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Dynamic Sources of Sovereign Bond Market Liquidity*

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Abstract

Using 482 US Dollar and Euro denominated bonds issued by 72 sovereigns, we examine the dynamic sources of time-series and cross-sectional variations in *market-wide liquidity* of sovereign bonds as a novelty in the sovereign fixed income literature. Vector autoregression analysis shows that macroeconomic fundamentals and the financial market variables play a substantial role in the movements of aggregate liquidity throughout the whole sample period (1999-2010), although their effects are stronger during the financial crisis. Specifically, US industrial production growth rate and inflation rate have significant informative powers on the sovereign bond market liquidity. An increasing shock to the TED spread (the spread between 3-Month Libor and US T-bill), a measure of distrust in the banking system, has detrimental impact, while on the other side equity market performance is positively linked to market-wide bond liquidity. Furthermore, the direction of causality from the world financial and macroeconomic variables towards the aggregate bond market liquidity is confirmed by Granger causality tests. Finally, impulse response functions show that these relationships are persistent up to one-year forecast horizon.

JEL Classifications: G10,G15, E4, E44

Keywords Sovereign Bond Market, Liquidity, Financial Markets

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Contents

1 Introduction

Recent studies on the sovereign and corporate bond markets show that a sizable component of bond yield spreads is due to factors other than default risk (Chen, Lesmond, and Wei (2007), Collin-Dufresne and Martin (2001), Huang and Huang (2003), Kucuk (2010)). Liquidity, the ability of investors to buy or sell large quantities of securities quickly at low cost and without substantially influencing the price, is found to be essential in explaining the variations in yield spreads across different bonds (Kucuk (2010), Ferrucci (2003), Duffie, Pedersen, and Singleton (2003), and Beber, Brandt, and Kavajecz (2006)). Although, there is extensive research on the relationship between the liquidity and the yield spreads of corporate bonds, researchers have done little to explain the sources of time series variation in the bond market liquidity. To fill this gap therefore, this paper analyzes the sources of time-series and cross-section variation in aggregate sovereign bond market liquidity.

The studies by Chordia, Roll, and Subrahmanyam (2000) and Chordia, Roll, and Subrahmanyam (2001) identified the concept of *liquidity commonality*. Their results have introduced the research on the effects of market-wide liquidity. Indeed, Pastor and Stambaugh (2003) investigate whether market-wide liquidity is an important state variable for asset pricing and find that expected stock returns are related cross-sectionally to the sensitivities of returns to fluctuations in aggregate liquidity. As an attempt to determine the sources of liquidity, Fujimoto (2004) using a long time-span data set finds that macroeconomic sources play important role in determining the the time-series variation in the US stock market liquidity. Studies including Chordia (2005) and Goyenko and Ukhov (2009) go one step further to analyze the joint dynamics of US stock and US Treasury bond market liquidity.

In this paper, we examine the sources of time-series and cross-sectional variation in the aggregate liquidity of sovereign bond market by analyzing the joint dynamics of world financial and macroeconomic variables and aggregate bond liquidity. Our research has a number of significant contributions to both sovereign debt literature and to the literature on the aggregate bond market liquidity. First, to the best of our knowledge, this work is the first attempt to identify the sources of aggregate liquidity in the sovereign bond market.

Second, we investigate the time-series link between aggregate sovereign bond market liquidity, the financial market variables and the macroeconomic fundamentals by employing vector autoregression (VAR) analysis. VAR results reveal that macroeconomic fundamentals play a substantial role in the movements of liquidity throughout the whole sample period while their effects are stronger during the financial crisis, i.e. 2006 to 2010. We find that US industrial production growth and inflation rates are positively associated with the aggregate bond market liquidity. Positive relationship between the inflation rate and market-wide liquidity could be due to the fact that inflation reflects the demand side of the economy and an increase in the inflation would be a sign of improving demand and thus recovery during recessions. Similarly, the market variables, TED spread (3-Month Libor - T-bill Spread) and equity market performance have bigger impacts on bond liquidity during the current crisis.

Third, we exploit the Granger causality tests in order to test the direction of causality. Further, we use impulse response functions to quantify the persistence of the effects of the macroeconomic and the financial market variables on the aggregate bond liquidity. The findings of this section confirm the VAR results that the innovations in industrial production, equity market performance and TED spread are particularly important during the period of 2006 to 2010.

Fourth, variance decomposition results reveal that sovereign bond market liquidity is more

responsive to real sector and financial market shocks than the monetary shocks. This is a striking result as it has been documented that the US Federal Reserve, through its ability of changing the money supply, significantly influences the trading of T-bills (Harvey and Huang (2001)). In our case however, 81% of the variance in the bond liquidity measured as bid-ask spread is explained by US industrial production growth rate, TED spread and S&P500 performance index.[1]

We further analyze the cross-section determinants of the bond market liquidity across all the eligible bonds 72 sovereigns traded during 1999 to 2010. We use balanced panel regressions of bond liquidity variables on bond specific variables, the financial market and the macroeconomic variables. While an expansionary monetary policy by the FED turns out to be positively related to the sovereign bond liquidity, the episodes of distrust among the banking system, i.e. a substantial increase in Libor and a decrease in T-bill yields, are negatively associated with the bond liquidity. Contrary to our VAR analysis in the previous sections, in general, the panel regression results are robust to estimating the regression with different sub-sample time periods.

The rest of this paper is organized as follows. Section II describes our bond data, the financial market indicators and macroeconomic fundamentals used in our analysis. Section III presents our bond liquidity measures and their summary statistics. Section IV introduces our VAR model and its results together with the results of the Granger causality tests, variance decompositions and impulse response functions. Section V presents our panel regressions of bond liquidity on bond specific variables, the market and the macroeconomic variables. Finally , Section VI concludes.

[1]This is the result of variance decomposition analysis with *one-year forecast horizon*.

2 Data

2.1 Bond Sample

Our sample uses 482 internationally traded bonds, which were issued by 72 sovereigns. We include all of the US Dollar and Euro denominated sovereign bonds, for which the price, bid-ask and transaction volume data are available by the ISMA via Thomson Financial Datastream. By using the data from January 1999 to December 2009, a maximum of 132 monthly data points is reached to use in our vector autoregression analysis.

Table 1 presents the bond sample used in our analysis. The first column is the name of the borrower country, the second column is the number of its bonds, third column is the total issued amount of its bonds in our sample and the last column is the borrower country's long term rating by Moody's as of December 2009. For countries whose Moody's rating is not available we use the corresponding long term borrower rating from Standard and Poor's. Number of bonds per country varies from a minimum of one [2] to a maximum of 33 by Austria with an average of 6.8 bond per country. Moody's long term ratings vary from C to Aaa with median rating of Baa1.

Table 2 presents the summary statistics of internationally traded bonds of the sovereigns listed in Table 1. Rating variable is a number given to letter rating of Moody's Long Term Sovereign Debt Rating. Rating number 5 is given to the lowest rating C and the number 25 is given to the highest rating AAA.

[2]There is only one internationally traded bond for countries Abu Dhabi, Australia, Fiji Islands, Finland, France, Georgia, Ghana, Hong Kong, Iraq, Ireland, Luxembourg, Macedonia, Malaysia, Morocco, New Zealand, Serbia and Thailand.

2.2 Financial Market and Macroeconomic Variables

We employ commonly agreed financial and macroeconomic variables as candidates for the sources of market-wide sovereign bond liquidity movements. Below, we provide short explanations of the candidate variables used in our empirical analysis.

• *Libor-OIS Spread*: The Libor-Overnight Index Swap spread is the difference between the 3-month Libor(what banks pay to borrow US Dollars) and 3-month overnight index swap rate. It is commensurate with the amount of perceived credit and liquidity risk in the interbank lending market. Mainly during the crisis periods, when banks are unsure of the creditworthiness of other banks, they charge higher interest rates to compensate them for the greater risk.

We expect to see a negative relationship between Libor-OIS spread market-wide bond liquidity. The reasoning is the following. During the periods of distress, the interbank lending market declines as interbank lending interest rate, Libor, increases. Then banks are forced to hold more cash to conduct business; as a result, they lend less, not only to other banks, but also to consumers. Less lending means there is less money in the economy, which we think might hamper the bond market liquidity. Figure 2 depicts the relationship between bond Bid-Ask and Libor-OIS spreads from 2004 to 2009.

• *TED Spread*: The TED spread is the difference of interest rates paid on 3-month United States Treasury bills (T-bills) and the 3-month Libor for the United States dollar. The TED spread generally indicates confidence in the banking system, i.e. a narrow spread indicates confidence while a wide spread indicates generalized fear, and usually results from a flight to quality. We expect to see a negative relationship between the TED spread and bond market liquidity as in the case of Libor-OIS spread, following the same reasoning.

• *Cboe Volatility Index*: Cboe VIX is the Chicago Board Options Exchange Volatility Index, a popular measure of the implied volatility of S&P 500 index options. It measures the implied volatility, rather than the historical volatility, of the S&P 500 index. A high value corresponds to a more volatile market and therefore more costly options, which can be used to defray risk from this volatility by selling options. Often referred to as the fear index, it represents one measure of the market's expectation of volatility over the next 30 day period.

Market volatility is an important measure of market sentiment, as market volatility is the amount that prices of an index or security at a particular time deviates from the mean price as measured over a specified time period. The greater the volatility, the greater the anxiousness of the traders, and traders feel more anxious when the market is declining or at the bottom than when it is rising. Therefore, market volatility measured by Cboe VIX index is expected to be negatively associated with bond market liquidity. Figure 3, presents a snapshot of Cboe Volatility index with bond market price volatility during 1999 to 2009. It is clear to see the high correlation between the bond market and equity market volatilities.

• *US Money Supply and FED Funds Rate*: The recent search for an appropriate way to measure the impact of monetary policy has followed two paths: interest rates and monetary aggregates. Therefore, as indicators of the monetary policy stance, we include the US Fed Funds rate (FED) and money supply M1 following Bernanke and Blinder (1992), Harvey and Huang (2001), and Goyenko and Ukhov (2009)

A loose monetary policy usually implies an increase in liquidity via the decrease of credit constraints. Harvey and Huang (2001) showed that the Federal Reserve, through its ability of changing the money supply, impacts the trading of bonds and currencies. If we consider money supply as an exogenous variable, an expansionary policy should have a positive impact on the bond market

liquidity. So, one can expect a positive relationship between the bond liquidity and the money supply growth. On the other hand, during the crisis periods Federal Reserve might intervene to the financial markets by injecting liquidity into the system when there is a liquidity problem. We suggest that the relationship between the bond market liquidity and the money supply growth should be interpreted differently during normal and distressed periods. Therefore, while we expect to see a positive relationship between the money supply and bond liquidity during normal times, a contrary sign should not be surprising during the crisis periods.

• *Industrial Production and Consumer Price Indices*: We use the growth rate of US industrial production (IP) and US inflation (the growth rate of the consumer price index, CPI) as macroeconomic variables. While during normal times there is no direct relationship between the bond market liquidity and these macroeconomic variables, during crisis periods their relevance is accepted to be increased dramatically. A higher-than-expected IP growth rate during a time of economic downturn could trigger the purchase of equities on the hope of a recovery. On the other hand, during an expansionary period, a higher-than-expected IP growth rate could cause inflationary fears. Therefore, in the current crisis period it is natural to expect to see a positive relationship between IP and CPI growth rate and the bond market liquidity.

3 Liquidity Measures

3.1 Bond Market Liquidity

Numerous previous papers use different direct and indirect measures of liquidity. Bid-Ask spreads, trade sizes, trade frequencies and trade volume are main examples of direct bond liquidity measures

(Houweling, Mentink, and Vorst (2003)). Bid-Ask spreads and trade volume are available in our data set. Additionally, inline with the literature, we construct two indirect measures of bond liquidity, i.e. price volatility and missing prices. Table 3 presents the summary statistics of the liquidity proxies used in our time series analysis of the liquidity of internationally traded sovereign bonds.

3.2 Bid-Ask Spread

Bid-Ask spread is our main liquidity estimate for the internationally traded sovereign bonds. The quoted percentage spread for a sovereign bond is computed as

$$Bid - Ask = 100 * \frac{Ask - Bid}{\frac{1}{2}(Ask + Bid)} \tag{1}$$

where Ask and Bid are quoted ask and bid prices for a particular day. We compute the monthly average of daily bid-ask spreads and finally we obtain the equally-weighted average across all the sovereign bonds traded in that particular month. Figure 1 presents the time series graph of bid-ask spread. Bid-ask spread peaks to a level of 2% at the end of 2001, then falls back to a mean around 1% until 2007. It peaks to its historical maximum of more than 3% in September 2008 , after which it gradually shows a tendency to return to 1% level.

In the next figure, we present the time series lines of bid-ask spread and Libor-OIS spread where the Libor-OIS spread is the difference between the 3-month Libor and the overnight index swap rate, which is associated with the amount of perceived credit and liquidity risk in the interbank lending market. This Figure depicts a clear relationship between Libor-OIS spread and bid-ask spread and that Libor-OIS spread precede the bid-ask spread through 2007 and 2009.

3.3 Bond Price Volatility

We consider *price volatility* as a measure of price uncertainty. When trading bonds, an important source of uncertainty is the predictability of bond prices. Hence, higher price volatility might be associated with higher Bid-Ask spread and higher illiquidity. It is computed as the equally-weighted standard deviation of bond price in a particular month across all the traded bonds of sovereigns. Note that, in our analysis, we consider price volatility both as a separate liquidity measure and a determinant of bid-ask spread for robustness checks.

Figure 3 presents the time series graph of bond price volatility together with Cboe Volatility Index.[3] It is clear in the graph that there is a significant positive correlation between the bond market and equity market volatilities, therefore, there is a negative relationship between the market-wide bond liquidity and equity market volatility. Moreover, equity market option volatility turns out to be preceding the bond market price volatility.

3.4 Missing Prices

As argued by Warga (1992) if the liquidity of a bond is sufficiently low, it might be the case that on some business days there is no trading activity on that bond. In our analysis, we consider as a missing price if the price in two consecutive days is the same. The ratio of missing prices to working days in a month is our measure of illiquidity for the particular bond in a given month (Houweling, Mentink, and Vorst (2003)). Then, as we do in other liquidity measures, we take the equally-weighted average of missing price ratios across all the bonds traded in that month. As the

[3]Cboe VIX is the Chicago Board Options Exchange Volatility Index, a popular measure of the implied volatility of S&P 500 index options. A high value corresponds to a more volatile market and therefore more costly options, which can be used to defray risk from this volatility by selling options. Often referred to as the fear index, it represents one measure of the market's expectation of volatility over the next 30 day period.

ratio missing prices increase we expect the liquidity of that bond to decrease.

3.5 Volume Traded

It is natural to think that volume traded of a given bond in a particular month is positively associated to the bond liquidity. Since this direct measure is available in our data set, we include it as our forth liquidity measure. However the relationship between the liquidity and volume traded should be taken with caveat. We find a big correlation between *volume traded* and *amount issued* of a particular bond. So, higher issue size bonds are traded the most. Then, one can check to see if turnover ratio (the ratio of volume traded to amount issued) does better than volume traded to proxy the bond liquidity. We check the correlations of volume traded and turnover ratio with other bond liquidity measures, i.e. bid-ask spread, price volatility and missing prices. Since the former measures are associated with the illiquidity in the bond market, one should expect to see a negative relationship between the trading variables and other measures. We loose this negative sign in the case of turnover ratio, which forces us to prefer volume traded over turnover ratio.

4 VAR Analysis with Macroeconomic Variables

We study how sovereign bond liquidity is intertemporarily related to world financial market and macroeconomic conditions. For instance, world-wide shocks such as unanticipated increase the Libor causes a decline interbank lending market. Then banks are forced to hold more cash to conduct business; as a result, they lend less, not only to other banks, but also to consumers. Less lending means there is less money in the economy, which we think might hamper the bond market liquidity. Similarly, factors such as unexpected industrial productivity declines and excessive inflationary

pressures are likely to influence liquidity indirectly by inducing fund outflows, price declines and increased volatility for the stock and bond market. In our paper therefore, we analyze the impacts of world-wide shocks on sovereign bond market liquidity by testing if financial market indicators and macroeconomic factors are dynamically linked to market-wide liquidity of sovereign international bonds.

To study the intertemporal relationship between bond market liquidity, financial market and the macroeconomic variables, for each of our four bond liquidity measure, we estimate estimate seven variable VAR model consisted of US Industrial Production growth (IP), US Consumer Price Index growth (CPI), US Money Supply M1 growth (M1), FED funds rate (FED), S&P500 total return (Equity), TED Spread (TED) and finally a bond liquidity variable. Bond Liquidity variables are monthly averages of Bond Price Bid-Ask Spread, Price Volatility, Percentage of Missing Prices and Volume Transacted, respectively. It is estimated with two lag and a constant term according to AIC and BIC criteria and it uses 132 observations as monthly averages from January 1999 to December 2009. We consider the following VAR:

$$X_t = c + A_1 X_{t-1} + A_2 X_{t-2} + u_t \tag{2}$$

where X is a 7×1 vector that represents IP, CPI, M1, FED, Equity, TED and Bond Liquidity, i.e one of Bid-Ask Spread, Price Volatility, Missing Prices and Trade Volume. c is a 7×1 vector of constants, A_1 and A_2 are 7×7 matrices of parameters and u_t is assumed to be white noise; that is

$$E(u_t) = 0 \;\; E(u_t u_t\prime) = \Sigma \;\text{ and,} \tag{3}$$

$$E(u_t u_s\prime) = 0 \; for \; t \neq s \tag{4}$$

where σ is the covariance matrix. Note that, VAR is a dynamic system of equations where the current value of each endogenous variable is regressed on the past values of itself and the other endogenous variables in the VAR. With the VAR model, we are able to observe causalities between the variables in the system and quantify the effects of shocks in each variable on itself and the others. We test the stationarity of our seven endogenous variables using the augmented Dickey-Fuller and Phillips-Perron unit root tests. According to our results, the null hypothesis of non-stationarity is rejected for all the variables.

4.1 VAR Results

Based on the conventional practice in the macroeconomic literature, the standardized economic series are ordered as follows: IP, CPI, M1 and FED are placed ahead of the market variables whose ordering is Equity, TED Spread and Bond Liquidity. From the resulting VAR table, we report only the equations explaining the bond liquidity to save from space. Table 7 presents the VAR table for the bond liquidity equations, namely Bid-Ask Spread, Price Volatility, Missing Prices and Volume Traded for the data between 1999 and 2010. Considering the impact of macroeconomic variables on bond liquidity, we see that the industrial production and inflation have negative and significant parameters explaining the liquidity measured by the bid-ask spread, which is our main liquidity measure. Therefore, a positive shock to industrial production has a significant positive affect on bond liquidity as expected, considering both the bid-ask spread and price volatility measures are associated with the **illiquidity** of the bond market. Negative sign of the parameter of inflation

means that an inflationary shock is negatively associated with the bid-ask spread and thus positively related to bond liquidity. A possible explanation to this result could be the following. Since, inflation is positively associated with the aggregate demand of the economy, an increase in the inflation would be a sign of improving demand and thus a recovery during the crisis. Therefore, an increasing inflation news could result in an increase in the confidence in the overall financial market, which would lead to an improving market liquidity. On the other hand, we are unable to accept an impact of monetary variables, M1 and FED, on neither measure of bond liquidity at any level of confidence.

The financial market variables, S&P 500 growth rate and TED spread have significant parameters with expected signs. A positive performance of S&P 500, which can be thought indicator of overall confidence in the market, is negatively related to bid-ask spread and bond price volatility. Thus, it positively affects the bond market liquidity. Similarly, the negative sign in front of the parameter of TED spread was also expected as a thick TED spread (Libor-T-bill) indicates the distrust in the banking system. Therefore, a distrust in the banking system or in general in financial markets could significantly hamper the liquidity of international sovereign bond market.

4.2 Granger Causality Tests

We employ Granger causality tests in order to asses the direction of causality of VAR results in the previous section. Granger causality tests in Table 8 indicate that industrial production and inflation have informative power on bond liquidity measured as both bid-ask spread and price volatility. However, the reverse is not true, meaning we are unable to accept the hypothesis that the bond liquidity has significant informative power on industrial production and inflation. Moreover, we do

not to observe any significant Granger-causal relationship between the monetary variables and the bond market liquidity. This result for sovereign international bonds is different than that of the US T-bills, as it has been documented that the Federal Reserve, through its ability of changing the money supply, significantly impacts the trading of T-bills (Harvey and Huang (2001)).

Table 8 also confirms that financial market variables, S&P500 growth and TED spread Granger-cause bond liquidity with 99% confidence level. We are unable to reject the hypothesis that bond liquidity does not Granger-cause Equity with 90% confidence level only in the case of bid-ask spread. Overall, Granger causality results suggest that there is a significant relationship between the bond liquidity, macroeconomic variables (IP and CPI) and financial market variables. Moreover, the direction of causality points towards bond market liquidity.

4.3 Variance Decompositions

In Table 9, we report the variance decompositions after VAR analysis of the sovereign bond market liquidity variables. Industrial production, equity market performance, and TED spread seem to play the most important roles in explaining the variance of bond liquidity. Indeed, in one-year horizon, while industrial production (IP) explains 31% of the variation in bond liquidity, equity market performance‘s (Equity) and TED spread‘s shares in explaining the variance is 29% and 21%. This is a striking result as 81% of the variance of bond liquidity measured as bid-ask spread is explained by IP, TED and Equity. We obtain similar results when we choose price volatility as our bond market liquidity proxy. In one-year horizon, IP, Equity and TED explain 21%, 22% and 44% of the variance in price volatility, respectively. Overall, these results are consistent with the view that macroeconomic variables explain an important part of the variation in market-wide liquidity

(Fujimoto (2004), Goyenko and Ukhov (2009)). Another important finding here is that sovereign bond market liquidity is more sensitive to real economy and financial market surprises than the monetary shocks.

4.4 Persistence of the Effects of Shocks to Liquidity: Impulse Response Functions

The results of the orthogonal impulse response functions (IRF), given in Figure 2, indicate that innovations in industrial production, equity market performance and TED spread are persistent in 12 month horizon. Figure 2 implies that an orthogonal positive unit standard deviation shock in IP decreases bid-ask spread (increases liquidity) by one standard deviation in 3 months and its effect remains continuously significant even 10 months after the shock. Similarly, a positive shock to TED spread, i.e. in case of a distrust among the banking sector, increases immediately the bid-ask spread, thus hampers the bond market liquidity, and its impact is persistent even 10 months after the shock. Shocks to FED and M1 have smaller but interesting effects on bond liquidity. A positive shock to money supply first increases the bid-ask spread, and then its effect becomes negative (increasing liquidity) after 2 months. When the FED funds rate increases, it has an immediate negative but small effect on the bond liquidity, which die out in a couple of months.

An inflationary shock decreases the bid-ask spread in the first 5 months horizon, increasing the bond liquidity. As explained in the previous sections, this could be due to the fact that an increasing inflation news is seen to be associated with increasing aggregate demand and thus a sign of recovery. Then after 5 months, the impact of inflationary shock changes its sign, thereafter an inflationary shock has a persistent damaging effect on sovereign bond market liquidity, which is

what we expect to see in the middle and long run. As one might notice easily, the IRF graphs with price volatility as the response variable has similar characteristics. Other bond liquidity measures, Volume Traded and Percentage Missing Prices, which we use for robustness check, have similar IRF graphs. Of course, Volume Traded IRF should be interpreted reversely since unlike other measures it is positively related to bond liquidity.

4.5 Sub-sample Analysis, Before and After Financial Market Crisis

In order to test the robustness of our results in the previous section we re-estimate the same VAR models in two sub-periods, 1999 to 2006 (pre-crisis) and 2006 to 2010 (during crisis). This exercise is crucial since the stability of the interactions between liquidity and the market and the macroeconomic factors is our main concern. However, due to short time span of our sub-samples, the results should be taken into account with caution. Indeed, for bid-ask spread as our bond liquidity measure, from 2006 to 2010 we have only 46 monthly observations.

Tables 12 and 13 present the results of the VAR estimation results for bond liquidity equations for the sub-samples. In general, we see that bond liquidity is less sensitive to the market and the macroeconomic variables during 1999 to 2006. US industrial production growth rate and monetary variables have significant explanatory powers on bond liquidity measured by bid-ask spread, and non of the variables have significant impact on bond price volatility. The picture is entirely different in the VAR estimated using the data from the financial crisis period. VAR estimation results for the sub-period 2006 to 2010 indicate that all of the market and the macroeconomic variables except for CPI and FED have explanatory powers on the bond bid-ask spread.

Granger causality tests and impulse response functions for the sub-periods in Table 10, 11 and

Figure 3 confirm the VAR results that the market and the macroeconomic shocks play greater role on determining bond liquidity during the financial crisis.

5 Panel Regression Analysis: Cross-Section of Bond Liquidity

Up to now, we analyzed dynamic time-series link between the market-wide sovereign bond liquidity, financial market and macroeconomic variables. For that, we used monthly equal-weighted average of daily variables across all the sovereign bonds traded in that particular month. Next, we would like to investigate the cross-section determinants of sovereign bond market liquidity by exploiting panel regressions.

In order to examine the determinants of the bond market liquidity, we use balanced panel regressions of bond liquidity variables on coupon rate (Coupon), remaining maturity (Maturity), amount outstanding in billion US Dollars (AOS), Standard and Poor‘s long term borrower rating (Rating), 3 month Libor minus T-bill (TED) spread and percentage growth of US M1 money supply (M1). Bond Liquidity variables are monthly averages of bond price bid-ask spread and price volatility. Rating variable is the number assigned to the letters of Standard and Poor‘s long term ratings ranging from 5 for CCC- and 23 for AAA. Our sample uses 482 bonds issued by 72 sovereigns and traded internationally during January 1999 and December 2009, which allows to reach a sample size of 23000 data points. Regressions are run for three different time sub-periods in order to analyze the possible different dynamics in before and during the financial crisis period.

The academic literature on bond liquidity suggests the following relationships between the bond

liquidity and bond characteristics. High coupon bonds tend to be more liquid than the bonds with lower coupons. Higher issue size bonds are expected to be more liquid since the amount outstanding is used to measure general availability of the bond in the market. The bond liquidity also increases with the remaining maturity as the concept is similar to the notion of on-the-run and off-the-run bonds in US T-bill markets. There is extensive evidence that on-the-run Treasury bonds are much more liquid than off-the-run Treasury bonds. If there is a similar effect in sovereign international bond market, then older bonds may be less liquid than more-recently issued bonds (Longstaff, Mithal, and Neis (2005)).

Regressions of bid-ask spread on bond specific variables remaining maturity and ratings show expected significant signs (see Table 14). However, coupon and amount outstanding have unexpected signs, i.e. they seem to be positively associated with the bid-ask spread, hence negatively with the bond liquidity. The market variable TED, and monetary supply have significant explanatory power on bond liquidity. In general, the results are robust to estimating the regression with different subsample time periods. Indeed, the signs of the coefficients are the same both in before and during the crisis periods. In the episodes of distrust among the banking system, i.e. a substantial increase in Libor and a decrease in T-bill yields, the sovereign international bond liquidity declines. An expansionary monetary policy by the USA, increases the sovereign bond liquidity as M1 growth is negatively related to bid-ask spreads.

6 Conclusion

In this paper, we have examined the financial market and macroeconomic sources of time-series and cross sectional variation in market-wide liquidity of internationally traded sovereign bonds in

the last decade. Vector autoregression analysis have shown that macroeconomic fundamentals play a substantial role in the movements of liquidity throughout the whole sample period while their effects are stronger during the current financial crisis. Specifically, positive shocks in US industrial production growth rate and inflation are positively related to sovereign bond market liquidity. Financial market variables have also significant impacts. While a increasing shock to the TED spread, which generally indicates confidence in the banking system, has detrimental impact, US equity market performance has positive impact on the aggregate bond liquidity.

Further, Granger causality tests indicate that the direction of the causality is from the financial and macroeconomic variables towards the aggregate bond liquidity. The results of the orthogonal impulse response functions (IRF) imply that innovations in industrial production, equity market performance and TED spread are persistent in 12 month forecast horizon throughout the whole sample period. The IRFs and Granger causality tests also confirm the VAR results that the effects of macroeconomic fundamentals and the financial market variables are stronger during the financial turmoil, 2006 to 2010.

Lastly, to examine the *cross-section* determinants of the bond market liquidity, we used panel regressions of bond liquidity variables on bond specific variables, the financial market and the macroeconomic variables. We found that TED spread and US money supply have significant *cross-section* explanatory powers on aggregate liquidity. An expansionary monetary policy by the US Federal Reserve increases the sovereign bond liquidity as M1 growth is negatively related to bid-ask spreads. In the episodes of distrust among the banking system, i.e. a substantial increase in Libor and a decrease in T-bill yields, the sovereign international bond liquidity declines.

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Table 1: **Bond Sample.** This table presents bond sample used in our analysis. Our sample uses 482 bonds issued by 72 sovereigns and traded internationally during January 1999 and December 2009. We include all of the sovereign bonds for which the price, bid-ask and transaction volume data are available by ISMA (the International Securities Market Association) via Thomson Financial Datastream. The first column is the name of the borrower country, the second column is the number of its bonds, third column is the total issued amount of its bonds in our sample and the last column is the borrower country's long term rating by Moody's as of December 2009. For countries whose Moody's rating is not available we use the corresponding long term borrower rating by Standard and Poor's. The bond data are available at Thomson Financial Datastream

Borrower Name	Number of Bonds	Amount Issued in Billions	Borrower Long Term Rating
Abu Dhabi	1	1.00	
Argentina	20	56.35	Ca
Australia	1	0.15	Aaa
Austria	33	14.30	Aaa
Bahamas	1	0.10	A3
Barbados	4	0.59	Baa1
Belgium	3	2.60	Aa1
Belize	2	0.65	B2
Brazil	28	61.01	Baa3
Bulgaria	3	1.36	Ba2
Chile	2	1.75	A1
China	4	3.10	A1
Colombia	14	9.27	Ba1
Costa Rica	7	1.75	Ba1
Croatia	4	2.61	Baa3
Cyprus	2	1.05	Aa3
Czech	3	4.50	A1
Denmark	2	5.25	Aaa
Dominican Republic	4	1.82	B2
Ecuador	6	14.88	C
Egypt	2	2.00	Ba1
El Salvador	6	3.89	Ba1
Fiji Islands	1	0.15	B1
Finland	1	0.10	Aaa
France	1	0.00	Aaa
Georgia	1	0.50	
Germany	10	5.08	Aaa
Ghana	1	0.75	
Greece	15	14.70	A1
Grenada	1	0.10	B3
Guatemala	4	1.28	Ba2
Hong Kong	1	1.25	Aa1
Hungary	11	12.00	Baa1

Bond Sample: Table 1 continuing...

Borrower Name	Number of Bonds	Amount Issued in Billions	Borrower Long Term Rating
Iceland	3	1.45	Baa3
Indonesia	8	11.20	Ba3
Iraq	1	2.66	
Ireland	1	0.50	Aa1
Israel	6	4.25	A1
Italy	25	38.13	Aa2
Jamaica	9	2.68	Caa1
Korea	5	3.28	A2
Latvia	2	0.80	Baa3
Lebanon	18	12.66	B2
Lithuania	4	3.60	Baa1
Luxembourg	1	2.00	
Macedonia	1	0.15	
Malaysia	1	1.75	A3
Mexico	23	42.32	Baa1
Morocco	1	0.50	Ba1
New Zealand	1	0.20	Aaa
Pakistan	3	1.55	B2
Panama	10	8.84	Ba1
Peru	11	11.00	Ba1
Philippines	18	20.83	Ba3
Poland	18	23.93	A2
Qatar	2	2.80	Aa2
Romania	3	2.15	Baa3
Russia	6	34.49	Baa1
Serbia	1	1.02	Ba3
Slovakia	5	3.74	A1
Slovenia	4	2.95	Aa2
South Africa	5	5.00	A3
Spain	4	5.61	Aaa
Sweden	7	5.02	Aaa
Thailand	1	0.04	Baa1
Trinidad Tobago	2	0.40	
Turkey	20	28.50	Ba3
Ukraine	6	4.40	B1
Uruguay	21	7.77	Ba3
Venezuela	23	32.18	B2
Vietnam	3	1.03	Ba3
AVERAGE	6.8	7.8	Baa1
TOTAL	482	557.3	

Source: Thomson Financial Datastream

Table 2: **Summary statistics for all internationally traded sovereign bonds during the period 1998-December 2009.** This table presents the summary statistics of internationally traded bonds of the sovereigns listed in Table 1. Rating variable is a number given to letter rating of Moody's Long Term Sovereign Debt Rating. Rating number 5 is given to the lowest rating C and the number 25 is given to the highest rating AAA. The amount outstanding variable is presented in millions. The bond data are available at Thomson Financial Datastream.

	Mean	Standard Deviation	Minimum	Maximum
Price	101.26	23.51	4.83	186.83
Redemption Yield	7.28	4.72	-24.19	86.28
Coupon	7.52	2.47	2.70	13.63
Maturity	12.94	8.83	0.25	75.94
Life	11.25	8.06	0.24	50.00
Amount Out.(millions)	1131.35	1378.40	11.95	12489
Rating	16.19	4.90	5.00	25.00

Source: Thomson Financial Datastream

Table 3: **Summary statistics of the liquidity proxies for all internationally traded sovereign bonds during the period 1998-November 2009.** This table presents the summary statistics of liquidity variables for the internationally traded bonds of the sovereigns listed in Table 1. Variable definitions are presented in the text. The bond data are available at Thomson Financial Datastream.

	Mean	Standard Deviation	Minimum	Maximum	Obs.
Bid-Ask Spread	1.28	0.51	0.68	3.10	102
Price Volatility	1.20	0.55	0.43	4.92	131
Missing Prices	0.54	0.08	0.23	0.81	132
Volume Traded	34.91	24.00	3.59	135.21	130

Source: Thomson Financial Datastream

Table 4: **Summary Statistics for the World Financial and Macroeconomic Variables for the period of 1998-November 2009** This table presents the summary statistics for the monthly averages of the world financial and macroeconomic variables. For S&P 500, Cboe VIX, Money Supply, Industrial Production and Consumer Price Index the monthly growth variables are used. T-bill, Libor, OIS, TED Spread and Libor-OIS Spread are 3 month rates for which the definitions are presented in the text. The data are available at Thomson Financial Datastream.

	Mean	Standard Deviation	Minimum	Maximum	Obs.
S&P 500 RI Growth	0.01	0.23	-1.27	0.56	132
CboeVix	0.18	1.02	-1.54	5.2	132
Tbill	2.96	1.91	0.04	6.36	132
Libor US	3.47	1.95	0.26	6.81	132
OIS US	2.82	1.9	0.14	5.4	73
TED Spread	0.51	0.49	0.12	3.26	132
Libor-OIS	0.37	0.48	0.05	2.37	73
Policy Int Rate US	3.2	1.97	0.25	6.5	131
Money Supply M1	0.33	1.01	-3.16	4.73	130
Industrial Production	0.02	0.72	-3.96	1.37	130
CPI	0.21	0.34	-1.67	1.38	130

Source: Thomson Financial Datastream

Table 5: **Correlation Matrix of Bond Liquidity Variables** This table presents the correlation matrix of the liquidity variables for the internationally traded bonds of the sovereigns listed in Table 1. Variable definitions are presented in the text. Values specified with **bold numbers** are statistically significant at 1% level. The bond data are available at Thomson Financial Datastream.

	Bid-Ask Spread	Price Volatility	Pct Missing Prices	Volume Traded
Bid-Ask Spread	1.00			
Price Volatility	**0.65**	1.00		
Pct Missing Prices	**0.37**	-0.04	1.00	
Volume Traded	**-0.19**	0.13	**-0.41**	1.00

Source: Thomson Financial Datastream

Table 6: **Correlation Matrix of World Financial and Macroeconomic Variables.** This table presents the correlation matrix of the monthly averages of the world financial and macroeconomic variables. For S&P 500, Cboe VIX, Money Supply (M1), Industrial Production (IP) and Consumer Price Index (CPI) the monthly growth variables are used. T-bill, Libor, OIS, TED Spread and Libor-OIS Spread are 3 month rates for which the definitions are presented in the text. The data are available at Thomson Financial Datastream.

	S&P500	CboeVIX	T-bill	Libor	OIS	TED Sprd	Libor-OIS	FED	M1	IP	CPI
S&P500	1										
CboeVIX	-0.78***	1.00									
T-bill	0.04	0.03	1.00								
Libor	-0.05	0.09	0.97***	1							
OIS	0.06	0.05	0.99***	0.97***	1						
TED Sprd	-0.35***	0.25**	-0.05	0.21*	-0.14	1					
Libor-OIS	-0.50***	0.29*	-0.46***	-0.15	-0.39***	0.93***	1				
FED	0	0.05	0.99***	0.98***	0.99***	0.06	-0.35**	1			
Money Supply	-0.18*	0.14	-0.32***	-0.24**	-0.36**	0.27**	0.50***	-0.28**	1		
Industrial Prd	0.26**	-0.15	0.20*	0.1	0.24*	-0.38***	-0.52***	0.15	-0.33***	1	
CPI	-0.04	0.06	0.18*	0.12	0.19	-0.20*	-0.40***	0.16	-0.24**	0.12	1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Thomson Financial Datastream

Table 7: **Vector Autoregression Table for Bond Liquidity Equations.** The table presents the result table of Vector Autoregressions of endogenous variables Industrial Production (IP), Consumer Price Index (CPI), Money Supply (M1), FED Funds Rate, S&P500 Equity Market Total Return Index, Libor - T-bill (TED) Spread and Bond Liquidity. Note that for the sake of saving from space, we report only one equation for each VAR, i.e. only the equations explaining the bond liquidity. Bond Liquidity variables are monthly averages of Bond Price Bid-Ask Spread, Price Volatility, Percentage of Missing Prices and Volume Transacted, respectively. It is estimated with two lag and a constant term according to AIC and BIC criteria and uses 132 observations as monthly averages from January 1999 to December 2009. The prefixes "L." and "L.2" stand for the first lag and the second lag of the variables respectively. The numbers in parentheses are t-statistics.

	Bid-Ask Spread	Price Volatility	Missing Prices	Transaction Volume
L.IP	-0.097***	-0.203***	0.002	-1.207
	(-5.64)	(-4.63)	(0.22)	(-0.45)
L2.IP	0.027	0.080	-0.004	1.545
	(1.61)	(1.76)	(-0.48)	(0.56)
L.CPI	-0.077*	-0.177	-0.005	-4.203
	(-2.15)	(-1.82)	(-0.26)	(-0.69)
L2.CPI	0.024	0.162	-0.008	1.220
	(0.60)	(1.58)	(-0.43)	(0.18)
L.M1	-0.038	-0.033	-0.009	0.569
	(-1.57)	(-0.49)	(-0.71)	(0.13)
L2.M1	-0.021	-0.039	-0.012	5.207
	(-0.96)	(-0.63)	(-1.11)	(1.35)
L.FED	-0.039	-0.050	-0.021	-5.206
	(-0.79)	(-0.41)	(-0.92)	(-0.66)
L2.FED	0.023	0.029	0.021	6.102
	(0.46)	(0.24)	(0.91)	(0.78)
L.Equity	-0.196***	-0.458***	0.001	4.551
	(-3.73)	(-3.70)	(0.06)	(0.57)
L2.Equity	0.039	0.188	-0.016	-3.708
	(0.68)	(1.39)	(-0.67)	(-0.43)
L.TED Spread	0.146***	0.492***	0.017	-5.441
	(3.32)	(4.15)	(0.80)	(-0.72)
L2.TED Spread	-0.127**	-0.549***	0.004	-8.488
	(-2.88)	(-4.69)	(0.19)	(-1.16)
L.Bond Liquidity	1.231***	0.741***	0.613***	0.354***
	(11.70)	(8.90)	(6.92)	(3.97)
L2.Bond Liquidity	-0.360***	-0.021	-0.081	0.114
	(-3.82)	(-0.26)	(-0.87)	(1.31)
Constant	0.228***	0.459***	0.255***	20.863**
	(3.42)	(3.69)	(5.30)	(3.18)
R Squared	0.965	0.732	0.434	0.375
Obs.	99	128	128	128

t statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Thomson Financial Datastream

Table 8: **Granger Causality Tests. Chi-square statistics and P-values (in parenthesis) from Granger causality tests. Null hypothesis: Row variable does not Granger-cause column variable** This table presents Granger Causality tests after the Vector Autoregressions of endogenous variables Industrial Production (IP), Consumer Price Index (CPI), Money Supply (M1), FED Funds Rate, S&P500 Equity Market Total Return Index, Libor - T-bill (TED) Spread and Bond Liquidity using the data from January 1999 to December 2009. Bond Liquidity variables are monthly averages of Bond Price Bid-Ask Spread and Price Volatility. The numbers in parentheses are p-values.

Bond Liquidity as Bid-Ask Spread							
	IP	CPI	M1	FED	Equity	TED	Bond Liq.
IP		1.22	1.80	5.86	12.70	2.50	33.80
		(.544)	(.406)	(.053)*	(.002)*	(.286)	(.000)*
CPI	3.11		37.97	6.70	1.06	4.48	4.82
	(.211)		(.000)*	(.035)*	(.588)	(.107)	(.09)*
M1	0.43	0.34		7.70	2.87	2.18	2.87
	(.808)	(.846)		(.021)*	(.238)	(.336)	(.238)
FED	0.17	1.27	2.16		2.26	0.62	4.43
	(.92)	(.529)	(.34)		(.323)	(.732)	(.109)
Equity	2.09	1.91	12.48	6.27		10.02	15.36
	(.351)	(.386)	(.002)*	(.043)*		(.007)*	(.000)*
TED	11.26	3.64	0.30	20.61	9.87		11.18
	(.004)*	(.162)	(.859)	(.000)*	(.007)*		(.004)*
Bond Liquidity	4.84	15.56	0.05	1.40	7.69	2.67	
	(.189)	(.120)	(.977)	(.497)	(.021)*	(.263)	
Bond Liquidity as Price Volatility							
IP		3.80	4.78	4.96	14.67	0.96	22.92
		(.149)	(.092)*	(.084)*	(.001)*	(.62)	(.000)*
CPI	2.30		32.61	3.27	1.36	7.96	5.48
	(.317)		(.000)*	(.195)	(.507)	(.019)*	(.065)*
M1	0.21	0.84		2.97	2.05	1.56	0.53
	(.898)	(.659)		(.227)	(.36)	(.459)	(.767)
FED	1.58	2.11	10.46		0.17	0.05	2.24
	(.453)	(.348)	(.005)*		(.917)	(.974)	(.326)
Equity	1.13	0.44	19.40	3.20		9.75	16.67
	(.569)	(.803)	(.000)*	(.202)		(.008)*	(.000)*
TED	10.80	3.26	1.67	15.45	7.17		22.14
	(.005)*	(.196)	(.434)	(.000)*	(.028)*		(.000)*
Bond Liquidity	4.40	15.53	17.78	3.01	2.12	3.79	
	(.111)	(.000)*	(.000)*	(.223)	(.347)	(.15)	

Table 9: **Variance Decompositions for Bond Liquidity** The table presents the variance decomposition computed from a VAR with endogenous variables Industrial Production (IP), Consumer Price Index (CPI), Money Supply (M1), FED Funds Rate, S&P500 Equity Market Total Return Index, TED Spread and Bond Liquidity. Bond Liquidity variables are monthly averages of Bond Price Bid-Ask Spread, Price Volatility, Percentage of Missing Prices and Volume Transacted . It is estimated with two lag and a constant term, and uses 132 observations as monthly averages from January 1999 to December 2009. The numbers in parentheses are asymptotic standard errors. The bond data are available at Thomson Financial Datastream.

Forecast Horizon	IP	CPI	M1	FED	Equity	TED Sprd.	Bond Liq.
Bid-Ask Spread							
1	0.017	0.015	0.005	0.000	0.266	0.036	0.662
	(.026)	(.024)	(.014)	(.031)	(.075)	(.031)	(.077)
2	0.229	0.010	0.002	0.000	0.328	0.073	0.358
	(.076)	(.019)	(.003)	(.038)	(.077)	(.038)	(.064)
6	0.328	0.010	0.004	0.001	0.346	0.112	0.199
	(.118)	(.01)	(.013)	(.074)	(.113)	(.074)	(.068)
12	0.310	0.030	0.003	0.001	0.289	0.209	0.157
	(.123)	(.033)	(.009)	(.01)	(.115)	(.107)	(.056)
Volatility							
1	0.003	0.008	0.052	0.000	0.094	0.010	0.833
	(.01)	(.015)	(.038)	(.016)	(.048)	(.016)	(.06)
2	0.180	0.010	0.031	0.005	0.198	0.075	0.501
	(.061)	(.017)	(.028)	(.038)	(.063)	(.038)	(.067)
6	0.212	0.022	0.027	0.009	0.223	0.061	0.446
	(.082)	(.018)	(.026)	(.039)	(.083)	(.039)	(.081)
12	0.212	0.022	0.028	0.012	0.223	0.064	0.440
	(.083)	(.018)	(.026)	(.016)	(.083)	(.042)	(.083)
Missing Prices							
1	0.001	0.003	0.001	0.001	0.000	0.020	0.974
	(.005)	(.009)	(.006)	(.025)	(.002)	(.025)	(.028)
2	0.001	0.002	0.001	0.004	0.000	0.032	0.960
	(.006)	(.008)	(.004)	(.034)	(.002)	(.034)	(.037)
6	0.010	0.013	0.007	0.004	0.008	0.072	0.886
	(.019)	(.016)	(.014)	(.059)	(.019)	(.059)	(.072)
12	0.012	0.018	0.008	0.008	0.008	0.087	0.860
	(.022)	(.021)	(.015)	(.012)	(.019)	(.068)	(.092)
Transaction Volume							
1	0.005	0.002	0.001	0.011	0.026	0.022	0.933
	(.012)	(.008)	(.004)	(.025)	(.027)	(.025)	(.043)
2	0.005	0.009	0.001	0.012	0.023	0.030	0.920
	(.012)	(.017)	(.007)	(.032)	(.024)	(.032)	(.047)
6	0.013	0.040	0.022	0.018	0.019	0.092	0.796
	(.024)	(.04)	(.027)	(.059)	(.02)	(.059)	(.084)
12	0.015	0.049	0.023	0.020	0.018	0.117	0.758
	(.029)	(.045)	(.028)	(.022)	(.019)	(.072)	(.103)

Table 10: **Sub-Sample 1999 to 2006 Granger Causality Tests. Chi-square statistics and P-values (in parenthesis) from Granger causality tests. Null hypothesis: Row variable does not Granger-cause column variable** This table presents Granger Causality tests after the Vector Autoregressions of endogenous variables Industrial Production (IP), Consumer Price Index (CPI), Money Supply (M1), FED Funds Rate, S&P500 Equity Market Total Return Index, Libor - T-bill (TED) Spread and Bond Liquidity using the data from January 1999 to January 2006. Bond Liquidity variables are monthly averages of Bond Price Bid-Ask Spread and Price Volatility. The numbers in parentheses are p-values. The bond data are available at Thomson Financial Datastream.

Bond Liquidity as Bid-Ask Spread (1999-2006)							
	IP	CPI	M1	FED	Equity	TED	Bond Liquidity
IP		2.72	15.57	5.91	8.05	3.37	6.56
		(.257)	(.000)*	(.052)*	(.018)*	(.186)	(.038)*
CPI	0.26		7.90	2.41	0.07	2.74	0.01
	(.876)		(.019)*	(.3)	(.964)	(.255)	(.993)
M1	0.23	1.96		4.53	0.25	1.75	10.72
	(.893)	(.376)		(.104)	(.884)	(.417)	(.005)*
FED	6.96	7.90	1.68		1.40	13.12	4.09
	(.031)*	(.019)*	(.432)		(.496)	(.001)*	(.129)
Equity	1.11	2.21	0.90	0.05		2.79	2.81
	(.574)	(.331)	(.639)	(.975)		(.248)	(.245)
TED	5.63	0.93	14.26	10.31	9.23		3.69
	(.060)*	(.628)	(.001)*	(.006)*	(.01)*		(.158)
Bond Liquidity	0.83	3.80	1.51	0.02	2.15	3.64	
	(.661)	(.149)	(.47)	(.988)	(.341)	(.162)	
Bond Liquidity as Price Volatility (1999-2006)							
IP		1.62	13.30	15.65	3.59	6.92	1.15
		(.445)	(.001)*	(.)*	(.166)	(.031)*	(.562)
CPI	1.05		7.52	4.68	2.06	16.98	1.11
	(.592)		(.023)*	(.096)*	(.358)	(.000)*	(.574)
M1	0.63	3.56		4.44	0.52	0.25	0.15
	-0.73	(.169)		(.108)	(.772)	(.882)	(.926)
FED	9.40	4.97	0.17		2.63	22.37	0.58
	(.009)*	(.083)*	(.919)		(.269)	(.000)*	(.747)
Equity	1.49	0.41	2.72	2.93		0.89	1.30
	(.474)	(.815)	(.257)	(.231)		(.642)	(.523)
TED	7.94	0.06	1.49	1.43	17.36		0.71
	(.019)*	(.971)	(.476)	(.488)	(.000)*		(0.70)
Bond Liquidity	0.23	7.13	5.53	0.19	0.85	2.90	
	(.892)	(.028)*	(.063)*	(.908)	(.653)	(.235)	

Table 11: **Sub-Sample 2006 to 2010 Granger Causality Tests. Chi-square statistics and P-values (in parenthesis) from Granger causality tests. Null hypothesis: Row variable does not Granger-cause column variable** This table presents Granger Causality tests after the Vector Autoregressions of endogenous variables Industrial Production (IP), Consumer Price Index (CPI), Money Supply (M1), FED Funds Rate, S&P500 Equity Market Total Return Index, Libor - T-bill (TED) Spread and Bond Liquidity using the data from January 2006 to December 2009. Bond Liquidity variables are monthly averages of Bond Price Bid-Ask Spread and Price Volatility. The numbers in parentheses are p-values. The data are available at Thomson Financial Datastream.

Bond Liquidity as Bid-Ask Spread (2006-2010)							
IP		3.64	4.00	6.22	16.10	3.90	36.07
		(.162)	(.135)	(.045)*	(.000)*	(.142)	(.000)*
CPI	7.30		17.69	4.70	2.48	7.82	4.95
	(.026)*		(.000)*	(.095)*	(.29)	(.02)*	(.084)*
M1	2.28	1.31		3.71	7.48	4.97	8.42
	(.32)	(.518)		(.156)	(.024)*	(.083)*	(.015)*
FED	0.06	5.85	2.76		5.26	3.61	5.67
	(.973)	(.054)*	(.252)		(.072)*	(.164)	(.059)*
Equity	2.98	2.11	13.31	6.26		9.58	19.84
	(.225)	(.348)	(.001)*	(.044)*		(.008)*	(.000)*
TED	7.02	5.01	2.77	31.30	11.51		6.19
	(.03)*	(.082)*	(.25)	(.000)*	(.003)*		(.045)*
Bond Liquidity	4.38	23.31	4.88	6.70	16.21	4.49	
	(.112)	(.000)*	(.087)*	(.035)*	(.000)*	(.106)	
Bond Liquidity as Price Volatility (2006-2010)							
IP		0.62	0.25	2.04	11.38	1.67	26.48
		(.732)	(.884)	(.36)	(.003)*	(.434)	(.000)*
CPI	4.88		18.66	1.30	2.30	6.57	10.61
	(.087)*			(.522)	(.317)	(.037)*	(.005)*
M1	3.00	0.16		2.65	7.12	4.51	5.41
	(.223)	(.923)	(.)*		(.029)*	(.105)	(.067)*
FED	0.24	6.43	5.98		2.03	1.31	5.46
	(.888)	(.04)*	(.05)*	(.266)		(.519)	(.065)*
Equity	0.85	0.96	20.10	2.80		11.85	21.60
	(.653)	(.617)	(.000)*	(.247)	(.362)		(.)*
TED	3.98	11.09	3.75	26.07	11.07		16.80
	(.136)	(.004)*	(.154)	(.000)*	(.004)*	(.003)*	
Bond Liquidity	4.59	18.30	11.82	2.68	6.86	2.28	
	(.101)	(.000)*	(.003)*	(.262)	(.032)*	(.319)	(.000)*

Table 12: **Vector Autoregression Table for on Bond Liquidity Equations Estimated for the Period 1999-2006.** The table presents the result table of Vector Autoregressions of endogenous variables Industrial Production (IP), Consumer Price Index (CPI), Money Supply (M1), FED Funds Rate, S&P500 Equity Market Total Return Index, Libor - T-bill (TED) Spread and Bond Liquidity using the data from January 1999 to January 2006. Note that for the sake of saving from space, we report only one equation for each VAR, i.e. only the equations explaining the bond liquidity. Bond Liquidity variables are monthly averages of Bond Price Bid-Ask Spread, Price Volatility, Percentage of Missing Prices and Volume Transacted, respectively. It is estimated with two lag and a constant term according to AIC and BIC criteria and uses 132 observations as monthly averages from January 1999 to January 2006. The prefixes "L." and "L.2" stand for the first lag and the second lag of the variables, respectively. The numbers in parentheses are t-statistics.

	Bid-Ask Spread	Price Volatility	Missing Prices	Transaction Volume
L.IP	-0.051*	-0.051	0.007	-3.203
	(-2.31)	(-0.79)	(0.52)	(-0.64)
L2.IP	0.015	0.091	0.007	-3.400
	(0.59)	(1.30)	(0.47)	(-0.62)
L.CPI	-0.003	-0.132	0.000	-8.011
	(-0.08)	(-1.01)	(0.01)	(-0.81)
L2.CPI	-0.003	0.018	-0.024	-9.091
	(-0.06)	(0.13)	(-0.81)	(-0.84)
L.M1	-0.033	0.020	-0.004	-1.021
	(-1.39)	(0.27)	(-0.27)	(-0.19)
L2.M1	-0.064**	-0.008	-0.019	7.031
	(-3.18)	(-0.12)	(-1.32)	(1.38)
L.FED	-0.134*	-0.115	-0.051	1.238
	(-2.00)	(-0.66)	(-1.36)	(0.09)
L2.FED	0.135*	0.130	0.060	-1.435
	(2.01)	(0.73)	(1.58)	(-0.10)
L.Equity	0.056	-0.223	-0.031	9.566
	(0.91)	(-1.31)	(-0.85)	(0.71)
L2.Equity	-0.084	-0.080	-0.026	-9.170
	(-1.41)	(-0.48)	(-0.72)	(-0.71)
L.TED	-0.351	-0.131	-0.037	-19.205
	(-1.54)	(-0.42)	(-0.56)	(-0.77)
L2.TED	-0.049	-0.119	-0.042	25.184
	(-0.19)	(-0.34)	(-0.56)	(0.92)
L.Bond Liquidity	1.315***	0.643***	0.592***	0.152
	(11.01)	(5.47)	(5.45)	(1.33)
L2.Bond Liquidity	-0.423***	-0.027	-0.217*	-0.024
	(-3.64)	(-0.24)	(-1.99)	(-0.21)
Constant	0.252**	0.548***	0.335***	40.574***
	(2.79)	(3.43)	(5.62)	(4.19)
R squared	0.950	0.491	0.373	0.123
Obs.	52	81	81	81

t statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Thomson Financial Datastream

Table 13: **Vector Autoregression Table for on Bond Liquidity Equations Estimated for the Period 2006-2010.** The table presents the result table of Vector Autoregressions of endogenous variables Industrial Production (IP), Consumer Price Index (CPI), Money Supply (M1), FED Funds Rate, S&P500 Equity Market Total Return Index, Libor - T-bill (TED) Spread and Bond Liquidity using the data from January 2006 to December 2090. Note that for the sake of saving from space, we report only one equation for each VAR, i.e. only the equations explaining the bond liquidity. Bond Liquidity variables are monthly averages of Bond Price Bid-Ask Spread, Price Volatility, Percentage of Missing Prices and Volume Transacted, respectively. It is estimated with two lag and a constant term according to AIC and BIC criteria and uses 132 observations as monthly averages from January 2006 to December 2009. The prefixes "L." and "L.2" stand for the first lag and the second lag of the variables respectively. The numbers in parentheses are t-statistics.

	Bid-Ask Spread	Price Volatility	Missing Prices	Transaction Volume
L.IP	-0.152***	-0.296***	0.008	-0.328
	(-6.20)	(-4.62)	(0.92)	(-0.16)
L2.IP	0.057*	0.162*	0.003	0.714
	(2.27)	(2.40)	(0.37)	(0.39)
L.CPI	-0.075	-0.378**	-0.005	-2.706
	(-1.41)	(-2.66)	(-0.26)	(-0.59)
L2.CPI	0.047	0.163	-0.000	-8.182
	(0.82)	(1.05)	(-0.01)	(-1.51)
L.M1	-0.100*	-0.227	-0.017	-1.816
	(-2.23)	(-1.88)	(-0.87)	(-0.42)
L2.M1	0.052	0.074	0.003	-4.506
	(1.41)	(0.68)	(0.19)	(-1.26)
L.FED	0.001	0.056	0.008	8.606
	(0.02)	(0.31)	(0.29)	(1.42)
L2.FED	-0.031	-0.120	-0.013	-7.365
	(-0.49)	(-0.64)	(-0.45)	(-1.25)
L.EQUITY	-0.228**	-0.650***	0.028	1.035
	(-3.23)	(-4.01)	(1.15)	(0.19)
L2.EQUITY	0.135	0.311	-0.014	-3.127
	(1.53)	(1.37)	(-0.42)	(-0.43)
L.TED	0.098*	0.494***	0.035	-5.362
	(2.15)	(4.02)	(1.79)	(-1.21)
L2.TED	-0.089	-0.446**	-0.004	5.667
	(-1.80)	(-3.01)	(-0.21)	(1.19)
L.Bond Liquidity	1.449***	0.815***	0.288	0.452**
	(8.85)	(6.22)	(1.86)	(3.13)
L2.Bond Liquidity	-0.623***	-0.241*	0.198	0.094
	(-4.57)	(-1.99)	(1.20)	(0.62)
Constant	0.333*	0.677**	0.302*	7.308
	(2.31)	(2.79)	(2.55)	(1.29)
R squared	0.985	0.91	0.473	0.6
Obs.	46	46	46	46

t statistics in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Thomson Financial Datastream

Table 14: **Panel Regressions of Bond Liquidity.** This table presents the results from balanced panel regressions of bond liquidity variables,Bid-Ask Spread and Price Volatility, on coupon rate (Coupon), remaining maturity (Maturity), amount outstanding in billion US Dollars (AOS), Standard and poor's long term borrower rating (Rating), 3 month Libor minus T-bill (TED) spread and percentage growth of US M1 money supply (M1). Bond Liquidity variables are monthly averages of Bond Price Bid-Ask Spread and Price Volatility. Rating variable is the number assigned to the letters of Standard and Poor's long term ratings ranging from 5 for CCC- and 23 for AAA. Our sample uses 482 bonds issued by 72 sovereigns and traded internationally during January 1999 and December 2009. We include all of the sovereign bonds for which the price, bid-ask and transaction volume data are available by ISMA (the International Securities Market Association) via Thomson Financial Datastream.

	Bid-Ask Spread			Price Volatility		
	1999-2009	1999-2007	2007-2010	1999-2009	1999-2007	2007-2010
Coupon	0.06**	0.08***	0.07*	0.22	0.105***	0.284*
	(2.89)	(5.66)	(2.39)	(1.90)	(8.86)	(2.07)
Maturity	-0.04***	-0.01	-0.07***	0.06***	0.029***	-0.092***
	(-4.04)	(-1.31)	(-4.87)	(6.07)	(6.72)	(-7.59)
AOS	0.01***	0.00***	0.00***	-0.01	-0.001***	-0.003*
	(5.62)	(5.42)	(4.19)	(-1.75)	(-4.18)	(-2.03)
Rating	-0.08***	-0.04***	-0.09***	0.046	0.004	-0.007
	(-7.10)	(-5.26)	(-6.41)	(1.11)	(0.56)	(-0.12)
TED	0.30***	0.38	0.30***	0.472***	0.941***	0.511***
	(11.27)	(1.82)	(10.98)	(16.93)	(7.30)	(17.87)
M1	-0.01***	-0.01*	-0.01***	-0.014***	-0.038***	-0.009***
	(-4.46)	(-2.09)	(-3.57)	(-9.14)	(-6.49)	(-7.52)
Constant	1.97***	1.08***	2.42***	-2.138	0.043	-0.074
	(6.64)	(4.82)	(6.19)	(-1.54)	(0.23)	(-0.04)
R-squared	0.124	0.296	0.111	0.054	0.03	0.153
Obs.	21898	8483	13415	23246	10221	13025

Figure 1: **Bond Market Liquidity Variables and World Financial Market Indicators.** These graphs present the time series graphs of bond market liquidity as average bid-ask spread versus 3 month Libor-OIS (Overnight Indexed Swap) Spread and bond price volatility versus Cboe VIX index. Bond variables are monthly averages of bond price bid-ask spread and price volatility of all internationally traded sovereign bonds issued in Euros and United States Dollars between January 1999 and December 2009. The Libor-OIS spread is the difference between the Libor and the overnight indexed swap rate, and is commensurate with the amount of perceived credit risk in the interbank lending market. Cboe VIX is the Chicago Board Options Exchange Volatility Index, a popular measure of the implied volatility of S&P 500 index options. A high value corresponds to a more volatile market and therefore more costly options, which can be used to defray risk from this volatility by selling options. Often referred to as the fear index, it represents one measure of the market's expectation of volatility over the next 30 day period. The data are available at Thomson Financial Datastream.

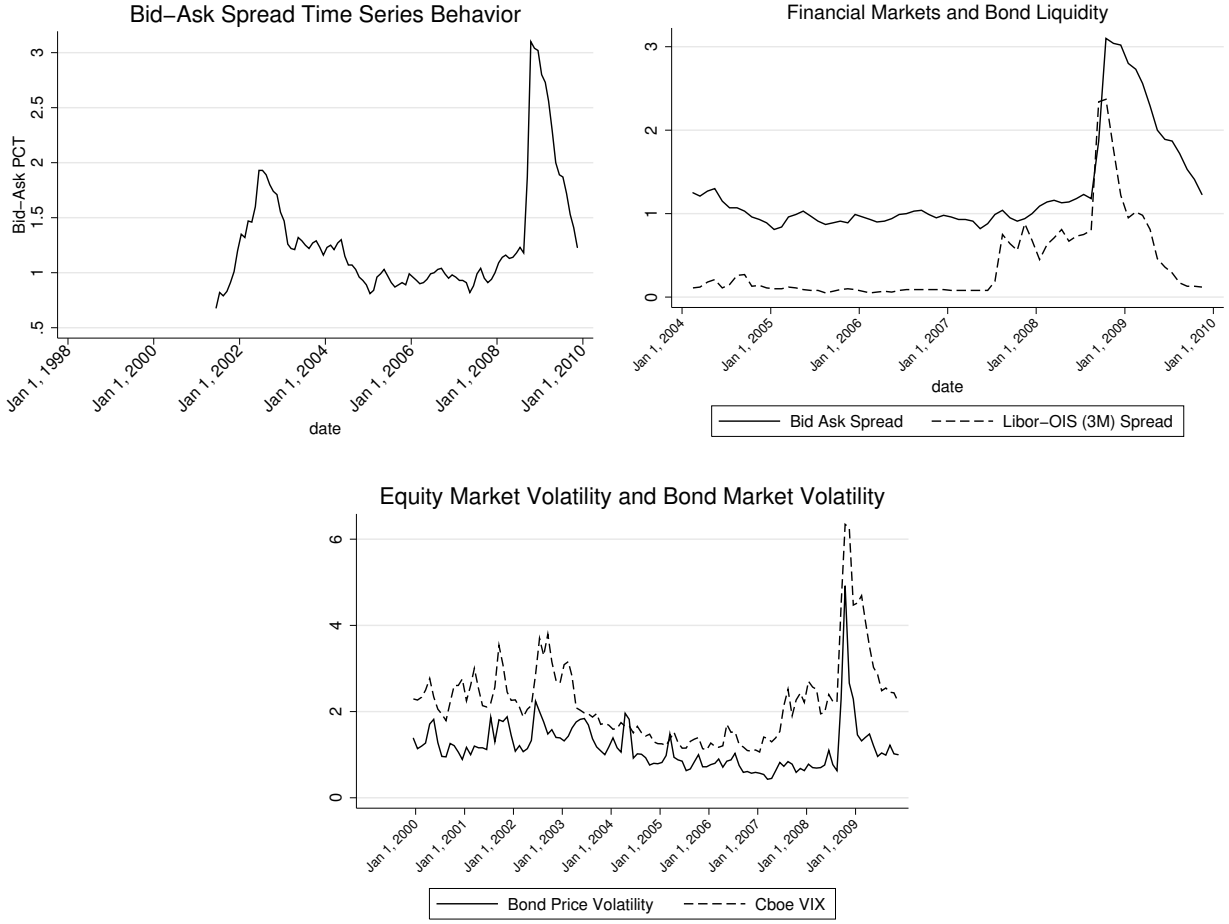

Figure 2: **Impulse Response Functions** These figures document dynamic responses of sovereign international bond liquidity to orthogonalized one-time unit standard deviation shocks in itself and the other variables. They are computed using standard Cholesky decompositions of the VAR residuals and assuming that innovations in the variables placed earlier in the VAR have greater effects on the following variables. The variable definitions can be found in the Data section of the text. The data are available at Thomson Financial Datastream.

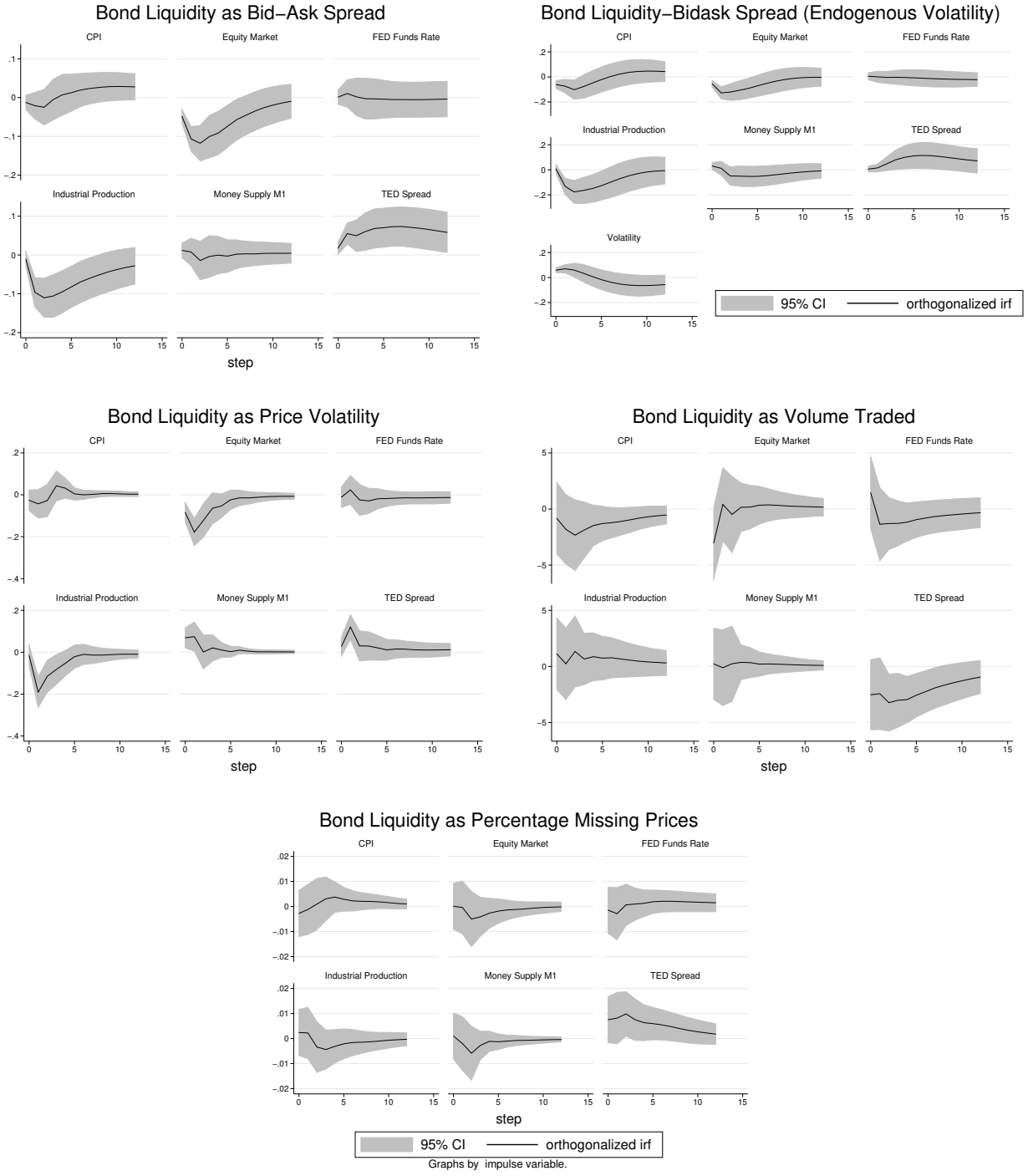

Figure 3: **Sub-Sample 1999 to 2006 and 2006 to 2009 Impulse Response Functions** These figures document dynamic responses of sovereign international liquidity in two sub-samples of time to orthogonalized one-time unit standard deviation shocks in itself and the other variables. They are computed using standard Cholesky decompositions of the VAR residuals and assuming that innovations in the variables placed earlier in the VAR have greater effects on the following variables. The variable definitions can be found in the Data section of the text. The data are available at Thomson Financial Datastream.