An Alternative Measure of Illiquidity: Insights on U.S. Treasury Bills, Notes and Bonds

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Abstract

The paper proposes an alternative measure of illiquidity based on the dynamics of the *j-th order conditional serial covariance*, relaxing the hypothesis of market efficiency. The empirical findings of the analysis are many: (i) A conditional metrics of illiquidity for short and long term U.S. government debt obligations, its level of skewness and kurtosis are discussed; (ii) The illiquidity of the U.S. treasuries is mainly related to the U.S. stock market illiquidity, the difference of illiquidity between Aaa and Baa U.S. corporate bonds, the spread between the U.S. corporate bond yields, as well as the illiquidity for the 5 Fama-French factors; (iii) The level of the CBOE Volatility Index is statistically significant for explaining the illiquidity premium for the term structure of the U.S. government debt obligations. (iv) The evidence of flight-to-liquidity, from the U.S. equity market to the U.S. treasuries as well as corporate bonds, is discussed during the recent financial turmoil.

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1. Introduction

From the time of *Salomon Brothers Inc.* auction bidding scandal that broke during the summer of 1991, the U.S. Treasury market started to undertake a series of reforms with the aim to improve the integrity of this market. At that time, the U.S. Treasury suspended Salomon Brothers Inc., one of the biggest and aggressive powerhouse for trading and investments in *The Wall Street*, from bidding in treasury auctions because of their ambiguous bidding in that market. The company admitted that perhaps some suspected deals happened, purchasing more than its allowed share of 35% at several treasury auctions and mentioned that an accidental mistake was done with the purchase of USD $ 1 billion worth of the securities, presumably because the company, although aware of the rules for these auctions, accidentally increased its bargaining power.

The investigations computed by the Federal Reserve as well as the U.S. Security and Exchange Commission (SEC) clarified a particular episode that happened during the summer of 1991, providing much more details to market participants, also related to previous (treasury) auctions. It was a hot summer, with an august characterized by an average daily high temperature of 78.8°F, where, *The Salomon Brothers Inc.* and its staff members were under the microscope and *The New York's* weather conditions, characterized by a humid continental climate season, although it was a bit chilly in some days during the evenings.

The debate of market illiquidity has been critical after several other episodes related to the secondary market, where, imperfections as well as frictions play an important role. For example, the 2013 "taper tantrum", where, the U.S. government bond prices tumbled and their yields sharply increased; the "U.S. flash rally" on October 15th, 2014, when the yields felt by nearly 37 basis points before recovering by the close of the trading day as well as the "bund tantrum" characterized by a high level of volatility and a dry up of liquidity repoint out the important role that treasury securities play for the financial markets, since they serve as a collateral for several bilateral transactions, for transactions created by stock exchanges and clearing houses, for developing monetary policy actions and for controlling the risks associated to market positions undertaken by financial institutions, particularly asset managers that hold a bigger share of the U.S. treasuries.

This paper proposes an alternative metrics of illiquidity based on the dynamics of the j-th order conditional serial covariance for the observed values of financial instruments. The framework is in line with the theoretical models proposed by Roll (1984), Glosten and Harris (1988), Harris (1990a) as well as Hansen and Hodrick (1980), although, the econometric methodology is developed relaxing the assumption of market efficiency, with time-varying levels of conditional dependence between unobserved variations of the U.S. treasury interest rates with variations of transaction costs as well as time-varying levels of conditional dependence for predicting the changes of the transaction costs. The causes that might create the degree of market efficiency for the U.S. treasury market also depend on the frictions as well as the transaction costs that market participants face in order to discover the observed market value of the U.S. treasuries.

This analysis studies the relationship between the level of illiquidity for the short and long term U.S. government debt obligations, showing an evidence of *flight to liquidity*, from the U.S. equity market to the U.S. treasuries as well as Aaa and Baa U.S. corporate bonds, particularly during the period of the recent financial crisis.

The results point out the statistical relationships between the illiquidity of the U.S. equity market with the level of illiquidity for the U.S. treasuries, the difference of illiquidity between Aaa and Baa U.S. corporate bonds and the spread of the yields between long term corporate bonds. A higher level of illiquidity for the CRSP value weighted U.S. stock market returns tends to decrease the level of illiquidity for the U.S. treasury bills as well as the level of illiquidity for the long term U.S. government debt obligations.

This market behavior is in line with the *flight to liquidity* effect (Longstaff 2004, Engle et al. 2012) that also corresponds to the flight to quality effect (Beber et al. 2009) in some circumstances, characterized by an outflow of capital from the U.S. equity market to the U.S. treasury markets. Particularly, during the recent financial turmoil, market participants change their investment choices provocating an increase of the liquidity for the short and long term U.S. government debt obligations. This effect turns out to be statistically consistent for the U.S. treasury bills, whereas, it is not significant for longer term U.S. government debt obligations much more sensitive to the dynamics of the difference between the illiquidity of Aaa and Baa U.S. corporate bond yields as well as to the changes of Aaa and Baa corporate bond yields.

The estimated coefficient for the difference of illiquidity between Aaa and Baa U.S. corporate bonds is positive and high statistically significant for explaining the dynamics of illiquidity for the U.S. government debt obligations. It tends to decrease across maturities concerned about the U.S. government debt obligations (from 11.90 to 0.86), meaning that the estimated coefficient is greater for the U.S. treasury bills than for longer term U.S. government debt obligations. This effect is also consistent, in case of a decrease of illiquidity for Baa U.S. corporate bonds respect to the illiquidity for Aaa U.S. corporate bonds, provided the change of the investor risk aversion with the aim to buy corporate bonds able to guarantee a higher yield with a lower price.

The empirical results also show the role provided by the illiquidity for the 5 Fama-French factors, such as the small minus big factor (SMB), the high minus low factor (HML), the robust minus weak factor (RMW), the conservative minus aggressive factor (CMA) and the U.S. stock market returns. The analysis finds statistical support for the illiquidity measure related to 4 out of 5 Fama-French factors (SMB, HML, CMA and the U.S. stock market). The estimated coefficient that depicts the level of illiquidity for the SMB factor increases across maturities from -1.625 (for the 7 years U.S. government debt obligations) to -0.800 (for the 20 years U.S. government debt obligations), meaning that an increase of illiquidity for this factor sharply decreases the level of illiquidity for the long term U.S. treasuries and the magnitude of the statistical effect turns out to increase across the term structure of the U.S. government debt. An increase of illiquidity for the SMB factor can be related to an increase of illiquidity for the portfolios based on the size to book indicator; an increase of illiquidity for the portfolios based on the size to operating level of profitability or an increase of illiquidity for the portfolios, computed with respect to the size to investment indicator.

Further, a sharp dry up of liquidity for the HML and CMA factors tends to increase the level of illiquidity for the long term U.S. treasuries, meaning that a dramatic increase of illiquidity for these factors can provocate a further deterioration of liquidity for the long term U.S. treasuries.

The analysis studies the relationship between the level of the CBOE Volatility Index (VIX) and the illiquidity premium related to the term structure of the U.S. government bond yields with a different maturity. In particular, an increase of the market expectations of near term volatility conveyed by options for the U.S. stock index prices tends to slightly increase the illiquidity premium between the 20 years U.S. treasury bonds and the 1 year U.S. treasury bill, due to an increase of illiquidity for the 20 years U.S. government debt obligations or a decrease of illiquidity for the 1 year U.S. treasury bill.

The statistical effect tends to decrease for the long term U.S. government debt obligations, showing how the level of illiquidity premium for the U.S. government bond term structure is almost not sensitive to the dynamics of the VIX. In particular, an increase of the fear related to the U.S. stock market expectations changes the investment choices of the market participants for preferring the U.S. treasury bonds rather than the U.S. treasury bills. Indeed, investors tend to rely on much more liquid investments such as the U.S. treasury notes and bonds as well as the U.S. corporate bonds, during the periods of increasing levels of the implied volatility, provided the statistical effect on the term structure of the illiquidity premium. This change of the investment choices also characterizes the dynamics of the illiquidity premium between the U.S. treasury bonds and the U.S. treasuries with a different maturity.

The paper is organized as follows. Section 2 discusses an overview of the literature. Section 3 describes the model that relaxes the assumption of market efficiency. The section 4 provides a summary and descriptive statistics of the data. The econometric methodology is developed in section 5. The empirical results are discussed in section 6. The section 7 concludes.

2. An overview of the literature

The first academic contributions on the topic of liquidity provided by Demsetz (1968) as well as Copeland and Galai (1983) study the relationship between firm size and volume and point out the negative relationship between volume and the bid-ask spread that can be inferred from the sequence of price changes and transformed to the sample serial covariance (Roll 1984), based on the hypothesis of market efficiency (Fama 1970).

For some financial applications, standard variance and serial covariance estimators respectively overestimate the variance and serial covariance of the underlying stock values (Harris 1990a), providing a biased level of the implied bid-ask spread. Glosten and Harris (1988) estimate the components of the bid-ask spread, one due to asymmetric information and one due to inventory costs, specialist monopoly power and clearing costs.

This empirical analysis complements several other studies that focus on the topic of liquidity for the U.S. treasury markets. A number of theoretical models discuss the phenomenon of liquidity (Vayanos 2004, Brunnermeier and Pedersen 2009) and empirical evidences are discussed by Amihud and Mendelson (1991), Longstaff (2004), Baele et al. (2010, 2013), Beber et al. (2009), Bansal et al. (2009) as well as by Chordia et al. (2005) that also discuss the relationship between equity and treasury markets. Fleming and Remolona (1997, 1999), Balduzzi et al. (2001) document the intraday patterns of trading volume and bid-ask spreads around some macroeconomic announcements; whereas, Huang et al. (2002) focus on the information based trading for the treasury note interdealer broker market.

This study also provides a methodology able to incorporate the dynamics of the j-th order conditional serial covariance and so correcting the bias for estimating this quantity and the time-varying level of the conditional illiquidity for the U.S. treasury markets. The framework is in line with the literature on market microstructure that studies the trading mechanisms as well as the origins of illiquidity in terms of bid-ask spreads (O'Hara 1995; Madhavan 2000; Harris 2003) and with studies that point out the association between trading activity and stock market returns (Benston and Hagerman, 1974; Gallant et al., 1992; Hiemstra and Jones, 1994; Lo and Wang, 2000).

In this respect, Amihud (2002) points out how a high level of illiquidity today predicts a high level of expected illiquidity for the next period, leading to a high required return, which is achieved by lowering current prices (Chordia et al. 2005). Theoretical justifications are provided by order imbalances that signal private information, which should reduce liquidity at least temporarily, changing the contemporaneous relation between stock volatility and volume (Fong 2000). The order imbalances could also move the market price permanently, as suggested by the theory of price formation proposed by Kyle (1985), based on inventory models (Stoll 1978a; Ho and Stoll 1983; Spiegel and Subrahmanyam 1995)[1].

The statistical justification for depicting the relationship between liquidity and asset prices is also provided by Richardson and Smith (1991), that relies on Hansen and Hodrick (1980) and Geweke (1981), where, the authors propose tests of financial models with the aim to test the joint serial dependence restrictions imposed by random walk and rational expectations, modeling the dependencies between overlapping observations. This statistical framework also represents the background for the papers proposed by Getmansky et al. (2004) and Kruttli et al. (2015), where, a simple econometric framework for depicting the level of serial correlation and illiquidity is developed for the hedge funds industry and for studying the impact of hedge funds on asset markets.

Another part of the literature studies the role provided by the level of liquidity for pricing an asset (Amihud 2002; Acharya and Pedersen 2005; Cochrane 2005), considering the constant trading frictions (Amihud and Mendelson 1986; Constantinides 1986; Vayanos 1998; Vayanos and Vila 1999; Garleanu and Pedersen 2004) and how asymmetric information and imperfect competition affect liquidity and asset prices (Vayanos and Wang 2012).

Several other studies point out empirical findings that have the aim to price the market liquidity (Pastor and Stambaugh 2003; Amihud and Mendelson 1986) that comoves and predicts future market returns (Chordia et al. 2001a; Jones 2001; Pastor and Stambaugh 2003; and Bekaert et al. 2003). Jones (2001) empirically studies the relationship between the expected annual stock market returns with the previous year's bid-ask spread that tends to decrease with the previous year's turnover; whereas, Bekaert et al. (2003) find a negative relationship between illiquidity and returns in emerging markets.

3. The Model

I assume that the observed price of an asset $(\hat{p})$, at a certain time t, consists of two components $\tilde{p}$ that is the unobserved price caused by the arrival of new information at a certain time t and p that is the transaction cost component that represents the costs incurred in making an exchange of a certain asset. In practice, these costs can be difficult to distinguish since they are usually related to the size or the volume of a given transaction, its level of riskiness, the *bargaining power* of the counterparts that can also negotiate the amount

[1] Academic studies on order imbalances around some specific event dates rely on the contributions provided by Blume et al. (1987), Sias (1997); whereas, Hasbrouck and Seppi (2001) and Brown et al. (1997) shed some light on order imbalances for thirty and twenty stocks, over one and two years, respectively.

of the transaction costs as well as many other variables related to the information that is power (Stigler 1971; Peltzman 1976) that changes over time as well as the search for different counterparts (Duffie et al. 2010) that can create frictions and so further costs for agents willing to exchange a certain asset[2].

Therefore, it is possible to write the following equality:

$$\hat{p_t} = \tilde{p_t} + p_t \tag{1}$$

where, the observed price change $(\triangle \hat{p_t})$, from $t-1$ to t is equal to the following quantity:

$$\triangle \hat{p_t} = \triangle \tilde{p_t} + \triangle p_t. \tag{2}$$

$\triangle \tilde{p_t}$ is the unobserved price change and $\triangle p_t$ is the change of the transaction costs component. If the markets are informationally inefficient, the dynamics of the j-th order conditional serial covariance related to $\triangle \hat{p_t}$, considering the ***lag*** variation of the observed price, the asset information set F_{t-j-1} at time $t-j-1$ and $j \geq 1$, can be computed in the following way:

$$Cov\left(\triangle \hat{p}_t\,,\, \triangle \hat{p}_{t-j} \;\mid\; F_{t-j-1}\right) = Cov\left(\triangle \tilde{p_t} + \triangle p_t\,,\, \triangle \tilde{p}_{t-j} + \triangle p_{t-j} \;\mid\; F_{t-j-1}\right) \tag{3}$$

whereas, the dynamics of the j-th order conditional serial covariance related to $\triangle \hat{p_t}$, considering the ***lead*** variation of the observed price, the asset information set F_{t-1} at time $t-1$ and $j \geq 1$, can be computed as follows:

$$Cov\left(\triangle \hat{p}_t\,,\, \triangle \hat{p}_{t+j} \;\mid\; F_{t-1}\right) = Cov\left(\triangle \tilde{p_t} + \triangle p_t\,,\, \triangle \tilde{p}_{t+j} + \triangle p_{t+j} \;\mid\; F_{t-1}\right). \tag{4}$$

3.1 The j-th order LAG dynamic Illiquidity measure

Considering the equality n. 3, the dynamics of the j-th order conditional serial covariance can be rewritten in the following way:

$$Cov\left(\triangle \hat{p}_t\,,\, \triangle \hat{p}_{t-j} \mid F_{t-j-1}\right) = E\left[\left(\triangle \tilde{p_t} + \triangle p_t\right)\left(\triangle \tilde{p}_{t-j} + \triangle p_{t-j}\right) \mid F_{t-j-1}\right] + \tag{5}$$

$$-E\left[\left(\triangle \tilde{p_t} + \triangle p_t\right) \mid F_{t-j-1}\right] \cdot E\left[\left(\triangle \tilde{p}_{t-j} + \triangle p_{t-j}\right) \mid F_{t-j-1}\right]$$

or simply, the dynamics of the j-th order conditional serial covariance can be also written as follows:

$$Cov\left(\triangle \hat{p}_t\,,\, \triangle \hat{p}_{t-j} \mid F_{t-j-1}\right) = E\left[\triangle \tilde{p_t} \cdot \triangle \tilde{p}_{t-j} + \triangle \tilde{p_t} \cdot \triangle p_{t-j} + \triangle p_t \cdot \triangle \tilde{p}_{t-j} + \triangle p_t \cdot \triangle p_{t-j} \mid F_{t-j-1}\right] + \tag{6}$$

$$-\left(E\left[\triangle \tilde{p_t} \mid F_{t-j-1}\right] + E\left[\triangle p_t \mid F_{t-j-1}\right]\right)\left(E\left[\triangle \tilde{p}_{t-j} \mid F_{t-j-1}\right] + E\left[\triangle p_{t-j} \mid F_{t-j-1}\right]\right).$$

[2]For some transactions, the adverse selection costs can be also equal to the transaction costs incurred in making an exchange of a certain asset, although these concepts are different from a finance standpoint. For simplicity, I rely on the framework proposed by Roll (1984), where, there is not a clear difference between adverse selection costs and transaction costs. From an empirical standpoint, it is not possible to even price certain costs that are not strictly due to the charges that market participants pay for exchanging a certain asset. In any case, this does not affect the empirical results of the paper.

The right hand side (RHS) of the equality can be also decomposed in the following way:

$$\left(E\left[\triangle\tilde{p}_t\cdot\triangle\tilde{p}_{t-j}\mid F_{t-j-1}\right]-E\left[\triangle\tilde{p}_t\mid F_{t-j-1}\right]\cdot E\left[\triangle\tilde{p}_{t-j}\mid F_{t-j-1}\right]\right)+ \tag{7}$$

$$+\left(E\left[\triangle\tilde{p}_t\cdot\triangle p_{t-j}\mid F_{t-j-1}\right]-E\left[\triangle\tilde{p}_t\mid F_{t-j-1}\right]\cdot E\left[\triangle p_{t-j}\mid F_{t-j-1}\right]\right)+$$
$$+\left(E\left[\triangle p_t\cdot\triangle\tilde{p}_{t-j}\mid F_{t-j-1}\right]-E\left[\triangle p_t\mid F_{t-j-1}\right]\cdot E\left[\triangle\tilde{p}_{t-j}\mid F_{t-j-1}\right]\right)+$$

$$+\left(E\left[\triangle p_t\cdot\triangle p_{t-j}\mid F_{t-j-1}\right]-E\left[\triangle p_t\mid F_{t-j-1}\right]\cdot E\left[\triangle p_{t-j}\mid F_{t-j-1}\right]\right).$$

Therefore, it is possible to rearrange the equality n. 6 as follows:

$$Cov\left(\triangle\hat{p}_t\,,\,\triangle\hat{p}_{t-j}\mid F_{t-j-1}\right)=Cov\left(\triangle\tilde{p}_t\,,\,\triangle\tilde{p}_{t-j}\mid F_{t-j-1}\right)+Cov\left(\triangle\tilde{p}_t\,,\,\triangle p_{t-j}\mid F_{t-j-1}\right)+ \tag{8}$$

$$+Cov\left(\triangle p_t\,,\,\triangle\tilde{p}_{t-j}\mid F_{t-j-1}\right)+Cov\left(\triangle p_t\,,\,\triangle p_{t-j}\mid F_{t-j-1}\right).$$

As such, the conditional time-varying j-th order level of illiquidity($Illiquidity$) at time t, considering the LAG variations, is defined in the following way:

$$LAG\,Illiquidity_t=-Cov\left(\triangle\hat{p}_t\,,\,\triangle\hat{p}_{t-j}\mid F_{t-j-1}\right) \tag{9}$$

3.2 The j-th order LEAD dynamic Illiquidity measure

Considering the equality n. 4, the dynamics of the j-th order conditional serial covariance can be rewritten in the following way:

$$Cov\left(\triangle\hat{p}_t\,,\,\triangle\hat{p}_{t+j}\mid F_{t-1}\right)=E\left[\left(\triangle\tilde{p}_t+\triangle p_t\right)\left(\triangle\tilde{p}_{t+j}+\triangle p_{t+j}\right)\mid F_{t-1}\right]+ \tag{10}$$

$$-E\left[\left(\triangle\tilde{p}_t+\triangle p_t\right)\mid F_{t-1}\right]\cdot E\left[\left(\triangle\tilde{p}_{t+j}+\triangle p_{t+j}\right)\mid F_{t-1}\right]$$

or simply, the dynamics of the j-th order conditional serial covariance can be also written as follows:

$$Cov\left(\triangle\hat{p}_t\,,\,\triangle\hat{p}_{t+j}\mid F_{t-1}\right)=E\left[\triangle\tilde{p}_t\cdot\triangle\tilde{p}_{t+j}+\triangle\tilde{p}_t\cdot\triangle p_{t+j}+\triangle p_t\cdot\triangle\tilde{p}_{t+j}+\triangle p_t\cdot\triangle p_{t+j}\mid F_{t-1}\right]+ \tag{11}$$

$$-\left(E\left[\triangle\tilde{p}_t\mid F_{t-1}\right]+E\left[\triangle p_t\mid F_{t-1}\right]\right)\left(E\left[\triangle\tilde{p}_{t+j}\mid F_{t-1}\right]+E\left[\triangle p_{t+j}\mid F_{t-1}\right]\right).$$

The right hand side (RHS) of the equality can be also decomposed in the following way:

$$\left(E\left[\triangle\tilde{p}_t\cdot\triangle\tilde{p}_{t+j}\mid F_{t-1}\right]-E\left[\triangle\tilde{p}_t\mid F_{t-1}\right]\cdot E\left[\triangle\tilde{p}_{t+j}\mid F_{t-1}\right]\right)+ \tag{12}$$

$$+\left(E\left[\triangle\tilde{p}_t\cdot\triangle p_{t+j}\mid F_{t-1}\right]-E\left[\triangle\tilde{p}_t\mid F_{t-1}\right]\cdot E\left[\triangle p_{t+j}\mid F_{t-1}\right]\right)+$$
$$+\left(E\left[\triangle p_t\cdot\triangle\tilde{p}_{t+j}\mid F_{t-1}\right]-E\left[\triangle p_t\mid F_{t-1}\right]\cdot E\left[\triangle\tilde{p}_{t+j}\mid F_{t-1}\right]\right)+$$

$$+\left(E\left[\triangle p_t\cdot\triangle p_{t+j}\mid F_{t-1}\right]-E\left[\triangle p_t\mid F_{t-1}\right]\cdot E\left[\triangle p_{t+j}\mid F_{t-1}\right]\right).$$

Therefore, it is possible to rearrange the equality n. 12 as follows:

$$Cov\left(\triangle\hat{p}_t\,,\,\triangle\hat{p}_{t+j}\mid F_{t-1}\right)=Cov\left(\triangle\tilde{p}_t\,,\,\triangle\tilde{p}_{t+j}\mid F_{t-1}\right)+Cov\left(\triangle\tilde{p}_t\,,\,\triangle p_{t+j}\mid F_{t-1}\right)+ \tag{13}$$
$$+Cov\left(\triangle p_t\,,\,\triangle\tilde{p}_{t+j}\mid F_{t-1}\right)+Cov\left(\triangle p_t\,,\,\triangle p_{t+j}\mid F_{t-1}\right).$$

As such, the conditional time-varying j-th order level of illiquidity($Illiquidity$) at time t, considering the $LEAD$ variations, is defined in the following way:

$$LEAD\,Illiquidity_t=-Cov\left(\triangle\hat{p}_t\,,\,\triangle\hat{p}_{t+j}\mid F_{t-1}\right) \tag{14}$$

The quantities $Cov\left(\triangle\tilde{p}_t\,,\,\triangle\tilde{p}_{t-j}\mid F_{t-j-1}\right)$ and $Cov\left(\triangle\tilde{p}_t\,,\,\triangle\tilde{p}_{t+j}\mid F_{t-1}\right)$ respectively represent the dynamics of the j-th order conditional serial covariances related to the unobserved price changes. These components depict the conditional time-varying surprises that are possible to discover during the evolution of the observed prices, provided the information related to an asset, that an investor respectively receives at time $t-j-1$ and $t-1$; the quantities $Cov\left(\triangle\tilde{p}_t\,,\,\triangle p_{t-j}\mid F_{t-j-1}\right)$ and $Cov\left(\triangle\tilde{p}_t\,,\,\triangle p_{t+j}\mid F_{t-1}\right)$ respectively represent the time-varying levels of the j-th order conditional serial dependence between the unobserved price variations and the changes in transaction costs, that an investor is willing to pay in order to acquire information about the evolution of the asset, provided the information respectively received till the time $t-j-1$ and $t-1$.

The components $Cov\left(\triangle p_t\,,\,\triangle\tilde{p}_{t-j}\mid F_{t-j-1}\right)$ and $Cov\left(\triangle p_t\,,\,\triangle\tilde{p}_{t+j}\mid F_{t-1}\right)$; as well as $Cov\left(\triangle p_t\,,\,\triangle p_{t-j}\mid F_{t-j-1}\right)$ and $Cov\left(\triangle p_t\,,\,\triangle p_{t+j}\mid F_{t-1}\right)$ respectively represent the time-varying levels of the j-th order conditional serial dependence between the variation of transaction costs and the unobserved price changes, provided the information set respectively acquired till the time $t-j-1$ and $t-1$ as well as the time-varying levels of the j-th order conditional serial covariance between the variations in transaction costs paid at time t, $t-j$ and $t+j$.

All these quantities incorporate the frictions that are possible to observe at a certain time t, between the unobserved price changes and the changes in transaction costs for a given asset and therefore impose market imperfections for discovering the dynamics of the observed asset price.

4. Data

The analysis respectively considers the U.S. treasury rates for short and long term debt obligations with a constant maturity, issued by the U.S. department of the treasury. The paper considers the 1 year term debt obligation (bill) for depicting the short term component of the debt issued by the U.S. treasury; whereas, it considers the notes with a maturity from 2 to 7 years and the bonds with a maturity of 10 and 20 years, for depicting the long term component of the U.S. debt obligations.

The difference between these two categories of obligations does not only rely on the maturity, but also on the interest paid by these U.S. debt obligations. The U.S. treasury bills do not pay an interest prior to the maturity and they are sold at a discount of the par value (face value) to create a positive internal rate of return that an investor receives when buying a fraction of the short term obligations at a certain time with a given market price, assuming that this fraction of the short term debt will be held until maturity and that all coupons and principal payments will be made on a precise schedule. Instead, the U.S. treasury notes and the U.S. treasury bonds have a coupon payment every six months and a denomination of USD $ 1000.

[Please Insert Table 1 around here]

The table 1 reports the descriptive and summary statistics for the changes of the interest rates for the short and long term U.S. debt obligations, from 01/03/1962 to 07/16/2015[3]. The average logarithmic and arithmetic changes for the short and long term U.S. debt obligations are negative during the recent financial crisis and the magnitude is greater in absolute value respect to the average rates computed from 03/15/2009 to 07/16/2015.

Before the recent financial crisis, the supply of the short term U.S. government debt was relatively constant, whereas, the supply of long term U.S. treasury bonds reported a slight upward movement till the end of June 2007. In this period, investors started to rely on riskier assets such as mortgage back securities (MBS) as well as collateralized debt obligations (CDOs), able to provide a higher rate of return compared to less risky investments such as the U.S. treasury bills, notes or bonds as well as Aaa and Baa corporate bonds.

During the period from 07/01/2007 to 03/15/2009, investors prefer to rely on safer investments, such as short and long term U.S. government debt obligations (*flight to quality*) and the demand for the U.S. treasuries starts to increase from July 2008, provided the high level of the equity market volatility. As such, the historical volatility related to the U.S. treasury bills and notes turns out to be higher than the uncertainty of the U.S. treasury bonds. The phenomenon of the flight to quality is also justified by the volatility of the mortgage market. Indeed, the market participants revise their expectations and start to decrease the demand for the mortgage backed securities as well as structured products.

After the period from March 2009, the market participants completely reconsider their degree of risk aversion for demanding structured products and their risk tolerance to safer and preferably much more

[3]The interest rates for the U.S. treasuries are interpolated using a spline technique able to construct the time series of the data, in case of missing values. In this empirical study, the author is not concerned about the most accurate procedure for interpolating the data, since it can depend on the time series of the U.S. treasuries and that perhaps can be different among time series, but about a trade-off between the estimation procedures based on missing data and interpolating techniques for a standard estimation of the coefficients.

liquid investments. This choice gradually decreases the total amount outstanding of structured products, since the market participants are much more receptive to the returns generated by the fixed income, the equity market as well as its derivatives. The historical volatility related to the U.S. government debt obligations increases even more for the 1 year U.S. treasury bill and the notes with different maturities. The higher level of uncertainty is compensated by a lower level of variation for the interest rates of the U.S. government debt obligations; whereas, the change of the interest rate is higher for the long term component of the U.S. government debt. The arithmetic changes of the interest rates reveal a higher increase of the yield generated by an investment on short and medium term U.S. treasuries than an investment related to long term U.S. treasury bonds, mainly reflecting the statistical procedure for computing the variations.

The analysis relies on the estimation of the time-varying level for the conditional serial covariance. In this respect, the table 2 reports the estimation of the historical auto-correlation, the partial auto-correlation and the Q statistics for the first five lags of the interest rates for the U.S. government debt obligations.

[Please Insert Table 2 around here]

The first order level of serial correlation denotes the magnitude of predictability for the U.S. treasuries that is respectively equal to -0.068 (for the 1 year U.S. treasury bill) and -0.048 (for the 2 years U.S. treasury note); whereas, it is positive and statistically significant for longer term U.S. treasuries. The second order serial level of correlation is negative across the maturities of the U.S. treasuries, meaning that the information related to two periods before the ensuing time, tends to provide a negative impact for the variation of the U.S. treasuries at a given time.

The table 2 also reports the values of the partial auto-correlation for the U.S. government debt obligations able to remove the linear dependence with the lags of the variations for the U.S. treasury interest rates. The values of the first order partial serial correlation are negative and statistically significant, for the 1 year U.S. treasury bill and the 2 years U.S. treasury note; whereas, they tend to be positive for longer term U.S. treasuries. The second order partial serial correlations are negative across all the U.S. treasuries with different maturities.

5. Econometric Methodology

The main goal of the section is to propose a simple econometric framework for estimating the time-varying level of the conditional illiquidity for the 1 year U.S. treasury bill as well as notes and bonds with a different maturity. The analysis considers the case in which $j = 1$ and aims to compute the dynamics of the first order serial covariance, respectively considering the *lag* and the *lead* logarithmic and arithmetic changes for the U.S. treasury rates. The arithmetic as well as the natural logarithm variations of the daily observed interest rates at time $t-1$, t and $t+1$ can be written in the following way:

$$\triangle \hat{p}_{1,t-1} = \left(\frac{\hat{p}_{t-1} - \hat{p}_{t-2}}{\hat{p}_{t-2}} \right) \backsimeq log \left(\frac{\hat{p}_{t-1}}{\hat{p}_{t-2}} \right) = \alpha + \varepsilon_{1,t-1} \tag{15}$$

$$\triangle \hat{p}_{2,t} = \left(\frac{\hat{p}_{t} - \hat{p}_{t-1}}{\hat{p}_{t-1}} \right) \backsimeq log \left(\frac{\hat{p}_{t}}{\hat{p}_{t-1}} \right) = \beta + \varepsilon_{2,t} \tag{16}$$

$$\triangle \hat{p}_{3,t+1} = \left(\frac{\hat{p}_{t+1} - \hat{p}_{t}}{\hat{p}_{t}} \right) \backsimeq log \left(\frac{\hat{p}_{t+1}}{\hat{p}_{t}} \right) = \gamma + \varepsilon_{3,t+1} \tag{17}$$

where, the quantities α, β, γ are respectively the coefficients of the mean equations that describe the evolution of the daily observed rates, at time $t-1$, $t\, and\, t+1$. The innovations related to these residuals follow a Diagonal BEKK (Baba et al. 1985, Engle and Kroner 1995) with a multivariate student t-distribution with a certain number of degrees of freedom, in order to compensate for the fat tails related to the arithmetic as well as the natural logarithmic variations of the daily observed interest rates. Therefore, the conditional variance processes for the observed rates can be estimated in the following way:

$$E\left[\varepsilon^2_{1,t-1} \mid F_{t-2}\right] = \sigma^2_{1,t-1} = m11 + a11 \cdot \varepsilon^2_{1,t-2} + b11 \cdot \sigma^2_{1,t-2} \tag{18}$$

$$E\left[\varepsilon^2_{2,t} \mid F_{t-1}\right] = \sigma^2_{2,t} = m22 + a22 \cdot \varepsilon^2_{2,t-1} + b22 \cdot \sigma^2_{2,t-1} \tag{19}$$

$$E\left[\varepsilon^2_{3,t+1} \mid F_{t}\right] = \sigma^2_{3,t+1} = m33 + a33 \cdot \varepsilon^2_{3,t} + b33 \cdot \sigma^2_{3,t} \tag{20}$$

where, $m11$, $m22$, $m33$ are the diagonal estimated coefficients concerned about the long period variance/covariance matrix; $a11$, $a22$, $a33$ are the diagonal estimated coefficients for the lagged squared residuals; whereas, $b11$, $b22$, $b33$ are the diagonal estimated coefficients that depict the persistence of the conditional variance components. The conditional cross-covariances among the error components are computed, in the following way:

$$E\left[\varepsilon_{1,t-1} \cdot \varepsilon_{2,t} \mid F_{t-2}\right] = \sigma_{12,t-2} = \rho_{12,t-2} \cdot \sigma_{1,t-1} \cdot \sigma_{2,t} \tag{21}$$

$$E\left[\varepsilon_{1,t-1} \cdot \varepsilon_{3,t+1} \mid F_{t-2}\right] = \sigma_{13,t-2} = \rho_{13,t-2} \cdot \sigma_{1,t-1} \cdot \sigma_{3,t+1} \tag{22}$$

$$E\left[\varepsilon_{2,t} \cdot \varepsilon_{3,t+1} \mid F_{t-1}\right] = \sigma_{23,t-1} = \rho_{23,t-1} \cdot \sigma_{2,t} \cdot \sigma_{3,t+1} \tag{23}$$

where, $\rho_{12,t-2}$ is the conditional cross-correlation between the *lag* and the *contemporaneous* observed changes of the interest rates, provided the information set at time $t-2$[4]. $\rho_{13,t-2}$ is the conditional cross-correlation between the *lag* and the *lead* observed rates, provided the information set at time $t-2$[5]; whereas,

[4]The quantities $\sigma_{1,t-1}$ and $\sigma_{2,t}$, mentioned in the equality n. 21, rely on the information set F, provided at time $t-2$

[5]The quantities $\sigma_{1,t-1}$ and $\sigma_{3,t+1}$, mentioned in the equality n. 22, rely on the information set F, provided at time $t-2$

$\rho_{23,t-1}$ is the conditional cross-correlation between the *contemporaneous* and the *lead* observed rates, provided the information set at time $t-1$[6].

6. Empirical Results

The analysis requires the estimation of the coefficients related to a Diagonal BEKK, with a disturbance assumption based on a multivariate t-student distribution. The table 3 reports the estimated coefficients that allow to determine the time-varying level of the first order conditional serial covariance and so the evolution of illiquidity for the U.S. government debt obligations.

[Please Insert Table 3 around here]

The coefficient α depicts the estimated values for the dynamics of the *lagged* natural logarithmic as well as arithmetic variations for the short and long term U.S. government debt obligations; the coefficient β depicts the expected values for the dynamics of the *contemporaneous* natural logarithmic as well as arithmetic variations; the coefficient γ depicts the expected values for the dynamics of the *lead* natural logarithmic as well as arithmetic variations of the U.S. treasury interest rates.

The coefficients $b11$, $b22$, $b33$ are greater than 0.983 and statistically significant at 1% level. These results are consistent for the analysis related to the natural logarithmic as well as arithmetic variations of the U.S. treasury interest rates and for the estimation of the lagged, contemporaneous and lead variations of the U.S. government debt obligations. A higher level of the variance concerned about the changes of the U.S. treasury interest rates increases the level of the variance for the next period, showing a high level of persistence for the dynamics of the uncertainty for the U.S. treasuries.

The estimated diagonal coefficients $a11$, $a22$, $a33$ are greater than 0.146 and statistically significant at 1% level. A decrease of the lagged squared residuals also diminishes the level of the variance for the next period. The estimated coefficient t that depicts the number of degrees of freedom increases across the dynamics of the term structure related to the changes of the U.S. treasury interest rates. If the computations are based on natural logarithmic variations, the coefficient t increases from 4.27 to 12.21; whereas, if the computations are based on arithmetic variations, the estimated coefficient t increases from 4.24 to 12.00. These high values reflect the fat tails of the distributions for the changing levels of the U.S. treasury interest rates, that increase for longer term U.S. government debt obligations, showing an asymmetric level of the distributions as well

[6] The quantities $\sigma_{2,t}$ and $\sigma_{3,t+1}$, mentioned in the equality n. 23, rely on the information set F, provided at time $t-1$

as a higher level of kurtosis and so extreme changes of the observed values.

[Please Insert Table 4 around here]

In line with Glosten (1989) as well as Glosten and Milgrom (1985), the competition among market makers and participants impacts the level of the skewness and kurtosis related to the distributions of illiquidity for the U.S. government debt obligations (see Table 4). During the recent financial turmoil, the flight to liquidity effect provocated a decrease of the bid-ask spreads for the U.S. treasuries, due to an increase of the risk aversion and a clustering of observations related to the changes in stock prices for the left tail of the distribution.

The level of the skewness for the illiquidity of the long term U.S. treasury notes and bonds increases along the time, meaning that the probability of a big negative variation of illiquidity is high and tends to increase from 01/01/1994 to 06/30/2015, becoming positive for the 3 years and 5 years U.S. treasury notes and so creating a greater than normal probability of a big positive variation of the illiquidity, after the recent financial crisis[7]. The clustering of observations linked to the changes of illiquidity for the U.S. treasuries in the left tail of the distributions decreases along the time, determining an increase of the magnitude for the skewness and a change of the competition among market participants that impact the level of illiquidity.

The distribution of illiquidity also shows a different level for the kurtosis that tends to decrease for the short term U.S. government debt obligations, implying an increase of the days characterized by a high level of illiquidity along the time. This evidence is also consistent for the long term U.S. government debt obligations, although the number of days of high illiquidity tends to decrease from 03/15/2009. This phenomenon is consistent with the increase of the risk propensity, where investors also tend to search investments able to generate higher levels of return.

[Please Insert Figure 1-2 around here]

The illiquidity related to the 1 year U.S. treasury bill (Figure 1) as well as for the U.S. treasury note (Figure 2) slightly fluctuates around 0 till December 2007 and increases from January 2008, where, several days of liquidity are anticipated by upward movements of the observed marked values for the 1 year U.S. treasury bill and the 2 years U.S. treasury note; whereas, several days of high illiquidity are anticipated by a downward movement of the 1 year U.S. treasury bill and the 2 years U.S. treasury note, showing a change

[7] The results are consistent for the metrics of the illiquidity computed with the *lag* as well as with the *lead* arithmetic and logarithmic variations.

of the market competition for the components of the U.S. government debt. The main explanation is the revision of the market expectations concerned about the observed market value of the 1 year U.S. treasury bill and the 2 years U.S. treasury note (Kyle 1985, Glosten and Milgrom 1985), where, prior information of the market value for these financial instruments is adjusted with the disclosure of new information also linked to the primary market. The changing nature of the asymmetric information for the observed market values of the U.S. treasury interest rates is one of the sources for the illiquidity[8] that sharply increases for the short term component of the U.S. government debt, as soon as investors require a higher yield for their investments, provocating an increase of the bid-ask spreads.

[Please Insert Figure 3-4 around here]

The stability of illiquidity measure is also consistent for the medium term component of the U.S. government debt (Figure 3 and Figure 4) that slightly fluctuates around 0, from January 1994 to December 2007. The fluctuations as well as the magnitude of illiquidity start to increase from January 2008, where, several days of uncertainty for the U.S. stock market are related to an increase of the risk aversion for the market participants, provocating a change of investments to safer and much more liquid assets. In particular, the recent financial turmoil as well as concerns for the stability of the eurozone, started to question the investment choices of many market participants that preferred to rely on high liquid assets (*flight to liquidity*), such as the U.S. treasury bonds (Figure 5, Figure 6 and Figure 7).

[Please Insert Figure 5-6-7 around here]

A change of the risk propensity started from the last quarter of 2011, where investors increased their search for higher levels of return, preferring riskier investments due to a further decline of the U.S. treasury interest rates as well as improvements of the U.S. stock market conditions and so provocating a large outflow of funds to different investments, characterized by a higher level of return such as junk bonds and U.S. stocks that pay big dividends. Indeed, as pointed out by Ms. Cathy Roy "the search for yield has just made people hold their nose and say, 'I like the yield"', although always aware of the risk. The search for higher levels of returns also penalized the investments for Aaa and Baa corporate bonds and so the level of liquidity for these financial instruments that turns out to fluctuate around 0 (Figure 8), with an average level of yields for 4.16% (Aaa corporate bonds) and 4.96% (Baa corporate bonds), from the second quarter of 2013.

[8]The findings are also consistent for the time-varying level of the conditional illiquidity, computed with the *lag* and the *lead* as well as with the *arithmetic* and *logarithmic* variations of the observed market value of the U.S. treasury bills.

[Please Insert Figure 8 around here]

During the recent financial crisis, the phenomenon of *flight to liquidity* is also evident for Aaa and Baa corporate bonds, where an increase of illiquidity for the U.S. stock market (Figure 8.2) creates a change of the market preferences and an increase of the risk aversion, where investors start to also allocate funds on corporate bonds able to guarantee an annualized average yield of 5.58% (Aaa corporate bonds) and 7.27% (Baa corporate bonds), compared to the yields provided by the U.S. treasury bonds that are sensitive to the duration and the maturity.

6.1 Illiquidity of the U.S. Treasury bills, notes and bonds vs. measures of Illiquidity

The increasing level of the U.S. government debt represents a clear source of uncertainty for the U.S. stock market characterized by a high level of illiquidity that picks around 0.00024. This effect also turns out to be consistent for the short term U.S. government debt obligations (Table 5); whereas, the level of illiquidity shows an opposite sign for the long term U.S. treasury bonds (Table 6), during the third quarter of 2011. This empirical finding is concerned about the competition among market participants that is higher for the long term U.S. treasury bonds and able to guarantee a higher yield respect to the U.S. treasury bills and medium term U.S. treasury notes.

[Please Insert Table 5 and Table 6 around here]

The empirical findings are corroborated by statistical results able to test the relationships between the illiquidity of short and long term U.S. government debt obligations with the illiquidity of the U.S. stock market, the difference of illiquidity between Aaa and Baa corporate bonds as well as the percentage change between Aaa and Baa corporate bond yields.

The coefficient that depicts the level of illiquidity for the U.S. stock market is negative and statistically significant for explaining the illiquidity for the 1 year U.S. treasury bill and the long term U.S. treasury notes and bonds. Further, the magnitude of the coefficient deteriorates during the period from July 2007 to March 2009, where, days of downside for the U.S. stock market tend to be followed by days of high illiquidity, since inventory financing constraints might be more binding during the days of the U.S. stock market downside.

This statistical relationship explains the illiquidity of the U.S. treasury notes with a maturity that is equal to 2 and 3 years, showing an increase of illiquidity for the U.S. stock market that also raises the level of illiquidity for these financial instruments. The statistical effect of the coefficients concerned about the illiquidity of the U.S. stock market is even greater during the recent financial crisis and it is also highly significant, during the period from March 2009 to June 2015.

[Please Insert Appendix A around here]

The difference of illiquidity between Aaa and Baa corporate bonds is positive and statistically significant for explaining the level of illiquidity for the short and long term component of the U.S. government debt obligations. A greater level of illiquidity for Aaa corporate bonds than a level of illiquidity for Baa corporate bonds or conversely a lower level of illiquidity for Baa corporate bonds respect to the level of illiquidity for Aaa corporate bonds increases the level of illiquidity for short and long term components of the U.S. government debt obligations. The coefficient that depicts the statistical effect of the variable able to explain the level of illiquidity for the 1 year U.S. treasury bill is equal to 11.902; whereas, it sharply decreases for the U.S. treasury notes and bonds.

The Appendix A reports the estimated coefficients able to describe the dynamics of illiquidity for Aaa and Baa corporate bonds. The diagonal coefficients $b11$, $b22$, $b33$ are statistically significant at 1% level and show a high level of persistence for the variance components greater than 0.980 and able to depict the dynamics of the time series for the lag, contemporaneous and lead as well as logarithmic and arithmetic variations of the U.S. treasury interest rates. The estimated diagonal coefficients $a11$, $a22$, $a33$ for the multivariate processes and able to describe the dynamics of illiquidity for Aaa corporate bonds are respectively equal to 0.172, 0.152 and 0.142; whereas, those coefficients able to depict the residuals and so the dynamics of illiquidity for Baa corporate bonds are equal to 0.162, 0.133 and 0.127.

6.1.1 Illiquidity of the U.S. Treasury bills, notes and bonds vs. measures of Illiquidity for the 5 Fama-French factors

The empirical analysis is also concerned about the relationship between the illiquidity for short and long term components of the U.S. government debt with the illiquidity of the 5 Fama-French factors. The Appendix B reports the estimated coefficients able to describe the dynamics of illiquidity for these factors.

[Please Insert Appendix B around here]

The estimated diagonal coefficients $b11$, $b22$, $b33$ are statistically significant at 1% level and show a high level of persistence of the uncertainty able to describe the dynamics of the variance for the lag, contemporaneous and lead arithmetic variations of the U.S. government debt obligations. The estimated coefficients (α, β, γ) of the mean equations; the estimated diagonal coefficients ($m11$, $m22$, $m33$) and the long period variance/covariance matrix as well as the estimated coefficients ($a11$, $a22$, $a33$) able to depict the effect of the residuals are all statistically significant at 1% level.

The correlation matrix among the time-varying metrics for the conditional illiquidity of the 5 Fama-French factors show values that are smaller than 0.55 (Appendix C), reflecting an unbiased statistical relationship between the level of illiquidity for the components of the U.S. government debt and the illiquidity of the 5 Fama-French factors.

[Please Insert Appendix C around here]

The statistical results are reported in Table 7 and show the role provided by the illiquidity of the 5 Fama-French factors, such as the small minus big factor (SMB), the high minus low factor (HML), the robust minus weak factor (RMW), the conservative minus aggressive factor (CMA) and the U.S. stock market returns, as regressors able to test the statistical relationships with the illiquidity of the U.S. treasuries across different maturities.

The analysis finds statistical support for the illiquidity measures related to 4 out of 5 Fama-French factors (SMB, HML, CMA and the U.S. stock market). The coefficient that depicts the level of illiquidity for the SMB factor increases across maturities from -1.625 (for the 7 years U.S. government debt obligations) to -0.800 (for the 20 years U.S. government debt obligations), meaning that an increase of illiquidity for this factor sharply decreases the level of illiquidity for the medium and long term U.S. treasuries. The statistical effect turns out to increase in terms of magnitude across the maturities of the U.S. government debt obligations. Conversely, the statistical relationship is positive for explaining the level of illiquidity for the 1 year U.S. treasury bill and the 2 years U.S. treasury note.

[Please Insert Table 7 around here]

An increase of illiquidity for the SMB factor is concerned about an increase of illiquidity for the portfolios based on the size to book indicator; an increase of illiquidity related to the portfolios based on the size to operating level of profitability or an increase of illiquidity for the portfolios, computed with respect to the size to investment indicator. The pattern of illiquidity for these portfolios as well as the level of dependencies and volatilities for describing the dynamics of these portfolios are crucial for determining the illiquidity concerned about the SMB factor and for depicting the statistical relationship with the illiquidity of the components for the U.S. government debt obligations.

It is also important to note that a reduction of liquidity for the HML and CMA factors tends to increase the level of illiquidity for the long term U.S. treasuries, meaning that a dramatic increase of illiquidity for these factors can further provocate an increase of illiquidity for the long term U.S. treasuries. The statistical effect turns out to decrease across the components of the U.S. government debt obligations, meaning that the statistical effect is greater for explaining the level of illiquidity for the short term U.S. government debt obligations rather than long term ones.

6.1.2 Illiquidity premium for the U.S. treasury bonds vs. CBOE Volatility Index

This subsection describes the statistical relationships between the illiquidity premium related to the U.S. treasury bills, notes and bonds with the market expectations of near term volatility conveyed by options for the U.S. stock index prices. The Figure 9 shows the time-varying evolution of the illiquidity premium between the level of illiquidity for the 20 years U.S. treasury bonds and the level of illiquidity for the U.S. treasuries with a different maturity. The illiquidity premium tends to fluctuate around 0 till the second quarter of 2007 and sharply fluctuates from January 2008, showing how the level of illiquidity for short and medium term U.S. treasuries is greater than the level of illiquidity for the U.S. treasury bonds.

[Please Insert Figure 9 around here]

The time-varying level of market competition that might influence the order imbalances also provocated by block trades (Kraus and Stoll 1972a,b) as well as situations of excess buy or sell orders (Spiegel and Subramanyan 1995) determine the level of the information for the U.S. treasury markets and so the level of the bid-ask spreads for these financial instruments, representing a clear motivation for characterizing days of more illiquidity for short term U.S. treasury bills compared to the U.S. treasury bonds and so impacting the illiquidity premium of the U.S. treasuries[9].

[Please Insert Table 8 around here]

[9] The figure 9 shows the difference (premium) of illiquidity between the 20 years U.S. treasury bond and the U.S. treasury bills, notes and bonds with a different tenor. The measure of illiquidity considers the LAG and the $LEAD$ arithmetic variations. The dynamics reports the values from 01/01/1994 to 06/30/2015.

Table 8 reports the statistical relationship with the level of the CBOE Volatility Index (VIX) that turns out to be high statistically significant[10]. In particular, an increase of the market expectations of near term volatility conveyed by options for the U.S. stock index prices tends to slightly increase the illiquidity premium between the 20 years U.S. treasury bonds and the 1 year U.S. treasury bill, due to an increase of illiquidity for the 20 years U.S. government debt obligations or a decrease of illiquidity for the 1 year U.S. treasury bill. The statistical effect tends to decrease for the long term U.S. government debt obligations, showing how the level of the illiquidity premium for the U.S. government bond term structure is almost not sensitive to the dynamics of the VIX. In particular, an increase of the fear related to the U.S. stock market expectations changes the investment choices of the market participants for preferring the U.S. treasury bonds rather than the U.S. treasury bills. Indeed, investors tend to rely on much more liquid investments such as the U.S. treasury notes and bonds, during periods of increasing levels of the implied volatility, provided the statistical effect on the term structure of the illiquidity premium. This change of the investment choices also characterizes the dynamics of the illiquidity premium between the U.S. treasury bonds and the U.S. treasuries with a different maturity.

7. Conclusion

The recent episodes of illiquidity for the interest rates of the U.S. government debt obligations have repointed out the need to be particularly watchful to the dynamics of illiquidity for these financial instruments. Therefore, the need for an alternative methodology able to model and predict the time-varying level of illiquidity is crucial for depicting dramatic changes of market competition and order imbalances that cause a pressure to the values of the U.S. treasury interest rates.

The paper discusses a statistical methodology based on the dynamics of the j-th order conditional serial covariance, relaxing the hypothesis of market efficiency and requires the estimation of the coefficients related to a Diagonal BEKK, with a disturbance assumption based on a multivariate t-student distribution. The level of the skewness and kurtosis concerned about the distribution of illiquidity for the U.S. treasuries is caused by a change of the market competition among market makers and participants (Glosten and Milgrom 1985, Glosten 1987a) as well as order imbalances also caused by block trades that impact the level of the skewness and kurtosis for the distributions of illiquidity related to the U.S. government debt obligations.

[10] The lagged value of the VIX is also statistically significant for explaining the dynamics of the illiquidity premium and slightly increases the Adjusted R^2.

Particularly, during the recent financial turmoil, the *flight to liquidity* effect provocated a decrease of the bid-ask spreads for the U.S. treasuries also caused by an increase of the risk aversion and a clustering of observations caused by the changes in stock prices for the left tail of the distribution.

The empirical evidence shows the statistical relationships between the illiquidity of the U.S. treasuries and the illiquidity of the U.S. stock market, the difference of illiquidity between Aaa and Baa U.S. corporate bonds, the spread between the U.S. corporate bond yields as well as the illiquidity for the 5 Fama-French factors. The analysis explains the statistical relationship between the illiquidity premium and the CBOE Volatility Index (VIX) that turns out to be high statistically significant. In particular, an increase of the market expectations of near term volatility conveyed by options for the U.S. stock index prices tends to slightly increase the illiquidity premium between the 20 years U.S. treasury bonds and the 1 year U.S. treasury bill, due to an increase of the illiquidity for the 20 years U.S. government debt obligations or a decrease of the 1 year U.S. treasury bill. The statistical effect tends to decrease for the long term U.S. government debt obligations, showing how the level of the illiquidity premium for the U.S. government bond term structure is almost not sensitive to the dynamics of the VIX.

The analysis corroborates the theoretical frameworks provided by Roll (1984), Harris (1990a), Richardson and Smith (1991) as well as Getmansky et al. (2004) and provides an econometric methodology able to depict the *conditional dynamics* and study the empirical findings concerned about the *illiquidity for the U.S. treasuries*, relaxing the assumption of market efficiency.

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Table 1.
Summary and Descriptive Statistics

The table reports the descriptive statistics related to the U.S. Treasury BILL, NOTES and BONDS for the period from 1/03/1962 to 7/16/2015. In particular, the table shows the mean (multiplied by 1000), median, max., min and the standard deviation for LOGARITHMIC (**Panel 1.1**) and ARITHMETIC (**Panel 1.2**) variations (**var**). **BC** indicates the period before the financial crisis; **DC** considers the period during the financial crisis as well as **AC** indicates the period after the financial crisis. The data are downloaded from the FRED database.

Panel 1.1: LOGARITHMIC Variations

BILL NOTES BONDS	Mean			Median			Max.			Min.			Std. Dev.		
	BC	DC	AC	BC	DC	AC	BC	DC	AC	BC	DC	AC	BC	DC	AC
1 year	0.015	-1.944	-0.220	0.000	-0.001	0.000	0.062	0.127	0.120	-0.048	-0.090	-0.125	0.005	0.020	0.027
2 years	-0.021	-1.565	-0.100	0.000	-0.001	0.000	0.057	0.084	0.138	-0.046	-0.098	-0.153	0.006	0.022	0.025
3 years	0.010	-1.249	-0.068	0.000	-0.001	0.000	0.053	0.072	0.091	-0.042	-0.086	-0.135	0.005	0.020	0.021
5 years	0.009	-0.944	-0.031	0.000	-0.001	0.000	0.040	0.052	0.064	-0.036	-0.059	-0.114	0.004	0.016	0.016
7 years	-0.014	-0.676	-0.047	0.000	-0.001	0.000	0.035	0.051	0.047	-0.035	-0.045	-0.097	0.004	0.013	0.013
10 years	0.008	-0.541	-0.053	0.000	0.000	0.000	0.026	0.028	0.037	-0.033	-0.038	-0.080	0.004	0.010	0.010
20 years	-0.027	-0.298	-0.082	0.000	0.000	0.000	0.018	0.027	0.035	-0.016	-0.032	-0.039	0.004	0.008	0.008

Panel 1.2: ARITHMETIC Variations

BILL NOTES BONDS	Mean			Median			Max.			Min.			Std. Dev.		
	BC	DC	AC	BC	DC	AC	BC	DC	AC	BC	DC	AC	BC	DC	AC
1 year	0.112	-3.430	1.430	0.000	-0.003	0.000	0.154	0.340	0.319	-0.104	-0.188	-0.250	0.012	0.046	0.063
2 years	0.055	-2.350	1.388	0.000	-0.002	0.000	0.140	0.213	0.375	-0.099	-0.202	-0.296	0.014	0.050	0.057
3 years	0.095	-1.824	0.968	0.000	-0.003	0.000	0.131	0.180	0.233	-0.092	-0.180	-0.267	0.012	0.046	0.048
5 years	0.073	-1.522	0.592	0.000	-0.003	0.000	0.098	0.127	0.159	-0.079	-0.128	-0.230	0.010	0.036	0.036
7 years	0.017	-1.102	0.315	0.000	-0.002	0.000	0.083	0.124	0.114	-0.077	-0.099	-0.201	0.010	0.030	0.029
10 years	0.054	-0.975	0.135	0.000	0.000	0.000	0.061	0.068	0.090	-0.074	-0.083	-0.169	0.009	0.023	0.023
20 years	-0.022	-0.534	-0.030	0.000	0.000	0.000	0.043	0.064	0.084	-0.035	-0.072	-0.085	0.009	0.017	0.018

Table 2.
Auto Correlation and Partial Auto Correlation

The table reports the Auto Correlation (AC) and the Partial Auto Correlation (PAC) related to the US Treasury BILL, NOTES and BONDS for the period from 1/03/1962 to 7/16/2015. The table reports the lags for computing the AC and the PAC as well as the corresponding probability related to the Q-statistics.

BILL NOTES BONDS	LAGS	Logarithmic Variations			Arithmetic Variations		
		AC	PAC	Prob.	AC	PAC	Prob.
1 year	1	-0.063	-0.063	0.000	-0.063	-0.063	0.000
	2	-0.069	-0.073	0.000	-0.070	-0.074	0.000
	3	-0.004	-0.013	0.000	-0.003	-0.013	0.000
	4	0.029	0.023	0.000	0.025	0.019	0.000
	5	0.000	0.002	0.000	-0.001	0.001	0.000
2 years	1	-0.043	-0.043	0.000	-0.040	-0.040	0.000
	2	-0.094	-0.096	0.000	-0.096	-0.098	0.000
	3	0.023	0.015	0.000	0.023	0.015	0.000
	4	0.006	-0.001	0.000	0.004	-0.003	0.000
	5	-0.026	-0.022	0.000	-0.029	-0.025	0.000
3 years	1	0.031	0.031	0.000	0.034	0.034	0.000
	2	-0.066	-0.067	0.000	-0.067	-0.068	0.000
	3	0.014	0.019	0.000	0.012	0.017	0.000
	4	-0.003	-0.008	0.000	-0.002	-0.008	0.000
	5	-0.030	-0.028	0.000	-0.031	-0.029	0.000
5 years	1	0.032	0.032	0.000	0.034	0.034	0.000
	2	-0.052	-0.054	0.000	-0.052	-0.054	0.000
	3	0.012	0.016	0.000	0.012	0.015	0.000
	4	0.001	-0.003	0.000	0.001	-0.002	0.000
	5	-0.027	-0.026	0.000	-0.028	-0.026	0.000
7 years	1	0.048	0.048	0.000	0.049	0.049	0.000
	2	-0.048	-0.051	0.000	-0.049	-0.051	0.000
	3	0.009	0.014	0.000	0.009	0.014	0.000
	4	-0.011	-0.014	0.000	-0.011	-0.015	0.000
	5	-0.034	-0.032	0.000	-0.035	-0.032	0.000
10 years	1	0.065	0.065	0.000	0.066	0.066	0.000
	2	-0.044	-0.049	0.000	-0.045	-0.049	0.000
	3	0.006	0.013	0.000	0.006	0.013	0.000
	4	-0.014	-0.018	0.000	-0.015	-0.019	0.000
	5	-0.022	-0.020	0.000	-0.023	-0.019	0.000
20 years	1	0.032	0.032	0.016	0.032	0.032	0.017
	2	-0.048	-0.050	0.000	-0.049	-0.050	0.000
	3	-0.006	-0.003	0.000	-0.006	-0.003	0.000
	4	-0.024	-0.026	0.000	-0.024	-0.026	0.000
	5	-0.033	-0.032	0.000	-0.033	-0.032	0.000

Table 3.
Empirical Results for the U.S. Treasury BILLS, NOTES and BONDS

The table shows the estimated coefficients related to the **Diagonal BEKK** specification, with a disturbance assumption based on a ***t-student***, for depicting the dynamics of the first order serial covariances. **Panel 3.1** reports the estimated values for the case in which we propose logarithmic variations; **Panel 3.2** reports the estimated coefficients for the case in which we propose arithmetic variations. The coefficients α , β , γ are the estimated coefficients of the mean equations. These coefficients are multiplied by 1000. **m11, m22** and **m33** are the diagonal estimated coefficients related to the long period variance/covariance matrix. These values are multiplied by 100000. **a11, a22** and **a33** are the diagonal estimated coefficients related to the residuals. **b11, b22** and **b33** are the diagonal estimated coefficients related to the persistence of the variance/covariance matrix. **t** is the estimated number of degrees of freedom. The optimization algorithm relies on the Berndt-Hall-Hall-Hausman (B-H-H-H) procedure and the estimated coefficients consider the period between 1/03/1962 and 7/16/2015. ***, ** and * indicate significance at 1%, 5%, 10% levels, respectively. In brackets, the table reports the standard errors.

Panel 3.1:Logarithmic Variations

Coefficients	**Logarithmic Variations**						
	1 Year	**2 Years**	**3 Years**	**5 Years**	**7 Years**	**10 Years**	**20 Years**
α	0.077*** (0.000)	0.060 (0.000)	0.079*** (0.000)	0.070*** (0.000)	0.035 (0.000)	0.053*** (0.000)	-0.094* (0.000)
β	0.079*** (0.000)	0.060 (0.000)	0.085*** (0.000)	0.066*** (0.000)	0.026 (0.000)	0.045*** (0.000)	-0.108* (0.000)
γ	0.085*** (0.000)	0.037 (0.000)	0.079*** (0.000)	0.062*** (0.000)	0.012 (0.000)	0.048*** (0.000)	-0.109* (0.000)
m11	0.001** (0.000)	0.002** (0.000)	0.000 (0.000)	0.003* (0.000)	0.002*** (0.000)	0.000 (0.000)	0.006*** (0.000)
m22	0.000 (0.000)	0.001 (0.000)	0.000 (0.000)	0.001 (0.000)	0.001* (0.000)	0.000 (0.000)	0.006*** (0.000)
m33	0.000 (0.000)	0.001* (0.000)	0.000 (0.000)	0.001 (0.000)	0.001*** (0.000)	0.000 (0.000)	0.005*** (0.000)
a11	0.198*** (0.005)	0.184*** (0.005)	0.185*** (0.004)	0.183*** (0.005)	0.184*** (0.005)	0.182*** (0.005)	0.162*** (0.008)
a22	0.169*** (0.004)	0.167*** (0.005)	0.167*** (0.004)	0.165*** (0.004)	0.168*** (0.005)	0.167*** (0.005)	0.154*** (0.008)
a33	0.156*** (0.004)	0.154*** (0.005)	0.155*** (0.005)	0.155*** (0.004)	0.156*** (0.005)	0.155*** (0.004)	0.146*** (0.008)
b11	0.983*** (0.001)	0.985*** (0.001)	0.985*** (0.001)	0.985*** (0.001)	0.984*** (0.001)	0.985*** (0.001)	0.986*** (0.001)
b22	0.988*** (0.001)	0.988*** (0.001)	0.988*** (0.001)	0.988*** (0.001)	0.987*** (0.001)	0.987*** (0.001)	0.987*** (0.001)
b33	0.989*** (0.001)	0.989*** (0.001)	0.989*** (0.001)	0.989*** (0.001)	0.989*** (0.001)	0.989*** (0.001)	0.989*** (0.001)
t	4.270*** (0.102)	4.858*** (0.152)	4.956*** (0.129)	5.507*** (0.149)	6.485*** (0.217)	5.992*** (0.174)	12.212*** (0.912)

Panel 3.2:Arithmetic Variations

Coefficients	Arithmetic Variations						
	1 Year	**2 Years**	**3 Years**	**5 Years**	**7 Years**	**10 Years**	**20 Years**
α	0.186*** (0.000)	0.157* (0.000)	0.191*** (0.000)	0.168*** (0.005)	0.094 (0.000)	0.127*** (0.000)	-0.185 (0.000)
β	0.190*** (0.000)	0.154* (0.000)	0.203*** (0.000)	0.160*** (0.005)	0.073 (0.000)	0.107*** (0.000)	-0.219* (0.000)
γ	0.205*** (0.000)	0.102 (0.000)	0.192*** (0.000)	0.151*** (0.005)	0.043 (0.000)	0.115*** (0.000)	-0.220* (0.000)
m11	0.006** (0.000)	0.012** (0.000)	0.001 (0.000)	0.002* (0.000)	0.008*** (0.000)	0.001 (0.000)	0.033*** (0.000)
m22	0.003 (0.000)	0.007 (0.000)	0.000 (0.000)	0.001 (0.000)	0.005* (0.000)	0.000 (0.000)	0.030*** (0.000)
m33	0.003 (0.000)	0.008* (0.000)	0.001 (0.000)	0.001 (0.000)	0.006*** (0.000)	0.001 (0.000)	0.027*** (0.000)
a11	0.197*** (0.005)	0.184*** (0.006)	0.185*** (0.005)	0.183*** (0.005)	0.184*** (0.005)	0.182*** (0.005)	0.163*** (0.008)
a22	0.169*** (0.004)	0.166*** (0.005)	0.166*** (0.004)	0.165*** (0.004)	0.168*** (0.005)	0.167*** (0.005)	0.154*** (0.008)
a33	0.156*** (0.004)	0.154*** (0.005)	0.155*** (0.004)	0.155*** (0.004)	0.156*** (0.005)	0.155*** (0.004)	0.146*** (0.008)
b11	0.983*** (0.001)	0.985*** (0.001)	0.985*** (0.001)	0.985*** (0.001)	0.984*** (0.001)	0.985*** (0.001)	0.986*** (0.001)
b22	0.988*** (0.001)	0.988*** (0.001)	0.988*** (0.001)	0.988*** (0.001)	0.987*** (0.001)	0.987*** (0.001)	0.987*** (0.001)
b33	0.989*** (0.001)	0.989*** (0.001)	0.989*** (0.001)	0.989*** (0.001)	0.989*** (0.001)	0.989*** (0.001)	0.989*** (0.001)
t	4.236*** (0.100)	4.822*** (0.145)	4.939*** (0.128)	5.505*** (0.149)	6.485*** (0.219)	5.997*** (0.175)	12.002*** (0.885)

Table 4.

Skewness and Kurtosis related to the ILLIQUIDITY for the U.S. Treasury BILL, NOTES and BONDS

The table reports the values related to the ILLIQUIDITY Skewness (**Panel 4.1**) and Kurtosis (**Panel 4.2**) for the period from 01/01/1994 to 06/30/2015 as well as for the sub-periods around the financial crisis (July 2007 to December 2008). The values are related to the 1 Year, 2 Years, 3 Years, 5 Years and 7 Years NOTES as well as for the 10 Years and 20 Years BONDS. The table considers *LAG* and *LEAD* as well as arithmetic (**AR**) and logarithmic (**LOG**) variations.

Panel 4.1: ILLIQUIDITY Skewness

BILL NOTES BONDS	ILLIQUIDITY SKEWNESS															
	ALL				BEFORE Financial Crisis				DURING Financial Crisis				AFTER Financial Crisis			
	LAG		LEAD		LAG		LEAD		LAG		LEAD		LAG		LEAD	
	AR	LOG	AR	LOG	AR	LOG	AR	LOG	AR	LOG	AR	LOG	AR	LOG	AR	LOG
1 Year	2.051	1.973	2.010	1.949	-0.082	-0.119	-0.055	-0.092	-1.300	-1.436	-1.144	-1.248	0.472	0.456	2.616	0.375
2 Years	1.831	1.969	1.795	1.894	-0.177	-0.022	-0.209	-0.058	2.004	1.996	1.821	1.803	0.227	0.328	3.238	0.276
3 Years	-0.028	0.393	-0.003	0.410	-1.863	-1.690	-1.859	-1.697	2.217	2.256	2.128	2.150	-0.489	-0.339	5.088	-0.273
5 Years	1.077	1.227	1.142	1.269	-2.571	-2.489	-2.460	-2.391	-0.430	-0.351	-0.457	-0.365	0.548	0.630	5.184	0.633
7 Years	-0.722	-0.750	-0.739	-0.777	-2.575	-2.510	-2.455	-2.400	-1.468	-1.459	-1.487	-1.474	0.398	0.352	6.257	0.360
10 Years	-2.744	-2.794	-2.794	-2.850	-2.424	-2.363	-2.333	-2.280	-1.759	-1.776	-1.741	-1.753	-0.892	-0.898	5.762	-0.980
20 Years	-2.082	-2.176	-2.058	-2.150	-2.010	-1.935	-1.958	-1.887	-1.803	-1.794	-1.789	-1.778	-0.968	-1.066	5.689	-1.042

Panel 4.2: ILLIQUIDITY Kurtosis

BILL NOTES BONDS	ILLIQUIDITY KURTOSIS															
	ALL				BEFORE Financial Crisis				DURING Financial Crisis				AFTER Financial Crisis			
	LAG		LEAD		LAG		LEAD		LAG		LEAD		LAG		LEAD	
	AR	LOG	AR	LOG	AR	LOG	AR	LOG	AR	LOG	AR	LOG	AR	LOG	AR	LOG
1 Year	8.498	8.530	7.707	7.679	12.999	13.077	12.116	12.162	6.381	6.765	5.367	5.623	2.884	2.944	2.616	2.633
2 Years	8.818	8.911	7.895	7.918	11.438	11.687	10.810	10.967	7.619	7.555	6.594	6.472	3.516	3.415	3.238	3.167
3 Years	15.227	15.126	14.062	13.959	12.047	11.498	11.673	11.185	8.546	8.765	7.832	7.961	5.487	5.094	5.088	4.737
5 Years	13.046	13.241	12.656	12.642	11.145	10.675	10.172	9.784	5.269	5.314	5.105	5.145	5.348	5.384	5.184	5.128
7 Years	15.252	15.302	14.853	14.902	12.195	11.973	10.988	10.823	4.669	4.639	4.564	4.527	6.511	6.495	6.257	6.257
10 Years	19.695	20.178	19.139	19.581	11.445	11.200	10.351	10.162	5.158	5.199	4.974	4.999	6.179	6.193	5.762	5.808
20 Years	15.279	15.697	14.570	14.978	12.313	11.927	11.474	11.146	5.591	5.518	5.453	5.382	6.112	6.429	5.689	6.004

Table 5.

ILLIQUIDITY of the U.S. Treasury BILLS, NOTES vs. measures of ILLIQUIDITY

The table shows the relationship between the ILLIQUIDITY of the U.S. Treasury BILLS and NOTES (1 Year, 2 Years, 3 Years, 5 Years, 7 Years) vs. the Illiquidity of Corporate BONDS (**DIFF_ILLIQ Aaa Baa**) and the Illiquidity of the Stock Market (**ILLIQ_MKT**) as well as the percentage difference related to the Corporate Bond Yields (**%DIFF Aaa Baa**). The Illiquidity of the U.S. Treasury NOTES is respectively computed with *LAG* arithmetic variations. (1) **ILLIQ_MKT** is the illiquidity measure related to the CRSP value weighted stock market returns (2) **DIFF_ILLIQ Aaa Baa** is the difference of illiquidity between Aaa and Baa Corporate Bond Yields. (3) **%DIFF Aaa Baa** is the percentage difference between corporate bond yields. The table also reports **dummy variables** for depicting the impact of daily calendar effects. ***, ** and * indicate significance at 1%, 5%, 10% levels, respectively. The table reports the **standard errors** in brackets. A Newey-West estimator is provided for estimating the covariance matrix related to the regressors.

Panel 5.1: ILLIQUIDITY measure related to the 1 Year U.S. Treasury BILL (LAG – arithmetic variations)

	1 Year U.S. Treasury BILL															
	ALL				**Before FC**				**During FC**				**After FC**			
ILLIQ_MKT	-2.523***			-5.480***	0.605**			0.487	-2.143**			0.276	-7.200***			-7.850***
	(0.719)			(0.771)	(0.309)			(0.314)	(0.948)			(0.638)	(1.021)			(0.946)
DIFF_ILLIQ Aaa Baa		11.902***		9.165***		-0.606		-0.085		10.064***		8.128***		-2.195		-1.344
		(2.148)		(2.085)		(1.079)		(1.153)		(0.842)		(1.303)		(3.447)		(3.152)
%DIFF Aaa Baa			-0.002***	-0.003***			0.000*	0.000			0.003***	0.001**			0.000	-0.001
			(0.001)	(0.000)			(0.000)	(0.000)			(0.001)	(0.001)			(0.001)	(0.001)
Mon (x100)	0.017***	0.014***	-0.007	-0.024***	-0.001***	-0.011***	-0.038***	-0.032***	-0.007**	-0.015***	0.036***	0.008	0.065***	0.062***	0.065***	0.046***
	(0.002)	(0.002)	(0.006)	(0.004)	(0.000)	(0.000)	(0.001)	(0.001)	(0.003)	(0.003)	(0.008)	(0.009)	(0.005)	(0.001)	(0.017)	(0.015)
Tue (x100)	0.017***	0.013***	-0.007	-0.024***	-0.001**	-0.010***	-0.038***	-0.031**	-0.010***	-0.016***	0.036***	0.007	0.067***	0.062***	0.065***	0.047***
	(0.002)	(0.002)	(0.006)	(0.004)	(0.000)	(0.000)	(0.001)	(0.001)	(0.004)	(0.003)	(0.008)	(0.009)	(0.005)	(0.001)	(0.017)	(0.015)
Wed (x100)	0.017***	0.013***	-0.007	-0.024***	-0.001*	-0.001***	-0.037***	-0.030**	-0.008**	-0.016***	0.036***	0.007	0.066***	0.062***	0.065***	0.047***
	(0.002)	(0.002)	(0.006)	(0.004)	(0.000)	(0.000)	(0.001)	(0.001)	(0.004)	(0.003)	(0.009)	(0.009)	(0.005)	(0.001)	(0.017)	(0.015)
Thu (x100)	0.017***	0.013***	-0.007	-0.024***	-0.001***	-0.001***	-0.037***	-0.031**	-0.006*	-0.015***	0.037***	0.008	0.065***	0.062***	0.064***	0.046***
	(0.002)	(0.002)	(0.006)	(0.004)	(0.000)	(0.000)	(0.001)	(0.001)	(0.004)	(0.003)	(0.009)	(0.009)	(0.005)	(0.001)	(0.017)	(0.015)
Fri (x100)	0.017***	0.013***	-0.007	-0.024***	-0.001***	-0.010***	-0.038***	-0.031**	-0.008**	-0.014***	0.037***	0.009	0.067***	0.062***	0.064***	0.048***
	(0.020)	(0.002)	(0.006)	(0.004)	(0.000)	(0.000)	(0.001)	(0.001)	(0.004)	(0.003)	(0.009)	(0.009)	(0.005)	(0.001)	(0.017)	(0.015)
Adj R^2	**2.17%**	**9.34%**	**3.95%**	**19.24%**	**1.56%**	**0.00%**	**1.41%**	**2.48%**	**13.85%**	**54.46%**	**36.00%**	**56.53%**	**6.40%**	**0.00%**	**0.00%**	**6.87%**

Panel 5.2: ILLIQUIDITY of the 2 Years U.S. Treasury NOTE (LAG – arithmetic variations)

	2 Years U.S. Treasury NOTE															
	ALL				Before FC				During FC				After FC			
ILLIQ_MKT	2.877*** (0.418)			1.186** (0.532)	0.189 (0.390)			0.269 (0.382)	3.817*** (0.627)			3.250*** (1.091)	2.090*** (0.676)			1.662*** (0.666)
DIFF_ILLIQ Aaa Baa		2.004 (1.384)		1.618 (1.336)		3.682** (1.662)		3.781** (1.728)		0.243 (1.701)		6.791*** (1.842)		-4.059** (1.707)		-5.449*** (1.666)
%DIFF Aaa Baa			-0.002*** (0.000)	-0.002*** (0.000)			0.000 (0.000)	0.000 (0.000)			-0.002*** (0.000)	-0.002** (0.001)			-0.001*** (0.000)	-0.001*** (0.000)
Mon (x100)	0.006*** (0.001)	0.008*** (0.001)	-0.018*** (0.002)	-0.015*** (0.002)	-0.002*** (0.001)	-0.001** (0.001)	-0.001 (0.002)	-0.001 (0.002)	-0.006 (0.004)	0.015*** (0.005)	-0.033*** (0.007)	-0.035*** (0.012)	0.025*** (0.003)	0.031*** (0.003)	0.002 (0.008)	0.005 (0.008)
Tue (x100)	0.006*** (0.001)	0.008*** (0.001)	-0.019*** (0.002)	-0.015*** (0.002)	-0.001*** (0.001)	-0.001** (0.001)	-0.001 (0.002)	-0.001 (0.002)	-0.006* (0.003)	0.013*** (0.005)	-0.035*** (0.006)	-0.036*** (0.012)	0.025*** (0.003)	0.031*** (0.003)	0.002 (0.008)	0.005 (0.008)
Wed (x100)	0.006*** (0.001)	0.008*** (0.001)	-0.019*** (0.002)	-0.015*** (0.002)	-0.001*** (0.001)	-0.001** (0.001)	-0.001 (0.002)	-0.001 (0.002)	-0.006 (0.004)	0.016*** (0.005)	-0.033*** (0.007)	-0.035*** (0.012)	0.024*** (0.003)	0.030*** (0.003)	0.001 (0.008)	0.004 (0.008)
Thu (x100)	0.006*** (0.001)	0.008*** (0.001)	-0.019*** (0.002)	-0.014*** (0.002)	-0.001*** (0.001)	-0.001* (0.001)	-0.001 (0.002)	-0.001 (0.002)	-0.004 (0.004)	0.016*** (0.005)	-0.032*** (0.007)	-0.034*** (0.012)	0.024*** (0.003)	0.030*** (0.003)	0.001 (0.008)	0.005 (0.008)
Fri (x100)	0.006*** (0.001)	0.008*** (0.001)	-0.019*** (0.002)	-0.015*** (0.002)	-0.001*** (0.001)	-0.001** (0.001)	-0.001 (0.002)	-0.001 (0.002)	-0.006 (0.004)	0.016*** (0.005)	-0.032*** (0.007)	-0.034*** (0.012)	0.024*** (0.003)	0.030*** (0.003)	0.001 (0.008)	0.004 (0.008)
Adj R^2	**8.88%**	**0.73%**	**16.53%**	**17.67%**	**0.00%**	**2.28%**	**0.00%**	**2.55%**	**42.10%**	**0.00%**	**24.18%**	**55.22%**	**1.36%**	**2.14%**	**2.39%**	**6.91%**

Panel 5.3: ILLIQUIDITY of the 3 Years U.S. Treasury NOTE (LAG – arithmetic variations)

	3 Years U.S. Treasury NOTE															
	ALL				**Before FC**				**During FC**				**After FC**			
ILLIQ_MKT	2.063***			2.230***	-0.072			0.142	2.408***			2.540***	3.180***			2.263***
	(0.406)			(0.431)	(0.284)			(0.283)	(0.596)			(0.848)	(0.525)			(0.522)
DIFF_ILLIQ		0.944		1.568*		5.169***		4.946***		2.523*		7.169***		1.390		-0.082
Aas Baa		(0.920)		(0.871)		(1.447)		(1.493)		(1.509)		(1.557)		(1.139)		(1.131)
%DIFF			-0.001***	0.000			0.000***	0.000*			-0.001***	-0.001			-0.002***	-0.001***
Aaa Baa			(0.000)	(0.000)			(0.000)	(0.000)			(0.000)	(0.001)			(0.000)	(0.000)
Mon	-0.003***	-0.002***	-0.009***	-0.002	-0.002***	-0.002***	0.002	0.012	-0.002	0.011***	-0.014**	-0.022***	-0.066***	-0.055***	-0.037***	-0.031***
(x100)	(0.001)	(0.001)	(0.002)	(0.002)	(0.000)	(0.000)	(0.001)	(0.013)	(0.003)	(0.004)	(0.006)	(0.009)	(0.023)	(0.023)	(0.063)	(0.006)
Tue	-0.003***	-0.002***	-0.010***	-0.002	-0.002***	-0.002***	0.002	0.012	-0.004	0.009***	-0.016***	-0.023***	-0.071***	-0.058***	-0.037***	-0.032***
(x100)	(0.001)	(0.001)	(0.002)	(0.002)	(0.000)	(0.000)	(0.001)	(0.013)	(0.003)	(0.003)	(0.006)	(0.009)	(0.022)	(0.024)	(0.064)	(0.006)
Wed	-0.003***	-0.002***	-0.010***	-0.003	-0.002***	-0.001***	0.002	0.012	-0.004	0.011***	-0.014**	-0.023***	-0.082***	-0.065***	-0.038***	-0.033***
(x100)	(0.001)	(0.001)	(0.002)	(0.002)	(0.000)	(0.000)	(0.001)	(0.013)	(0.003)	(0.004)	(0.006)	(0.009)	(0.021)	(0.022)	(0.063)	(0.006)
Thu	-0.003***	-0.002***	-0.010***	-0.002	-0.002***	-0.001***	0.002	0.012	-0.002	0.012***	-0.013**	-0.022***	-0.074***	-0.063***	-0.038***	-0.032***
(x100)	(0.001)	(0.001)	(0.002)	(0.002)	(0.000)	(0.000)	(0.001)	(0.013)	(0.003)	(0.004)	(0.006)	(0.009)	(0.021)	(0.022)	(0.063)	(0.006)
Fri	-0.003***	-0.002***	-0.009***	-0.002	-0.002***	-0.001***	0.002	0.012	-0.004	0.012***	-0.014**	-0.022***	-0.072***	-0.059***	-0.037***	-0.032***
(x100)	(0.001)	(0.001)	(0.002)	(0.002)	(0.000)	(0.000)	(0.001)	(0.013)	(0.003)	(0.004)	(0.006)	(0.009)	(0.022)	(0.023)	(0.063)	(0.006)
Adj R^2	**9.57%**	**0.29%**	**2.79%**	**10.52%**	**0.00%**	**8.03%**	**2.28%**	**9.63%**	**26.68%**	**4.22%**	**9.00%**	**52.28%**	**6.61%**	**0.22%**	**7.82%**	**10.83%**

Panel 5.4: ILLIQUIDITY of the 5 Years U.S. Treasury NOTE (LAG – arithmetic variations)

	5 Years U.S. Treasury NOTE															
	ALL				**Before FC**				**During FC**				**After FC**			
ILLIQ_MKT	0.075			-0.174	-0.316*			-0.083	-0.547			0.352	1.156***			0.132
	(0.289)			(0.280)	(0.178)			(0.151)	(0.367)			(0.340)	(0.472)			(0.451)
DIFF_ILLIQ Aaa_Baa		2.401***		2.204***		4.073***		3.648***		4.807***		4.949***		0.062		-1.071
		(0.574)		(0.633)		(0.839)		(0.876)		(0.525)		(0.611)		(0.780)		(0.743)
%DIFF Aaa Baa			0.000*	0.000*			0.000***	0.000***			0.001***	0.000			-0.002***	-0.002***
			(0.000)	(0.000)			(0.068)	(0.000)			(0.000)	(0.000)			(0.000)	(0.000)
Mon (x100)	-0.001*	-0.012***	-0.048***	-0.052***	-0.021***	-0.016***	0.021***	0.017***	0.002	0.001	0.018***	0.021	0.001	0.002	-0.028***	-0.028***
	(0.001)	(0.000)	(0.018)	(0.019)	(0.000)	(0.000)	(0.001)	(0.001)	(0.002)	(0.001)	(0.034)	(0.028)	(0.001)	(0.001)	(0.004)	(0.005)
Tue (x100)	-0.001*	-0.012***	-0.048***	-0.053***	-0.021***	-0.016***	0.021***	0.018***	0.001	0.001	0.017***	0.017	0.001	0.002	-0.028***	-0.028***
	(0.000)	(0.000)	(0.018)	(0.019)	(0.000)	(0.000)	(0.001)	(0.001)	(0.002)	(0.001)	(0.034)	(0.026)	(0.001)	(0.002)	(0.004)	(0.005)
Wed (x100)	-0.001**	-0.012***	-0.049***	-0.054***	-0.020***	-0.015***	0.021***	0.018***	0.002	0.001	0.018***	0.019	0.001	0.002	-0.028***	-0.028***
	(0.000)	(0.000)	(0.018)	(0.019)	(0.000)	(0.000)	(0.001)	(0.001)	(0.002)	(0.001)	(0.035)	(0.027)	(0.001)	(0.001)	(0.004)	(0.005)
Thu (x100)	-0.001*	-0.012***	-0.048***	-0.052***	-0.020***	-0.015***	0.022***	0.018***	0.002	0.011	0.018***	0.018	0.001	0.002	-0.028***	-0.028***
	(0.000)	(0.000)	(0.018)	(0.019)	(0.000)	(0.000)	(0.001)	(0.001)	(0.002)	(0.011)	(0.036)	(0.026)	(0.001)	(0.001)	(0.004)	(0.005)
Fri (x100)	-0.001**	-0.012***	-0.049***	-0.053***	-0.020***	-0.015***	0.021***	0.018***	0.001	0.011	0.018***	0.018	0.001	0.002	-0.028***	-0.028***
	(0.000)	(0.000)	(0.018)	(0.019)	(0.000)	(0.000)	(0.001)	(0.001)	(0.002)	(0.010)	(0.035)	(0.027)	(0.001)	(0.002)	(0.004)	(0.005)
Adj R^2	**0.00%**	**7.02%**	**2.27%**	**8.69%**	**1.20%**	**14.12%**	**10.55%**	**21.87%**	**4.31%**	**67.78%**	**22.70%**	**68.41%**	**2.18%**	**0.00%**	**18.28%**	**19.15%**

Panel 5.5: ILLIQUIDITY of the 7 Years U.S. Treasury NOTE (LAG – arithmetic variations)

	7 Years U.S. Treasury NOTE															
	ALL				**Before FC**				**During FC**				**After FC**			
ILLIQ_MKT	-0.561***			-0.310*	-0.040			0.092	-1.177***			0.068	-0.196			-0.440
	(0.227)			(0.172)	(0.113)			(0.104)	(0.330)			(0.212)	(0.209)			(0.322)
DIFF_ILLIQ		2.439***		2.387***		4.054***		3.961***		5.580***		4.652***		0.339		0.220
Aaa Baa		(0.553)		(0.468)		(0.768)		(0.800)		(0.411)		(0.440)		(0.518)		(0.504)
%DIFF			0.000	0.000			0.000***	0.000**			0.001***	0.001***			0.000	0.000
Aaa Baa			(0.000)	(0.000)			(0.004)	(0.005)			(0.000)	(0.000)			(0.000)	(0.000)
Mon	-0.001***	-0.002***	0.001	0.000	-0.002***	-0.001***	0.000	0.000	0.003***	-0.001	0.027***	0.010***	0.000	0.000	-0.005*	-0.006*
(x100)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.005)	(0.001)	(0.000)	(0.003)	(0.002)	(0.000)	(0.000)	(0.003)	(0.004)
Tue	-0.001***	-0.002***	0.001	0.000	-0.002***	-0.001***	0.000	0.000	0.002	-0.001	0.026***	0.010***	0.000	0.000	-0.005	-0.006*
(x100)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.000	(0.003)	(0.002)	(0.000)	(0.000)	(0.003)	(0.004)
Wed	-0.001***	-0.002***	0.001	0.000	-0.002***	-0.001***	0.000	0.000	0.003**	-0.001	0.027***	0.010***	0.000	0.000	-0.005*	-0.007*
(x100)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.004)	(0.002)	(0.000)	(0.000)	(0.003)	(0.004)
Thu	-0.001***	-0.002***	0.001	0.000	-0.002***	-0.001***	0.000	0.000	0.004***	-0.001	0.027***	0.009***	0.000	0.000	-0.005*	-0.006*
(x100)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.004)	(0.002)	(0.000)	(0.000)	(0.003)	(0.004)
Fri	-0.011***	-0.002***	0.001	0.000	-0.002***	-0.001***	0.000	0.000	0.002	-0.001	0.026***	0.009***	0.000	0.000	-0.006*	-0.007*
(x100)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)	(0.003)	(0.002)	(0.000)	(0.000)	(0.003)	(0.004)
Adj R^2	**4.21%**	**15.02%**	**1.54%**	**17.96%**	**0.00%**	**24.85%**	**3.90%**	**27.11%**	**21.34%**	**82.05%**	**51.14%**	**85.54%**	**0.00%**	**0.00%**	**1.11%**	**1.88%**

Table 6.

ILLIQUIDITY of the U.S. Treasury BONDS vs. Measures of ILLIQUIDITY

The table shows the relationship between the Illiquidity of the U.S. Treasury BONDS (10 Years, 20 Years) vs. the difference of Illiquidity related to Corporate BONDS (**DIFF_ILLIQ Aaa Baa**) and the Illiquidity of the Stock Market (**ILLIQ_MKT**) as well as the percentage difference related to the Corporate Bond Yields (**%DIFF Aaa Baa**). The Illiquidity of the U.S. Treasury BONDS is respectively computed with *LAG* arithmetic variations. ***, ** and * indicate significance at 1%, 5%, 10% levels, respectively. The table reports the **standard errors** in brackets. A Newey-West estimator is provided for evaluating the covariance matrix related to the regressors.

Panel 6.1: ILLIQUIDITY of the 10 Years U.S. Treasury BOND (LAG – arithmetic variations)

	10 Years U.S. Treasury BOND															
	ALL				**Before FC**				**During FC**				**After FC**			
ILLIQ_MKT	-0.517*** (0.196)			-0.167* (0.099)	-0.032 (0.093)			0.085 (0.083)	-1.133*** (0.278)			-0.098 (0.103)	0.140 (0.157)			0.160 (0.170)
DIFF_ILLIQ Aaa Baa		1.995*** (0.491)		2.026*** (0.371)		3.397*** (0.556)		3.292*** (0.587)		4.745*** (0.223)		3.782*** (0.245)		0.146 (0.406)		0.162 (0.396)
%DIFF Aaa Baa			0.000*** (0.000)	0.000*** (0.000)			0.000*** (0.000)	0.000*** (0.000)			0.001*** (0.000)	0.000*** (0.005)			0.001 (0.000)	0.005 (0.000)
Mon (x100)	-0.001*** (0.000)	-0.002*** (0.000)	0.002* (0.001)	0.002** (0.001)	-0.001*** (0.000)	-0.001*** (0.000)	0.000 (0.000)	0.000 (0.000)	0.002** (0.001)	-0.002*** (0.001)	0.023*** (0.003)	0.008*** (0.001)	-0.001 (0.001)	-0.001 (0.001)	0.000 (0.002)	0.000 (0.002)
Tue (x100)	-0.001*** (0.000)	-0.002*** (0.000)	0.002* (0.001)	0.002** (0.001)	-0.001*** (0.000)	-0.001*** (0.000)	0.000 (0.000)	0.000 (0.000)	0.001 (0.001)	-0.002*** (0.001)	0.023*** (0.003)	0.008*** (0.001)	-0.001 (0.001)	-0.001 (0.001)	0.000 (0.002)	0.000 (0.002)
Wed (x100)	-0.001*** (0.000)	-0.002*** (0.000)	0.002* (0.001)	0.002** (0.001)	-0.001*** (0.000)	-0.001*** (0.000)	0.000 (0.000)	0.000 (0.000)	0.002** (0.001)	-0.002*** (0.001)	0.023*** (0.003)	0.008*** (0.001)	-0.001* (0.001)	-0.001 (0.001)	0.000 (0.002)	0.000 (0.002)
Thu (x100)	-0.001*** (0.000)	-0.002*** (0.000)	0.002* (0.001)	0.002** (0.001)	-0.001*** (0.000)	-0.001*** (0.000)	0.000 (0.000)	0.000 (0.000)	0.002** (0.001)	-0.002*** (0.001)	0.023*** (0.003)	0.008*** (0.001)	-0.001* (0.001)	-0.001* (0.001)	0.000 (0.002)	0.000 (0.002)
Fri (x100)	-0.001*** (0.000)	-0.002*** (0.000)	0.002* (0.001)	0.002* (0.001)	-0.001*** (0.000)	-0.001*** (0.000)	0.000 (0.000)	0.000 (0.000)	0.001 (0.001)	-0.002*** (0.001)	0.022*** (0.003)	0.008*** (0.001)	-0.001* (0.001)	-0.001* (0.001)	0.000 (0.002)	0.000 (0.002)
Adj R^2	**6.97%**	**19.26%**	**6.09%**	**27.54%**	**0.00%**	**28.16%**	**5.16%**	**31.03%**	**29.68%**	**87.48%**	**61.03%**	**93.76%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**

Panel 6.2: ILLIQUIDITY of the 20 Years U.S. Treasury BOND (LAG – arithmetic variations)

	20 Years U.S. Treasury BOND															
	ALL				**Before FC**				**During FC**				**After FC**			
ILLIQ_MKT	-0.197**			0.025	0.007			0.061*	-0.424***			-0.040	0.028			0.158*
	(0.091)			(0.051)	(0.039)			(0.034)	(0.127)			(0.042)	(0.114)			(0.090)
DIFF_ILLIQ		0.864***		0.930***		1.765***		1.733***		1.976***		1.735***		0.163		0.287
Aaa Baa		(0.222)		(0.169)		0.244)		(0.257)		(0.119)		(0.123)		(0.235)		(0.205)
%DIFF			0.000***	0.000***			0.007***	0.005***			0.001***	0.000***			0.000***	0.000***
Aaa Baa			(0.000)	(0.000)			(0.002)	(0.002)			(0.006)	(0.002)			(0.001)	(0.007)
Mon	0.000***	-0.001***	0.001***	0.002***	0.000***	0.000***	0.000*	0.000	0.001**	-0.001***	0.009***	0.002***	0.000	0.000*	0.003***	0.004***
(x100)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Tue	0.000***	-0.001***	0.001***	0.002***	0.000***	0.000***	0.000*	0.000	0.001	-0.001***	0.009***	0.002***	0.000	0.000	0.003***	0.004***
(x100)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Wed	0.000***	-0.001***	0.001***	0.002***	0.000***	0.000***	0.000*	0.000	0.001*	-0.001***	0.009***	0.002***	0.000	0.000*	0.003***	0.003***
(x100)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Thu	0.000***	-0.001***	0.001***	0.002***	0.000***	0.000***	0.000*	0.000	0.001**	-0.001***	0.009***	0.002***	0.000	-0.001**	0.003***	0.003***
(x100)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Fri	0.000***	-0.001***	0.001***	0.002***	0.000***	0.000***	0.000*	0.000	0.000	-0.001***	0.009***	0.002***	0.000	-0.001**	0.003***	0.003***
(x100)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Adj R^2	**4.04%**	**14.46%**	**7.66%**	**24.52%**	**0.00%**	**37.66%**	**4.86%**	**40.49%**	**24.35%**	**90.34%**	**52.59%**	**93.55%**	**0.00%**	**0.08%**	**4.47%**	**6.61%**

Table 7.

ILLIQUIDITY of the U.S. Treasury BIIL, NOTES and BONDS vs. Measures of ILLIQUIDITY related to the 5 FAMA-FRENCH Factors

The table shows the relationship between the Illiquidity of the U.S. Treasury BILL (1 Year), NOTES (2 Years, 3 Years, 5 Years, 7 Years) and BONDS (10 Years, 20 Years) vs. the Illiquidity measure related to the **5** Fama-French factors (**Market returns, RMW, SMB, HML, CMA**). The Illiquidity of the U.S. Treasury BILLS, NOTES and BONDS is respectively computed with *LAG* and *LEAD* arithmetic variations. ***, ** and * indicate significance at 1%, 5%, 10% levels, respectively. The table reports the **standard errors** in brackets. A Newey-West estimator is provided for evaluating the covariance matrix related to the regressors.

	1 Year		**2 Years**		**3 Years**		**5 Years**		**7 Years**		**10 Years**		**20 Years**	
	LAG	**LEAD**	**LAG**	**LEAD**	**LAG**	**LEAD**	**LAG**	**LEAD**	**LAG**	**LEAD**	**LAG**	**LEAD**	**LAG**	**LEAD**
ILLIQ_MKT	-3.995***	-4.188***	2.236***	2.295***	2.100***	2.254***	0.084	0.087	-0.453**	-0.518***	-0.406***	-0.450***	-0.115	-0.138*
	(0.689)	(0.663)	(0.407)	(0.405)	(0.370)	(0.358)	(0.252)	(0.250)	(0.186)	(0.189)	(0.151)	(0.151)	(0.078)	(0.079)
ILLIQ_SMB	4.445*	5.186*	2.757**	3.016**	-1.134	-1.330	-1.364***	-1.384***	-1.625***	-1.634***	-1.587***	-1.614***	-0.800***	-0.860***
	(2.611)	(2.665)	(1.229)	(1.245)	(0.910)	(0.836)	(0.545)	(0.549)	(0.528)	(0.521)	(0.467)	(0.460)	(0.235)	(0.239)
ILLIQ_HML	5.103***	6.009***	1.363	1.305	1.841	1.675	1.755***	1.867***	0.940**	0.974**	1.126***	1.220***	0.310**	0.351**
	(1.836)	(2.087)	(1.701)	(1.860)	(1.182)	(1.192)	(0.702)	(0.741)	(0.455)	(0.487)	(0.377)	(0.409)	(0.148)	(0.163)
ILLIQ_RMW	1.694	0.763	-0.351	-0.342	-1.126	-0.990	0.683	0.535	0.486	0.398	0.419	0.323	0.305	0.300
	(2.017)	(2.023)	(1.397)	(1.327)	(1.130)	(1.022)	(0.613)	(0.588)	(0.512)	(0.490)	(0.431)	(0.418)	(0.216)	(0.215)
ILLIQ_CMA	25.180***	28.092***	8.025***	9.875***	-0.149	-0.040	2.984***	3.193***	3.849***	3.976***	2.201**	2.179**	0.828*	0.808
	(4.919)	(5.171)	(2.464)	(2.607)	(1.381)	(1.369)	(1.089)	(1.079)	(1.107)	(1.072)	(1.005)	(0.981)	(0.498)	(0.504)
Mon (x100)	0.023***	0.024***	0.008***	0.008***	-0.003***	-0.003***	0.000	0.000	0.000	0.000	0.000*	0.000*	0.000*	0.000
	(0.003)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Tue (x100)	0.024***	0.024***	0.008***	0.008***	-0.003***	-0.003***	0.000	0.000	0.000	0.000	0.000*	0.000*	0.000	0.000*
	(0.003)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Wed (x100)	0.023***	0.024***	0.008***	0.008***	-0.003***	-0.003***	0.000	0.000	0.000	0.000	0.000**	0.000**	0.000**	0.000**
	(0.003)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Thur (x100)	0.023***	0.024***	0.008***	0.008***	-0.003***	-0.003***	0.000	0.000	0.000	0.000	0.000*	0.000**	0.000*	0.000**
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Fri (x100)	0.024***	0.024***	0.008***	0.009***	-0.003***	-0.003***	0.000	0.000	0.000	0.000	-0.001**	0.000**	0.000**	0.000*
	(0.003)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Adj R^2	**9.09%**	**10.13%**	**11.26%**	**12.88%**	**10.25%**	**11.80%**	**4.17%**	**4.49%**	**11.70%**	**13.57%**	**17.59%**	**19.59%**	**11.71%**	**13.29%**

Table 8.

ILLIQUIDITY Premium related to the term structure of the U.S. Treasury BONDS vs. Measures of ILLIQUIDITY and VIX

The table shows the relationship between the ILLIQUIDITY Premium of the 20 Years U.S. Treasury BONDS vs. the difference of Illiquidity of Corporate BONDS (**DIFF_ILLIQ Aaa Baa**), the Illiquidity of the Stock Market (**ILLIQ_MKT**), the percentage difference related to the Corporate Bond Yields (**%DIFF Aaa Baa**) as well as the **VIX**. The ILLIQUIDITY Premium of the 20 Years U.S. Treasury BONDS is respectively computed with *LAG* arithmetic variations. The coefficients related to the daily dummies are multiplied by 100. ***, ** and * indicate significance at 1%, 5%, 10% levels, respectively. The table reports the **standard errors** in brackets. A Newey-West estimator is provided for estimating the covariance matrix related to the regressors.

	ILLIQUIDITY Premium of the 20 Years U.S. Treasury BONDS vs.											
	1 Year		**2 Years**		**3 Years**		**5 Years**		**7 Years**		**10 Years**	
ILLIQ_MKT	5.504*** (0.767)	3.729*** (0.725)	-1.161** (0.514)	-1.622*** (0.468)	-2.205*** (0.408)	-1.706*** (0.360)	0.198 (0.248)	0.186 (0.223)	0.334*** (0.135)	0.193* (0.116)	0.192*** (0.067)	0.091 (0.062)
DIFF_ILLIQ Aaa Baa	-8.235*** (2.151)	-8.250*** (2.134)	-0.687 (1.340)	-0.691 (1.332)	-0.638 (0.789)	-0.634 (0.779)	-1.274*** (0.521)	-1.274*** (0.520)	-1.457*** (0.331)	-1.458*** (0.322)	-1.095*** (0.224)	-1.096*** (0.218)
%DIFF Aaa Baa	0.003*** (0.000)	0.003*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.000 (0.000)	0.000 (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
VIX (x100)		0.002*** (0.000)		0.000** (0.000)		0.000*** (0.000)		0.000 (0.000)		0.000*** (0.000)		0.000*** (0.000)
Mon (x100)	0.026*** (0.004)	0.001 (0.005)	0.016*** (0.002)	0.010*** (0.003)	0.004** (0.002)	0.010*** (0.003)	0.007*** (0.002)	0.007*** (0.002)	0.001 (0.001)	-0.001 (0.001)	0.000 (0.001)	-0.002*** (0.001)
Tue (x100)	0.026*** (0.004)	0.002 (0.005)	0.016*** (0.002)	0.010*** (0.003)	0.004** (0.002)	0.011*** (0.003)	0.007*** (0.002)	0.007*** (0.002)	0.001 (0.001)	-0.001 (0.001)	0.000 (0.001)	-0.001*** (0.001)
Wed (x100)	0.026*** (0.004)	0.002 (0.005)	0.016*** (0.002)	0.010*** (0.003)	0.004** (0.002)	0.011*** (0.003)	0.007*** (0.002)	0.007*** (0.002)	0.001 (0.001)	-0.001 (0.001)	0.000 (0.001)	-0.001*** (0.001)
Thu (x100)	0.026*** (0.004)	0.002 (0.005)	0.016*** (0.002)	0.010*** (0.003)	0.004** (0.002)	0.010*** (0.003)	0.007*** (0.002)	0.007*** (0.002)	0.001 (0.001)	-0.001 (0.001)	0.000 (0.001)	-0.001*** (0.001)
Fri (x100)	0.025*** (0.004)	0.001 (0.005)	0.016*** (0.002)	0.010*** (0.003)	0.004** (0.002)	0.010*** (0.003)	0.007*** (0.002)	0.007*** (0.002)	0.001 (0.001)	-0.001 (0.001)	0.000 (0.001)	-0.001*** (0.001)
Adj. R^2	**18.55%**	**23.09%**	**19.21%**	**20.11%**	**12.24%**	**14.64%**	**8.86%**	**8.85%**	**12.91%**	**14.89%**	**25.05%**	**28.29%**

Figure 1.

ILLIQUIDITY Measure for the 1 year U.S. Treasury BILL

The figure shows the dynamics for the *conditional* level of the illiquidity for the **1 year U.S. Treasury BILL,** considering *LAG* and *LEAD* variations. The figure also reports the dynamics for arithmetic and logarithmic variations that for simplicity of explanations are defined as “returns”, from 01/01/1994 to 06/30/2015.

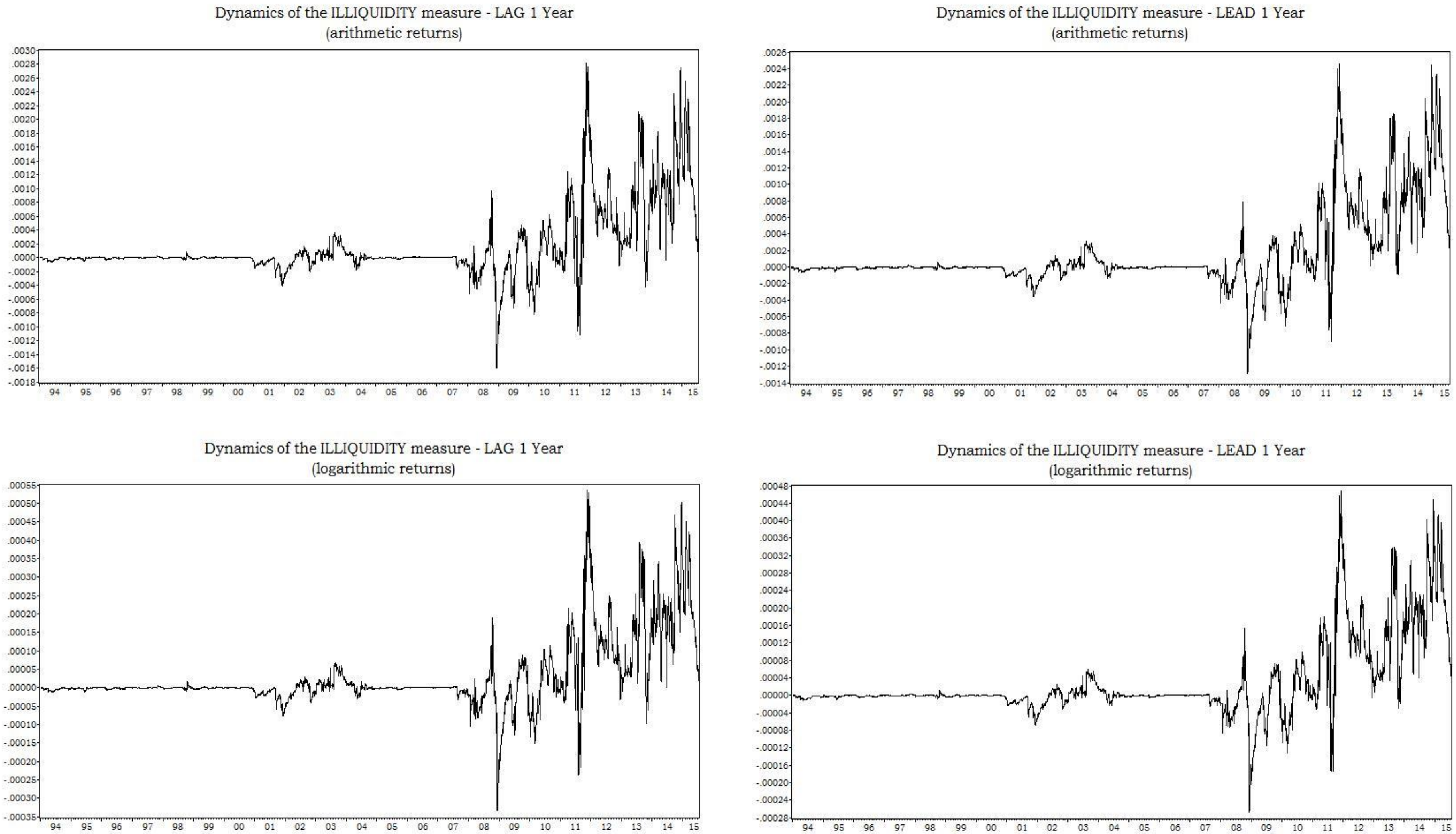


Figure 2.

ILLIQUIDITY Measure for the 2 years U.S. Treasury NOTE

The figure shows the dynamics for the *conditional* level of illiquidity concerned about the **2 years U.S. Treasury NOTE,** considering *LAG* and *LEAD* variations. The figure also reports the dynamics for arithmetic and logarithmic variations from 01/01/1994 to 06/30/2015.

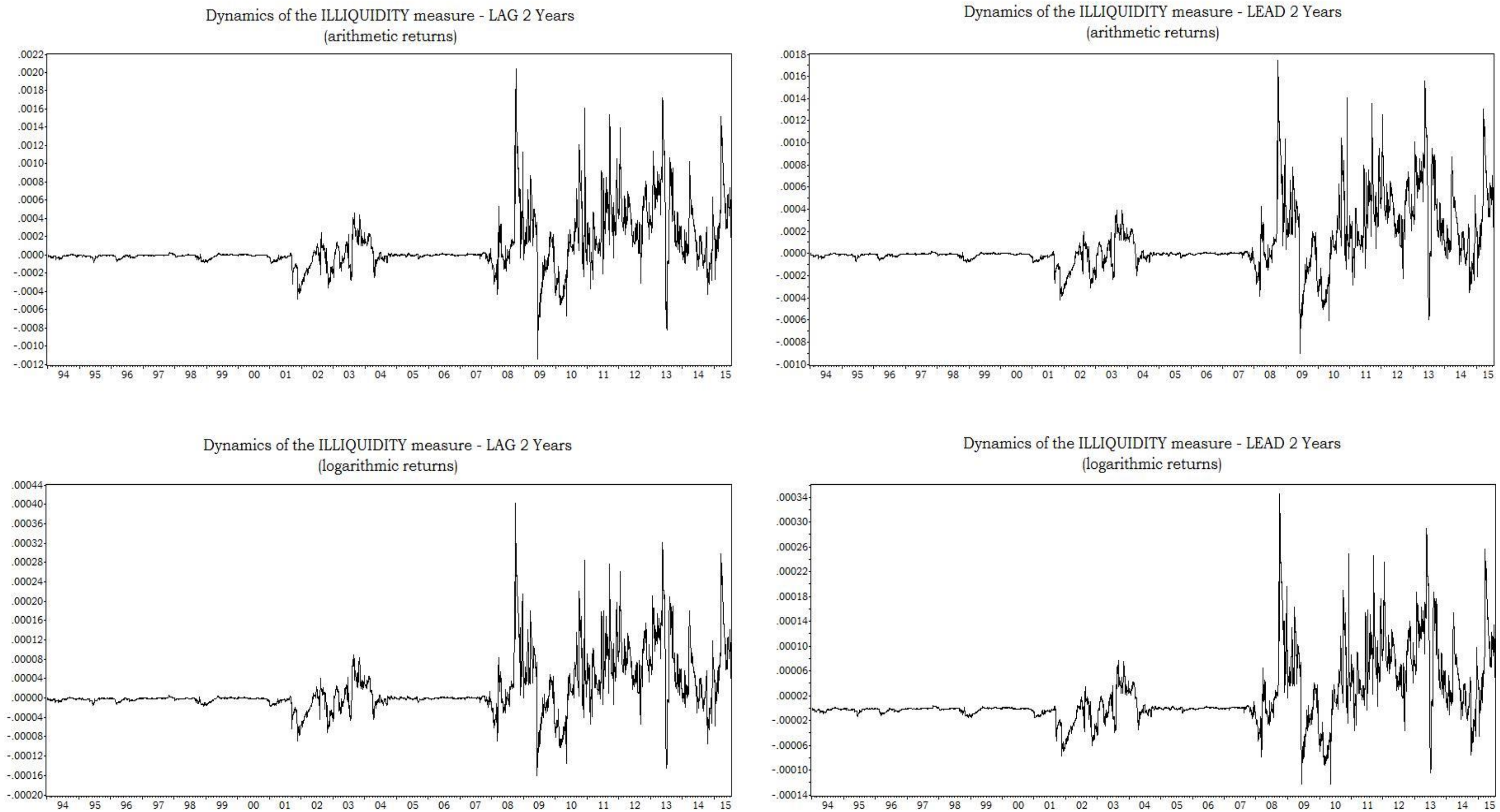


Figure 3.

ILLIQUIDITY Measure for the 3 years U.S. Treasury NOTE

The figure shows the dynamics for the *conditional* level of illiquidity concerned about the **3 years U.S. Treasury NOTE,** considering *LAG* and *LEAD* variations. The figure also reports the dynamics for arithmetic and logarithmic variations from 01/01/1994 to 06/30/2015

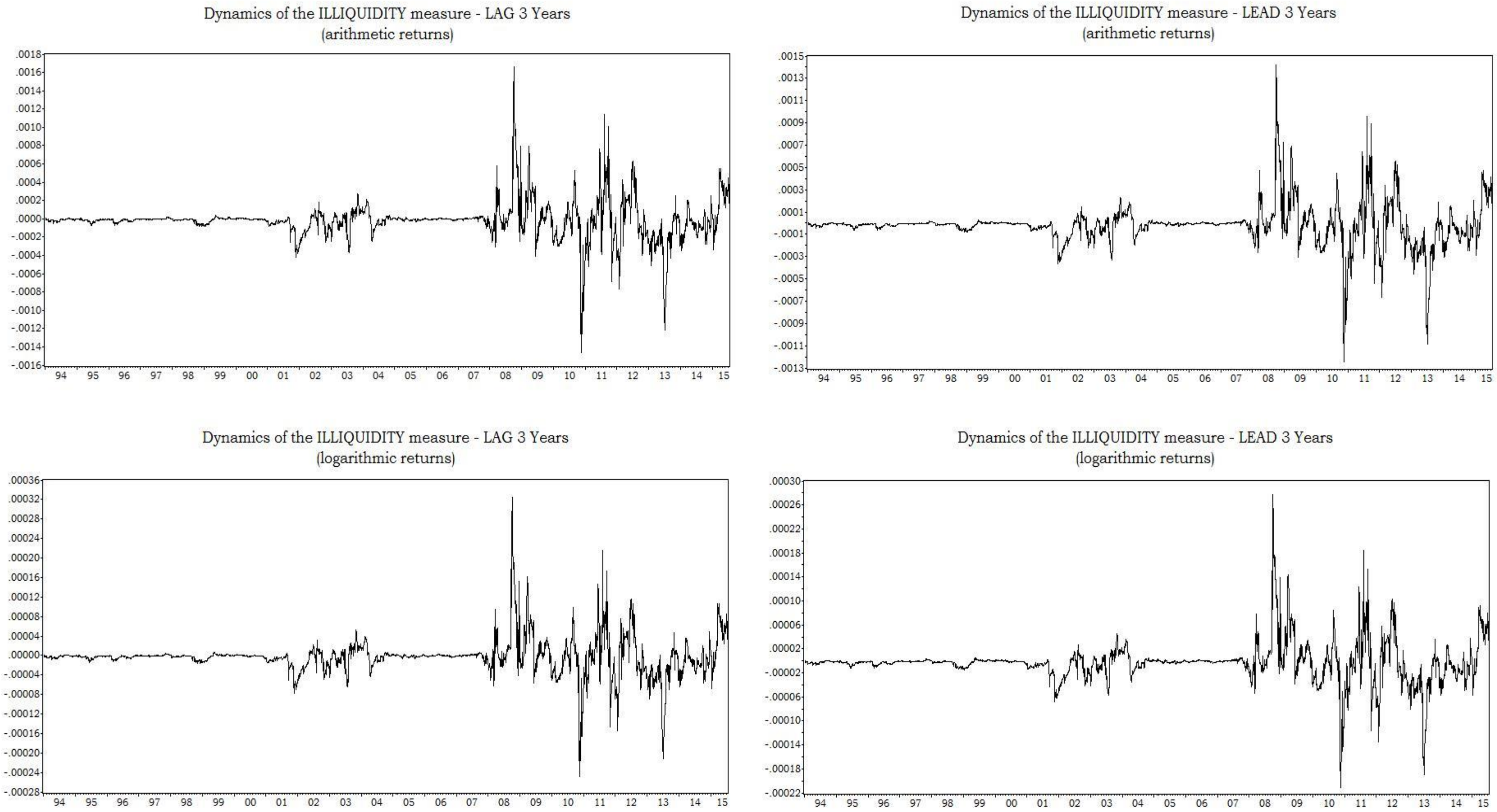


Figure 4.

ILLIQUIDITY Measure for the 5 years U.S. Treasury NOTE

The figure shows the dynamics for the *conditional* level of illiquidity concerned about the **5 years U.S. Treasury NOTE,** considering *LAG* and *LEAD* variations. The figure also reports the dynamics for arithmetic and logarithmic variations from 01/01/1994 to 06/30/2015

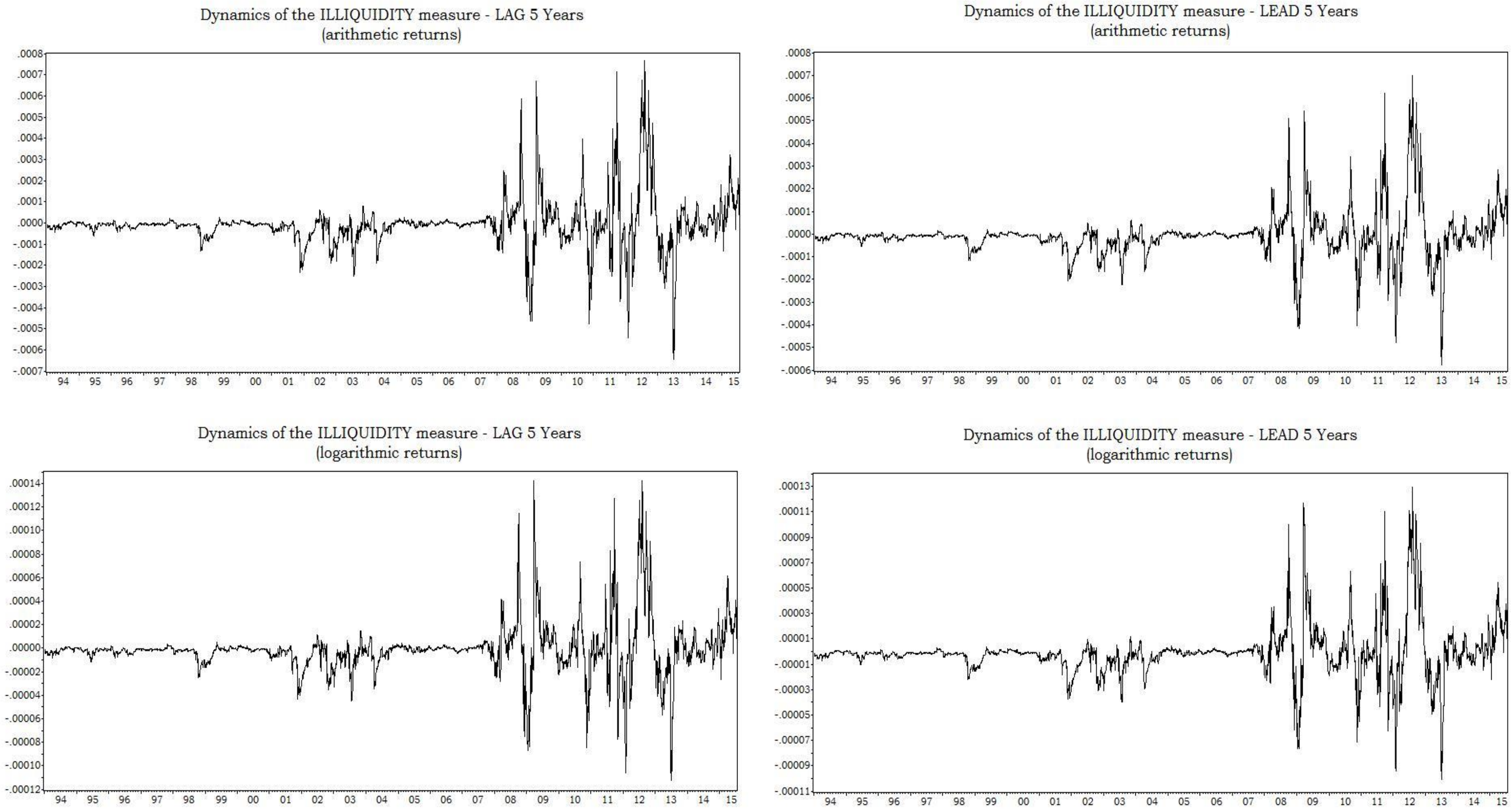


Figure 5.

ILLIQUIDITY Measure for the 7 years U.S. Treasury NOTE

The figure shows the dynamics for the *conditional* level of illiquidity concerned about the **7 years U.S. Treasury NOTE,** considering *LAG* and *LEAD* variations. The figure also reports the dynamics for arithmetic and logarithmic variations from 01/01/1994 to 06/30/2015

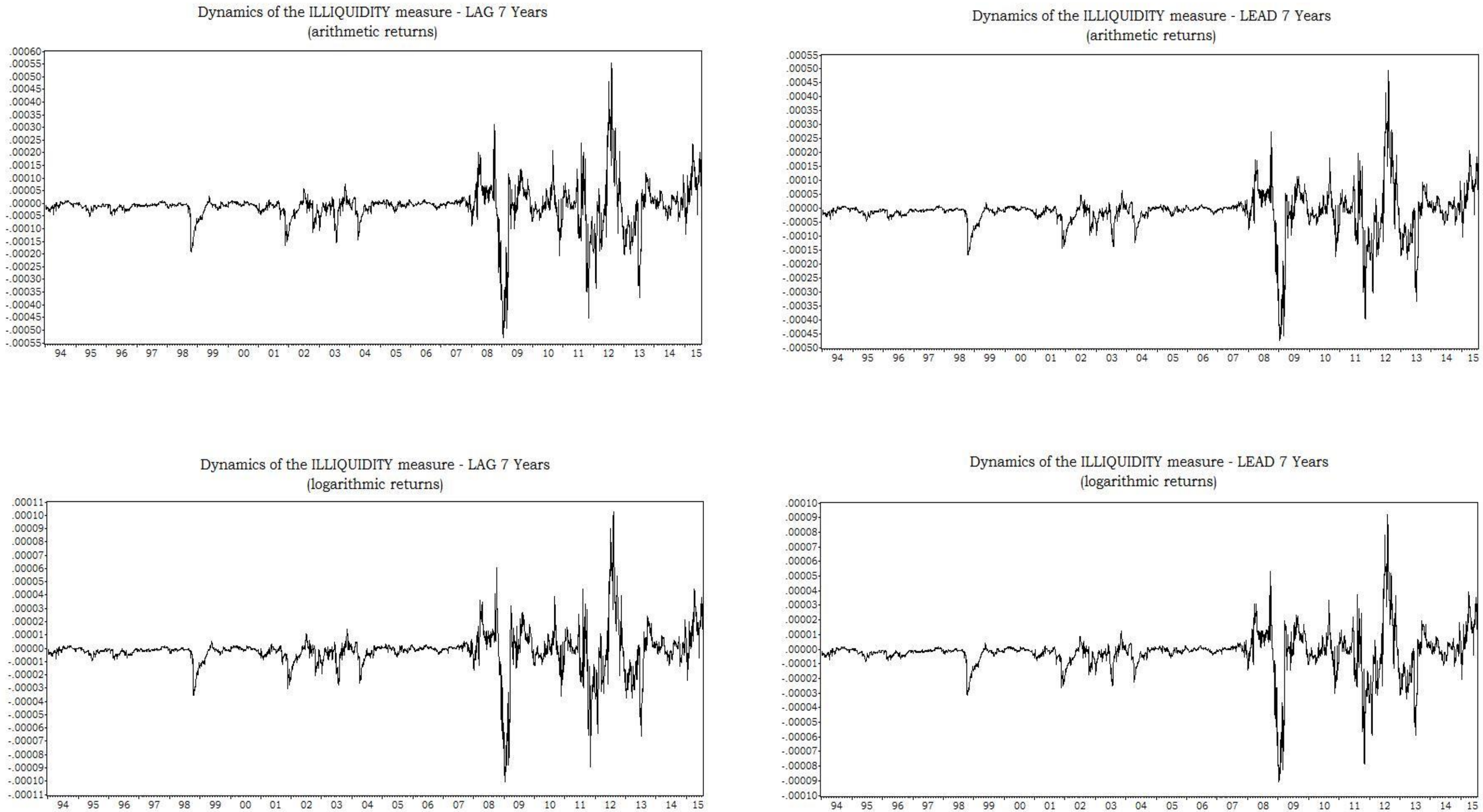


Figure 6.

ILLIQUIDITY Measure for the 10 years U.S. Treasury BOND

The figure shows the dynamics for the *conditional* level of illiquidity concerned about the **10 years U.S. Treasury BOND,** considering *LAG* and *LEAD* variations. The figure also reports the *conditional* dynamic for arithmetic and logarithmic variations from 01/01/1994 to 06/30/2015

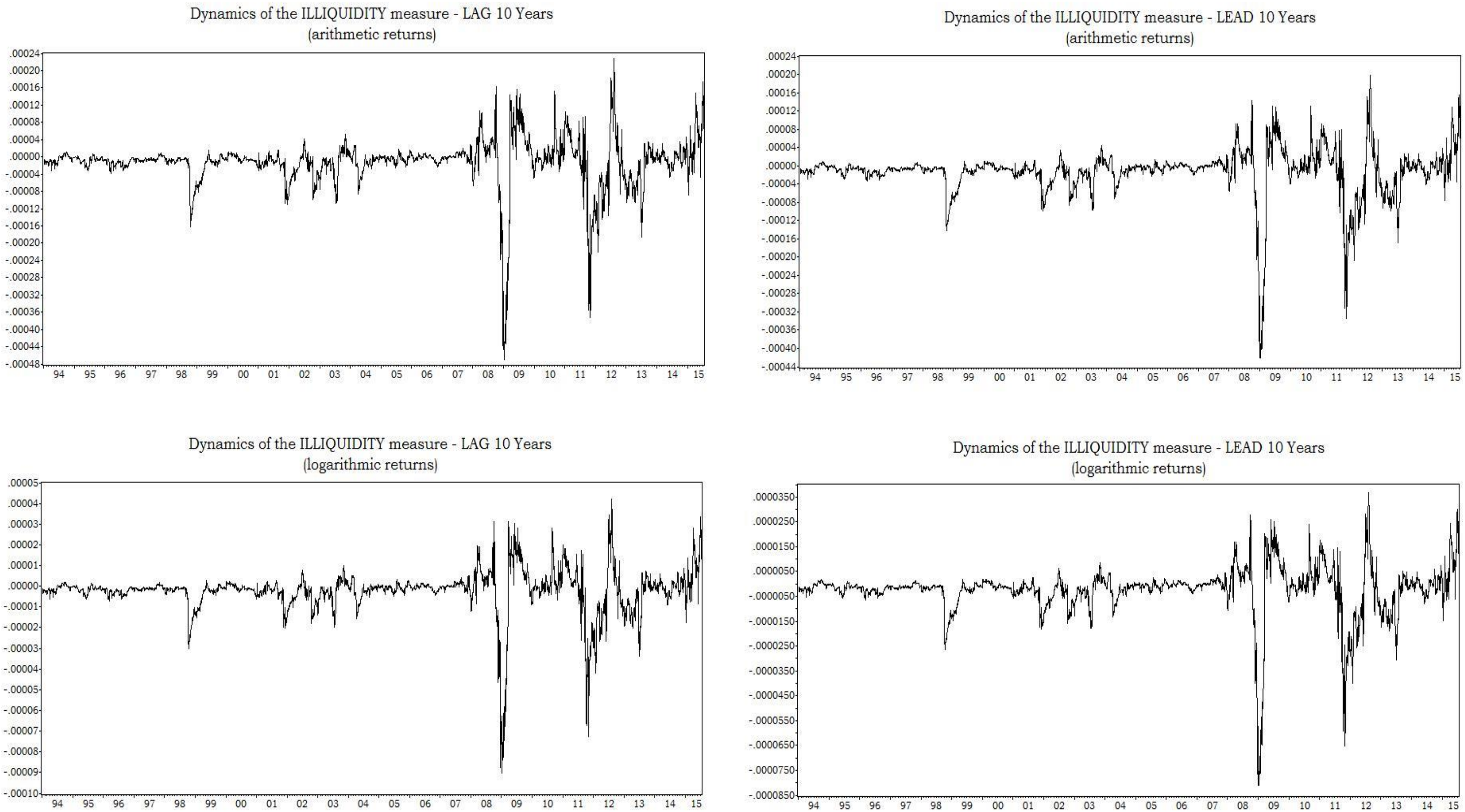


Figure 7.

ILLIQUIDITY Measure for the 20 years U.S. Treasury BOND

The figure shows the dynamics for the *conditional* level of illiquidity measure related to the **20 years U.S. Treasury BOND,** considering *LAG* and *LEAD* variations. The figure also reports the *conditional* dynamic for arithmetic and logarithmic variations from 01/01/1994 to 06/30/2015

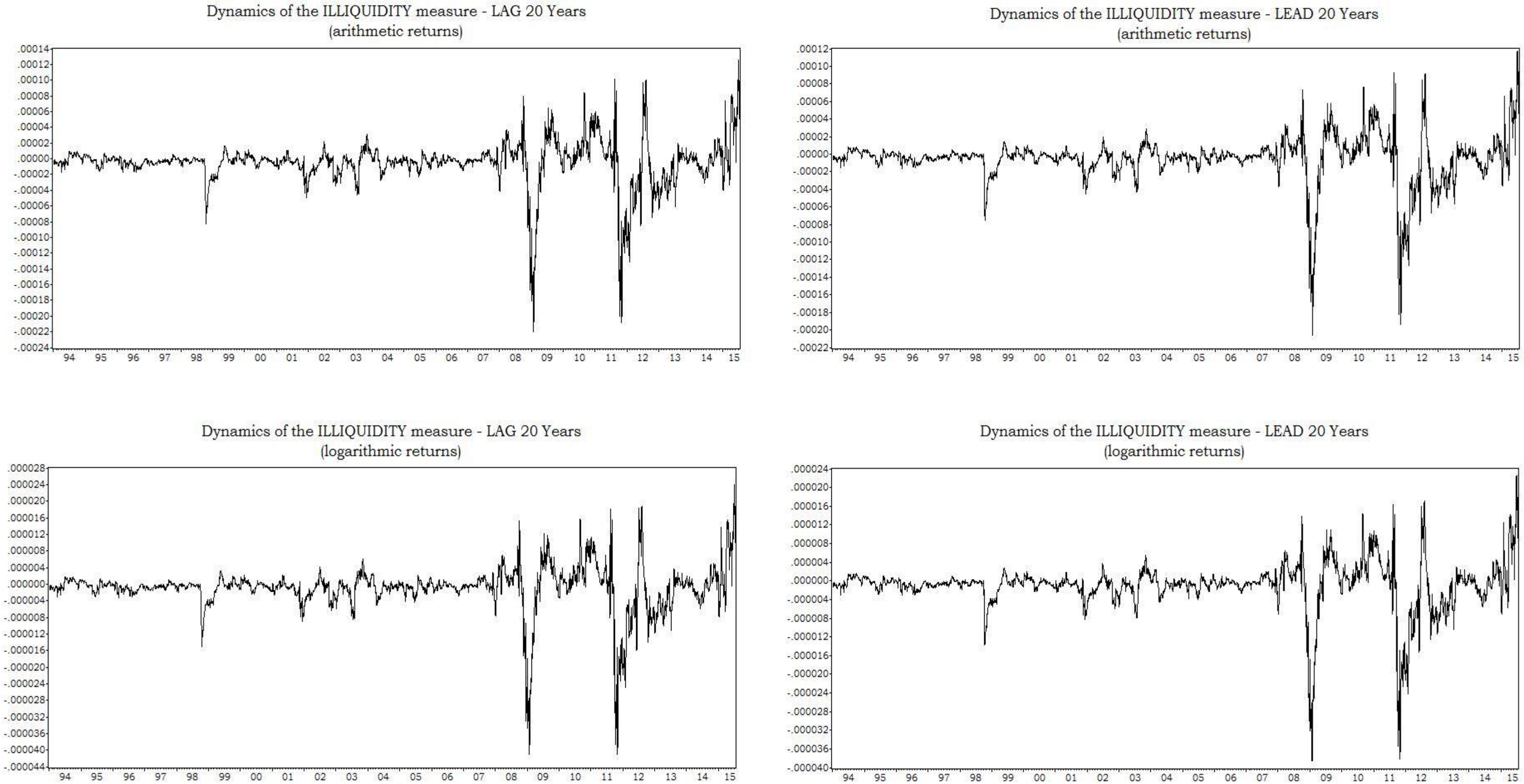
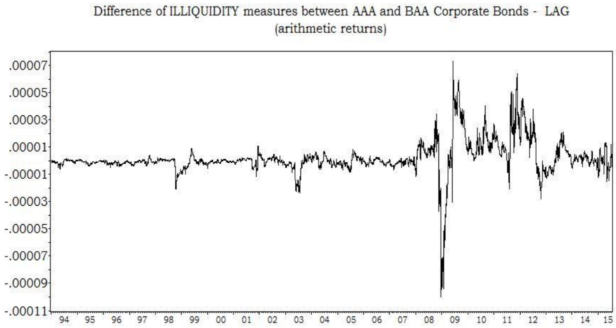
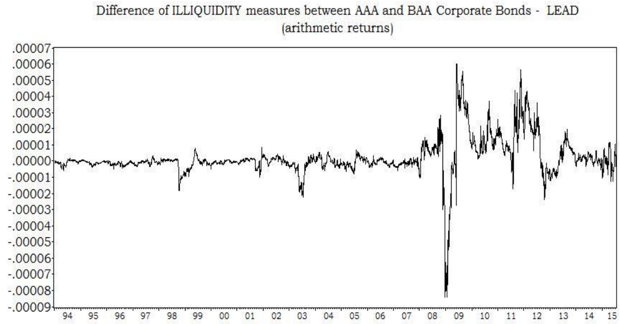


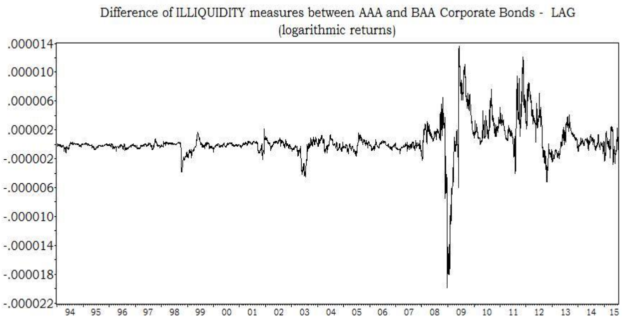
Figure 8.
Dynamics of the ILLIQUIDITY measures for CORPORATE BONDS and the STOCK MARKET

The plot shows the dynamics for the difference between the conditional level of illiquidity measure for Aaa and Baa Corporate BONDS (**Figure 8.1**) and for the CRSP Value Weighted Market Returns (**Figure 8.2**) for *LAG* and *LEAD* arithmetic and logarithmic variations/returns. The figure shows the evolution from 01/01/1994 to 06/30/2015.

Figure 8.1: Conditional illiquidity measures for Aaa and Baa Corporate Bonds







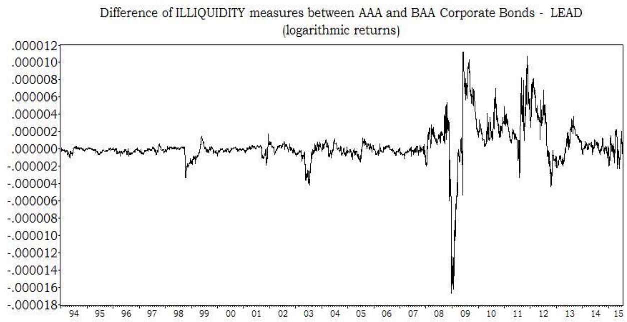
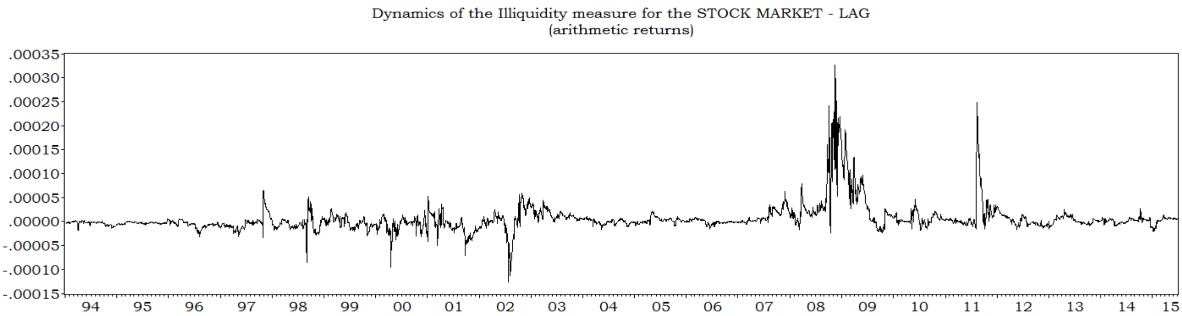


Figure 8.2: Conditional illiquidity measures for the CRSP Value Weighted Market returns



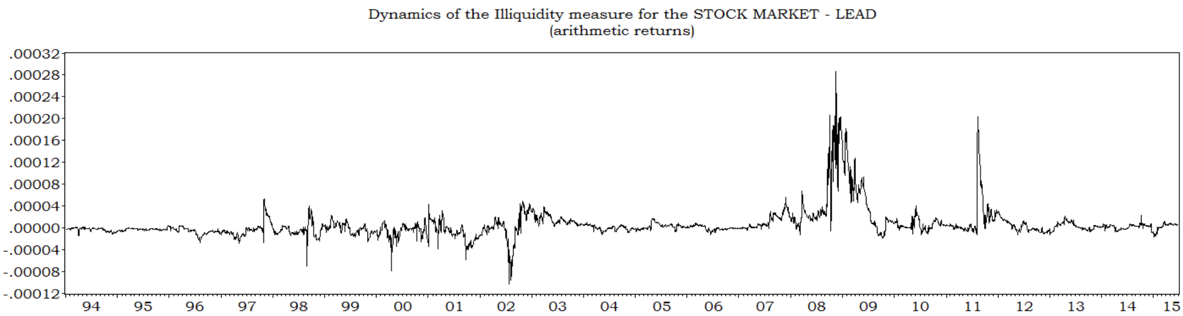
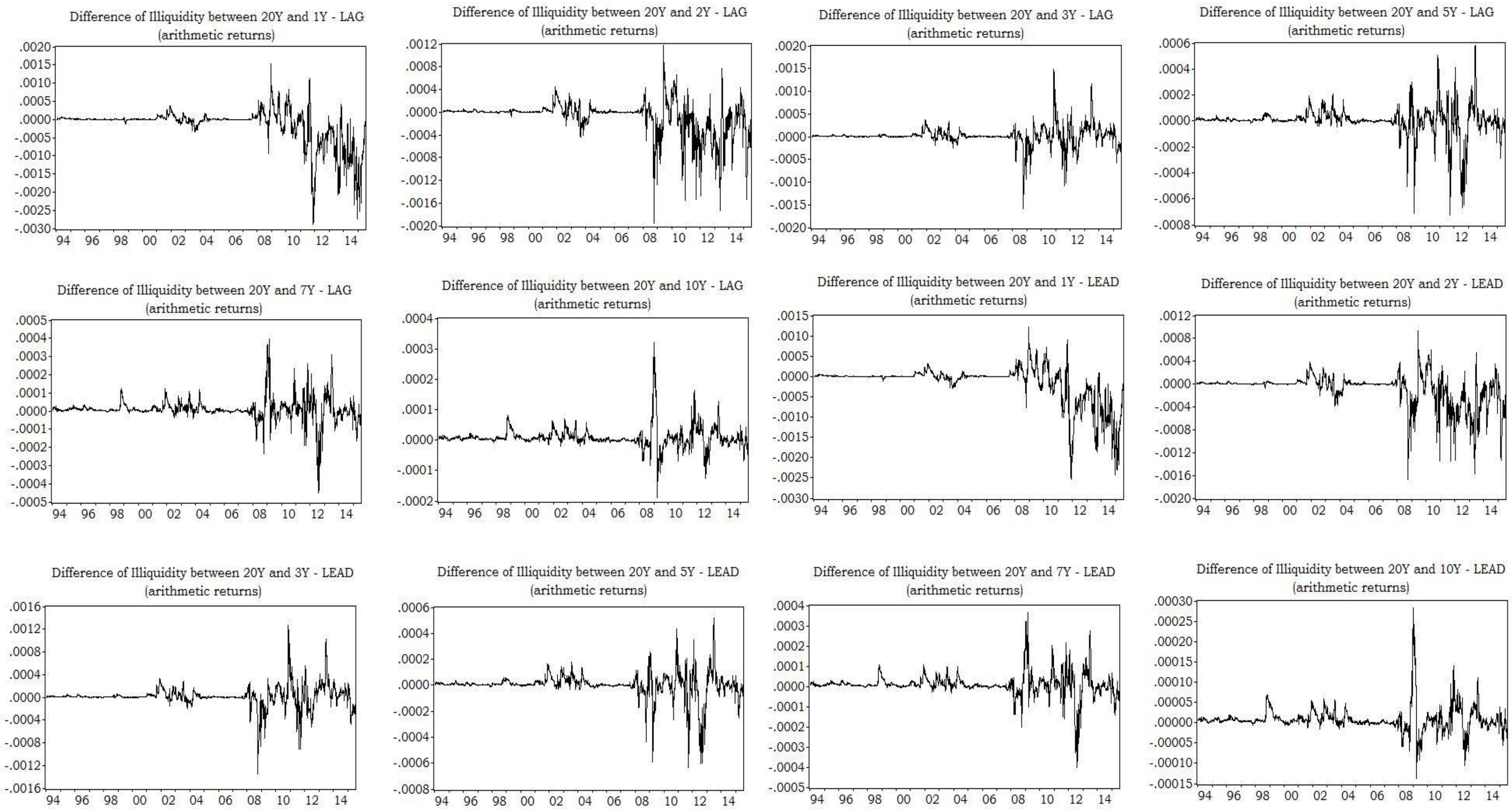


Figure 9.

ILLIQUIDITY Premium between 20 Years U.S. Treasury BONDS and NOTES with different tenors

The figure shows the difference (premium) for the *conditional* level of illiquidity between the 20 years U.S. Treasury BOND, and the U.S. treasuries with a different maturity. This measure of illiquidity considers the *LAG* and the *LEAD* arithmetic variations. The dynamics reports the values from 01/01/1994 to 06/30/2015.



Appendix A.
Estimation Results for the illiquidity related to Aaa and Baa Corporate BONDS

The table shows the estimated coefficients related to the **Diagonal BEKK** specification, with a disturbance assumption based on a ***t-student***, for depicting the dynamics of the first order serial covariances. The coefficients α , β , γ are the estimated coefficients of the mean equations. These coefficients are multiplied by 1000. **m11, m22** and **m33** are the diagonal estimated coefficients related to the long period variance/covariance matrix. These values are multiplied by 100000. **a11, a22** and **a33** are the diagonal estimated coefficients related to the residuals. **b11, b22** and **b33** are the diagonal estimated coefficients related to the persistence of the variance/covariance matrix. **t** is the estimated number of degrees of freedom. The optimization algorithm relies on the Berndt-Hall-Hall-Hausman (B-H-H-H) procedure and the estimated coefficients consider the period between 1/03/1962 and 7/16/2015. ***, ** and * indicate significance at 1%, 5%, 10% levels, respectively. The table brackets report the standard errors.

	Aaa		Baa	
Coefficients	**ARITH.**	**LOG.**	**ARITH.**	**LOG.**
α	-0.019*** (0.051)	-0.084*** (0.022)	-0.163*** (0.053)	-0.074*** (0.023)
β	-0.194*** (0.052)	-0.087*** (0.022)	-0.165*** (0.054)	-0.074*** (0.023)
γ	-0.020*** (0.052)	-0.090*** (0.023)	-0.166*** (0.054)	-0.075*** (0.023)
m11	0.002** (0.001)	0.000** (0.000)	0.002* (0.001)	0.000* (0.000)
m22	0.002* (0.001)	0.000* (0.000)	0.001 (0.001)	0.000 (0.000)
m33	0.001* (0.001)	0.000* (0.000)	0.001 (0.001)	0.000 (0.000)
a11	0.172*** (0.007)	0.172*** (0.006)	0.162*** (0.007)	0.162*** (0.007)
a22	0.152*** (0.006)	0.152*** (0.006)	0.133*** (0.006)	0.133*** (0.006)
a33	0.142*** (0.006)	0.142*** (0.005)	0.127*** (0.006)	0.127*** (0.006)
b11	0.986*** (0.001)	0.986*** (0.001)	0.987*** (0.001)	0.987*** (0.001)
b22	0.989*** (0.001)	0.989*** (0.001)	0.991*** (0.001)	0.991*** (0.001)
b33	0.990*** (0.001)	0.990*** (0.001)	0.992*** (0.001)	0.992*** (0.001)
t	8.724*** (0.370)	8.775*** (0.373)	9.036*** (0.448)	9.125*** (0.457)

Appendix B.

Estimation Results for the illiquidity related to the 5 Fama-French factors

The table shows the estimated coefficients related to the **Diagonal BEKK** specification, with a disturbance assumption based on a ***t-student***, for depicting the dynamics of the first order serial covariances. The coefficients α , β , γ are the estimated coefficients of the mean equations. These coefficients are multiplied by 1000. **m11, m22** and **m33** are the diagonal estimated coefficients related to the long period variance/covariance matrix. These values are multiplied by 100000. **a11, a22** and **a33** are the diagonal estimated coefficients related to the residuals. **b11, b22** and **b33** are the diagonal estimated coefficients related to the persistence of the variance/covariance matrix. **t** is the estimated number of degrees of freedom. **MKT** is the U.S. stock market return; **SMB** is the small minus big factor; **HML** is the high minus low factor; **RMW** is the robust minus weak factor and **CMA** is the conservative minus aggressive factor. The optimization algorithm relies on the Berndt-Hall-Hall-Hausman (B-H-H-H) procedure and the estimated coefficients consider the period between 1/03/1962 and 7/16/2015. ***, ** and * indicate significance at 1%, 5%, 10% levels, respectively. The brackets report the **standard errors**.

Coefficients	**MKT**	**SMB**	**HML**	**RMW**	**CMA**
α	0.779*** (0.059)	0.180*** (0.034)	0.079*** (0.028)	0.100*** (0.021)	0.057*** (0.022)
β	0.740*** (0.058)	0.166*** (0.033)	0.075*** (0.028)	0.096*** (0.021)	0.058*** (0.022)
γ	0.637*** (0.060)	0.146*** (0.034)	0.094*** (0.029)	0.103*** (0.021)	0.070*** (0.023)
m11	0.031*** (0.005)	0.010*** (0.002)	0.010*** (0.001)	0.003*** (0.000)	0.004*** (0.001)
m22	0.018*** (0.003)	0.005*** (0.001)	0.006*** (0.001)	0.002*** (0.000)	0.003*** (0.001)
m33	0.022*** (0.004)	0.006*** (0.001)	0.006*** (0.001)	0.002*** (0.000)	0.003*** (0.001)
a11	0.202*** (0.006)	0.204*** (0.006)	0.213*** (0.006)	0.166*** (0.006)	0.179*** (0.006)
a22	0.178*** (0.005)	0.175*** (0.006)	0.179*** (0.005)	0.146*** (0.005)	0.162*** (0.005)
a33	0.164*** (0.005)	0.155*** (0.005)	0.165*** (0.005)	0.135*** (0.005)	0.151*** (0.005)
b11	0.978*** (0.001)	0.978*** (0.001)	0.975*** (0.001)	0.985*** (0.001)	0.982*** (0.001)
b22	0.983*** (0.001)	0.984*** (0.001)	0.982*** (0.001)	0.988*** (0.001)	0.985*** (0.001)
b33	0.985*** (0.001)	0.987*** (0.001)	0.984*** (0.001)	0.990*** (0.001)	0.987*** (0.001)
t	7.984*** (0.229)	8.844*** (0.268)	8.563*** (0.277)	11.466*** (0.416)	10.509*** (0.388)

Appendix C.

The table shows the correlation matrix among covariates (**ILLIQ_MKT, ILLIQ_SMB, ILLIQ_HML, ILLIQ_RMW, ILLIQ_CMA, DIFF ILLIQ Aaa Baa, % DIFF Aaa Baa, VIX**), considering the ***LAG*** (**Panel C.1**) and ***LEAD*** (**Panel C.2**) arithmetic returns, from 01/03/1994 to 06/30/2015.

Panel C.1: Correlation Matrix among covariates, where the Illiquidity measures are based on ***LAG*** returns

	ILLIQ_MKT	ILLIQ_SMB	ILLIQ_HML	ILLIQ_RMW	ILLIQ_CMA	DIFF ILLIQ Aaa Baa	% DIFF Aaa Baa	VIX
ILLIQ_MKT	1.000							
ILLIQ_SMB	0.433	1.000						
ILLIQ_HML	0.271	0.353	1.000					
ILLIQ_RMW	0.074	0.489	0.505	1.000				
ILLIQ_CMA	0.120	0.100	0.392	0.294	1.000			
DIFF ILLIQ Aaa Baa	-0.101	-0.042	0.203	0.164	0.170	1.000		
% DIFF Aaa Baa	-0.555	-0.406	-0.277	-0.169	-0.198	-0.097	1.000	
VIX	0.525	0.235	-0.015	-0.185	-0.243	-0.020	-0.433	1.000

Panel C.2: Correlation Matrix among covariates, where the Illiquidity measures are based on ***LEAD*** returns

	ILLIQ_MKT	ILLIQ_SMB	ILLIQ_HML	ILLIQ_RMW	ILLIQ_CMA	DIFF ILLIQ Aaa Baa	% DIFF Aaa Baa	VIX
ILLIQ_MKT	1.000							
ILLIQ_SMB	0.463	1.000						
ILLIQ_HML	0.264	0.379	1.000					
ILLIQ_RMW	0.072	0.500	0.546	1.000				
ILLIQ_CMA	0.118	0.089	0.407	0.313	1.000			
DIFF ILLIQ Aaa Baa	-0.112	-0.042	0.224	0.166	0.176	1.000		
% DIFF Aaa Baa	-0.592	-0.433	-0.308	-0.174	-0.208	-0.097	1.000	
VIX	0.546	0.242	-0.026	-0.189	-0.254	-0.020	-0.433	1.000