Flight to Quality and Flight to Liquidity as Factors in Bond Pricing

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Abstract

Illiquidity and default risk are determinants of bond spreads that models suggest vary across the term structure and across market states. But existent attempts to empirically identify the separate impact of these factors are affected by correlation between them. The Australian sovereign debt market, where the Australian government provided an explicit guarantee over semi-government debt, provides a clean environment in which to examine these separate factors. Using this clean environment, we find that the illiquidity premium is conditional upon market states and particularly important during periods of market stress. We also show that the short end of the term structure premia is explained by illiquidity risk while the long end is explained by market volatility. Spreads at the short end of the term structure are more sensitive to illiquidity shocks than those at the long end.

1. Introduction

Two key factors have been shown to be determinants of time-varying bond spreads; namely default risk and illiquidity risk. For a survey of the impact of illiquidity risk on asset prices, see for example Amihud *et al.* (2005).

Theoretical models of the price of illiquidity risk by, for example, Acharya and Pedersen (2005) and Ericsson and Renault (2006), provide three central implications; namely that aversion towards illiquidity is time-varying and positively related to volatility, that cross-asset correlations are positively related to illiquidity, and that illiquid assets demonstrate greater price sensitivity than do liquid assets to aggregate market-wide illiquidity. Consistent with predictions from these models, studies such as those by Acharya *et al.* (2013) and Dick-Nelson *et al.* (2012) report that illiquidity premia are significantly larger during periods of crisis than they are in normal states.

But as demonstrated by Beber *et al.* (2009), both default risk and illiquidity risk become more prevalent during periods of market stress, when investors increase their aversion towards risky and illiquid assets, resulting in both a flight-to-quality and a flight-to-liquidity. Specifically, Beber *et al.* (2009) report that while default risk is the key determinant of bond spreads during normal periods, illiquidity is the key driver of spreads during crises.

However the correlation between default risk and illiquidity risk, and the concomitant correlation between flight-to-quality and flight-to-liquidity, creates empirical challenges when attempting to disentangle their impacts on bond spreads. Crucially, as all of the above-mentioned studies focus on bonds with different default risks, namely US corporate bonds and European sovereign bonds respectively, they are not able to provide a clean examination of the differential impact of illiquidity risk across market states. Ericsson and Renault (2006) show that default risk and illiquidity risk are usually positively correlated in the United States corporate bond market, while Beber *et al.* (2009) report a negative correlation between default risk and illiquidity for European sovereign debt.

This study provides a clean examination of bond spreads by exploiting an environment that permits the separate identification of default risk and illiquidity risk factors. We examine the spread between Australian government bonds and semi-government bonds. From 25 March 2009 to 31 December 2010 the Australian government provided a guarantee on semi-government debt (Lancaster and Dowling (2011)). For this period the spread between Australian government and semi-government debt will solely reflect illiquidity risk.

Further, vertical fiscal integration between the States and Commonwealth Government minimises the probability of a state defaulting *conditional* on the Commonwealth Government not defaulting over the period before and after the explicit Australian government guarantee was implemented. Our sample period from 2002 to 2012 also includes two periods of significant market stress: the Global Financial Crisis and the subsequent European sovereign debt crisis. By minimising the impact of default risk over this extended period, we are better able to isolate the impacts of illiquidity risk and flight-to-liquidity across market states.

The differential impact of illiquidity premia across the term structure has also garnered recent attention. Ericsson and Renault (2006) provide a theoretical model where illiquidity premia are positively correlated with default risk and the illiquidity premia is a decreasing function of time to maturity. Only two existent studies have undertaken an empirical examination of this relationship in an environment that controls for default risk (Longstaff, 2004; Kempf *et al.* 2012). Longstaff (2004) reported a U-shaped liquidity term structure when comparing the yield between Treasuries and so-called Refcorp bonds, that is, bonds issued by a government agency and where their principal is fully collateralised by Treasury bonds and full payment of coupons is guaranteed by the Treasury. However, his sample was limited as only six Refcorp bonds were available for comparison. Kempf *et al.* (2012) reported that separate economic factors drive short-and long-term illiquidity premia. They showed that asset market volatility explains the short-term illiquidity premium, while long-term economic risks affect the long-term illiquidity premium.

Both existent studies of the term structure of the illiquidity premia focus on the period prior to the Global Financial Crisis and do not examine the differential impact of illiquidity and default risk on the term structure across different market states. Our sample period from 2002 to 2012 permits us to examine the differential impact of the term structure of illiquidity across different market states and to extend upon Beber *et al.* (2009) to determine whether the flight to liquidity during periods of market stress occurs at the short or long end of the term structure.

The paper proceeds as follows. Section 2 provides a discussion of the institutional features of the Australian sovereign debt market. The data are described in Section 3 with the results presented in Section 4. A summary is provided in Section 5.

2. Institutional Features of the Australian Sovereign Debt Market

As detailed in Twomey and Withers (2007, p. 37), the level of vertical fiscal integration resulting from the Australian Constitution is 'the most extreme of any federation in the industrial world'. As they document, across the 1990s for the five major federations that they examined (Australia, Canada, Germany, Switzerland and the United States), Australia had the highest share of federal government spending, the highest share of federal taxation, and the largest relative gap between these two measures.

This imbalance is addressed by the States receiving Federal funding from two main sources. Commonwealth revenue received from Goods and Services Tax is paid to the States and Territories according to a formula applied by the Commonwealth Grants Commission aimed at producing 'horizontal fiscal equity' across the jurisdictions. The intention of this formula is to ensure the equalisation of infrastructure and services across the States and Territories. The other main source of revenue to the States and Territories is via so-called Specific Purpose Payments provided by the Commonwealth Government. The effect of strong vertical fiscal integration in Australia is that, while there is no explicit Commonwealth guarantee of State and Territory debts, the system of revenue sharing results in cash flows to State and Territory governments that are relatively uncorrelated with economic conditions within those jurisdictions.

With respect to the State of New South Wales, there are reasons in additional to that of vertical fiscal integration between the States and Commonwealth Government to expect the probability of that state defaulting *conditional* on the Commonwealth Government not defaulting to be minimal.. Both NSW and Commonwealth debt held a AAA credit rating with Standard and Poor's across the study period. Further, these debts are both risk-weighted at 0% under the Basel regulations and are both eligible securities for repurchase agreements.[1] Further, in 2012 New South Wales represented 32% of the Australian population (Australian Bureau of Statistics (2013)) and 30% of Australian Gross Domestic Product (Australian Bureau of Statistics (2012)).

While over our entire study period the probability of New South Wales defaulting *conditional* on the Commonwealth Government not defaulting is expected to be minimal, from25 March 2009 to 31 December 2010 it was reduced to zero due to the Australian government guarantee of semi-government debt.

The implementation of this Australian government guarantee provides us with a unique environment that we can exploit to undertake a model-free examination of the relative importance of the default and illiquidity premia during times of market stress and normalcy. Figure 1 reports the daily change in the 3-, 5- and 10-year spreads upon the initiation of the Australian government guarantee. The spreads declined by 28, 31 and 27 basis points respectively upon implementation. The magnitude of the decline in each spread represents the size of the conditional default premia that was priced into the market yields of each of the bonds examined in this study. Furthermore, the magnitude of the remaining spread represents illiquidity risk. After the government guarantee was implemented, the spreads were 82, 91 and 111 basis points respectively across the term structure. Therefore, we can ascertain that default risk attributes a relatively small proportion to the total spread during periods of market stress, as it only accounts for 25% (20%) of the total spread at the short (long) end of the term structure.

Figure 2 shows the change in spreads at the cessation of the Australian government guarantee. The 3-, 5- and 10-year spreads increased by 12, 18 and 18 basis points respectively on the day that the government guarantee was removed. The magnitude of the liquidity premium for these three spreads on the day before cessation was 17, 27 and 36 basis points respectively. Therefore, default risk can be shown to account for 41%

[1] See Reserve Bank of Australia Technical Notes http://www.rba.gov.au/mkt-operations/resources/tech-notes/eligible-securities.html Accessed 26 August 2013

(33%) of the total spread at the short (long) end of the term structure at a period when relatively calm had returned to financial markets. This result suggests that default risk is a more important determinant of spreads during periods of normalcy.

3. Data

Our analysis is based on bond yield data provided by the Reserve Bank of Australia. The market yield for 3-, 5- and 10-year maturities is provided for both Australian government bonds and NSW semi-government bonds on a daily basis. The spread between semi-government and government bonds is then calculated as follows:

$$\Psi_{n,t} = i_{NSW,n,t} - i_{Australia,n,t} \quad (1)$$

Where Ψ_t is the spread for bonds with *n* years to maturity at time *t*, $i_{NSW,n,t}$ is the market yield on NSW semi-government bonds with *n* years to maturity at time *t* and $i_{Australia,t}$ is the market yield on Australian government bonds with *n* years to maturity at time *t*.

We also examine the term structure of the spread to perform an empirical test of Ericsson and Renault's (2006) theoretical model where the illiquidity premia is a decreasing function of time to maturity. The term structure of the spread is calculated as the difference between the 10-year spread and the 3-year spread, as follows:

$$\delta_t = \Psi_{10,t} - \Psi_{3,t} \quad (2)$$

Where δ_t is the term structure of the spread at time *t*.

Our analysis takes place across a ten-year period from September 2002 to September 2012. This sample period provides two key benefits. First, it includes two periods of market stress: the Global Financial Crisis and the European sovereign debt crisis. The inclusion of periods of market stress within our sample is important, as recent studies have argued that a 'flight to liquidity' takes place during periods of market stress, increasing illiquidity premia during these periods (Brunnermeier and Pedersen (2009), Acharya *et al.* (2013)). Second, our sample includes a 21-month period where NSW semi-government bonds were covered by the Commonwealth Government guarantee, allowing for illiquidity premia to be examined across this period without the confounding impact of default risk.

Figure 1 reports innovations in the 3-, 5- and 10-year spreads across our sample period. The average spreads across the entire sample are 25 basis points, 28 basis points and 31 basis points respectively. All three spreads increased substantially from mid 2007 onwards and then again from early 2011. It could be argued that the periods where the spreads increased substantially are associated with the Global Financial Crisis and the European sovereign debt crisis. The grey shaded areas in Figure 1 represent periods when the Australian economy is contracting according to the Melbourne Institute's 'phase of the business cycle' dating of the business cycle. It is clear that, on average, the spreads increase during periods of contraction and decrease during periods of expansion. The average 3-, 5- and 10-year spreads are 21 basis points, 26 basis points and 27 basis points respectively during of 'expansion' and 46 basis points, 54 basis points and 58 basis points respectively during periods of "contraction". Figure 1 provides formative evidence in support of the argument that illiquidity premia increase significantly during periods of market stress (Beber *et al.* (2009), Brunnermeier and Pedersen (2009)).

The term structure of the spread across time is reported in Figure 2. While the term structure of the spread is generally positive, there are three instances across our sample in which it becomes negative, and all three instances are during periods of 'contraction' as defined by the Melbourne Institute. These negative values of the term structure during periods of contraction provides formative evidence to suggest that flights to liquidity are more prominent at the shorter end of the term structure in times of market stress.

We examine the economic drivers behind the bond spread and the term structure of the spread by incorporating into our models a number of are proxies for default risk and illiquidity risk.

To calculate our bond illiquidity measure, we collected the full order book of quoted prices for on-the-run Australian government bonds from Sirca. For each quote, we calculate an adjusted spread as the bid-ask spread divided by the midpoint of the quote. The bond illiquidity measure is then calculated as the first difference of the equal-weighted average of these adjusted spreads. Following Acharya *et al.* (2013), we add a second illiquidity variable as a control variable. This second variable is aggregate stock market illiquidity, which is measured as the market's average Amihud (2002) price impact ratio. We use daily returns and volume data from Sirca and calculate the Amihud (2002) measure as the equal-weighted average of the ratio of the absolute value of a stock's daily returns to its daily volume. This measure is averaged over each of the trading days in the month to provide a monthly stock illiquidity measure.

We measure default risk by using variations in international risk factors, as proxied by the spread between US Aaa and Baa corporate bonds. This data was obtained from Laura Xiaolei Liu's homepage and is an updated version of the default spread variable used by Liu and Zhang (2008). The US default spread is used for two reasons. First, several studies that examine spreads on sovereign debt in the Euro zone show that the spreads are related to an international measure of risk aversion, which can be measured as the US default spread (Codogno *et al*. (2003), Favero *et al*. (2009)). Second, as the Australian corporate bond market has only a small number of listed securities and is very illiquid, Australian measures of the default spread are unreliable.

It has been suggested that flights to liquidity may be conditioned by market-wide volatility, as investors place greater value on the ability to rebalance their portfolios during periods of high volatility (Acharya and Pedersen (2005), Ericsson and Renault (2006)). We measure volatility independently for each term to maturity by using a GARCH (1,1) model to estimate one-day-ahead volatility. The estimated daily volatility is then averaged across each month.[2]

We also include a variable that measures the international flow of funds into Australian sovereign debt markets. International flow of funds is measured as the first difference of the proportion of Australian government bonds owned by international investors less the proportion of semi-government bonds owned by international investors. The inclusion of this variable is motivated by Lancaster and Dowling (2011), who argued that the widening of the spread between Australian government and NSW semi-government bonds during the Global Financial Crisis may have been due to an irrational inflow of funds from international investors who are were unaware of the degree of vertical fiscal integration in Australia. Data on the international flows of funds into government and semi-government bonds was collected from the Australian Bureau of Statistics.

[2] In unreported results, we also calculated volatility as the standard deviation of daily yields within each month. All of the results reported in this paper are robust to this alternative measure of volatility.

Table 1 reports descriptive statistics for each of the explanatory variables used in this study. As expected, there is a moderate positive correlation between the two illiquidity measures (Illiq and Ami). This positive correlation indicates that there is some commonality in the factors that affect illiquidity across asset classes. The default risk factor (DEF) is positively correlated with both illiquidity measures and volatility. The positive correlation between default risk and illiquidity is consistent with previous findings (Ericsson and Renault (2006)) and emphasises the importance of ability to observe the illiquidity premium independently from the default premium for the duration of the government guarantee.

4. Unconditional model of sovereign bond spreads

We begin by examining the unconditional effect of economic factors on the bond spreads examined in this study. Our baseline unconditional model is specified as follows:

$$\Psi_{n,t} - \Psi_{n,t-1} = \alpha_t + \beta_1(\Psi_{n,t-1} - \Psi_{n,t-2}) + \beta_2 Illiq_t + \beta_3 Ami_t + \beta_4 DEF_t + \beta_5 Vol_t + \beta_6 FOF_t + \varepsilon_t \qquad (3)$$

where $Illiq_t$ is the bond illiquidity measure at time *t*, Ami_t is the Amihud (2002) measure of equity market liquidity at time *t*, DEF_t is the spread between US Baa and Aaa corporate bonds at time *t*, Vol_t is the volatility of the Australian government yields at time *t* and FOF_t is the flow of international funds into the Australian government bond market relative to the flow of international funds into the semi-government bond market at time *t*.

Given our sample period includes a 21-month period where semi-government debt was explicitly guaranteed by the Australian government, we augment Equation 3 with additional slope and intercept dummy variables to account for variation in the sensitivity to our economic factors across this period. This augmented model is specified as follows:

$$\Psi_{n,t}-\Psi_{n,t-1} = \alpha_t + \beta_1(\Psi_{n,t-1} - \Psi_{n,t-2}) + \beta_2 Illiq_t + \beta_3 Ami_t + \beta_4 DEF_t + \beta_5 Vol_t + \beta_6 FOF_t \qquad (4)$$
$$+ \beta_7 D_{GG} + \beta_7(D_{GG} \; x \; Illiq_t) + \beta_8(D_{GG} \; x \; DEF_t) + \beta_9(D_{GG} \; x \; Vol_t) + \varepsilon_t$$

where D_{GG} is a dummy variable that takes the value of 1 during the period of the Australian government guarantee and 0 otherwise.

Table 2 reports the coefficient estimates for Equation 4, with the 3-, 5- and 10-year spreads used as dependent variables. Of note, the bond illiquidity variable is positively related to changes in the spread at the short end of the term structure, but not the long end. The coefficient on the volatility variable is positive and statistically significant for all three spreads. This result indicates that volatility is the key driver of spreads at the long end of the yield curve, as it is the only statistically significant factor. Interestingly, the coefficient on the interaction term between volatility and the government guarantee is negative and significant for both the 5- and 10-year spreads, indicating that volatility was We interpret this result to mean that our volatility variable is capturing default risk, as this component of the spread is removed during the period of the government guarantee. Taken together, these results can be interpreted as showing that illiquidity is an important determinant of spreads at the short end of the yield curve, but default risk is the key driver of long term spreads.

We also investigate the factors affecting the term structure of bond spreads, by estimating the following model:

$$\delta_t = \alpha_t + \beta_1(\Psi_{n,t-1} - \Psi_{n,t-2}) + \beta_2 Illiq_t + \beta_3 Ami_t + \beta_4 DEF_t + \beta_5 Vol_t + \beta_6 FOF_t \qquad (5)$$
$$+ \beta_7 D_{GG} + \beta_7(D_{GG}\ x\ Illiq_t) + \beta_8(D_{GG}\ x\ DEF_t) + \beta_9(D_{GG}\ x\ Vol_t) + \varepsilon_t$$

Table 3 reports the results from the estimation of Equation 5. The coefficient on the bond illiquidity variable is negative and statistically significant. The significance of this coefficient indicates that the term structure of the spread moves towards being downward sloping in periods of high illiquidity. This result provides further evidence to support the argument that the shorter end of the yield curve is more sensitive to illiquidity shocks.

5. Conditional models of sovereign bond spreads

It has been suggested that the relative importance of default and illiquidity risk varies across market states (Beber *et al.* (2009), Brunnermeier and Pedersen (2009)). We provide an empirical test of this assertion. In our model the world is defined as being in one of two states: expansionary or contractionary. We use the Melbourne Institute's dating of the business cycle as an exogenous measure of the market state. Equation 3 is estimated across both states and a Wald test is used to test for any differences between coefficients.

The results from our Wald tests for differences in coefficients across market states are reported in Table 4. The differences between the coefficients for the bond illiquidity variable are positive and statistically significantly for the 3- and 5-year spreads. Similarly, the difference between coefficients for the Amihud (2002) measure is also positive and significant for the 5-year spread. These differences provide empirical evidence to support the notion that illiquidity has a greater impact on spreads during market stress. Furthermore, the difference between coefficients for the volatility variable are negative and significant for the 5-year spread, which indicates that changes in this spread are less sensitive to volatility during contractionary periods.

None of the coefficients are statistically significantly different for the 10-year spread or the term structure. The lack of significant differences between coefficients for the 10-year spread indicates that market stress has a differential impact along the term structure. Shorter term securities become significantly more sensitive to illiquidity during market stress, but the effect is not as strong for longer term securities.

6. Summary

The Australian sovereign debt market provides a clean environment in which to examine the separate impact of default risk and illiquidity risk across market states and across the term structure. The illiquidity premium is found to be conditional upon market states and particularly important during periods of market stress. We show that the short end of the term structure premia is explained by illiquidity risk while the long end is explained by market volatility. Spreads at the short end of the term structure are more sensitive to illiquidity shocks than those at the long end.

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Figure 1: Change in spreads at the implementation of the Australian government guarantee

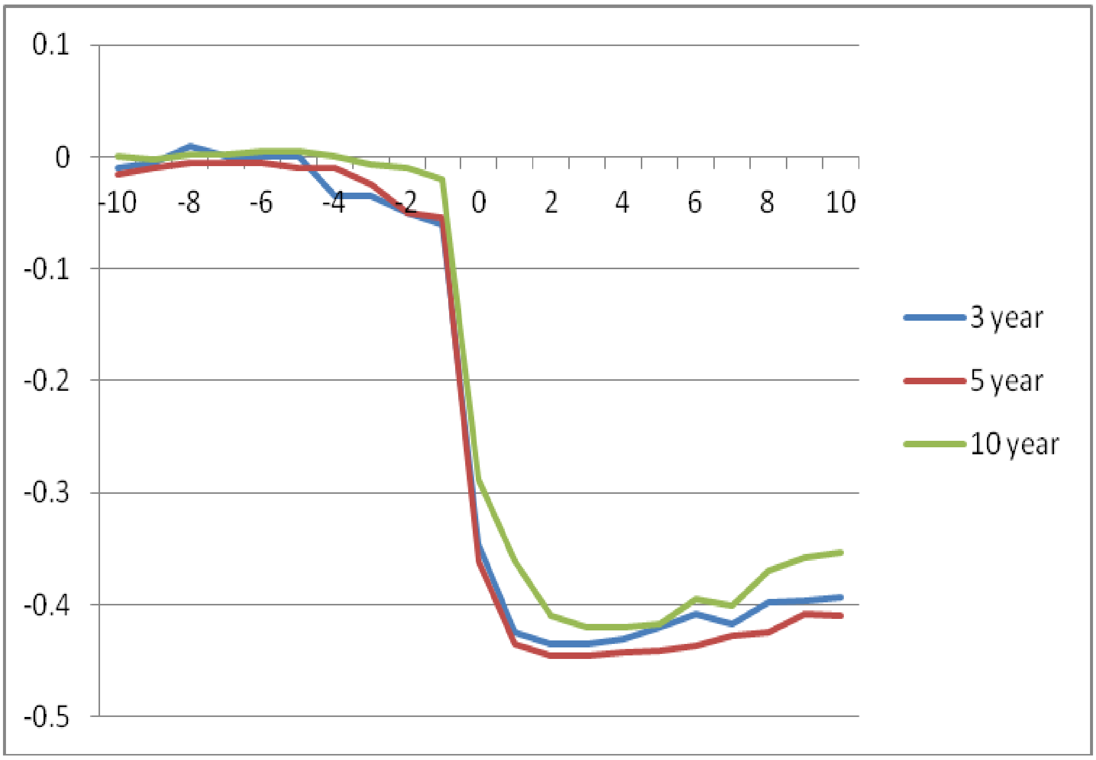

Figure 2: Change in spreads at the cessation of the Australian government guarantee

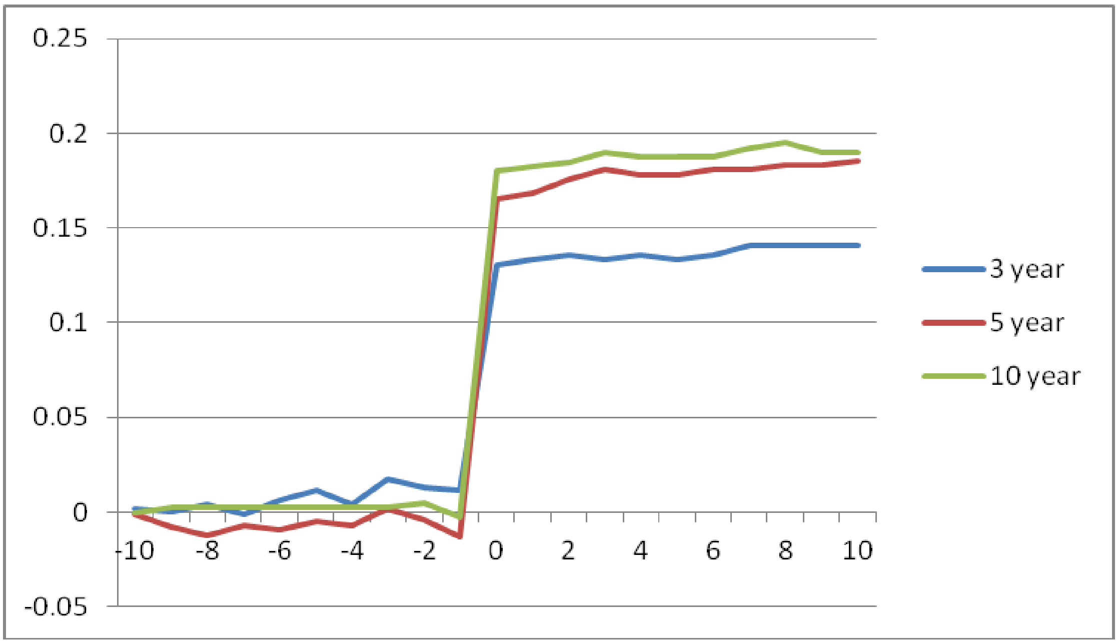

Figure 3: Spreads across time

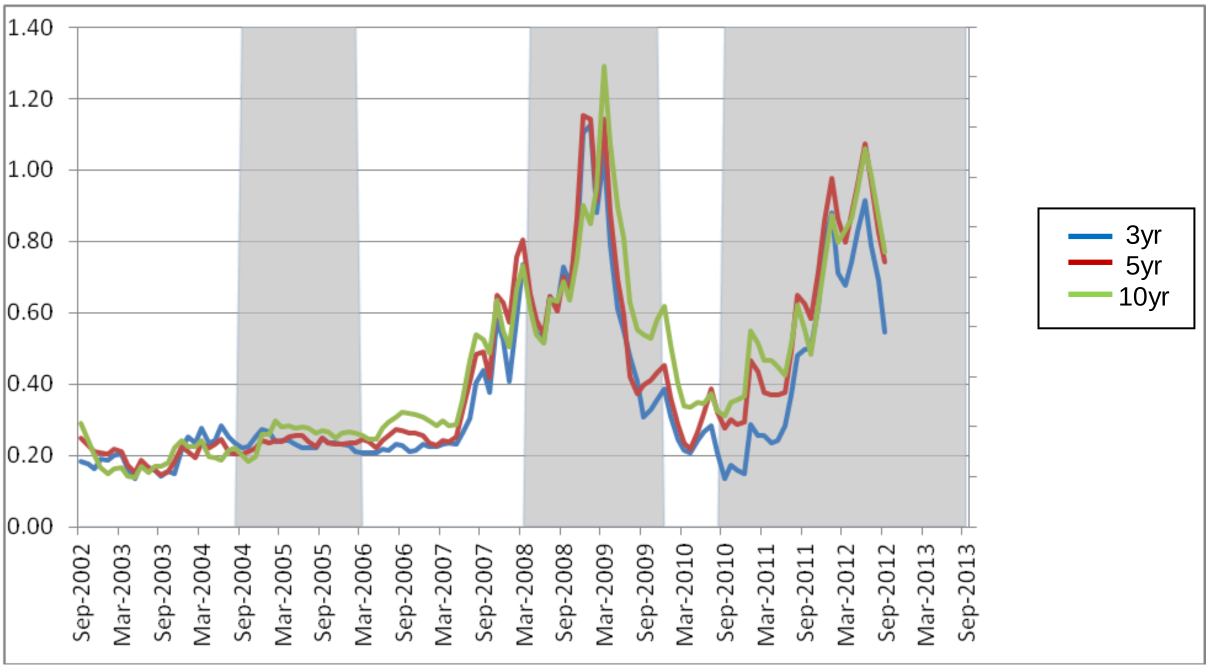

Figure 4: Term structure of spreads across time

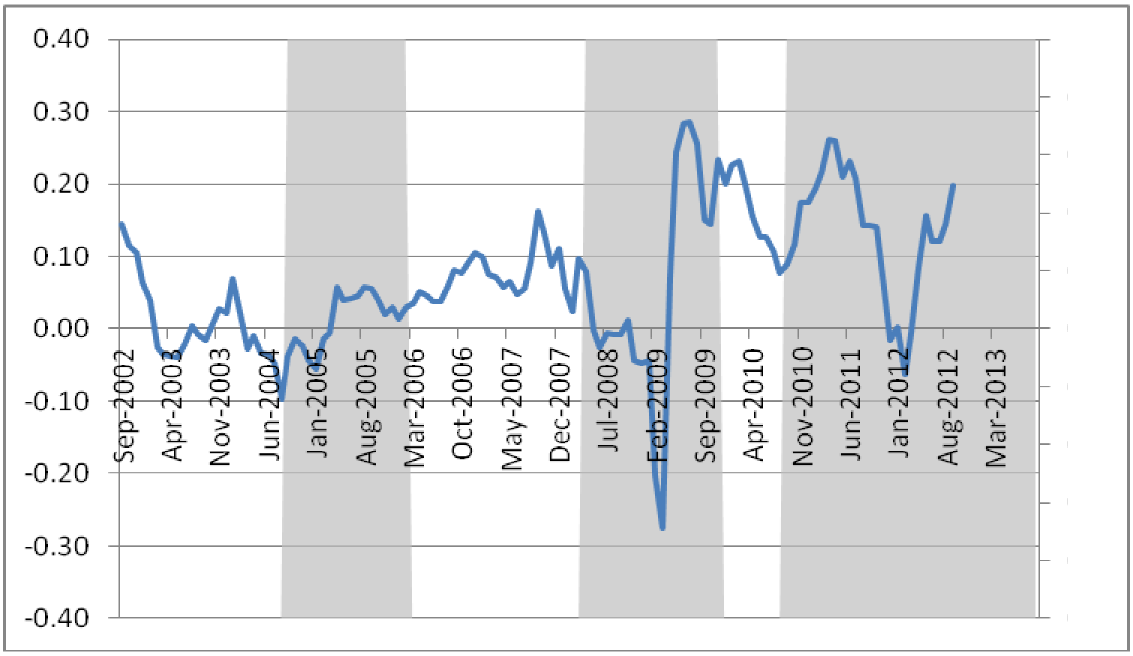

Table 1: Descriptive Statistics

Panel A

	Illiquid	Ami	Vol	DEF	FOF
Average	0.011	0.157	0.028	0.012	0.008
Median	0.009	0.065	0.014	0.01	0.009
St Dev	0.131	0.259	0.034	0.005	0.03
Min	-0.388	0.008	0.003	0.006	-0.06
Max	0.712	2.084	0.204	0.034	0.092

Panel B: Correlation Matrix

	Ami	Vol	DEF	FOF
Illiquid	0.295	0.204	0.165	-0.103
Ami		0.238	0.496	-0.037
Vol			0.65	0.106
DEF				-0.022

Table 2: Unconditional model of spreads

	3 Year Spread	5 Year Spread	10 Year Spread
Intercept	0.083	0.044	0.044
	(1.732)	(1.186)	(1.251)
$\Psi_{n,t-1} - \Psi_{n,t-2}$	-0.094	-0.015	0.057
	(-1.026)	(-0.163)	(0.624)
Illiquid	0.323	0.197	0.081
	(2.324*)	(1.74)	(0.803)
Ami	0.032	0.09	0.047
	(0.423)	(1.453)	(0.847)
Vol	1.535	1.503	1.7
	(2.283*)	(2.787**)	(3.474**)
DEF	-8.234	-5.399	-6.626
	(-1.525)	(-1.421)	(-1.683)
FOF	0.411	0.634	0.38
	(0.772)	(1.437)	(0.976)
D_{GG}	-0.104	-0.071	-0.017
	(-0.772)	(-0.626)	(-0.166)
D_{GG} ***Ill**	0.063	0.535	0.102
	(0.124)	(1.263)	(0.275)
D_{GG} ***DEF**	7.022	9.941	4.942
	(0.585)	(0.986)	(0.553)
D_{GG} ***Vol**	-3.164	-4.437	-4.08
	(-1.148)	(-1.984*)	(-2.001*)
R^2	0.184	0.218	0.226

Table 3: Unconditional model of term structure

	Term Structure
Intercept	-0.000
	(-0.025)
$\Psi_{n,t-1} - \Psi_{n,t-2}$	0.849
	(14.091**)
Illiquid	-0.147
	(-3.737**)
Ami	-0.002
	(-0.071)
Vol	0.315
	(1.625)
DEF	0.275
	(0.171)
FOF	-0.106
	(-0.697)
D_{GG}	0.01
	(0.258)
D_{GG} *Ill	0.176
	(1.197)
D_{GG} *DEF	3.399
	(0.983)
D_{GG} *Vol	-1.495
	(-1.902)

Table 4: Differential coefficients across states

This table reports the differential coefficients for the following model estimated across market states:

$\Psi_{n,t} - \Psi_{n,t-1} = \alpha_t + \beta_1(\Psi_{n,t-1} - \Psi_{n,t-2}) + \beta_2 Illiq_t + \beta_3 Ami_t + \beta_4 DEF_t + \beta_5 Vol_t + \beta_6 FOF_t + \varepsilon_t$

Two market states are identified: expansionary and contractionary. These market states are identified using the Melbourne Institute's phases of the business cycles. The table below reports the difference between coefficients in the contractionary and expansionary states. P-values from the Wald test for difference are reported in parentheses underneath their associated values.

	3 year	5 year	10 year	Term Structure
Illiq	0.546	0.657	0.328	-0.138
	(0.043*)	(0.003**)	(0.099)	(0.078)
DEF	2.995	-1.297	6.583	0.378
	(0.840)	(0.914)	(0.554)	(0.382)
Vol	-2.946	-2.790	-1.400	-0.098
	(0.482)	(0.021*)	(0.205)	(0.982)
Ami	0.239	0.369	0.245	0.044
	(0.274)	(0.034*)	(0.129)	(0.498)
FOF	1.211	0.919	0.847	-0.199
	(0.267)	(0.288)	(0.293)	(0.532)