# Discounting and the market valuation of defined benefit pensions*

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**Abstract**

We investigate how defined benefit pension schemes of FTSE firms are valued by the equity market, focusing on how future liabilities are discounted (since UK data allows us to estimate the duration of pension liabilities fairly accurately). Our primary sample of FTSE 100 constituents includes mostly large DB sponsors with mature schemes, primarily closed to new entrants but still active for current employees. We find that equity market valuation of pension liabilities is consistent with discounting without allowing for credit risk, thus incorporating a valuation closer to their settlement value. This differs from the approach used in published accounts for which IAS 19 (and SFAS No. 158, its US equivalent) allows for discounting with a corporate bond yield. The difference is significant, as credit risk free discounting would decrease the reported value of FTSE 100 firms by about 7%.

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# 1 INTRODUCTION

A defined benefit pension (DB) requires the sponsoring company to provide its employees a pension, computed according to a contractually agreed benefit formula; this usually takes into account the employees' wage and years of service and is indexed to inflation.[1] These obligations are then financed by a pool of pension fund assets. Despite the fact that the pension scheme's assets and liabilities are formally separated from the company, the shareholders are ultimately responsible for its solvency hence pension deficits/surpluses affect the firm's value. The IAS 19 accounting standard introduced in the EU in 2006 aimed to make this potential liability explicit by requiring the sponsoring firm to report any pension fund deficit/surplus on its balance sheet.

Whilst pension assets are generally easy to value, the unique features of DB pension liabilities make them problematic from both an accounting and valuation perspective. Pension liabilities are not quoted in any market and are by their nature long term, hence depend crucially on a wide range of long term assumptions, such as inflation, discount rate, life expectancy, salary growth, employee turnover etc.

Although UK companies have been steadily moving from defined benefit to defined contribution pensions, DB schemes still represent a substantial commitment for most companies. Table 1 below presents some statistics highlighting the importance of DB pensions in the UK, indicating that in 2012 (the last year before the introduction of IAS 19 revised) DB liabilities - as measured under IAS 19 standards - were about 30% of market capitalisation for both the FTSE 100 and FTSE 350 and that the overall DB deficit (pension assets minus liabilities) stood at over 3% of market capitalisation for both indices.[2] The sheer size of these liabilities makes them important from a valuation perspective and there is growing evidence they have a significant impact on the free cash flow of the parent company and its investment decisions.[3]

[1] The benefits granted in a DB scheme also depend on the relevant regulation of the jurisdiction where the employment contract is signed. There are considerable differences in regulation across jurisdictions: for instance, in the UK the indexation of DB pensions is enshrined in law, while in the US is not. We discuss the UK's regulatory framework for DB pensions in section 3.

[2] Under risk-free discounting discussed below, liabilities stand at around 37% of market capitalisation and the deficit at about 11% for the FTSE 100.

[3] See for instance Rauh (2006) who shows how DB pensions affect firms' investment in fixed assets and Liu & Tonks (2013) who look at the impact of mandatory contributions to DB pension funds on investment and dividends for UK companies. Alderson & Betker (2009) show that, after the bursting of the dotcom bubble, firms with underfunded pension schemes redirected investment towards activities that produce higher cash flow, while Duygun et al. (2017) finds that DB coverage influences the propensity of making major investments and

TABLE 1 HERE

Another important insight from Table 1 is that, despite their importance, almost all DB schemes are now closed to new members. This reflects the large scale move to defined contribution schemes that has occurred over the last few years. We do not address the causes behind the closure of DB pensions in the UK, but Kiosse & Peasnell (2009) argue that accounting regulations have a role in determining both the size of pension deficits and how companies respond to these shortfalls. Also, Klumpes et al. (2009) reach a similar conclusion showing that pension curtailment decisions are linked to both strategic corporate risk management considerations and economic and regulatory pressures.

In this paper we estimate the market valuation of pension deficits/surpluses for FTSE 100 and FTSE 350 companies. While the value relevance of DB pensions has been studied extensively in the US context, the literature on European countries is much scarcer and the institutional differences among pension systems make the US results not directly generalisable to European countries. Our contribution aims to reduce this gap, however our main focus is on one key aspect of pension valuation, the discount rate used to value future pension liabilities. Using data available in the notes of most companies' accounts we create an alternative value of liabilities based on 'risk-free' (government bond yield) discounting and compare the market valuation of pension deficits/surpluses based on that measure as compared with the published measure. We use a risk-free rate as that is arguably the most appropriate to discount pension liabilities in order to determine the funding position of the pension plan.[4]

The issue of how to discount pension liabilities is widely debated as we discuss in section 4, mostly from a theoretical standpoint. Our paper provides an empirical contribution to that debate, showing that equity investors in UK companies value DB pension commitments using risk-free discounting. In estimating pension liabilities with a different rate from that used in the published accounts, we link to a stream of the literature that adjusts reported pension liabilities to a common basis to make them comparable (Asthana, 1999; Hann et al., 2007; Salewski & Zülch, 2015; Billings et al., 2017), with an important difference: while most of the previous literature

the type of such investments. Sasaki (2015) shows that actuarial losses cause a significant decrease in investment for Japanese manufacturing firms.

[4]This does not imply that a risk-free rate should always be used to discount pension liabilities. The appropriate discount rate depends on the goal of the valuation exercise, as we discuss in section 4.

standardises actuarial assumptions to industry medians, we can use the unique features of UK data to recover the duration of pension liabilities for each company and thus use the appropriate risk-free rate to discount them.[5]

We find that only in the case of risk-free discounting are our estimates consistent with the prediction that a £1 increase in the tax-adjusted deficit has a £1 impact on the value of the sponsoring company.[6] It is also the case that model estimates based on risk-free discounting are statistically superior and that, as expected, the difference between the market valuation and reported value of pensions is larger for firms with longer duration pension liabilities. This result implies that the market's valuation of pension liabilities is closer to their buy-out value rather than their accounting value.[7] Given that most of the pensions schemes in both our sample and in the wider UK DB universe are closed to new members, our results complement those of Anantharaman & Henderson (2021) for the US, providing additional evidence that investors use a settlement perspective to value mature DB pension schemes.

The rest of the paper is organized as follows. Section 2 offers a brief review of the empirical literature on DB pension valuation. Section 3 briefly describes the institutional background in the UK, highlighting the differences with the US. Section 4 gives an overview of the debate over the pricing of pension liabilities, focusing in particular on the appropriate discount rate. Section 5 describes the techniques we employ to investigate the pricing of DB schemes and how we adjust the discounting of pension liabilities. The next two sections describe the data we use and present our main results. Their robustness is discussed in section 8, which also includes a different empirical specification using Tobin's Q model and extends our results to a wider sample. Section 9 discusses the similarities and differences between this work and Anantharaman & Henderson (2021), a recent paper that analyzes the issue of discounting pension liabilities in the US context. The last section concludes, further robustness tests are presented in the supplementary results appendix.

[5] Also mortality assumptions have a material impact on the size of pension liabilities. However they depend on the composition of the workforce of each company, making it impossible to adjust them reliably.

[6] We document that this is the case for financially healthy firms. We do not have companies in clear financial distress in our sample, and sorting observations by Z-score does not provide any additional insights.

[7] See section 4 for a discussion of the buy-out valuation of pension liabilities.

# 2 EMPIRICAL RESEARCH ON THE VALUATION OF DEFINED BENEFIT PENSION SCHEMES

A full review of the literature on corporate DB schemes is outside the scope of this paper so in the next sub-sections we refer to the papers that are most relevant to our work. For a broader discussion of the academic work on DB pension see, for example, Cocco (2014).

## 2.1 Pension effect on market valuation and returns

Most papers investigating the effect of defined benefit pension schemes on companies' valuation have focussed on the US and over the period when reporting standards were arguably more opaque. Before the introduction of SFAS No. 158 the value of pension assets and of the projected benefit obligation (PBO) were disclosed only in the notes to the financial statements, while the number recognized on the balance sheet was just an accounting accrual representing the difference between contributions paid and costs charged to the income statement.[8] The first set of papers taking the market valuation approach to study US DB pensions dates back to the 1980s and found that stock prices fully reflected the funding situation of the pension plans. The main examples in this literature are the works by Feldstein & Seligman (1981), Feldstein & Morck (1983), Landsman (1986) and Bulow et al. (1987). Barth (1991) uses a different methodology, investigating which measures of pension assets and liabilities are most closely associated with share prices, and finds that investors use the disclosure in the notes to value DB pensions rather than the accrual recognised on the balance sheet under SFAS No. 87.

A number of more recent papers use the Ohlson model to address the value relevance of DB pensions. Barth et al. (1993) find that firms' market values reflect the funding position of DB pensions disclosed in the notes, while the pension cost component is largely redundant once pension balance sheet variables are included in the regression. These findings are in sharp contrast with those of Coronado & Sharpe (2003) and Coronado et al. (2008), who using a similar research design find that investors and analysts seem to fixate on the earnings impact of DB pensions and disregard the net position of the pension plans disclosed in the notes. Work

[8] This was also the case in the UK prior to the introduction of IAS 19.

by Hann et al. (2007) is somewhat in between, arguing that both earnings and the pension plan net position are taken into account by market participants. Their study compares the value relevance of smoothed pension amounts under SFAS No. 87 with their more volatile counterparts disclosed at fair value in the notes, finding that net pension assets are valued similarly under both measures while pension cost components are less persistent and hence less value relevant under fair value accounting.

The introduction of SFAS No. 158 has been investigated by a number of authors trying to disentangle the different valuation of disclosed and recognized DB pensions deficits/surpluses. Mitra & Hossain (2009) find a negative relation between stock returns and the pension transition adjustment caused by this accounting reform, while Beaudoin et al. (2011) find no difference in the value relevance of pensions between the two regimes. Yu (2012) uses a larger sample and finds that the value relevance under both regimes depends on the level of institutional ownership and analyst following of each firm, so that the market prices more accurately reflect disclosed information for firms that enjoy a high level of attention by institutional investors, while recognition improves the pricing of pension surpluses/deficits of companies that have less analyst following or lower institutional ownership.

Looking at the effect of DB pensions on returns rather than market value, Franzoni & Marin (2006) find that companies with severely underfunded pension plans earn significantly lower returns, controlling for a set of other factors; they argue that pension deficits impact companies' profitability with a lag. Their findings are reinforced by Picconi (2006), who shows that analysts systematically fail to take into account the effect of DB pensions in forecasting earnings. Jin et al. (2006) take a slightly different approach, focusing on the risk that a pension plan adds to the sponsoring company; they observe that for firms with normal leverage ratios the risk of pension liabilities is similar to that of corporate debt, whereas the portion of plan's assets invested in equities (or similar securities) has a significantly higher risk profile. Using a model much in the spirit of the CAPM they find that firms' betas reflect the additional risk generated by the DB schemes' assets and liabilities. Choy et al. (2014) find evidence that firms are comfortable taking more risks after freezing their defined benefit pension plans, increasing research and development expenses and leverage. On the other hand, Phan & Hegde (2013) find that firms freezing their DB scheme improve their financial position, but do not increase capital spending significantly.

As Glaum (2009) notes in his review, the literature on DB schemes for European countries is much scarcer. Moreover, as Gordon & Gallery (2012) argue using pension accounting as an example, different institutional settings may appear similar giving an illusion of comparability. In their analysis of optimal asset allocation of DB schemes McCarthy & Miles (2013) show that institutional details are crucial in understanding the trustee's payoff and hence in explaining the actual portfolios of pension funds. It is therefore far from given that the conclusions of the US literature can be readily applied to the UK or EU context. In the German setting, where most of the schemes are unfunded, Fasshauer & Glaum (2012) find that DB pensions are value relevant. Salewski & Zülch (2015) use the same research approach as Hann et al. (2007) with German data, finding that only the non discretionary part of pension liabilities is priced by equity market participants. Liu & Tonks (2010) use UK data, testing both a market valuation model and the asset price approach; they find that pension deficits reduce the market value of the sponsoring firm but less than one-for-one. A similar result is found by McKillop & Pogue (2009), who also find that pension deficits have an impact on credit ratings. Cardinale (2007) focuses on the bond market and finds that pension deficits have a non-monotonic impact on credit spreads, for both the UK and the US. It should however be noted that these works on the UK use data before 2006 and the implementation of IAS 19, which significantly increased the transparency in pension accounting. The change in accounting standard could be responsible for the different results that we find in this paper, though we do not address this question directly as our sample starts in 2006.

There is little research using accounting data after the introduction of IAS 19, either in the UK or the rest of Europe. Notable exceptions are Barthelme et al. (2019), who show that the revision of IAS 19 that eliminated the corridor method for actuarial gains and losses caused firms to shift their pension asset allocation out of equities and towards fixed income, and Glaum et al. (2018), who show that companies used the choices available under IAS 19 accounting opportunistically. Billings et al. (2017) use a panel of UK companies accounting under IAS 19 and show that management chooses actuarial assumptions in order to reduce the reported pension liabilities. The literature investigating managerial discretion in setting actuarial assumptions is vast, especially in the US, and indicates that management uses this discretion in opportunistic

ways.[9] We refer to the papers investigating opportunistic choices of the discount rate in the next section, but we do not discuss the rest of this literature as it is tangential to our study.

# 3 UK INSTITUTIONAL BACKGROUND

This short section gives an overview of the most important rules governing DB pensions in the UK context, highlighting the differences with the institutional background of the United States, the most commonly studied market. Besides the accounting rules, the most important piece of legislation regulating DB pensions in the UK during our sample is the Pension Act 2004.[10] It contains a number of provisions that make the institutional framework in the UK considerably different from that of the US.

Following the work of Bulow (1982), there has been a considerable debate in the US literature concerning whether the appropriate measure of pension liabilities is the Projected Benefit Obligation (PBO), which is a measure of liabilities that include future accruals, or the Accumulated Benefit Obligation (ABO), which reflect the liabilities of the sponsoring company as of today, not including future accruals. In other words, if the sponsor were to terminate the DB scheme today, it would be liable only for the ABO. Bulow (1982) argues that the ABO is the best measure of the sponsors' liabilities and a number of subsequent empirical works have compared the value relevance of both measures.

While under US GAAP accounting both ABO and PBO are disclosed, this is not the case under IAS accounting, where only the PBO is disclosed. In the UK context we believe that a number of factors point to the PBO being the most relevant measure of pension liabilities from an investors' perspective. Following the Pension Act 2004, pension benefits effectively vest after 3 months of service.[11] Moreover, the same law mandates the revaluation of both deferred benefits and pension in payment to inflation (with a cap). This is likely to reduce significantly the difference between the ABO and the PBO in the UK. On the other hand, in the US there is no such a rule, with the cost of living adjustment being a part of the pension contract between employer and employee rather than regulated by law.

[9] This is the conclusion that Glaum (2009) draws in his survey of the literature.

[10] This legislation integrated and replaced the previous Pension Act 1997.

[11] If the employment relationship is terminated after more than 3 months but before the vesting of the benefits under the scheme's rules, the benefits earned by employee can be transferred into a new plan.

The other main difference between the ABO and the PBO comes from future salary increases, but this is relevant only in the context of a final salary pension scheme: the PBO includes an estimate of future salary growth, while the ABO does not. No company in our sample is still offering a final salary DB, all the open schemes are career average (where each year employee accrue pension benefits based on their current salary) but some companies still have legacy sections of their schemes with final salary accruals. Given the vesting and indexation rules in the UK discussed above, for a career average salary DB scheme the ABO and the PBO are effectively identical. Even for a final salary scheme, the difference between ABO and PBO is likely to be small: as deferred benefits are linked to inflation, the two only differ if wage growth is substantially different from inflation.

Another consequence of the Pension Act 2004 is effectively to make unilateral changes of the pension benefits by the employer more complicated, so it is difficult for companies to modify their current pension commitments. If an employer wants to reduce future benefits (for instance by increasing the retirement age, closing to new members or decreasing the rate of future benefits accrual), it has to consult the trustees of the scheme, the employees and the unions. While this is a consultation rather than a consent requirement, the employer has to take into account any objections raised during the process, thus making it more difficult to change future benefits. The rules are much stricter concerning proposed changes to actual rather than future benefits, in which case consent is necessary but for the case of actuarial equivalence (i.e. the proposed benefits are actuarially equivalent to the actual ones).[12] While in the US a firm could close its pension scheme freezing the benefits and hence only be liable for the ABO, in the UK this is effectively impossible as the law makes clear that if a solvent sponsor decides to wind up its scheme liabilities should be valued on a full buy-out basis.

# 4 DISCOUNTING OF PENSION LIABILITIES

Although both IAS 19 in Europe and SFAS No. 158 in the US prescribe that net pension assets should be recognized in the sponsoring company's balance sheet, there are a number of assumptions in the process of determining pension liabilities that are controversial. Given their

[12] These rules also have implication for the value of the pension put in the UK, which we discuss in section 1 of the supplementary results appendix.

long duration probably the single most important of these debated assumptions is the discount rate used to estimate the present value of those liabilities. This debate is summarised in Brown & Pennacchi (2016) who argue that, whilst it is appropriate for the future pension recipients to include some measure of default risk when valuing their future pension benefits, from the sponsoring firm's point of view the pension liability has no default risk and so should be valued without allowing for credit risk (in practice using government bond yields). In other words, Brown & Pennacchi (2016) point out that the appropriate discount rate for pension liabilities depends on the objective of the valuation exercise. The risk-free rate should be used to measure the funding of a pension scheme, while a discount rate reflecting the risk of the sponsoring company is appropriate when measuring the value of the company's pension promises (i.e. to members of the pension scheme). Novy-Marx (2015) stresses a similar point, arguing that the valuation of pension liabilities depends on both the concept of liability being used and from whose point of view the liabilities are valued.

To see why Brown & Pennacchi (2016) argue that pension liabilities should be discounted using a risk-free rate it is useful to split the process of their determination in two parts. The first is estimation, where the schedule of future pension payments is computed using a range of actuarial assumptions that depend upon the specific situation of each DB scheme and the demographics of its participants. Once the future cash outflows of the pension fund deemed to be in respect of past service have been estimated, they need to be discounted to compute the projected benefit obligation (PBO) that the sponsoring company has to fund and disclose in its financial statements. From the sponsor's perspective these future benefit payments are not subject to default risk.[13] However the risk of sponsor default does complicate the market valuation of pensions somewhat and this is discussed in section 1 of the supplementary results appendix.

Indeed, in the UK, the settlement rate for pension liabilities (the discount rate used to value liabilities for pension buy-outs) is based on a risk-free rate. While the buy-out market in the UK has been steadily growing, it remains small when compared to the UK DB universe, possibly because buy-outs appear expensive for DB sponsors (i.e. the buy-out valuation of

[13]The only way in which a company could reduce the burden of future pension payments is to renegotiate the contributions or benefits of the pension scheme's participants. This is effectively equivalent to a salary cut.

pension liabilities is significantly higher than the accounting value, partly because the buy-out valuation uses a risk-free discount rate).[14] The consultancy Mercer publishes a global pension buy-out index, where the UK section estimates that the cost of a buy-out at 140 per cent of the accounting liabilities.[15] Lin et al. (2015) show in their simulations that de-risking strategies such as buy-outs have significant costs, and that the benefits do not always justify these costs.[16]

A set of papers focused on the US context, most notably Novy-Marx & Rauh (2011) and Brown & Wilcox (2009), discuss the discount rate for pension liabilities of public sponsors such as states and other local government bodies, arguing that a credit risk-free rate is appropriate. Fabozzi (2015) focuses on the investment policy and liability valuation concept of the Pension Benefit Guaranty Corporation, maintaining that a correct valuation of liabilities is key to design an optimal investment strategy and arguing the this valuation should be undertaken using risk-free rates for both public and private pension plans.

Various papers have also documented that managers choose the discount rate on pension liabilities opportunistically. Bodie et al. (1987) and Feldstein & Morck (1983) find that the discount rate is higher for companies where the pension deficit is large relative to the sponsors' equity or assets, while Godwin et al. (1996) and Asthana (1999) show that well funded plans use more conservative discount rates. Bodie et al. (1987), Godwin et al. (1996) and Asthana (1999) also find that the discount rate choice is linked to the financial health of the sponsor, with management using discretion to mitigate adverse circumstances. Kisser et al. (2017) find evidence that US corporate DB scheme sponsors manipulate reported pension liabilities, underestimating them by approximately 10 per cent on average, mainly using discount rates that are higher than appropriate. Also Comprix & Muller (2011) find that companies are opportunistic in choosing the discount rate and other assumptions, providing evidence that firms use them to exaggerate pension commitments before freezing benefits. The literature on the UK is scarcer, but the

[14] As we discuss below, the Pension Protection Fund - PPF - also uses risk-free discounting to value pension liabilities of bankrupt firms.

[15] See Mercer (2017) for the details of this estimation. It is worth nothing that there are other factors beside the discount rate that contribute to the difference between the accounting and buy-out valuation of pension liabilities. Insurers have strict solvency capital requirements and the buy-out price also takes into account their profit margins. Moreover there are considerable administrative costs in running a DB scheme, which in the case of buy-out are transferred to the insurer. Another important point to note is that the buy-out valuation of pension liabilities changes over time, depending upon the spread between corporate and government bonds among other factors.

[16] There are other strategies to reduce the risk of DB pensions, such as buy-ins and longevity swaps. Blake et al. (2013) reviews them discussing the development of the market for longevity and mortality risks.

evidence available tends to confirm the US findings discussed above. Li & Klumpes (2013) find that firms use inflated discount rates to manage their leverage ratio,[17] while Byrne et al. (2007) show that companies with well funded pension plans tend to use high discount rates. Billings et al. (2017) use a panel of UK companies reporting under IAS 19 and find that sponsors manage the discount rate (and other actuarial assumptions) to improve the funding status of their DB scheme when this is weak and its size is big relative to that of the sponsor. We interpret this evidence as an additional possible explanation of why market participants do not take the companies' accounting pension deficits at face value.

Despite the arguments against allowing for credit risk in the discount rate of pension liabilities discussed above, both IAS 19 and SFAS No. 158 allow discounting using corporate bond yields that are significantly above those of government bonds due, largely, to perceived credit risk. Under both standards, the pension obligation is discounted using high quality corporate bonds yields; most of the companies interpret this provision as AA rated corporate bonds of currency and duration matching those of their pension obligation.[18] There is however a long standing debate about which discount rate should be used, discussed in Napier (2009). Kiosse & Peasnell (2009) in their review of the evidence on the effect of accounting rules on pension provisions conclude that the determination of the discount rate is a complex matter and that arguably the most appropriate choice would be the rate applied by an insurance company in a buy-out, that is a (credit) risk-free rate. Indeed there is some apparent contradiction within IAS 19 itself as to the nature of the discount rate. Paragraph 83 and 84 of the last version of IAS 19 read as follows:

> 83. The rate used to discount post-employment benefit obligations (both funded and unfunded) shall be determined by reference to market yields at the end of the reporting period on high quality corporate bonds. (...) 84. One actuarial assumption that has a material effect is the discount rate. The discount rate reflects the time value of money but not the actuarial or investment risk. Furthermore, the discount rate does not reflect the entity-specific credit risk borne by the entity's creditors, nor

[17] As their sample spans 1998 to 2002, the relevant accounting standard is SSAP 24 (and the transition to FRS 17), so in their case the expected return on pension assets and the discount rate on pension liabilities coincide.

[18] The wording of the two accounting standards is slightly different, but their practical implementation has been identical.

does it reflect the risk that future experience may differ from actuarial assumptions.[19]

Paragraph 84 seems to suggest the use of a risk-free rate, contradicting the previous provision. In fact, the interpretation committee of the IFRS has been requested to clarify the passage above and the amendment for paragraphs 83-84 proposed by the IFRS' staff explicitly mentions credit risk:

> The objective of the discount rate is to reflect only the time value of money and at most very low credit risk, the currency and the estimated term of the post-employment benefit obligations. The discount rate does not reflect the actuarial or investment risk of the plan assets (as defined in paragraph 28). Furthermore, the discount rate does not reflect the entity-specific credit risk borne by the entity's creditors, and nor does it reflect the risk that future experience may differ from actuarial assumptions.[20]

Even in this formulation it remains unclear why the discount rate should reflect "at most very low credit risk" since pension liabilities are not subject to such risk from the sponsoring firm's perspective.

Unsurprisingly, the decision to use a discount rate that reflects some credit risk is not uncontroversial in the accounting industry. Among others, the Accounting Standard Board (ASB), the former British accounting standard setter, has recommended in a discussion paper (Pro-Active Accounting Activities in Europe, 2008) that pension liabilities should be discounted at a (credit) risk-free rate. A similar position has been expressed also by Blake et al. (2008) in a report authored by the Pension Institute. It is also striking that the UK Pension Regulator and the Pension Protection Fund (PPF) use government bond yields rather than corporate bond rates as the basis on which to discount defined benefit obligations in their annual publication investigating the DB universe (the Purple Book) and in calculating the levy that each sponsor has to pay to fund the PPF's guarantee.[21]

Of course, although it is often argued that credit risk should not be allowed for when estimating the present value of pension liabilities from the sponsor's perspective, it is possible that

[19] IASB (2011)
[20] IFRS (2013)
[21] See The Pension Protection Fund (2016) for a detailed discussion of the PPF's valuation method for pension liabilities.

other considerations mean that the effective discount rate need not be the yield on government bonds. The literature (e.g.Brown & Wilcox, 2009) highlights two important differences between government bonds and pension liabilities that may make bond yields inappropriate for discounting DB liabilities. First, government bonds are significantly more liquid than pension liabilities as, although the latter can be traded, it is a complex process unlike government bond trading. This liquidity premium would tend to mean that the yield on government bonds is too low a rate for discounting pension liabilities. Second, since pension liabilities tend to be at least partially indexed to inflation, they have a lower inflation risk premium than nominal government bonds (see Breedon & Chadha, 2003 and Buraschi & Jiltsov, 2005 for evidence on the inflation risk premium in nominal bonds). Thus the yield on nominal government bonds may be too high a rate for discounting pension liabilities (sadly we have too little information on indexing to estimate the present value of real liabilities using inflation indexed bond yields). Since there is no consensus on the scale of either of these effects (and they work in opposite directions), the approach of previous papers has been to assume they cancel each other out.[22]

A recent paper by Anantharaman & Henderson (2021) tackles similar issues in the US context, looking at how credit and equity investors value pension liabilities. They find that these two groups of investors value pension commitments differently and that their valuations depend upon the characteristics of the pension plan. In particular, for companies that have short duration plans the most relevant measure is the settlement value. This finding is very close to what we document in this paper, namely that equity investors use a valuation closer to the settlement basis than the accounting one to value mature and mostly closed UK DB schemes. We discuss the method and results of Anantharaman & Henderson (2021) in more detail in section 9.

# 5 MODEL SPECIFICATION

The main model we employ is a parsimonious specification of the residual income model as put forward by Feltham & Ohlson (1995). In their model, the market value of a firm's equity is expressed as the sum of the value emanating from the company's non-financial core activities plus the unrelated financial activities. We modify this model to make room for pensions as in

[22] We discuss other factors that may influence this calculation in section 1 of the supplementary results appendix.

Coronado & Sharpe (2003) and Coronado et al. (2008), dividing both income statement and balance sheet variables into pension and non-pension components. This model expresses the market value of equity (Mcap) as a function of the core book value of equity (BVc) defined as non-pension assets minus non-pension liabilities.[23] Net pension assets in turn represent the economic deficit/surplus of the DB pension schemes of the company; we define it as pension assets minus pension liabilities, not taking into account any surplus restriction, minimum funding liability, corridor adjustment or deferred tax asset arising under the current accounting standard.[24] Although entering pension assets and liabilities separately into the model rather than the net position might be useful for our analysis, the high correlation between the two items means it is not practical to do so.

For income statement variables, we divide earnings into core earnings (Ec) defined as net earnings minus net periodic pension cost (NPPC) and NPPC itself. NPPC collects all the pension related entries in the income statement: service cost (benefits accrued during the accounting period), interest cost (the effect of time on the pension obligation), expected return on plan's assets and temporary events such as curtailment and settlements.[25] Coronado & Sharpe (2003) and Coronado et al. (2008) use a slightly different definition of NPPC, where service cost is considered as a core expense rather than a pension item. We prefer to aggregate all the pension variables, but changing this definition has no major effect on the results. Hence we use the following models, where all variables are standardized by total company assets to make the series stationary and reduce heteroskedasticity:

$$Mcap_{i,t} = \alpha + \sum_{s=1}^{10} \gamma_s S_s + \sum_{t=1}^{7} \gamma_t T_t + \beta_1 BVc_{i,t} + \beta_2 NPAt_{i,t} + \beta_3 Ec_{i,t} + \beta_4 NPPC_{i,t} + \epsilon_{i,t} \quad (1)$$

$$Mcap_{i,t} = \alpha + \sum_{i=1}^{75} \gamma_i I_i + \beta_1 BVc_{i,t} + \beta_2 NPAt_{i,t} + \beta_3 Ec_{i,t} + \beta_4 NPPC_{i,t} + \epsilon_{i,t} \quad (2)$$

where subscript $i$ and $t$ identify firm and year, respectively. The only difference between the

[23] This is equivalent to the book value of equity minus the net pension assets (NPA)

[24] We do not consider the deferred tax assets disclosed by the companies as this disclosure its patchy at best. In most of our estimates we adjust NPA for the associated tax asset using the corporate tax rate, as discussed below.

[25] Excluding these exceptional events altogether does not alter our results.

two specification is given by the fixed effects, which we include at either the sector and year level ($S_s$ and $T_t$, respectively) or the company level ($I_i$).[26] All the variables are defined in Table 2.

As contributions to the pension fund are tax deductible in the UK, our estimates are based on a tax adjusted NPA that adds back the associated deferred tax asset/liability.[27] We compute this as NPA times the corporation tax rate that the companies in our sample face every year.[28] Although we do not directly observe the marginal tax rate paid by companies, the fact that the average tax rate paid by our sample of companies is about 24% provides support to the assumption that our firms face a marginal tax rate equal to or very close to the corporation tax rate. Shivdasani & Stefanescu (2010) provide evidence that firms incorporate the tax implications of DB pensions in their capital structure decisions, so disregarding the tax credit associated with pension contributions could limit the validity of our results. We use the tax adjusted NPA in the main paper and include estimates based on unadjusted NPA in section 3 of the supplementary results appendix as a robustness check.

TABLE 2 HERE

### 5.1 Estimating risk-free pension liabilities

As discussed in section 4, an important question mark over pension liabilities as they are reported in company accounts is the discount rate used to estimate their present value. In this section we describe how we adjust that valuation such that liabilities are discounted at the 'risk-free' rate - the yield on UK government bonds (known as gilts). Although not required to do so over our sample, most of the companies in the FTSE 100 disclose a sensitivity analysis to help users of financial statements understand the impact of the assumptions used in calculating the pension obligation. However for our sample almost none of the firms in the FTSE 350, other than those in the FTSE 100, report this information. It is for this reason we conduct most of our analysis on the FTSE 100, though we report some more limited results for the FTSE 350 in section 8.

[26] We used the Global Industry Classification Standard (GICS) and take the broadest sectoral definition, using 10 different sectors in total.

[27] In the UK there is a strong link between scheme funding and employer's contribution, sponsors of scheme in deficit have to agree a schedule of additional contribution with the trustees of the pension fund to address the deficit.

[28] UK Corporation tax has been changing during the period that we take as our sample, starting at 30% and being lowered first to 28% in 2009, then to 26% in 2011 and finally to 24% in 2012.

We use the interest rate sensitivity analysis to compute the duration of the defined benefit obligation; this in turn allows us to find the corresponding gilt rate appropriate for that liability and calculate the value of pension liabilities under 'risk-free' discounting; we label the resulting estimate risk-free pension liabilities and obtain the associated risk-free NPA by subtracting it from the reported pension assets (as assets are already marked-to-market, no adjustment is necessary).[29] The formula used in both passages above is just the standard duration approximation:

$$\frac{\Delta P}{P} = -\frac{\Delta i}{1+i} D \tag{3}$$

where $P$ is the price of a future cash flow (or cash flows), $i$ its yield and $D$ its duration. The duration of the pension obligation averages about 18 years, with a median very close to it but with wide variation over a span of more than 15 years; half of the companies are within the 15 to 20 years range. Since only a minority of companies disclose this sensitivity analysis for every year in our sample, we impute the duration of missing years based on the closest available year for which a duration estimate is available. Since pension liabilities are very long term and almost all schemes in our sample are closed to new members we find that this is a relatively accurate method.[30] The alternative approach of dropping these observations delivers similar results (albeit with larger standard errors).[31]

The yields on UK gilts come from the Bank of England historical yield curve data; in adjusting the pension liabilities, we retrieved the yields at the balance sheet closing date. Changing the discount rate of pension liabilities to the gilt rate increases the size of the pension commitments considerably. On average the increase amounts to more than 20 per cent of the reported liabilities. Thus, under risk-free discounting, only five companies have posted a surplus in at least one year and none has had a consistent surplus throughout our sample period with the median company having a deficit totalling more than 5 per cent of assets.

[29] We did not adjust NPA to account for the deferred tax credit/debit that they generate in this section. We choose not to present the results with both adjustments as they are nearly identical to the ones in this section.

[30] Relative to the schemes that disclose duration for all the years in our sample.

[31] These results are available in section 2 of the supplementary results appendix.

# 6 DATASET CONSTRUCTION AND SUMMARY STATISTICS

Our main dataset includes all the FTSE 100 constituents with a defined benefit pension scheme.[32] It spans from 2006, the first year when IAS 19 became mandatory, until 2012, when the revised version of IAS 19 became mandatory. We decided not to include the data from 2013 onwards as this revision could significantly influence our results and so we preferred to have a homogeneous sample. The major changes for IAS 19R from IAS 19 were: immediate recognition of actuarial gains and losses and use of net interest income (expense) rather than expected return on plan assets. These changes could be important to our study since many firms in our sample were deferring gains and losses using the corridor approach and especially since the impact of the use of net interest expense would differ according to discount rate choice. This change in the role of the discount rate is potentially problematic given our focus in this paper. Indeed, there is a growing body of work that shows the revision had a significant effect on firm behaviour in ways that could distort our results, as in Anantharaman & Chuk (2018) and Barthelme et al. (2019).

To deal with the wide variation in balance sheet closing dates, we defined time in our sample as fiscal year, i.e. all the companies closing their accounts from May 2008 to April 2009 are considered in year 2008. All the pension related variables have been hand-collected from the notes to the financial statements. The rest of the companies' account data have been retrieved from Bloomberg, using the balance sheet closing date as reference; for companies that do not use sterling as their reporting currency, the data have been converted into pounds using the closing exchange rate at the balance sheet date. The market capitalisation of each company has been retrieved at the reporting date instead of the balance sheet date, focusing on when the financial statements became publicly available. This leaves us with 83 companies that have a DB scheme for at least one of the years in our main sample of FTSE 100 constituents;[33] we drop two of them (Burberry and Lonmin) because their DBs were demerged or wound up in 2008. We also drop Fresnillo and Vedanta Resources because they do not have a DB scheme in

[32] Recall that we use the FTSE 100 for the main part of the paper because the pension reporting - particularly of interest rate sensitivity is superior to that of the FTSE 250. We present results for the FTSE 350 in section 8.

[33] During this period there was a merger between British Airways and Iberia. For the sake of dataset construction, we consider the resulting company (International Airlines Group) as a new firm that takes the place of BA.

Europe or the United States, but only very small arrangements in developing countries.[34] We also drop four companies that do not disclose any duration or sensitivity analysis in any of their accounts (including them with duration fixed at the sample mean or median does not influence the results). These exclusions do not affect our results in any material way.

Given that for some companies we do not have the full seven years of data, our main dataset includes 511 observations. Table 3 below summarizes the variables used in the estimation for the main sample of FTSE 100 firms, already standardized by assets. The main variable of interest for this study, net pension assets, averages at about - 2 per cent of assets when adjusted for the associated tax credit, but the distribution is considerably skewed to the right so the median company has a deficit of only 0.8 per cent. Also the distribution of pension liabilities is skewed to the right, with some supersized pension funds pushing the mean up to 30 per cent. For the median company pension liabilities represent about 19 per cent of assets, but in some cases the pension fund is actually bigger than the company itself. Obviously using a risk-free rate to discount pension liabilities increases their size considerably. Non pension earnings average at 6.5 per cent of assets, while the direct impact of DB schemes on the sponsoring firms' income statement is very modest as testified by NPPC. Moreover, nearly 15 per cent of our sample's companies are actually booking negative pension expenses, with the DB scheme contributing to firm profitability despite being in deficit in some cases. We should however note that a great deal of these profits comes from settlements and curtailments related to the restructuring of the pension fund.

TABLE 3 HERE

Table 4 shows the correlation among variables of interest. Net pension assets, pension liabilities and pension costs (NPPC) appear all to be uncorrelated with market value. This is not the case for pension deficits when liabilities are discounted at a risk-free rate, with risk-free net pension assets displaying a strong negative correlation with market value. This negative correlation might look perplexing at first blush, implying that an increase in pension deficit increases the value of the sponsoring company. However at a closer inspection this correlation is explained by

[34] In 2012 their combined pension liabilities were under 100m £, less than 0.2 per cent of the whole liabilities of FTSE 100 constituents.

the correlation between equity value and the risk premium on AA rated corporate bonds: our adjustment of the discount rate depends entirely upon the spread between AA corporate bonds and gilts. As this spread increases (decreases), the equity value is depressed (increased), hence the negative correlation. Pension liabilities are correlated with net pension assets, indicating that companies with larger liabilities show a larger deficit. This effect is stronger using risk-free discounting. Also pension expenses are positively correlated with liabilities, as companies with larger DB schemes have higher accounting pension costs.

TABLE 4 HERE

# 7 ESTIMATION AND RESULTS

Columns 1 and 2 of Table 5 report the parameter estimates for the basic Ohlson model, using only book value and earnings as independent variables. The estimation in column 1 includes sector and year fixed effects, while in column 2 we use company fixed effects. Throughout the paper we run our specifications both in cross-section, using controls for years and sectors, and controlling at the firm level. The former specification focuses on the differences in market valuation across firms, controlling for unobserved time and industry effects. The latter specification using company level fixed effects highlights the difference in valuation at the company level across years, controlling for time invariant unobserved effects specific to each firm in our sample.

Estimates for the model with sector and year fixed effects correspond quite closely to those found in the US literature (see for example Hann et al., 2007 and Dechow et al., 1999) even though the book value coefficient is only marginally significant in our case (though it is better estimated when we include FTSE 250 companies as in Table 8). The use of company fixed effects is less common in the literature since the firm level dummies often pick up some of the impact of book value and earnings making the coefficients on those variables more difficult to interpret, but despite this the coefficients in our estimation are both significant. Interestingly, the coefficient estimates that we get with company fixed effects are much closer to the Ohlson's model implied values that Dechow et al. (1999) find assuming a 12% cost of capital and using the realized persistence of abnormal earnings, suggesting that company fixed effects absorb some of this persistence. Columns 3 and 4 show our results for equation (1) and (2) with net pension

assets. A comparison of column 1 with 3 and 2 with 4 shows that our modification of the Ohlson model to make room for pensions does not have a big impact on the estimated coefficients on book value and earnings, even though in column 3 the coefficient on core book value is estimated less precisely. Although NPA is only marginally significant in the sector and year dummy case, the specifications in Table 5 seem to give some support to the transparent view that net pension assets influence market valuation. The estimated coefficient on pension expenses is noisy and indistinguishable from zero, implying that pension costs do not have an impact of firms' valuation.

TABLE 5 HERE

Although it is positive and significant as value relevance would predict, the coefficient on NPA in column 3 is puzzling as it is consistently larger than one, implying that the market gives a disproportionate weight to pension deficits, with £1 of net pension deficit reducing the market value of the company by about £2. Although this result is not present in the specifications where we include fixed effects at the company level (column 4) this is probably because the discount rate effect we discuss below is mitigated by the firm level fixed effects (since the difference between Risk-free NPA and the reported value is firm specific and moves only slowly through time, in this specification its effect is likely to be captured at least partially by the company fixed effects).

In all the specifications in the main paper we decided to cluster the standard errors at the company level as Petersen (2009) suggests is appropriate for panel data with a relatively short time dimension. We present estimates that allow for standard errors to be correlated at the sector rather than the company level in section 2 of the supplementary results appendix. Assuming correlation at sector rather than the company level is a less restrictive assumption about the structure of our data, but it has the problems of unequal cluster size and small number of clusters. Of the various bootstrap based improvements proposed by the literature, in section 2 of the supplementary results appendix we choose to use the wild cluster bootstrap of t-statistics as in Cameron et al. (2008) since this method corrects for both the small number of clusters and the unequal cluster size. Overall, both results using sector level clustering and their bootstrap version are similar to those presented in Table 5, in most cases the standard errors are actually smaller.

### 7.1 Risk-free pension liabilities: results

We now compare the estimates of the valuation of pension deficits using our alternative 'risk-free' measure described in section 5.1. First, we re-estimate equation (1) using gilt discounted liabilities. As column 1 in Table 6 shows, on this basis the coefficient on net pension assets is more precisely estimated and close to its predicted value of one, while column 2 shows that this result is robust to firm fixed effects as in equation (2). As in the previous estimation, we cluster standard errors at the company level and present results using sector level clustering (and its bootstrap improvement) in section 2 of the supplementary results appendix. To confirm the importance of the risk-free measure, column 3 separates the NPA and the additional component due to the gilt adjustment, creating a variable named Risk-free adjustment (Adj) defined as Risk-free NPA - NPA which amounts to testing the following:[35]

$$Mcap_{i,t} = \alpha + \sum_{i=1}^{75} \gamma_i I_i + \beta_1 BVc_{i,t} + \beta_2 NPAt_{i,t} + \beta_3 Adj_{i,t} + \beta_4 Ec_{i,t} + \beta_5 NPPC_{i,t} + \epsilon_{i,t} \quad (4)$$

.

Both the coefficients on NPA and on the adjustment term are significant and very close to what we found for the risk-free net pension assets. Whilst this result indicates that it is the variation of the adjustment across firms (due to differences in the duration of their pension liabilities) that makes the adjustment significant, column 4 confirms this by testing directly the prediction that companies with long duration liabilities should see a larger coefficient on their reported liabilities. We define a new variable called Ddif, equal to the duration of each company's pension liabilities minus the average duration across the sample, and interact it with pension liabilities.[36] This amounts to testing:

$$Mcap_{i,t} = \alpha + \sum_{s=1}^{10} \gamma_s S_s + \sum_{t=1}^{7} \gamma_t T_t + \beta_1 BVc_{i,t} + \beta_2 PL_{i,t} + \beta_3 Ddif_{i,t} + \beta_4 PL * Ddif_{i,t} + \beta_5 Ec_{i,t} + \beta_6 NPPC_{i,t} + \epsilon_{i,t} \quad (5)$$

[35] All the variables are defined in Table 2.

[36] Using NPA or the accounting deficit for the interaction yield results with the same interpretation.

The interaction term is significant and has the predicted sign, indicating that firms with longer duration liabilities have a larger coefficient on reported pension deficits. This ensures that our results for Risk-free NPA are genuinely driven by discounting rather than by an additional premium attached to pension liabilities irrespective of their firm specific characteristics. In this specification we only use fixed effects at the sector and year level as this is a test of the cross-section properties of pension liabilities.

TABLE 6 HERE

Overall, our results suggest that risk-free discounting is the most plausible explanation for the higher than expected effect of pension deficits on market valuation, not least since the effect is larger for firms with longer duration liabilities.

### 7.2 Model selection tests

Standard model selection tests of whether the model with Risk-free NPA is preferable to the model using the accounting NPA are problematic in our framework as the two models are non-nested, thus we use two approaches most commonly used in this context.

First, we use the Vuong (1989) test statistic, as Hann et al. (2007) do in this literature. Vuong (1989) is a likelihood based test statistic that allows to compare the explanatory power of non-nested econometric models. It does indeed confirm that the risk-free model is better specified, preferring it to the specification with reported NPA at the 5% confidence level using sector and year fixed effects, while the test statistic is just shy of significance at the conventional level using company fixed effects. In the latter specification the test has less power as the company dummies common to both models push the $R^2$ up and reduce the improvement of model fit provided by Risk-free NPA. Second, we effectively force the two models to be nested by running a regression with both Risk-free NPA and NPA as independent variables. We do this in column 5 of Table 6, where Risk-free NPA completely dominates its reported counterpart: the coefficient and standard error on Risk-free NPA are almost unchanged from what we present in columns 1 and 2 of Table 6 whilst NPA is insignificant and has a coefficient very close to zero.

Therefore for both approaches it seems that pension deficit based on risk-free discounting dominates the reported deficit in terms of value relevance.

# 8 EXTENSIONS

This section presents a set of extensions to our basic results that aim to confirm the validity of our results. First, we extend our sample to the full FTSE 350, though the lack of liability duration data for smaller firms means we cannot recalculate pension liabilities using a risk-free rate. Second we use Tobin's Q model rather than the residual income model as the basis of our estimation. Further extensions are presented in the supplementary results appendix.

## 8.1 FTSE 350 firms

In the extended sample of FTSE 350 constituents we have 215 firms with a defined benefit pension scheme for at least one year in our sample. We drop all the observations that have a negative book value of equity together with two firms that experienced exceptional circumstances during the years that we consider in our sample, namely Howden Joinery and ITV. This leaves us with 1408 firm-year observations. As Table 7 shows, the FTSE 350 sample is remarkably similar to the FTSE 100 for the variables that we consider, even if the pension commitments of companies in the FTSE 250 are only a fraction of those of their larger peers.[37]

TABLE 7 HERE

The disclosure of firms in the FTSE 250 is not as comprehensive as that of the constituents of the FTSE 100, so for those firms we could not calculate the duration of the pension obligation and hence the discount rate adjustment. However as this enlarged sample is similar in terms of firms' characteristics to the main sample of FTSE 100 companies analyzed above, if our hypothesis that equity investor use risk-free discounting for pension liabilities holds we would expect to find the same overvaluation of reported net pension assets documented in Table 5.

TABLE 8 HERE

Our estimates for the enlarged sample of FTSE 350 companies are reported in Table 8, which has the same structure as Table 5. The first two columns report estimates for the Ohlson model with just book value and earnings as independent variables using sector and year controls in

[37] See section 1, in particular Table 1.

column 1 and company fixed effects in column 2. The estimated coefficients are remarkably similar to the estimates for core book value and earnings in the following two columns. Columns 3 and 4 report estimates for equations (1) and (2). Net pension assets are still overvalued but slightly less than in our main sample of FTSE 100 constituents when using sector and year fixed effect, while the overvaluation is reduced using company fixed effects, as it was in the case in the main FTSE 100 sample. As we discuss above, this difference is likely to be due to the firm level fixed effects absorbing at least part of the duration effect. The estimated coefficient on pension expenses is quite noisy. Indeed, in one specification the coefficient on pension earnings is significant but negative. This is due to the service cost anomaly, a fact well documented in the literature: effectively service cost expenses are a proxy for human capital formation and hence can contribute positively to the value of the company.[38] As in the previous estimations we use clustered standard error at the company level.

As the results in Table 8 display the same features that we documented in Table 5, we interpret them as hinting that the same discount rate effect might be driving the results, thus adding to the validity of our main results.

### 8.2 Tobin's Q

The second model we employ to test the valuation of defined benefit pension schemes for FTSE 100 constituents is derived from Tobin (1969), much in the spirit of Feldstein & Seligman (1981) and Liu & Tonks (2010). We define Q as in the latter, namely as market value of equity plus book value of long term debt over total firm assets. Under strict assumptions, the value of Q should be equal to one in equilibrium; however the situation in the real world could be different. To take this into account, we include a set of control variables that may have an effect on Q, following Liu & Tonks (2010).

TABLE 9 HERE

We define Total earnings (Etot) as net earnings plus interest expenses on debt.[39] To control for the growth trajectory of the firm, we include 5 year earnings growth, defined as the average

[38] The service cost anomaly was first documented by Barth et al. (1992). Its explanation as proxy for the value created by human capital is suggested by Hann et al. (2007). Given our focus on the valuation of pension liabilities and the limited role of the service cost anomaly in our data, we do not investigate this issue further.

[39] Using net earnings instead of this variable does not alter our results.

of the last five years earnings minus the average of the five previous years; we also define its three years equivalent to limit the loss of observations caused by the data requirement of this variable. We also include net debt, defined as cash holdings minus total debt; hence a positive value indicates that the firm is a net creditor. All these variables are standardized by total company assets. The last control variable we add is the firm's CAPM beta, computed using one year of weekly returns against the FTSE 100 index. We test this model using both the reported and gilt adjusted value for net pension assets, bringing to the data the following equations:

$$Q_{i,t} = \alpha + \sum_{s=1}^{10} \gamma_s S_s + \sum_{t=1}^{7} \gamma_t T_t + \beta_1 Etot_{i,t} + \beta_2 5yGrowth_{i,t} + \beta_3 NPAt_{i,t} + \beta_4 Debt_{i,t} + \beta_5 Beta_{i,t} + \epsilon_{i,t} \tag{6}$$

Where all the variables are defined in Table 2. In the estimation we progressively drop the control variables to ensure that they are not driving the results. The values for Tobin's Q are plausible, with an average about 1.1 and median close to 1; for most of the financial companies in our dataset (mainly the high street banks) the value for Q is understandably lower. Excluding them from the sample as in Liu & Tonks (2010) does not materially change our results. Net debt averages at about 18 per cent of total assets but with considerable variation, with most firms being net debtors as expected. The beta against the FTSE 100 is very close to one on average. The estimation results are presented in Table 9. We start with equation (6) in the first column, then substitute the 5 year growth term with its 3 year counterpart in column 2 (total earnings average about 50 per cent above net earnings. The growth trajectory of earnings is positive for most companies, both if measured over a five or three year period). Column 3 drops the earnings growth term entirely, while column 4 drops the net debt term as well. Columns 5 to 8 repeat the same exercise using Risk-free NPA instead of the reported values. The results in Table 9 broadly confirm the findings we highlighted in the previous sections: the coefficients on net pension assets are consistently above one, even though their significance depends on the specification and the sample. On the other hand, adjusting their value using a discount rate that does not allow for credit risk gives estimates very close to unity with substantially lower standard errors, irrespective of the different samples and controls. As in the rest of the paper, we cluster the standard errors at the company level.

As with the Ohlson model, we compared the models with Risk-free NPA in Table 9 with their counterparts that use reported NPA as measure of pension deficit. Vuong's test statistics indicates that each Risk-free NPA model is always preferred to its counterpart at least with a 5% confidence level. Also enforced nesting confirms that Risk-free NPA is preferred (results not reported for brevity).

# 9 COMPARISON WITH ANANTHARAMAN & HENDERSON (2021)

A recent paper by Anantharaman & Henderson (2021) looks at the issue of valuation of pension liabilities from a slightly different angle, comparing the value and credit relevance of different measures of pension deficits/surpluses. The authors compare the accounting measure of pension liabilities with their settlement value, which is assumed to be the ABO discounted at AA corporate bond rates, and their going concern measure, given by the PBO discounted at the scheme specific expected return on plan assets (ERPA). Moreover, they partition the sample according to the estimated duration of the pension plan and see how the results differ for three buckets of pension plans ranked by duration.

Anantharaman & Henderson (2021) find that the best fit in terms of equity valuation is given by the going concern measure of pension liabilities, using ERPA discounting, but for the plans with the shortest duration, in which case the settlement measure of pension liabilities (the ABO) gives the best fit. In this work the authors use the method proposed by Hann et al. (2007) to estimate the PBO using different discount rates. While appropriate for US data, this method assumes that the DB schemes are final salary and that the benefits are not linked to inflation, making it inappropriate for our sample and the UK institutional setting. Moreover, this method relies on the difference between the PBO and the ABO, which is not disclosed under IAS 19. The authors then partition the schemes in their sample in three buckets according to their duration with the method of Blankley et al. (2018), using the ratio of forward benefits paid to the PBO to approximate the duration of the plan, assuming that plans that pay out a larger proportion of the PBO are more mature and hence have lower duration.

Anantharaman & Henderson (2021) find that the settlement measure of pension liabilities gives the best fit in explaining both credit and equity investors' valuation of pension plans in the short duration bucket, while the going concern measure fits the data best in the case for the schemes in the longer duration bucket. Given the UK institutional setting and the characteristics of our sample, where most of the schemes are mature and hence similar to what they consider to be shorter duration schemes, these results seem to agree with what we find in our work, highlighting the importance of a settlement valuation for DB schemes.

The same authors also have an older working paper discussing the valuation of pension liabilities in US context (Anantharaman & Henderson, 2016), using a different methodology from the paper discussed here. We provide a comprehensive comparison between our methodology and result and that of Anantharaman & Henderson (2016) in section 3 of the supplementary results appendix available online.

# 10 CONCLUSION

Our analysis focuses on the value relevance of DB pensions deficits/surpluses in the UK context, filling a gap in the literature that has mostly focused on investors' valuation of US pensions and also allowing us to measure liability duration more precisely than has been done in other studies. We find that the net position of pension plans is reflected in equity values, but that investors use a different valuation for pension liabilities than that prescribed by the international accounting standards, discounting at the risk-free rate rather than using corporate bond yields as in the published accounts. As the pension schemes in our sample are mature and mostly closed, our finding that investors use a risk-free rate to discount pension liabilities points to investors' valuation of DB pensions being close to their settlement value, that is the value at which the sponsoring company could wind-up its pension scheme though a buy-out or a buy-in with an insurer. This result complements the findings of Anantharaman & Henderson (2021) in the US context.

Even though our results are limited to UK firms and mostly closed schemes, our ability to measure the duration of pension liabilities fairly accurately allows us to contribute empirically to the thorny debate concerning the discount rate on pension liabilities, most notably by using cross

section variation in duration to sharpen estimates of discount rate effects. Our results therefore complement the theoretical discussions that have criticised the recognised pension deficit/surplus as an "unreal" number (for example Blake et al., 2008), showing that investors are able to process complex information disclosed in the notes and go beyond the headline number recognised on the balance sheet.

While our results show that for equity investors the risk-free valuation of pension liability is more relevant than the accounting measure, this does not necessarily imply that the IAS should move to risk-free discounting for pension liabilities. Determining the appropriate discount rate for financial reporting is a complex task that involves considerations that go beyond the equity markets' valuation on which we focus here. While our findings imply that the market looks through standard financial statement measures, they might also imply that increased disclosure could improve market pricing. This is important, especially as the IASB is currently at the early stages of a review into the disclosure requirements of IAS 19. Our work highlights the importance of information disclosed in the notes in helping value complex items such as pension liabilities and so suggests that more detailed disclosure of other assumptions used to determine the size of pension liabilities (the most important being mortality assumptions) could materially effect market values.

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Table 1: DB Pension Facts

| | FTSE 100 | FTSE 350 | UK DB universe |
|---|---|---|---|
| Firms with DB scheme | 77 | 210 | 6225 |
| of which open | 8 | 31 | 841 |
| of which closed to future accruals | 4 | 36 | - |
| total reported DB liabilities | 526.8 | 599.9 | 1329.2 |
| as percent of market cap | 29.50% | 29.95% | - |
| total reported deficit | 57.7 | 65.8 | 210.8 |
| as share of market cap | 3.23% | 3.28% | - |
| contributions as share of earnings | 18% | 18.70% | - |

This table presents statistics on DB pensions in the UK. It uses values at the end of 2012 fiscal year using IAS 19 data, but for market capitalisation, computed at the corresponding reporting date. Data for the UK DB universe come from the Purple Book 2013. We defined schemes as closed to future accruals if their service cost is zero. Liabilities of schemes closed to future accrual represent around 0.6% of the total for FTSE 100 companies and around 2.4% for FTSE 350 Companies. Figures are in billion pounds.

Table 2: Variable definition

| | |
|---|---|
| Market capitalisation (Mcap) | Market capitalisation at the reporting date |
| Core book value (BVc) | Core Book Value: non-pension total assets - non-pension total liabilities |
| Net pension assets (NPA) | Pension assets - pension liabilities |
| Pension liabilities (PL) | Projected benefit obligation |
| Tax-adjusted NPA (NPAt) | Net pension assets * corporation tax rate |
| Core earnings (Ec) | Net income - NPPC |
| Net periodic pension cost (NPPC) | Pension-related entries in the income statement |
| Risk-free NPA | Pension assets - pension liabilities discounted at a risk-free rate |
| Risk-free adjustment (Adj) | Risk-free NPA - NPA |
| Duration difference (Ddif) | Duration of pension liabilities - average duration across sample |
| Total earnings (Etot) | Net income + interest expenses |
| 5y earnings growth (5yGrowth) | Average of last five years earnings - average of the previous five years earnings |
| 3y earnings growth (5yGrowth) | Average of last three years earnings - average of the previous three years earnings |
| Beta | CAPM beta against the FTSE 100 using one year of weekly returns |
| Net debt (Debt) | Cash - total debt |

This table presents the definitions of the variables used in the empirical analyses.

Table 3: Descriptive Statistics

| variable | N | mean | standard dev | 1st quartile | median | 3rd quartile |
|---|---|---|---|---|---|---|
| Market Capitalisation | 511 | 0.9416 | 0.7420 | 0.4223 | 0.7560 | 1.3519 |
| Core Book Value | 511 | 0.3355 | 0.1821 | 0.1918 | 0.3535 | 0.4859 |
| Tax-adjusted NPA | 511 | -0.0207 | 0.0378 | -0.0288 | -0.0077 | -0.0009 |
| Pension Liabilities (PL) | 511 | -0.3048 | 0.4159 | -0.3606 | -0.1939 | -0.0400 |
| Risk-free NPA | 511 | -0.0986 | 0.1311 | -0.1124 | -0.0626 | -0.0127 |
| Risk-free PL | 511 | -0.3750 | 0.5028 | -0.4689 | -0.2432 | -0.0496 |
| Core Earnings | 511 | 0.0644 | 0.0722 | 0.0213 | 0.0615 | 0.0958 |
| NPPC | 511 | -0.0028 | 0.0054 | -0.0045 | -0.0018 | -0.0003 |

This table presents descriptive statistics for the main FTSE 100 sample. All variables are standardised by total company assets and were collected on the balance sheet closing date, except market capitalisation which was retrieved at the reporting date.

Table 4: Correlation table

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| (1) Market Capitalisation | 1 | | | | | |
| (2) Core Book Value | 0.098 | 1 | | | | |
| | (0.014) | | | | | |
| (3) Tax-adjusted NPA | 0.017 | -0.145 | 1 | | | |
| | (0.666) | (<0.01) | | | | |
| (4) Risk-free NPA | -0.899 | -0.066 | 0.302 | 1 | | |
| | (<0.01) | (0.114) | (<0.01) | | | |
| (5) Core Earnings | 0.141 | 0.273 | -0.055 | -0.047 | 1 | |
| | (<0.01) | (<0.01) | (0.168) | (0.258) | | |
| (6) NPPC | 0.024 | -0.033 | 0.421 | 0.134 | -0.050 | 1 |
| | (0.543) | (0.412) | (<0.01) | (<0.01) | (0.210) | |
| (7) Pension Liabilities | 0.002 | -0.069 | 0.664 | 0.357 | -0.152 | 0.450 |
| | (0.958) | (0.081) | (<0.01) | (<0.01) | (<0.01) | (<0.01) |

This table presents the Pearson correlation of variables in the main FTSE 100 sample, already standardised by total assets. P-values are shown in parenthesis below the correlation coefficients.

Table 5: Residual income model

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Book Value | 0.502* | 1.490*** | | |
| | (0.255) | (0.391) | | |
| Earnings | 4.849*** | 2.019*** | | |
| | (1.271) | (0.733) | | |
| Core Book Value | | | 0.431 | 1.591*** |
| | | | (0.266) | (0.395) |
| Tax-adjusted NPA | | | 2.120* | 1.115 |
| | | | (1.200) | (0.744) |
| Core Earnings | | | 4.802*** | 2.113*** |
| | | | (1.239) | (0.737) |
| NPPC | | | 4.635 | -5.689 |
| | | | (8.339) | (6.504) |
| Fixed Effects | Sector, Year | Company | Sector, Year | Company |
| N | 511 | 511 | 511 | 511 |
| $R^2$ | 0.598 | 0.834 | 0.602 | 0.836 |

This table presents results using the main FTSE 100 sample, stretching from 2006 to 2012. The independent variable is market capitalisation at the reporting date. Core book value is non-pension assets minus non-pension liabilities, core earnings are net income minus net periodic pension cost (NPPC), the measure of pension-related earnings in income. Tax-adjusted NPA is the difference between pension assets and liabilities for each firm, adjusted for the tax credit associated with pension contributions in the UK. All the variables are standardized by total company assets. When imposing fixed effect at the sector level, we use the broadest GISC sector classification with 10 sectors in total. The standard errors are clustered at the company level.

Table 6: Risk-free pension liabilities

| Variable | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Core Book Value | 0.398 | 1.627*** | 1.623*** | 0.360 | 1.624*** |
| | (0.267) | (0.379) | (0.382) | (0.263) | (0.380) |
| Risk-free NPA | 0.949** | 1.010*** | | | 1.021*** |
| | (0.399) | (0.327) | | | (0.375) |
| Core Earnings | 4.896*** | 2.028*** | 2.034*** | 4.908*** | 2.029*** |
| | (1.232) | (0.735) | (0.741) | (1.230) | (0.740) |
| NPPC | 0.751 | -4.338 | -4.254 | 1.750 | -4.292 |
| | (7.766) | (6.381) | (6.700) | (7.398) | (6.705) |
| Tax-adjusted NPA | | | 1.336** | | -0.043 |
| | | | (0.660) | | (0.732) |
| Risk-free Adjustment | | | 0.963** | | |
| | | | (0.368) | | |
| Pension Liabilities | | | | 0.384** | |
| | | | | (0.149) | |
| Duration Difference | | | | 0.031** | |
| | | | | (0.013) | |
| Ddiff*Pension Liabilities | | | | 0.064** | |
| | | | | (0.032) | |
| Fixed Effects | Sector, Year | Company | Company | Sector, Year | Company |
| N | 511 | 511 | 511 | 511 | 511 |
| $R^2$ | 0.611 | 0.838 | 0.838 | 0.624 | 0.838 |
| $R^2$ using Tax-adjusted NPA | 0.602 | 0.836 | | | |
| Difference in $R^2$ | 0.009 | 0.002 | | | |
| Vuong Z-Statistic | 2.036 | 1.454 | | | |
| p-value | 0.042 | 0.146 | | | |

This table presents results using net pension assets discounted at a risk-free rate (UK gilt yields). The independent variable is market capitalisation at the reporting date. Core book value is non-pension assets minus non-pension liabilities, core earnings are net income minus net periodic pension cost (NPPC), the measure of pension-related earnings in income. Adjustment is defined as Risk-free NPA minus reported NPA. Duration difference is the duration of pension liabilities minus its average across the sample. All the variables but duration difference are standardized by total company assets. Fixed effects at the sector level are based on the broadest GISC sector classification with 10 sectors in total. The standard errors are clustered at the company level. We compare models' fit between the specifications using Tax-adjusted NPA (column 3 of table 5 for sector and years fixed, column 4 of the same table for company fixed effects) and those using Risk-free NPA (columns 1 and 2 of this table) using Vuong (1989) test statistic.

Table 7: Descriptive Statistics for FTSE 350

| variable | N | mean | standard dev | 1st quartile | median | 3rd quartile |
|---|---|---|---|---|---|---|
| Market Capitalisation | 1408 | 0.9695 | 0.8556 | 0.4376 | 0.7487 | 1.2665 |
| Core Book Value | 1408 | 0.3881 | 0.1904 | 0.2621 | 0.3893 | 0.5205 |
| Tax-adjusted NPA | 1408 | -0.0201 | 0.0369 | -0.0305 | -0.0900 | -0.0007 |
| Pension Liabilities | 1408 | -0.2826 | 0.3470 | -0.3896 | -0.1729 | -0.0399 |
| Core Earnings | 1408 | 0.0624 | 0.0796 | 0.0259 | 0.0570 | 0.0928 |
| NPPC | 1408 | -0.0020 | 0.0068 | -0.0036 | -0.0013 | -0.0001 |

This table presents descriptive statistics for the FTSE 350 sample. All variables are standardised by total company assets and were collected on the balance sheet closing date, except market capitalisation which was retrieved at the reporting date.

Table 8: FTSE 350 companies

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Book Value | 1.002*** | 1.461*** | | |
| | (0.222) | (0.269) | | |
| Earnings | 4.511*** | 1.339*** | | |
| | (0.779) | (0.387) | | |
| Core Book Value | | | 1.026*** | 1.535*** |
| | | | (0.225) | (0.279) |
| Tax-adjusted NPA | | | 1.625** | 1.157* |
| | | | (0.809) | (0.635) |
| Core Earnings | | | 4.564*** | 1.395*** |
| | | | (0.787) | (0.396) |
| NPPC | | | -3.985 | -3.856* |
| | | | (3.289) | (2.034) |
| Fixed Effects | Sector, Year | Company | Sector, Year | Company |
| N | 1408 | 1408 | 1408 | 1408 |
| $R^2$ | 0.467 | 0.818 | 0.471 | 0.819 |

This table reports estimation results using the enlarged FTSE 350 sample, from 2006 to 2012. The independent variable is market capitalisation at the reporting date. Core book value is non-pension assets minus non-pension liabilities, core earnings are net income minus net periodic pension cost (NPPC), the measure of pension-related earnings in income. Tax-adjusted NPA is the difference between pension assets and liabilities for each firm, adjusted for the tax credit associated with pension contributions in the UK. All the variables are standardized by total company assets. When imposing fixed effect at the sector level, we use the broadest GISC sector classification with 10 sectors in total. The standard errors are clustered at the company level.

Table 9: Tobin's Q Model

| Variable | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| Total Earnings | 4.061*** | 5.237*** | 5.191*** | 3.068*** | 3.965*** | 5.244*** | 5.214*** | 3.074*** |
| | (1.296) | (1.554) | (1.299) | (0.928) | (1.253) | (1.532) | (1.286) | (0.926) |
| Beta | -0.105* | -0.095 | -0.076 | -0.112* | -0.111* | -0.097 | -0.078 | -0.111* |
| | (0.061) | (0.062) | (0.058) | (0.059) | (0.060) | (0.064) | (0.059) | (0.061) |
| Net Debt | -0.777** | -0.545 | -0.617* | | -0.732** | -0.462 | -0.535 | |
| | (0.347) | (0.387) | (0.343) | | (0.342) | (0.387) | (0.345) | |
| Tax-adjusted NPA | 1.848* | 1.949* | 1.907* | 2.598** | | | | |
| | (1.062) | (1.025) | (0.983) | (1.269) | | | | |
| Risk-free NPA | | | | | 0.968*** | 0.877** | 0.862** | 1.032** |
| | | | | | (0.342) | (0.354) | (0.339) | (0.391) |
| 5y Earnings Growth | 2.415** | | | | 2.791*** | | | |
| | (1.056) | | | | (0.901) | | | |
| 3y Earnings Growth | | -0.353 | | | | -0.339 | | |
| | | (0.686) | | | | (0.677) | | |
| N | 395 | 433 | 463 | 497 | 395 | 433 | 463 | 497 |
| $R^2$ | 0.565 | 0.566 | 0.582 | 0.540 | 0.581 | 0.576 | 0.592 | 0.550 |
| $R^2$ using Tax-adjusted NPA | | | | | 0.565 | 0.566 | 0.582 | 0.540 |
| Difference in $R^2$ | | | | | 0.016 | 0.010 | 0.010 | 0.010 |
| Vuong Z-Statistic | | | | | 2.550 | 2.321 | 2.309 | 2.134 |
| p-value | | | | | 0.011 | 0.020 | 0.021 | 0.033 |

This table presents our estimation results for the Tobin's Q model. Q is defined as market value of equity plus long term debt over total assets. Total earnings are net earnings plus interest expenses, net debt is cash minus total debt. The CAPM beta is computed against the FTSE 100. Tax-adjusted NPA is the difference between pension assets and liabilities for each firm, adjusted for the tax credit associated with pension contributions in the UK. Its risk-free version is obtained discounting liabilities using gilt rates. All specification include sector and year fixed effects. We cluster the errors at the company level. We compare models' fit using Vuong (1989) test statistic.