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Defined benefit company pensions and corporate valuations: simulation and empirical evidence from the United Kingdom

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Abstract

This paper examines the role of defined benefit company pensions in amplifying the effect of common shocks to companies' stock market valuations. It identifies and evaluates the significance of two channels of amplification: cross-holdings of equities in pension schemes, and leverage induced by pension liabilities. Econometric analysis of weekly stock market data for a sample of FTSE 350 UK companies confirm that these effects are statistically significant and robust to outlying observations.

Key words: Cross-holdings, pensions, leverage, stock volatility.

JEL classification: G12, G23, G32.

Summary

Shareholders of sponsoring companies are primarily responsible for ensuring the solvency of the defined benefit (DB) pension schemes that firms offer their workers. Hence, even though the assets and liabilities of such pension schemes are distinct from the company's balance sheet, corporate sponsors are clearly the residual claimants or guarantors, and hence they should be analysed together. This paper investigates whether this feature of UK company pensions affects how company stock prices respond to common shocks. We consider two channels through which common shocks to companies' real business values can be amplified. First, to the extent that defined benefit pension liabilities are debt-like, they add to the overall leverage or indebtedness of companies. For given asset risk, we should expect that more highly levered stocks are more volatile. Second, in the United Kingdom pension scheme assets are largely invested in equities of other UK companies. These cross-holdings of equity mean that common shocks to company valuations are transmitted among each other via their defined benefit pension schemes, and the response of stock prices to such a shock can be amplified.

If it does exist, this kind of amplification is clearly of relevance to systemic financial stability, since it can rapidly push corporate valuations upwards or downwards, and there could be corresponding knock-on effects on the wider macroeconomy. For example, if capital investment is sensitive to corporate valuations, through either cost of capital or Tobin's Q effects, then this could exacerbate the real economic cycle. In addition, stock return volatility can also be costly for individual companies and their shareholders. Higher volatility can increase a company's perceived riskiness, and therefore its cost of external capital. Alternately, as a company's stock price becomes a less informative signal of 'true' value, stock-based compensation becomes less effective at providing appropriate incentives to managers.

To investigate these issues we start with a stylised model of a company's balance sheet – in which pension fund assets and liabilities are treated in exactly the same way as a company's ordinary, or on balance sheet, liabilities. Using the model we demonstrate how common shocks can be amplified on account of 'economic leverage' and equity cross-holdings. We then calibrate this model for about 90 of the FTSE 100 companies and simulate it to illustrate the possible size of such amplification effects. We perform two simulations where the company's business value is reduced by 5%. In the first simulation the total effect of the shock is the sum of the effect from the

cross-holdings channel and the leverage channel. We compare these effects with a second simulation where we switch off any effects from the cross-holdings channel (consistent with the company's pension fund equity assets being invested abroad). The comparison allows us to break down the total impact of the 5% shock into the part that comes from additional leverage and the part that comes from cross-holdings. Our main result is that on average, the shock causes a 10.5% reduction in market value. Of the additional 5.5% reduction, 1.4% was due to companies holding other companies' equity in their pension funds. The remainder is due to the higher leverage induced by pension liabilities.

We also examine whether such effects, in fact, exist in data within the framework of a standard Capital Asset Pricing Model (CAPM). Empirical analysis using matched balance sheet data (from Datastream) and pension scheme data (collected by hand from individual FRS 17 disclosures) suggests that stock return volatility is systematically related to proxies for the two channels of amplification discussed above. These effects are statistically significant and robust to the inclusion of control variables and the exclusion of outliers.

1 Introduction

The majority of full-time workers in the United Kingdom are members of funded, company-sponsored pension schemes. Most pension entitlements accumulated in these schemes are defined benefit (DB) in nature.[(1)] These usually promise a fixed pension related to an employee's final salary or some similar pre-determined formula, and are increased in line with inflation.[(2)] The shareholders of sponsoring companies are primarily responsible for ensuring the solvency of the pension scheme, and in the United Kingdom most DB pension scheme assets are heavily invested in equities – estimates for the share of equities vary from 60% to 70% on average. This means that a negative shock to company A's equity price could reduce the value of assets in company B's pension fund. Because company B would need to divert more cash to its pension fund from other uses such as investment, this could potentially damage its future profitability and perhaps credit rating, and this may trigger a fall in company B's stock price. In turn, this could affect the pension equity assets of company C or indeed company A again, and so on until the spiral converges. In other words, the value of a company's pension fund assets and, in turn, the overall value of the company depends on the valuations of other companies. This interdependence creates a channel through which common shocks to companies may be amplified.

This kind of amplification, if it does exist, is clearly of relevance to systemic financial stability since it can exaggerate the response of corporate valuations to shocks and there could be corresponding knock-on effects on the wider macroeconomy. For example, if capital investment is sensitive to corporate valuations, through either cost of capital or Tobin's Q effects, then this could exacerbate distortions in the savings and investment allocation process. In addition, stock return volatility can also be costly at a micro level for individual companies and their shareholders. Higher volatility can increase a company's perceived riskiness, and therefore its cost of external capital (Froot, Perold, and Stein (1992)). Alternately, inasmuch as a company's stock price becomes a less informative signal of 'true' value, stock-based compensation for managers becomes a less effective solution to the standard principal-agent problem (Baiman and Verrecchia (1995)).

(1) For more details see Hewitt, Bacon and Woodrow (2003), page 38.
(2) Note that final salary defined benefit schemes in the United Kingdom are being increasingly replaced by defined contribution or hybrid schemes. It is estimated that 60% of defined benefit schemes (weighted by number of employees) are now closed to new members (Pension Commission (2004)). Nevertheless, the overwhelming proportion of accrued pension entitlements are still defined benefit.

Consequently, the aim of this paper is to understand and evaluate the significance of such amplification of shocks and concomitant stock price volatility in the UK corporate sector.

To the best of our knowledge there is little academic literature on amplification effects on account of corporate pension asset cross-holdings, although there has been some commentary in the financial press. In a *Financial Times* article (in February 2003) entitled 'Retirement funds caught in downward spiral', Philip Coggan compares the UK pension fund situation to a Japanese *zaibatsu* – the business conglomerates that enabled Japanese companies to invest in each other:

> '...as the bear market has unfolded, it has become clear that the US and UK did have their own versions of the *zaibatsu* – occupational pension funds. These funds had invested, albeit in a very diversified fashion, in the rest of the corporate sector. ... As the market went up, pension fund surpluses rose, boosting corporate cash flow and profits. That justified higher share prices, increasing surpluses even further. ... Now the bear market has been running for three years, (this) is working in reverse.'

There was also press comment on this type of phenomenon in the upswing, and that some market participants may have gained from it. Consider, for example, the following excerpt from a *Financial Times* article (in July 2003):

> 'Companies plagued by pension problems, such as Rolls-Royce, British Airways and BT Group, are the surprise stock market favourites of top investors. In a survey published in today's FTfm, seven of the 10 companies most exposed to the "pension crisis" have significantly outperformed the FTSE 100 index since March, when it hit its eight year low.'

There is, however, a strand of academic literature on whether stock markets appropriately value company pensions, and this is related to our paper. Most recently, Jin, Merton and Bodie (2004) – which looks at US data – and Cardinale (2004), which looks at UK data – have focused on the issue of whether the risk inherent in company pension schemes is priced into the market. The overall conclusion from these studies is that stock markets do seem to process available pension information. This conclusion is consistent with our empirical results, since we also find that the volatility of company stock prices is positively related to measures of pension equity cross-holdings and pension liabilities. Indeed, these findings also accord with evidence from an older set of papers in the 1980s (Bulow, Morck and Summers (1987), Feldstein and Morck (1983)) which generally concluded that investors did not ignore pension liabilities in valuing US firms. (3) One paper that goes the other way is Coronado and Sharpe (2003), which investigates whether incorrect valuation of pension plans contributed to the US stock market bubble of the 1990s. They concluded that markets did not appropriately value the underlying position of company pension schemes, and that the biggest valuation errors were produced between 1998 and 2001 – a period that includes the peak and subsequent sharp fall in the equity market. These findings need not be contradictory since it is possible that bigger valuation errors are committed in periods of high volatility (Shleifer and Vishny (1997)), or simply that investors become more aware of pension scheme characteristics in periods of substantial underfunding. Our paper does not seek to discriminate between these hypotheses, although to the extent that we find that company stock valuations are more volatile on account of their pension scheme characteristics, the results are clearly related.

Our results show that sponsorship of defined benefit pension schemes has a significant effect on the response of equity valuations to shocks, partly through additional leverage and partly through cross-holdings. The latter effect comes about because cross-holdings introduce a form of double-counting that affects and distorts overall market valuations.

The paper is organised as follows. Section 2 uses a highly stylised model of a company's market value to show how shocks can be amplified through the additional leverage induced by pension liabilities and pension fund equity asset cross-holdings. Section 3 evaluates the significance of these effects for FTSE 100 companies by simulation. Section 4 investigates the evidence for these effects informally through graphical presentations of the data and formally using econometric techniques. We estimate CAPM style models to assess if within the cross-section of large UK-listed companies, individual firm volatility is correlated with the kind of pension scheme variables that fall out of our simulations, *ceteris paribus*. We are able to find a systematic relation between company stock volatility on the one hand, and the leverage induced by pension funds and the scale of equity holdings by pension funds on the other. Section 5 presents some concluding remarks.

(3) Many of these studies were provoked by the prevalence of underfunded pension plans in the United States in the late 1970s. An important concern was that if unfunded pension liabilities were not fully reflected in stock prices, equity owners would fail to increase their savings whereas pension plan participants would reduce their savings, producing a net reduction in national saving.

2 Stylised model of company valuation

Consider a 'consolidated' or 'augmented' balance sheet expression for a company's value:

$$E_i = K_i - D_i + \left(E_i^O + A_i - L_i\right) \qquad \textbf{(1)}$$

where, for each company i, E is the market value of its equity (ie its market capitalisation), K is the market value of its core business (ie the present value of the stream of future profits generated by its capital), D is the value of its conventional debt, E_i^O is the market value of equity of other companies held in its pension fund, A_i is the value of its other pension fund assets, and L denotes its pension fund liabilities.

In equation **(1)** the assets and liabilities of the pension scheme are treated in the same fashion as all other assets and liabilities of the firm.[(4)] This assumes that ownership of the sponsoring company confers ownership of the assets in its pension fund and so implies that the members of the pension fund have no separate claims over the assets in the fund.[(5)] This approach is consistent with current market practice. During the downturn in equity markets in the early part of this decade a number of credit rating agencies clarified that they do, in effect, pierce the *off balance sheet* pension fund veil. For instance, according to a news release in 2003, Standard & Poor's stated that it "views unfunded post-retirement liabilities as debt-like in nature, given the future call on cash these liabilities necessarily represent". Thus an unexpected decline in the value of other companies held in the pension fund would, *ceteris paribus*, reduce the value of the equity of this company.[(6)]

The market capitalisation of each company can also be split into that component that is owned by other companies through *their* pension funds (E_i^C) and that component that is owned outside the corporate sector (E_i^H - where H stands for households for concreteness). Substituting into **(1)** and summing over all companies indicates that:

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(4) See Jin, Merton and Bodie (2004) and previously Tepper (1981), which uses a similar approach in an analysis of taxation and corporate pension funding and asset allocation decisions. **(1)** is often modified to reflect the tax deductibility of pension contributions, so that the net pension liability incurred and funded through such contributions reduces the equity value of the firm by only $(1 - \tau)$, where τ is the marginal tax rate.
(5) They do of course have rights over their contractual pension promises expressed here as liabilities of the sponsoring company. These rights are intended to be safeguarded by trustees of the plan, although trustees might themselves be sponsoring company executives. Cocco and Volpin (2005) investigate whether such 'insider' trustees act in the interests of shareholders or pension plan members.
(6) For more details, see 'Review of Euro Corporate Post-Retirement Liabilities Leads to 10 CreditWatch Negative Listings' published by Standard & Poor's on 7th February 2003.

$$\Sigma_i E_i = \Sigma_i E_i^C + \Sigma_i E_i^H = \Sigma_i (K_i - D_i + (E_i^O + A_i - L_i)) \qquad \textbf{(2)}$$

Since the total value of equity owned by companies ($\Sigma_i E_i^O$) is equal to the total value of their equity held by other companies ($\Sigma_i E_i^C$), this expression reduces to

$$\Sigma_i E_i^H = \Sigma_i (K_i - D_i + A_i - L_i) \qquad \textbf{(3)}$$

This expression states that the aggregate market value of equity held outside the corporate sector is equal to the aggregate market value of their core business plus non-corporate pension fund assets, less conventional debt and pension fund debt. Importantly, corporate crossholdings of equity through pension funds do not affect the aggregate value of the equity held outside the corporate sector. Nevertheless, corporate cross-holdings do affect the total market capitalisation of the corporate sector in aggregate. To see this, suppose that the equity in the company's pension fund is given by:

$$E_i^O = s_i \Sigma_j E_j \qquad \textbf{(4)}$$

where s_i denotes the share of the overall equity market held by company i.(7) Then the equity market capitalisation for each company can be expressed as

$$E_i = K_i + s_i \Sigma_j E_j + A_i - D_i - L_i \qquad \textbf{(5)}$$

By summing over all companies, it can be seen that the overall equity market valuation is given by:

$$\Sigma_i E_i = \Sigma_j E_j = \frac{1}{1-s} \Sigma_j (K_j + A_j - D_j - L_j) \qquad \textbf{(6)}$$

where s ($\Sigma_i s_i$) is the share of corporate equity held by companies themselves.

(7) Note that we do not include the equity of company i in the sum of other equity (over j). This is because in the United Kingdom, trustees are constrained by regulation from investing more than 5% of the plan's assets in employer-related investments, including shares or property. This legal restriction substantially simplifies our analysis since we can safely assume that corporate pension plan equity assets (E_i^O) are distinct from sponsoring company equity (E_i). Apart from this limit on self-investment there are no quantitative portfolio restrictions on most UK pension funds. For more details, see Davis (2000).

A comparison of **(3)** and **(6)** makes clear that there is a difference between the overall market capitalisation of companies and what non-corporate outsiders have to pay to acquire them. This arises because an outsider who purchases a unit of stock also gets, on average, $\frac{s}{1-s}$ in other stocks through indirect ownership of the assets in the pension funds of the companies purchased. As such the effect of cross-holdings is to inflate the total market value of corporate equity relative to its underlying value to outside investors. This inflation of value arises because of double-counting that part of the value of companies that reflects the value of other companies held in their pension funds. The measure of value that outsiders need to pay to acquire the companies is $\Sigma_i E_i^H$, which is unaffected by such double-counting, rather than $\Sigma_i E_i$.

Nevertheless, the total market capitalisation is important in determining the values of individual shares. Equation **(6)** suggests that shocks to companies have a multiplied impact on valuations because they hold each others' equity. In effect, companies are more highly geared in aggregate than would be apparent by looking at their balance sheets in isolation. One way of seeing this is to note from **(3)** that a negative shock to the aggregate value of the core business of companies of $\Delta \Sigma_i K_i = X$ reduces the aggregate market value of equity held outside the corporate sector ($\Sigma_i E_i^H$) by X, but, by **(6)**, reduces aggregate market capitalisation ($\Sigma_i E_i$) by $\frac{1}{1-s}X$. In proportionate terms though the effects of a shock also depend on the leverage of the companies that experience it. Since investors are interested in rates of return we focus from now on on proportionate rather than absolute changes in value.

Suppose companies experience a common proportional negative shock to the market value of their core business, K_i, i.e. $\frac{\partial K_i}{\partial X} = xK_i$. Then the proportional impact of the shock on the market value of the equity of an individual company is given by:

$$\frac{\partial E_i}{\partial X}/E_i = x\frac{\left[K_i + \frac{s_i}{1-s}\Sigma_j K_j\right]}{\left[K_i + \frac{s_i}{1-s}\Sigma_j[K_j + A_j - D_j - L_j] + A_i - D_i - L_i\right]} \qquad \textbf{(7)}$$

This expression highlights the twin effects of cross-holdings of equity and leverage in magnifying the impact of shocks on the valuations of corporate equity. Clearly the size of the effect depends on the circumstances of each company. In the next section we evaluate the impact of a common shock on the market valuations of large UK companies, most of whom hold each others' equity. We consider a common shock that reduces the market value of the core business, K_i, of each company by 5% – Simulation A. From **(5)** it is clear that the market value of each company is directly affected by the change in its capital stock relative to its debt and pension liabilities,

$(K_i + A_i - D_i - L_i)$, but it will also be affected by its holding of equity in other companies, $s_i \Sigma_j E_j$ (because $\Sigma_j E_j$ will be lower as a consequence of each E_i being lower). Hence the change in E_i for each company will comprise the change as a result of the shock to its own capital stock, plus the change as a result in the lower value of its pension equity assets. This latter impact is the result of equity cross-holdings through pension schemes, while the former is the effect of 'augmented' or 'economic leverage'.(8)

In order to quantify what part of this gross effect comes from the cross-holdings of equity assets by pension funds, we run a second simulation – Simulation B. This is similar to Simulation A, except that we hold the total market capitalisation fixed, equivalent to assuming the company pension fund assets are invested in foreign countries, not affected by the shock. In other words, $\Sigma_j E_j$ (in equation **(5)**) is held fixed. By holding $\Sigma_j E_j$ fixed in this fashion, in effect we are ruling out any impact on E_i from the equity cross-holding channel, and all the response in equation **(5)** will be from the 'economic leverage' of the company. Therefore, the difference in impact between Simulation A and Simulation B provides a measure of the impact from the pension assets cross-holding channel.

3 Simulation evidence

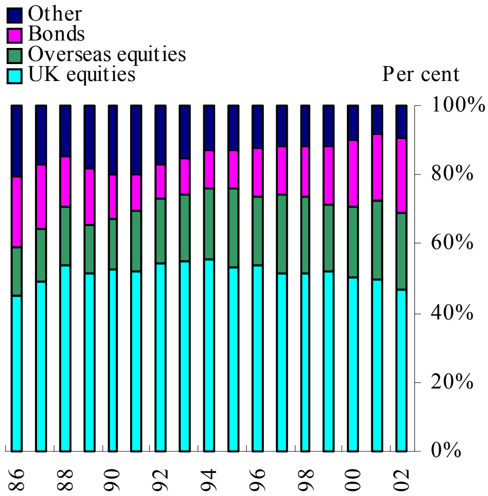
3.1 Preliminaries

In this section we analyse how company valuations respond to common shocks when these valuations are interdependent on account of pension fund asset cross-holdings by applying a common shock to the value of the core business of FTSE 100 companies, where their individual valuations are grounded on equation **(5)**.(9)

Of the elements that determine the value of a company in equation **(5)**, we specify D_i and L_i directly from a standard company accounts database, Datastream, and these are assumed fixed for the duration of the simulations. We define D_i as short-term debt (borrowings repayable within one year) plus long-term debt (total loan capital). We can specify E_i for the FTSE 100 companies on a

(8) In what follows, we use the term 'economic' leverage to signifiy that company valuations are likely to be affected by the leverage induced by pension liabilities (L_i) in addition to standard leverage (D_i).
(9) In fact, for the calculations below and for the subsequent simulations we use between 85 and 95 of the FTSE 100 companies depending on data availablility. Some FTSE 100 companies do not have material DB schemes, and for others all relevant data were not available.

Chart 1: Broad asset allocations of major UK pension funds, 1986-2002



Sources: *Pension Funds and their Advisers* (2002), and Bank calculations.

common date – as of 31 January 2003. K_i is calculated as a residual once the other (pension fund related) elements of equation **(5)** are estimated.

It is possible to obtain estimates of A_i and L_i at the firm level on account of the disclosure requirements of the new accounting standard FRS (Financial Reporting Standard) 17. FRS 17 is more of a 'fair value' standard and is meant to replace the current accounting standard for pensions SSAP 24 (Statement of Standard Accounting Practice No. 24: 'Accounting for Pension Costs'). Full implementation of FRS 17, which includes recognition of the relevant pension amounts in the primary statements, is required for company accounts in 2005. However, since 2001 companies are meant to provide detailed information in the notes to company accounts, including the distribution of scheme assets valued at market prices and scheme liabilities in present value terms. We collected this data from individual company annual reports, and updated the reported values to a common date in line with market movements so that they are comparable across companies.[(10)]

In the case of most companies, the FRS 17 data on pension fund assets provides a split between equities and bonds, and an 'other' category which can include property, cash, etc. For the FTSE 100 companies, as of 31 January 2003, an average of 67% of assets were invested in equities. However, to estimate s_i for each company, we want to know the share of equities invested in the United Kingdom only, and this information is not available in the FRS 17 disclosures. Chart 1

(10) Details of calculations and estimates are available from the authors.

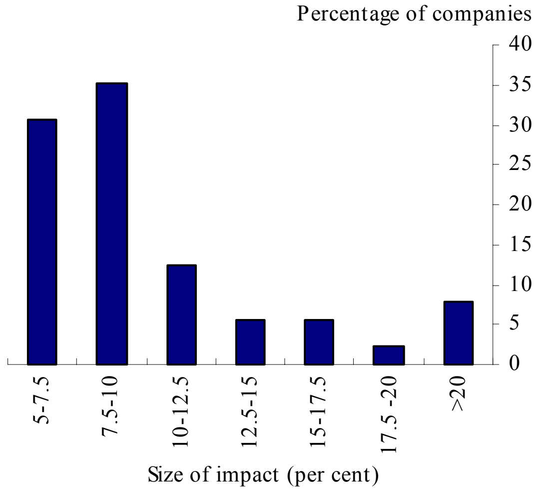
shows a more detailed breakdown of pension assets for UK funds based on actuarial information compiled in the 2002 edition of *Pension Funds and their Advisers*. It shows that approximately 47% of UK pension fund assets were invested in UK equities in 2002. While it has been higher than this in the recent past, there appears to be a downward trend in the share of UK equities over the past decade. To ensure that our simulations are consistent with this stylised fact, we assume that two-thirds of the equity assets of each FTSE 100 company are invested in equity of the FTSE 100. On average, a two-thirds share of 67% gives a net investment in UK equities of 44.6%.

Given data on the total market capitalisation of the FTSE 100 on a common date ($\Sigma_i E_i$), we can compute a value for two-thirds of pension equity assets for each company i, and use **(4)** to work out a measure of s_i. If we calculate s_i in this manner, the average s_i is 0.001; s_{MAX} =0.011 is the highest in the sample, and unsurprisingly s_{MIN} =0 is the lowest since one company has no equities in its pension fund asset portfolio. $\Sigma_i s_i$ is equal to approximately 0.1. This means that approximately 10% of the FTSE 100 is owned by the FTSE 100 via pension fund assets, under our assumptions. Like D_i and L_i, s_i is also held fixed for the duration of the simulations.

In order to evaluate the total percentage effect of a common shock to the FTSE 100, we shock the business value (K_i) of each company by 5% (Simulation A). This reduces the total market value of all firms by 9.5%. The mean and standard deviations of the impact (relative to the base run) for individual companies are presented in the first column of Table A below. This suggests that a 5% common shock to the business value of UK companies would reduce a typical firm's market value by a further 5.5% on average, doubling the total effect.

There is, moreover, considerable variation across companies in the size of the effect: in the case of the largest change depicted in Table A, the relevant company's market value is reduced by more than seven times the size of the initial shock, relative to its level in the base run. Chart 2 shows that the distribution of impacts from Simulation A is skewed. For most companies, the simulated impacts on market valuations are less than or equal to 10%; but for a substantial minority the impacts are very significant. In the next subsection, we separate the effect of equity cross-holdings from that of 'economic leverage' on corporate valuations.

Chart 2: The distribution of simulated impacts on companies' market values



Sources: Individual annual reports, Thomson Financial Datastream and Bank calculations.

Table A

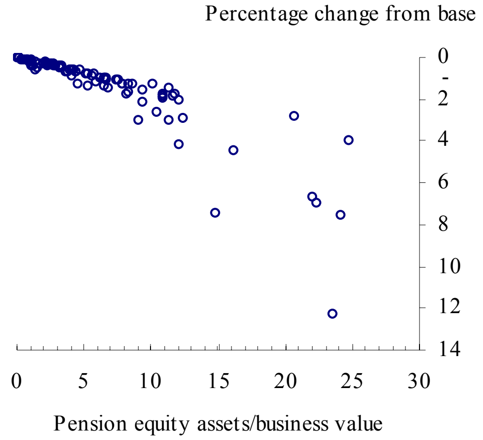
	Simulation A	Simulation B	Leverage effect: Simulation B less 5.	Cross-holdings effect: Difference between A and B	S_i
	% Change from base		% points	% points	
Mean	-10.4788	-9.0709	-4.0709	-1.4079	0.0011
Median	-8.4702	-7.6141	-2.6141	-0.7660	0.0006
Standard Deviation	5.5491	3.9964	3.9964	1.9821	0.0016
Minimum	-5.4318	-5.2083	-0.2083	0.0000	0.0000
Maximum	-37.2619	-25.0142	-20.0142	-12.2477	0.0107

Notes: Simulation A shows the % response when K_i for all firms is reduced by 5%. Simulation B shows the % response when Simulation A is repeated but the total market value of all firms is held constant. The leverage effect in column (3) is isolated by subtracting the initial shock of 5% from Simulation B. The cross-holdings effect is isolated in column (4) by subtracting Simulation B from Simulation A. S_i is the share of UK equities held by each company as part of their pension assets.

3.2 Distinguishing between pension fund cross-holdings effects and leverage effects

In Section 2, we outlined our simulation strategy for identifying the significance of the cross-holdings channel in amplifying common shocks. This involved performing a second simulation (Simulation B) which held the overall market capitalisation constant. The second column in Table A presents the summary statistics of the effects in Simulation B. Since all the amplification in this simulation occurs only on account of 'economic leverage', we can isolate the

Chart 3: The importance of cross-holding effects in determining the impact of a shock to business value

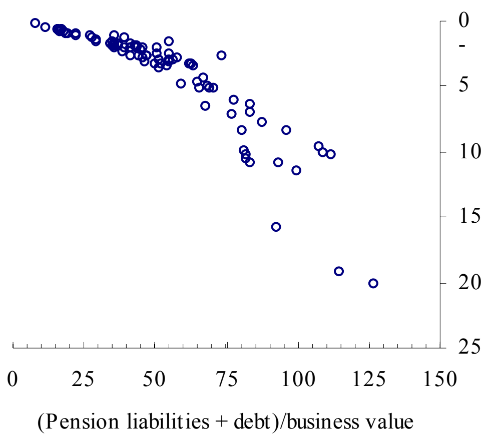


Sources: Individual annual reports, Thomson Financial Datastream, and Bank calculations.
Note: Vertical axis shows the additional response (due to cross-holdings) of company market value to a 5% shock to each company's business value. Horizontal axis depicts a proxy for size of cross-holdings.

size of this amplification by subtracting the initial 5% shock. This is done in the third column which presents the summary statistics for the leverage effect. The fourth column reports the summary statistics for the differences between Simulations A and B, which isolates the cross-holdings effect. The final column of the table provides summary statistics for s_i. The results suggest that, on average, the extra proportionate effect on a company's market value coming from its pension fund's cross-holdings of equity is significant – a change of 1.4 percentage points greater than what it would otherwise have been. To gain intuition for the magnitude of this effect, consider that on average a 5% reduction in the value of the core business of companies caused a 10.5% reduction in their stock market value. Of the additional 5.5% points reduction 1.4% points was due to companies holding other companies' equity in their pension funds. On average, therefore, shocks to companies were amplified by approximately 25% due to the cross-holdings of equities via their pension schemes.

There is once again a large difference in the effects across companies. The median effect is about 0.8 (column (3), Table A), and for most companies is less than 1 percentage point. However, there are 15 companies for whom the effect is greater than 2 percentage points and 5 companies where it is greater than 6 percentage points. For these companies, the effect of a common shock to the

Chart 4: The importance of 'economic leverage' in determining the impact of a shock to business value



Sources: Individual annual reports, Thomson Financial Datastream, and Bank calculations.
Note: Vertical axis shows the additional response (due to 'economic leverage') of company market value to a 5% shock to each company's business value. Horizontal axis depicts degree of 'economic leverage'.

entire market is amplified because of the extra exposure that comes from holding a substantial amount of equity of other companies in their pension funds.

The other striking feature of the results presented in Table A is the relative size of the leverage effect. If companies had no debts, pension liabilities or non-equity pension assets, so that $\forall i : D_i + L_i - A_i = 0$, then, as is clear from **(7)**, the effect of a 5% common shock to all companies would be a 5% drop in the market values of all companies. Leverage affects the way in which this reduction in value is allocated among the claimants on companies. Since the equityholders are the only claimants whose payments are reduced in response to such a shock, the value of their claim must absorb the entire effect and in this case it falls by roughly 9% – an additional 4% points comes about on account of on balance sheet debt and pension liabilities.[11]

While equation **(7)** shows analytically the factors determining the response for each company, it can be useful in practice to relate the vulnerability to a common shock of an individual company's equity valuation to more straightforward measures. Charts 3 and 4 show how the simulated

(11) This impact of leverage on the stock price is consistent with the Modigliani and Miller (1958) theorems, where for given asset risk, the volatility of equity returns should be amplified if companies are more highly leveraged.

response varies according to measures of cross-holdings and 'economic leverage' respectively. Chart 3 shows that larger simulated impacts are associated with bigger equity cross-holdings when these are proxied by the size of a company's pension equity assets relative to capital. Analogously Chart 4 shows that companies with higher 'economic leverage' have larger negative impacts in response to a common shock.

4 Empirical evidence

4.1 Preliminaries and graphical analysis

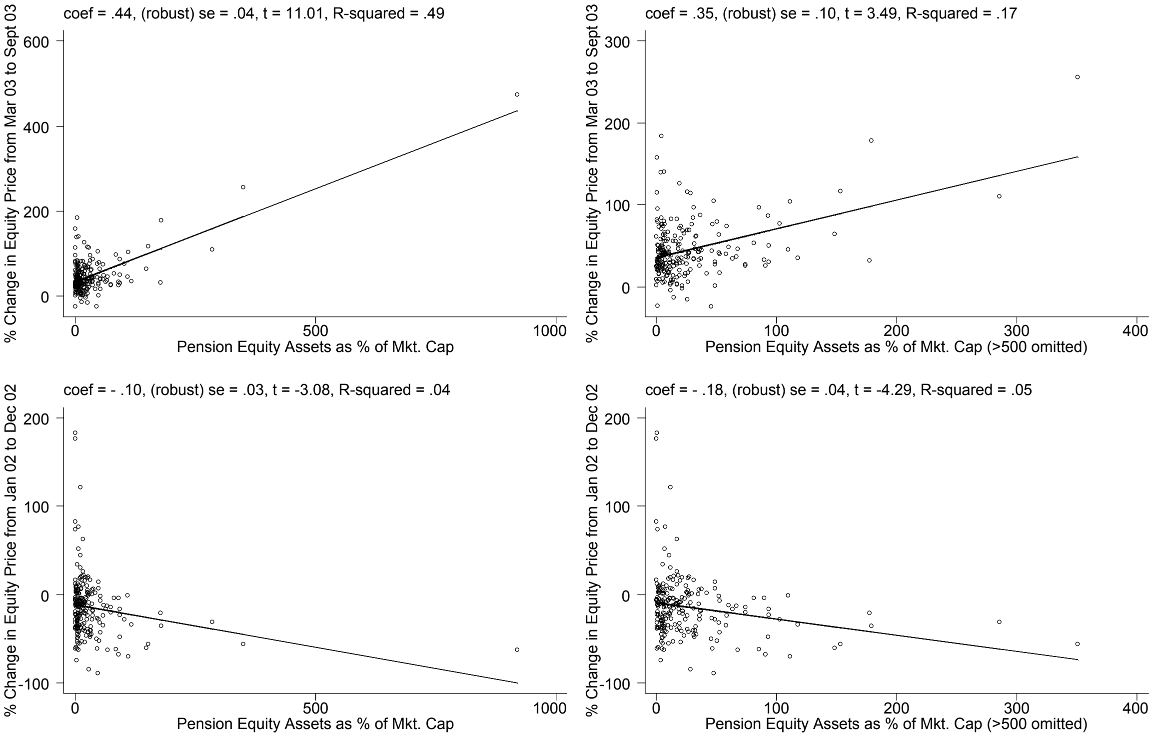
The aim of this section is to investigate if the effects identified in the simulations are, in fact, reflected in stock market data. We first assess whether there is any evidence that the simulated relationships shown in Charts 3 and 4 between corporate valuations and economic leverage and cross-holdings are apparent in practice during periods when companies experienced common shocks. We consider two separate periods: the period from January to December 2002 when the FTSE All-Share index *fell* by roughly 25% and the six month period following the low of March 2003 when the index *increased* by about 30%.

Chart 5 looks at the relationship in both periods between corporate valuations and cross-holdings as measured by companies' pension equity assets (as a share of market capitalisation), so that the relationships depicted here are empirical counterparts to Chart 3. Consider first the figure in the top left corner. It plots the change in equity prices for companies during the positive common shock. The figure clearly depicts the relationship referred to in the market commentary cited in Section 1: companies with large pension fund equity assets also had some of the largest gains in stock price over this six month recovery period. The figure also plots a positively sloped and statistically significant regression line, which serves to highlight an extreme outlier with very large pension fund equity assets (relative to market capitalisation). In the next graph on the top right-hand corner of Chart 5 we exclude this company from the sample. This suggests that the relationship holds more widely within the sample than appeared from the figure on the left.[12]

In the bottom half of Chart 5, we consider the common negative shock. This suggests that, in this case, companies with larger pension equity assets also experienced bigger falls in their stock

(12) Notice that removing the outlying observation causes the R-squared of the regression to drop from 0.5 to 0.2, and yet the regression on the right with the lower R-squared is, in may ways, more credible.

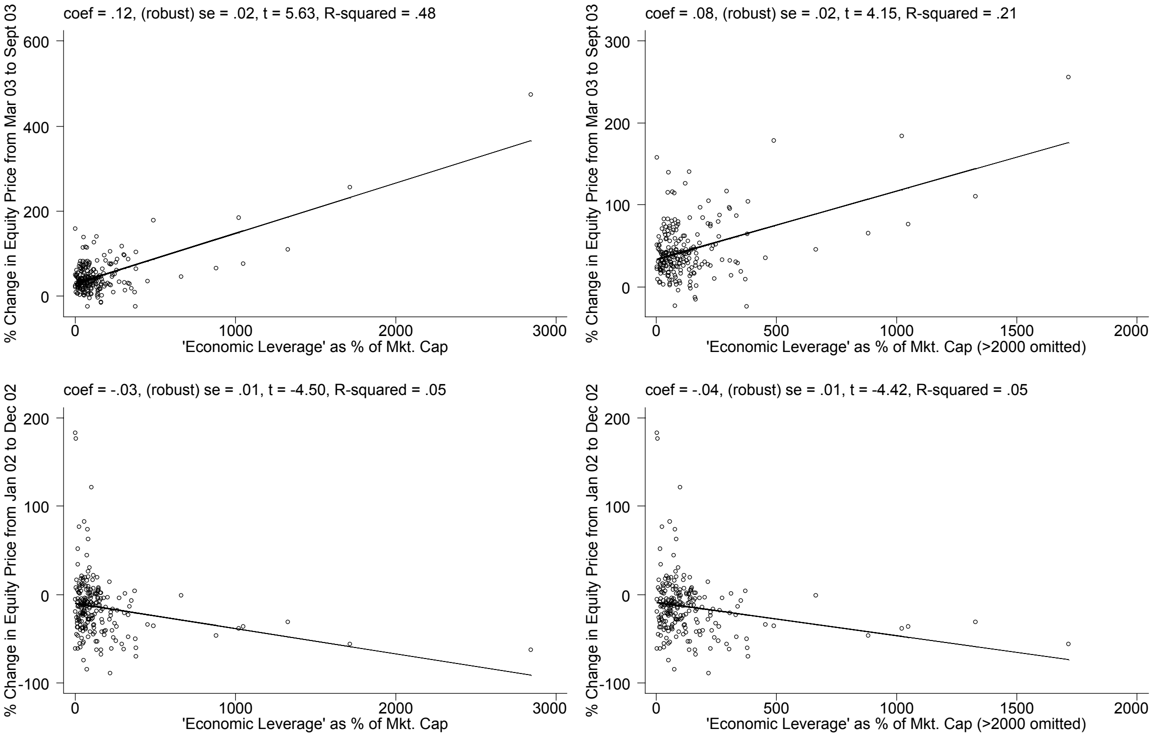
Chart 5: Market movements and pension equity assets



prices. This supports the idea that pension equity assets amplify the impacts of shocks on companies. The final figure on the bottom right-hand corner confirms that this observed relationship in the downward phase of the stock market is not distorted by the same outlying company.

In Chart 6 we plot stock price changes against the 'economic leverage' of companies (similar to Chart 4) to check if an analogous *prima facie* relationship exists in this case as well. The first graph on the top left-hand corner shows a positive relationship between 'economic leverage' and stock price movements in response to the positive common shock. The relationship persists even when the (same) outlying observation – which has 'economic leverage' in excess of 20 times its market capitalisation – is excluded from the sample in the graph on the top right. The figures in the bottom half of Chart 6 depict the parallel negative relationship (including and excluding the outlying company) during the negative common shock period. Once again the evidence in Chart 6 shows how the impact of such shocks is amplified on account of the total 'economic leverage' of companies, which includes their pension liabilities.

Chart 6: Market movements and 'economic leverage'



The graphs in Charts 5 and 6 are encouraging inasmuch as the key implications of our simulation exercise can be discerned within stock market data, but they are only suggestive. An important concern relates to the time periods of the data. The data plotted in Charts 5 and 6 relate to 223 of the FTSE 350 companies, where the sample size is determined by the availability of relevant pension scheme data from their 2002 annual accounts report.(13) To make the pension schemes data for these 223 companies comparable we have updated them in line with market movements up to end-April 2003. Whereas ideally we would want to relate these pension scheme data with subsequent fluctuations in the company stock price, some of the price changes on the vertical axes in Charts 5 and 6 include time periods earlier than April 2003.

We address this issues in the econometric analysis of the next two subsections, where we investigate weekly stock return volatility after April 2003 within the framework of a Capital Asset Pricing Model (CAPM). In addition, we also adopt a more systematic treatment of outliers for robust inference: we drop the influential observation identified in Charts 5 and 6 (and by nearly every other technique of outlier detection), and always employ a robust regression procedure to

(13) Many of the remaining companies either did not have material DB schemes or all the relevant data from their FRS 17 disclosures were not available.

cross-check the validity of our empirical results. Further details of the precise empirical strategy and the key results are described in the following subsection.

4.2 Econometric analysis

Our empirical investigation is conducted within the framework of the well-known CAPM. The CAPM relates the excess return on firm i's equity over the riskless rate of interest (R_{it}) to the excess return on the market (R_{mt}) and firm i's beta $\left(\beta_i\right)$. In addition, there is a firm-specific error (ε_{it}), so that:

$$R_{it} = \beta_i R_{mt} + \varepsilon_{it} \qquad \textbf{(8)}$$

According to the CAPM, firm betas are the only reason that expected returns can differ between stocks.[(14)] This provides a natural way to investigate the relationship between company pension schemes and their stock returns since we can check if the pension equity assets and 'economic leverage' systematically affect company betas. This is because a company's pension scheme is likely to have a direct impact on the contribution of its stock to portfolio risk, ie the betas. Demonstrating this empirical relationship constitutes our main empirical result. However, given the widespread research into the inadequacies of single factor models like the CAPM, it is likely that residual volatility from such a model may also contain some systematic influences. For the sake of completeness, we also examine if residual volatility from a CAPM model is affected by company pension scheme characteristics.

Note that we deliberately estimate fairly parsimonious specifications in the next subsection. It would be possible to add more variables to the right-hand side to improve the R-squared of the regressions, but that is not the aim of this study. We are not seeking to provide a comprehensive explanation of stock price volatility, but rather to assess if a statistically significant and reasonably robust relationship exists between features of a company's pension scheme and its own stock volatility.

Our empirical strategy involves first estimating equation **(8)** for our sample of UK FTSE 350 companies on a company-by-company basis using weekly stock return data over a continuous 56 week period. From this first stage regression, we obtain estimates of $\widehat{\beta_i}$ and also of the residuals $\widehat{\varepsilon_{it}}$. These are then used as dependent variables for second stage regressions, in which pension

(14) For a detailed explanation of the CAPM, its assumptions and implications, see Brealey and Myers (2000).

equity assets (relative to company market value) and 'economic leverage' are included on the right-hand side. Positive and statistically significant coefficients on each of these would support the idea that shocks to companies are amplified on account of their pension schemes. In all cases, we compare the results of our OLS estimates with estimates from a Re-Weighted Least Squares (RWLS) procedure to ensure that our results are robust to outliers and influential observations.(15) RWLS estimates are less sensitive to outliers than standard OLS estimates, and are obtained in the following fashion: in the first place an OLS regression is estimated, and Cook's distance D is estimated – where D_i is a scaled measure of the distance between the coefficient estimates when the ith observation is omitted and when it is not.(16) Next, any gross outliers for which $D > 1$ are eliminated. After this initial screening a series of weighted regressions are performed iteratively. Iterations stop when the maximum change in weights drops below a predetermined level of *tolerance*. Weights derive from two weight functions used successively – *Huber* weights and biweights – wherein cases with larger residuals receive gradually smaller weights.

The data is made up of FRS 17 disclosures of 223 companies, which probably cover a major portion of existing DB liabilities in the United Kingdom. Estimates from the Government Actuaries Department (GAD) suggest that the largest 221 private sector pension schemes accounted for about two-thirds of all UK companies' pension fund assets in 2000.(17) We cannot check how well the 221 schemes in the GAD report match with our 223 companies. But of the 223 companies, 89 are members of the FTSE 100 index and the remaining 134 are members of the FTSE 250 index, so the intersection set is unlikely to be small. Data on market values, debt and other balance-sheet variables is taken from Datastream. As in the simulations, ordinary debt is defined as short-term debt (borrowings repayable within one year) plus long-term debt (total loan capital).

For the first stage CAPM regression, we have 56 weeks of stock return data from 30 April 2003 until 26 May 2004. This ensures that our right-hand side pension scheme variables (measured as of 30 April 2003) are prior to the stock return data on the left-hand side and hence precludes any

(15) In alternative contexts, a number of authors like Temple (2000) have warned about sensitivity to outliers in small sample cross-sectional regressions. He suggests using robust estimation procedures alongside OLS estimates to ensure that a few influential buy atypical observations do not distort parameter estimates.
(16) Cook's Distance, D, can be thought of as an index which is affected by the size of residuals – outliers – and the size of the leverage of each observation. Large residuals raise the value of D, as does high leverage. For the exact formulae, relation with other outlier diagnostics, and additional references see *Stata Reference Manual*, Release 7.
(17) For more details, see Table 6.2 from *Occupational Pension Schemes 2000, Eleventh Survey by the Government Actuary*, April 2003.

contemporaneous correlation with the regression errors. We use returns on the FTSE All-Share index to measure total market returns, and the excess return transformations use the return on UK gilts from the Merrill Lynch index system. Note also that the results reported below use total return data which includes re-invested dividends, but none of our results are altered if price return data are used instead of total return data. Summary statistics and precise data sources are provided in Appendix 1.

4.3 Analysis of stock betas

In this subsection we investigate whether company stock betas from a first stage CAPM style regression are related to pension equity holdings and 'economic leverage'. The average R-squared from these first stage regressions is about 0.24 as shown in the top panel of Table B.(18) The betas from these regressions are used as the dependent variables in the cross-sectional regressions presented in the bottom half of Table B.(19)

In column [1] we include our two variables of interest – pension equity assets as a percentage of market capitalisation and 'economic leverage' – on the right-hand side. In both cases the OLS estimates are positive and they are precisely estimated. The R-squared of the regression implies that about 13% of the systematic variation in stock returns is on account of the fact that companies with larger pension equity assets and higher 'economic leverage' have bigger betas. The RWLS estimates in column [2] confirm that these results persist even when extreme observations are down-weighted. The positive impact of ordinary leverage on stock return volatility has previously been recorded by Bushee and Noe (2000),(20) but they do not consider the impact of pension liabilities. Cardinale (2004) uses a differently scaled measure of pension liabilities but he also finds that these are positively related to stock return volatility.

In columns [3] and [4] we add the log of total assets on the right-hand side to proxy for the size of the companies in the sample. A number of researchers have suggested that the size of companies is correlated with stock market return (Fama and French (1992)) and volatility (Bushee and Noe (2000)). The OLS coefficient on this variable is positive and statistically significant in column [3] suggesting that larger companies in our sample period have larger betas. On the other hand, the

(18) This is of a similar magnitude to other estimates from single factor CAPM type models. See for example Roll (1988).
(19) Note that the coefficient estimates and standard errors in Table B (and Table C) are multiplied by 100.
(20) See also Bhandari (1988).

RWLS coefficient in column [4] is not precisely estimated, which indicates that this inference may not be as robust in this sample. By contrast, the coefficients on both pension equity holdings and 'economic leverage' remain positive and statistically significant in both specifications.

Table B

First-stage regressions

Dependent variable:	Weekly excess total return company *i*
RHS variables:	Weekly market excess total return
Average R-squared	0.2357
Number of observations	223 companies, 56 weekly stock returns

Second-stage regressions

Dependent variable:	Company betas from first-stage CAPM regressions					
	[1]	*[2]*	*[3]*	*[4]*	*[5]*	*[6]*
	OLS	RWLS	OLS	RWLS	OLS	RWLS
Pension equity assets as % of market capitalisation	0.2234** (0.1054)	0.1989* (0.1102)	0.2517** (0.1048)	0.2317** (0.1116)	0.2009* (0.1085)	0.1850* (0.1073)
Pension liabilities + debt as % of market capitalisation	0.0534*** (0.0159)	0.0555** (0.0235)	0.0426*** (0.0171)	0.0454* (0.0243)	0.0415** (0.0186)	0.0443** (0.0227)
Log of total assets			3.544* (1.9363)	3.0716 (1.9975)	7.2828*** (2.2551)	6.4727*** (2.1213)
Industry dummies	No	No	No	No	Yes	Yes
R-squared	0.129	n.a.	0.142	n.a.	0.328	n.a.
Number of observations	216	216	216	216	216	216

Notes: *** Statistically significant at 1%; ** Statistically significant at 5%; * Statistically significant at 10%.
Coefficients and standard errors of second-stage regressions are multiplied by 100.
Heteroscedasticity corrected estimates of standard errors reported in parentheses for OLS estimates.

In columns [5] and [6] we further augment the specification by including ten dummy variables for industry sectors.[21] Roll (1988) *inter alia* found that industry factors are a significant influence in explaining stock returns in the United States. Besides, it may be particularly important to control for these influences in this case if, for instance, large DB pension liabilities and equity holdings were more likely to exist in certain 'old' industry sectors which have had long histories of

(21) The industrial dummy variables are based on Datastream's three digit industrial classification. They are Basic Industries, Cyclical Consumer Goods, Cyclical Services, General Industrials, Information Technology, Non-Cyclical Consumer Goods, Non-Cyclical Services, Resources, Total Financials, Utilities.

generous DB pension schemes. If our variables of interest retain statistical significance in these augmented specifications as well, then this should alleviate some concerns that we are picking up industry specific factors that are also correlated with the features of company pension schemes. However, the results are encouraging since not only do both pension equity assets and 'economic leverage' remain positive and statistically significant, but even the size of the OLS and RWLS estimates is barely affected (relative to the more parsimonious specifications in columns [1] and [2] respectively). Note also that the richer specification in column [5] explains about a third of the total variation in the cross-section of firm betas.

In order to explore potential non-linearities in the relationship between company betas and pension scheme variables, we also estimated the specifications in Table B using the log of the betas as the dependent variables. In general, these regressions were less well determined. Moreover, there was little evidence that the relationships were in fact non-linear, and the coefficient estimates of pension equity assets were also less robust.

In terms of economic significance, consider first the effect of pension equity assets. The coefficient estimates across the six specifications are fairly stable at around 0.2. This means that starting from the median, a 10% increase in the ratio of pension equity assets to market capitalisation implies a 0.27% increase in the firm's beta.(22) This estimated size of impact is close to that suggested in our simulation results presented in Section 3. In the simulations, the impact on the total market capitalisation of the 5% shock to core business was approximately 9.5%. Since the estimated beta measures the sensitivity of a firm's security to market movements (see equation **(8)**), we can check how increasing the size of pension equity assets from its median level affects a firm's return in response to a 9.5% change in the market. In the median case, a 9.5% market shock and a beta of 0.88 would change the return on an individual stock by 8.4%.(23)

Now the mean level of pension equity assets is 2.5 times the median level (see Table 1 in Appendix 1). Given an impact elasticity of 0.027 calculated in the previous paragraph, a 250% increase in pension equity assets to their mean level would increase the estimated beta from 0.88 to 0.94. With a beta of 0.94, a 9.5% movement in the overall market would change the return on an

(22) The median value of pension equity assets relative to market capitalisation is 12%, and the median beta is 0.88 (see Appendix 1), so that the impact elasticity is $\frac{0.2 \times 0.12}{0.88} = 0.027$.
(23) This 8.4% impact is almost identical to the median impact in Simulation A in Table A. Note that in these calculations, any additional volatility from the residuals of the CAPM is not considered. That effect is explored in the next subsection.

individual stock by 8.9%. Thus, increasing pension equity assets by 2.5 times (or from the median level in the sample to the mean level) raises the response of an individual stock to a common 9.5% market movement by about 0.5 percentage points. This magnitude can be compared with the difference between mean and median levels of the simulation impacts brought about by cross-holdings (column (4), Table A), which at about 0.6 percentage points is reassuringly similar.

Analogously, the impact elasticity of beta with respect to 'economic leverage' is 0.046.[(24)] This means that a 10% increase in 'economic leverage' implies a 0.46% increase in the firm's beta, starting from median levels. Hence, the proportional impact elasticity of 'economic leverage' is higher than that of pension equity assets, and this larger effect from leverage is consistent with the simulation results presented in Section 3. In the same way as the previous paragraph, we can evaluate the effect of raising 'economic leverage' from its median level to its mean level (about 2 times), derive the corresponding change in estimated betas, and calculate the size of the response to a 9.5% change in the market. It turns out that doubling leverage in this way, increases the estimated beta from 0.88 to 0.94, and this has the effect of increasing the response of an individual stock by about 0.7 percentage points. This is about half the difference between the mean and median simulation impacts in column (3), Table A, which is 1.4 percentage points.

These calculations suggest that the magnitude of impacts suggested from our simulations are in the same ballpark as our empirical estimates. They also confirm that the impact from leverage is larger proportionately than that of cross-holdings. Moreover, whereas for the typical firm the impacts do not appear very large, for a significant minority with above average 'economic leverage' and cross-holdings, these effects are clearly economically large. For these firms, the higher betas will raise any standard cost of capital calculation, and may have substantial real effects.

4.4 Analysis of residual volatilities

In this subsection we check if pension equity assets and 'economic leverage' are related to the volatility of estimated residuals from a first stage CAPM regression. A significant empirical relationship between pension scheme characteristics and such residual volatility would lend further support to our main argument. The main results of the regressions are reported in Table C.

(24) This is calculated at the medians and based on a point estimate of 0.05 from Table B. (The median value of pension liabilities plus debt to market values in the sample is about 81%.)

In columns [1] and [2] we start by introducing our two variables of interest on the right-hand side. In the case of pension equity assets, the coefficient is very imprecisely estimated by OLS but is highly significant when estimated by RWLS in column [2]. A closer examination of the RWLS weights reveals that one company – which has the highest volatility in the sample, more than three times the cross-sectional mean – has been omitted in the course of the iterations. Omitting this observation halves the standard error, whereas the coefficient estimate increases about three times. This pattern persists through the rest of the table: as we augment our specifications in columns [3] to [6], the effect of pension equity assets is only discerned once the outlying observation has been appropriately down-weighted. Importantly, the effect from 'economic leverage' is statistically significant irrespective of the estimation procedure.

Columns [3] to [6] include the proxy for company size on the right-hand side. The coefficient is positive, statistically significant and robustly estimated across specifications, suggesting that larger companies have less volatile stock returns. A similar effect of company size on stock return volatility is also recorded by Bushee and Noe (2000). Finally, columns [5] and [6] include the full set of industry dummies to further ensure the robustness of the estimated effects from company pension schemes. The RWLS estimates in column [6] show that the statistically significant positive effect of pension equity assets and 'economic leverage' on residual volatility persists as well as the negative effect of company size on residual volatility.

In terms of magnitude, we compute impact elasticities with respect to the two pension fund variables using the summary statistics in Table 1 (in Appendix 1). For pension equity assets relative to market capitalisation, we consider an estimate of 0.00005 from column [4] since it lies between the other statistically significant estimates. This gives an impact elasticity of 0.05, so that a 10% increase in pension equity assets (relative to market value) raises the volatility of residuals by about 0.5%. Similarly based on a coefficient estimate of 0.00002 for 'economic leverage', the impact elasticity is 0.1. In proportional terms, this is about double the effect from pension equity assets, and this larger effect is consistent with the simulation and empirical results presented above.

Table C

Analysis of residual volatility

Dependent variable:	Standard deviation of company residuals from first-stage CAPM-style regression (in Table B)					
	[1] OLS	*[2]* RWLS	*[3]* OLS	*[4]* RWLS	*[5]* OLS	*[6]* RWLS
Pension equity assets as	0.0022	0.0070***	0.0003	0.0049**	-0.0003	0.0058***
% of market capitalisation	(0.0045)	(0.0024)	(0.0046)	(0.0023)	(0.0049)	(0.0022)
Pension liabilities + debt as	0.0024**	0.0010*	0.0032***	0.0018***	0.0033***	0.0018***
% of market capitalisation	(0.0012)	(0.0005)	(0.0012)	(0.0005)	(0.0012)	(0.0005)
Log of total assets			-0.2398***	-0.2061***	-0.1841***	-0.1882***
			(0.0399)	(0.0381)	(0.0410)	(0.0426)
Industry dummies	No	No	No	No	Yes	Yes
R-squared	0.204	n.a.	0.309	n.a.	0.414	n.a.
Number of observations	216	215	216	215	216	216

Notes: *** Statistically significant at 1%; ** Statistically significant at 5%; * Statistically significant at 10%.
Coefficients and standard errors of second-stage regressions are multiplied by 100.
Heteroscedasticity corrected estimates of standard errors reported in parentheses for OLS estimates.

Overall, the evidence in Table C suggests that some of the effects of pension scheme characteristics can be discerned in volatility of the estimated residuals as well, further supporting our main hypothesis that companies with greater equity assets in their pension fund and companies with total leverage also have higher stock volatility.[25]

5 Concluding remarks

The main conclusion of this paper is that company sponsored DB pension funds amplify the effect of common shocks on the value of corporate equity, affecting stock market volatility through two distinct channels. The first derives from the fact that through their pension funds, companies

(25) An alternative to the first stage CAPM style model estimated above is to regress excess returns on a series of weekly time dummies. Time dummies will capture maximal systematic variation in returns in each period, and they capture the idea of a common shock to companies that was investigated in the simulations above. If the standard deviation of residuals from such a regression are also related to pension equity holdings and 'economic leverage', then this is analogous to the notion that pensions schemes amplify stock returns, over and above any returns induced by the time dummies in the first place. We do not present all the results of this exercise for the sake of brevity, and also because the conclusions are very similar. The second stage regressions suggest that there is once again a clear positive relationship between residual volatility on the one hand, and pension scheme equity assets and 'economic' leverage on the other. The coefficients are broadly similar to those presented in Table C, and the relationships are robust to outlying observations.

invest in each other. The second relates to the additional leverage induced by pension liabilities. Simulations based on a stylised model of company net worth suggest that the amplification in volatility on account of these channels may be of an economically significant magnitude. The simulations also suggest that the total 'economic leverage' effect is larger than the cross-holdings effects. Econometric analysis of weekly stock market data confirmed that these effects are statistically significant as well. It is especially encouraging that despite the small size of the cross-holdings effect in the simulations, it was precisely identified in the data even when other controls such as leverage, firm size and industrial dummies were included.

These specific findings are important and interesting, but the results of this paper are also related to at least a couple of separate issues. These are concerned with evaluating the riskiness of the UK corporate sector. The paper emphasises the additional volatility to share prices that comes about as a consequence of corporates holding shares in other companies via their pension funds. Companies may want to reduce such risks and, to that extent, our findings are related to the vast literature on the optimal investment policy for DB pension funds.[26] However, more generally our results also point to the need to monitor the whole 'economic' balance sheet of companies in assessing corporate health. From a systemic perspective, they underline the fact that the aggregate UK corporate sector may be more highly leveraged than what would be apparent from standard gearing measures. After all, if a proportion of the equities held by pension funds are cross-holdings, then at the aggregate level equity claims are smaller relative to the total 'economic leverage' of the sector. For the same reasons, other economic variables that utilise market valuations might also be incorrectly measured, such as Tobin's Q.

Cross-holdings can also make a difference to corporate valuations in ways that we have not considered in this paper. For example in the presence of potential bankruptcy, cross-holdings of UK equity reduce the diversification that non-UK equity would provide, especially if shocks to UK and non-UK equity are less correlated. Moreover, for firms close to bankruptcy, the institution of the new Pension Protection Fund (in April 2005) introduces a complexity in the relation between the value and risk of the pension scheme and the value and risk of investor capital.[27] Research on the impact of these issues for UK companies remains a task for the future.

(26) See *inter alia* Exley, Mehta and Smith (1997) and Haberman, Khorasanee, Ngwira and Wright (2004).
(27) The precise relationship will depend on the rate of premiums, extent of co-insurance and so forth. While many of these details have not been determined, it is likely that its economic effects will be broadly similar to that of the Pension Benefit Guarantee Corporation (PBGC) in the United States. For more details see Jin, Bodie and Merton (2004).

Appendix 1

Summary statistics and number of observations

Table 1: Summary statistics

Variable	Mean	Median	Standard deviation		Number of observations
Raw weekly return on stocks	0.0050	0.0037	Overall	0.0384	12,488 (NT)
			Between	0.0038	223 (N)
			Within	0.0382	56 (T)
Raw weekly return on gilts	0.0001	-0.0004	Overall	0.0063	56 (T)
Raw weekly return on FTSE All-Share	0.0034	0.0060	Overall	0.0150	56 (T)
Excess weekly return on stocks	0.0049	0.0039	Overall	0.0394	12,488 (NT)
			Between	0.0038	223 (N)
			Within	0.0392	56 (T)
Excess weekly return on FTSE All-Share	0.0032	0.0029	Overall	0.0176	56 (T)
Estimated betas	0.9631	0.8804	Overall	0.5291	223 (N)
Estimated residual standard deviation	0.0321	0.0286	Overall	0.0129	223 (N)
Pension equity assets as % of market capitalisation	29.8114	11.8021	Overall	72.8117	223 (N)
Pension total assets as % of market capitalisation	56.5388	21.4207	Overall	184.0388	223 (N)
Pension liabilities as % of market capitalisation	69.1896	27.0912	Overall	195.1767	223 (N)
Pension liabilities + debt as % of market capitalisation	147.5284	81.4362	Overall	269.2053	217 (N)
Log of total assets	7.8136	7.4640	Overall	1.6923	217 (N)

Notes: All company accounts variables and pension scheme information is dated as of 30 April 2003.
Market data on stock and gilt returns is for 56 weeks from 30 April 2003 to 26 May 2004.

Variable definitions and sources

Firm-level returns: Total return indices, comprising both price changes and dividend income. Weekly observations taken at week-end.

Source: Thomson Financial Datastream (code: RI).

Market returns: Total return index for the FTSE All-Share.Weekly observations taken at week-end.

Source: Thomson Financial Datastream (code: RI).

Risk-free returns: Total return index for UK gilts. Weekly percentage change.

Source: Merill Lynch Global Index System (code: G0L0).

Market capitalisation: End-of-day value (£ millions) as of 30 April 2003.

Source: Thomson Financial Datastream (code: MV).

Total debt: Annual company accounts (£'000s). Borrowing repayable with one year (code: x309) + Total loan capital (code: x321).

Source: Thomson Financial Datastream.

Total assets: Annual company accounts (£'000s). Total assets (code: x392).

Source: Thomson Financial Datastream.

Pension scheme variables: All pension scheme variables on pension assets, pension equity assets, pension liabilities were collected by hand from the FRS 17 disclosures at the end of company annual reports. For all companies except three, 2002 year-end annual reports were used. For those three companies, because their 2002 year-end reports were not available, 2001 year-end accounts were used. Since annual accounts of different companies are published on different dates, the raw data collected from the FRS 17 disclosures were updated in line with market movements up to a common date: as at 31 January 2003 for the simulations, and as at 30 April 2003 for the empirical analysis. More details of these calculations are available from the authors.

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