Research Document

Summary of Liquidity Premium Estimation Methods

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Contents

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1 Overview

This report is concerned with the estimation of liquidity premia (LP) embedded in the prices of financial instruments. The existence, magnitude and measurability of LP remain the subject of a lively debate among practitioners, accountants, actuaries and regulators. The outcome of the debate will have an impact on the future price of certain financial products and, arguably, the cost of finance for firms using the capital markets.

It should be noted that this report is not concerned with how to apply an LP estimate to the valuation of insurers' liabilities. Our focus is on how to estimate benchmark LPs and to understand the practical challenges and sensitivities of the estimation approaches and not the comparison of the estimates. It is worth stressing that each estimate is merely for a point on a wide spectrum of LP, with each of our methods estimating a different point of this spectrum. These are likely to vary across type of financial instrument and according to characteristics such as, term, credit risk, etc – not least because of the different levels of liquidity (transactions costs) among the instruments themselves. It should be noted that our results are not anticipated to be directly comparable and that an LP applied to a specific class of liabilities could be larger than the benchmark LPs presented here.

Our aim here is to contrast results from different practical approaches to LP estimation applied to the recent past (i.e. a period spanning the market crisis) as well as highlighting sensitivities and implementation challenges. In our previous report ("*Liquidity Premium: Literature review of theoretical and empirical evidence*", September 2009[1]) we provided a survey of researchers' findings on these questions. Key findings from that report were:

- There is a clear consensus (across an extensive research literature accumulated over more than 30 years) that LP *do* exist across many markets, they can be substantial and vary through time. For certain markets, i.e. corporate credit, there is strong evidence that LP increase in stressed market conditions.
- Although different estimation approaches have been adopted, researchers' empirical results are broadly consistent.

In the main body of this report we present three common estimation methods with the purpose of informing a choice of the ongoing estimation of a 'benchmark' LP – that is the liquidity premium associated with a specific pool of illiquid financial instruments relative to some liquid reference portfolio.

The three methods considered are:

CDS basis	Credit default swaps provide a mechanism for insuring against the default of a bond issuer. The spread on an insured portfolio (which has relatively low liquidity and is free of credit risk) relative to a liquid risk-free bond is a widely-used method for estimating LP.
Structural model	This method compares the yield on an illiquid corporate bond portfolio with the cost/yield on a liquid position with otherwise equivalent risk characteristics constructed from risk-free bonds and notional options, using the Merton model.
Covered bond spreads	If (illiquid) covered bonds are viewed as being essentially free of credit risk, the spread over the risk-free reference rate (in the analysis shown here this is assumed to be the swap rate) can be considered as an estimate for LP.

These methods are discussed in more detail in section 2 of this report. We present results, relative to the swap rate, in section 3.

Results

Whilst the existence of LP is widely accepted, the estimation of the price of liquidity for a specific financial instrument or portfolio at a specific point in time is clearly a non-trivial challenge. Although we might seek to quantify LP across types of financial instrument and their characteristics, such as term, risk and currency, this turns out to be a difficult task. These challenges are not restricted to LP – unravelling the expectations and various risk premia embedded in any financial instrument is a notoriously difficult task. So, what observations *can* we make on the results?

[1] *Available at http://www.barrhibb.com/documents/downloads/Liquidity_Premium_Literature_Review.PDF*

- Individual estimates vary considerably, through time, across economies and compared to each other.
- In aggregate, clear patterns emerge from the analysis irrespective of the method used. Estimated LP rise over each of the year ends from 2006 to 2008 with a dramatic increase over the last quarter of 2008.
- From the end of 2005 until mid 2007 we estimate little or no liquidity premium – although it should be noted that during this period bond spreads and market premiums were unusually low and far from typical historically.
- LP estimates generally appear higher for the USD than for the EUR and GBP sectors.
- The EUR estimates derived using the structural model are far lower during the stress periods than both USD/GBP estimates using the same model and other EUR estimates.

Sensitivities & Practical challenges

The CDS methods have much to recommend them given their relative simplicity (in principle at least) and their foundation in trades that should be achievable. Our analysis does show that care needs to be taken in the construction of calculations – aligning estimated CDS costs with actual bonds held can make a material difference to estimates. The most appropriate calculation will depend on the reference portfolio of bonds being used in a given application. On the downside, there is limited coverage of the CDS markets for estimation and the historic estimates are undoubtedly biased (upwards) by the presence of counterparty risk. On a more positive note, there are a number of initiatives to develop central counterparty clearing mechanisms for CDS contracts. This is an important development for those using the CDS basis as a measure of LP since it has the potential to effectively remove counterparty risk from the basis equation[2].

The structural approach provides a powerful framework for understanding the forces that drive credit spreads. Of the different approaches it does have the greatest parameter and model risk (the potential for mistakes in parameter selection and model specification) and requires the largest number of parameter estimates. Nevertheless, the model does deliver a consistent set of results alongside the other methods and therefore strengthens our confidence in overall estimates. On the plus side, the model can – in principle at least – be extended across maturities and markets subjective to the availability of credible parameter estimates.

The covered bonds method used here – essentially observing spreads – is simple to implement and is relatively free from judgment. A question we need to ask here is whether the spreads are influenced by factors other than liquidity.

Way forward

This report illustrates results from some easy-to-compute methods for LP estimation for which data inputs are readily available. In every case, there is scope to refine the methods further through additional research and extension of data sets. Also, there are more sophisticated approaches that could be added to the list of candidate approaches to LP estimation. These include data-intensive regression methods (see for example Dick-Nielsen et al. (2009)) and 'scorecard' methods which aim to exploit information from a variety of indicators including proxies.

Where does this leave us in terms of building credible, robust estimates of liquidity premia? Unravelling expectations, risk premia and liquidity premia from the prices of financial instruments is notoriously challenging. However, the measures analysed in this report, and research literature analysed previously, suggest that, in aggregate, we ***are*** able to identify LP during periods of stress as well as more benign periods. Whilst no single measure offers a simple, satisfactory approach to quantification, the remaining challenge is how to combine the rich information set discussed in our reports into a robust estimation method.

Audience

This paper should be of interest to all those concerned with the valuation of assets and liabilities where market prices can be demonstrated, in part, to be determined by liquidity factors. Given the ongoing development of market-consistent, 'fair' valuations, the magnitude and measurability of LP will be of interest to accountants, actuaries, financial intermediaries and regulators.

[2] *For more details see the BIS quarterly review September 2009 – "Central counterparties for over-the-counter derivatives", available from http://www.bis.org/publ/qtrpdf/r_qt0909f.htm.*

2 Methods Summary

The purpose of this section is to summarise the different methods used to estimate LP as well as highlighting key assumptions and some practical considerations.

LP estimation methods aim to quantify the difference between the yields (or prices) of financial instruments which are considered identical in all respects other than liquidity i.e. the anticipated cost of trading. Here, we will focus on fixed income markets, in particular corporate and covered bonds, and consider the following approaches to estimation:

1. A comparison of yields on risk-free liquid bonds with an equivalent position in corporate bonds protected against default risk using Credit Default Swaps (CDS) - the 'negative CDS basis'.
2. A Structural ('Merton') model used to infer a fair spread on a liquid asset using option pricing theory which can be compared with market yields on equivalent illiquid bonds.
3. Direct computation of a specific LP by considering the spread between covered bonds and swaps.

2.1 Model free negative CDS basis approach

2.1.1 Summary

A Credit Default Swap (CDS) is a contract involving two parties - the protection buyer and the protection seller which allows holders of corporate bonds to insure against the risk of bond default. The protection buyer wants to hedge the risk that a bond of a given issuer (the reference entity) will default. He enters into a contract to pay the protection seller a periodic premium called the Credit Default Swap premium. This premium represents a fixed percentage of the notional amount specified in the contract and is usually paid quarterly. If no default event occurs before the maturity of the CDS (not the reference bond), the protection seller makes no payment to the protection buyer and the contract expires. On the other hand, if a default occurs during the life of the contract, the protection seller pays compensation to the protection buyer and the protection buyer ceases to pay periodic premia. Alternatively, for some contracts the CDS buyer will deliver an agreed quantity of (defaulted) bonds in exchange for a cash payment equal to the face value of the bonds.

How can information on CDS contracts be used to estimate liquidity premia? Using arbitrage arguments it can be shown that the spread of a corporate floating rate note (FRN) over a default free FRN should be equal to the CDS premium. This argument is commonly applied to ordinary fixed income coupon bonds as well, although it is an approximation. In practice, empirical results show a meaningful negative difference between the CDS premium and the bond spread. This difference is called the ***negative basis*** and provides evidence for the existence of other components priced in the corporate spread such as the liquidity risk of the underlying bond. This (negative basis) can be viewed as the difference between the yield on an (illiquid) corporate bond (or portfolio) insured with CDS (i.e. risk-free) and the yield on a liquid risk-free bond.

For a given reference entity, CDS and credit-risky bonds might be expected to trade similarly, since both should reflect market views on default risk. CDS are synthetic instruments that are designed to implement pure credit views. In principle, a higher CDS spread reflects deterioration in the perceived creditworthiness of an issuer and the market price of bearing the credit risk.

Following Longstaff et al. (2005), we use the credit default swap premium directly as a measure of the default component of corporate bond spreads (and hence the non-default component or liquidity premium)[3]. In other words, we assume the simple relation of:

CDS basis = CDS premium – corporate bond spread

Liquidity Premium = -CDS basis = Corporate bond spread – CDS premium

One way to think about the Longstaff et al. (2005) approach is as effectively creating a synthetic credit-risk-free corporate bond by buying a CDS on the reference entity. The *residual* spread is interpreted as a measure of the price of corporate bond liquidity.

Synthetic defaultable bond = default-free bond + CDS protection seller position

This method requires us (ideally) to:

- Identify a suitable sample of corporate bonds and collate prices / yields.

[3] *Note that this component contains an allowance for expected (i.e. average) defaults and an associated credit risk premium to compensate for unexpected defaults.*

- Collate CDS prices for equivalent maturities or interpolate them from adjacent maturities.
- Collate data on risk-free bonds.

In practice, aligning the samples and maturities is not a trivial task and it may be necessary to apply approximations. We have adopted two approaches to produce the analysis shown in section 3, both relying on an existing CDS index.

- Use the CDS index (e.g. iTraxx) to identify a sample of bonds and collate bond data to match the CDS in the index.
- Use a CDS index and a separate bond index, which may not be aligned in terms of constituent composition.

Some care needs to be taken to understand the impact of any mismatch between constituents. As a result the choice of method will depend on application and these practical considerations.

Our focus has been on easy-to-compute methods. Other approaches to estimation are possible, including starting with a bond index and then identifying issues for which CDS quotes are available at the relevant maturities. Further work is required to understand how easy it is to obtain data and other practical implications.

2.1.2 Key Assumptions and Data

The key assumption of this approach is that the CDS spread measures the pure credit risk component of the corporate-bond spread. In practice the CDS spread may also price the counterparty risk that the protection seller will default. Whilst this may not be material in benign market conditions, it may be important in times of extreme stress. The sharp rise in CDS spreads following the Lehman collapse and AIG's problems in September 2008 suggest that, in stress conditions, other factors can influence CDS prices.

One of the effects of the dislocation in CDS markets in 2008 has been a move by regulators, dealers and investors to develop central counterparty clearing mechanisms for CDS contracts and greater standardisation of contracts. These initiatives are beginning to develop momentum - particularly in Europe with Eurex clearing a sample of CDS contracts from the end of July 2009. This is an important development for those using the CDS basis as a measure of LP since it has the potential to effectively remove counterparty risk from the basis equation[2].

Note that the CDS markets are typically more active for investment grade issuers than speculative grades. The iTraxx index of CDS consists exclusively of investment grade issuers.

When calculating the LP relative to swaps we use 5 year swap spreads, matching the term of both the CDS and bond indices used.

Although we are not directly considering the application of our liquidity premium estimates here, there is an implicit assumption that the constituents of CDS index are somehow representative of the portfolio financial instruments for which we aim to measure the LP.

2.1.3 Practical Implementation considerations

Direct CDS spread-based approaches are attractive because of their simplicity but are also sensitive to the choice of bond sample and strongly dependent on data availability which may not match the portfolio being considered.

- ☑ No model dependence and relatively easy to compute – only requires us to take yield differences between two market observable instruments.
- ☑ Provides evidence of the existence of LP from a trade that takes advantage of it.
- ☑ Emerging central clearing counterparties should ensure the negative basis becomes a 'cleaner' estimate for the LP, even in times of market stress.
- ☒ Past estimates could be biased due to CDS liquidity risk, counterparty credit risk, etc.
- ☒ The practicalities of matching CDS and bonds by issuer and maturity and performing calculations in a timely manner are not trivial. Relying on easy-to-compute methods using available indices may create a mismatch which could have a material impact on the results.
- ☒ Attempts to adjust for different applications using easy-to-calculate methods will be limited by the availability of CDS indices.

☒ CDS indices are not available for a broad range of economies (e.g. no CDS index for GBP), making the measures more difficult to calculate. Further work is required to understand how to use this method in other markets and whether conversion of negative basis to different currencies provides a meaningful measure of LP.

2.2 Structural Merton-style model

2.2.1 Summary

An alternative approach is based on a structural model of the default of a firm (proposed by Merton in 1974). Structural approaches using the Merton model are related to the direct method, as discussed below, in that a corporate bond yield is compared to the cost of manufacturing an economically equivalent synthetic position from a risk-free (liquid bond) and an option on the issuing firm's total assets. The fair spread on the synthetic bond is obtained by viewing companies' equity as a call option on its total assets where the strike is the face value of debt. Similarly, debt can be viewed as a package which combines a risk-free bond with a written put option on the firm's assets. As such, the model exclusively describes credit risk and excludes liquidity costs. The liquidity premium is then inferred as the *residual* between the fair spread and the market spread[4]. Figure 1 illustrates the decomposition of the corporate bond (market) spread.

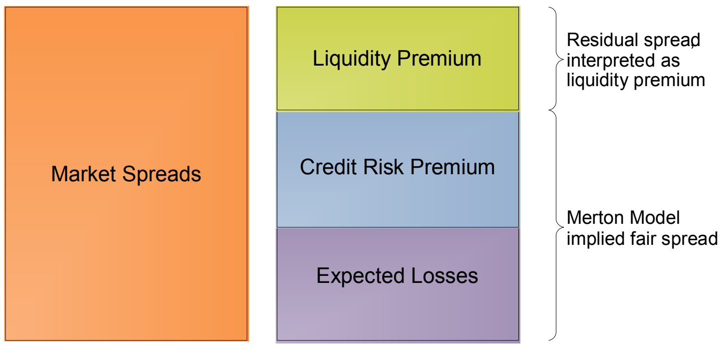

Figure 1: Decomposition of corporate bond spread (not to scale)

As an aside, although we are not interested (for the purposes of this report) in understanding how the fair spread is comprised, the model does provide some important additional insights. The fair spread can be considered to be comprised of two elements. First, an allowance for expected, average default losses. Second, a credit risk premium. In principle, this exists because the holder of a credit-risky bond bears market risk and should be rewarded for carrying that risk in exactly the same way that equity investors demand a risk premium. Indeed, it can be shown that the replicating position for the short put notionally held by bond holders is a geared position in firm assets, so this required risk premium is quite natural. Although the risk premium is sometimes described as an allowance for unexpected defaults it should ***not*** be seen simply as a prudent allowance. Rather, it is a price for risk bearing and will fluctuate in line with other risk premia. Finally, note that Figure 1 is ***not*** drawn to scale. The split between the various elements of the spread will depend on both individual bond characteristics and market conditions.

The options we want to value do not trade but such notional derivatives but can be valued using Merton's model. The model uses the assumption that the firm's assets follow the classical model of finance: geometric Brownian motion.

The model requires a number of inputs:

- Assumptions for the maturity of the debt of the company (T) and its face value (B)
- The volatility of the firm's assets (sigma)
- A risk-free interest rate (r)
- The initial value of total firm assets (V).

[4] *Residual spread is observable if the Merton model fair credit spread estimation does not match the market spread. In addition to liquidity risk, residual spread could also be driven by a mismatch between constituent entities of the corporate bond spread and the Merton model portfolio. Furthermore, residual spread could also reflect differences in model choices and parameterisation.*

In principle, it is possible to apply the model at the level of the individual issuer. KMV's methodology for credit risk is based on this type of thinking although they have their own proprietary approach to exploiting equity market information. In practice, the calculations presented below are based on analysis of a typical firm of a given rating and bond of a specified maturity. The typical spread is then compared to a market average spread for the rating and maturity. The approach followed here can be summarised in terms of the following steps:

1. Set the implied level of debt at bond maturity to be consistent with historic cumulative default rates assuming firm assets exhibit volatility in line with de-leveraged firm-specific equity volatility.
2. Set option volatility based on observed market option costs and de-leverage assumption.
3. Collate risk-free interest rate data.
4. Price the synthetic corporate bond using the Merton model as a risk free bond plus a short put option plus a short binary option on bankruptcy cost.
5. Liquidity premium = market spread – Fair spread (yield on corporate bond)

Note that the frictional costs of bankruptcy are not taken into consideration in the original Merton model. It assumes that in the event of a default, the assets of the company are sold without any discount and the proceeds, in the amount of the actual value of the assets, are distributed among debt holders. In reality, this costless transfer is very unlikely due to legal and accounting implications when liquidation occurs. We believe that the existence of bankruptcy costs has a material impact on the valuation of debt and the extended implementation of the Merton model used in our analysis does take into account these costs. Bankruptcy costs have higher priority than bonds and therefore reduce the proceeds that bond holders will receive in liquidation. Hence, the value of debt decreases when such costs exist. Bankruptcy costs are captured by valuing an additional put option (notionally written by bondholders) that pays a fixed amount (the bankruptcy cost) if firm assets fall below the default threshold at bond maturity.

Note that the Bank of England has adopted a similar structural model approach in their LP estimation work (see Webber 2007). Their estimates tend to be slightly higher than our own, which we believe is in part because they do not including a bankruptcy cost element in their calculations.

2.2.2 Key Assumptions and Data

Our implementation of the structural model includes a number of simplifying assumptions:

- Rather than look at firm balance sheets, the default barrier is simply adjusted to align the probability of default with observed long-term default frequencies.
- The asset value process follows a geometric Brownian motion with constant, non-stochastic asset volatility and interest rates.
- Debt can be adequately represented by a single zero-coupon bond.
- Default only occurs at maturity.

In addition it requires us to input a number of parameters:

- We provide quarterly updates of our dividend yield expectations.
- Expected default rates (for USD and GBP we two alternative data sets are used - from 1920 and from 1970, for EUR we use a dataset starting in 1985).
- Estimates for average firm leverage and the average cost of bankruptcy.

The calculations also require the following input data:

- Interest rates.
- Market spreads: Merrill Lynch market spreads over government bond yields for EUR, GBP and USD, adjusted by subtracting the swap spread.
- Firm asset volatility is estimated by combining equity index implied volatility and estimates for firm-specific equity volatility. A quarterly survey of banks' OTC prices provides estimates for option-implied index volatilities and a market data vendor provides estimates for specific stock volatilities. The relevant index for the option-implied index volatility is chosen according to the economy - EuroStoxx for EUR, FTSE 100 for GBP and S&P 500 for USD.

In terms of application we make no implicit assumption of underlying portfolio since we are able to provide input parameters for different rating and maturity profiles. However, in presenting our results we use the constituent weighting of a Merrill-Lynch investment grade bond index to weight our average. For different applications, alternative weights will be more appropriate and may result in higher estimates.

2.2.3 Practical Implementation considerations

This approach is appealing due to its intuitive explanation and theoretical foundations. However, LP results rely heavily on the quality of the model parameter choices and will also be sensitive to model specification choices.

- ☑ Intuitive explanation of LP effects for corporate bonds.
- ☑ Required data sources available for most major economies, no reliance on high frequency trade data.
- ☑ Calculations are feasible for different rating/maturity combinations.
- ☒ The results are sensitive to model parameter estimates and model choice which are often underpinned by strong assumptions.
- ☒ Model calibration requires expert judgement.
- ☒ In practice, implementation of the model can be complicated which may obscure sensitivities.
- ☒ The equity market volatility assumptions used rely on OTC price quotations rather than actual traded data. This reliance on market information which does not meet the demanding 'deep, liquid and transparent' definition of European regulators may be an issue for some users.

2.3 Direct computation - covered bonds

2.3.1 Summary

Direct methods involve choosing a pair of financial instruments which – other than liquidity – are assumed to offer equivalent cash flows and then comparing prices, expected returns or yields to infer an LP for the relatively liquid asset or portfolio. In principle, there are many potential pairings. In this study we focus on comparing covered bonds to swaps.

A defining feature of covered bonds is the dual nature of protection they offer an investor. Like a normal bond, the issuer (typically a bank) is liable to repay the bond, in the event of default. Unlike a normal bond the investor also has a priority claim on an actively managed pool of high-grade assets. To ensure quality, the types of assets allowed are subject to legalisation (or contracts in some countries).

Given the structure of these instruments many investors assume that covered bonds are virtually risk free. This is not an unfair assumption to make, given that they have a very long history with no default, have an actively managed collateral pool and the investor has dual recourse on the issuer. We found some evidence to support this view – the authors of the BIS September 2007 quarterly review[5] claim that *"covered bonds offer an alternative to developed country government securities for bond investors interested in only the most highly rated securities."* Their event study analysis shows that covered bond spreads have been robust to shocks to both issuer creditworthiness and the value of the underlying collateral – although it should be noted that this work was completed before the onset of the recent crisis. Any difference in yields between these instruments might therefore be attributed to liquidity.

A practical approach relies on having a yield curve for a covered bond index and one for swaps. The calculation is simply:

$$LP_t = CoveredBondIndexYield_t - SwapYield_t$$

Note this gives us a term structure for LP.

2.3.2 Key Assumptions and Data

Since we were interested in examining the term structure we wanted to use an index with a readily available yield curve. We were unable to obtain a 'pure' covered bond yield curve from readily-available market data sources, so a EUR Composite AAA curve is used as a proxy. This is comprised of five euro-denominated fair market curves with a rating of AAA from S&P, Moody's, Fitch and/or DBRS. The constituents at the end of September 2009 included a total of 480, bonds 59% of which are covered and 21% of which have a central

[5] *http://www.bis.org/publ/qtrpdf/r_qt0709f.pdf*

government or FDIC[6] guarantee. 5% have some sort of asset backing are secured or have a company or local government guarantee. Of the remaining bonds the vast majority have implicit government guarantees.

The obvious key assumption here is that AAA-rated covered bonds are risk-free. From a practical standpoint we believe that assuming AAA-rated covered bonds are risk free is a valid assumption to make. Given the significant levels of implicit guarantees in the curve we are using as a proxy, we believe it currently contains very little, if any, credit risk. Note, however, that we did not look at historic constituents, or have any guarantees that this will be case in the future. To verify this we compared the spread over swaps between particular maturities on the composite curve and an index of covered bonds (e.g. iBoxx Covered 5-7 years) with a similar average maturity.

In terms of application this method makes a strong implicit assumption that the portfolio of instruments we are trying to estimate the LP for has very similar features to covered bonds. It is not immediately clear how these estimates can applied to a portfolio containing less liquid instruments, but we believe this approach is useful – potentially as a prudent measure of LP in the corporate bond market.

2.3.3 Practical Implementation considerations

This is a straightforward measure to calculate and explain.

- ☑ No model dependence and relatively easy to compute. Only requires yield curve differences between two market observable instruments.
- ☑ Does not rely on expert judgement.
- ☑ Allows analysis of the term structure.
- ☒ The simple method used here relies on a readily available index that contains some other non-covered/government guaranteed bonds. While these are very high quality they will not be risk free.
- ☒ Potentially biased by other risk factors affecting spreads. For example, despite the active management and rating process there could be additional credit risk resulting from collateral liquidation concerns for covered bonds.
- ☒ While there is an increasing interest in covered bonds, there is still only a limited range of instruments so this method is not readily available for a broad range of economies.

[6] The Federal Deposit Insurance Corporation (FDIC) is a US government corporation that provides deposit insurance to guarantee the safety of deposits in member banks.

3 Results

In this section we present the results of the analytical approaches described in section 2. When reviewing these results we ask the reader to keep following things in mind:

1) The **period analysed is far from typical** when viewed in a long-term context. During the 2005-2006 period bond spreads and market risk premia were unusually low. By contrast, the 2008-2009 period is even more exceptional spanning the extraordinary falls in asset prices and disruption of markets.
2) We do not consider how these methods can be used to estimate the LP for a particular portfolio. Each of the methods make an (implicit or explicit) assumption about the portfolio of financial instruments we are estimating the LP for. The absolute level of our estimate is directly related to these assumptions which we summarise in . Consequently **estimates are not directly comparable** and for any application (such as determining the value of insurance liabilities) **actual estimates could be lower or higher than those presented here**.
3) Despite the broadly consistent overall pattern of results, individual results do raise **questions about the robustness of individual methods** and model choices.
4) All results shown in this section are **relative to swap rates**. Measures relative to government bonds require adding the appropriate swap spread. Note that over this period swap rates have been far from stable - see Figure 2.
5) Although **negative LP is not intuitive and most practitioners believe it should be no less than 0** some of our estimates against swaps are negative. Although we have not explored the reason for this fully we think this could be partly due to the extremely low bond spreads during 2005 and 2006 and instrument specific factors such as differences in coupon rates or the quotation basis and other practical measurement issues.

Table 1: Reference portfolio assumptions used in the different methods

Method	Reference Portfolio Assumption	Issues
CDS Basis approach with CDS Index and synthetic bonds portfolio	Investment grade bonds, 5 year maturity	CDS index not typically representative of investable portfolio.
CDS Basis approach with CDS Index and bond index	Investment grade bonds, 5 year maturity	CDS and bond indices are not well matched – Bond index does not necessarily match the assumption.
Structural Methods	Investment grade bonds, 7-10 year average maturity	Average maturity changes with index constituents used to create average. Provides results for different maturity and credit rating so can target what we need to.
Covered Bonds	AAA covered bonds, Various maturities	Non-covered bonds used in our proxy curve.

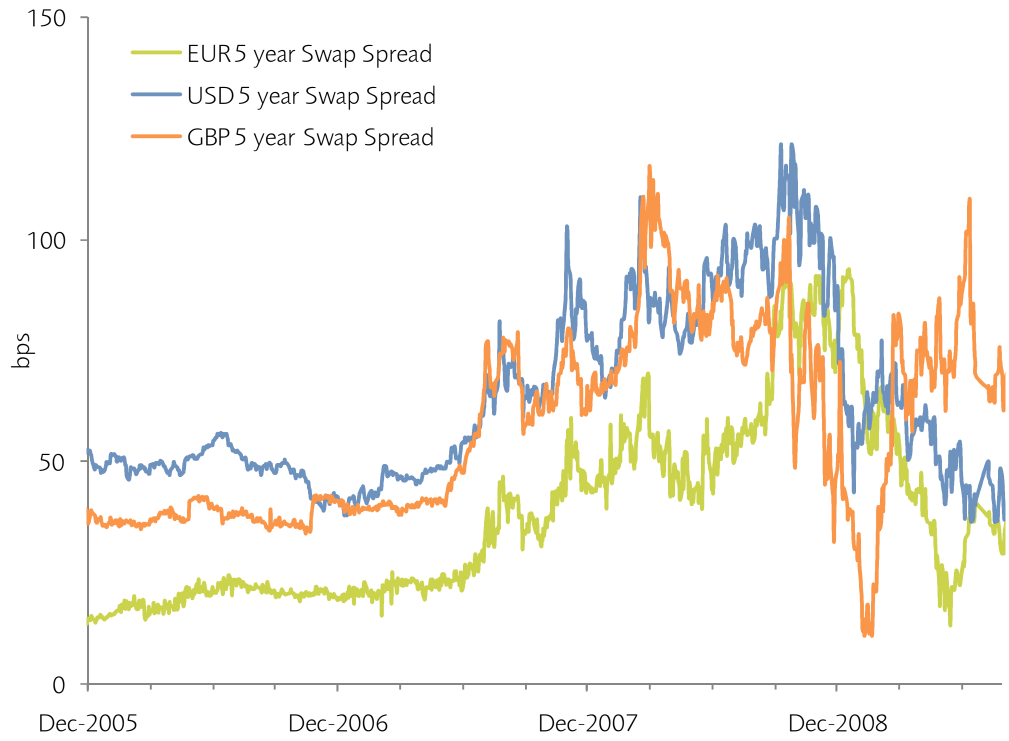

Figure 2: 5 year swap spreads relative to government bonds

Let us examine individual results in more detail[7].

[7] *For reference, the Bank of England model is published in their financial stability reviews available from* *http://www.bankofengland.co.uk/publications/fsr*

3.1 Model free negative CDS basis approach

This approach directly estimates the LP in corporate bond markets. We consider three different pairings:

1. iTraxx CDS index (EUR) and a synthetic corporate bond index consistent with iTraxx[8].
2. iTraxx CDS index (EUR) and the iBoxx 3-5 year investment grade corporate bond index.
3. CDX CDS index (USD) and a Merrill Lynch 3-5 year investment grade corporate bond index.

Figure 3 shows how these estimates vary over time using swaps as the risk-free rate. We see a general increase in LP starting in mid-to-late 2006 and jumping again in mid-to-late 2007. The two estimates for the Euro highlight the sensitivity of this method to choice of reference portfolio. While the iBoxx-Traxx pairing is more readily available and easier to compute, the synthetic index is consistent with the actual constituents of iTraxx and produces an estimate somewhat lower. As a result, care is required when choosing which approximations are made when applying this method.

One way to increase the usability and robustness of this method for different applications would be to create rating and maturity specific buckets from underlying CDS and bond data. Work would be required to explore the liquidity, determining the rules for inclusion and making simplifying assumptions for each bucket.

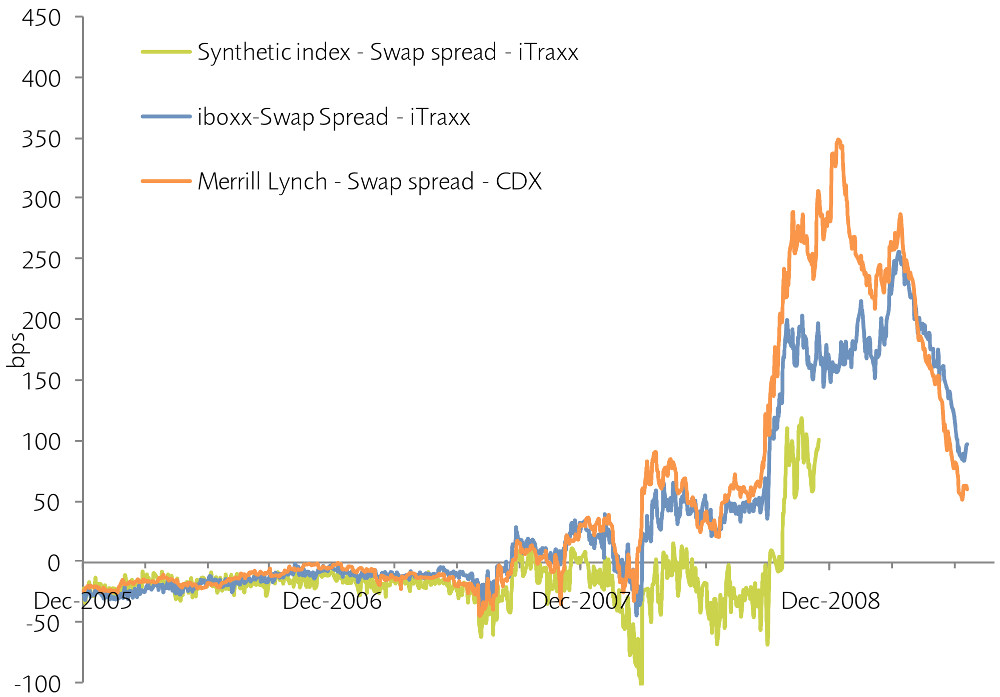

Figure 3: LP estimates derived using the model free negative CDS basis approach using swaps as risk-free rate.

[8] *Note this data series stops at the end of 2008 as the name matching process we used to create an iTraxx portfolio gave too few rating and maturity matches for more recent observations.*

3.2 Structural Merton-style model

We use our own model and assumptions to estimate LP at different points in time. We are only able to provide quarterly updates since we rely here on long-term maturity equity index option data collated from a panel of investment banks[9]. We produce results for each credit class and duration bucket and aggregate this into an average, using the credit class and maturity characteristics of the Merrill Lynch investment grade bond index.

Figure 4 shows our structural model estimates for the three economies and for two sets of default assumptions for the US and UK (where we have a long time-series available) using the spread over swap rates. For USD and GBP similar behaviour to the above estimates can be observed. For EUR, although an increase is apparent, it is not as steep and is yet to fall. Although we are not entirely clear why this is the case, it could be due to the relevance of US default experience for calibrating the model for EUR issuers, or sampling error.

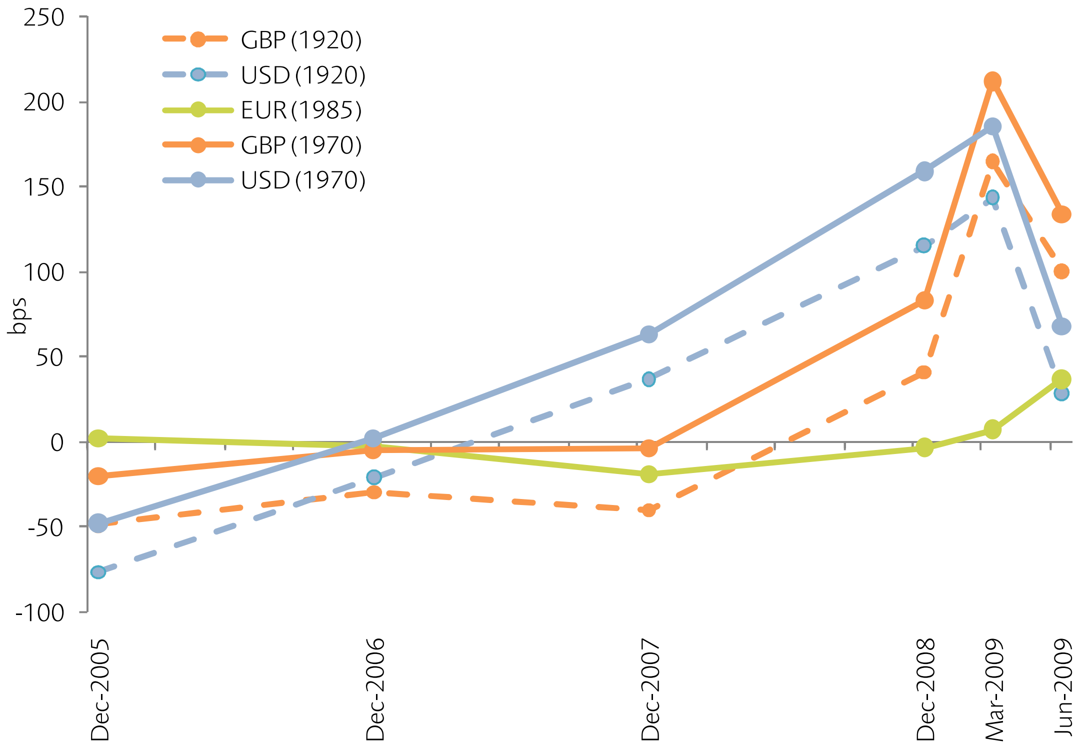

Figure 4: Weighted averages of liquidity premium for EUR (1985 calibration), GBP and USD (1970 and 1920 calibration) for investment grade bonds relative to the spread over swaps.

[9] *Other data sources are available which will provide this data more frequently, but they will make a number of interpolation and extrapolation choices that need to be considered. We are currently investigating other data sources to provide a more frequent service.*

3.3 Direct computation - covered bonds

Figure 5 plots the spread of a covered bond index (here a EUR AAA Composite bond index is used as a proxy) through time for different maturities. We observe a similar pattern to that seen above – with a significant rise in spreads from the onset of the financial crisis. Recall that our methodology looks at the difference in fitted yield curves so this method gives some indication for how the term structure of LP varies through time. We also note a change in the term structure at the end of 2008 for all but 1 year maturity. Before this we see that there is a larger LP in longer maturities, but in 2009 it can be seen that the LP for 15 year maturities is lower, at times, than both that for 5 and 10 maturities. Further analysis is required to understand why, but this does raise questions about how LP estimates can be transformed to instruments with different maturities.

Pure covered bond indices are available but not as yield curves, so an obvious extension here is to construct a covered bond curve which contains only covered bonds.

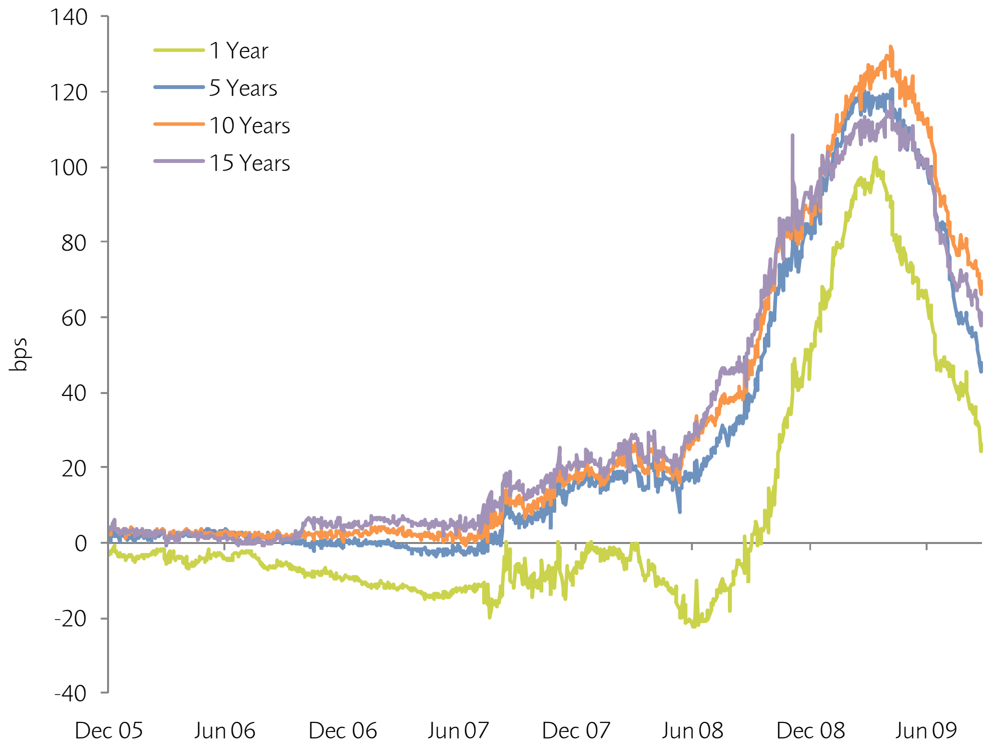

Figure 5: EUR covered bond index proxy - EUR swaps at different maturities

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