Pension scheme valuation versus funding pensions: the limitations of financial economics models and the Universities Superannuation Scheme*

Dennis Leech
Department of Economics
University of Warwick

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Abstract

A valuation of a pension scheme is not the same as funding of its pensions, except under the strict conditions assumed by financial economics. The introduction of regulation based on valuation using techniques of financial economics has made many schemes appear unstable or unaffordable and many have closed. USS illustrates the problems, having swung round from having a large deficit at the 2020 valuation to a surplus in 2023. As a scheme, for the important university sector, that is open to new members, with multiple employers and strong covenant, its pensions are well funded yet in recent years the valuation methodology has suggested otherwise. Its existence as a defined benefit scheme has been threatened due to overuse of methods from financial economics to manage risk. It would be better to focus on funding as the key issue. Uncertainty about the future should be resolved by informed judgement rather than pretending it is risk to be managed using financial models. The paper makes concrete proposals to improve USS funding.

Two decades or so ago the actuarial profession started to apply new ideas from finance theory. This led to radical new approaches to the way they saw the funding of pensions instead of the more traditional pragmatic methods they used before. The belief was that embracing the insights from a body of new theory that had been developed by economists and mathematicians, and was now taught widely in universities and business schools as a new orthodoxy, would provide precise, rigorous answers to issues of uncertainty and risk.

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This methodology, several of whose progenitors have been awarded Nobel prizes, was embraced enthusiastically by many and has largely become the professional standard for pensions actuaries, accountants and others involved in managing pension schemes. It has also been the basis of government regulation and legislation, most notably enshrined in the Pensions Act 2004. It is often claimed that it has the character of objective truth, free of subjectivity, because of its basis in rigorous models of general equilibrium and scientific probability theory.

Unfortunately this method has been overused to an extent where it cannot always be relied upon. The consequence for pension schemes in recent years has been disastrous, many of which have been closed, in some cases despite seeming to be perfectly viable on other, more pragmatic grounds, only to be replaced by inferior defined contribution schemes. Financial economics is a substantial contributor to the problematic valuation methodology and investment management of the University Superannuation Scheme (USS).

1 Financial economics and the efficient markets fallacy

Central to the financial economics approach to pensions valuation and funding is the efficient markets hypothesis (EMH). In general terms this is the assumption that the market price of a financial asset reflects all publicly available information about the future returns to that asset.[1]

Its analytical foundation is the mathematical relation between present value and a future payment, on the principle that a pound today is worth more than a pound next year. This formula for discounted present value defines a precise equivalence relationship between a sequence of payments in the future over a period of time and an amount of capital at a specific date. As well as being the foundation of the EMH, the formula's ability in general to establish equivalence between cash flows over many years and capital balance sheet values gives it a central role in pensions, which is all about intertemporal economics, and both interpretations are used. It was devised by J.B. Williams in the 1930s and is widely used throughout economics and finance[2]

[1] Fama (1970)

[2] Williams (1938) The present value, *P(0)*, of a stream of payments, *D(0), D(1), D(2), ..., D(t), ...,* is defined by the discounted cash flow (DCF) formula,

$$P(0) = D(0) + \frac{D(1)}{(1+r)} + \frac{D(2)}{(1+r)^2} + ... + \frac{D(t)}{(1+r)^t} + ... \tag{1}$$

where r is the relevant discount rate. As it stands without specifying the discount rate this formula is little more than a tautology. Thus the discount rate r is the internal rate of return on an investment of $P(0)$ with dividend earnings $D(0), D(1)$ etc. Alternatively if the discount rate is fixed exogenously, equation (1) can be used to determine either the present value corresponding to a given flow of payments, or a flow of

1.1 Market efficiency

An asset market is said to be efficient (specifically, efficient in the use of information) when the prices of all assets completely reflect all information about their future investment earnings for a given discount rate. This equilibrium is established on the principle of 'no arbitrage' such that if any price were to differ from its equilibrium level, this would represent an opportunity to make a profit without incurring any risk. This arbitrage opportunity would be instantly exploited by rational traders with perfect information. Therefore a market consisting of rational and perfectly informed individuals will be in equilibrium and efficient.

This 'no arbitrage' proof of the existence of equilibrium was first proposed by Modigliani and Miller, to establish a theorem that said that under certain conditions the value of a firm is independent of its capital structure.[3] In fact those conditions are very restrictive and the theorem has often been applied without due regard for them, including to the valuation and funding of defined benefit pension schemes.[4]

In an efficient market the price of a financial asset can be said to hold all the information about the future expected earnings to be received from ownership of the asset. There is therefore no need to estimate the future earnings that will pay pensions when they are due - it is all in the market price. This assumption follows from the so-called 'law of one price', that is a theory for a world of rational market actors and perfect information. The law holds and general equilibrium prevails in this world because any slight departures from it would mean an opportunity for profitable arbitrage, which would immediately be exploited and disappear.

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payments equivalent to a given capital sum if invested at that rate.

[3] Modigliani & Miller (1958). Their argument was to assume two identical firms, one of which borrowed and one did not, in a world with no taxes, where individuals and firms could all borrow and lend at the same rate. They then compared the value of the shares of the leveraged firm with those of the debt-free bought by shareholders using their personal borrowing. They argued that unless the values of the two firms were the same there would be an arbitrage opportunity, which cannot exist in equilibrium. Therefore they claimed to have 'proved' that corporate debt did not affect the value of the firm. However this is pushing the 'no arbitrage' principle too far. A true arbitrage opportunity exists where there are different sale and purchase prices of the same good, so a profit can be made without risk. It is a very strong assumption to claim that two firms can always be found that are perfectly matched in the precise way the theorem requires.

[4] For example Exley *et al.* (1997)

1.2 The evidence: excess volatility in asset markets refutes the EMH

The real world is rather different however and even in financial markets market efficiency cannot be assumed. The forces of supply and demand that determine the market price of an asset are not limited to a narrow focus on expected earnings. Decisions to buy or sell in the stock or bond market include speculation on price changes (having little regard for earnings), investment strategies related to a long term plan (such as a pension scheme de-risking or rebalancing), animal spirits (emotional changes in expectations generally maybe related to political factors or irrational exuberance), and so on. Many of these factors are naturally variable in the short term.

Meanwhile the earnings, dividends, interest, rent, etc, will be determined by market forces in the respective market. Dividend payments by for example a pharmaceutical company are derived from the pharmaceuticals market, interest on a government bond is fixed by the state, and so on. So the premise that the market price of an asset embodies all publicly available information about its future earnings is a fallacy. This is an empirical fact that ought to inform the methods used to value pensions.

The hypothesis of market efficiency has been tested by numerous scholars since the 1970's, most notably by Robert Shiller and his co-authors, who have argued that there is excess volatility in asset prices, and that this effect is large.[5]

This is illustrated in Figure 1 (from Robert Shiller's Nobel prize lecture in 2013[6]) which graphs the relation between stock market prices and what the efficient markets hypothesis predicts they should be, the perfect foresight graph. It is a clear refutation of the hypothesis.[7] This excess volatility suggests that it is a mistake to base pension funding regulation on asset prices.

The theoretical model says that the two graphs should be pretty much the same. Prices should be the expected discounted present value of future earnings, with expectations based on all publicly available data at the time. Yet they are strikingly different. The perfect foresight price graph is relatively smooth. It is smooth for two reasons, first, because it is constructed using the Williams present value formula, a type of moving average of a long series comprising all future dividend payments, suitably discounted. Second, the future dividend payments themselves tend to have followed the growth of the economy and have not varied dramatically around a trend. But on the other hand, market prices are very

[5]See for example, Shiller (1981, 1979) and his more recent book, Shiller (2015).See also the important theoretical paper published about the same time by Grossman & Stiglitz (1980), which demonstrates that an informationally efficient market is actually an impossibility.

[6]Reprinted in Shiller (2015) This is a revised version of the graph in his seminal paper, "Do Stock Prices Move Too Much to be Justified by Subsequent Movements in Dividends", Shiller (1981)

[7]See also Haugen (1999a,b) for more evidence.

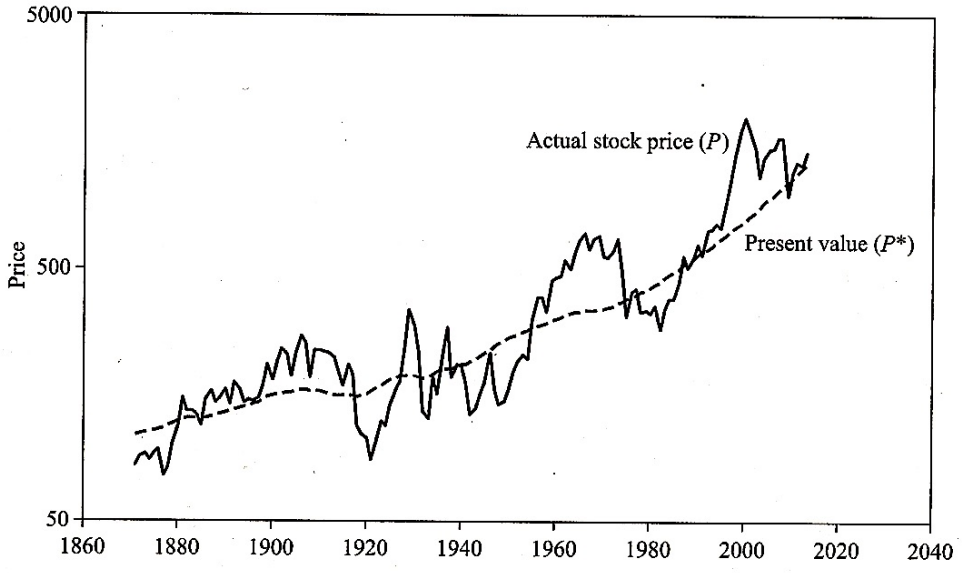


Figure 11.2

Stock Prices and Dividend Present Values, 1871–2013

Real S&P Composite Stock Price Index, 1871–2013 (heavy irregular curve), and present values, 1871–2013, of subsequent real dividends calculated using a constant discount rate (dashed smooth curve). *Source:* Author's calculations using data from sources given in Figure 1.1 and described in Chapter 1, note 3. See text and note 28 of this chapter for a description of the calculations. The vertical axis uses a log scale, in contrast to earlier figures in this book, and also shows only January of each year; hence the real stock price curve, which is otherwise the same as in Figure 1.1, looks different here.

Figure 1: Perfect foresight stock prices (P^*) versus actual market prices (P)

volatile. This is a massive difference and quite significant.

The efficient markets theory says that market prices ought to be less volatile than the perfect foresight value. As Shiller puts it, "Assuming that stock prices are supposed to be an optimal predictor of the dividend present value, then they should not jump around erratically if the true fundamental value is growing along a smooth trend. Only if the public could predict the future perfectly should the price be as volatile as the present value, and in that case it should match up perfectly with the present value. If the public cannot predict well, then the forecast should move around a lot less than the present value. But that is not what we see in [Figure 1]" [8]

The graph shows that instead of actual stock prices (P) being less volatile than the perfect foresight prices (P^*),[9] as the efficient markets theory states, in fact, they are *more* volatile, and considerably so. This is a striking finding, not only because the direction of the difference is opposite to the prediction of theory, but also because it is such a large effect.

In a later analysis of the same data, Campbell and Shiller estimated that only 27% of the annual return volatility of the U.S. stock market might be justified in terms of genuine information about future dividends.[10] Later Campbell and Ammer, using similar methodology and a different, more recent data set, found that only 15% of the variability in monthly returns in the U.S. stock market could be attributed to genuine information about future dividends.[11].

It would be hard to imagine there being stronger evidence against the EMH than this. Yet, although Shiller's findings were originally published as long ago as 1981, and moreover prominently so, in the *American Economic Review*, the leading academic economics journal in the world, it had little impact. Moreover, policy makers went ahead with designing regulations based on a theory lacking sound evidential support.

1.3 Why this is important for pensions valuation methodology

The evidence leads us to conclude that there is only a weak relation between the value of assets at market prices and future earnings. Of course it can be plausibly argued that the theory is correct on the average, and that market prices are unbiased estimators of the predictions of the EMH, they are just noisy indicators.

[8] Shiller (2015), p. 211)
[9] P^* corresponds to $P(0)$ in Equation (1).
[10] Campbell & Shiller (1988), cited in Shiller, *Irrational Exuberance*.
[11] Campbell & Ammer (1993).

But that is a serious issue for a DB pension scheme which must make prudent allowance for risk due to market volatility. Use of asset prices that are excessively volatile in a market based valuation creates the need for a larger margin of costly prudence than otherwise would be required.

We are therefore led to conclude that a valuation methodology that uses asset prices in a balance sheet, mark-to-market approach, as required by the Statutory Funding Objective at each triennial valuation, entails a quantum of risk that would not be present if investment earnings could be used. Prudent trustees should therefore look at the funding of the scheme using projected income/outgo and may well find such valuations to be much more stable and less likely to be in deficit.

The use of excessively volatile asset prices as the measure of the adequacy of funding for an open scheme rather than the more stable projected income leads to what we could perhaps call a deadweight loss.

On the other hand, for a mature scheme closed to accrual, the market prices of the assets matter crucially since pensions will have to be paid out of asset sales as it runs off; likewise if the scheme is envisaging buyout. But for an open scheme like the USS in which pensions are not paid from asset sales, the market valuation of assets is not relevant as long as there are enough investment earnings coming in.

The regulatory code that governs triennial valuations is a statutory requirement only and should not be regarded as providing a realistic picture of funding adequacy given that the scheme is expected to remain open. For the USS this would require a comparison of income and pension commitments over the future decades of the scheme's lifetime, which may reasonably be taken to be indefinite, in the absence of any indications otherwise.

The trustees are aware of this issue because they have argued for a separate regulatory code for open schemes. It is therefore perhaps surprising that their approach to the 2023 valuation adheres exclusively to statutory mark-to-market balance sheet methodology which requires a margin of prudence for risks that are not material. It would surely make sense to provide a statement of funding adequacy for the open scheme. Actuaries already provide a range of valuations for different scenarios - wind up, buyout, self sufficiency, etc. - but all of them are balance sheet numbers, capital values. This would just be another one but with the difference that it would recognise the reality of funding in cash flow terms.

2 The USS funding and valuation approach

The USS DB scheme ("Retirement Income Builder Section") is unique. The fact that it is open to new members and accrual, and is supported by a strong covenant based on an industry-wide network of employers in an important sector, means that much of the regulatory framework, [12] whose subtext is that every scheme is on an 'end-game journey, is not of much direct practical relevance to USS.

The USS is lobbying to change this. In its evidence to the recent Regulators Consultation on the new DB Funding Code, due next year, the USS was quite clear about how it should be regulated. It said:

> "There is an assumption within the Code that long term the position that needs planning for is scheme closure. In the case of USS our long term view is one of a scheme open for an indefinite period into the future and so closure is not a logical or reasonable planning goal [...]
>
> "[...] USS is an open scheme which is not expected to close either to new entrants or future accrual, let alone in the near future.
>
> "The nature of the higher education sector, and the fact that the USS employer base is sector-wide, means the USS employer covenant is very different to that of most other schemes. [...] USS believes there is good visibility of covenant support over a substantially longer period than most DB schemes and pressure to significantly reduce that view would also potentially have consequences for the funding of the scheme.
>
> "Without proper recognition of the effect of new entrants over a long visibility period that is perhaps unique to USS, the time horizon for the scheme will become artificially short which, in turn, will mean an unnecessary pressure to de-risk [...]"[13]

These comments received a positive response from the Regulator's new CEO:"We recognise the specific issues of the USS scheme and we intend to appropriately account for these, and open schemes more generally, in our Code."

[12] including the Pension Regulators Funding code for Defined Benefit Schemes, ThePensionsRegulator (2014)

[13] USS (2023a)

Following this in its July 19th Consultation document on the Technical Provisions for the 2023 Valuation, the USS has stated:

> "Our approach might need to change for future valuations.
> We are required to perform this (ie 2023) actuarial valuation in compliance with the current regulatory and legislative funding regime. Recently, there have been consultations on changes to DWPs funding and investment regulations and TPRs funding code of practice. We have responded to both consultations. A new code and underpinning Regulations are currently due to come into force for valuations carried out from April 2024, at the earliest. With UCU and UUK, we have also issued a joint stakeholder letter to TPR, calling for the draft code to recognise the unique nature of USS and other open schemes among UK defined benefit pension schemes."[14]

It might therefore not be unreasonable for the USS to use a revised valuation and funding methodology along the lines it has advocated in its evidence, as providing a more realistic picture. That would reduce volatility and hence bring down the cost of prudence.
There is nothing to prevent trustees doing this (alongside the SFO requirement). We stakeholders and trustees should be requiring this in order to better - and more prudently - manage the scheme.

However that would mean a change of direction from the present approach based almost exclusively on algorithmic, financial economics, which I now discuss.

3 Issues with the USS valuation and funding methodology

The valuation, dated 31 March 2023, is currently under way.[15] It has followed the same general methodology as for previous valuations but this time it shows a surplus of £7.4 billion whereas the last valuation in 2020 revealed a deficit of £14.1 billion. This is the first valuation to show a surplus since 2008.

The Reconciliation of this three-year turnaround[16] shows that the improvement is dominated by the change in discount rates, which alone is worth a staggering £44.5 billion to the fund - more than half of all the assets. This somewhat dramatically illustrates the massive instability inherent in the mark-to-market approach.

[14] USS (2023b)
[15] "Technical Provisions Consultation", and "— Supporting Information", USS (2023b)
[16] "Technical Provisions Consultation Supporting Information", p 14, 'Reconciliation of 2020 valuation and 2023 proposed results', USS (2023b)

The main driver of the improvement is the mathematical formula for the liabilities as a discounted present value. But this number is essentially an artefact because USS pensions are not directly affected by changes in a discount rate. Its role is in creating an *accounting valuation* for the liabilities rather than funding actual pension payments. In theory this is the amount of money that, invested at the discount rate, would be enough to pay all the future benefits. But in practice the investment portfolio does not change just because the accountants' discount rate has changed. It is a misapplication of a theory from financial economics.

So it is doubtful if this massive turnaround represents much in the way of a real improvement. Maybe the scheme has always been well funded and there was never a deficit 'black hole'. The big reported 2020 deficit was just the result of the chosen valuation methodology confronted with very low discount rates at the time.

The valuation makes extensive use of conventions and methods from financial economics: the efficient markets hypothesis, a stylised, simplistic model of asset risk and return, use of probabilistic modelling as a technique to deal with uncertainty, extensive use of stochastic simulation, unduly pessimistic scenarios and intellectual fudge.

The approach to valuing the technical provisions relies on the Integrated Risk Management Framework. This is a high level analysis of risks bringing together actuarial assumptions, the ability of the employers to support the scheme, volatility of market investment returns, choice of investment portfolio. This forms the context for trustees to determine the amount of prudence to apply when selecting discount rates for the liabilities. I will comment on some aspects of this which lead to excessive prudence or are otherwise problematic.

3.1 Why place so much emphasis on an arbitrary valuation date?

Why - apart from the obvious need to comply with statutory regulation requirements - should an open scheme like the USS define its liabilities by discounting projected future pensions commitments to an (arbitrary) valuation date? This is a roundabout procedure that first requires actuarial assumptions about future demographics, inflation, earnings in order to project benefits far into the future, then to apply the discounted present value formula to them, to get the present value, as of 31 March 2023. This figure - the liabilities - is then compared with market prices of assets as of the same date.

Given that the scheme is confidently expected to remain open indefinitely,[17] the question arises as to how the valuation is supposed to work as a guide to funding. To simply assume that pensions that fall due over many years into the future, until the end of the

[17] (in the absence of any tangible grounds or plausible indications to believe otherwise,)

century and beyond, can be paid out of the capital assets in the scheme's portfolio on the valuation date begs some rather big questions. A valuation is incomplete as a story about funding in an open scheme; there is a whole missing story of how the assets get converted into income with which to pay pensions in the intervening period. It is not good enough to invoke the EMH, which is what the valuation methodology implicitly does. This is an important economic question in the real world that cannot be answered with a financial model belonging to a no-arbitrage world of general equilibrium.

3.2 Intellectual fudge surrounding discount rates

The Government's technical provisions regulations require the trustees to choose discount rates for the liabilities calculation. The regulations give them a wide area of discretion provided they do so prudently and on actuarial advice. The Regulations say:

> "Discount rates used in setting technical provisions must be chosen prudently, taking into account either:
>
> the yield on assets held by the scheme to fund future benefits and the anticipated future investment returns;
> and/or
> the market redemption yields on government or high quality bonds."[18]

Given that the scheme is open with a strong covenant, it makes sense to use a discount rate based on the expected investment yield from the assets held, with a margin for prudence. That would include the equities that are a substantial part of its portfolio. So why does the USS use discount rates based on interest rates (particularly gilts) which is the other alternative open to the trustees according to these regulations?

Thus on page 3,[19] "Since the last valuation, rising long-term interest rates have reduced the value placed on our liabilities...", or page 4, "Rising long term interest rates have driven an improvement in the scheme's financial position...". This is for a scheme with 60% of its investments in growth assets. This improvement comprises direct effects on bond yields (a minor part of the portfolio) and weaker indirect effects on growth assets via macroeconomic impact of monetary policy. It does not follow that the discount rate should be based on interest rates.

On page 9 it says,

[18] ThePensionsRegulator (2014)
[19] USS (2023b)

> "In the context of pension scheme valuations, the impact of a change in expected returns on assets *or* interest rates is amplified due to the long-term nature of scheme cash flows, which are the benefit payments we make to members and which extend many decades into the future."

> "Higher long-term interest rates *tend to increase* our overall expected investment return. This means we need less money today to meet benefit payments in the future. In other words, the value of the Technical Provisions (the liabilities) and the cost of future service benefits both tend to fall as long-term interest rates rise bringing positive news at this valuation." [emphasis added]

This is again confusing because it conflates two different things: the effect of interest rates on bonds is fundamentally different from their effect on returns to equities and other growth assets, that make up more than half of USS investments. Overall investment returns on the portfolio are a combination of the two. It does not follow from this that discount rates should be based on interest rates.

It is repeatedly suggested that interest rates drive investment returns on all asset classes. Thus on page 20, under technical provisions:

> "The primary contributing factor to the movement in the position [since the 2020 valuation] has been the rise in long-term interest rates, which has *led to* higher expected returns on the assets we expect to hold ..." [emphasis added]

The claim here of such a causal role for interest rates in leading returns on other asset classes is totally lacking any evidential basis in economics. The correlation between interest rates and rates of return on equities has been studied extensively by economists. [20] The general finding has been that there tends to be a low and variable positive correlation. An analysis published by brokers Courtiers[21] reported a correlation coefficient between annual real returns on UK equities and gilts since 1900 equal to 0.505.

That equities and bonds are not *perfectly* correlated enables risk to be managed by diversification; such as the widely used 60:40 (60% equities and 40% bonds) rule for a diversified portfolio.

At some points in the document there is an explanation that the USS does indeed base discount rates on the expected return on its assets, as allowed in the regulations, but they are then expressed in the form of gilts-plus numbers. For example page 33 explains the derivation of the pre- and post-retirement discount rates:

[20] The literature is extensive: for example Fama & French (1989); Shiller & Beltratti (1992); Barsky (1989); Ilmanen (2003); Anderson & Breedon (1996); Chiang *et al.* (2015); Baur & Lucey (2009). See also Dimson *et al.* (2020) for recent evidence on investment returns to different asset classes.

[21] Courtiers (2018)

> "The discount rates for liabilities are a prudent allowance for future investment returns on the notional portfolios developed in respect of pre- and post-retirement liabilities, taking into account the trustee's integrated risk management framework (and in particular the strength of the covenant)."
> "The pre-retirement discount rate uses an addition of 2.5% to the gilt curve. The post-retirement discount rate uses an addition of 0.9% to the gilt curve."

That begs the question, however, of why it is necessary to use gilts and why the addition to them - the 'plus' - should be a constant. The relation between gilt yield and returns to equities and other growth assets is not fixed in this way as I have shown. If it were then they would be perfectly correlated which we know is not true. Also if it were true there would be no gains from diversification.

The argument that the use of leveraged liability driven investment by USS has not resulted in loss, and may actually have improved the funding position, relies entirely on the discount rate being gilts. The USS invested heavily in LDI and lost £16 billion in the last year. However it is argued that the funding level improved because higher interest rates have meant higher discount rates in the liabilities formula. And yet the *real* liabilities - that is the pensions that will have to be paid month by month long into the future - have not changed barely at all.[22]

The use of gilts plus a fixed margin looks like an intellectual fudge whereby, we are informed, the actual discount rate is the expected return on the investment portfolio *expressed as gilts-plus*. This seems an odd thing to do unless the intention is to use gilts anyway, despite the discretion the regulations allow to the trustees to choose a suitable discount rate for the technical provisions. The gilts-plus approach flies in the face of the statistical evidence and contradicts the fundamental principle of diversification.

3.3 Inflation projections based on efficient markets hypothesis

The inflation forecast is computed by comparing market yields on index linked gilts and conventional gilts giving the implied inflation forward rate. The assumption is that both conventional and index-linked bond markets are efficient, and are arbitraged by investors. Since both markets incorporate the same information, then the difference between nominal and real interest rates should contain information about investors expectations of future inflation. In the simplest version of this method it is just the difference between the nominal and real expected interest rate.

[22] There may be some weak macroeconomic effects such as on inflation, salaries and university employment.

This approach depends heavily on the EMH and in practice it has not been very reliable. An illustration of this is that there is a large change in inflation expectations between the 2020 and 2023 valuations, resulting in a very large additional cost of the liabilities of £17.0 billion.

This dependence on financial economic theory in this way to forecast inflation seems to be an important issue for the USS. It is expecting too much to assume, as this approach does, that something so important and often unpredictable can be left to a contested financial economics model. Instead of hiding behind the EMH trustees should embrace the radical uncertainty that inflation represents and make investments in real assets that respond positively to inflation matching changes in the pensions commitments.

3.4 Use of stochastic simulation modelling

The valuation makes extensive use of stochastic modelling carried out by an outside firm, Ortec. The main method is Monte Carlo simulation whereby random numbers are used to generate scenarios for the scheme going forward. Thousands of scenarios are computer generated and the frequencies used to represent probabilities.This approach is used to generate expected investment returns and various probabilities associated with aspects of the IRMF. It is a useful analytical tool but taken too far by USS and uses it to try to answer too many important questions. Stochastic modelling is problematic for a number of reasons.

3.4.1 Simulated probabilities are synthetic not real

The probabilities derived from stochastic modelling that are reported in the valuation document are not *actual* probabilities (which in fact do not exist because investment returns are not random in the sense of obeying stable probability laws) although they are reported as if they are real. Probabilities are reported at various points in the document and referred to as if they are objective - whereas they are *synthetic*. They have been generated in a computer program and the input assumptions that are fed into that are vital to understanding.

The markets are not a stationary universe like some kind of physical or biological entity, such as the weather, human mortality, the tides, that can be modelled using the tools of probability theory. We can for example state with some objectivity the probability that the height of the tide at London Bridge will be above 5 meters on 31 March 2026, using a model. But the behaviour of financial markets cannot be modelled in that way; they are inherently unstable because they are social institutions.

Stochastic simulation models used by USS/Ortec are driven by basic assumptions about

distributions of returns (eg lognormality, variances, covariances/correlations, etc) that all have to be fed in as the basis on which the scenarios are generated. This information ought to be transparently shared in the document.

These parameters are not constants and can change (especially covariances/correlations). The documentation should explain clearly what assumptions are made in the simulations. Yet there is nothing. The USS relies on the simulation modelling company's expertise.

Stochastic simulation cannot tell us what the expected investment returns are to inform the discount rate, because that is an input not an output.

We should be careful with the simulation results and recognise their limitations. Stochastic simulation is a useful technique to help with risk management for a complex organisation as big as the USS. But the results are only indicative. USS reports them as if they are real, objective numbers and builds a lot of the analysis on them but they are misleading. It is using probabilistic methods suitable for analysing risk for what is essentially a case of uncertainty.

3.4.2 Misuse of probabilistic arguments

Much use is made of probabilistic definitions. Thus we are told that the discount rates are chosen prudently, prudence being a probability of success (confidence level) of 70% for the pre-retirement discount rate, 69% for the post-retirement. This is incomplete since prudence requires specifying the rest of the distribution as well: what happens in the other 30%(29%) of cases? Surely it is necessary to discuss that.

Self sufficiency is defined as a low risk investment strategy having a confidence level of 95% of passing the following two tests: (1) being able to pay all benefits when they are due (not exhausting all capital before the final benefit is paid) (2) not falling below 90% funding level at each triennial valuation. That leaves 5% of scenarios undiscussed.

One thinks of the example of playing a single round of Russian roulette, where the probability of success is 5/6 or 83.33%, - much larger than the prudent discount rate confidence level. But such an action is in no way prudent because it has fatal consequences with probability 16.67%.

3.4.3 Stylised assumptions about asset classes

Stochastic modelling relies on the use of generic asset classes and associated distributional assumptions: equities, gilts, etc. There are questions about how these categories compare with the actual assets held. Is the modelling about the risks and returns of the invested portfolio held by USS or simply stylised categories. Not all assets fit into the template: there are low risk equities for example.[23]

3.5 Too much prudence

A number of assumptions appear to be unduly pessimistic or exaggerate risk, with the result that there is much more prudence at cost to the scheme. The result is to inflate the technical provisions liability.

3.5.1 Self sufficiency

The foundation of the Integrated Risk Management Framework is self sufficiency, an assumption that the scheme receives no further contributions from employers and members. Its justification is the principle that accrued benefits should not require further contributions. It represents a sharp discontinuity from the actual scheme where employers and members pay contributions and may be considered as being able to continue to do so at an affordable rate in a self sufficiency scenario.

The question is: why should this be the 'benchmark'? It is not suggested that there is any prospect whatever of this scenario ever being implemented since the USS has a strong covenant and a long horizon without question. Self sufficiency no doubt makes sense as part of the valuation approach for a company scheme in runoff closed to new members or accrual, but not for the USS. It seems absurd to assume something unreal and make it the centrepiece of your risk management strategy at great expense. It seems like excessive prudence that will have to be paid for.

Ignoring the sustainable contributions (say 20% of payroll - a number in line with the recommended contribution rate in the valuation) is a very large item, with discounted present value somewhere in the region of £56 billion.[24]

[23] See for example Baker & Haugen (2012)

[24] Double the figure of £28.1billion for the affordable risk capacity (given on page 14) which is based on 10% of payroll over 30 years.

3.5.2 Affordable risk capacity

The affordable risk capacity is defined as the maximum amount the employers (including presumably the members) are assumed to be able to pay if the investment performance is so poor that the deficit exceeds the self sufficiency level. It is defined as 10% of payroll. That seems an excessively prudent figure in comparison with the contribution rate of 20.6% of payroll being recommended in the draft valuation. Might it not make more sense for this calculation to use a consistent figure? The pessimism of this idea adds unnecessary prudence to the liabilities.

3.5.3 Dual discount rate

The technical provisions uses two discount rates, in respect of member benefits before, and after, retirement. For the 2023 valuation these are: pre-retirement Gilts+2.5%, post-retirement Gilts+0.90%.

The thinking behind this is the idea of a lifestyle investment strategy whereby an individual should invest in high return but risky assets during the accumulation stage of the pension during working life (when they can effectively ignore short term asset price variation) and then switch to a low risk portfolio after retirement. This is similar to the logic of an individual DC pension plan. Or of a mature or closed DB scheme.

The dual discount rate was adopted following its recommendation by the second Joint Expert Panel in 2018, as an automatic stabilising mechanism for when the scheme matures. But as long as the scheme is open and immature, with new members joining to replace those retiring, it is not needed. Its effect, however, is to reduce the overall discount rate relative to what it had been before. That has had the effect of raising the liabilities via the discounted present value formula.

The effect of the dual discount rate, therefore, is to add a layer of unnecessary and costly prudence - so long as the scheme remains immature. This suggests the need for an *immaturity benefit* in the technical provisions to offset that effect. That would remain as long as the scheme remains immature.

3.5.4 Stochastic modelling of balance sheets overstates risks

The stochastic modelling used by USS, called asset/liability modelling, which is carried out by an external company, focuses on the stochastic variation in balance sheets: assets and liabilities. But as we know from the work of Shiller and coauthors, described above, asset prices are excessively volatile. So if the parameters (means, standard deviations and

covariances of returns) are taken from the real world the simulations are likely to be excessively volatile as well. Since pensions are payments of income in cash we need to look at the stochastic behaviour of investment earnings receipts and ignore the unrealised capital valuation movements. Therefore the stochastic modelling will overstate volatility, needing more prudence. Thus for example the probability of capital exhaustion and other risks are likely to be overstated.

Simulating the behaviour of balance sheet assets and liabilities - rather than income and outgo - although it is standard practice for many financial institutions, is the wrong approach for a pension scheme because pensions are cash flows. The stochastic modelling would be better if the random variables whose distributions are simulated were the investment earnings and pension payments in cash terms - in other words ignoring the effects of short term fluctuations in capital values.

3.5.5 Volatility of the difference of independent numbers

The valuation is a comparison of market-valued assets at a given date with liabilities calculated as a discounted present value at the same date. The discount rate (or rates) for calculating the liabilities plays a central role. Small variations in it have a large impact without any change to the actual projected pensions. The assets are inherently highly variable.

The surplus or deficit is the difference between two large - essentially random - numbers each with large variability. Therefore the difference between them will behave like a random number with - as is well known from elementary statistics[25] - amplified variability if they are not perfectly correlated. For two very large random numbers like the USS assets and liabilities this effect is considerable.

Since, as I have argued, there is no necessity for the funding of an open scheme like USS to be based on this kind of - market priced, balance sheet - valuation, this variability is likely to increase the perception of risk requiring an unnecessary layer of prudence, that is, in fact, due purely to the methodology.

[25]The variance of the difference between any two random variables equals the sum of the variances minus twice their covariance. If they are independent their covariance is zero so the variance of the difference is the *sum* (not the difference) of their variances.

4 The importance of not conflating uncertainty and risk

A pension scheme requires key decisions to be made about a future which is by definition unknown. It is in a situation of *uncertainty*, sometimes referred to as Knightian uncertainty after the economist Frank Knight who first discussed it and explained how it differed fundamentally from *risk*.

> The practical difference between the two categories, risk and uncertainty, is that in the former the distribution of the outcome in a group of instances is known (either through calculation a priori or from statistics of past experience), while in the case of uncertainty that is not true, the reason being in general that it is impossible to form a group of instances, because the situation dealt with is in a high degree unique.[26]

John Maynard Keynes made the same distinction and explained it as follows.

> By uncertain knowledge, let me explain, I do not mean merely to distinguish what is known for certain from what is only probable. The game of roulette is not subject, in this sense, to uncertainty; nor is the prospect of a Victory bond being drawn. Or, again, the expectation of life is only slightly uncertain. Even the weather is only moderately uncertain. The sense in which I am using the term is that in which the prospect of a European war is uncertain, or the price of copper and the rate of interest twenty years hence, or the obsolescence of a new invention, or the position of private wealth owners in the social system in 1970. About these matters there is no scientific basis on which to form any calculable probability whatever. We simply do not know.[27]

The fundamental importance of uncertainty to economics got largely forgotten about in the postwar development of models of decision theory with such mathematical sophistication that some came to believe that it could eliminated, that probabilistic risk models deal with it.The historical background is explained by Kay and King in their book *Radical Uncertainty*.[28] Following in this tradition, a pensions valuation seeks to replace the inherent uncertainties by risk metrics which can be analysed using well known mathematical tools and stochastic modelling. I have shown that this is highly problematical. Also the fact of the enormous - implausible - variation in the USS assets and liabilities seen from one valuation to the next, and even between monthly FMP monitoring reports, reinforces this.

[26] Knight (1921)
[27] Keynes (1937)
[28] Kay & King (2020)

Kay and King argue for a different framing: decisions in terms of a *reference narrative* which recognise and embrace uncertainty. Uncertainty is a lack of information about an unpredictable future, but certain kinds of uncertainty may be resolved by further information. For example the uncertainty surrounding mortality rates may be resolved (although not eliminated entirely) by modelling life tables and risk pooling. On the other hand investment returns, inflation predictions, catastrophic climate change are not so easily resolvable and should be treated as radical uncertainty.

The term risk should be used in the non-technical sense as meaning negative departures from the reference narrative rather than, as has become common, as the variance of a probability distribution.

As John Kay puts it: "The overarching lesson is that decisions under uncertainty are by their nature unique. They require an understanding of the overall environment in which they are made, and cannot be entrusted to algorithms - or made by reference to models whose parameters are necessarily speculative. Judgment is indispensable." [29]

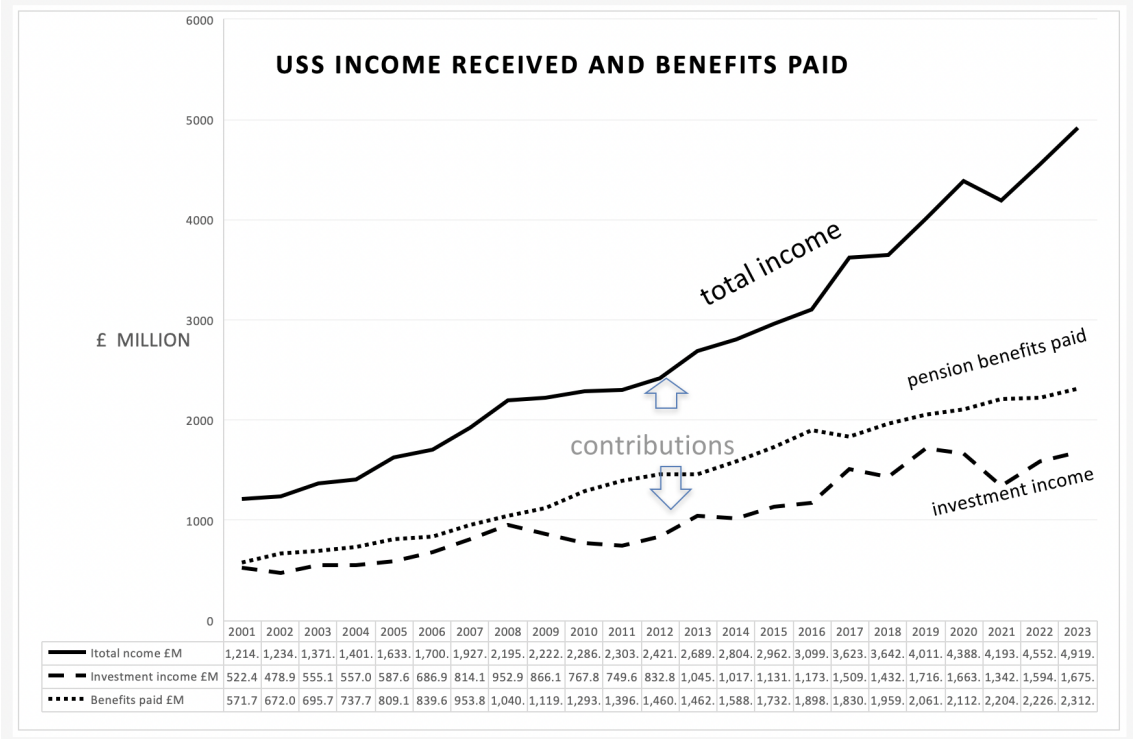
5 Conclusion

A part of a suitable reference narrative for a pension scheme like the USS would be the annual accounts, recording income and outgo and actuarial projections of them for future. That would be a much better approach than a balance sheet type of valuation because it would avoid the excess volatility and consequent dead weight of unnecessary prudence and the other problems I have described with the algorithms based in financial economics.

Figure 2 shows the USS cash flows in the past 24 years. The scheme has been in surplus - in the normal meaning of the word as an excess of income over outgo - every year. Actuarial projections suggest that this pattern is likely to persist in the absence of major changes to the scheme.

To apply this approach requires trustees to make decisions that are 'resilient to an unknowable future'. The investment portfolio should be responsive to unforecastable events such as inflation. Funding monitoring could be based on projections of future cash flows using actuarial judgment, based on evidence. Trustees would need to carefully monitor trends in membership. There would be less need to emphasise short term risk as measured by financial returns in the stock market. A low risk investment strategy could be achieved

[29] John Kay,"Manage risk, embrace uncertainty", keynote for the Event: 'Risk and uncertainty in the pensions world: correcting the biggest avoidable UK public policy failure of recent decades', CISI, 25 October 2023



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Itotal ncome £M	1,214.	1,234.	1,371.	1,401.	1,633.	1,700.	1,927.	2,195.	2,222.	2,286.	2,303.	2,421.	2,689.	2,804.	2,962.	3,099.	3,623.	3,642.	4,011.	4,388.	4,193.	4,552.	4,919.
Investment income £M	522.4	478.9	555.1	557.0	587.6	686.9	814.1	952.9	866.1	767.8	749.6	832.8	1,045.	1,017.	1,131.	1,173.	1,509.	1,432.	1,716.	1,663.	1,342.	1,594.	1,675.
Benefits paid £M	571.7	672.0	695.7	737.7	809.1	839.6	953.8	1,040.	1,119.	1,293.	1,396.	1,460.	1,462.	1,588.	1,732.	1,898.	1,830.	1,959.	2,061.	2,112.	2,204.	2,226.	2,312.

Figure 2: USS Income received and Benefits paid 2001-2023 (Data source: USS Annual Reports and Accounts 2001-23, Fund Accounts and Notes to the Financial Statements: see Note 9, for years until 2015, Note 10 thereafter.)

investing in real assets with suitable diversification. The reference narrative would be that the scheme remains open to provide affordable pensions to future generations of members and to the strategically important higher education sector.

The fundamental issue with a pension scheme is that ultimately it is funding that matters and that valuation comes into the picture only to the extent it contributes to that end, which differs between open or immature and closed or mature schemes.

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