small, and thus firms in these countries are excluded from the analysis. The final sample consists of an unbalanced panel of 33,260 companies from 50 countries during the period 2002–2009.[15]

I classify firms as having defined-benefit pension and healthcare plans depending on whether their annual reports show projected benefit obligations for these plans. Firms with either type of plan are classified as having a DB postretirement plan. Separately for pension and medical plans, WorldScope has information on the projected benefit obligations (PBO), the fair value of plan assets, which are reported off-balance sheet, and the net periodic cost. I manually verify the data on postretirement plans in the WorldScope database via a comparison with their recognition and disclosure in annual reports based on a subsample of firms across different countries and years. The items prepaid costs and accrued costs reflect the net recognition of these plans on the balance sheet. They combine information on different types of postretirement benefit plans (domestic and foreign, pensions and healthcare, etc.), and thus, for consistency, I also combine the off-balance-sheet information into corresponding variables for all postretirement plans (as does Standard & Poor's (S&P)).

In addition to regular leverage ratios, consolidated leverage ratios are calculated based on consolidated balance sheets where the accounts are adjusted for off-balance-sheet information on postretirement benefit plans. In particular, all recognized pension and other postretirement items are removed from the balance sheet, and the true values of the assets and liabilities of postretirement benefit plans are incorporated. Specifically, consolidated leverage is calculated by redefining assets as total assets minus prepaid costs (including intangible pension asset where applicable) plus fair value of plan assets. Similarly, debt is increased by the present value of the postretirement plan liabilities minus already recognized postretirement items (including additional minimum liability where applicable).

WorldScope utilizes consolidated account data when they are disclosed. In other cases, where there are no subsidiaries or no requirement to consolidate, only parent company accounts are available. Because information on the consolidation practice is available for only about 40% of all firm-year observations, and the vast majority of these indicate that all subsidiaries are consolidated, my main analysis is based on all observations. Nevertheless, I also perform robustness tests on the subsample of firm-years where the accounts confirm that subsidiaries of any type are consolidated.

Weekly stock return data in U.S. dollars are obtained from DataStream. For firms with returns data available for at least 25 weeks in the observation year, I calculate total risk as the annualized standard deviation of returns. Appendix B provides definitions of the main variables used in the paper, and Appendix C shows their summary statistics.

4. Results

I first briefly characterize the size and popularity of defined-benefit plans across different countries. Subsequently, I investigate how postretirement benefit plans relate to real investment in portfolio sorts and regression analyses.

4.1. Size and Popularity of Postretirement Benefit Plans

Defined-benefit plans for pensions and healthcare exist in many countries. Table 1 shows averages of the relative importance of these plans by country based on the firms in the sample, where countries are sorted by the percentage of firms with a DB postretirement plan.[16] Switzerland is on top of the list, with 61.9% of all firms having some type of DB plan. More than 30% of firms have a DB plan in Austria (57.6%), Ireland (54.4%), Mexico (48.1%), the Philippines (45.0%), the Netherlands (42.7%), Taiwan (38.5%), Pakistan (38.2%), Luxembourg (38.0%), Japan (37.6%), and Norway (36.5%). Although these plans are also important in the United States, they are in fact more important in many other countries. Overall, pension plans are much more common than medical plans. In the United States, 13.7% of firms have a healthcare plan, which is the highest frequency across countries, followed by Pakistan (10.8%), South Africa (9.4%), the Netherlands (7.3%), and Canada (7.3%).[17]

The ratio of projected benefit obligations to consolidated total assets is a measure of the size of postretirement benefit plans. By this measure, there is also large variation in the economic importance of postretirement plans across countries, with Venezuela, the United Kingdom, the Netherlands, Switzerland, and

Table 1. Popularity and Size of Postretirement Benefit Plans

		Percentage of firms					
	Number of firms	Postretirement benefit plan	Pension plan	Healthcare plan	PBO/Total assets	Funding level/ Total assets	Net amounts on balance sheet/Total assets
Switzerland	173	61.9	61.7	6.5	0.206	−0.032	−0.026
Austria	56	57.6	57.6	0.3	0.069	−0.052	−0.036
Ireland	46	54.4	54.4	4.4	0.167	−0.050	−0.033
Mexico	104	48.1	48.1	1.5	0.074	−0.017	−0.009
Philippines	122	45.0	45.0	0.0	0.026	−0.012	−0.011
Netherlands	121	42.7	42.7	7.3	0.220	−0.053	−0.046
Taiwan, Province of China	1,396	38.5	38.5	0.0	0.022	−0.014	−0.011
Pakistan	98	38.2	35.2	10.8	0.048	−0.007	−0.014
Luxembourg	8	38.0	38.0	2.6	0.038	−0.037	−0.038
Japan	3,601	37.6	37.6	0.0	0.098	−0.051	−0.040
Norway	190	36.5	36.5	0.6	0.065	−0.028	−0.018
Germany	691	29.3	29.3	1.5	0.099	−0.072	−0.068
Finland	114	29.0	29.0	4.6	0.088	−0.023	−0.018
Belgium	104	28.1	28.1	3.5	0.116	−0.045	−0.046
Indonesia	261	27.5	27.4	0.4	0.026	−0.021	−0.020
United Kingdom	1,543	26.1	26.1	2.0	0.273	−0.079	−0.053
France	672	22.9	22.9	3.7	0.059	−0.029	−0.029
United States	4,899	21.1	20.0	13.7	0.153	−0.076	−0.067
Greece	256	20.9	20.9	0.7	0.018	−0.014	−0.012
Russian Federation	90	18.8	18.8	0.1	0.019	−0.018	−0.013
Portugal	49	17.7	17.7	5.6	0.063	−0.032	−0.033
Denmark	117	17.5	17.5	0.9	0.048	−0.011	−0.014
Sweden	345	17.3	17.3	1.1	0.105	−0.041	−0.031
South Africa	270	17.1	13.7	9.4	0.092	0.002	−0.015
India	1,236	13.1	13.0	0.7	0.023	−0.010	−0.012
Brazil	233	12.6	12.3	5.2	0.096	−0.016	−0.020
Canada	1,195	12.5	12.1	7.3	0.102	−0.033	−0.018
Israel	72	11.3	10.6	1.7	0.038	−0.010	−0.023
Iceland	8	10.7	10.7	0.0	0.077	−0.001	−0.001
Italy	206	9.8	9.8	2.0	0.049	−0.030	−0.028
Sri Lanka	19	9.5	9.5	0.0	0.014	−0.012	−0.011
Malaysia	818	8.2	8.2	0.0	0.016	−0.013	−0.012
Spain	100	7.1	7.1	0.0	0.021	−0.009	−0.009
Slovakia	11	6.8	6.8	0.0	0.003	−0.003	−0.003
Hong Kong	847	4.8	4.8	0.3	0.044	−0.006	−0.008
Argentina	53	4.5	4.5	0.2	0.006	−0.004	−0.004
Venezuela	16	3.8	3.8	3.8	0.334	−0.239	−0.179
Australia	1,318	3.7	3.7	0.1	0.053	−0.005	−0.010
Morocco	15	3.3	3.3	2.4	0.013	−0.013	−0.018

Ireland representing the top five. The size of these plans can be economically quite significant: to illustrate, postretirement benefit obligations are on average 27.3% of total assets in the United Kingdom.[18] They tend to be larger in countries where many firms sponsor a defined-benefit plan. The second to last column in Table 1 shows the degree of underfunding of postretirement benefit plans, calculated as the difference between fair value of plan assets and projected benefit obligations scaled by total assets. Strikingly, the typical plan is underfunded in 48 of 50 countries: only in South Africa and New Zealand does the average plan not show a deficit. Although the average degree of underfunding is 2.6% of total assets, underfunding is much more significant in a number of countries such as Venezuela (23.9%), the United Kingdom (7.9%), the United States (7.6%), Germany (7.2%), the Netherlands (5.3%), Austria (5.2%), Japan (5.1%), and Ireland (5.0%). There is a high correlation between plan size and degree of underfunding—i.e., plan deficits are large in countries where plan obligations are large. Finally, the last column of the table shows the net amounts of postretirement plans recognized on the balance sheet, calculated as prepaid postretirement costs (and intangible pension asset where applicable) minus accrued postretirement costs (including additional minimum liabilities where applicable), scaled by total assets. With a 2.3% deficit on average, these amounts tend to be smaller than the true economic levels of underfunding,

Table 1. (Continued)

	Number of firms	Percentage of firms: Postretirement benefit plan	Percentage of firms: Pension plan	Percentage of firms: Healthcare plan	PBO/Total assets	Funding level/ Total assets	Net amounts on balance sheet/Total assets
Turkey	176	3.0	3.0	0.0	0.015	−0.014	−0.013
New Zealand	97	2.7	2.7	0.0	0.082	0.003	−0.011
Qatar	15	1.6	1.6	1.6	0.005	−0.002	−0.007
Singapore	588	1.4	1.4	0.1	0.029	−0.009	−0.015
Peru	50	1.2	1.2	1.0	0.053	−0.020	−0.019
Kuwait	53	1.1	1.1	0.0	0.043	−0.010	−0.011
Hungary	26	1.0	1.0	0.0	0.010	−0.010	−0.006
Thailand	401	0.5	0.5	0.0	0.015	−0.015	−0.015
Poland	240	0.2	0.2	0.0	0.014	−0.005	−0.005
Korea, Republic of	986	0.1	0.1	0.0	0.014	−0.002	−0.002
China	1,249	0.0	0.0	0.0	0.001	−0.001	−0.001
Developed countries	17,343	22.5	22.2	5.0	0.132	−0.056	−0.046
Developing countries	8,253	13.9	13.8	0.8	0.029	−0.014	−0.012
All countries	25,596	19.7	19.5	3.6	0.109	−0.047	−0.038

Notes. The table shows averages of the importance and further characteristics of postretirement benefit plans by country, separately for firms in developed and developing countries (defined based on the MSCI classification as of June 2006), as well as for firms in all countries. In particular, it shows the number of firms; the percentage of firms with a defined-benefit postretirement plan, pension plan, and healthcare plan; the ratios of PBOs to total assets, the plan funding level to total assets, and the net recognition of postretirement benefit plans on the balance sheet to total assets. The funding level is calculated as the difference between the fair value of plan assets and the projected benefit obligations of pension and healthcare benefits, scaled by total assets. The amounts recognized on the balance sheet are prepaid postretirement costs (including intangible pension asset where applicable) minus accrued postretirement costs (including additional minimum liabilities where applicable), scaled by total assets. Averages are calculated by country (or by degree of development, or for all firms), first averaging across firms, then across years. The observations are sorted in descending order by the relative frequency of defined-benefit postretirement plans. Definitions of all variables are provided in Appendix B.

particularly for plans in countries with the most underfunded plans.

4.2. Univariate Results and Correlations

Panel A of Table 2 shows average real investment based on sorting observations into five groups from low to high, as well as tests between the extreme portfolios (high and low), where quintiles are formed based on the size of the postretirement benefit plan as measured by projected benefit obligations (scaled by consolidated total assets). The panel shows evidence of the hypothesized opposite relation of postretirement benefit plans with different types of real investment: research and development expenses (scaled alternatively by total assets or total investment) increase with the size of the postretirement plan, whereas capital expenditures decrease with larger defined-benefit plans; the differences between the top and bottom quintiles are statistically and economically significant.

Panel B of Table 2 shows differences in firm characteristics between firms with high and low real investment. Although these forms of real investment are not mutually exclusive, firms that conduct a lot of R&D tend to have smaller capital expenditures, and vice versa. Consistent with the results in panel A, firms with high R&D have larger postretirement plans. By contrast, the difference is negative (but not significant) for capital expenditures. Both regular leverage ratios (0.214 versus 0.269) and those consolidating postretirement plans (0.303 versus 0.342) are significantly lower for research-intensive firms compared with firms with no or little R&D, which is consistent with them having significantly lower tangible assets (0.279 versus 0.357) that could be used as collateral. Firms with high R&D investment are also larger, older, pay dividends, and hold more cash, consistent with attempts to buffer the effects of shocks to internal finance on their investment program. Thus, these firms share many characteristics that would actually allow them to bear more debt (such as larger size, higher Z-score, and profitability; see Graham 2000). Firms with high CapEx have significantly higher regular leverage ratios (0.253 versus 0.230) compared with firms with less capital expenditures, which is consistent with substantially more tangible assets (0.404 versus 0.232) as collateral. However, once postretirement obligations are considered, leverage ratios are similar across firms with different degrees of capital expenditure. High-CapEx firms are larger and pay dividends but have less cash, which might reflect the fact that their adjustment costs are lower and that they can more easily borrow if needed. These differences in firm characteristics call for a multivariate analysis of real investment that controls for other firm characteristics.

Before investigating the relations between postretirement benefit plans and real investment in a regression

Table 2. Portfolio Sorts of Postretirement Plans and Real Investment

Panel A: Sort by size of postretirement plan

	PBO/Total assets						
	Low	2	3	4	High	High − Low	*p*-Value
PBO/Total assets	0.006	0.024	0.060	0.129	0.325	0.319	[0.00]
R&D/Total assets	0.013	0.015	0.013	0.018	0.021	0.009	[0.00]
R&D share	0.139	0.164	0.187	0.239	0.248	0.110	[0.00]
Capital expenditures/Total assets	0.064	0.051	0.046	0.044	0.044	−0.020	[0.00]
Observations	1,015	1,016	1,016	1,016	1,015		

Panel B: Sort by real investment

	R&D/Total assets				*R&D share*				*Capital expenditures/Total assets*			
	Low	High	High − Low	*p*-Value	Low	High	High − Low	*p*-Value	Low	High	High − Low	*p*-Value
R&D/Total assets	0.000	0.032	0.032	[0.00]	0.000	0.032	0.032	[0.00]	0.017	0.015	−0.002	[0.03]
R&D share	0.004	0.387	0.383	[0.00]	0.001	0.390	0.388	[0.00]	0.260	0.131	−0.130	[0.00]
Capital expenditures/ Total assets	0.054	0.046	−0.008	[0.01]	0.056	0.043	−0.013	[0.00]	0.018	0.082	0.064	[0.00]
PBO/Total assets	0.093	0.125	0.032	[0.02]	0.093	0.125	0.032	[0.01]	0.111	0.107	−0.004	[0.96]
Regular leverage	0.269	0.214	−0.055	[0.00]	0.269	0.214	−0.056	[0.00]	0.230	0.253	0.022	[0.02]
Consolidated leverage	0.342	0.303	−0.039	[0.03]	0.342	0.303	−0.039	[0.02]	0.318	0.327	0.009	[0.37]
Net PPE/Total assets	0.357	0.279	−0.078	[0.00]	0.362	0.275	−0.087	[0.00]	0.232	0.404	0.172	[0.00]
Total assets in USD (log)	13.31	13.58	0.273	[0.00]	13.31	13.57	0.259	[0.01]	13.22	13.66	0.447	[0.00]
Age (log)	2.507	2.644	0.137	[0.01]	2.501	2.649	0.148	[0.01]	2.593	2.559	−0.033	[0.19]
(*Cash + Short-term investments*)/*Total assets*	0.145	0.197	0.052	[0.00]	0.144	0.198	0.054	[0.00]	0.198	0.144	−0.054	[0.00]
Dividend	0.726	0.788	0.062	[0.02]	0.728	0.787	0.059	[0.02]	0.708	0.806	0.098	[0.00]
Z-score	2.020	2.855	0.836	[0.00]	2.022	2.853	0.831	[0.00]	2.483	2.422	−0.061	[0.71]
Gross profit margin (3-year average)	0.242	0.273	0.031	[0.00]	0.244	0.271	0.027	[0.00]	0.251	0.264	0.013	[0.04]
Observations	2,538	2,539			2,538	2,539			2,538	2,539		

Notes. The table shows average firm characteristics for sorts by the size of the postretirement plan (panel A) and real investment (panel B), respectively. Panel A shows average corporate real investment for observations sorted into five groups (quintiles) from low to high based on the ratio of projected benefit obligations of postretirement benefit plans to total assets. Real investment is measured alternatively as the ratios of capital expenditures to total assets and research and development expenses to total assets, respectively, where missing values of capital expenditures and research and development expenses are set to 0. *R&D share* is the ratio of R&D to the sum of R&D and capital expenditures. The table also reports the difference between the high group and the low group, as well as *p*-values of nonparametric Wilcoxon tests. Panel B shows average firm characteristics for sorts by alternative measures of real investment. Firms are sorted each year into groups above and below the median. Definitions of all variables are provided in Appendix B.

framework, it is useful to take a look at the correlations between the variables to be used in the analysis. These are shown in Table 3. In line with the results from portfolio sorts, CapEx and R&D show correlations with PBO of opposite signs and similar magnitude (−0.091 and 0.092, respectively). Comparing the correlations of CapEx and R&D with other variables, it is clear that these two dimensions of real investment capture different effects, as the sign of the relations with several variables are of opposite signs, such as *ROA* (return on assets), *Age*, *Net PPE* (property, plant, and equipment), *Dividend*, *Tangible assets*, *Net FX exposure* (foreign exchange exposure), *Preferred stock*, *Convertible debt*, *Negative book equity*, and *Cash + Short-term investments*.

4.3. Multivariate Results for Real Investment

To investigate the predicted relations, I investigate the associations of projected benefit obligations with real investment in a multivariate setting. In particular, the real investment equations are specified as follows:

$$
\begin{aligned}
&\mathit{RealInvestment}\\
&\quad = c_0 + c_1 \mathit{PBO} + c_2 \mathit{MarketToBook} + c_3 \mathit{LogAge}\\
&\qquad + c_4 \mathit{Leverage} + c_5 \mathit{LogTotalRisk} + c_6 \mathit{LogTotalAssetsUSD}\\
&\qquad + c_7 \mathit{Dividend} + c_8 \mathit{TangibleAssets} + c_9 \mathit{NetFXExposure}\\
&\qquad + c_{10} \mathit{DebtMaturity} + c_{11} \mathit{GrossProfitMargin}\\
&\qquad + c_{12} \mathit{PreferredStock} + c_{13} \mathit{NetPPE} + c_{14} \mathit{ConvertibleDebt}\\
&\qquad + c_{15} \mathit{LogCashSTInvestment} + \gamma, \qquad (1)
\end{aligned}
$$

where *RealInvestment* is either the ratio of research and development expenses to total assets, or the ratio of capital expenditures to total assets, with missing values of CapEx and R&D set to 0. As in Shivdasani and Stefanescu (2010), *PBO* is the ratio of projected benefit obligations to consolidated total assets (with missing

Table 3. Correlation Analysis

Variable	*PBO/Total assets*	*Consolidated leverage*	*Regular leverage*	*Industry median leverage*	*Total risk* (log)	*Capital expenditures/Total assets*	*R&D expense/Total assets*	*R&D share*	*Employees* (log)	*Market-to-book*	*ROA* (3-year average)	*Volatility of ROA* (log)	*Age* (log)
Consolidated leverage	38.9***												
Regular leverage	−1.2**	90.6***											
Industry median leverage	2.9***	30.4***	32.2***										
Total risk (log)	−18.2***	0.0	7.6***	−6.5***									
Capital expenditures/Total assets	−8.9***	5.8***	9.7***	11.1***	3.5***								
R&D expense/Total assets	9.2***	−11.4***	−16.1***	−28.3***	3.5***	−9.3***							
R&D share	17.4***	−9.9***	−17.3***	−29.1***	−1.2**	−24.5***	78.6***						
Employees (log)	27.3***	17.6***	8.6***	6.2***	−25.5***	1.2**	−0.3	3.0***					
Market-to-book	2.8***	0.3	−0.6	−11.0***	−4.8***	6.2***	10.2***	6.1***	6.2***				
ROA (3-year average)	−5.4***	−12.5***	−11.6***	−1.8***	−10.8***	17.5***	−6.8***	−9.1***	8.8***	19.7***			
Volatility of ROA (log)	−5.6***	−6.9***	−5.7***	−18.6***	31.1***	1.7***	15.6***	9.3***	−24.1***	9.7***	−3.8***		
Age (log)	29.2***	10.1***	−0.9	7.3***	−17.6***	−11.1***	4.1***	11.1***	27.4***	−6.5***	−9.4***	−12.9***	
Tax rate	7.0***	4.7***	2.9***	1.3**	−4.6***	−6.3***	−2.2***	2.6***	4.2***	−4.8***	−14.9***	−13.6***	9.4***
Total assets in USD (log)	26.7***	22.9***	14.9***	7.6***	−27.5***	0.7	1.8***	8.6***	79.0***	6.0***	5.8***	−27.6***	32.0***
Net PPE/Total assets	−4.6***	20.1***	23.9***	34.5***	−7.1***	54.4***	−22.2***	−32.2***	2.8***	−8.2***	1.8***	−12.4***	2.1***
Dividend	15.2***	−1.4***	−7.6***	12.1***	−31.2***	2.1***	−11.0***	−7.3***	22.8***	−3.1***	19.5***	−31.7***	14.7***
Tangible assets/Total assets	−5.7***	−11.3***	−9.9***	17.2***	3.3***	20.5***	−6.5***	−11.8***	−12.6***	−8.4***	2.4***	−8.5***	3.6***
Net FX exposure	8.5***	−3.9***	−8.0***	−13.0***	−0.1	−7.4***	22.5***	23.4***	7.1***	3.3***	0.7	9.6***	4.0***
Debt maturity	9.9***	27.8***	26.3***	5.3***	−6.3***	10.9***	0.4	−1.1*	20.5***	6.4***	2.9***	0.9*	6.9***
Gross profit margin (3-year average)	−2.5***	−6.1***	−5.8***	−20.4***	−6.9***	3.2***	30.8***	27.7***	−2.8***	16.7***	21.7***	9.4***	−5.0***
Preferred stock/Size market value	0.9*	6.1***	6.0***	−0.1	8.5***	−2.3***	2.4***	0.2	−5.4***	−4.5***	−10.1***	8.7***	1.4**
Convertible debt/Size market value	−3.7***	13.4***	16.1***	−5.0***	4.4***	−1.9***	8.1***	9.5***	3.7***	−1.8***	−9.2***	5.7***	1.4***
Negative book equity	7.9***	27.5***	27.6***	0.4	11.8***	−2.8***	3.1***	0.6	−4.0***	−30.5***	−5.8***	13.7***	−1.5***
Cash flow/Total assets	−0.2	−20.9***	−23.2***	−20.1***	1.6***	17.8***	48.1***	30.5***	−0.5	28.0***	45.0***	28.8***	−9.5***
(*Cash + Short-term investments*)/*Total assets* (log)	−4.1***	−30.9***	−31.8***	−24.5***	4.4***	−12.6***	23.7***	25.3***	−2.3***	8.7***	5.0***	13.3***	−6.8***

Table 3. (Continued)

Variable	Tax rate	Total assets in USD (log)	Net PPE/ Total assets	Dividend	Tangible assets/ Total assets	Net FX exposure	Debt maturity	Gross profit margin (3-year average)	Preferred stock/Size market value	Convertible debt/Size market value	Negative book equity	Cash flow/ Total assets
Total assets in USD (log)	8.6***											
Net PPE/Total assets	−3.3***	6.2***										
Dividend	−1.4***	24.0***	10.6***									
Tangible assets/Total assets	−4.0***	−16.0***	38.7***	17.1***								
Net FX exposure	−4.1***	8.7***	−15.0***	−6.6***	−7.9***							
Debt maturity	4.1***	29.7***	13.4***	−9.3***	−30.3***	6.2***						
Gross profit margin (3-year average)	2.0***	6.4***	−3.6***	−9.7***	−26.9***	11.1***	17.2***					
Preferred stock/Size market value	−1.7***	−5.4***	−1.9***	−6.6***	−3.9***	−0.3	3.3***	−0.2				
Convertible debt/Size market value	2.3***	7.3***	−4.6***	−11.8***	−6.9***	6.3***	17.1***	4.6***	0.7			
Negative book equity	−1.8***	−6.2***	−3.1***	−11.6***	−2.5***	0.50	4.1***	2.3***	26.7***	3.3***		
Cash flow/Total assets	−31.0***	−7.8***	−3.1***	−1.7***	0.3	15.2***	2.9***	30.6***	0.0	−3.1***	6.3***	
(*Cash + Short-term investments*)/*Total assets* (log)	−4.1***	−3.3***	−30.7***	0.3	15.4***	12.4***	−16.0***	13.7***	−3.4***	6.0***	−2.0***	10.5***

Notes. The table shows correlations (in percentages) between the main variables used in the empirical analysis. *Regular leverage* is the ratio of total debt to total assets. For *consolidated leverage*, accrued postretirement costs (including additional minimum liabilities where applicable) are subtracted from total debt, and projected benefit obligations are added. Similarly, prepaid postretirement costs (including intangible pension asset where applicable) are subtracted from the measure of firm size, and the fair value of plan assets is added. For capital expenditures to total assets and research and development expenses to total assets, missing values of capital expenditures and research and development expenses are set to 0. For projected benefit obligations, missing values of PBO to total assets are set to 0. Definitions of all variables are provided in Appendix B.

*, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

values set to 0), which is a measure of the size of the postretirement plan. *MarketToBook* is the ratio of market value of equity to book value, *LogAge* is the natural logarithm of the age of the firm, *Leverage* is the ratio of total debt to consolidated total assets, *LogTotalRisk* is the natural logarithm of the annualized standard deviation of stock returns in U.S. dollars, and *LogTotalAssetsUSD* is the natural logarithm of total assets in U.S. dollars.

Dividend is a dummy variable with value 1 if the company paid a dividend (and 0 otherwise), *TangibleAssets* is the difference between total assets and intangible assets scaled by total assets, *NetFXExposure* is the difference between the percentage of foreign sales and the percentage of foreign assets, *DebtMaturity* is the ratio of long-term debt (due more than one year) to total debt, and *GrossProfitMargin* is the average gross profit margin over three years. *PreferredStock* is the ratio of preferred stock to the market value of the firm (market capitalization plus preferred stock plus total debt), *NetPPE* is the ratio of net property, plant, and equipment to total assets, *ConvertibleDebt* is the ratio of convertible debt to total assets, and *LogCashSTInvestment* is the natural logarithm of the ratio of cash and short-term investment to total assets. The set of exogenous variables is motivated by theoretical and empirical research in the literature as well economic intuition. In particular, investment is expected to be positively related to the market-to-book ratio (capturing investment opportunities), cash, and profitability (indicating internally generated funds). Dividend payments could indicate the lack of financial constraints (Fazzari et al. 1988), which would predict a positive relation with investment. By contrast, the relation could be negative if dividends are a constraint on a firm's cash flows, since firms are reluctant to cut dividends. To the extent that preferred stock and convertible debt help to manage the agency costs of debt, both variables should positively relate to R&D where this is particularly important. Childs et al. (2005) predict that the (optimal) debt level is conditional on the type of investment opportunity. Other variables are included as controls.[19]

The relation between projected benefit obligations and real investment is explored in Table 4 in a multivariate regression analysis. The results in panel A are based on research and development expenses, and results in panel B are based on capital expenditures as a proxy for real investment. The table shows results for six different estimation techniques using alternatively standard errors clustered by firm and year or adjusted based on Newey and West (1987), treatment effect models, Tobit models (with and without treatment effects), and models with firm fixed effects.

The results in the first column are based on estimating model (1) including country, industry, and year fixed effects, which control for possible differences across country, industry, and time. In empirical estimations os f models based on panel data, the residuals may be correlated across firms or across time, which can potentially bias the standard errors (Petersen 2009). To assess the robustness of the empirical results to these concerns, I estimate the real investment equation using various ways of clustering the standard errors, i.e., by firm, country, industry, year, and permutations of these dimensions. The estimations in the first and second columns adjust the standard errors alternatively by clustering by firm and year or by using the Newey and West procedure (Newey and West 1987).

To address potential concerns about selection bias, a treatment effects model is estimated using the following selection equation (probit), including industry and year fixed effects:

$$\begin{aligned} &\mathit{PostRetirementBenefitPlan} \\ &\quad = b_0 + b_1 \mathit{LogEmployees} + b_2 \mathit{MarketToBook} \\ &\qquad + b_3 \mathit{TangibleAssets} + b_4 \mathit{ROA} + b_5 \mathit{ROAVolatility} \\ &\qquad + b_6 \mathit{NetPPE} + b_7 \mathit{Unionization} \\ &\qquad + b_8 \mathit{EmployeeTenure} + \varepsilon, \end{aligned} \tag{2}$$

where *PostRetirementBenefitPlan* is a dummy variable with value 1 if the firm has a defined-benefit plan and value 0 otherwise, and *LogEmployees* is the natural logarithm of the number of employees. *Unionization* is the ratio of wage and salary earners that are trade union members divided by the total number of wage and salary earners, and *EmployeeTenure* is the average employee tenure for dependent employment. The adoption of a defined-benefit plan is likely to be positively related to the number of employees (as a result of economies of scale) and firm profitability but is negatively related to growth opportunities and the volatility of profits. Unionization and employee tenure also likely have positive coefficients because of the negotiating power of an organized labor force regarding the adoption of a pension plan and employee retention (Shivdasani and Stefanescu 2010).

The results for the treatment effects model are reported in the third column of the table. R&D (and to a much more limited extent CapEx) is characterized by many observations censored at zero. Consequently, results for Tobit models are reported as well, alternatively with fixed effects and with treatment effects (models using both do not converge) in the fourth and fifth columns, respectively. Finally, the last column reports results from regressions with firm and year fixed effects, which are commonly included in investment models in the financial constraints literature (e.g., Fazzari et al. 1988).

The economic magnitudes and levels of statistical significance are overall similar across specifications, so I combine the discussion focusing on the fixed effects

Table 4. Regression Analysis of Postretirement Plans and Real Investment

Panel A: Research and development

	OLS with fixed effects		OLS with Newey–West standard errors		Treatment effects model		Tobit		Tobit with treatment effects		OLS with firm fixed effects	
	Coef	*p*-Value	Coef	*p*-Value	Coef	*p*-Value	Coef	*p*-Value	Coef	*p*-Value	Coef	*p*-Value
PBO/Total assets	0.015	[0.00]	0.015	[0.00]	0.020	[0.00]	0.045	[0.00]	0.039	[0.00]	0.003	[0.01]
Market-to-book	0.000	[0.00]	0.000	[0.00]	0.000	[0.00]	0.001	[0.00]	0.000	[0.79]	0.000	[0.17]
Leverage	−0.010	[0.00]	−0.010	[0.00]	−0.013	[0.00]	−0.021	[0.00]	−0.021	[0.00]	−0.003	[0.00]
Age (log)	0.001	[0.00]	0.001	[0.00]	0.001	[0.01]	0.003	[0.00]	0.001	[0.02]	0.001	[0.00]
Total risk (log)	0.004	[0.00]	0.004	[0.00]	0.003	[0.00]	0.006	[0.00]	0.006	[0.00]	0.000	[0.66]
Total assets in USD (log)	0.000	[0.99]	0.000	[0.99]	0.000	[0.04]	0.001	[0.00]	0.002	[0.00]	−0.003	[0.00]
Dividend	−0.004	[0.00]	−0.004	[0.00]	−0.001	[0.37]	−0.006	[0.00]	0.000	[0.75]	0.000	[0.34]
Tangible assets/Total assets	0.013	[0.00]	0.013	[0.00]	0.013	[0.00]	0.013	[0.00]	0.037	[0.00]	0.013	[0.00]
Net FX exposure	0.017	[0.00]	0.017	[0.00]	0.011	[0.00]	0.027	[0.00]	0.027	[0.00]	0.001	[0.12]
Debt maturity	−0.001	[0.41]	−0.001	[0.39]	−0.002	[0.00]	−0.001	[0.21]	−0.015	[0.00]	−0.001	[0.00]
Gross profit margin (3-year average)	0.048	[0.00]	0.048	[0.00]	0.054	[0.00]	0.091	[0.00]	0.082	[0.00]	0.008	[0.00]
Preferred stock/Size market value	0.055	[0.03]	0.055	[0.01]	−0.007	[0.58]	0.099	[0.00]	−0.102	[0.00]	−0.010	[0.06]
Net PPE/Total assets	−0.010	[0.00]	−0.010	[0.00]	−0.012	[0.00]	−0.027	[0.00]	−0.046	[0.00]	0.006	[0.00]
Convertible debt/Size market value	0.020	[0.02]	0.020	[0.01]	0.012	[0.03]	0.027	[0.00]	0.096	[0.00]	−0.002	[0.50]
(*Cash + Short-term investments*)/ *Total assets* (log)	0.002	[0.00]	0.002	[0.00]	0.000	[0.01]	0.004	[0.00]	0.003	[0.00]	0.000	[0.00]
Intercept	−0.014	[0.01]	−0.014	[0.00]	−0.024	[0.00]	−0.081	[0.00]	−0.041	[0.00]	0.036	[0.00]
Firm fixed effects	No		No		No		No		No		Yes	
Industry fixed effects	Yes		Yes		Yes		Yes		No		No	
Country fixed effects	Yes		Yes		Yes		Yes		No		No	
Year fixed effects	Yes		Yes		Yes		Yes		No		Yes	
SE cluster	Firm, year		No		No		No		No		No	
R^2	0.35		0.35								0.96	
Observations	32,589		32,589		32,589		32,589		32,589		32,589	

model to be conservative since the coefficients tend to be smallest.[20] The main results of Table 4 are that postretirement benefit plans are positively related to research and development (panel A) but negatively related to capital expenditures (panel B), where the coefficients are of the same absolute magnitude but opposite sign (+0.015 and −0.017, respectively). The effect is not only statistically significant, but it is also economically sizable. Given an average ratio of postretirement plan obligations to total assets of 10.5%, the average plan sponsor has 12.2% more research and development and 5.2% less capital expenditures, compared with a firm without a postretirement benefit plan that has otherwise similar characteristics. This result is in line with the prediction that the size of postretirement plans and corporate real investment are related, as discussed above. The positive coefficients on the market-to-book ratio indicate that firms undertake more real investment of either type when they have more growth opportunities. However, to the extent that larger postretirement obligations allow for better retention of human capital and entail more flexibility on the financing side, it facilitates more R&D investment. Firms with capital expenditures, however, have investments with different characteristics that they can finance better and more cheaply with regular debt given the tangibility of their assets. Because the adjustment costs of these firms are lower, and since regular debt crowds out postretirement obligations (Bartram 2015), defined-benefit plans are less favorable for these firms from a cost-benefit point of view.[21]

Table 5 shows results from traditional investment regressions with cash flow and Tobin's Q, using firm and year fixed effects to control for unobservable firm effects.[22] As before, PBO is positively related to R&D and negatively related to capital expenditures. Moreover, the large sample of international firms shows positive and significant coefficients for the cash flow variable, indicating that the sample firms are financially constrained (Fazzari et al. 1988).[23]

Companies with a lot of research and development in this study are large pharmaceutical and technology companies, not small start-up companies. They are all publicly listed, and the analysis controls for many dimensions such as firm age; market-to-book; firm size; firm risk; profitability; leverage; net property, plant, and equipment; etc. Examples of sample firms with significant research and development expenses and big postretirement benefit plans are companies such as Johnson & Johnson, Merck, NEC, Novartis, Pfizer, Pioneer, Sanofi-Aventis, Roche, Texas Instruments, and Toshiba. Overall, the results confirm the predictions

Table 4. (Continued)

Panel B: Capital expenditures

	OLS with fixed effects		OLS with Newey–West standard errors		Treatment effects model		Tobit		Tobit with treatment effects		OLS with firm fixed effects	
	Coef	*p*-Value	Coef	*p*-Value	Coef	*p*-Value	Coef	*p*-Value	Coef	*p*-Value	Coef	*p*-Value
PBO/Total assets	−0.017	[0.00]	−0.017	[0.00]	−0.016	[0.00]	−0.017	[0.00]	−0.019	[0.00]	−0.015	[0.00]
Market-to-book	0.001	[0.00]	0.001	[0.00]	0.001	[0.00]	0.001	[0.00]	0.001	[0.00]	0.001	[0.00]
Leverage	−0.005	[0.22]	−0.005	[0.05]	−0.007	[0.00]	−0.006	[0.00]	−0.021	[0.00]	−0.009	[0.00]
Age (log)	−0.006	[0.00]	−0.006	[0.00]	−0.003	[0.00]	−0.006	[0.00]	−0.005	[0.00]	−0.011	[0.00]
Total risk (log)	0.003	[0.03]	0.003	[0.00]	0.004	[0.00]	0.003	[0.00]	0.009	[0.00]	−0.001	[0.32]
Total assets in USD (log)	0.000	[0.99]	0.000	[0.984]	0.001	[0.00]	0.000	[0.72]	0.001	[0.00]	0.004	[0.00]
Dividend	0.001	[0.53]	0.001	[0.49]	0.005	[0.00]	0.001	[0.40]	0.005	[0.00]	0.006	[0.00]
Tangible assets/Total assets	0.011	[0.00]	0.011	[0.00]	0.015	[0.00]	0.011	[0.00]	0.003	[0.19]	0.020	[0.00]
Net FX exposure	−0.006	[0.00]	−0.006	[0.00]	−0.008	[0.00]	−0.005	[0.00]	−0.002	[0.29]	0.004	[0.06]
Debt maturity	0.003	[0.08]	0.003	[0.00]	0.004	[0.00]	0.003	[0.00]	0.007	[0.00]	0.003	[0.00]
Gross profit margin (3-year average)	0.014	[0.00]	0.014	[0.00]	0.018	[0.00]	0.013	[0.00]	0.007	[0.00]	0.046	[0.00]
Preferred stock/Size market value	−0.040	[0.00]	−0.040	[0.00]	−0.038	[0.05]	−0.042	[0.00]	−0.037	[0.07]	−0.030	[0.14]
Net PPE/Total assets	0.149	[0.00]	0.149	[0.00]	0.136	[0.00]	0.150	[0.00]	0.137	[0.00]	0.157	[0.00]
Convertible debt/Size market value	−0.003	[0.64]	−0.003	[0.67]	0.014	[0.09]	−0.003	[0.64]	0.024	[0.00]	0.002	[0.84]
(*Cash + Short-term investments*)/ *Total assets* (log)	0.002	[0.00]	0.002	[0.00]	0.001	[0.00]	0.002	[0.00]	0.001	[0.06]	−0.001	[0.00]
Intercept	0.008	[0.18]	0.008	[0.19]	−0.031	[0.00]	0.008	[0.23]	0.014	[0.00]	−0.065	[0.00]
Firm fixed effects	No		No		No		No		No		Yes	
Country fixed effects	Yes		Yes		Yes		Yes		No		No	
Industry fixed effects	Yes		Yes		Yes		Yes		No		No	
Year fixed effects	Yes		Yes		Yes		Yes		No		Yes	
SE cluster	Firm, year		No		No		No		No		No	
R^2	0.38		0.38								0.78	
Observations	32,589		32,589		32,589		32,589		32,589		32,589	

Notes. The table reports results from estimations of multivariate regression models with real investment measured by the ratio of research and development expenses to total assets (panel A) and capital expenditures to total assets (panel B), respectively, as dependent variable. For each regression, the table shows the estimated coefficients and associated *p*-values; the use of firm, country, industry, and year fixed effects; information about the clustering of standard errors (SEs); as well as the *R*-squared and the number of observations. Industry fixed effects are based on the 48 Fama–French industries. The first column of the table shows results from estimating the model using OLS with country, industry, and year fixed effects where the standard errors are clustered by firm and year. The second column shows results from estimating the model using OLS with country, industry, and year fixed effects where the standard errors are corrected using the Newey and West (1987) procedure. The third column shows results from estimating a treatment effects model with country, industry, and year fixed effects where the probability of a firm having a defined-benefit plan is a function of the natural logarithm of the number of employees, the market-to-book ratio, the three-year average of the return on assets, tangible assets (scaled by total assets), the natural logarithm of the volatility of the return on assets, net PPE to total assets, employee tenure, unionization, and industry and year fixed effects. The fourth column shows results from estimating a tobit model with country, industry, and year fixed effects. The fifth column shows results from estimating a Tobit model with treatment effects. The sixth column shows the results from estimating the model using OLS with firm and year fixed effects. Definitions of all variables are provided in Appendix B.

and earlier findings from portfolio sorts regarding the relation between real investment and postretirement plans that is conditional on the type of investment opportunity/growth option.

To provide further evidence how defined-benefit plans provide financial flexibility to plan sponsors, I analyze the relation between DB plan contributions, cash flow, and real investment. Plan contributions are likely determined first by characteristics of the plan itself, such as the funding level, the return on plan assets, and paid benefits (Ballester et al. 2002). In particular, firms will likely make larger contributions if their plan is underfunded, if the return on plan assets is low, and if they have to pay higher levels of benefits. Alternatively, plan sponsors might make larger contributions if the return on plan assets is high since they represent an attractive investment opportunity. Moreover, the incentives to make contributions to postretirement plans are greater if the marginal tax rate of the plan sponsor is high.

The results in the first column of Table 6 show that the relation of plan contributions with the return on plan assets and paid benefits is positive, whereas it is negative for the funding level and insignificant for the tax rate. The specification in the second column adds cash flow, R&D, and capital expenditures to the regression model.[24] The coefficient on cash flow is positive and significant, indicating that plan sponsors

Table 5. Traditional Investments Regressions

	R&D expense/Total assets				*Capital expenditures/Total assets*			
	Coef	*p*-Value	Coef	*p*-Value	Coef	*p*-Value	Coef	*p*-Value
PBO/Total assets			0.006	[0.00]			−0.013	[0.03]
Cash flow/Total assets	0.057	[0.00]	0.057	[0.00]	0.050	[0.00]	0.050	[0.00]
Tobin's Q	−0.001	[0.00]	−0.001	[0.00]	0.003	[0.00]	0.003	[0.00]
Firm fixed effects	Yes		Yes		Yes		Yes	
Year fixed effects	Yes		Yes		Yes		Yes	
R^2	0.96		0.96		0.76		0.76	
Observations	31,997		31,997		31,997		31,997	

Notes. The table reports results from estimations of multivariate regression models with real investment as dependent variable. Real investment is measured by the ratio of research and development expenses to total assets and capital expenditures to total assets, respectively. The cash flow variable adds R&D to the standard measure of net cash flow (after-tax earnings plus depreciation allowances) because R&D is treated as a current expense for accounting purposes. The regressions include firm fixed effects and year fixed effects. For each regression, the table shows the estimated coefficients and associated *p*-values, as well as the *R*-squared and the number of observations. Definitions of all variables are provided in Appendix B.

exploit their flexibility with regard to contributions by varying them as a function of available cash flow (e.g., making smaller contributions when their cash flow is low).[25] Moreover, the coefficients on R&D and capital expenditures are negative, indicating that plan sponsors reduce their contributions when they invest more, both in R&D and capital expenditures. The results are similar for firm-year observations with positive cash flow. Although the coefficient on R&D is not significant for the full sample, it is for the subsample of firms with high R&D (i.e., firms with R&D above the median alternatively of all firms or firms with positive R&D). Similarly, the coefficient on capital expenditures is negative and significant for firms with high CapEx (though positive for firms with low levels of capital expenditures). These results illustrate that plan sponsors use the financial flexibility that DB plans afford them to facilitate corporate real investment. Although capital expenditures of the sample firms are on average four times more volatile than R&D, the average time-series volatility of both R&D and CapEx is significantly higher for firms without a DB plan compared with plan sponsors, even though they hold significantly more liquid assets, which could also buffer against shocks.

Table 6. DB Plan Contributions and Real Investment

	All firms				*R&D/Total assets* Low		*R&D/Total assets* High		*Capital expenditures/Total assets* Low		*Capital expenditures/Total assets* High	
	Coef	*p*-Value	Coef	*p*-Value	Coef	*p*-Value	Coef	*p*-Value	Coef	*p*-Value	Coef	*p*-Value
R&D/Total assets			−0.001	[0.55]			−0.007	[0.00]	−0.001	[0.37]	0.000	[0.80]
Capital expenditures/ Total assets			−0.001	[0.00]	−0.001	[0.02]	−0.003	[0.02]	0.016	[0.00]	−0.003	[0.00]
Cash flow/Total assets			0.004	[0.00]	0.002	[0.00]	0.008	[0.00]	0.003	[0.00]	0.004	[0.00]
Return on plan assets/ Total assets	0.285	[0.00]	0.284	[0.00]	0.327	[0.00]	0.247	[0.00]	0.296	[0.00]	0.267	[0.00]
Funding level/Total assets	−0.107	[0.00]	−0.106	[0.00]	−0.111	[0.00]	−0.101	[0.00]	−0.103	[0.00]	−0.110	[0.00]
Paid benefits/Total assets	0.105	[0.00]	0.105	[0.00]	0.104	[0.00]	0.108	[0.00]	0.111	[0.00]	0.100	[0.00]
Tax rate	0.000	[0.58]	0.000	[0.00]	0.000	[0.50]	0.001	[0.00]	0.000	[0.03]	0.000	[0.23]
Intercept	−0.002	[0.28]	−0.002	[0.18]	−0.001	[0.36]	−0.004	[0.27]	−0.002	[0.28]	−0.002	[0.31]
Country fixed effects	Yes		Yes		Yes		Yes		Yes		Yes	
Industry fixed effects	Yes		Yes		Yes		Yes		Yes		Yes	
Year fixed effects	Yes		Yes		Yes		Yes		Yes		Yes	
R^2	0.60		0.60		0.58		0.58		0.60		0.61	
Observations	29,388		29,388		16,840		12,548		14,633		14,755	

Notes. The table reports results from estimations of multivariate regression models with DB plan contributions scaled by total assets as dependent variable. Results are shown alternatively for all firms and firms with low and high R&D or capital expenditures scaled by total assets. The cash flow variable adds R&D and DB plan expenses to the standard measure of net cash flow (after-tax earnings plus depreciation allowances) because they are treated as a current expenses for accounting purposes. For each regression, the table shows the estimated coefficients and associated *p*-values; the use of country, industry, and year fixed effects; and the *R*-squared and number of observations. Industry fixed effects are based on the 48 Fama–French industries. Definitions of all variables are provided in Appendix B.

Even beyond the role of defined-benefit plans for real investment, it is interesting and important to understand which firm characteristics relate to different types of corporate investment in general, and internationally, where little is known about these relations in particular. The extent to which financing policies matter for investment policies when capital markets are not frictionless (Modigliani and Miller 1958) can be tested by regressing proxies for various dimensions of corporate financing policies as well as operating characteristics on corporate real investment. To this end, the results in Table 4 show that, contrary to some theoretical predictions of no or little effect of financial policy on operating policies, various facets of financial policy matter for real investment: leverage, debt maturity, dividends, preferred stock, convertible debt, and cash holdings are all significantly related to CapEx or R&D.

In particular, firms with lower levels of regular leverage, longer debt maturity, less preferred stock, and more liquidity have higher capital expenditures, whereas firms with lower levels of regular leverage, smaller dividends, more preferred stock, convertible debt and liquidity have more research and development. These relations are in most cases as predicted by financial theory. Contrary to predictions by Childs et al. (2005), my results show that leverage is negatively related to both capital expenditures and research and development. Purnanandam and Rajan (2013) argue that the effect of growth option exercise on leverage depends on the degree to which information asymmetry is reduced when a firm invests and also find a negative relation between leverage and capital expenditures for U.S. firms.

4.4. Multivariate Results by Country and Industry

Although the pooled results are important in and of themselves, it is interesting to explore possible differences in the role of occupational postretirement plans for real investment across countries and industries. To this end, the regression models are estimated by country and by industry (based on 48 industry classifications from Fama and French). Although the results in Table 4 control for country (as well as industry and year) fixed effects, the by-country analysis allows investigating the extent to which the direction and strength of the effects conform or differ across countries (and at the same time ensures that the pooled results are not driven by the large number of U.S. firms in the sample or by imperfect controls for institutional differences of postretirement plans across countries). The results are shown in Table 7, with separate columns for research and development expenses and capital expenditures. The underlying regression framework is the same multivariate setup as in Table 4, but the estimation is performed by country or industry, and the table only reports the coefficients and associated p-values of *PBO*.

Table 7, panel A, shows that the relation between R&D and PBO is positive in most countries (15 of 20), with large coefficients for Denmark (0.207), Taiwan (0.146), and Norway (0.052).[26] Surprisingly, the coefficient for Switzerland is negative and significant. Similarly, defined-benefit plans have a negative relation to capital expenditures in most countries (17 of 20), even though the effect is not always significant (but it is never positive and significant). The countries with the largest coefficients are Finland (−0.202), Taiwan (−0.131), and Australia (−0.110).

Panel B of Table 7 shows results from estimating the models by industry (but including year and country dummies). This is an interesting test because one would expect research and development and capital expenditures to cluster by industry, with less variation within industry, which makes it tough to demonstrate the relation between real investment and postretirement plans. Moreover, statistical power will be lower with many industries. Nevertheless, the results confirm the earlier findings. The relation of R&D with postretirement benefits is positive in 28 industries (and significant in 21 at the 10% level or better), with the largest coefficients in oil (0.106), drugs (0.083), agriculture (0.067), aircraft (0.063), and lab (measuring and control) equipment (0.057). The relation between CapEx and postretirement obligations is typically negative (in 27 industries, in 14 of which it is significant at the 10% level or better), and the largest coefficients occur in recreation (−0.078), telecom (−0.075), and medical equipment (−0.068).

To the extent that defined-benefit plans provide funding for real investment, the variation of the importance of these plans across countries could be a function of available alternative financing sources and the financial system in a country. To this end, I estimate the investment regressions including country characteristics related to the access to or availability of financing—i.e., venture capital availability as well as stock market capital, private credit, private bond market capital, net foreign bank loans, and international debt issues (all scaled by GDP), which are obtained from the World Economic Forum, World Bank, and OECD.[27] Venture capital investment is an important way of financing R&D, especially for smaller firms. Stock markets offer firms access to permanent external equity financing for large, indivisible projects, but they also provide an exit mechanism to venture capitalists (Rousseau and Wachtel 2000). Domestic and foreign banks and bond markets provide funding opportunities with regard to external borrowing.

Further variables are the measures of financial openness by Quinn and Toyoda (2008), the financial structure index of Demirguc-Kunt and Levine (2001) that captures the extent to which the financial system in a country is bank-based or market-based,

Table 7. Regression Analysis by Country and Industry

	R&D expense/Total assets		*Capital expenditures/Total assets*		
	Coef	*p*-Value	Coef	*p*-Value	Observations
	Panel A: Results by country				
Denmark	0.207	[0.01]	−0.103	[0.33]	190
Taiwan, Province of China	0.146	[0.00]	−0.131	[0.02]	1,492
Norway	0.052	[0.04]	−0.107	[0.38]	150
Malaysia	0.052	[0.00]	−0.011	[0.90]	1,085
Austria	0.048	[0.23]	0.062	[0.60]	118
Germany	0.039	[0.00]	−0.033	[0.02]	901
Japan	0.038	[0.00]	−0.001	[0.87]	5,362
Netherlands	0.024	[0.06]	−0.024	[0.12]	264
Canada	0.021	[0.13]	−0.065	[0.05]	746
United Kingdom	0.021	[0.00]	−0.010	[0.04]	2,850
South Africa	0.019	[0.00]	−0.038	[0.08]	374
Australia	0.017	[0.51]	−0.110	[0.00]	863
Hong Kong	0.009	[0.52]	−0.089	[0.16]	1,421
India	0.003	[0.84]	−0.001	[0.99]	1,212
Indonesia	0.002	[0.63]	0.017	[0.82]	508
United States	−0.001	[0.74]	−0.010	[0.01]	9,135
France	−0.009	[0.77]	−0.003	[0.89]	640
Sweden	−0.020	[0.39]	0.000	[0.99]	422
Switzerland	−0.031	[0.03]	0.001	[0.90]	420
Finland	−0.068	[0.30]	−0.202	[0.01]	215
	Panel B: Results by industry				
Agriculture	0.067	[0.00]	0.003	[0.95]	289
Aircraft	0.063	[0.03]	−0.011	[0.46]	154
Apparel	0.013	[0.07]	−0.042	[0.08]	366
Automobiles	0.004	[0.58]	−0.033	[0.00]	1,056
Beer and liquor	−0.002	[0.30]	0.030	[0.33]	228
Books	−0.008	[0.03]	−0.015	[0.41]	346
Business services	0.025	[0.00]	−0.020	[0.00]	3,367
Business supplies	0.015	[0.00]	−0.046	[0.06]	465
Candy and soda	0.036	[0.00]	−0.039	[0.25]	276
Chemicals	0.022	[0.00]	−0.048	[0.00]	1,356
Computers	0.003	[0.86]	−0.001	[0.94]	959
Construction material	0.019	[0.00]	0.006	[0.70]	1,352
Construction	0.001	[0.59]	−0.007	[0.55]	1,167
Consumer goods	0.014	[0.06]	−0.018	[0.16]	796
Drugs	0.083	[0.00]	−0.050	[0.02]	912
Electrical equipment	0.000	[0.96]	−0.023	[0.09]	569
Electronic equipment	0.029	[0.00]	−0.029	[0.00]	1,823
Entertainment	−0.014	[0.64]	0.090	[0.37]	461
Fabricated products	0.012	[0.28]	−0.024	[0.61]	180
Food products	0.017	[0.00]	−0.033	[0.02]	1,068
Lab equipment	0.057	[0.00]	−0.019	[0.24]	444
Machinery	−0.018	[0.00]	−0.022	[0.00]	1,605
Medical equipment	0.048	[0.03]	−0.068	[0.00]	608
Mines	0.014	[0.00]	−0.049	[0.33]	305

and OECD membership. Equity market liberalization directly reduces financing constraints in the sense that more foreign capital becomes available, and foreign investors could insist on better corporate governance, which indirectly reduces the cost of internal and external finance (Bekaert et al. 2005). The country variables are z-scored to allow for comparability across characteristics.

Regressions are estimated that include one country variable at a time as well as the interaction of that variable with postretirement benefit obligations. Table 8 reports the coefficient and corresponding p-value of the interaction variable, stacked across different specifications.[28] The coefficients on the interaction variable are negative for regressions with R&D and positive for regressions with CapEx, indicating that that the

Table 7. (Continued)

	R&D expense/Total assets		*Capital expenditures/Total assets*		
	Coef	p-Value	Coef	p-Value	Observations
		Panel B: Results by industry (continued)			
Oil	0.106	[0.00]	0.005	[0.91]	1,068
Personal services	0.012	[0.21]	0.109	[0.01]	299
Recreation	−0.028	[0.30]	−0.078	[0.00]	358
Restaurants	0.003	[0.00]	0.123	[0.00]	795
Retail	−0.005	[0.39]	−0.049	[0.00]	2,016
Rubber	−0.001	[0.78]	0.007	[0.69]	387
Shipping containers	0.005	[0.25]	−0.023	[0.56]	196
Steel	0.006	[0.22]	−0.017	[0.24]	979
Telecom	0.018	[0.00]	−0.075	[0.00]	852
Textiles	0.037	[0.00]	0.018	[0.62]	461
Transportation	0.000	[0.98]	−0.024	[0.21]	1,333
Wholesale	0.033	[0.00]	−0.004	[0.65]	2,505

Notes. The table reports results from estimations of multivariate regression models with real investment as dependent variable. Real investment is measured by the ratio of research and development expenses to total assets and capital expenditures to total assets, respectively. The regression setup is the same as in the first column of Table 4, but the table shows for each regression only the estimated coefficients and associated p-values of projected benefit obligations, and the last column shows the number of observations. The model is estimated by country (panel A) and by industry (panel B), respectively. Countries and industries are sorted by the size of the coefficient in the R&D column. All models in panel A include year and industry fixed effects (based on the 48 Fama–French industries) and all models in panel B include year and country fixed effects. Definitions of all variables are provided in Appendix B.

Table 8. DB Plans and Country Characteristics

	R&D/Total assets		*Capital expenditures/Total assets*	
	Coef	p-Value	Coef	p-Value
PBO/Total assets	0.037	[0.00]	−0.038	[0.00]
	Country variables interacted with *PBO/Total assets*			
Venture capital availability	−0.029	[0.00]	0.014	[0.00]
Stock market capital/GDP	−0.017	[0.00]	−0.002	[0.74]
Private credit/GDP	−0.030	[0.00]	0.026	[0.00]
Private bond market capital/GDP	−0.010	[0.00]	0.002	[0.35]
Net foreign bank loans/GDP	−0.004	[0.02]	0.008	[0.01]
International debt issues/GDP	−0.011	[0.00]	0.016	[0.00]
Financial current openness	−0.024	[0.00]	0.025	[0.00]
Capital openness	−0.035	[0.00]	0.026	[0.00]
Financial structure index	−0.012	[0.00]	0.015	[0.00]
OECD	−0.047	[0.00]	0.039	[0.06]
Observations	23,791		23,791	
Adj. R^2	0.33		0.21	

Notes. The table reports results from estimations of multivariate regression models with real investment as dependent variable. Real investment is measured by the ratio of research and development expenses to total assets and capital expenditures to total assets, respectively. In addition to the independent firm-level variables in Table 4, the regressions include country variables and their interactions with *PBO/Total assets*. Variables of country characteristics are standardized to a mean of 0 and a standard deviation of 1. The regression setup is the same as in the first column of Table 4, but the table shows only the estimated coefficients and associated p-values of selected variables. In particular, it stacks results from 10 regressions, each of which include all firm-level variables of Table 4. In addition, each regression includes one selected country characteristic and the corresponding interaction variable with projected benefit obligations. The column shows the average coefficient and p-value of *PBO/Total assets*, the average number of observations, and average adjusted R^2. In addition, it shows the estimate and p-value of the interaction term of the respective country characteristic with *PBO/Total assets*. All models include year and industry fixed effects (based on the 48 Fama–French industries). Definitions of all variables are provided in Appendix B.

role of postretirement obligations for real investment is attenuated in countries with more alternative funding sources and more open economies. This is particularly true for R&D, where all variables are statistically significant. Across different alternative funding sources, venture capital and private credit are most important for moderating the role of PBO with regard to R&D investment, whereas private credit and international debt issues are most important for capital expenditures. Moreover, the effects of postretirement obligations for real investment are smaller in market-based financial systems and more developed (OECD) countries.

4.5. Robustness Tests

A number of additional tests are undertaken to verify the robustness of the results. Although the availability of information on the degree of consolidation is limited, a robustness test is conducted that restricts the sample to firm-year observations where subsidiaries of any type, significant or not, domestic and foreign, are consolidated. The results are reported in Table 9 and are very similar to the earlier results (in Table 4), in terms of the size of the coefficients as well as their significance levels. In further robustness tests, I also perform a separate estimation of the models for firms reporting under U.S. GAAP, IAS/International Financial Reporting Standards (IFRS) (see Table 10). Alternatively, I estimate the models on the full sample when including additional fixed effects for the respective accounting standards used to prepare an annual report. The results are comparable, and the main findings of the paper maintain economic and statistical significance of similar magnitude.

The large set of exogenous variables in the regression models ensures that the results are as robust as possible to omitted variable biases, but this comes at the expense of a reduction in the number of observations with nonmissing values of all variables. To this end, Table 11 shows the results for an alternative specification where the variables that have the biggest effect on sample size are excluded—namely, *Tax rate*, *Convertible debt*, *Net FX exposure*, and *Number of employees*. This increases the number of observations from 32,589 to 126,959. Remarkably, the results are very robust, with only small variation in the size of coefficients. In separate analyses, I find that the relation between PBO and real investment in the main regression model is particularly strong for subsamples of firm-year observations with above firm-level average investment levels, though the effect is present in

Table 9. Firms with Consolidated Accounts

	R&D expense/Total assets		*Capital expenditures/Total assets*	
	Coef	p-Value	Coef	p-Value
PBO/Total assets	0.015	[0.00]	−0.017	[0.00]
Market-to-book	0.000	[0.00]	0.001	[0.00]
Leverage	−0.011	[0.00]	−0.003	[0.11]
Age (log)	0.001	[0.00]	−0.006	[0.00]
Total risk (log)	0.004	[0.00]	0.003	[0.00]
Total assets in USD (log)	0.000	[0.06]	0.000	[0.25]
Dividend	−0.004	[0.00]	0.000	[0.52]
Tangible assets/Total assets	0.013	[0.00]	0.011	[0.00]
Net FX exposure	0.017	[0.00]	−0.005	[0.00]
Debt maturity	−0.001	[0.30]	0.002	[0.02]
Gross profit margin (3-year average)	0.050	[0.00]	0.012	[0.00]
Preferred stock/Size market value	0.057	[0.00]	−0.040	[0.01]
Net PPE/Total assets	−0.011	[0.00]	0.151	[0.00]
Convertible debt/Size market value	0.022	[0.00]	−0.007	[0.35]
(*Cash + Short-term investments*)/ *Total assets* (log)	0.002	[0.00]	0.002	[0.00]
Intercept	0.008	[0.00]	0.018	[0.00]
Country fixed effects	Yes		Yes	
Industry fixed effects	Yes		Yes	
Year fixed effects	Yes		Yes	
R^2	0.35		0.40	
Observations	27,047		27,047	

Notes. The table reports results from estimations of multivariate regression models with real investment as dependent variable. Real investment is measured by the ratio of research and development expenses to total assets and capital expenditures to total assets, respectively. The regression setup is the same as in the first column of Table 4, but the sample is limited to observations where the accounts confirm that all subsidiaries are consolidated. For each regression, the table shows the estimated coefficients and associated p-values, as well as the R-squared and number of observations. All regressions include year, country, and industry fixed effects (based on the 48 Fama–French industries). Definitions of all variables are provided in Appendix B.

Table 10. U.S. GAAP and IAS Compliant Firms

	R&D expense/Total assets		*Capital expenditures/Total assets*	
	Coef	p-Value	Coef	p-Value
PBO/Total assets	0.011	[0.00]	−0.017	[0.00]
Market-to-book	0.000	[0.00]	0.001	[0.00]
Leverage	−0.014	[0.00]	−0.013	[0.00]
Age (log)	0.001	[0.00]	−0.002	[0.00]
Total risk (log)	0.004	[0.00]	0.005	[0.00]
Total assets in USD (log)	−0.001	[0.00]	0.000	[0.77]
Dividend	−0.003	[0.00]	−0.007	[0.00]
Tangible assets/Total assets	0.018	[0.00]	0.007	[0.00]
Net FX exposure	0.021	[0.00]	−0.004	[0.00]
Debt maturity	0.003	[0.00]	−0.001	[0.20]
Gross profit margin (3-year average)	0.057	[0.00]	0.014	[0.00]
Preferred stock/Size market value	0.087	[0.00]	−0.035	[0.03]
Net PPE/Total assets	−0.014	[0.00]	0.162	[0.00]
Convertible debt/Size market value	0.014	[0.03]	−0.008	[0.29]
(*Cash* + *Short-term investments*)/ *Total assets* (log)	0.003	[0.00]	0.001	[0.00]
Intercept	0.006	[0.05]	0.014	[0.00]
Country fixed effects	Yes		Yes	
Industry fixed effects	Yes		Yes	
Year fixed effects	Yes		Yes	
R^2	0.37		0.47	
Observations	15,943		15,943	

Notes. The table reports results from estimations of multivariate regression models with real investment as the dependent variable. Real investment is measured by the ratio of research and development expenses to total assets and capital expenditures to total assets, respectively. The regression setup is the same as in the first column of Table 4, but the sample is limited to firms reporting under IAS/U.S. GAAP. For each regression, the table shows the estimated coefficients and associated p-values, as well as the R-squared and number of observations. All regressions include year, country, and industry fixed effects (based on the 48 Fama–French industries). Definitions of all variables are provided in Appendix B.

samples of observations with normal and excessive investment levels (Purnanandam and Rajan 2013).

I also conduct a number of tests to address potential endogeneity concerns. In particular, the results are robust to models with lagged independent variables, simultaneous equations models for real investment, leverage, PBO, and postretirement plans,[29] as well as instrumental variables models using unionization and the age of the firm (as a proxy for the age of the plan) as instruments for pension obligations.[30] I also investigate the introduction of the Pension Protection Act of 2006 (PPA) in the United States and the global financial crisis (GFC) as economic shocks. To this end, I include dummy variables and interaction terms with PBO for the years after 2007 (or, alternatively, 2008). The results suggest that firms did not reduce their real investment as a result of the PPA or GFC, unless they did not have a postretirement plan.

Finally, I also split the sample by the size of the postretirement obligations or, alternatively, the funding level (both scaled by total assets). The results show that the size of the postretirement plan is positively related to research and development and negatively related to capital expenditures for both firms with large plans and firms with small plans. Similarly, the relations exist for all funding levels. I also investigate the conjecture that R&D-intensive firms sponsor very small benefit plans (e.g., for key employees), whereas capital expenditure–intensive firms sponsor much larger plans. Although information on the number of participants in the postretirement plans is not available, I use PBO scaled alternatively by total assets and number of employees as a measure of the size of the benefit plan. Even though the patterns across quintiles are not always entirely monotonic, it appears that firms with the most R&D have larger PBO (scaled by either measure) compared with firms with the least R&D. By contrast, firms with the most CapEx have less PBO than firms with the least capital expenditure. Overall, there is little evidence that firms with high research and development expenses (capital expenditures) sponsor small (large) plans.

5. Conclusion

Postretirement benefit plans provide plan sponsors with a number of benefits. Because of the convexity of the benefits, defined-benefit schemes are a means of employee retention. Moreover, because a part of the compensation is deferred and the funding rules

Table 11. Alternative Model Specification

	R&D expense/Total assets		*Capital expenditures/Total assets*	
	Coef	p-Value	Coef	p-Value
PBO/Total assets	0.005	[0.00]	−0.012	[0.00]
Market-to-book	0.000	[0.00]	0.001	[0.00]
Leverage	0.003	[0.00]	−0.002	[0.01]
Age (log)	0.001	[0.00]	−0.009	[0.00]
Total risk (log)	0.005	[0.00]	0.000	[0.33]
Total assets in USD (log)	−0.002	[0.00]	0.000	[0.00]
Dividend	−0.007	[0.00]	0.009	[0.00]
Tangible assets/Total assets	0.017	[0.00]	0.009	[0.00]
Debt maturity	0.000	[0.34]	0.004	[0.00]
Gross profit margin (3-year average)	0.022	[0.00]	0.009	[0.00]
Preferred stock/Size market value	0.051	[0.00]	−0.025	[0.00]
Net PPE/Total assets	−0.010	[0.00]	0.126	[0.00]
(*Cash + Short-term investments*)/ *Total assets* (log)	0.005	[0.00]	0.003	[0.00]
Intercept	0.033	[0.00]	−0.024	[0.00]
Country fixed effects	Yes		Yes	
Industry fixed effects	Yes		Yes	
Year fixed effects	Yes		Yes	
R^2	0.28		0.30	
Observations	126,959		126,959	

Notes. The table reports results from estimations of multivariate regression models with real investment as dependent variable. Real investment is measured by the ratio of research and development expenses to total assets and capital expenditures to total assets, respectively. The regression setup is the same as in the first column of Table 4, but the variables that have the biggest effect on sample size—namely, tax rate, convertible debt, net FX exposure, and number of employees—are excluded. For each regression, the table shows the estimated coefficients and associated p-values, as well as the R-squared and number of observations. All regressions include year, country, and industry fixed effects (based on the 48 Fama–French industries). Definitions of all variables are provided in Appendix B.

are flexible, these schemes provide plan sponsors with financial flexibility. These features are particularly attractive for companies with high levels of R&D that have high adjustment costs, because they rely on highly skilled labor that is expensive to hire. In addition, the departure of employees risks sharing research ideas and results with competing firms. Therefore, the retention of human capital is key for research intensive firms. Compared with otherwise similar firms, companies with defined-benefit plans pay lower salaries in return for future benefit payments, which provides internal financing that fits the nature of stable investment in R&D. Given the lower extent of tangible assets, it is harder for R&D-intensive firms to borrow externally, while postretirement plans allow them to borrow from their employees, where agency costs and monitoring are lower.

By contrast, companies that undertake physical investment have lower adjustment costs. Moreover, although capital expenditures tend to be lumpy, larger-sized expenditures, they result in tangible assets that can be used as collateral for borrowing. CapEx-intensive firms benefit from credit multiplier effects with regard to regular debt, because pledgeable assets support more borrowing, which allows for further investment in pledgeable assets. Thus, these firms can more cheaply and flexibly borrow externally than from their employees. Since postretirement obligations substitute for regular debt, postretirement plans are overall less attractive for firms with high capital expenditures.

The empirical results indeed show a positive relation of postretirement obligations with research and development and a negative relation with capital expenditures. The typical plan sponsor has 12% more research and development and 5% less capital expenditures in comparison to a similar firm without a defined-benefit plan. Since plan contributions are flexible, plan sponsors contribute less to DB plans when their cash flow is low and they undertake more real investment. Consequently, postretirement plans are important not just for the capital structure but also for the real operations of a company, which is an important way in which financing and investment interact. The role of DB plans for real investment is smaller in countries where alternative sources of funding for investment are available to firms. Moreover, the study provides international evidence that other dimensions of financial policy—such as debt maturity, preferred stock, convertible debt, leverage, and corporate payout—have an impact on firms' real investment, despite some theoretical predictions of a limited role of financial policies for operating policies. In summa, the paper shows that corporate defined-benefit postretirement schemes matter internationally for the real investment of nonfinancial firms.

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Appendix A. Corporate Defined-Benefit Pension Plans

Defined-benefit (DB) pension plans and defined contribution (DC) pension plans are the main types of institutional pension arrangements. For defined contribution pension plans, the employer only has a legal obligation to make specific contemporaneous payments into the pension account of the employee. Consequently, the beneficiaries, i.e., the employees, bear the investment risk. By contrast, a defined-benefit plan specifies the benefits of the employees at retirement, and the employer bears the investment risk. The employer is legally required to make contributions to the pension plan so that the assets are sufficient to meet the pension obligations. The analysis in this paper focuses on DB plans, since the obligations of the employer are limited to periodic pension contributions in the case of DC plans. Although DB plans have been very common in the past, they have lost their popularity in recent years because of reduced tax advantages, increased costs, and competitive pressures given that few companies tend to adopt new DB plans. However, given the slow nature of these changes, defined-benefit plans will continue to exist in many cases for a long time into the future.

Pension assets and liabilities are typically treated as off-balance-sheet items. Pension contributions, however, appear in the cash flow statement (as the actual payment to fund the pension assets), and the income statement shows the pension cost as an expense. It is typically the pension contribution, not the pension expense, that is tax deductible (Rauh 2006). Pension costs differ from contributions since companies try to smooth pension expenses in order to avoid fluctuations in plan assets and liabilities causing significant variation in corporate accounts, particularly income. The difference between the actual experience and that expected based on the actuarial assumptions that have not yet been recognized as a component of net periodic benefit cost yields an unrecognized actuarial gain/loss off-balance-sheet. The extent to which employers have to make contributions each year depends on the funding status of the pension plan. Although companies are required to increase their contributions over a period of time if the plan is severely underfunded (mandatory contributions), they have discretion to make voluntary contributions or not.

Annual reports contain information on the pension scheme both on- and off-balance-sheet. The pension liability is measured as the projected benefit obligation, which reflects the present value of the future benefits to employees, based on current service and future expected salaries. It is a measure of a pension plan's liability at the calculation date assuming that the plan is ongoing and will not terminate in the foreseeable future.[31] By contrast, the pension assets are valued at fair market value. Pension plan assets and liabilities are reported in the footnotes of the annual report while the balance sheet shows the net amount—i.e., the extent to which pension contributions are above or below pension cost. For severely underfunded pension plans, Financial Accounting Standards Board required U.S. firms until 2006 to recognize an additional minimum liability on the balance sheet that is offset by an intangible asset and, for amounts in excess of unrecognized prior service costs, by a charge to book equity. In addition to pension plans, companies may offer other postretirement employee benefits, such as medical plans, insurance coverage, and other welfare benefits such as tuition assistance, day care, legal services, and housing subsidies provided after retirement. Provisions for these are largely similar to those for pensions. In particular, the footnotes of the annual report contain the estimated healthcare benefit obligation and the fair value of the plan assets.[32] To the extent that funding requirements are often lower (or voluntary), medical plans provide more flexibility than pension plans.[33]

In the United States, Financial Accounting Standards (FAS) 87 and 88 mandated the disclosure of key pension plan information, such as the fair value of the pension assets and the projected benefit obligations, since 1985. FAS 106, issued in 1990, required similar disclosure for postretirement benefits other than pensions. FAS 132 (passed in 1998, revised in 2003) was issued as an amendment to both earlier statements, standardizing the disclosure requirements for pensions and other postretirement benefits to the extent practicable, requiring additional information on changes in the benefit obligations and fair values of plan assets, and eliminating certain disclosures that were no longer deemed as useful. Since 2006, FAS 158 requires an employer to recognize the funded status of a defined-benefit postretirement plan in its statement of the financial position and to recognize changes in the year of their occurrence. U.S. and international accounting standards are largely similar with regard to the recognition and disclosure of postretirement benefit plans. International Accounting Standard (IAS) 19 was originally issued in 1983 and subsequently revised in 1993, 1998, and 2000. The provisions of IAS 19, which underwent a limited amendment in 2002, are very similar to FAS 87. Following the European Union's IFRS

Appendix B. Variable Definitions

Variable	Definition
Age (log)	Natural logarithm of firm age
Capital expenditures/Total assets	Capital expenditures divided by total assets, with missing values of capital expenditures set to zero
(*Cash + Short-term investments*)/*Total assets* (log)	Natural logarithm of (Cash + Short-term investments)/(Total assets − (Cash + Short-term investments))
Cash flow/Total assets	(NetIncome before extraordinary items + Depreciation + R&D expenses)/Total assets
Contributions/Total assets	Contributions to defined-benefit plans divided by total assets
Convertible debt/Size market value	Convertible debt divided by size market value
Debt maturity	Long-term debt (due more than one year) divided by total debt
Dividend	Dummy variable with value 1 if a dividend was paid and 0 otherwise
Employees (log)	Natural logarithm of the number of both full- and part-time employees of the company; it excludes seasonal employees and emergency employees
Employee tenure	Average employee tenure for dependent employment (OECD)
Gross profit margin (3-year average)	Average of up to three years of gross profit margin
Healthcare plan	Indicator variable with value 1 if firm has a defined-benefit healthcare plan and 0 otherwise
Industry median leverage	Industry median book leverage at the four-digit SIC code level
Market-to-book	Market capitalization divided by book value of common equity
Negative book equity	Dummy variable with value 1 if book value of common equity or book value per share is negative and 0 otherwise
Net FX exposure	(Foreign sales/Total sales) − (Foreign assets/Total assets)
Net amounts on balance sheet/Total assets	(Prepaid postretirement costs − Accrued postretirement costs)/Total assets
Net PPE/Total assets	Property, plant, and equipment (net) divided by total assets
PBO/Total assets	Projected benefit obligations divided by consolidated total assets, with missing values of PBO set to 0
Pension plan	Indicator variable with value 1 if firm has a defined-benefit pension plan and 0 otherwise
Postretirement benefit plan	Indicator variable with value 1 if firm has a defined-benefit pension or healthcare plan and 0 otherwise
Preferred stock/Size market value	Preferred stock/(Market capitalization + Preferred stock + Total debt)
PBO	A measure of a plan's liability at the calculation date assuming that the plan is ongoing and will not terminate in the foreseeable future, alternatively for pension plans, healthcare plans, or total postretirement plans; it reflects combined plans data where multiple plans exist
R&D expense/Total assets	Research and development expenses/Total assets, with missing values of R&D set to 0
R&D share	R&D expense/(R&D expense + Capital expenditures)
ROA (3-year average)	Average of up to three years of return on assets
Size market value	Market capitalization + Preferred stock + Total debt
Tangible assets/Total assets	(Total assets − Intangible assets)/Total assets
Tax rate	Corporate tax rate (Income taxes/pre-tax income)
Tobin's Q	(Total assets + Market capitalization − Common equity − Deferred taxes)/Total assets
Total assets	Total assets
Total assets in USD (log)	Natural logarithm of total assets in U.S. dollars
Total debt	Total debt
Total risk (log)	Natural logarithm of annualized standard deviation of stock returns in U.S. dollars
Total debt/Total assets	Total debt divided by total assets
Unionization	Ratio of wage and salary earners that are trade union members divided by the total number of wage and salary earners (OECD)
Volatility of ROA (log)	Natural logarithm of the standard deviation of return on assets over prior five years
Z-score	Altman (2013) *Z*-score

Note. The table shows the definitions of the main variables used in the analysis.

Appendix C. Summary Statistics

							Percentiles							
	Observations	Mean	Std. dev.	Skewness	Kurtosis	Minimum	1st	5th	25th	Median	75th	95th	99th	Maximum
Postretirement benefit plan	325,710	0.12	0.33	2.27	3.2	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00
Pension plan	325,710	0.12	0.33	2.30	3.28	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00
Healthcare plan	325,710	0.02	0.15	6.39	38.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00
PBO/Total assets	325,710	0.01	0.06	6.35	47.9	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.31	0.64
Net amounts on balance sheet/ Total assets	41,288	−0.03	0.05	−2.46	6.92	−0.25	−0.25	−0.13	−0.04	−0.01	0.00	0.00	0.02	0.02
Total risk (log)	197,526	−0.65	0.61	0.33	−0.05	−2.05	−2.03	−1.58	−1.08	−0.69	−0.28	0.47	0.94	0.94
Capital expenditures/Total assets	325,710	0.03	0.06	2.89	9.47	0.00	0.00	0.00	0.00	0.01	0.04	0.16	0.34	0.34
R&D expense/Total assets	325,710	0.01	0.05	5.01	27.0	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.33	0.33
R&D share	325,688	0.10	0.25	2.44	4.6	0.00	0.00	0.00	0.00	0.00	0.00	0.82	0.98	0.98
Employees (log)	164,534	6.35	2.11	−0.23	0.11	0.69	0.69	2.56	5.09	6.40	7.74	9.79	11.2	11.2
Cash flow/Total assets	203,527	−0.03	0.43	−5.35	32.8	−3.08	−3.08	−0.50	−0.01	0.05	0.11	0.24	0.42	0.42
Market-to-book	186,845	2.28	4.59	2.77	19.0	−15.1	−14.9	−0.03	0.75	1.43	2.69	8.00	29.8	31.1
ROA (3-year average)	189,144	−0.02	0.21	−2.54	7.52	−1.00	−1.00	−0.49	−0.02	0.03	0.08	0.18	0.28	0.40
Volatility of ROA (log)	200,634	−3.15	1.25	−0.16	0.05	−9.56	−6.16	−5.17	−4.00	−3.18	−2.27	−1.06	−0.60	−0.01
Age (log)	325,582	2.45	0.76	−0.69	0.22	0.00	0.00	1.10	1.95	2.56	3.00	3.61	3.71	3.83
Tax rate	129,634	0.30	0.20	1.10	2.33	0.00	0.00	0.00	0.17	0.30	0.39	0.65	1.00	1.00
Total assets in USD (log)	203,893	11.60	2.10	−0.03	0.19	5.86	5.89	8.11	10.3	11.6	12.9	15.2	16.9	16.9
Z-score	175,594	1.35	4.13	−1.81	5.29	−17.6	−17.2	−6.52	0.09	1.98	3.73	6.44	8.20	12.1
Net PPE/Total assets	202,970	0.30	0.24	0.71	−0.32	0.00	0.00	0.01	0.10	0.26	0.45	0.76	0.92	0.92
Tangible assets/Total assets	193,939	0.90	0.16	−2.21	4.39	0.25	0.25	0.51	0.89	0.99	1.00	1.00	1.00	1.00
Dividend	325,710	0.33	0.47	0.74	−1.45	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Net FX exposure	84,256	0.08	0.21	1.37	4.20	−1.00	−0.39	−0.12	0.00	0.00	0.11	0.54	0.85	1.00
Debt maturity	171,702	0.48	0.35	0.00	−1.42	0.00	0.00	0.00	0.12	0.49	0.80	1.00	1.00	1.00
Gross profit margin (3-year average)	188,199	0.24	0.26	−1.21	5.57	−1.00	−0.90	−0.08	0.12	0.23	0.37	0.66	0.84	0.89
Preferred stock/Size market value	185,688	0.00	0.02	7.29	54.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.20
Convertible debt/Size market value	128,890	0.01	0.04	4.87	24.6	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.28	0.28
(*Cash + Short-term investments*)/ *Total assets* (log)	201,083	−2.21	1.57	−0.96	1.88	−15.7	−7.00	−5.01	−3.08	−2.05	−1.10	0.00	0.00	0.00
Negative book equity	325,710	0.04	0.19	4.88	21.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00
Industry median leverage	322,992	0.18	0.11	0.45	0.6	0.00	0.00	0.02	0.10	0.17	0.25	0.35	0.45	1.00
Total debt/Total assets	203,696	0.23	0.22	1.22	1.53	0.00	0.00	0.00	0.03	0.18	0.35	0.64	1.00	1.00

Note. The table shows summary statistics of the main variables used in the analysis. Definitions of all variable are provided in Appendix B.

regulation of July 19, 2002, all publicly traded companies in the European Union are required, in most cases since 2005, to prepare their consolidated financial statements in accordance with IFRS. Similarly, this standard is required since 2005 for firms in Australia and South Africa, it is used among many international firms, and in fact, many firms adopted IAS already in the 1990s. In the United Kingdom, Financial Reporting Standard (FRS) 17 sets out the accounting treatment for retirement benefits such as pensions and medical care during retirement, replacing Statements of Accounting Practice 24 and Urgent Issues Task Force Abstract 6. It was issued in 2000 (and revised in 2006) but was fully effective only in 2005 after a long transition period, with early adoption encouraged (see Bartram 2015, for an overview of the various accounting standards).

Although these accounting standards are not identical, they apply similar principles in terms of the valuation of the assets and liabilities of postretirement plans and the disclosure of their full values in footnotes, but only limited recognition in terms of accrued costs/funding deficits on the balance sheet. Similarly, although the recognition of the funded status required by FAS 158 is an important change compared with (net) accrued costs, the actual size of plan assets and liabilities remains off the balance sheet so that consolidation continues to have a significant effect. Nevertheless, to control for potential differences across accounting standards and time, the analysis uses various fixed effects—e.g., for countries, accounting standards, and years—and the results are robust to estimation by country or by year, for the subperiods before and after 2006, or for U.S. GAAP and IAS compliant firms.

Endnotes

[1] In 2013, pension fund assets in Organisation for Economic Cooperation and Development (OECD) countries were on the order of 84% of gross domestic product (GDP) on average, suggesting that these plans are economically very significant.

[2] Financial flexibility refers to the ability of a firm to respond in a timely and value-maximizing manner to unexpected changes in its cash flows or investment opportunity set and to exercise discretion in the timing of making payments (Denis 2011).

[3] Alderson and Betker (1996) find that liquidation costs and R&D are positively related across firms.

[4] The hypothesis that investment in R&D is particularly constrained by cash flow as a result of the moral hazard problem in transferring information about risky projects from the firm to investors is developed theoretically by Leland and Pyle (1977) and Bhattacharya and Ritter (1983). The lemons' premium for R&D will be higher than that for capital expenditure because investors have more difficulty distinguishing good projects from bad when the projects are long-term R&D investments than when they are more short-term or low-risk projects (Leland and Pyle 1977). Furthermore, the cost of revealing the quality of their innovation to the market might be another reason for the reliance of R&D firms on internal finance (Bhattacharya and Ritter 1983).

[5] Hall (1992) and Himmelberg and Petersen (1994) argue that the presence of either asymmetric information or principal–agent conflicts implies that new debt or equity finance will be relatively more expensive for R&D than for capital expenditure, and that considerations such as lack of collateral further reduce the possibility of debt finance. Hall (1992) suggests that that the extreme riskiness of R&D projects and the difficulty and costs of revealing information about such projects lead firms to prefer internal finance when they undertake them, to an extent that is not true of investments in physical capital (Bhattacharya and Ritter 1983). Hall and Lerner (2010) conclude that large established firms prefer internal funds for financing R&D and that they manage their cash flow to ensure this. Hall (1992) and Himmelberg and Petersen (1994) note that positive cash flow may be more important for R&D than for other types of investment.

[6] Since DB plan promises are risky for participants of (underfunded) plans even without considering bankruptcy of the plan sponsor as a result of capital loss in case of dismissal or closure of the plan, alteration of benefit and contribution formulas, and cost-of-living adjustments, participants might require a compensating wage premium. However, there is relatively little evidence that workers understand the risks they face and value pension insurance against risks that are difficult to understand (Gustman et al. 1994). Back-of-the-envelope calculations indicate that, on average, total compensation is similar across firms but that salaries are lower for firms that offer DB plans after controlling for various firm characteristics and country, industry, and year fixed effects.

[7] On the other hand, employees might be able to monitor the firm's risk-taking behavior more effectively than outside lenders (Dasgupta et al. 2014) and, similar to junior debtholders, have a stronger incentive to do so (Fama 1990). Better monitoring could entail lower cost of borrowing both from employees and outside lenders (Dasgupta et al. 2014).

[8] Obligations that require cash payments are a source of inflexibility, and to the extent that such obligation can be deferred, this is a source of flexibility. In some situations, companies can also access excess pension assets through plan terminations or conversions to cash balance plans (Petersen 1992). Similarly, other dimensions of financial flexibility of postretirement plans are that plan sponsors can terminate the pension plan, alter benefit and contribution formulas, or change cost-of-living adjustments (Gustman et al. 1994).

[9] To illustrate, a 1%t decrease in the discount rate will typically boost the estimated pension obligation by 10%–15% (Revsine et al. 2005, p. 777).

[10] Comprix and Muller (2011) show that employers select downward-biased accounting assumptions to exaggerate the economic burden of their benefit plans when "hard"-freezing their defined-benefit pension plans.

[11] In recent years, the costs of defined-benefit plans have become more apparent for many firms. Changes in demographics are leading to longer working lives and thus higher contributions, whereas longer life expectancies are causing higher valuations of pension obligations. Consequently, many defined-benefit pension plans have reached the limits of their economic viability, and in recent years, some employers have frozen their DB plans (for instance, by closing schemes to new entrants) while existing plans are being restructured (e.g., through limits on the benefits of existing members) and contribution levels are being raised. The financial crisis has presented a particular challenge to defined-benefit pension plans because of drops in plan asset and increases in plan obligations, causing funding gaps and higher contributions.

[12] Moreover, debt-based compensation of managers (usually in the form of pensions and deferred compensation, also referred to as inside debt) has been shown to be an effective remedy to agency costs of debt, since its payoff depends not only on the incidence of bankruptcy but also firm value in bankruptcy (Edmans and Liu 2011). Sundaram and Yermack (2007) suggest that inside debt is important in highly levered companies where risk-shifting considerations are of first-order importance, as it causes chief executive officers (CEOs) to manage their firms conservatively and even transfers value from shareholders to debtholders (Wei and Yermack 2011). However, executive pension plans contain many special arrangements to ensure benefit security, which may reduce or

eliminate potential incentive-alignment effects (Bebchuck and Fried 2003, Bebchuk and Jackson 2005). Empirically, higher CEO debt-like compensation is associated with lower promised yield and fewer covenants on bank loans, consistent with creditors perceiving pension plans as aligning managerial interests closer to their own (Anantharaman et al. 2014, Wang et al. 2010).

[13] It is also harder to switch jobs, and the decision is affected by many other factors compared with external financing decisions. According to Hall (2002), research and development activities are difficult to finance in a freely competitive marketplace.

[14] Booth and Booth (2006) show that secured loans have predicted spreads substantially lower than if they had been made on an unsecured basis controlling for the interdependence between the decision to pledge collateral and borrowing costs. Van Bisbergen et al. (2011) show that the cost of debt is high when firms have fewer collateralizable assets.

[15] Although the documentation of the WorldScope database indicates that items on pensions and other postretirement benefits have been collected in a systematic way since 2005, several items have been populated for prior years as well and, thus, have a longer history. The most important items for the analysis in this paper have decent coverage starting in 2002.

[16] Note that the consolidated accounts combine information on domestic and foreign plans.

[17] Only about 3% of all firms have both a pension and a healthcare plan. For these firms, the average obligations of healthcare plans are about a sixth of those of pension plans.

[18] The size and deficits of the defined-benefit pension plans of several large UK companies such as British Airways, British Telecom, and BSkyB have been widely publicized. The joke about British Airways (BA) being a large pension fund with a relatively modest airline operation is part of the UK pension industry's folklore. BA's defined-benefit pension schemes are at least four times larger than the company's market capitalization.

[19] The industry dummies are based on the 48 Fama–French industries.

[20] With regard to self-selection, a Wald test rejects the hypothesis of all coefficients of the selection model being equal to 0. At the same time, Heckman's lambda is not statistically significant at conventional levels, suggesting that correction for self-selection may not be important.

[21] Regressions with R&D share as the dependent variable also show that the presence of a postretirement plan tilts investment toward R&D.

[22] As in Brown et al. (2009), the cash flow variable adds R&D expenses to the standard measure of net cash flow (net income before extraordinary items plus depreciation) because R&D is treated as a current expense for accounting purposes.

[23] The regressions with firm and year fixed effects in Table 4 include market-to-book and cash, which have been used in the financial constraints literature (e.g., Kashyap et al. 1994). They also include dividends, leverage, age, asset tangibility, size, and profitability, which have been used in this literature as conditioning variables to identify subsamples of financially constrained firms. However, there exists ambiguity in the existing literature with regard to defining subsamples of financially constrained firms and estimating and interpreting cash flow sensitivities (Fazzari et al. 2000; Kaplan and Zingales 1997, 2000).

[24] The cash flow variable adds R&D and DB plan expenses to the standard measure of net cash flow (net income before extraordinary items plus depreciation).

[25] Additional analysis shows that older firms make higher contributions, especially when they have larger cash flows, in line with old and long-tenured employees generating large service costs for the sponsoring company that require large contributions.

[26] The coefficient on PBO in the R&D equation is insignificant for the United States, which might be because there are many other ways of financing R&D available to U.S. firms (such as venture capital and others). The coefficient is positive but insignificant when using data from Compustat and CRSP.

[27] Results for venture capital investment/GDP are similar, but the data are only available for fewer years and countries.

[28] Correlations between the country characteristics do not allow the inclusion of many country variables simultaneously in the regressions. However, models with permutations of variables capturing different alternative funding sources overall yield similar inferences.

[29] Since real investment and postretirement obligations are likely both endogenous, some degree of bidirectional causality will likely exist. However, the results are robust to the likelihood of sponsoring a DB plan increasing with R&D and R&D share and decreasing with CapEx.

[30] The degree of unionization likely has substantial negotiation power over the adoption of a postretirement plan and may be able to hinder the termination of the plan, but it should be uncorrelated with the extent of real investment. Since older plans likely have accumulated more benefits, age is expected to be positively correlated with plan size, whereas there is no a priori reason to expect it to be correlated with real investment. Underidentification (LM statistic), weak identification (Stock and Yogo), and overidentification (Sargan statistic) tests confirm union membership and age as relevant and valid instruments and the model identified (Anderson 1951, Stock and Yogo 2005, Sargan 1988).

[31] IAS 19 refers to this item as the "Defined-Benefit Obligation."

[32] Much of the accounting for postretirement benefits other than pensions parallels that required for pensions. To illustrate, similar principles are applied to estimate the expected obligations of medical plans and to value the plan assets; plan assets and obligations are disclosed in the footnotes, and only a measure of the net liability is recognized on the balance sheet. Given these similarities, it is sensible to consider plans for pensions and other postretirement benefits together, and annual reports (and thus WorldScope) typically show the combined prepaid/accrued costs of these plans on the balance sheet, even though they show separate information on their assets and obligations. Similarly, Standard & Poor's combines all benefits plan assets and liabilities. At the same time, there are also a number of differences, such as various additional required assumptions about healthcare cost trend rates, the tax incentives of contributions, funding levels, and guarantees from industry/government agencies, but the main features of these plans and their accounting treatment are overall similar for the purpose of this paper.

[33] To illustrate, the funding for nonpension postretirement benefits is optional but not uncommon in the United States (Deloitte 2007).

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