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Authors
Dr Jamie Ballin
Director, Buy Side Solutions

Simon Robinson FIA
Director, Buy Side Solutions

Contact Us
Americas
+1.212.553.1658
clientservices@moodys.com

Europe
+44.20.7772.5454
clientservices.emea@moodys.com

Asia (Excluding Japan)
+85 2 2916 1121
clientservices.asia@moodys.com

Japan
+81 3 5408 4100
clientservices.japan@moodys.com

The impact of credit risk for pension plans engaging with CDI, including considerations for climate change and climate policy

ABSTRACT
Cashflow-driven investing (CDI) has gained traction as pension plans have successfully de-risked and strengthened their balance sheets over the last decade. Plans are now able to strategically design allocations to fixed income debt so that income matches liabilities at high levels of precision, thus providing a more natural hedge and reducing the need for complex swap portfolios. Sometimes these cashflows are assumed to be contractually certain, or globally haircut according to a macro view. In this paper we use the Moody's Analytics CreditEdge structural model of individual issuer credit default risk to adjust individual contractual cashflows due from fixed income assets, and thus provide a more accurate view of how asset income may finance pension liabilities. We also consider scenarios where expected default frequencies (EDFs) vary under various key climate change assumptions and show that the potential credit losses can be substantially larger than in the baseline case. We develop a present value of the losses and a fair value credit spread measure to facilitate comparison with mark-to-market pricing.

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Background & Context

Cashflow driven investing

Cashflow driven investing is conceptually a simple approach to investing increasingly possible because of funding level improvements and cessation of benefit accrual. If an asset owner (typically a pension plan) has a clear view of the payments they are expecting to make to beneficiaries over the long term (50 years), cashflow driven investing seeks to construct an asset portfolio that is expected to generate the same cashflows, so that the asset owner can then use those proceeds to make the payments to beneficiaries.

As an investment approach, it shifts the focus of an investor's risk management approach and the associated risk metrics used. Whilst a typical investment risk approach considers market risk and the variablility of metrics such as funding level for a pension plan, a cashflow driven investing approach moves investors towards considering whether or not they will receive the cashflows they are expecting from their portfolio and when these cashflows will be received.

Whilst there are a number of cashflow timing risks that need to be managed, this paper focuses on the impact of credit risk on this investment strategy and the impact on level and timing of cashflows. A simple approach often used in this area is to use the security or issuer credit ratings and apply a haircut to contractual cashflows (as per the prospectus or term sheet).

In this paper we use a combination of **PFaroe DB** and Moody's **CreditEdge** EDF capabilities to create sophisticated default adjusted asset cashflow profiles and define some alternative metrics. We then explore these capabilities in the context of climate change scenarios, and the consequences for asset/liability matching.

Climate risk

Climate scenarios are based on work by the Network for Greening the Financial System (NGFS) [1], but also enhanced with data from Moody's ESG Solutions [2]. The methodology for integrating these scenarios into CreditEdge's EDF model is described in [3]. Risk is assessed according to its source:

» **Physical risk**: forecasts both direct and indirect effects of weather and climate events on businesses' infrastructure, operations, and markets. Physical effects may be acute (e.g. hurricanes, floods) or chronic (e.g. sea level rise, water stress). An analysis is made of the firm's physical assets and operations.

» **Transition risk**: forecasts the risks and potential rewards associated with the transition to a lower carbon economy. A firm's financial health may be affected by carbon taxation, technology, socioeconomic trends. An Integrated Assessment Model (IAM) is used to understand how future scenarios affect a firm, and this is further enhanced with an equilibrium firm-level competition model to understand the effect on a firm's financial health.

» **Combined risk**: combines the effects of physical and transition risks.

Furthermore there are a number of key scenarios referred to throughout the paper:

» Early policy: assumes climate policies are introduced early and gradually become more stringent. Net zero CO2 emissions are achieved before 2070, giving a 67% chance of limiting global warming to below 2 degrees centigrade. Physical and transition risks are both relatively low.

» **Late policy:** assumes climate policies are not introduced until 2030. Since actions are taken relatively late and limited by available technologies, emission reductions need to be sharper than in the early policy scenario to limit warming to the same targe. The result is higher transition risk.

» **No policy:** Assumes that only currently implemented policies are preserved. Nationally Determined Contributions are not met. Emissions grow into 2080 leading to warming of 3 degrees or more and severe physical risks. This includes irreversible changes like higher sea level rise.

» **No policy (tail):** Based on the no policy scenario, the tail corresponds to a 95-percentile damage level. This scenario reflects tail physical risk.

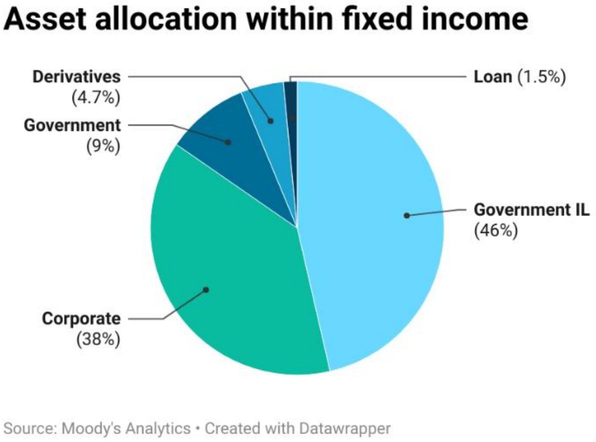
What this paper will show

This paper will now demonstrate how cashflow modelling and credit default risk can be combined to give new insights into the credit risk implicit in a pension plan's asset allocation and what the consequences are for cashflow matching. We will describe the methodology we have developed to adjust the forecast contractual cashflows for a plan's fixed income portfolio and give specific examples of the result for our example pension plan. We develop some new interpretative risk metrics. We will then examine the risk implications under the climate scenarios described above. The appendix separately describes some of the capabilities that Moody's offers that have been drawn upon to create this analysis.

Our example pension plan for study

The pension plan studied in this study is representative of a medium-sized UK corporate. The plan is approximately 100% funded on a Technical Provisions basis. The duration of the liabilities is approximately 20 years. Overall assets under management (AuM) are £3bn and 90% of assets are allocated to fixed income (the remainder to equity, property and some alternative assets). The asset allocation within fixed income is shown Figure 1. The allocation to corporate debt is approximately 35% of total AuM. The bulk of the remainder goes to government nominal and inflation-linked debt.

Figure 1: The fixed income allocation (90% of total assets) is led by inflation-linked government debt, followed by corporate debt.



Moody's CreditEdge covers publicly traded corporate debt and calculates EDFs subject to the following criteria [4]:

» The bond's duration is less than 30 years;

» The bond has no put or call features, or pay-in-kind clauses;

» The issuer is active and covered by Moody's;

» The bond's spread is valid in the last 13 weeks.

Two classes are not covered by CreditEdge in the analysis presented by this paper:

1. Sovereign bonds: a different approach is required not least because the process of recovery is different.
2. MBS, ABS, Municipals: these securities are not covered.

Both classes typically account for material allocations for pension plans. While sovereign debt is not covered in this paper, we approximate the credit losses arising from corporates issuing MBS, ABS, and municipals by multiplying the estimated credit losses by a multiplicative factor. We justify this on the grounds that the plan is well diversified among all corporates (also countries, ratings) and that at a high level the risks affecting ABS, MBS, and municipals are similar to conventional corporate debt. For our plan under study, the factor is 2 (i.e. the allocation to MBS, ABS, and municipals is about as large as that to standard corporate debt at 21%).

Application of the EDF model

Methodology

Our starting point is the contractual cashflow profile for each security held by the plan as defined by the terms and conditions and appropriate assumptions for non vanilla fixed income bonds (allowance for puts/calls, indexation etc).

For each year into the future from the analysis date, the probability that the issuer defaults is then considered (sourced from the CreditEdge model. Any cashflow due in that year is effectively reduced ('haircut') by a proportion equal to the cumulative probability of default, with linear interpolation used to account for the precise timing of the cashflow in the year. If there is a default in that year, the owner of the bond can expect to recover some fraction of the bond's principal value. Each sector has its own recovery rate, R. However, we also recognise that there will inevitably be a delay λ between the point of default and the beneficiary receiving recovered funds, and we specify this in the model as an adjustable parameter. In this paper we assume λ = 2 years. These time-delayed defaulting cashflows are not only multiplied by the recovery rate R but also by the probability of default in that time period.

Let us consider a hypothetical bond, using the EDF for a typical corporate, and shown in Figure 2. The cashflow profile of a hypothetical 10 year bond with 5% coupons is shown in Figure 2 and the numerical values for the exercise are shown in **Error! Reference source not found.** contained in the Appendix. A recovery rate of R = 40% has been assumed which is close to the recovery rate of the corporate's sector.

To first order, one would expect the effect of defaults to indeed haircut the cashflow profile. The non-obvious effect though is the contribution of potential defaults (and subsequent recovery) relatively early in a bond's life. For long-dated, low-coupon bonds with issuers with high short-term probabilities of default, and high sector recovery rates, the distortion of the cashflow profile is at its most extreme. Note that cash may be received earlier than originally expected due to recovery, and that defaults in years 1 and 2 won't be recovered until years 3 and 4 respectively, under the assumption of λ = 2 years. Defaults in years and 9 and 10 extend the potential for cashflows to be received beyond the original term of the bond.

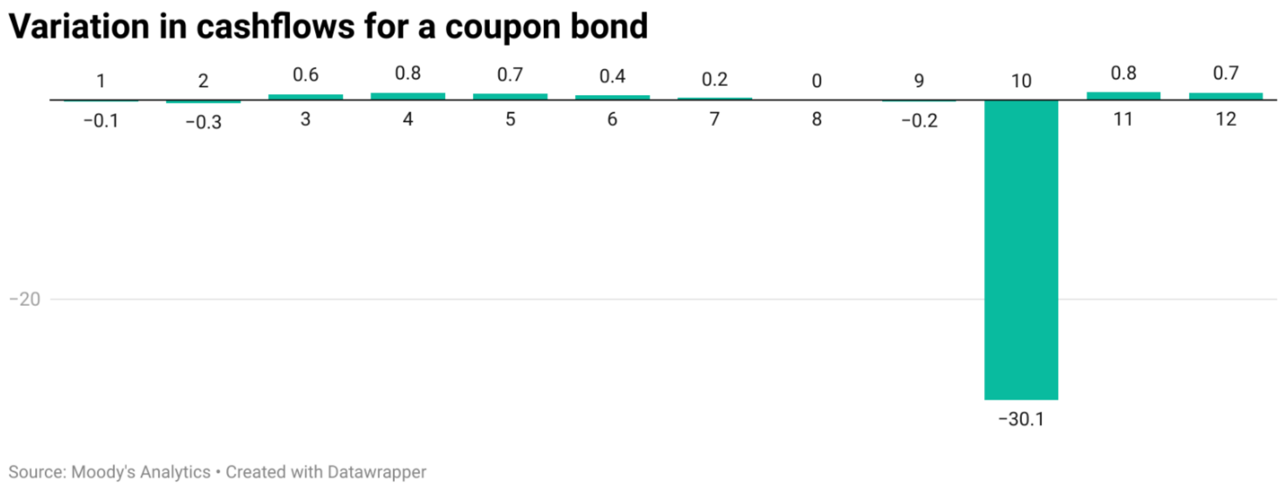


Figure 2: Variation in cashflows for a 5% coupon bond with a 10 year maturity. The EDFs used correspond to a typical corporate.

Expected loss and implied default spread

We define the **expected loss** measure as the difference in total future contracted cashflow less total default-adjusted flows. This is a well-defined measure at an individual bond level and at the portfolio level.

We typically calculate the z-spread over a risk-free curve based for each of the individual securities in the portfolio. A z-spread can also be calculated at a **portfolio** level as that spread which, when added to the chosen risk-free curve (UK Government in this case), discounts the aggregate cashflows such that the value of the cashflows matches the market value of the portfolio. By comparing the value of the credit portfolio discounted at risk-free rates with the market price, we therefore imply a present value of the market's expected losses on the portfolio (ignoring factors such as liquidity and compensation for risk).

We can invert this relationship and consider the projected losses and discount these at the risk-free rate, and derive an **implied default spread**. Intuitively this represents expected losses as an annual spread.

Let the nominal cashflows in each year i be n_i, and the risk-free spot rate be r_i. The spread z (portfolio z spread) adds to the risk-free rate such that the nominal cashflows discount to the market value Q:

$$Q = \sum_i n_i (1 + r_i + z)^{-i}$$

The spread can be determined numerically. We can compare this to the value of the cashflows where $z = 0$ (i.e. no credit spread) and define the present value of the expectation of loss as the difference:

$$M = \sum_i n_i (1 + r_i)^{-i} - \sum_i n_i (1 + r_i + z)^{-i}$$

By setting Q equal to the observed market value of the flows, we can derive the market's view of the spread z. We can easily calculate M as estimated by the market. Consider the adjustment of the cashflows already described, and let the loss (or gain) l_i be the difference between the nominal cashflow n_i and adjusted cashflow in each year. As these losses are already risky, we discount them at the risk-free rate r_i to derive an alternative view of the present value of the losses, labelled M':

$$M' = \sum_i l_i (1 + r_i)^{-i}$$

We can imply an alternative view of the credit spread, z' by setting $M' = M$ and rearranging:

$$\sum_i (n_i - l_i)(1 + r_i)^{-i} = \sum_i n_i (1 + r_i + z')^{-i}$$

The left-hand side is the present value of the default-adjusted cashflows using the risk-free rate. The right-hand side is the value Q' of nominal cashflows discounted at the risky rate $r_i + z'$. Expanding the terms to second order in r_i with the binomial theorem and rearranging for z' we get the following approximation:

$$z' \approx \frac{\sum_i l_i (1 - i r_i + \frac{1}{2} i (1 + i) r_i^2)}{\sum_i i n_i (1 - (1 + i) r_i)}.$$

The expansion is higher than first order because the cashflows are very long-dated (up to 100 years) and second-order terms are not immaterial to accuracy. Alternatively, the equivalent spread z' can be determined numerically from Q' and we expect that to be the approach followed.

For the portfolio under study, the market z-spread is 101 bps and we will compare the results of adjusting the cashflows with EDFs with this metric.

Analysis of example plan

The asset and liability cashflow match for our example plan is shown in Figure 3. While the contractual cashflows are a good match to the liabilities, especially in the bulk between 2030 and 2050, the impact of incorporating the probability of default is clearly evident as a marked reduction in cashflows and deterioration in matching quality. While the market z-spread is 101 bps, the implied default spread, z', from the baseline scenario is 43 bps, implying that the reward to investors for investment risk, liquidity provision etc is just under 60 bps pa. The total accumulated expected loss is £126m by 2070.

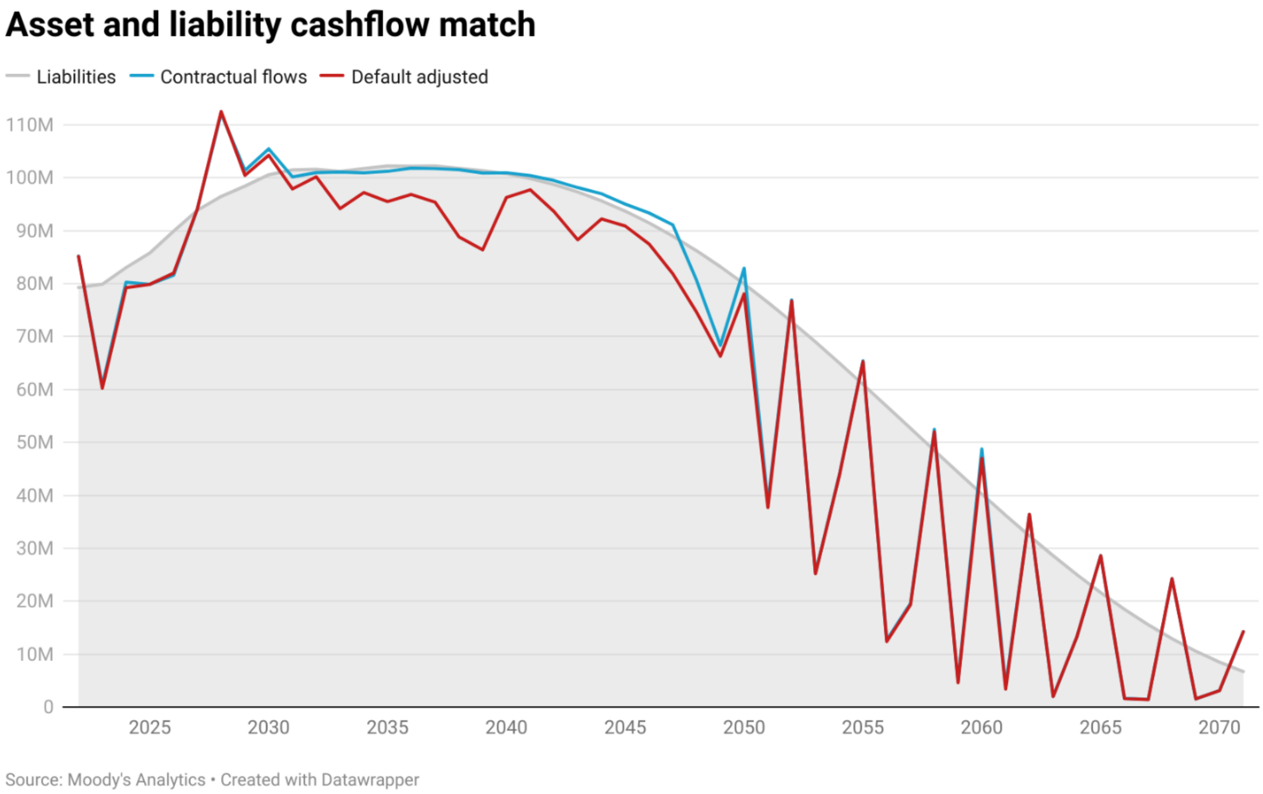


Figure 3: Assets and liabilities for the plan under study. The contractual cashflows are a close match to the bulk of the mid-term liabilities but we can readily see that adjusting the cashflows for credit default risk implies a less than optimal match. The spikes in the cashflows at longer dates reflect allocations to individual government gilts (with a corresponding paucity of long-dated corporate debt). Data reflects the baseline scenario.

Consideration of climate risk

The climate scenarios are quite different from typical credit scenarios. First, they are based on a forward-looking view of how climate change and policy affects default risk, but these forward-looking views cannot be calibrated by or conditioned on historical experience. Second, the EDFs are highly idiosyncratic. Different issuers within the same sectors may have very different climate scenario profiles. It is important therefore to consider the EDFs are the issuer level, especially in climate, and that is what we have done in this paper.

Figure 4 shows the losses arising from credit defaults and Figure 5 shows the accumulation of those same losses. While the impact of early and late policy transitions increase the potential for losses over the baseline condition, the effects are severe in case of a no policy scenario (reaching up to 3.8x the baseline on the tail scenario). Recall that the no policy scenario is dominated by the physical risks that arise if emissions and warming continue unabated. This quantifies in monetary terms the effect that global warming may have if it is not managed.

We do note however that the analysis presented in this paper assumes that a buy and hold strategy applies to the investments, whereas the investment policy would no doubt evolve. We have also not accounted for the likely related changes in key interest rates and inflation rates which may occur under each of the climate scenarios which would have other important effects for the overall asset and liability match and management of risk.

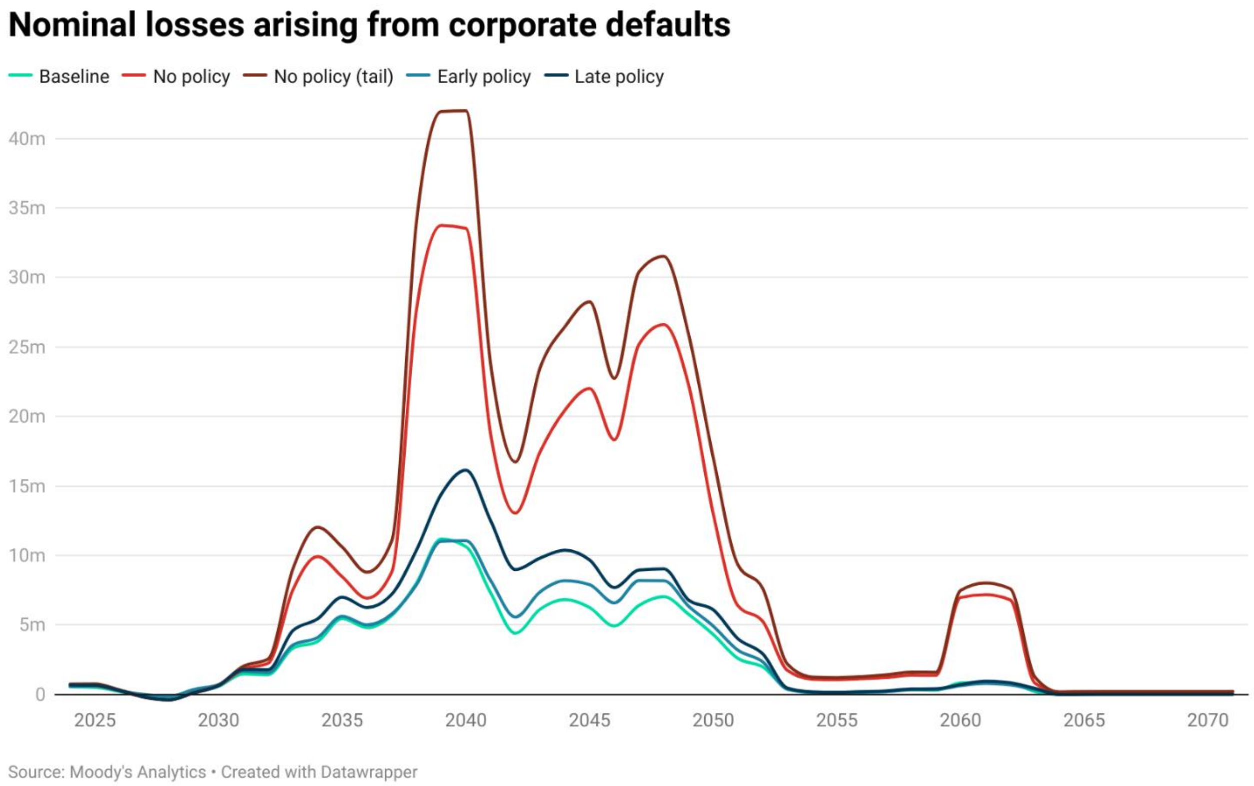


Figure 4: Losses arising from credit defaults under each of the climate scenarios.

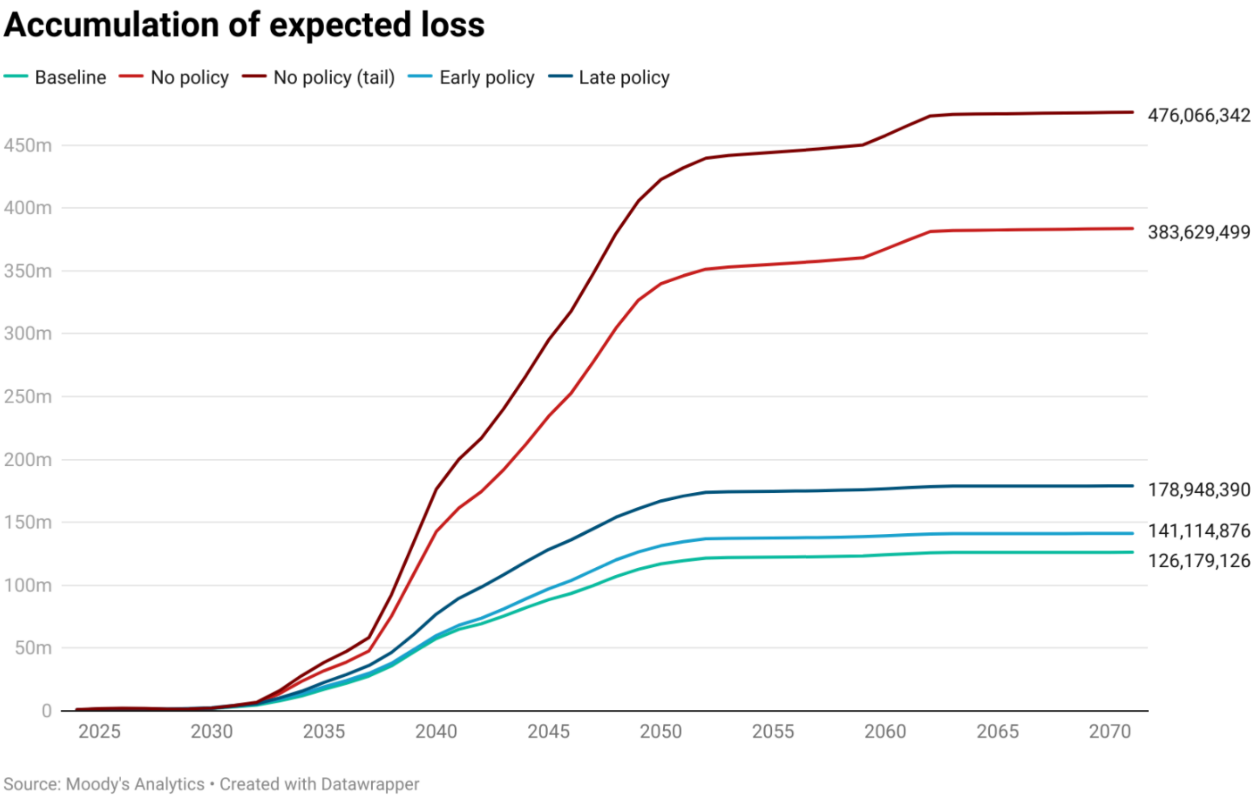


Figure 5: Accumulated of expected losses from credit defaults under each of the climate scenarios.

The accumulated mismatch between assets and liabilities is shown in Figure 6. Armed with this information, the plan can take steps to understand the sources of credit losses in the portfolio and adjust the perspective used for CDI exercises. Assuming action is taken to mitigate the worst effects of climate change (early or late policy scenarios) the deterioration in mismatch is not too great, but under the no policy scenario, the mismatch deteriorates rapidly from 2035 as climate change drives credit losses arising from material physical risks.

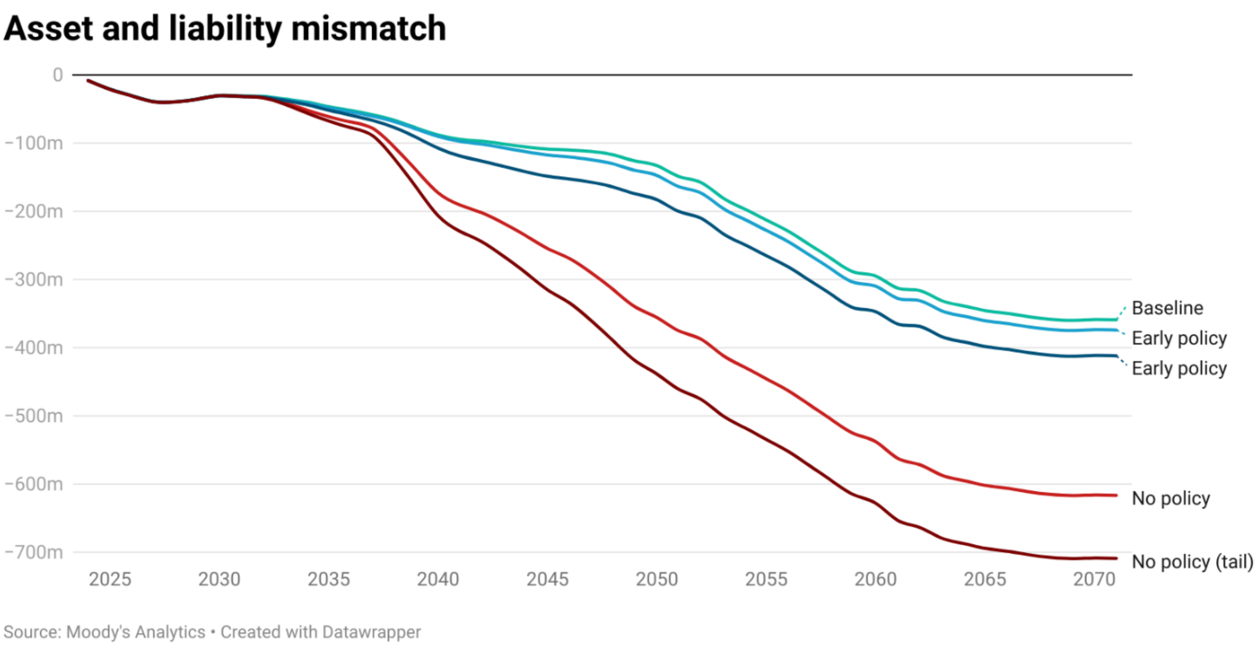


Figure 6: Accumulation of the mismatch between asset cashflows and liabilities for each of the scenarios.

Market credit spread compared to implied default spreads

Finally we present a comparison of the implied default spreads implied by each of the scenarios in Figure 7. We must remember that the portfolio z-spread under 'Market' includes all factors incorporated in bond pricing, whereas the implied credit spreads only account for the expected default risk alone.

The relative size of the spreads under each of the scenarios is certainly unambiguous: a no policy scenario implies a material increase in default risk for many corporates above what is currently assumed. For this portfolio, no policy outcomes imply default losses well in excess of the portfolio spread.

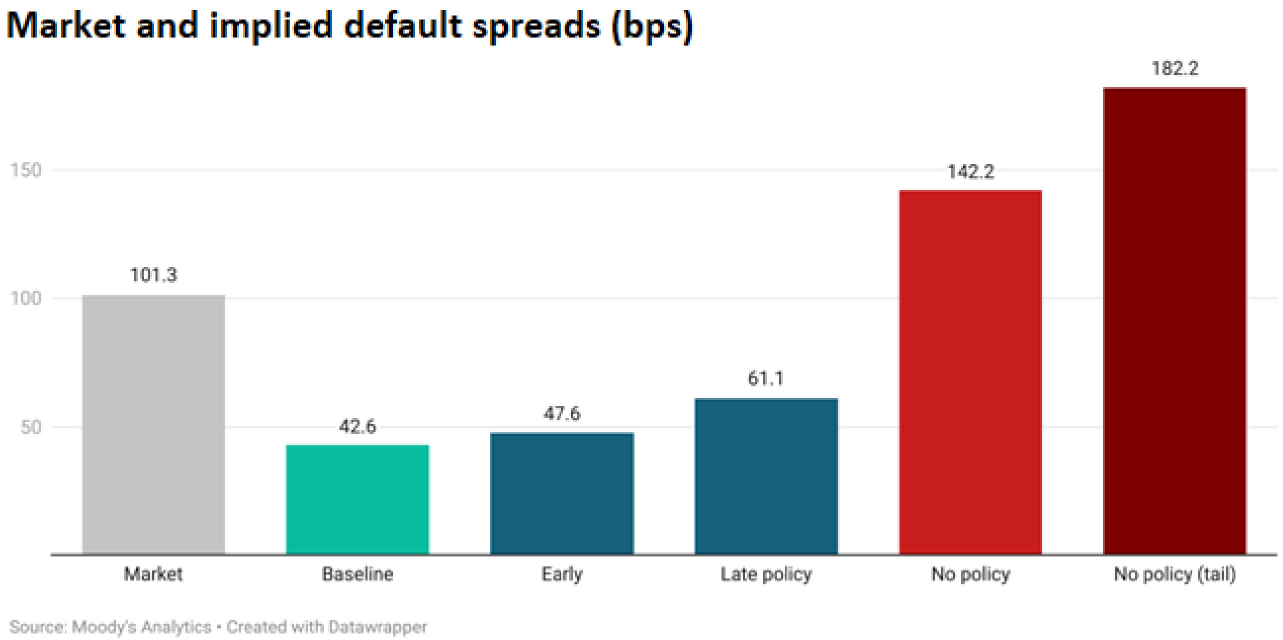


Figure 7: Implied market credit spread (methodology described in the text) compared to the implied default spread under each scenario.

Conclusion

Given the increasing importance of using cashflows from bonds to hedge and finance defined benefit liabilities, it is vital to understand the possible sources of realized mismatch between the liabilities and asset cashflows. This paper has shown how expected default frequencies (EDF) can be interpreted as adjustments to contractual cashflows due from corporate debt issuers. The term structure of the EDF, combined with a simple model of recovery, causes the magnitude and timing of a bond's cashflows to change. We interpreted the change in cashflow as an expected loss and derived an implied credit spread to facilitate comparison with the z-spread derived from mark-to-market pricing.

We also considered the impact that climate change may have on EDF term structures and saw that in the unmitigated "no policy" scenario, the likelihood of default for certain issuers increases substantially. Based on the prevailing allocation to those issuers, the effect on cashflow driven investment policy is material and may indeed present surprises.

Using these data and the capabilities that Moody's Analytics, Credit Edge, and Buy Side Solutions have, we anticipate offering a new generation of tools to manage assets for defined benefit pension plans. We ultimately seek to convert speculation and views around climate change into models that can be applied to real-world portfolios and help those responsible for managing those portfolios to interpret the results in familiar terms such as the present value of losses and implied credit spread.

Appendix

PFaroe DB

Moody's and PFaroe DB [6] have focused on building detailed asset and liability cashflow profiles since inception over ten years ago. Assets and liabilities can be modelled at varying levels of detail in accordance with the data available, and hybrid approaches are possible where parts of a portfolio are modelled in full detail while others use a proxy or representative approach. The pension liabilities can be modelled at the individual member level or using 2 dimensional cashflow tables, again in accordance with data availability and the ultimate needs of the client and their use case.

PFaroe DB is capable of projecting contractual cashflows for a wide variety of fixed income assets, based on modelling the security in accordance with the relevant terms and conditions. Analytics for individual assets can be computed, one typical example a credit z-spread relative to the appropriate risk free rate. Multiple factors contribute to the z-spread:

» The risk of the issuer defaulting on the contractual cashflow

» The compensation the holder of the contractual flow would likely receive if a default were to occur

» Liquidity

» Other factors such as the term structure of cashflows, desirability of the issuer, or the complexity of the particular instrument relative to others available causing pricing inefficiencies and discrepancies

» General market risk appetite for the class of debt, rating, and sector

CreditEdge

Moody's CreditEdge [7] provides daily analysis of probability of default for over 38,000 publicly traded firms. It also provides specific analysis for credit default swaps (CDS) spreads and over 260,000 individual bonds. At the core of the service is the Moody's EDF model. This structural model considers a firm's balance sheet in terms of outstanding liabilities (short term and long term), market capitalization, the volatility of assets and evaluates the likelihood that the value of assets will diffuse downwards and render the firm insolvent. Consideration is given to the incentive for a particular firm to prefer to default rather than honour obligations. The model is calibrated using over 45 years of default data [7]. Financial firms are specifically calibrated.

CreditEdge also provides comparisons for an issuer against peers in its industry sector. The loss given default (LGD) can be determined for a particular firm or for a sector. It is possible for users to stress the balance sheet assumptions in real-time to test and understand the EDF calculation.

The Authors

Jamie Ballin joined Buy Side Solutions (previously RiskFirst) in 2010 as a quantitative analyst. He has designed many of the key risk systems used in BSS's products including risk and fixed income attribution. He has a PhD in High Energy Physics from Imperial College London.

Simon Robinson also joined Buy Side Solutions in 2010. He oversees the strategic direction of BSS' growing range of products for companies in the institutional asset space. Lately he has led the design of products addressing the needs of TCFD reporting. He is a qualified actuary and worked at Towers Watson as an investment consultant prior to joining BSS.

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