MOODY'S ANALYTICS

CALIBRATION METHODS

Illiquidity and Credit Premia for IFRS 17 at End December 2018

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Executive Summary

This note sets out our calibrations of corporate credit yield curves for selected economies at End December 2018 alongside our estimates of the split between credit risk premia and illiquidity premia for the same data. Market yields of corporate bonds are adjusted by removing both an expected credit loss and a unexpected credit loss using a Merton-style structural model based on Moody's Analytics Expected Default Frequency (EDF™) model combined with a cost-of-capital approach to set credit risk premia.

Yield curves are fitted to market yields with and without credit adjustment using a cubic-spline Nelson-Siegel method. The residual difference between the credit risk adjusted corporate bond yields and the equivalent currency government bond yields defines an implicit relative illiquidity premium for those assets.

These illiquidity premia and credit risk premia, split per rating and by financial and non-financial status could form the basis for a firm to define an appropriate entity-specific liability discount curve for the purposes of International Financial Reporting Standard (IFRS) 17 reporting.

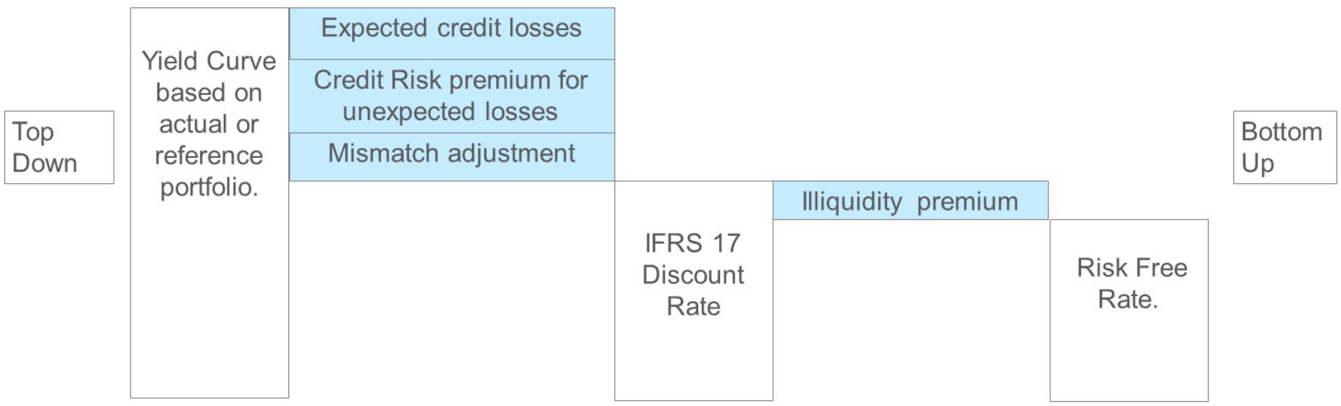
Introduction

IFRS 17 allows for two different approaches to yield curve construction and discounting, a "top-down" approach and a "bottom-up" one, as shown schematically in Figure 1. The top down approach requires an insurer to build a curve based on their actual asset portfolio or a reference portfolio and then adjust the yield on this portfolio by deducting an allowance for credit risk. The insurer also needs to adjust the yield to account for any mismatch between asset and liability cash flows. Credit risk within this approach can further be decomposed into a compensation for expected losses (real world default risk) and a specific credit risk premium, which reflects the uncertainty around expected losses.

The bottom up approach requires an insurer to choose financial instruments to reflect the (liquid) risk free rate and then to fit a curve to those data and then determine an appropriate liability specific illiquidity premium to be applied above the risk free curve.

Whilst in principle both approaches should give the same results, section B84 of the IFRS 17 standard acknowledges that the top down and bottom up calculations may give different answers in practice and do not need to exactly reconcile.

Figure 1 Top-Down and Bottom-Up Approaches to IFRS 17 Discount Curve Construction



There are related, but distinct, challenges to both top-down and bottom-up approaches. Top-down the primary questions relate to estimating the credit risk premium and the selection of an appropriate reference portfolio. Bottom-up the standard states that the illiquidity premium applied must reflect the liquidity characteristics of the insurance product being valued, determining the appropriate liquidity characteristics and mapping these to asset data where the illiquidity premium can be estimated is a key task for this approach. The liquid risk-free rate also needs to be defined for a bottom-up approach, we discuss this point in more detail on page 6.

Methodology overview

Within this report we follow the top-down structural method defined in our previous white paper Thompson and Jessop (2018) to calculate the credit risk premium and to decompose market spreads into three components: 1) expected losses from defaults 2) Unexpected losses (credit risk premium) and 3) illiquidity premium. The derived illiquidity premia are then presented in a form where they could be applied bottom-up.

Our method uses a Merton-style structural model of credit risk to calculate fair value spreads based on a combination of real world probabilities of default, estimated at an individual firm level, sectoral estimates of loss given default and a weighted cost-of-capital adjustment for credit risk premium. This method leverages Moody's Analytics CreditEdge™ expected default frequency (EDF™) model of real world probability of default. CreditEdge EDFs are an industry recognized standard for point-in-time probability of default, please refer to Nazeran and Dwyer (2015) for more detail of the EDF model.

The forward looking nature of the EDF estimates is well aligned to recent developments in the IFRS standards, in particular the IFRS 9 impairment methodologies which were introduced as a response to 'too little too late' during the financial crisis (Zhang, 2018). EDFs are procyclical estimates of credit risk, and will also drive a proportionately procyclical estimate of the credit risk premia using our method. This means that all three components of spread changes (expected losses, credit risk premium and illiquidity premia) are all expected to be positively correlated with market spread changes when using the method outlined. Understanding and being able to provide robust justification for this aspect of the IFRS 17 yield curve calibrations is likely to be a critical component of a successful and acceptable implementation of the standards.

Methodology Considerations

Credit risk adjustment

In brief, the structural model of credit risk employed in our method calculates a firm's credit risk by treating the traded equity of the firm as a call option on the firm's assets, with a strike price given by the default point, where the firm's assets cannot cover its liabilities. By modelling the value of the firm's assets with a stochastic process, a geometric Brownian motion, the real-world probability of default can be calculated at a given horizon, dependent on the leverage or the firm, the expected return on the firm's assets and the asset volatility. The final real world probability of default is calculated using an empirical mapping based on a database of historical defaults.

Mathematically, the compensation for expected credit losses is given by combining the real world probability of default with the recovery rate, or loss given default:

$$Expected\ Credit\ Loss\ Spread_i = -\frac{1}{T_i}\ln(1 - CPD_i \cdot LGD_i),$$

where CPD_i is the duration matched cumulative probability of default for a given bond i and LGD_i is the loss given default for that issuer's industrial sector, a parameter also derived from CreditEdge.

The unexpected loss is then calculated by adjusting the real world probability of default to account for a credit risk premium. This credit risk premium is calculated based on a cost-of-capital approach, assuming that the expected return on a firm's assets is related to the leverage weighted cost of capital for that firm. We say the cost of capital is given by

$$Cost\ of\ Capital = Leverage \cdot Cost\ of\ Debt + (1 - Leverage) \cdot Cost\ of\ Equity,$$

where the cost of debt is derived from the corporate bond spread and the cost of equity is the equity risk premium.

The cost of capital is estimated at a portfolio level, where we can more easily determine an average equity risk premium, and then scaled using a portfolio beta to get the credit risk premium for a given issuer. The portfolio betas are estimated using the market implied returns for the overall portfolio and each individual issuer.

$$\frac{Credit\ Risk\ Premium_i}{Issuer\ Market\ Implied\ Return_i} = \frac{Portfolio\ Weighted\ Cost\ of\ Capital\ \cdot}{Portfolio\ Market\ Implied\ Return}$$

The total credit adjustment is then the sum of the expected credit loss spread and the unexpected credit loss due to the credit risk premium.

By defining the observed market spread as the sum of expected loss, unexpected loss and illiquidity premium, the implied illiquidity premium can then be backed out as the residual of the market spread minus the total credit adjustment

$$Illiquidity\ Premium_i = Market\ Spread_i - Total\ Credit\ Adjustment_i.$$

RATING AND SECTOR BREAKDOWN

Within each economy we break down the estimate of the credit risk premium and the implied illiquidity premium for each bond rating for which there is sufficient data and across ratings between financial and non-financial issuers. As the leverage and volatility characteristics of firms vary significantly between sectors our cost-of-capital adjustment should also vary between these categories. To do this we follow the method described in Thompson and Jessop (2018) to adjust the equity risk premium assuming a constant asset price of risk. The market implied returns indicate that this is a more reasonable quantity to hold constant as leverage and volatility change than the equity risk premium itself and the results quoted in this report are more intuitive when this adjustment is performed.

Reference Portfolio Construction

As a principles based approach, IFRS 17 allows firms freedom to choose reference portfolios aligned to their own business lines and products. In theory insurers could choose to set a distinct reference portfolio for each line of business or separate product type, reflecting the difference in liquidity characteristics between each liability. Alternatively insurers may wish to use a single reference portfolio and scale top-down curves or illiquidity premia derived from it as appropriate to each liability.

The composition of the reference portfolio will be crucial and there does not yet appear to be consensus in the industry on how this should be constructed, or on whether the portfolio should represent the actual assets used to back the relevant liabilities.

Some insurers (particularly the UK bulk annuity players) will be looking to derive a discount rate curve which, at least partially, reflects an illiquid asset portfolio. Much of the analysis on illiquidity premia, including within this report, relates to corporate bonds. Extending this to illiquid assets such as infrastructure debt or real estate loans increases the challenge. Moody's Analytics are looking at ways to leverage the credit expertise and data which exists within the company to assist with this task. This is likely to be a more significant issue where an insurer has chosen to use their actual assets as the reference portfolio.

The choice of reference portfolio is not only a concern for a top-down approach to discount curve construction, however, even for bottom-up insurers need to understand the liquidity characteristics of liability contacts and resolve how to transfer an illiquidity premia derived for a portfolio of assets to a set of insurance contracts. An obvious starting point for many insurers may be the old QIS5 "bucketing" approach, where for example annuities were allocated 100% of the premium, with-profits 75% and unit-linked 50%. A more sophisticated approach may be to examine the underlying liability cashflows and quantify their predictability, thereby determining how much of the illiquidity premium on the backing assets could realistically be earned by holding assets to maturity. In either case, the choice of backing assets is still key: it is no use to know that the liabilities should apply 75% of the premium on the assets without knowing to which assets this refers.

Extrapolation and Interpolation

Within the standard for IFRS 17 the method for interpolating and extrapolating market data is not specified, though the standard does require that all appropriate and relevant market data are included. That, however, cannot be our only guiding principle.

When performing our standard Scenario Generator calibrations there are a number of core principles we value in constructing appropriate yield curves:

1) Accuracy: liquid markets should be accurately priced
2) Continuity: the forward curve should be continuous.
3) Smoothness: the forward curve should be smooth, i.e. the first derivative should be continuous.
4) Neutrality where data is missing: avoid extrapolating or interpolating spurious features or views (such as oscillations, humps, or bumps).

As in the IFRS 17 standard we first need to ensure that relevant market data are accurately priced, but to that we also add considerations that the calibrated curves should be continuous, smooth and without spurious variation.

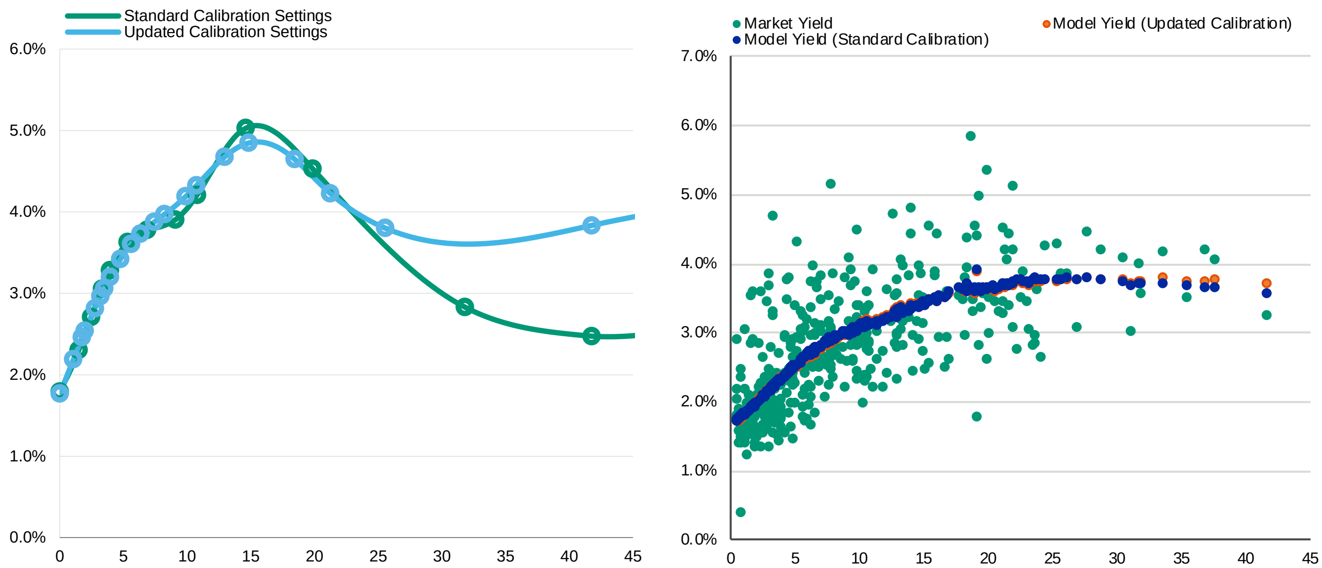
Moody's Analytics standard calibrations use a cubic spline Nelson-Siegel (CSNS) algorithm to interpolate and extrapolate market data. This method proceeds by selecting a set of knot points, optimising forward rates at these knot points to satisfy an objective function and finally matching gradients at the last knot point to extrapolate to a specified ultimate forward rate (UFR) using a Nelson-Siegel form.

In order to follow our third and fourth core principles several penalty terms are added to the objective function, which control the final gradient of the forward rate curve and the smoothness of the first and second gradients. As standard the number of knot points scales with the square root of the number of fitting data, but caps at 12.

When fitting to corporate bond data, instead of swap rates or government bonds, the calibration is more challenging: due to differences in credit risk corporate bonds display far more variation in yields to maturity then the equivalent risk free instruments.

In order to achieve smoother and more neutral fitted curves, the calibrations in this report relax the constraint on the number of knot points but also increase the second derivative smoothing penalty compared to our standard calibrations. Figure 2 shows a comparison of the two calibration parameter sets for GBP investment grade corporate bonds at end December 2018. Where market data is relatively sparser, generally at longer maturities, calibrated yield curves can be sensitive to individual points and if knot points are spaced too widely can produce unintuitive forward rate curves. Note that whilst the forward rates are noticeably different between calibrations, the model yields are very similar.

Figure 2 Alternative Calibrations for GBP Corporate Bonds at End Dec 2018
(Left) Forward Rates, Knot Points Marked with Circles. (Right) Bond Yields



The IFRS 17 standard does not prescribe the extrapolation method, nor any choice of last liquid points (LLP) or UFR. Some firms may wish to use the Smith-Wilson method. This method is not well suited to fitting to large sets of data with substantial variation, i.e. to raw corporate bonds as used in this report, however, firms could first smooth corporate bond yields with a cubic spline, and then fit the final curve and extrapolation using Smith-Wilson. Other firms may wish to simply extrapolate using constant forward rates without setting an explicit UFR target; this avoids the need to set an assumption for unconditional illiquidity premia, but may result in less stable long term curves. In this report we use Nelson-Siegel extrapolated to our standard swap UFR for all calibrations but report only the first 30 years.

Risk-Free Basis

For any IFRS 17 discount rate methodology which follows the bottom-up approach, the choice of risk-free basis is essential. Within our top-down approach to calculating credit risk premia, however, the choice of risk-free rate can also impact the final results. The total credit risk adjustment is weakly dependent on the choice of risk-free rate through a change in spread component of the cost-of-capital. By changing the underlying basis the spread level, and hence the credit risk premium, or unexpected loss adjustment, will vary.

For some economies there is a significant difference between the swap and government curves. Figure 3 shows the difference between Moody's Analytics standard SG calibration for Germany at end December 2018, alongside the official EIOPA Solvency II curve at the same date. In periods of market stress this can become even more pronounced; Figure 4 shows the one year LIBOR spread for Germany, UK and US from 1997 to 2017.

In principle, the "risk-free" curve may need adjustment itself. Either swap contracts or government bonds could in practice contain some illiquidity premia over a fully liquid risk-free rate. Both LIBOR and treasury rates could be adjusted to account for residual credit risk, for example using interbank-OIS spread data, or CDS spreads. Directly using OIS swap data might provide the most robust estimate of a truly risk-free yield curve.

Figure 3 Government and Swap Spot Rates for Germany at End Dec 2018

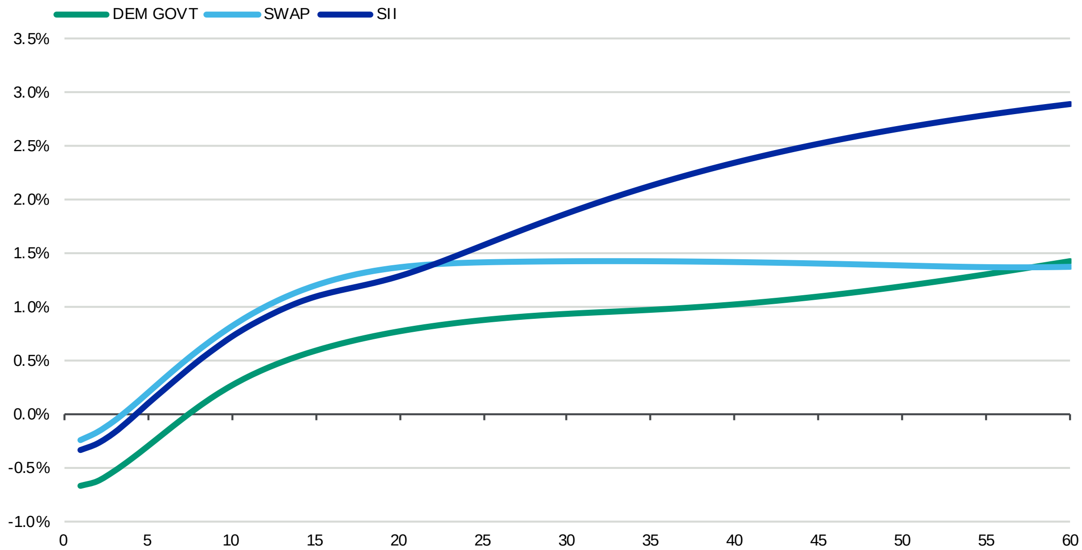
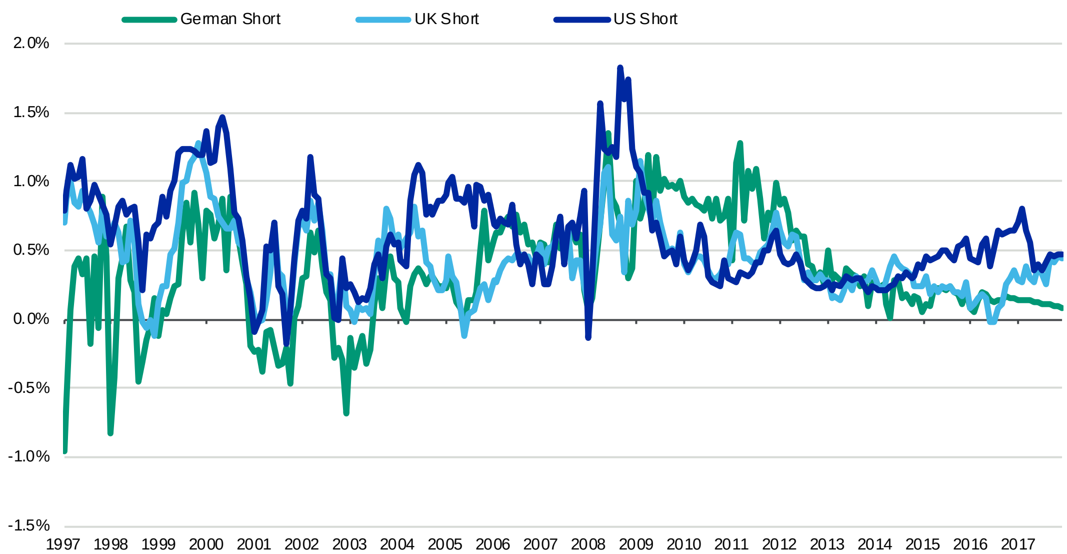


Figure 4 One Year Swap Spread For Selected Economies



Within this report we have used unadjusted government rates as the reference liquid risk-free rates against which to define the implied illiquidity premia. Whilst insurers wishing to align their IFRS 17 balance sheet with Solvency II may wish to start from swap rates, doing so would require understanding the current swap spreads and performing appropriate adjustments to understand the decomposition of that spread otherwise unintuitive results for the corporate bond decomposition could be produced.

Results

EUR

Top-down credit risk adjusted yield curves are shown in Figure 5 and Figure 6 firstly for a composite portfolio of 1585 investment grade corporate bonds and secondly split by rating. In Figure 5 the fit to the raw yields is shown alongside the fitted yield curves produced after adjusting the yield to maturity on each bond for the expected credit loss and after removing the credit risk premium. The CRP adjusted curve represents the top-down curve for that portfolio. For reference Moody's Analytics standard calibration for German government bonds is also shown. Figure 6 shows the fitted yield curve for portfolios of AA, A and BBB rated corporate bonds using both the raw market yields (solid lines) and after removing credit risk (dotted lines), the latter represent the top down curves for those portfolios. Average characteristics of the bonds, by rating, are presented in Table 1.

Implied illiquidity premia per rating class can be derived by calculating the spread of the top-down curves over the government curve: these are presented in Figure 7. Average illiquidity premia per rating and maturity bucket are presented in Table 2. Figure 8 shows a regression of the excess spread, defined as the market spread at end Dec18 minus the expected credit loss, versus the implied illiquidity premia for each bond, this regression allows us to derive an average relationship between spreads and illiquidity premia, these proxy coefficients are listed in Table 3. These numbers could be compared to Solvency II where EIOPA define the VA as 65% of the credit-adjusted spread (referred to as the fundamental spread).

Finally data are split into financial and non-financial categories. Figure 9 shows the unadjusted (solid) and credit adjusted (dotted) top-down yield curves for each category. Figure 10 displays the implied illiquidity premia for each category. Table 4 presents the average implied illiquidity premia per category and maturity bucket. Although the unadjusted market yields are similar for both financial and non-financial corporate bonds, there is a significant difference in the implied illiquidity premia.

Financial bonds have a significantly higher probability of default and expected loss than non-financial bonds (an average of 37 bp for financials to 17 bp for non-financial corporate bonds), this is consistent with the EIOPA VA and MA calculations where financial bonds generally have higher fundamental spreads. Driving this change, Figure 12 shows that financial issuers have higher leverage and lower asset volatility than non-financial issuers, these factors affect both the EDF and the credit risk premium. Table 1 also shows that financial issuers have a higher average credit rating, and the analysis per rating shows that a higher rating leads to lower illiquidity premia.

Data in all figures and tables are quoted as percentages except where stated otherwise.

Table 1 EUR Bond Characteristics

RATING	NUMBER OF BONDS	AVERAGE YIELD TO MATURITY	AVERAGE DURATION	FINANCIAL PROPORTION
All bonds	1585	1.08 %	4.80	25%
AAA	7	0.88 %	7.77	0
AA	163	0.57 %	4.45	57%
A	581	0.89 %	5.05	31%
BBB	834	1.31 %	4.67	15%

TOP-DOWN YIELD CURVES

Figure 5 Credit Risk Adjusted Yield Curves
EUR End Dec 2018 – All Investment Grade Bonds

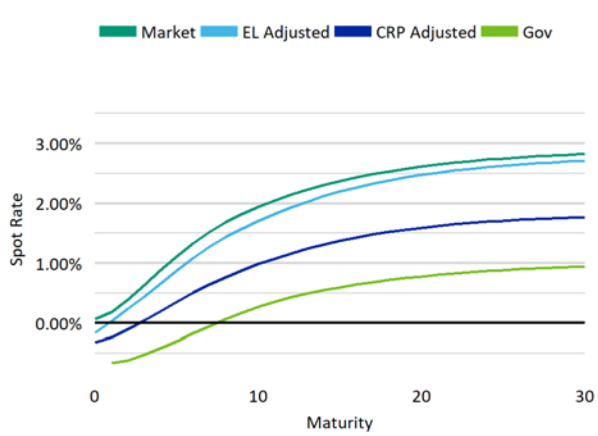
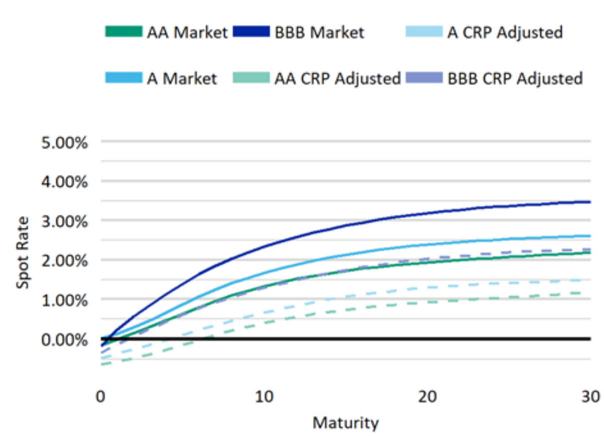


Figure 6 Credit Risk Adjusted Yield Curves
EUR End Dec 2018



ILLIQUIDITY PREMIA

Figure 7 Implied Illiquidity Premia
EUR End Dec 2018

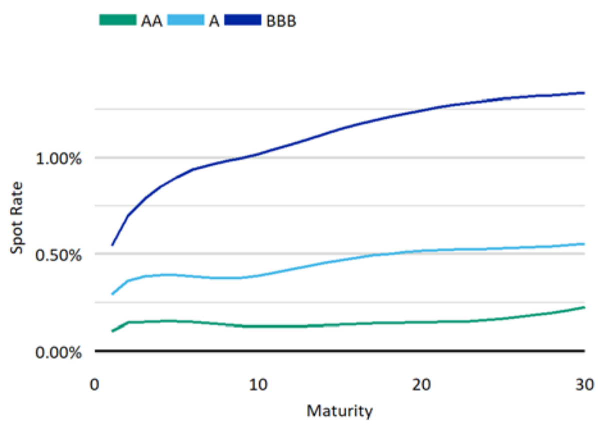


Figure 8 Illiquidity Premia vs Excess Spread
EUR End Dec 2018

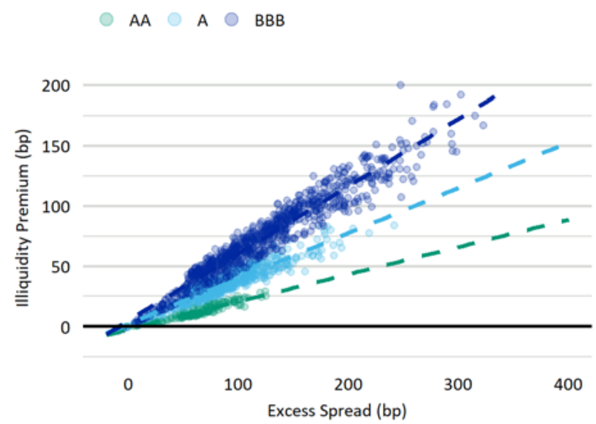


Table 2 Illiquidity Premia in Basis Points per Annum

MATURITY -> /RATING	1-3	3-5	5-10	10+
AAA	3	15	42	53
AA	10	10	15	19
A	26	31	40	52
BBB	55	66	93	117
All Bonds	41	46	67	81

Table 3 Illiquidity Premia Proxy Coefficients[1]

MATURITY -> /RATING	AVERAGE EXPECTED LOSS SPREAD (BP)	IP PROPORTION
AAA	4.3	0.56
AA	24.1	0.20
A	22.1	0.38
BBB	22.4	0.60
All Bonds	22.4	0.51

[1] Coefficients should be interpreted as the intercept and slope, e.g. for EUR all bonds: $IP = 0.51 * (\,Spread - 22.4\ bp)$

SECTORAL ANALYSIS

Figure 9 Financial and Non-Financial Yield Curves
EUR End Dec 2018

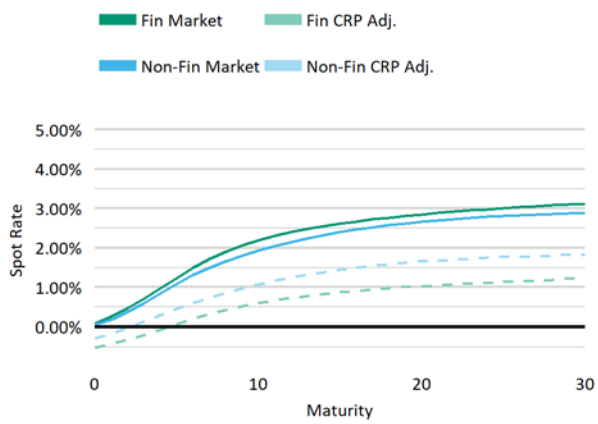


Figure 10 Financial and Non-Financial Implied Illiquidity Premia
EUR End Dec 2018

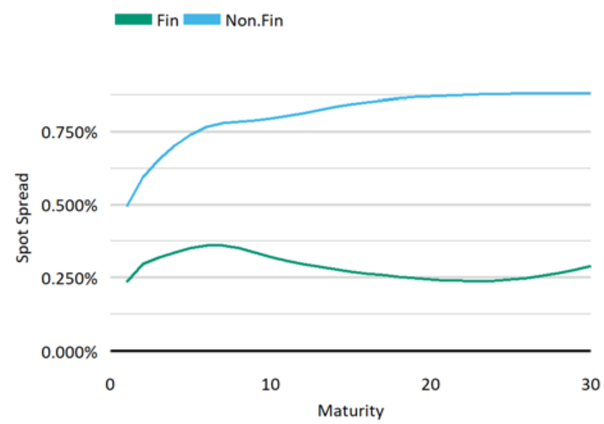


Figure 11 Financial and Non-Financial Illiquidity Premia vs Excess Spread
EUR End Dec 2018

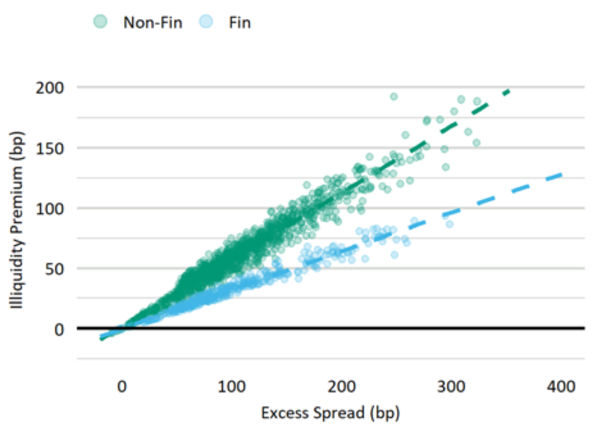


Figure 12 Financial and Non-Financial Leverage
EUR End Dec 2018

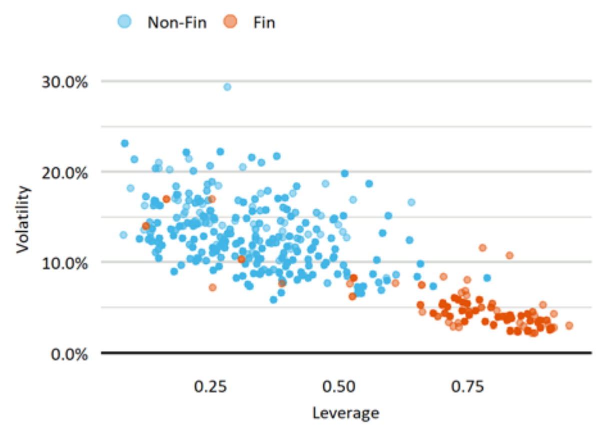


Table 4 Financial and Non-Financial Illiquidity Premia in Basis Points per Annum

MATURITY -> /SECTOR	1-3	3-5	5-10	10+
Non-Financial	44	51	74	87
Financial	27	31	40	42
All Bonds	41	46	67	81

GBP

Top-down credit risk adjusted yield curves are shown in Figure 13 and Figure 14, firstly for a composite portfolio of 413 investment grade corporate bonds and secondly split by rating. In Figure 13 the fit to the raw yields is shown alongside the fitted yield curves produced after adjusting the yield to maturity on each bond for the expected credit loss and after removing the credit risk premium. The CRP adjusted curve represents the top-down curve for that portfolio. For reference Moody's Analytics standard calibration for UK government bonds is also shown. Figure 14 shows the fitted yield curve for portfolios of AA, A and BBB rated corporate bonds using both the raw market yields (solid lines) and after removing credit risk (dotted lines), the latter represent the top down curves for those portfolios. Average characteristics of the bonds, by rating, are presented in Table 5.

Implied illiquidity premia per rating class can be derived by calculating the spread of the top-down curves over the government curve: these are presented in Figure 15. Figure 16 shows a regression of the excess spread, defined as the market spread minus the expected credit loss, versus the implied illiquidity premia for each bond, this regression allows us to derive an average relationship between spreads and illiquidity premia, these proxy coefficients are listed in Table 7. These numbers could be compared to Solvency II where EIOPA define the VA as 65% of the credit-adjusted spread. Average illiquidity premia per rating and maturity bucket are presented in Table 6.

Finally data are split into financial and non-financial categories. Figure 17 shows the unadjusted (solid) and credit adjusted (dotted) top-down yield curves for each category. Figure 18 displays the implied illiquidity premia for each category. Table 8 presents the average implied illiquidity premia per category and maturity bucket. Although the unadjusted market yields are similar for both financial and non-financial corporate bonds, there is a significant difference in the implied illiquidity premia.

Financial bonds have a significantly higher probability of default and expected loss than non-financial bonds (an average of 36 bp to 18 bp), this is consistent with the EIOPA VA and MA calculations where financial bonds generally have higher fundamental spreads. Driving this change, Figure 20 shows that financial issuers have higher leverage and lower asset volatility than non-financial issuers, these factors affect both the EDF and the credit risk premium. Table 5 also shows that financial issuers have a higher average credit rating, and the analysis per rating shows that a higher rating leads to lower illiquidity premia.

Table 5 GBP Bond Characteristics

RATING	NUMBER OF BONDS	AVERAGE YIELD TO MATURITY	AVERAGE DURATION	FINANCIAL PROPORTION
All bonds	413	2.67%	6.47	31%
AAA	1	1.70%	4.96	0
AA	66	1.97%	5.34	62%
A	135	2.42%	6.38	37%
BBB	211	3.04%	6.91	18%

TOP-DOWN YIELD CURVES

Figure 13 Credit Risk Adjusted Yield Curves
GBP End Dec 2018 – All Investment Grade Bonds

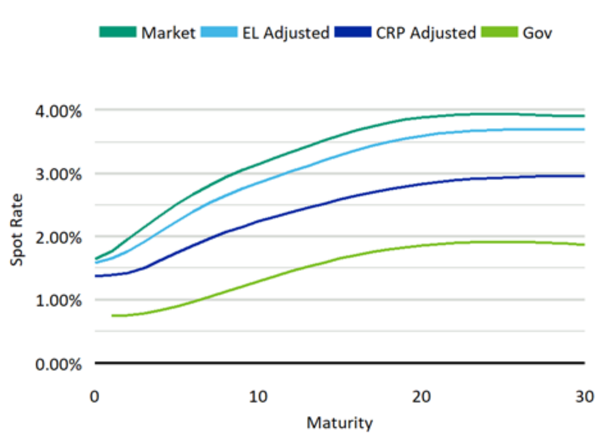
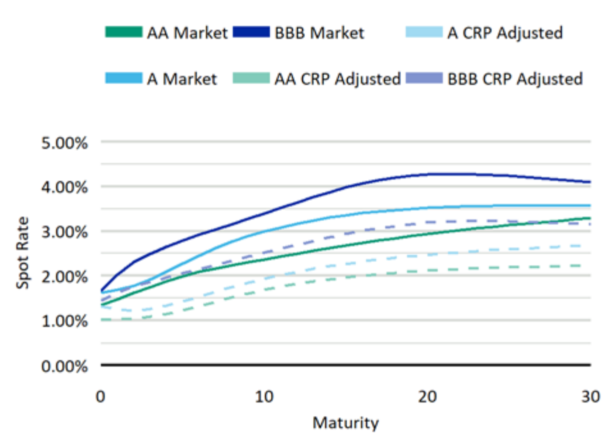


Figure 14 Credit Risk Adjusted Yield Curves
GBP End Dec 18



ILLIQUIDITY PREMIA

Figure 15 Implied Illiquidity Premia
GBP End Dec 2018

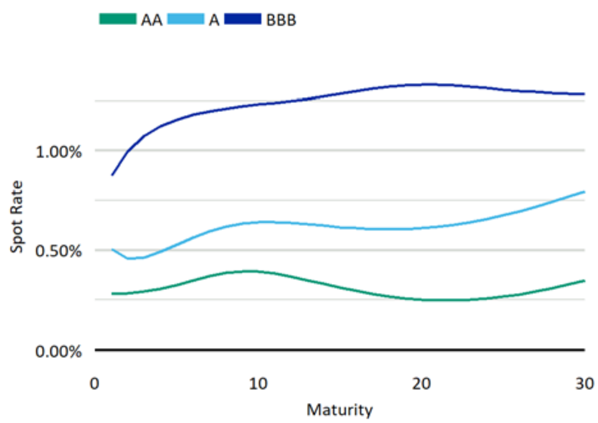


Figure 16 Illiquidity Premia vs Excess Spread
GBP End Dec 2018

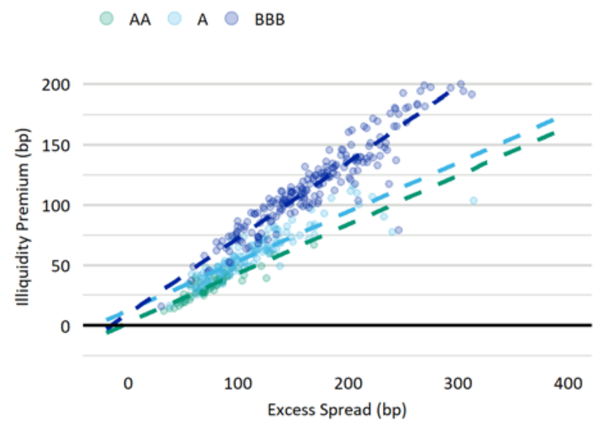


Table 6 Illiquidity Premia in Basis Points per Annum

MATURITY -> /RATING	1-3	3-5	5-10	10+
AAA	NaN	NaN	60	NaN
AA	30	31	40	39
A	46	51	65	67
BBB	98	112	123	133
All Bonds	65	75	96	100

Table 7 Illiquidity Premia Proxy Coefficients

MATURITY -> /RATING	AVERAGE EXPECTED LOSS SPREAD (BP)	IP PROPORTION
AAA	3.7	0.81
AA	22.9	0.44
A	25.7	0.51
BBB	22.2	0.69
All Bonds	23.4	0.62

SECTORAL ANALYSIS

Figure 17 Financial and Non-Financial Yield Curves
GBP End Dec 2018

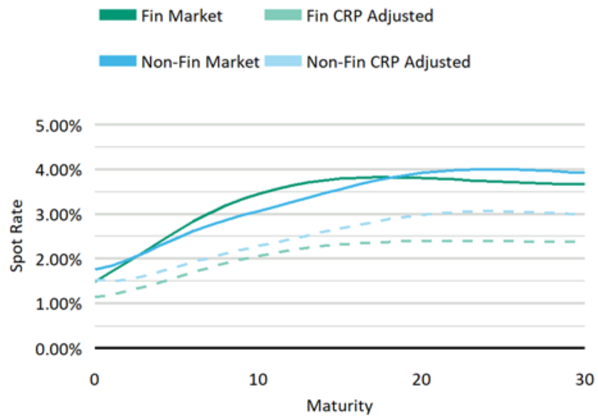


Figure 18 Financial and Non-Financial Implied Illiquidity Premia
GBP End Dec 2018

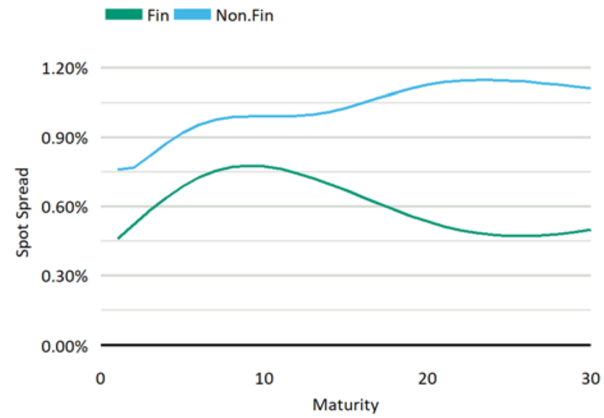


Figure 19 Financial and Non-Financial Illiquidity Premia vs Excess Spread
GBP End Dec 2018

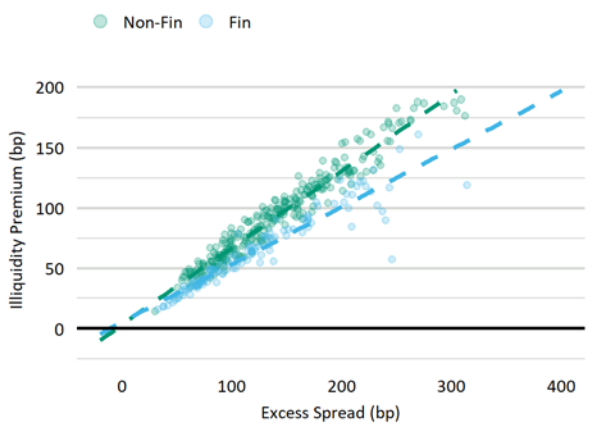


Figure 20 Financial and Non-Financial Leverage
GBP End Dec 2018

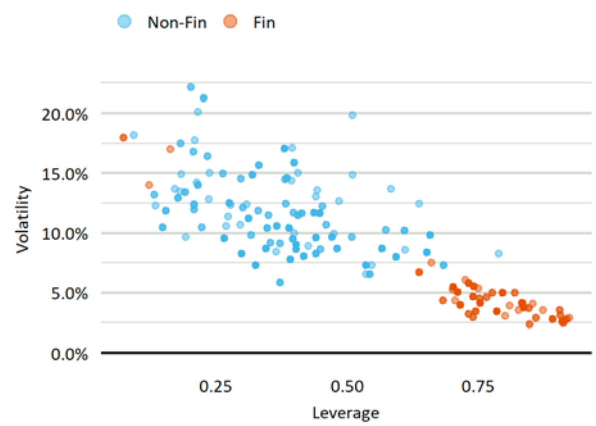


Table 8 Financial and Non-Financial Illiquidity Premia in Basis Points per Annum

MATURITY -> /SECTOR	1-3	3-5	5-10	10+
Non-Financial	75	83	101	107
Financial	50	62	82	68
All Bonds	65	75	96	100

USD

Top-down credit risk adjusted yield curves are shown in Figure 21 and Figure 22, firstly for a composite portfolio of 7453 investment grade corporate bonds and secondly split by rating. In Figure 21 the fit to the raw yields is shown alongside the fitted yield curves produced after adjusting the yield to maturity on each bond for the expected credit loss and after removing the credit risk premium. The CRP adjusted curve represents the top-down curve for that portfolio. For reference Moody's Analytics standard calibration for US government bonds is also shown. Figure 22 shows the fitted yield curve for portfolios of AAA, AA, A and BBB rated corporate bonds using both the raw market yields (solid lines) and after removing credit risk (dotted lines), the latter represent the top down curves for those portfolios. Average characteristics of the bonds, by rating, are presented in Table 9.

Implied illiquidity premia per rating class can be derived by calculating the spread of the top-down curves over the government curve: these are presented in Figure 23. Figure 24 shows a regression of the excess spread, defined as the market spread minus the expected credit loss, versus the implied illiquidity premia for each bond, this regression allows us to derive an average relationship between spreads and illiquidity premia, these proxy coefficients are listed in Table 11. These numbers could be compared to Solvency II where EIOPA define the VA as 65% of the credit-adjusted spread. Average illiquidity premia per rating and maturity bucket are presented in Table 10.

Finally data are split into financial and non-financial categories. Figure 25 shows the unadjusted (solid) and credit adjusted (dotted) top-down yield curves for each category. Figure 26 displays the implied illiquidity premia for each category. Table 12 presents the average implied illiquidity premia per category and maturity bucket. Although the unadjusted market yields are similar for both financial and non-financial corporate bonds, there is a significant difference in the implied illiquidity premia.

Financial bonds have a significantly higher probability of default and expected loss than non-financial bonds (an average of 38 bp to 20 bp), this is consistent with the EIOPA VA and MA calculations where financial bonds generally have higher fundamental spreads. Driving this change, Figure 28 shows that financial issuers have higher leverage and lower asset volatility than non-financial issuers, these factors affect both the EDF and the credit risk premium.

Table 9 USD Bond Characteristics

RATING	NUMBER OF BONDS	AVERAGE YIELD TO MATURITY	AVERAGE DURATION	FINANCIAL PROPORTION
All bonds	7453	4.14%	6.42	0.25
AAA	135	3.32%	5.56	0.21
AA	738	3.58%	5.87	0.33
A	2768	3.85%	6.61	0.30
BBB	3812	4.50%	6.43	0.20

TOP-DOWN YIELD CURVES

Figure 21 Credit Risk Adjusted Yield Curves
USD End Dec 2018 – All Investment Grade Bonds

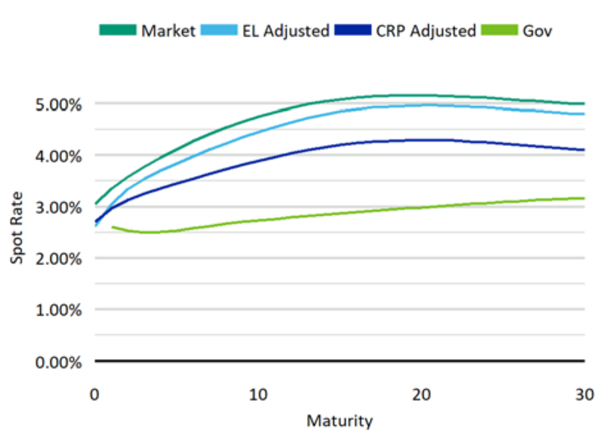
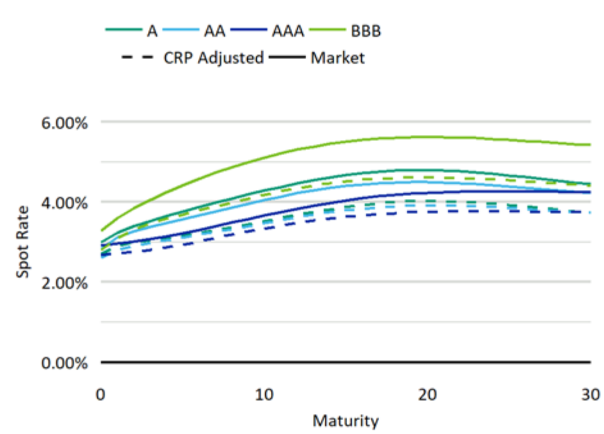


Figure 22 Credit Risk Adjusted Yield Curves
USD End Dec 18



ILLIQUIDITY PREMIA

Figure 23 Implied Illiquidity Premia
USD End Dec 2018

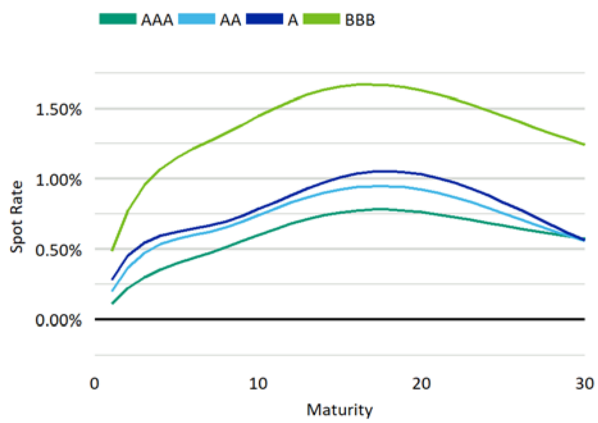


Figure 24 Illiquidity Premia vs Excess Spread
USD End Dec 2018

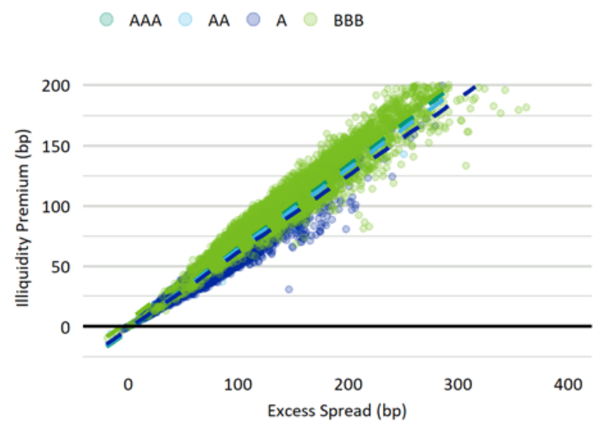


Table 10 Illiquidity Premia in Basis Points per Annum

MATURITY -> /RATING	1-3	3-5	5-10	10+
AAA	21	24	47	68
AA	32	46	54	79
A	41	52	60	86
BBB	7	96	115	145
All Bonds	54	75	91	115

Table 11 Illiquidity Premia Proxy Coefficients

MATURITY -> /RATING	AVERAGE EXPECTED LOSS SPREAD (BP)	IP PROPORTION
AAA	10.9	0.65
AA	14.7	0.64
A	21.1	0.61
BBB	29.3	0.65
All Bonds	24.5	0.63

SECTORAL ANALYSIS

Figure 25 Financial and Non-Financial Yield Curves
USD End Dec 2018

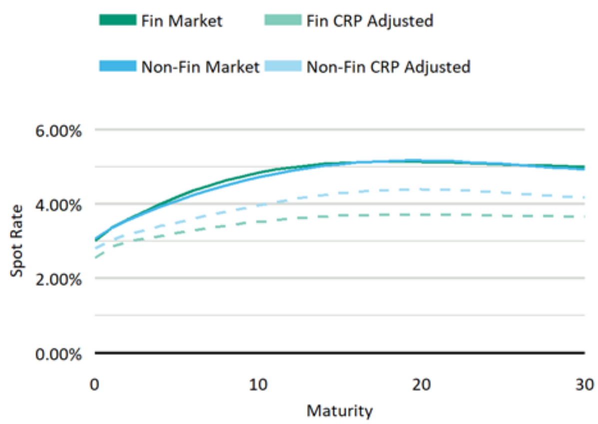


Figure 26 Financial and Non-Financial Implied Illiquidity Premia
USD End Dec 2018

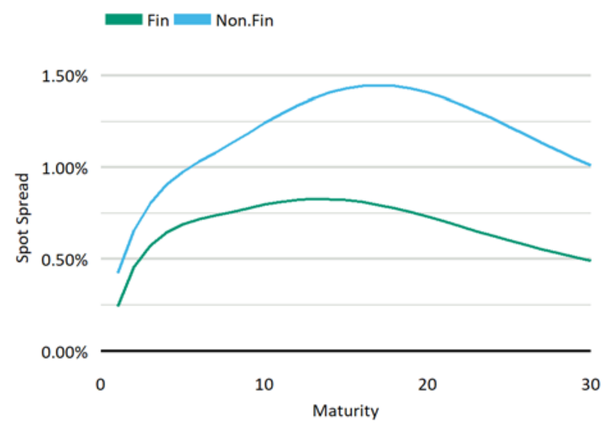


Figure 27 Financial and Non-Financial Illiquidity Premia vs Excess Spread
USD End Dec 2018

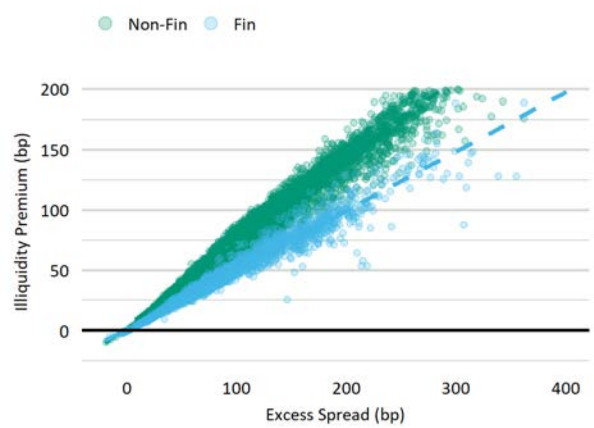


Figure 28 Financial and Non-Financial Leverage
USD End Dec 2018

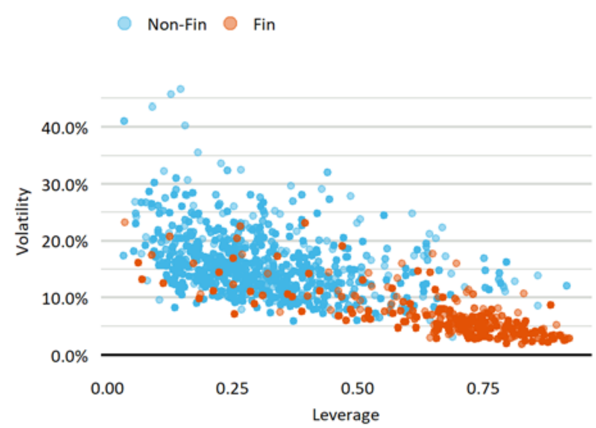


Table 12 Financial and Non-Financial Illiquidity Premia in Basis Points per Annum

MATURITY -> /SECTOR	1-3	3-5	5-10	10+
Non-Financial	61	81	98	123
Financial	38	54	65	69
All Bonds	54	75	91	115

CAD

Top-down credit risk adjusted yield curves are shown in Figure 29 and Figure 30, firstly for a composite portfolio of 356 investment grade corporate bonds and secondly split by rating. In Figure 29 the fit to the raw yields is shown alongside the fitted yield curves produced after adjusting the yield to maturity on each bond for the expected credit loss and after removing the credit risk premium. The CRP adjusted curve represents the top-down curve for that portfolio. For reference Moody's Analytics standard calibration for CA government bonds is also shown. Figure 30 shows the fitted yield curve for portfolios of AAA, AA, A and BBB rated corporate bonds using both the raw market yields (solid lines) and after removing credit risk (dotted lines), the latter represent the top down curves for those portfolios. Average characteristics of the bonds, by rating, are presented in Table 13.

Implied illiquidity premia per rating class can be derived by calculating the spread of the top-down curves over the government curve: these are presented in Figure 31. Figure 32 shows a regression of the excess spread, defined as the market spread minus the expected credit loss, versus the implied illiquidity premia for each bond, this regression allows us to derive an average relationship between spreads and illiquidity premia, these proxy coefficients are listed in Table 15. These numbers could be compared to Solvency II where EIOPA define the VA as 65% of the credit-adjusted spread. Average illiquidity premia per rating and maturity bucket are presented in Table 14.

Finally data are split into financial and non-financial categories. Figure 33 shows the unadjusted (solid) and credit adjusted (dotted) top-down yield curves for each category. Figure 34 displays the implied illiquidity premia for each category. Table 16 presents the average implied illiquidity premia per category and maturity bucket. Although the unadjusted market yields are similar for both financial and non-financial corporate bonds, there is a significant difference in the implied illiquidity premia.

Financial bonds have a significantly higher probability of default and expected loss than non-financial bonds (an average of 24 bp to 12 bp), this is consistent with the EIOPA VA and MA calculations where financial bonds generally have higher fundamental spreads. Driving this change, Figure 36 shows that financial issuers have higher leverage and lower asset volatility than non-financial issuers, these factors affect both the EDF and the credit risk premium. Table 13 also shows that financial issuers have a higher average credit rating, and the analysis per rating shows that a higher rating leads to lower illiquidity premia.

Table 13 CAD Bond Characteristics

RATING	NUMBER OF BONDS	AVERAGE YIELD TO MATURITY	AVERAGE DURATION	FINANCIAL PROPORTION
All bonds	356	3.40%	5.13	26%
AAA	3	2.33%	1.04	33%
AA	69	2.69%	2.33	83%
A	98	3.26%	5.22	19%
BBB	186	3.76%	6.19	9%

TOP-DOWN YIELD CURVES

Figure 29 Credit Risk Adjusted Yield Curves
CAD End Dec 2018 – All Investment Grade Bonds

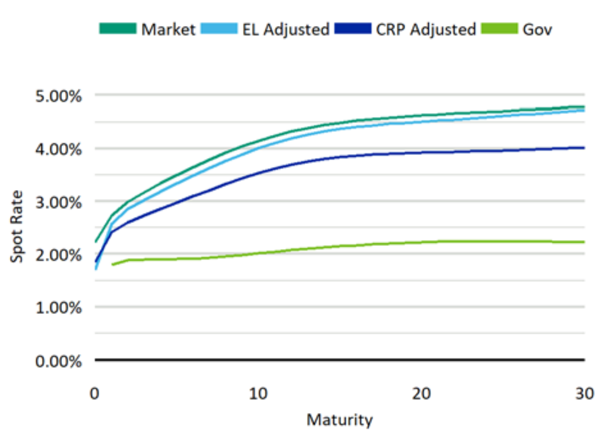
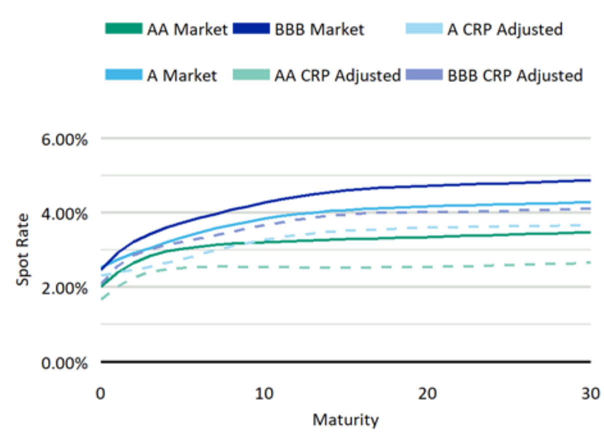


Figure 30 Credit Risk Adjusted Yield Curves
CAD End Dec 18



ILLIQUIDITY PREMIA

Figure 31 Implied Illiquidity Premia
CAD End Dec 2018

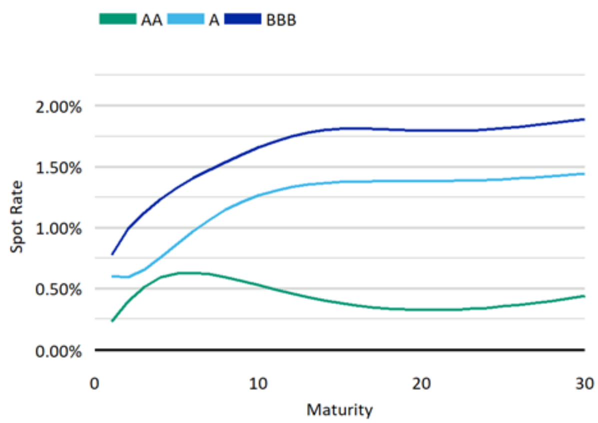


Figure 32 Illiquidity Premia vs Excess Spread
CAD End Dec 2018

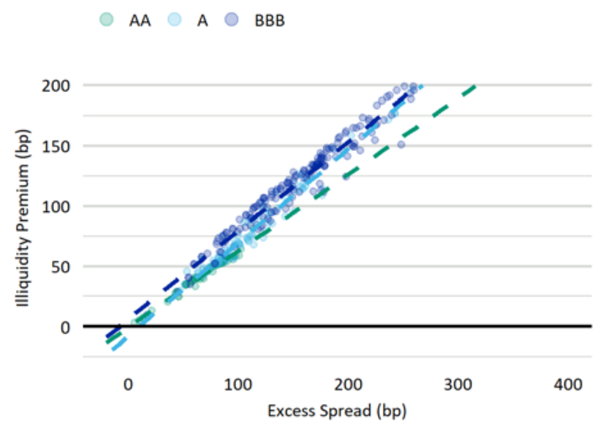


Table 14 Illiquidity Premia in Basis Points per Annum

MATURITY -> /RATING	1-3	3-5	5-10	10+
AAA	31	NaN	NaN	NaN
AA	43	52	59	NaN
A	61	72	101	133
BBB	93	126	137	177
All Bonds	69	91	120	164

Table 15 Illiquidity Premia Proxy Coefficients

MATURITY -> /RATING	AVERAGE EXPECTED LOSS SPREAD (BP)	IP PROPORTION
AAA	20.3	0.66
AA	21.3	0.46
A	15.5	0.72
BBB	13.4	0.78
All Bonds	15.6	0.74

SECTORAL ANALYSIS

Figure 33 Financial and Non-Financial Yield Curves
CAD End Dec 2018

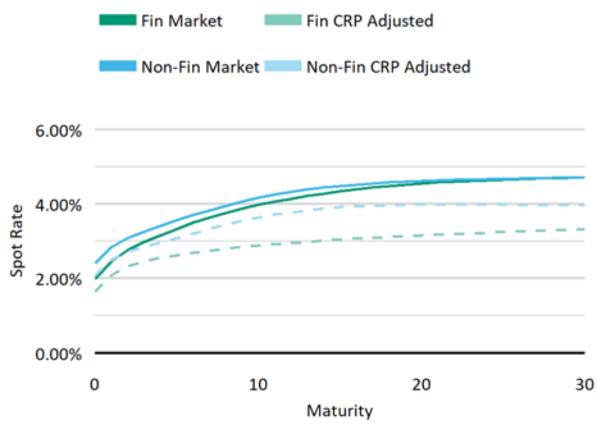


Figure 34 Financial and Non-Financial Implied Illiquidity Premia
CAD End Dec 2018

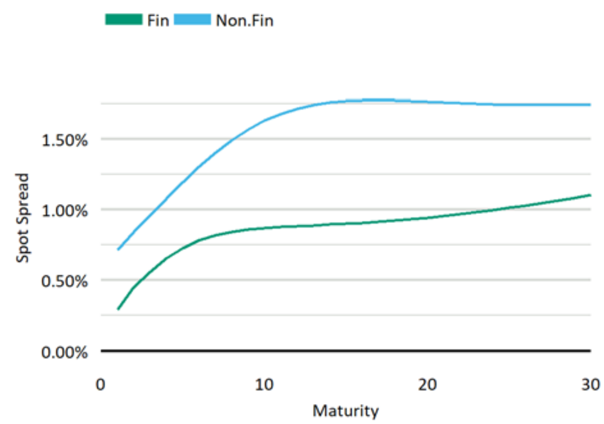


Figure 35 Financial and Non-Financial Illiquidity Premia vs Excess Spread
CAD End Dec 2018

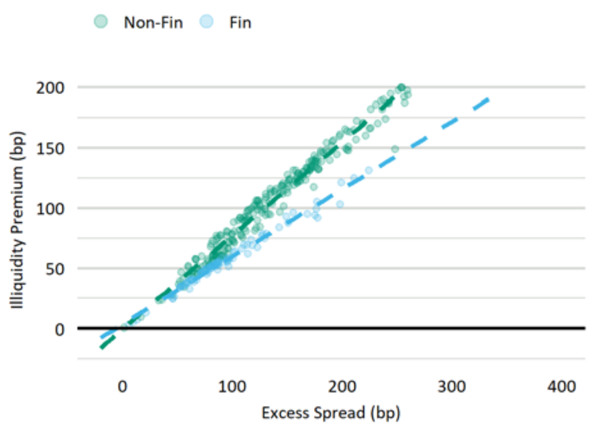


Figure 36 Financial and Non-Financial Leverage
CAD End Dec 2018

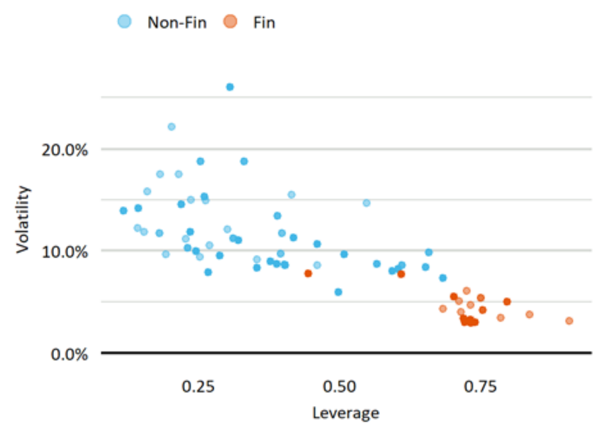


Table 16 Financial and Non-Financial Illiquidity Premia in Basis Points per Annum

MATURITY -> /SECTOR	1-3	3-5	5-10	10+
Non-Financial	80	104	131	169
Financial	46	59	80	96
All Bonds	69	91	120	164

CNY

For CNY corporate bonds there is a lack of coverage from agencies like Moody's Investor Services, as such we cannot use agency data in order to perform the split between rating categories. Implied ratings can be derived from EDF data, however, even using a PD rating mapping appropriate to APAC data, as in Robinson and Hibbert (2019) there is no clear relationship between market yields and rating class. As such we do not present a breakdown by rating for CNY data.

Top-down credit risk adjusted yield curves are shown in Figure 37 for a composite portfolio of 584 corporate bonds. The fit to the raw yields is shown alongside the fitted yield curves produced after adjusting the yield to maturity on each bond for the expected credit loss and after removing the credit risk premium. The CRP adjusted curve represents the top-down curve for that portfolio. For reference Moody's Analytics standard calibration for CN government bonds is also shown.

Implied illiquidity premia can be derived by calculating the spread of the top-down curves over the government curve: this is presented in Figure 38. Figure 39 shows a regression of the excess spread, defined as the market spread minus the expected credit loss, versus the implied illiquidity premia for each bond, this regression allows us to derive an average relationship between spreads and illiquidity premia, these proxy coefficients are listed in Table 19. These numbers could be compared to Solvency II where EIOPA define the VA as 65% of the credit-adjusted spread. Average illiquidity premia per maturity bucket are presented in Table 18.

Finally data are split into financial and non-financial categories. Figure 40 shows the unadjusted (solid) and credit adjusted (dotted) top-down yield curves for each category. Figure 41 displays the implied illiquidity premia for each category. Table 20 presents the average implied illiquidity premia per category and maturity bucket. Although the unadjusted market yields are similar for both financial and non-financial corporate bonds, there is a significant difference in the implied illiquidity premia.

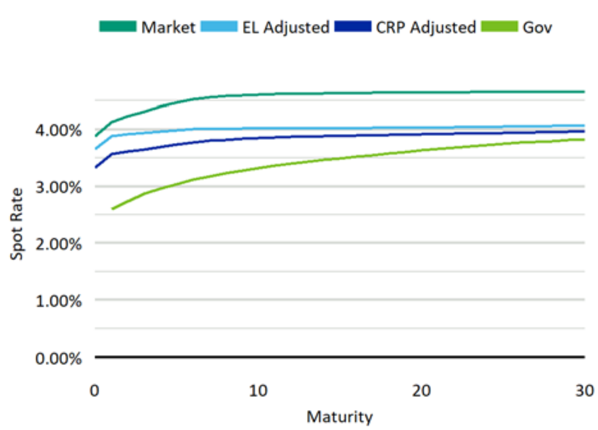
Financial bonds have a significantly higher probability of default and expected loss than non-financial bonds (an average of 29 bp to 15 bp), this is consistent with the EIOPA VA and MA calculations where financial bonds generally have higher fundamental spreads. Driving this change, Figure 43 shows that financial issuers have higher leverage and lower asset volatility than non-financial issuers, these factors affect both the EDF and the credit risk premium.

Table 17 CNY Bond Characteristics

RATING	NUMBER OF BONDS	AVERAGE YIELD TO MATURITY	AVERAGE DURATION	FINANCIAL PROPORTION
All bonds	584	4.15%	2.10	85%

TOP-DOWN YIELD CURVES

Figure 37 Credit Risk Adjusted Yield Curves
CNY End Dec 2018



ILLIQUIDITY PREMIA

Figure 38 Implied Illiquidity Premia
CNY End Dec 2018

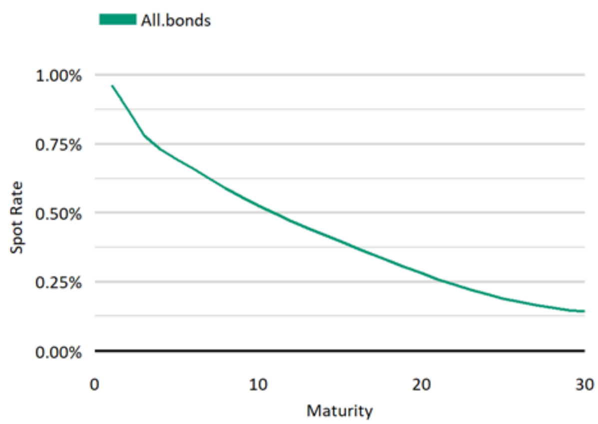


Figure 39 Illiquidity Premia vs Excess Spread
CNY End Dec 2018

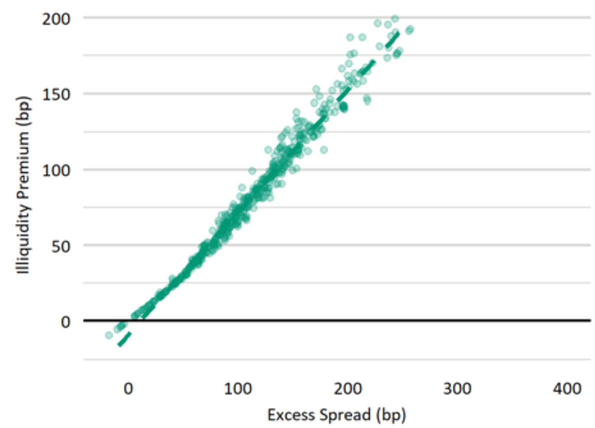


Table 18 Illiquidity Premia

MATURITY	1-3	3-5	5-10	10+
All Bonds	74	74	32	30

Table 19 Illiquidity Premia Proxy Coefficients

MATURITY	AVERAGE EXPECTED LOSS SPREAD (BP)	IP PROPORTION
All Bonds	27.0	0.75

SECTORAL ANALYSIS

Figure 40 Financial and Non-Financial Yield Curves
CNY End Dec 2018

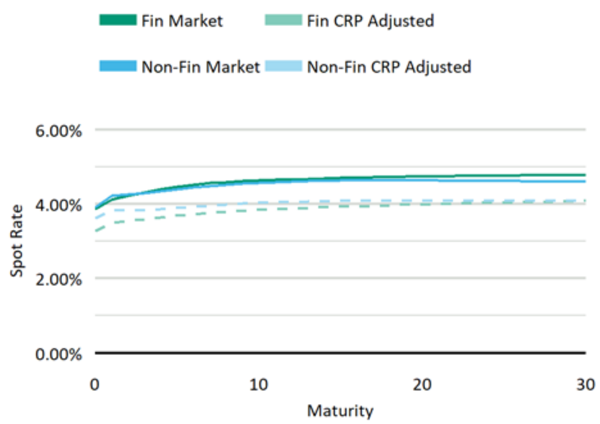


Figure 41 Financial and Non-Financial Implied Illiquidity Premia
CNY End Dec 2018

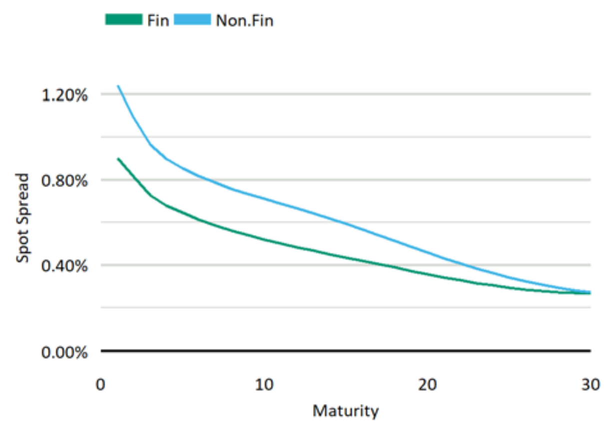


Figure 42 Financial and Non-Financial Illiquidity Premia vs Excess Spread
CNY End Dec 2018

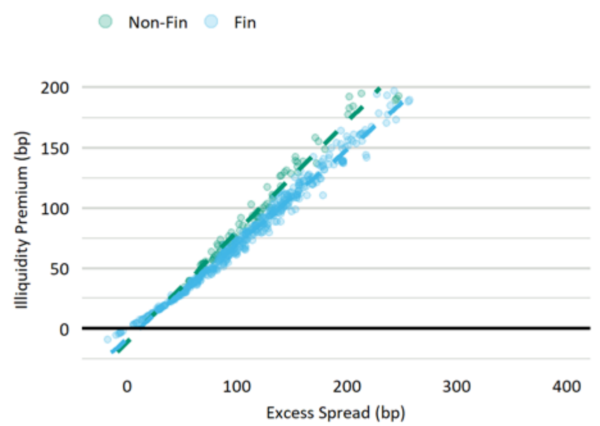


Figure 43 Financial and Non-Financial Leverage
CNY End Dec 2018

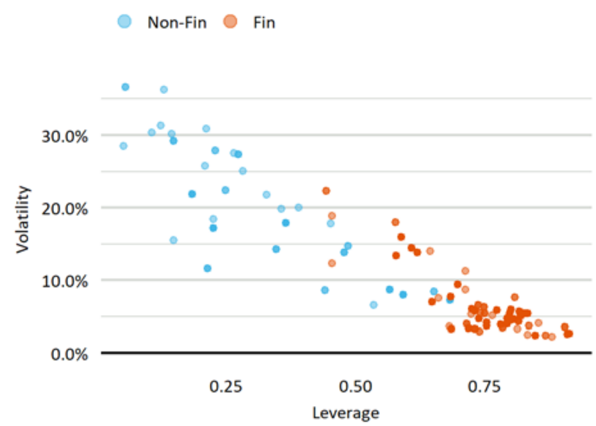


Table 20 Financial and Non-Financial Illiquidity Premia in Basis Points per Annum

MATURITY -> /SECTOR	1-3	3-5	5-10	10+
Non-Financial	89	122	61	48
Financial	71	58	29	25
All Bonds	74	74	32	30

HKD

Top-down credit risk adjusted yield curves are shown in Figure 44 for a composite portfolio of 395 corporate bonds. The fit to the raw yields is shown alongside the fitted yield curves produced after adjusting the yield to maturity on each bond for the expected credit loss and after removing the credit risk premium. The CRP adjusted curve represents the top-down curve for that portfolio. For reference Moody's Analytics standard calibration for HK government bonds is also shown.

Implied illiquidity premia can be derived by calculating the spread of the top-down curves over the government curve: this is presented in Figure 45. Figure 46 shows a regression of the excess spread, defined as the market spread minus the expected credit loss, versus the implied illiquidity premia for each bond, this regression allows us to derive an average relationship between spreads and illiquidity premia, these proxy coefficients are listed in Table 23. These numbers could be compared to Solvency II where EIOPA define the VA as 65% of the credit-adjusted spread. Average illiquidity premia per maturity bucket are presented in Table 22.

Finally data are split into financial and non-financial categories. Figure 47 shows the unadjusted (solid) and credit adjusted (dotted) top-down yield curves for each category. Figure 48 displays the implied illiquidity premia for each category. Table 24 presents the average implied illiquidity premia per category and maturity bucket. Although the unadjusted market yields are similar for both financial and non-financial corporate bonds, there is a significant difference in the implied illiquidity premia. Unlike other economies in this report HKD financial bonds have a higher illiquidity premia than non-financial bonds.

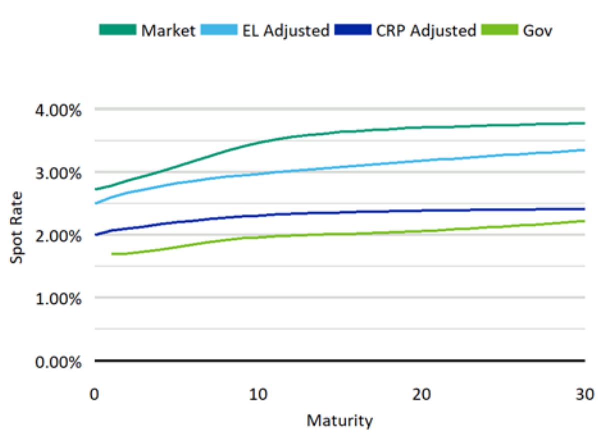
Financial bonds have a slightly lower probability of default and expected loss than non-financial bonds (an average of 27 bp to 35 bp), this is in contrast to other economies examined here. Despite this difference, Figure 50 shows that as across other economies, financial issuers have higher leverage and lower asset volatility than non-financial issuers, these factors affect both the EDF and the credit risk premium. Implied illiquidity premia, in particular for non-financial bonds, show a downward trend with maturity. This is likely driven by the limited availability of government bond data and the early point at which extrapolation begins: HK government bond data in Moody's Analytics standard calibrations ends around 10 years, while corporate bond data extends to 30 years. The low, or negative, implied illiquidity premia are perhaps an indication that the risk-free curve extrapolates towards the UFR too quickly.

Table 21 HKD Bond Characteristics

RATING	NUMBER OF BONDS	AVERAGE YIELD TO MATURITY	AVERAGE DURATION	FINANCIAL PROPORTION
All bonds	395	3.07%	4.34	55%

TOP-DOWN YIELD CURVES

Figure 44 Credit Risk Adjusted Yield Curves
HKD End Dec 2018



ILLIQUIDITY PREMIA

Figure 45 Implied Illiquidity Premia
HKD End Dec 2018

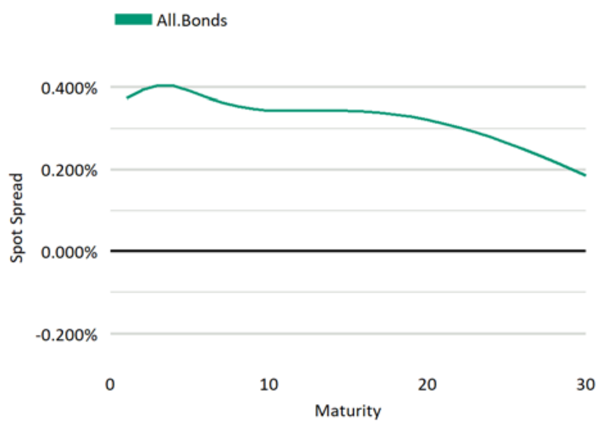


Figure 46 Illiquidity Premia vs Excess Spread
HKD End Dec 2018

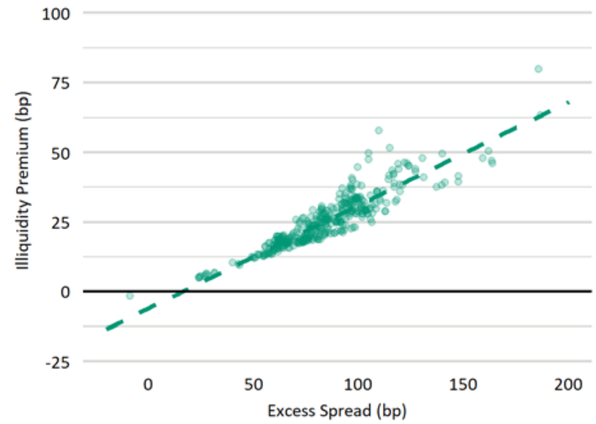


Table 22 Illiquidity Premia in Basis Points per Annum

MATURITY	1-3	3-5	5-10	10+
All Bonds	27	27	24	26

Table 23 Illiquidity Premia Proxy Coefficients

MATURITY	AVERAGE EXPECTED LOSS SPREAD (BP)	IP PROPORTION
All Bonds	29.7	0.31

SECTORAL ANALYSIS

Figure 47 Financial and Non-Financial Yield Curves
HKD End Dec 2018

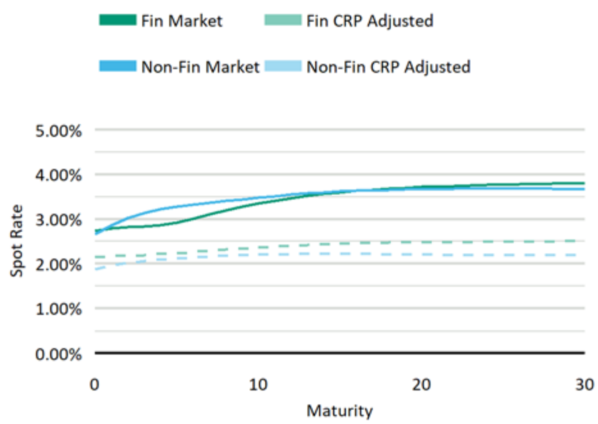


Figure 48 Financial and Non-Financial Implied Illiquidity Premia
HKD End Dec 2018

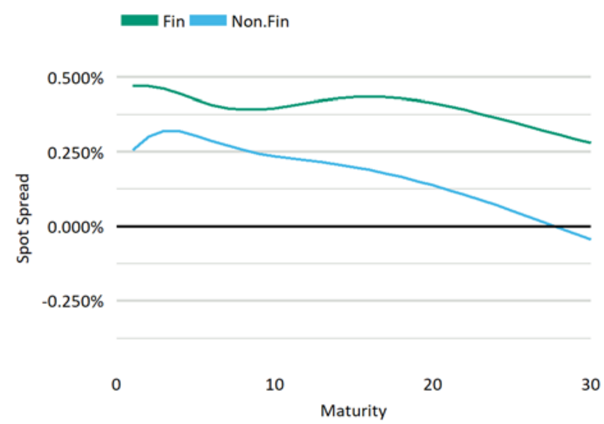


Figure 49 Financial and Non-Financial Illiquidity Premia vs Excess Spread
HKD End Dec 2018

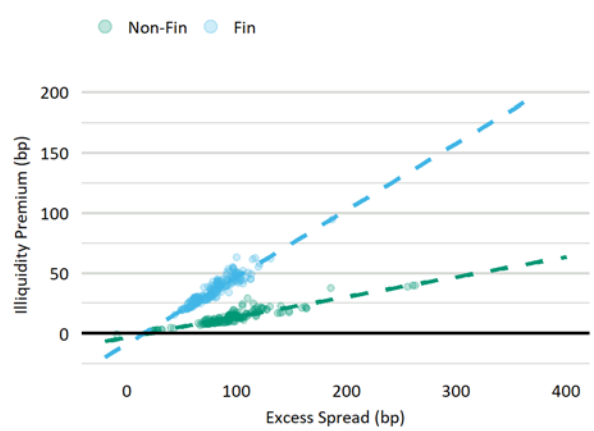


Figure 50 Financial and Non-Financial Leverage
HKD End Dec 2018

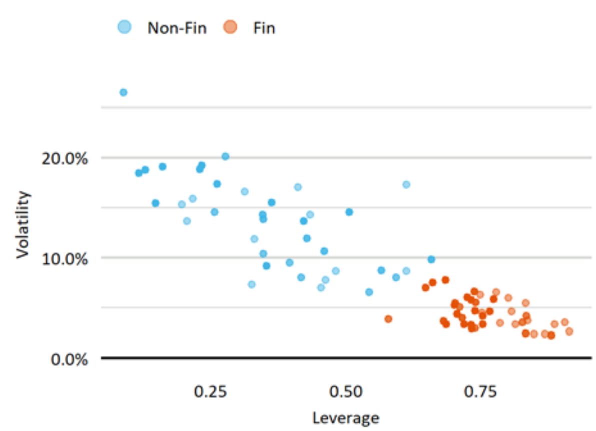


Table 24 Financial and Non-Financial Illiquidity Premia in Basis Points per Annum

MATURITY -> /SECTOR	1-3	3-5	5-10	10+
Non-Financial	15	17	11	11
Financial	38	33	31	32
All Bonds	27	27	24	26

Conclusion

The results presented in this report are an attempt to provide a market data driven, structural approach to determining appropriate components for either a top-down or bottom-up approach to constructing discount curves for use under IFRS 17. The modelling leverages Moody's Analytics substantial experience in expected credit loss modelling alongside standard accounting techniques to determine a cost-of-capital adjustment for credit risk premia.

The IFRS 17 standard states that discount curves, whether produced bottom-up or top-down, should relate to the liquidity characteristics of a firm's own liabilities. As such, we do not believe that it likely that a standard discount curve can be defined which is appropriate to all insurers. Instead, we aim to provide standard components which can be utilised to derive an appropriate discount rate for any business. In order to determine the appropriate liability discount rate, a mapping will have to be performed between specific insurance contracts and market traded assets. As we have shown in this report, the choice of portfolio can have a significant impact on the final discount rate; the implied illiquidity premia for different ratings of corporate bonds are substantially different. This is an essential consideration for both top-down and bottom-up approaches.

The method used in this report provides a straightforward application to break down estimates of illiquidity premia by rating and sector. We have focussed on corporate bonds, but the methodology could be extended to other asset classes if probability of default, recovery rate and cost-of-capital assumptions are available. The specific illiquidity premia for each asset class can then be combined appropriately for any reference portfolio to derive a final discount rate.

Appendix: Additional Data Tables

Table 25 Settings

Economy	Equity Risk Premium	Rating Source	Targeted Ratings	Base Risk Free Rate
CAD	3.40%	Moody's SRA	AA, A, BBB	CAD Treasury
CNY	4.61%	EDF-Implied	AA, A, BBB, BB	CNY Treasury
EUR	4.43%	Moody's SRA	AA, A, BBB	DEM Treasury
GBP	3.41%	Moody's SRA	AA, A, BBB	GBP Treasury
HKD	4.94%	Moody's SRA	AA, A, BBB	HKD Treasury
USD	4.04%	Moody's SRA	AAA, AA, A, BBB	USD Treasury

Table 26 Estimated ERP by Rating

Economy	AAA	AA	A	BBB	BB
CAD	N/A	2.49%	3.68%	3.57%	N/A
CNY	N/A	3.54%	3.59%	3.32%	5.18%
EUR	N/A	4.31%	4.36%	4.51%	N/A
GBP	N/A	3.59%	3.44%	3.41%	N/A
HKD	N/A	3.79%	5.52%	4.72%	N/A
USD	4.01%	3.57%	3.81%	4.30%	N/A

Table 27 Estimated ERP by Sector

Economy	Financial	Non-Financial
CAD	1.67%	3.74%
CNY	3.66%	6.67%
EUR	1.60%	4.73%
GBP	0.91%	3.87%
HKD	2.91%	5.93%
USD	2.17%	4.35%

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