Flight to liquidity due to heterogeneity in investment horizon

Qin Lei
Department of Finance, Cox School of Business, Southern Methodist University, Dallas, Texas, USA, and

Xuewu Wang
Department of Economics and Finance, Kania School of Management, University of Scranton, Scranton, Pennsylvania, USA

Abstract

Purpose – The purpose of this paper is to provide some rational perspectives for the flight-to-liquidity event rather than simply attributing it to the change in investor sentiment.

Design/methodology/approach – The paper builds a model to highlight the inherent difference in investors' investment horizon, and thus their sensitivity to changes in transaction costs in the stock and bond markets. When stock market deterioration results in higher trading costs, the existing marginal investor shifts wealth to bonds instead of remaining indifferent between stocks and bonds. At the new equilibrium, there is a higher fraction of bond ownership and a longer average investment horizon among stock holders. The paper then empirically tests the model predictions using data in the US stock and bond markets.

Findings – The authors find evidence strongly supporting this paper's theoretical predictions. Days with high stock illiquidity, high stock volatility and low stock return are associated with high yield spread in the bond market. This contemporaneous linkage between the stock market and the bond market is even stronger during periods with strong net outflows from stock mutual funds and strong net inflows to money market funds. The paper also demonstrates the existence of a maturity pattern that the predicted effects, especially the effects of stock illiquidity, are much stronger over shorter maturities.

Originality/value – The finding of this model that the investment horizon of the marginal investor (and thus the equilibrium price impact in the bond market) responds to changes in market conditions contributes to the theoretical debate on whether transaction costs matter. The flow evidence strengthens our understanding of the asset pricing implications of portfolio rebalancing decisions, and the maturity effect bolsters the case for flights to liquidity/quality due to heterogeneity in investment horizon without resorting to investor irrationality or behavioral attributes. In fact, it is arguably difficult to reconcile with a behavioral explanation.

Keywords Flight to liquidity, Flight to quality, Investor heterogeneity, Investment horizon, Endogenous trading cost, Investments, United States of America, Stock markets

Paper type Research paper

JEL classification – G11, G12, G14

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1. Introduction

Though there exists extensive literature on the role of stock liquidity[1], practitioners and academics alike are still often surprised by a sudden shift of capital flows toward most liquid assets or safest assets. The episodic occurrences of such events are popularly known as "flight to liquidity" and "flight to quality", respectively. For example, the market value of sovereign debt in many Latin American countries dropped substantially following the Russia default in 1998. Higher perceived default risk on these sovereign issues made many investors withdraw funds out of these countries and invest in safer assets such as the US Treasury bonds. Some call it a flight to quality because of the investor concern over credit quality on the assets out of flavor, others see a flight to liquidity in that investors suddenly prefer the most liquid asset. In fact, the heightened demand for US Treasury bonds pushed their prices sharply higher after the Russian default in 1998, leading to a significantly larger yield spread for less liquid bonds relative to the Treasury bonds despite no change in credit risk.

It is important to study the economic forces behind such events because the Long Term Capital Management debacle in 1998 suggests that it can be very costly to misjudge the sudden arrival of such events[2]. In an "exploratory analysis", Longstaff (2004) advocates a behavioral explanation for the occurrence of the flight-to-liquidity event by linking measures of investor sentiment to the price impact on the bond market. Though the findings in Longstaff (2004) have intuitive appeal, behavioral factors need not be the sole force driving the asset re-allocation toward the safest and most liquid bond, resulting in a large price impact in the Treasury market. The goal of this paper is to provide a risk-based alternative explanation within the setting of Longstaff (2004).

Specifically, we build a one-period model to illustrate the intuition that the heterogeneity in investment horizon can contribute to the flight-to-liquidity and flight-to-quality events. In our model, investors are identical clones except that they have an innate difference in investment horizon, which is uniformly distributed between zero and one. Their investment objective is to distribute $1 between a risky stock and a risk free bond. The cost associated with trading a risky stock is a decreasing function of investment horizon, while the cost of trading a risk free bond is equally shared by all bond investors in the form of a price impact due to the limited supply of the bond. All investors with horizon shorter than the marginal investor, who is indifferent between investing in the risky stock and the risk free bond, will invest their entire wealth in the bond and the rest of the investors will fully invest in the stock. Therefore, the investment horizon of the marginal investor is also the equilibrium fraction of bond ownership.

It is very intuitive that investors would prefer bonds to stocks in response to a deteriorating stock market, reflected by lower stock liquidity, higher stock volatility or lower expected equity premium before transaction costs. In the event of stock distress, the stock trading costs become higher. The existing marginal investor is no longer indifferent between stocks and bonds and shifts wealth to bonds instead. The price impact in the bond market would lower the bond yield following the higher demand for bonds. The market reaches a new (partial) equilibrium when the reduction of bond yield is exactly offset by the bond advantage relative to the stock. At the new equilibrium, there is a higher fraction of bond ownership and a longer average investment horizon among stock investors.

The finding that the investment horizon of the marginal investor (and thus the equilibrium price impact in the bond market) responds to changes in market conditions contributes to the theoretical debate on whether transaction costs matter. Many one-period portfolio selection models show that the presence of a fixed transaction cost significantly affects the liquidity premium (Leland, 1974; Mukherjee and Zabel, 1974; Brennan, 1975; Goldsmith, 1976; Levy, 1978; Mayshar, 1979). Constantinides (1986) provides the perhaps surprising result that transaction costs have only a second-order effect on the liquidity premium because infinitely-lived agents can trade substantially less frequently in response to higher transaction costs. It is recognized by Constantinides (1986), however, that an infinite-horizon model misses a crucial feature captured by single-period models, namely the possibility of a forced liquidation. Therefore, the actual effect of transaction costs depends upon the expected arrival of the forced liquidation. Vayanos (1998) studies an overlapping-generation model with life cycle liquidation and finds results similar to Constantinides (1986), but Huang (2003) shows in an overlapping-generation model that transaction costs matter when the agents face liquidity shocks (in the form of unexpected death and thus forced liquidation) and borrowing constraints. The fixed investment horizon parameter modeled in this paper can best be understood as a normalized version of the expected arrival of the forced liquidation. That is, investors who expect to withdraw large amount of funds from their investment portfolio in the near term (for instance, investors near their retirement age) have shorter investment horizon. As our model suggests, the distribution of investment horizon for the entire cohort of investors provides a unique angle through which transaction costs can affect the portfolio selection decision.

Another contribution of this paper is to directly model the price impact in the bond market in relation to changes in the stock market condition. Because of the collective move of many investors who choose to rebalance their portfolio in the same direction, the asset valuation has to change, sometimes dramatically, to reflect the supply and demand gap[3]. Therefore, it is beneficial for investors to incorporate the price impact in the bond market as realistic costs of rebalancing their portfolio. Even investors who shift wealth from stocks to money market funds are not immune from this fallout because of their indirect ownership of Treasury securities through money market funds.

This paper shares the same model prediction as in Vayanos (2004) that investors' liquidity preference is an increasing function of volatility, but we arrive there in different routes. In the general equilibrium model of Vayanos (2004), investors are mutual fund managers subject to performance-based liquidations, so a high volatility would trigger forced liquidation that in turn increases the effective risk aversion. Vayanos (2004) assumes time-invariant transaction cost and thus significantly limits its role. In contrast, our model assumes a constant risk aversion and the equilibrium outcome hinges upon the comparative advantage of the risky stock versus the risk free bond in terms of transaction costs. A high volatility weakens the stock appeal to the marginal investor, tipping the balance in favor of the risk free bond. The new (partial) equilibrium corresponds to a new marginal investor who has an investment horizon longer than the previous marginal investor, along with a higher transaction cost in the bond market. In both models a volatility change leads to a new investment horizon for the marginal investor, except that Vayanos (2004) implements a volatility-triggered liquidation ignoring transaction costs while our model emphasizes the role of transaction costs for investors who inherently face a forced liquidation due to different time to retirement, unexpected death or random shocks. Ideally, both the performance-based liquidation and the non-performance-based liquidation should be considered in a complementary fashion.

Longstaff (2004) argues that the yield spread between the Refcorp agency bond and Treasury bond of matching maturities is a natural proxy for the price impact in the bond market[4]. In the empirical analysis of this paper, we study the same yield spread and test the statistical relevance of theory-guided contributing factors for the spread. We find evidence that strongly supports this paper's theoretical predictions. Days with high stock illiquidity, high stock volatility and low stock return are associated with high yield spread for the Refcorp bond. This contemporaneous linkage between the stock market and the bond market is even stronger during periods with strong net outflows from stock mutual funds and strong net inflows to money market funds.

We also demonstrate the existence of a maturity pattern that the predicted effects, especially the effects of stock illiquidity, are much stronger over shorter maturities. It is quite natural that investors with longer investment horizon are less concerned about the day-to-day fluctuations in the stock market because they are better able to depreciate the transaction costs over time. This finding is entirely consistent with the maturity effects in Amihud and Mendelson (1991a), who argue that the excess yield investors demand as a compensation for transaction costs should be lower for longer maturities.

The flow evidence strengthens our understanding of the asset pricing implications of portfolio rebalancing decisions and the maturity effect bolsters the case for flights to liquidity/quality due to heterogeneity in investment horizon without resorting to investor irrationality or behavioral attributes. In fact, it is arguably difficult to reconcile with a behavioral explanation.

A few empirical papers have studied the potential determinants for the yield spread in the Treasury securities market with different emphases. Amihud and Mendelson (1991a) attribute the yield spread between Treasury notes and bills to liquidity and Kamara (1994) stresses the importance of other factors such as difference in tax treatment. When explaining the time-series variation in the yield spread between on-the-run and off-the-run Treasury bonds, Krishnamurthy (2002) points to aggregate factors related to market demand for and supply of liquid bonds, whereas Goldreich *et al.* (2005) emphasize the role of expected future liquidity rather than contemporaneous liquidity[5]. As mentioned earlier, Longstaff (2004) highlights the role of consumer sentiment measures in influencing the yield spread between the Refcorp agency bond and the Treasury bond. One common feature of these papers is that they study the bond market in isolation from the stock market, while our paper explicitly allows for the interaction of the two markets based on theoretical guidance.

This paper is naturally related to the cross-market hedging literature pioneered by Fleming *et al.* (1998), who document strong volatility linkages between the stock and bond markets. During periods of high stock volatility, Connolly *et al.* (2005) uncover a negative correlation between stock and bond returns while Underwood (2009) documents a negative correlation between the signed order flows in the stock and bond markets. Our paper differs from Connolly *et al.* (2005) and Underwood (2009) in the channel through which we observe the comovement of the stock and bond markets. Instead of focusing on a measure of correlation between the two markets, this paper specifically targets the pricing impact in the bond market as a result of investors reacting to changes in the stock market condition by rebalancing their portfolio and provides evidence supporting the model predictions both in a full sample unconditional analysis and in subsamples conditional on days with likely flights. The evidence is particularly strong during periods that witness large net flows out of stock mutual funds and into money market funds. Though related, note that signed order flows in Underwood (2009) are not the same as fund flows here. Signed order flows in the stock market are available at the intra-day level yet subject to errors of misclassifying trades into buy or sell categories. The fund flows are available only at a lower frequency but immune from that type of classification errors.

Both Chordia *et al.* (2005) and Goyenko and Ukhov (2009) document evidence of comovement between the stock and bond market illiquidity. The former study finds no evidence of cross-market causation using a relatively short sample, whereas the latter finds evidence of two-way Granger causality using a substantially longer sample. Instead of relying on a vector autoregressive approach that these two papers depend on, the present paper uses the time-series regression approach, which is the standard approach in the fixed-income literature. We use the Refcorp yield spread to measure the price impact in the bond market and this differs from the bond liquidity measures based on transaction level details in Chordia *et al.* (2005) and Goyenko and Ukhov (2009).

Also related to this paper is the study by Beber *et al.* (2009), who examine the yield spread between the European sovereign bonds and the Euro swap and successfully exploit the negative correlation between credit quality and liquidity in this market to separate investors concerns over credit quality from those over liquidity. The authors demonstrate that during market turmoil investors chase liquidity instead of credit quality. However, a few important differences separate their work from this paper. First, the negative correlation in the euro-area government bond market is rather unique in that in the US the safest bonds happen to also be the most liquid, leading to a positive correlation in the US Treasury market. This paper abstracts from attending to the credit quality concern that would be important in a cross-section of bonds with varying degree of default risk. Second, the primary focus of their paper is on the development in the European government bond market as a whole rather than on the interactions between markets in different asset categories. As this paper demonstrates, changes in stock market condition have important ramifications on the bond market. Third, their paper provides unique perspectives on how flows across different sovereign bonds are related to the contemporaneous credit quality and liquidity conditions. When analyzing the flight-to-liquidity and flight-to-quality events, it is useful to consider both flows into the favored asset and flows out of the less favored asset to form a complete view. In this paper we consider both net outflows from stock mutual funds and net inflows to money market funds, the latter of which are good substitutes to Treasury securities[6]. In this sense, this paper complements the analysis in Beber *et al.* (2009) through a different vantage point.

The remainder of the paper proceeds as follows. Section 2 discusses how academics adopted the related terms from journalists and how we plan to use them in this paper. We describe the model in Section 3 and the empirical methodology in Section 4. The data sources and the full sample analysis are discussed in Section 5. Section 6 contains the empirical analysis conditional on days with likely flight-to-liquidity and flight-to-quality events and Section 7 concludes.

2. Terminology

Though the extant academic literature lacks an authoritative etymology on terms such as “flight to quality”, “flight to safety”, “flight to liquidity”, among other variations, they are commonly attributed to participants of financial markets[7]. Generally used to describe a major shift in capital flows across different financial assets or asset categories in a period of financial turmoil, these phrases are both catchy and elusive. The term “flight” points to the abruptness of a quick change in trend, while “quality”, “safety” or “liquidity” alludes to where the money is going. Confusion can arise from using these terms due to the lack of a clear definition of the origination and destination market and the failure to reveal the cause of such a move or its underlying mechanism of propagation. So it is worthwhile briefly tracing through the origin and the expansion of their usage over time.

The public appearance of the term “flight to quality” coincided with the New York City fiscal crisis around 1975 (see Gramlich, 1976, for an academic account). After years of deficit spending primarily funded by borrowing from the bond market, the New York City found itself in a precarious situation where the city could no longer market any securities in April, 1975. Investors were increasingly concerned whether the city would default its obligations and whether such a default could jeopardize the solvency of major financial institutions in New York. Therefore, many investors shied away from New York City bonds in pursuit of quality issues with lower perceived probability of default. A string of news articles written by Vartan (1974, 1975a, b) reflected this common spirit when he repeatedly invoked the term “flight to quality,” citing a dealer in the government bond market in one occasion.

Around the same time, the first use of “flight to safety” in the finance context appeared in a *New York Times* article by Phalon (1975), who quoted the term from money market analysts to describe the sharp decline in New York City commercial bank holdings of certificates of deposit. Given growing concern that New York City might default its obligations, investors cascaded into safer alternatives such as Treasury bills and the highly liquid certificates of deposit issued by out-of-town institutions.

Even though these generic terms can cause confusion, journalists in the popular press frequently cited them to explain large movement in the financial markets. The scope of what constitutes “quality” or “safety” also expanded over time. For instance, Maidenberg (1982) described the flight to quality as a situation where “investors are willing to sacrifice a point or two of interest [. . .] by investing in money market funds that only buy Government securities.” Vartan (1982) affiliated the flight to quality with “bills, notes and bonds backed by the US Government.” A few months later on *Financial Times*, The Lex Column (1982) commented, “the much-discussed flight to quality in the world’s financial markets continues in an almost violent way and the definition of quality now goes far beyond the Government bond markets.” Stocks, bonds and cash equivalent financial instruments were no longer the only types of securities being pursued during a flight to quality. A series of articles on *Wall Street Journal* (Hughes, 1984; Zaslow, 1984) pointed to futures in bank certificates of deposit, Treasury-bill futures and the US dollar as a currency hedge against political crises elsewhere. The flight to quality or flight to safety already became one of the usual suspects when the US stock market crashed in October, 1987. The place of refuge then turned out to be “bonds, money market funds and utility stocks,” according to Hinden (1987). By the time when the term “flight to liquidity” appeared on *New York Times* in an article by Sloane (1987), mortgage backed securities were trumpeted as an alternative to Treasury bonds because "the likelihood of being hurt with mortgage-backed securities is not that great"[8]. Ironic as it may be especially in light of the recent global financial crisis that rooted in the collapse of mortgage-based securities in the USA, the blanket of flights to quality, safety or liquidity has continued to grow as crises take place in different shapes, forms and locations.

To a large extent, these three terms have been used interchangeably in that they all reflect the investor aversion to risk or uncertainty, but the subtle distinction among them is not lost to all. Some journalists attempted to better qualify the context of the term by saying "flight to safety from worldwide equities" (Fidler, 1987b) or "flight to money market funds" (Gould, 1987), while others cited more than one term at once. Michael Waldman at Salomon was quoted by Sloane (1987) as saying, "Since the (1987 stock) crash, there's been a flight to quality and a flight to liquidity." The implication was that these two terms are somewhat different, yet the exact differences were not elaborated.

Some early adopters among academics often mention these terms only anecdotally when discussing a crisis. Smirlock and Kaufold (1987) briefly talked about the role of "flight to safety" in the credit markets when Mexican government defaulted on its foreign loans in August, 1982. In the discussion section of Friedman *et al.* (1989), Matthew Shapiro conveyed Fischer Black's view that the stock market crash in 1987 was caused by "flight to safety – a sudden decline in the demand for risky assets." In contrast, Gramlich (1976) notably departed from such a casual treatment when quoting "flight to quality" to describe the higher yield spread for municipal bonds of poorer credit rating relative to the Aaa-rated corporate bonds in the New York City fiscal crisis around 1975. Gramlich tried to explain the yield spread in a regression framework using the average income tax rate and the unemployment rate for different municipalities and found much larger residuals for municipal bonds of lower credit quality. In the first academic paper mentioning the term "flight to liquidity," Amihud and Mendelson (1991b) document evidence that investors prefer stocks with lower transaction costs to those with higher costs around the US stock market crash in 1987.

Since then, researchers have embraced these terms eagerly as evidenced by dozens of papers with such terms published in various academic journals. Most of these papers continued to deploy the "flights" only casually and verbally, while a handful of papers put these terms on the spot light with rigorous analysis in theoretical models and/or empirical exercises. It seems though researchers have shown no less liberty than journalists when applying these terms to different contexts, sometimes leading to confusion because the same label was used to represent different things.

For example, the banking literature (Bernanke *et al.*, 1996; among many others) reserves "flight to quality" to describe the notion that borrowers with higher agency costs should have less access to credit markets. The fixed-income literature carries on the spirit of Gramlich (1976) in using "flight to quality" to express investors' preference for bonds with lower credit risk to bonds with higher credit risk. The literature concerning the cross-market hedging applies "flight to quality" to the event of investors exiting the stock market in pursuit of Treasury bonds (Fleming *et al.*, 1998; Chordia *et al.*, 2005; Goyenko and Ukhov, 2009; Underwood, 2009). Similarly, Amihud and Mendelson (1991b) use "flight to liquidity" to describe the investors' preference for stocks with low transaction costs, while Longstaff (2004) utilizes this term to describe the investors' preference for Treasury bonds.

Most academic papers mention only one of these terms and thus naturally avoid the potential distinction among them. Some papers use the terms interchangeably and a few other depict the subtle differences. For instance, Longstaff (2004) ascribes the flight to quality to a sudden change of investor preference in favor of bonds with lower credit risk and the flight to liquidity to a sudden change of investor preference for the most liquid securities available, the US Treasury bonds. Beber *et al.* (2009) share this way of conceptually distinguishing the two terms. Furthermore, Beber *et al.* (2009) argue that it is empirically difficult to tell these terms apart in the US markets because Treasury bonds happen to be both the safest and the most liquid of all securities. Given this confusing state of labeling in the extant literature, it is useful to clarify our usage of using these terms and articulate the particular setting of this paper.

As far as the distinction between the flight to liquidity and the flight to quality is concerned, we take the views of Beber *et al.* (2009). While mindful of the empirical difficulty to disentangle these two elements in the US markets, the flight to liquidity refers to the liquidity preference and the flight to quality refers to the credit risk concern. Therefore, we use the flight to liquidity in the title to highlight the subject of study in the empirical exercise similar to Longstaff (2004) and use the flight to liquidity and the flight to quality interchangeably for the remainder of the paper, unless noted otherwise.

We adopt the convention in the fixed-income literature that focuses on yield spreads in the context of sudden shift of capital flows[9]. Our choice of yield spread follows Longstaff (2004) in treating the spread between the yield on Treasury bonds and the yield on the Refcorp agency bonds of identical maturities as a measure of flight to liquidity premium. Longstaff (2004) makes a convincing case that there is virtually no difference in credit risk between these two bonds, yet his empirical exercise suggests a fairly narrow interpretation of flights given the lack of consideration of rational factors that could plausibly drive stock investors into government bonds in periods of stock turmoil.

The main point of departure in this paper is that we explicitly consider changes in equity markets in terms of risk and liquidity as potential determinants for the flight to liquidity premium in the bond market, whereas Longstaff (2004) almost exclusively focuses on measures of investor sentiment as the sole contributing factor to the investors' sudden preference for Treasury bonds. We construct a simple model to illustrate the importance of cross-market interactions among investors who have inherently different investment horizons and thus face different sensitivities to changes in transaction costs. This intuitive focus on transaction costs is in the same vein as Amihud and Mendelson (1991a) except that they do not consider cross-market interactions. We now turn to details of the model.

3. Model

Suppose that investors are homogeneous in every aspect except for the innate difference in investment horizon, h, which is assumed to be uniformly distributed between 0 and 1. The fixed parameter h is essentially a normalized version of expected time span until a forced liquidation. For instance, investors near their retirement age have shorter investment horizon. Alternatively, the forced liquidation can materialize in the form of unexpected death (Huang, 2003) or more generally random shocks. All investors share the same mean-variance utility function[10] with absolute risk aversion coefficient γ and make a decision on how to allocate the investment of \$1 between a risky stock and a risk free zero-coupon bond during their respective investment horizons. For simplicity, capital gains taxes are assumed to be zero for both assets.

The unit of time is normalized to one. Before the consideration of transaction costs, etc. the return on the risky stock has mean r_s and variance σ_s^2 and the return on the risk free bond is r_b, all of which are defined over one standardized unit of time. In terms of transaction costs, the fundamental difference between the stock and the bond is that stock investors incur a proportional cost of τ per transaction, whereas bond investors share a price impact $\pi(w^*)$ over one standardized unit of time. Denote by λ the extent of stock market liquidity and the stock transaction cost $\tau(\lambda)$ is strictly decreasing in λ,, i.e. $\tau < 0$ and $\tau > 0$. Denote by w^* the equilibrium fraction of bond investment over one unit of time and it is assumed to be common knowledge prior to investors' decision. Each bond investor with horizon h contributes to the price impact only for the span of their respective horizon. The price impact in the bond market is modeled after the real world observation that the surge of public demand for Treasury bonds leads to higher bond prices due to a limited supply of Treasury bonds and thus lower yield on holding the bond, i.e. $\pi' > 0$ and $\pi > 0$. For a stock investor with horizon h, the expected return on the stock is $r_s h - \tau(\lambda)$ and the variance is $h\sigma_s^2$. For a bond investor with horizon h, the expected return is $r_b h - \pi(w^*)h$.

Investors decide the fraction w of investment in the risk free bond so as to maximize their expected utility over horizon h:

$$\max_{0\le w\le 1} 1 + w[r_b h - \pi(w^*)h] + (1-w)[r_s h - \tau(\lambda)] - \frac{\gamma}{2}(1-w)^2\sigma_s^2 h. \tag{1}$$

Clearly, it is equivalent to maximize the following objective over one standardized unit of time:

$$\max_{0\le w\le 1} w(r_b - \pi(w^*)) + (1-w)\left(r_s - \frac{\tau(\lambda)}{h}\right) - \frac{\gamma}{2}(1-w)^2\sigma_s^2. \tag{2}$$

Note that the stock returns adjusted for transaction costs depend on both the stock liquidity and the investment horizon. This feature also appears in the model of Amihud and Mendelson (1986).

The marginal utility gain from investing in the bond is $(r_b - r_s) + \tau(\lambda)/h - \pi(w^*) + \gamma(1-w)\sigma_s^2$, which is strictly decreasing in investor horizon h. In other words, the investor with a long horizon prefers the stock to the bond because of the lower transaction cost with the stock, all else being equal. Note that the second-order condition for the investor's maximization problem holds. The existence of an inner solution is equivalent to the existence of one marginal investor with $h^* \in (0,1)$ who is indifferent between investing in the bond or the stock. At the equilibrium, all investors with horizon $h < h^*$ will fully invest in the bond and all investors with horizon $h \ge h^*$ will fully invest in the stock because the marginal utility gain from investing in the bond is declining as the investment horizon gets longer. The fact that there will be h^* fraction of investors investing in the bond at the equilibrium indicates that in a fully revealing equilibrium, $h^* = w^*$. In the remainder of the discussion we assume that the price impact function is well behaved and there exists an inner solution $h^* \in (0, 1)$ such that:

$$(r_b - r_s) + \frac{\tau(\lambda)}{h^*} - \pi(h^*) + \gamma(1 - h^*)\sigma_s^2 = 0. \quad (3)$$

The model is one-period in nature and thus parameters are fixed within this standardized unit of time. It is nevertheless useful to work out the comparative statics and examine how the equilibrium level of bond ownership will change following a small perturbation to the risk aversion γ, the stock risk level σ_s^2, the expected equity premium before transaction costs $r_s - r_b$, or the extent of stock market liquidity λ. Working out the algebra, we have:

$$\frac{\partial w^*}{\partial \gamma} = \frac{(1 - w^*)\sigma_s^2}{[\tau(\lambda)/w^{*2}] + \pi'(w^*) + \gamma\sigma_s^2} > 0; \quad (4)$$

$$\frac{\partial w^*}{\partial \sigma_s^2} = \frac{\gamma(1 - w^*)}{[\tau(\lambda)/w^{*2}] + \pi'(w^*) + \gamma\sigma_s^2} > 0; \quad (5)$$

$$\frac{\partial w^*}{\partial (r_s - r_b)} = -\frac{1}{[\tau(\lambda)/w^{*2}] + \pi'(w^*) + \gamma\sigma_s^2} < 0; \quad (6)$$

$$\frac{\partial w^*}{\partial \lambda} = \frac{\tau'(\lambda)/w^*}{[\tau(\lambda)/w^{*2}] + \pi'(w^*) + \gamma\sigma_s^2} < 0. \quad (7)$$

The first result indicates that a cohort of investors with higher risk aversion will allocate more of their wealth in the risk free bond as opposed to the risky stock. The second result shows that investors will invest more in the bond when facing increased uncertainty in the stock. The third result shows that the bond ownership at the equilibrium is decreasing in the expected equity premium (before transaction costs). While the first three results contribute to the rational explanation of the flight-to-quality event, the fourth result touches upon the flight-to-liquidity phenomenon. That is, the liquidity deterioration in the stock market induces some investors to shift wealth from the stock to the bond.

The intuition behind these results is straightforward. A worsening stock market can trigger a flight-to-quality event due to higher stock return volatility or lower equity premium. It can also trigger a flight-to-liquidity event due to lower stock liquidity because the existing marginal investor is no longer indifferent between the stock and the bond and prefers the bond instead. The price impact in the bond market would lower the bond yield when some investors shift wealth from the stock to the bond. The market reaches a new (partial) equilibrium when the reduction of bond yield is exactly offset by the bond advantage relative to the stock. The new equilibrium corresponds to a higher fraction of bond ownership and the average investment horizon among stock investors becomes higher than before as some previous stock owners at the lower end of investment horizon have now become bond holders.

This model shares the same predictions as in Vayanos (2004) that the liquidity preference is an increasing function of volatility and that the volatility change induces changes in the investment horizon for the marginal investor. We arrive at the same conclusion via different approaches, however. In the general equilibrium model of Vayanos (2004), investors are mutual fund managers subject to performance-based liquidation. Given the assumption of time-invariant transaction costs in his model, Vayanos stifles the role of transaction costs and instead focuses on how high stock volatility triggers performance-based liquidation, leading to a stronger investor preference for liquidity. In this process, the investment horizon of the marginal investor is changed because of the forced liquidation. In our model, the transaction costs not only are time-varying but also play a central role of depicting the comparative advantage of the risky stock versus the risk free bond. A high stock volatility weakens the stock appeal to the existing marginal investor, tipping the balance in favor of the risk free bond. The new (partial) equilibrium outcome corresponds to a new marginal investor who has an investment horizon longer than the previous marginal investor, along with a higher transaction cost in the bond market. The previous marginal investor is now a bond investor and there is a higher bond ownership at the new equilibrium.

The finding that the investment horizon of the marginal investor (and thus the equilibrium price impact in the bond market) responds to changes in market conditions contributes to the theoretical debate on whether transaction costs matter. Many one-period portfolio selection models show that the presence of a fixed transaction cost significantly affects the liquidity premium (Leland, 1974; Mukherjee and Zabel, 1974; Brennan, 1975; Goldsmith, 1976; Levy, 1978; Mayshar, 1979). Constantinides (1986) provides the perhaps surprising result that transaction costs have only a second-order effect on the liquidity premium because infinitely-lived agents can trade substantially less frequently in response to higher transaction costs. It is recognized by Constantinides (1986), however, that an infinite-horizon model misses a crucial feature captured by single-period models, namely the possibility of a forced liquidation that may occur at the most unfortunate time from a strategic point of view. Therefore, the actual effect of transaction costs depends upon the arrival of forced liquidation.

Both Vayanos (2004) and this paper emphasize the role of forced liquidation in affecting the equilibrium outcome, but we choose different vehicles of delivery. Vayanos (2004) allows the volatility-triggered liquidation to increase the effective risk aversion for the marginal investor while ignoring the role of transaction costs. In contrast, this paper assumes a constant risk aversion and takes the different time span until forced liquidation as an innate attribute for investors, all of whom are sensitive to changes in transaction costs over time. Hence, changes in the market condition lead to a new equilibrium that corresponds to a different marginal investor. Overall, the similar results despite different treatments between Vayanos (2004) and this paper suggest a close tie between investment horizon and risk aversion and modeling the heterogeneity in investment horizon can be a useful alternative to capturing the differences in investor risk aversion.

Since the bond price impact is assumed to be strictly increasing in the bond ownership at the equilibrium, we can also do the comparative statics for the bond price impact. It is straightforward to show that:

$$\frac{\partial \pi(w^*)}{\partial \gamma} > 0; \quad \frac{\partial \pi(w^*)}{\partial \sigma_s^2} > 0; \quad \frac{\partial \pi(w^*)}{\partial (r_s - r_b)} < 0; \ \text{ and } \ \frac{\partial \pi(w^*)}{\partial \lambda} < 0. \tag{8}$$

The basic message from this single-period model is that the price impact in the bond market is positively related to the investor risk aversion and the stock return volatility and negatively related to the equity premium and the stock market liquidity. These model predictions form the basis of our empirical tests and we now turn to the methodology of doing so.

4. Empirical methodology

To test the model predictions, we regress the daily measure of bond liquidity premium on contemporaneous measures of stock market illiquidity, volatility and return, while allowing for an intercept and a time trend. The choice of daily interval partially reflects the notion that a flight-to-liquidity event takes place rather quickly, hence the term "flight"[11]. Also the one-period nature of our model implies a contemporaneous analysis. Though the model speaks to the important role that investor risk aversion can play in the asset re-allocation process, the empirical estimates of risk aversion coefficients typically arise from macro consumption data and thus are available only at much lower frequency than the daily level used here. Therefore, we have to partially delegate the role of risk aversion to the intercept and the time trend in the following regression design:

$$premium_t = \beta_0 + \beta_1 illiq_t + \beta_2 retvol_t + \beta_3 ewret_t + \beta_4 t + \varepsilon_t. \quad (9)$$

The dependent variable of regression (9) is the Refcorp bond premium, defined as the yield spread between the Refcorp bond and the Treasury bill/note/bond at comparable maturity, both of which are stripped of coupons. Longstaff (2004) argues convincingly that bonds issued by the government agency Refcorp are essentially as creditworthy as Treasury bonds because the legal and operational provisions of the agency bonds constitute an implicit Treasury guarantee. Moreover, there is no tax or legal treatment differential between the Refcorp and the Treasury bonds. Therefore, the yield spread between the Refcorp bond and the Treasury bond with identical features is a good proxy for the price impact on the bond market[12].

In the set of explanatory variables, the measures of stock market condition include the stock illiquidity (the Amihud measure denoted as *illiq*), the stock volatility (squared daily returns excluding distributions denoted as *retvol*) and the stock return excluding distributions (denoted as *ewret*). When computing the market aggregates for these variables, we use only common stocks listed on NYSE, AMEX and NASDAQ. The equal-weighting scheme is adopted to avoid over-emphasizing large stocks. A wide variety of liquidity measures have been proposed and studied in the literature[13]. Goyenko *et al.* (2009) provide detailed references to some of these measures and run a horse race among them. Defined as the dollar volume weighted absolute stock return, the Amihud (2002) measure of stock illiquidity turns out to be quite appealing, according to Goyenko *et al.* (2008). It is very simple to compute without resorting to transaction-level details, yet compares favorably against competing measures of liquidity as far as effective spread and price impact are concerned. Hence, we use the Amihud measure to represent stock market illiquidity in this paper.

The regression (9) is estimated separately for the bond premium at different maturities ranging from three-month to 30-year. The statistical significance for the estimated coefficients relies on Newey-West standard errors adjusted for heteroskedasticity and autocorrelations. The model specifically predicts that $\widehat{\beta}_1 > 0$, $\widehat{\beta}_2 > 0$ and $\widehat{\beta}_3 < 0$, as the asset re-allocation process favors bonds when the stock trading environment deteriorates, leading to a simultaneous price impact in the bond market. Empirical evidence consistent with the model predictions would support the justification of a flight to liquidity/quality for risk-based reasons, since our model is purely based on considerations of risk and transaction costs in the absence of investor irrationality or behavioral attributes.

In addition to testing in the full sample the statistical relevance of theory-guided contributing factors for the bond yield spread, we also repeat the same regression over a set of carefully chosen trading days during which the flight-to-liquidity and flight-to-quality events likely have occurred. The rationale behind this exercise of conditional events is to examine whether the theory-guided factors play an important role on days when they potentially matter the most so as to guard against finding a spurious relation. Evidence that these factors better explain the variation in the bond yield spread during the most likely scenarios for flight-to-liquidity and flight-to-quality events would further substantiate the model predictions. Toward this goal, we classify trading days with the following characteristics as likely periods of flight-to-liquidity/quality events: extreme periods with high stock market volatility, high stock market illiquidity, or low stock market return. The estimation is done separately for each cohort of trading days identified from one of the above attributes and the same set of expected signs applies to the estimated coefficients.

The empirical exercise thus far focuses on identifying the contemporaneous linkage between the stock market conditions (liquidity, volatility and return) and the price impact on the bond market, a relationship that would be consistent with the occurrence of the flight-to-liquidity and flight-to-quality events. The most direct and conclusive evidence for such an event would be seeing the existing marginal investor actually exiting the stock market and entering the bond market. Though it remains a luxury and empirical challenge to identify such an ideal situation, we nevertheless make important progress in this paper along this direction.

To analyze the market implications of the portfolio rebalancing acts by investors who react to the changing market conditions, it is useful to keep track of the flow of funds on both the origination market and the destination market. Specifically, we investigate whether the theory-driven relationship holds among days associated with large net outflows from stock mutual funds and days associated with large net inflows into money market funds. Though we do not have access to GovPX data that would have allowed the observation of flow changes in the Treasury securities market, observing net inflows into money market funds should serve the purpose to a large extent given that money market funds are good substitutes to Treasury bonds. Evidence in support of the theory-driven relationship during periods with large flows out of the stock market and into the money market funds would strongly support the existence of flight-to-liquidity/quality events and the risk-based justification put forth by the model.

The following two sections discuss the results of implementing the empirical strategy delineated above.

5. Full sample unconditional analysis

We rely on CRSP for daily stock returns (excluding distributions) and dollar volumes for all common stocks listed on NYSE/AMEX/NASDAQ. After computing the Amihud measure of stock illiquidity as well as squared returns, we apply the equal-weighting scheme to get the market level measures of stock illiquidity, volatility and returns. Following Longstaff (2004), we obtain from Bloomberg the daily yields on zero-coupon Refcorp agency bonds (the C091 index series) and the daily yields on zero-coupon Treasury bonds (the C079 index series). Both series have 11 bonds with different maturities, including three-month, six-month, one-year though five-year, seven-year, ten-year, 20-year and 30-year. The yield series for the Refcorp agency bonds share the common inception date of April 16, 1991. Among these series, the Refcorp yield with 30-year maturity ceased on September 2, 2004, while other daily series are ongoing.

Table I presents some summary statistics of the main variables, sampled daily between April 16, 1991 and December 31, 2008. The stock market illiquidity averages about 0.06 basis point per $1 volume, though with a maximum of 1.26 basis points. During this period, the daily stock market return is about nine basis points on average (compared to 8.2 basis points for the same period using all stocks in CRSP), with its standard deviation approaching nearly 1 percent. The stock market volatility measured as average daily squared returns has a mean of 28 basis points. After purging six potential outliers (each with an absolute yield spread higher than 400 basis points), the average Refcorp bond premium ranges from 11 basis points at the two-year maturity to 21 basis points at the 30-year maturity. The minimum premium is negative for all maturities, a clear indication for the presence of some measurement errors in the data. A formal test, results for which are not reported for brevity, strongly rejects for each of the 11 maturities the null hypothesis that the yield spread between the Refcorp

	Number of obs.	Mean	SD	Minimum	Median	Maximum
illiq	4,460	0.06	0.07	0.00	0.04	1.26
retvol	4,460	27.79	19.13	3.89	25.59	338.90
ewret	4,460	0.09	0.96	−8.58	0.18	9.35
premium3m	4,458	19.84	28.19	−61.00	12.00	207.61
premium6m	4,458	17.21	27.53	−50.00	10.00	193.83
premium1y	4,460	13.17	23.26	−47.34	8.00	165.61
premium2y	4,460	11.07	16.85	−29.30	7.00	133.71
premium3y	4,460	12.32	17.38	−27.84	8.00	149.94
premium4y	4,459	12.82	16.69	−19.57	8.77	181.00
premium5y	4,460	12.67	15.30	−16.00	8.21	154.35
premium7y	4,460	14.98	15.09	−10.00	12.00	126.58
premium10y	4,460	16.72	13.68	−15.00	14.00	151.31
premium20y	4,460	18.77	11.86	−1.00	15.81	129.03
premium30y	3,369	20.95	12.29	−3.00	17.00	98.00

Notes: This table reports the summary statistics for daily data between April 16, 1991 and December 31, 2008; the sample consists of measures of stock illiquidity, volatility and return at the aggregate market level; the stock illiquidity is based on Amihud measure (denoted as illiq in basis points), the stock volatility is squared daily returns (denoted as retvol in percentage squared) and the stock return is daily return excluding distributions (denoted as ewret in percentage); when computing the stock market variables, we use only common stocks listed on NYSE, AMEX and NASDAQ with the equal-weighting scheme; the sample also consists of daily yield spreads between the Refco agency bond and Treasury bill/bond/note with matching maturity stripped of coupons; the yield spreads are denoted as premium in basis points, with 11 different maturities ranging three-month to 30-year; note that the yield series for the Refcorp agency bond with 30-year maturity ceased on September 2, 2004 and the corresponding 30-year premium has fewer observations than others

Table I.
Summary statistics

agency bond and the Treasury bond of matching maturity is zero. It suggests that the results are not entirely due to measurement errors.

The daily series for three measures of stock market condition are plotted in Figure 1. The stock illiquidity at the market level is high in the early 1990s, increases slightly around the crash of Internet bubble period and dramatically increases during 2008. The stock volatility is fairly high in 1998 and around the internet bubble period. The second half of 2008 witnesses sustained increase in stock volatility. The equal-weighted stock market return hovers around zero for much of the sample before experiencing extreme positive or negative returns in 2008.

Figure 1 also plots the daily series for the yield spread at the three-month, three-year and 20-year maturities. One common feature of the three series is that a relatively stable period predates the more volatile period that coincides with the build-up and ultimate burst of the Internet bubble. The three series also share a visible upward trend in 2007 and 2008 as the global financial crisis unfolds. It is also clear that the yield spread with three-month maturity is much more volatile than the other two series with medium-term and long-term maturities.

Table II reports the OLS regression results of design (9) for the Refcorp bond premium at each of the 11 maturities. Two main results stand out from this table.

First, the data strongly support the theoretical predictions. All estimates have exactly the same sign as predicted. The influence of stock market illiquidity is statistically significant at the 1 percent level for ten maturities and at the 5 percent level for one maturity. The coefficient for stock market volatility is also significant at the 1 percent level for ten out of 11 maturities. Consistent with the theory, days with low stock market return are associated with high price impact in the bond market. This relationship is statistically significant for seven maturities.

Second, the data exhibit a maturity pattern that the predicted effects are much stronger over shorter maturities such as three-month and six-month. Because the same set of variables are used to explain the time-series variation in yield spread for all maturities, the estimated coefficients are directly comparable across maturities. In fact, the estimated impact of stock market illiquidity for the three-month and six-month maturities more than doubles the estimated coefficients in other maturities. While similar effects are also observed for the stock market volatility and return, the difference in estimated coefficients across maturities is less dramatic.

This contrast highlights the importance of considerations over transaction costs in the asset re-allocation process and our model serves this role well. Though the model abstracts from explicitly modelling the bond maturity, it is quite intuitive that investors with really long investment horizon are less concerned about the day-to-day fluctuations in the stock market because they are better able to depreciate the transaction costs over time. The stronger impact on shorter term maturities, at least from the perspective of stock market illiquidity, is entirely consistent with the maturity effects shown by Amihud and Mendelson (1991a) who argue that the excess yield investors demand as a compensation for transaction costs should be lower for longer maturities. Beber *et al.* (2009) also show a stronger liquidity effect over shorter maturities, even though they focus on the European sovereign bond market instead of the US Treasury market. Moreover, the evidence for a maturity effect is also consistent with practitioners' observation. Fidler (1987a) had the following remark after the stock crash of 1987. "Falling shares prices on Wall Street had encouraged a flight to liquidity in the short end

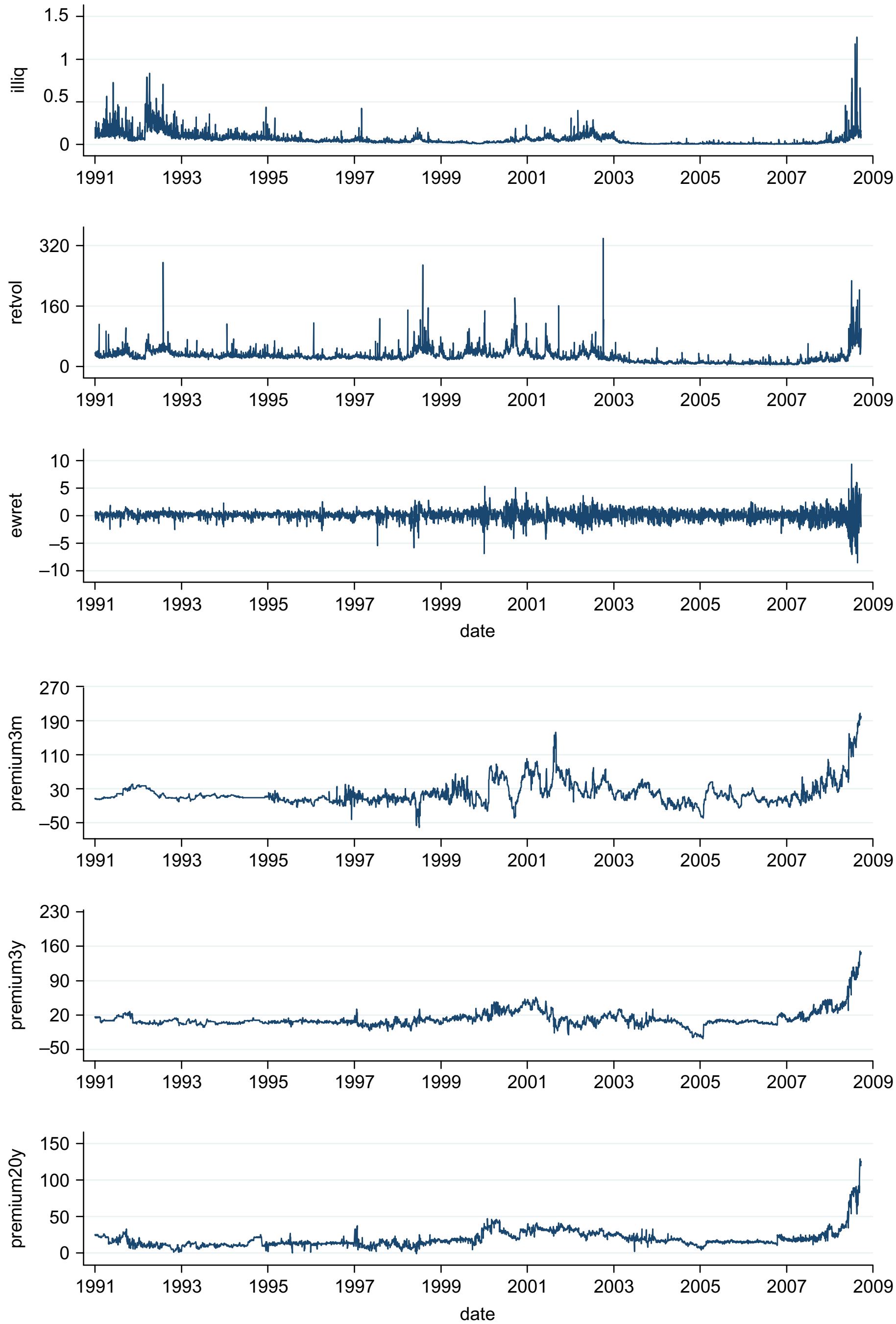

Figure 1.
Daily series of selected variables

Table II.
Determinants of bond liquidity premium with full sample

labels	premium3m		premium6m		premium1y		premium2y	
illiq	98.9779	(4.88)***	94.0548	(4.51)***	44.0428	(2.63)***	30.7246	(2.22)**
retvol	0.4423	(2.85)***	0.4677	(3.65)***	0.4988	(5.91)***	0.4093	(5.72)***
ewret	−0.9902	(−1.14)	−1.4743	(−1.74)*	−0.9256	(−1.39)	−0.7937	(−1.50)
dateid	0.0097	(5.15)***	0.0083	(5.36)***	0.0061	(4.91)***	0.0055	(4.96)***
constant	−20.3090	(−2.79)***	−20.1531	(−3.63)***	−16.8903	(−4.10)***	−14.5152	(−3.56)***
num. obs.	4,458		4,457		4,460		4,460	
adj. R^2	0.248		0.235		0.231		0.308	
labels	premium3y		premium4y		premium5y		premium7y	
illiq	41.8525	(2.68)***	47.4835	(3.16)***	40.7399	(2.94)***	52.2245	(4.34)***
retvol	0.3964	(4.51)***	0.3592	(3.98)***	0.3471	(4.34)***	0.3129	(4.05)***
ewret	−1.0060	(−2.14)**	−1.0009	(−2.22)**	−0.7922	(−1.91)*	−0.8412	(−1.84)*
dateid	0.0068	(5.15)***	0.0070	(5.26)***	0.0063	(5.11)***	0.0069	(6.21)***
constant	−16.4225	(−3.30)***	−15.7836	(−3.02)***	−13.4761	(−2.88)***	−12.3741	(−2.92)***
num. obs.	4,460		4,459		4,460		4,460	
adj. R^2	0.344		0.362		0.363		0.400	
labels	premium10y		premium20y		premium30y			
illiq	44.2437	(3.33)***	33.0272	(3.05)***	34.4782	(3.85)***		
retvol	0.2874	(3.53)***	0.2411	(4.16)***	0.0166	(0.56)		
ewret	−0.6284	(−1.98)**	−0.6656	(−2.04)**	−0.1037	(−0.32)		
dateid	0.0065	(5.64)***	0.0056	(6.87)***	0.0094	(11.37)***		
constant	−8.3875	(−1.81)*	−2.4820	(−0.79)	2.0885	(1.22)		
num. obs.	4,460		4,460		3,369			
adj. R^2	0.410		0.397		0.449			

Notes: Statistical significant at: *10, **5 and ***1 percent levels; this table reports the OLS regression results for the daily yield spread between the Refco agency bond and the Treasury bond between April 16, 1991 and December 31, 2008; the dependent variable is the yield spread (premium) of bonds with matching maturity stripped of coupons and the estimation is done separately for different maturities, ranging from three-month to 30-year; in addition to a constant, the set of explanatory variables include a time trend (dateid), average Amihud measure of illiquidity (illiq), average of squared daily returns (retvol) and average stock return (ewret); when computing the aggregated stock measures of illiquidity, volatility and return, we use only common stocks listed on NYSE, AMEX and NASDAQ with the equal-weighting scheme; the table presents the estimated coefficients, the number of observations used and adjusted R^2; the *t*-stats (inside parentheses) are based on Newey-West standard errors adjusted for heteroskedasticity and autocorrelations of the US Treasury market, pushing Treasury bill rates sharply lower. This failed to benefit longer maturity US paper." The identification of a maturity effect in this paper reinforces the case for flights to liquidity/quality due to investor heterogeneity in investment horizon without resorting to investor irrationality or behavioral attributes. In fact, it is rather difficult to reconcile the maturity pattern with a behavioral explanation.

It is worth noting that the time trend remains positive and statistically significant at the 1 percent level for all maturities. It is a partial reflection of the higher levels of yield spread as the global financial crisis unfolds in the last two years of the sample (Figure 1). As briefly explained in the methodology section, the time trend can also partially represent the time-varying risk aversion of the marginal investor.

Apart from the statistical significance, the estimated relationship implies a substantial amount of economic impact. Take the stock market illiquidity as an example. An increase of one standard deviation in the stock market illiquidity translates into an increase of 6.8 basis points in the yield spread for three-month and six-month maturities, which is quite large relative to the mean spread of 17.1 and 19.8 basis points, respectively. Even the average impact on the yield spread with maturities between one and seven years is about three basis points, or more than 23 percent of their average yield spread. Similarly, corresponding to a one standard deviation increase in the stock market volatility, the yield spread goes up by 7.7 basis points on average for all maturities lower than ten years, which represent about 54.3 percent of their average yield spread. The effect of one standard deviation decrease in the stock market return is a modest increase of 0.9 basis points on average for the seven maturities with significant estimates, or 5.8 percent of the respective average yield spread.

6. Analysis conditional on days with likely flights

Flight-to-liquidity and flight-to-quality events are not a business norm; therefore, the underlying linkage between the stock market conditions and the price impact on the bond market can be stronger in some periods than others. Though Table II demonstrates that the full data sample supports the theoretical predictions, it is useful to tie the relationship to scenarios when the occurrence of flight-to-liquidity/quality events can be reasonably inferred *ex post*. The theoretical model itself is entirely symmetric in that the relationship should hold when investors exit the stock market in favor of the bond market and vice versa. We focus only on scenarios of investors exiting the stock market in this section because Beber *et al.* (2009) document evidence of "asymmetric timing" in that investors do not face the same kind of urgency returning to the stock market as they do when exiting the stock market. In other words, the sample of daily data is better suited to detect flights to liquidity rather than flights away from liquidity.

We classify the trading days into ten deciles based on a given characteristic that proxies for the likelihood of flights to liquidity/quality and repeat the regression (9) for all trading days within the decile affiliated with the highest likelihood.

6.1 Subsample based on stock market characteristics

We start with days associated with the highest decile in terms of stock market illiquidity and the results in Table III show that stock volatility retains its positive

Table III.
Analysis on days with extremely high stock market illiquidity

labels	premium3m		premium6m		premium1y		premium2y	
illiq	43.2946	(2.96)***	25.7802	(2.56)**	18.3034	(2.44)**	7.8583	(1.05)
retvol	0.2897	(2.04)**	0.1643	(1.58)	0.2016	(2.08)**	0.2229	(2.27)**
ewret	−0.0664	(−0.04)	0.1035	(0.13)	−0.7865	(−1.21)	0.1741	(0.22)
dateid	0.0191	(3.15)***	0.0205	(5.32)***	0.0146	(3.72)***	0.0127	(3.35)***
constant	−15.1530	(−2.12)**	−9.1653	(−1.75)*	−10.9932	(−1.93)*	−10.1740	(−1.86)*
num. obs.	401		401		401		401	
adj. R^2	0.605		0.705		0.623		0.585	
labels	premium3y		premium4y		premium5y		premium7y	
illiq	12.5622	(1.36)	16.0874	(1.73)*	14.8675	(1.82)*	18.2613	(2.24)**
retvol	0.2445	(2.10)**	0.2300	(1.80)*	0.1922	(1.72)*	0.2236	(1.92)*
ewret	−0.3565	(−0.42)	−0.8240	(−0.92)	−0.2681	(−0.38)	−0.9778	(−1.14)
dateid	0.0130	(2.60)***	0.0130	(2.53)**	0.0118	(2.56)**	0.0108	(2.73)***
constant	−11.3475	(−1.67)*	−9.8017	(−1.38)	−6.8834	(−1.02)	−5.5408	(−0.83)
num. obs.	401		401		401		401	
adj. R^2	0.554		0.520		0.508		0.542	
labels	premium10y		premium20y		premium30y			
illiq	11.9236	(1.60)	4.8711	(0.77)	−1.1317	(−0.26)		
retvol	0.1762	(2.03)**	0.1184	(1.67)*	−0.0499	(−1.43)		
ewret	−0.4402	(−0.73)	−0.4986	(−0.88)	0.2359	(0.58)		
dateid	0.0126	(3.07)***	0.0110	(3.90)***	0.0074	(6.82)***		
constant	−3.1495	(−0.58)	2.5943	(0.59)	14.1745	(4.32)***		
num. obs.	401		401		366			
adj. R^2	0.596		0.630		0.543			

Notes: Statistical significant at: *10, **5 and ***1 percent levels; this table reports the OLS regression results for the daily yield spread between the Refco agency bond and the Treasury bond; the dependent variable is the yield spread (premium) of bonds with matching maturity stripped of coupons and the estimation is done separately for different maturities, ranging from three-month to 30-year; in addition to a constant, the set of explanatory variables include a time trend (dateid), average Amihud measure of illiquidity (illiq), average of squared daily returns (retvol) and average stock return (ewret); when computing the aggregated stock measures of illiquidity, volatility and return, we use only common stocks listed on NYSE, AMEX and NASDAQ with the equal-weighting scheme; the analysis focuses on days associated with the highest decile of stock market illiquidity; the table presents the estimated coefficients, the number of observations used and adjusted R^2; the *t*-stats (inside parentheses) are based on Newey-West standard errors adjusted for heteroskedasticity and autocorrelations relationship with the yield spread, being statistically significant for nine maturities. The effect of stock illiquidity is weakened as it is only significant for six maturities, compared to being significant across all 11 maturities in the full sample. This result is not entirely surprising because the date selection is already based on the magnitude of stock illiquidity. The stock market return is no longer significant for any maturity, but the positive time trend remains highly significant in all cases. Lastly, the same regression design holds better for the selected days than the full sample, because the adjusted R^2 improves in each maturity, with the improvement from the average of 0.34 to 0.58, despite the 90 percent reduction of observations.

When focusing on days with extremely high stock market volatility, Table IV shows results with similar patterns. While the dates selected based on stock market volatility relegate an insignificant role for stock volatility to explain the variation in yield spread, the influence of the stock illiquidity more than compensates the loss in influence of the stock volatility. With the only exception on the 30-year maturity, the stock illiquidity is highly significant at the 1 percent level and even increases the magnitude of estimated coefficients.

In Table V, the focus is on days with extremely low stock market returns and stock investors are likely to exit stocks in pursuit of cash or bonds during such periods. Once again, the sorting variable has no statistical significance, but all the non-sorting variables are highly significant for ten maturities other than the 30-year one.

The collective evidence in Tables III through V suggest that the model predictions do hold during periods that more likely witness flight-to-liquidity/quality events and the goodness of fit for the regression (9) also improves among the selected trading days. Nevertheless, it is useful to directly examine the predicted relationship within the context of fund flows in and out of the stock market.

6.2 Subsample based on money market fund flows

In this section we focus on days with large flows into money market funds using two different data sources. Money market funds can be considered as close substitutes to the ultra-safe Treasury securities and in times of stock market turmoil investors can turn to money market funds, many of which in turn hold Treasury securities. Therefore, the observation of large flows into money market funds is synonymous to flight-to-liquidity/quality events.

The Federal Reserve reports institutional as well as retail investments on money market mutual funds on a weekly and monthly basis[14]. We sum up the non-seasonally adjusted series for both institutional and retail investments and compute the weekly/monthly growth rate. We focus on trading days in months associated with the highest decile in terms of growth rate in money market funds and report the results of regression (9) in Table VI. The similar patterns in subsamples solely based on stock market attributes such as illiquidity, volatility and return appear in the current subsample as well. Stock illiquidity matters in a statistically significant way for all 11 maturities, once again highlighting the importance of transaction cost considerations for investors' portfolio rebalancing decisions. Stock volatility is significantly positive for ten maturities. The estimated coefficients for both the stock illiquidity and volatility variables have higher magnitude compared to the estimates in the full sample. Once again, the theoretical predictions have largely been verified here, except that the influence of stock return is subsumed by other explanatory variables.

Table IV.
Analysis on days with extremely high stock market volatility

labels	premium3m		premium6m		premium1y		premium2y	
illiq	122.6945	(4.53)***	102.1721	(3.58)***	51.2606	(3.70)***	40.5053	(3.08)***
retvol	−0.0092	(−0.09)	−0.0582	(−0.87)	0.0194	(0.62)	0.0380	(1.49)
ewret	−0.1461	(−0.15)	−0.3801	(−0.50)	0.1664	(0.29)	−0.0884	(−0.22)
dateid	0.0307	(5.17)***	0.0282	(6.86)***	0.0219	(7.23)***	0.0188	(6.69)***
constant	−42.0301	(−2.96)***	−32.9351	(−2.92)***	−21.8454	(−2.89)***	−18.9291	(−2.91)***
num. obs.	401		401		401		401	
adj. R^2	0.561		0.615		0.642		0.652	
labels	premium3y		premium4y		premium5y		premium7y	
illiq	52.6622	(4.63)***	58.6446	(5.30)***	48.8874	(4.51)***	56.0433	(5.63)***
retvol	0.0414	(1.11)	0.0078	(0.24)	0.0345	(1.05)	0.0419	(1.21)
ewret	−0.1855	(−0.40)	−0.2268	(−0.58)	−0.0680	(−0.17)	−0.5784	(−1.51)
dateid	0.0218	(5.51)***	0.0224	(5.47)***	0.0202	(5.63)***	0.0198	(5.95)***
constant	−26.5778	(−3.23)***	−26.2746	(−3.28)***	−23.6069	(−3.34)***	−23.0097	(−3.63)***
num. obs.	401		401		401		401	
adj. R^2	0.664		0.653		0.673		0.688	
labels	premium10y		premium20y		premium30y			
illiq	56.2338	(5.16)***	36.6374	(3.53)***	13.3386	(1.16)		
retvol	0.0197	(0.63)	0.0129	(0.60)	−0.0050	(−0.24)		
ewret	0.0333	(0.09)	−0.1779	(−0.65)	0.4699	(1.34)		
dateid	0.0202	(5.12)***	0.0163	(6.43)***	0.0087	(5.62)***		
constant	−21.9298	(−2.88)***	−11.6393	(−2.18)**	5.1703	(1.17)		
num. obs.	401		401		331			
adj. R^2	0.666		0.708		0.490			

Notes: Statistical significant at: *10, **5 and ***1 percent levels; this table reports the OLS regression results for the daily yield spread between the Refco agency bond and the Treasury bond; the dependent variable is the yield spread of bonds with matching maturity stripped of coupons and the estimation is done separately for different maturities, ranging from three-month to 30-year; in addition to a constant, the set of explanatory variables include a time trend (dateid), average Amihud measure of illiquidity (illiq), average of squared daily returns (retvol) and average stock return (ewret); when computing the aggregated stock measures of illiquidity, volatility and return, we use only common stocks listed on NYSE, AMEX and NASDAQ with the equal-weighting scheme; the analysis focuses on days associated with the highest decile of stock market volatility; the table presents the estimated coefficients, the number of observations used and adjusted R^2; the *t*-stats (inside parentheses) are based on Newey-West standard errors adjusted for heteroskedasticity and autocorrelations

Table V. Analysis on days with extremely low stock market return

labels	premium3m		premium6m		premium1y		premium2y	
illiq	142.7671	(2.82)***	146.4643	(2.47)**	75.7653	(2.40)**	41.8600	(1.72)*
retvol	0.8998	(1.97)**	0.9507	(2.22)**	0.9266	(3.66)***	0.7565	(4.48)***
ewret	5.5829	(0.91)	7.2784	(1.19)	6.2422	(1.51)	3.3836	(1.09)
dateid	0.0175	(3.31)***	0.0142	(3.38)***	0.0102	(3.25)***	0.0099	(3.63)***
constant	−47.9750	(−3.07)***	−38.9412	(−3.42)***	−30.2402	(−3.40)***	−30.5526	(−3.75)***
num. obs.	490		490		490		490	
adj. R^2	0.436		0.417		0.405		0.483	
labels	premium3y		premium4y		premium5y		premium7y	
illiq	58.3057	(2.54)**	78.8243	(3.67)***	57.0933	(2.79)***	74.0759	(3.63)***
retvol	0.7453	(3.24)***	0.6902	(2.66)***	0.6869	(2.90)***	0.5903	(3.18)***
ewret	2.9365	(0.74)	2.5343	(0.59)	3.1234	(0.75)	1.6593	(0.64)
dateid	0.0128	(3.73)***	0.0126	(3.50)***	0.0110	(3.34)***	0.0117	(3.81)***
constant	−37.3421	(−3.86)***	−37.0869	(−3.59)***	−30.9641	(−3.45)***	−31.3324	(−3.35)***
num. obs.	490		490		490		490	
adj. R^2	0.545		0.561		0.552		0.576	
labels	premium10y		premium20y		premium30y			
illiq	77.2966	(4.81)***	56.9455	(3.81)***	30.1025	(1.17)		
retvol	0.6252	(2.71)***	0.5044	(2.96)***	0.0696	(0.75)		
ewret	3.8601	(1.10)	3.1973	(1.15)	1.3818	(1.07)		
dateid	0.0108	(3.44)***	0.0089	(3.79)***	0.0110	(5.60)***		
constant	−24.9778	(−2.68)***	−14.1416	(−2.15)**	−0.1505	(−0.03)		
Num. obs.	490		490		324			
adj. R^2	0.577		0.563		0.417			

Notes: Statistical significant at: *10, **5 and ***1 percent levels; this table reports the OLS regression results for the daily yield spread between the Refco agency bond and the Treasury bond; the dependent variable is the yield spread (premium) of bonds with matching maturity stripped of coupons and the estimation is done separately for different maturities, ranging from three-month to 30-year; in addition to a constant, the set of explanatory variables include a time trend (dateid), average Amihud measure of illiquidity (illiq), average of squared daily returns (retvol) and average stock return (ewret); when computing the aggregated stock measures of illiquidity, volatility and return, we use only common stocks listed on NYSE, AMEX and NASDAQ with the equal-weighting scheme; the analysis focuses on days associated with the highest decile of stock market return; the table presents the estimated coefficients, the number of observations used and adjusted R^2; the *t*-stats (inside parentheses) are based on Newey-West standard errors adjusted for heteroskedasticity and autocorrelations

Table VI.
Analysis on months with extreme growth in money market funds (Fed data)

labels	premium3m		premium6m		premium1y		premium2y	
illiq	144.6781	(2.37)**	126.0404	(2.12)**	85.4396	(2.00)**	55.1558	(1.78)*
retvol	0.6361	(2.13)**	0.6237	(2.74)***	0.6036	(6.01)***	0.4731	(7.07)***
ewret	−1.0062	(−0.74)	−0.5056	(−0.43)	−0.1148	(−0.14)	−0.3188	(−0.54)
dateid	0.0167	(2.58)**	0.0103	(2.28)**	0.0074	(2.30)**	0.0065	(2.42)**
constant	−51.4072	(−2.27)**	−33.5604	(−2.41)**	−23.9662	(−2.42)**	−15.9081	(−1.76)*
num. obs.	394		394		394		394	
adj. R^2	0.469		0.459		0.498		0.498	
labels	premium3y		premium4y		premium5y		premium7y	
illiq	69.6327	(2.05)**	77.3391	(2.12)**	72.1031	(1.94)*	70.6170	(2.28)**
retvol	0.5390	(5.04)***	0.5586	(4.81)***	0.5466	(5.28)***	0.4699	(4.45)***
ewret	−0.4373	(−0.57)	−1.1815	(−1.37)	−0.3652	(−0.53)	−0.9898	(−0.97)
dateid	0.0121	(3.53)***	0.0120	(3.51)***	0.0099	(3.08)***	0.0110	(4.26)***
constant	−33.4830	(−3.00)***	−34.8910	(−3.10)***	−31.2686	(−2.96)***	−28.7699	(−3.64)***
num. obs.	394		394		394		394	
adj. R^2	0.569		0.549		0.549		0.598	
labels	premium10y		premium20y		premium30y			
illiq	79.2712	(2.16)**	57.7745	(1.82)*	51.5192	(2.09)**		
retvol	0.4833	(3.98)***	0.3546	(4.15)***	−0.0624	(−1.48)		
ewret	−0.6046	(−0.73)	−0.2110	(−0.30)	1.4767	(2.78)***		
dateid	0.0126	(4.11)***	0.0086	(4.00)***	0.0097	(4.79)***		
constant	−32.1800	(−3.30)***	−16.7064	(−2.53)**	1.1398	(0.21)		
num. obs.	394		394		207			
adj. R^2	0.585		0.552		0.563			

Notes: Statistical significant at: *10, **5 and ***1 percent levels; this table reports the OLS regression results for the daily yield spread between the Refco agency bond and the Treasury bond; the dependent variable is the yield spread (premium) of bonds with matching maturity stripped of coupons and the estimation is done separately for different maturities, ranging from three-month to 30-year; in addition to a constant, the set of explanatory variables include a time trend (dateid), average Amihud measure of illiquidity (illiq), average of squared daily returns (retvol) and average stock return (ewret); when computing the aggregated stock measures of illiquidity, volatility and return, we use only common stocks listed on NYSE, AMEX and NASDAQ with the equal-weighting scheme; the analysis focuses on days associated with the highest decile of growth in money market funds according to non-seasonally adjusted monthly time series from the Fed (including retail investors and institutional investors); the table presents the estimated coefficients, the number of observations used and adjusted R^2; the *t*-stats (inside parentheses) are based on Newey-West standard errors adjusted for heteroskedasticity and autocorrelations

We then repeat the exercise on days falling into weeks with the highest decile of growth in money market funds based on the data from the Fed. The results in Table VII are somewhat weaker than the results based on monthly growth in money market funds.

Starting in January of 1998, the Investment Company Institute (ICI) reports monthly trends in the mutual fund industry, one of which concerns the net inflows to money market funds. Based on the percentage of net inflows relative to the total net assets of money market funds (both taxable and tax-free), we identify months in the highest decile of net inflows and run the regression (9) for all trading days in these months. Table VIII shows that the effect of the stock market return is negative for all maturities and highly significant for all maturities except the 30-year one. The stock volatility variable retains the right sign and the significance at the 1 percent level for all maturities except for 30-year maturity. Even though the influence of stock illiquidity is substantially undercut by the strong competition from the stock market return, the stock illiquidity variable has the predicted sign and significance at conventional levels for six maturities.

Table IX presents the results from an exercise fairly close to Table VIII and the only difference is that we now focus on days in months associated with the highest decile of growth in total net assets of money market funds. The results are again supportive of the theoretical predictions.

6.3 Subsample based on stock mutual fund flows

Another way of taking advantage of monthly trends reported by the ICI is to build a monthly measure of buying intensity among stock funds, which is defined as new sales net of redemptions divided by total flow (new sales plus absolute redemptions) of stock funds. In this calculation we ignore net exchanges (redemption of some funds becoming new sales of other funds in the same category of stock funds) because net exchanges are broken into exchange sales and exchange redemptions only after August of 2003. Even if we were to account for exchange sales and redemptions separately, the resulting shorter series has a correlation of 0.99 with the longer series ignoring exchanges over the common period. Table X reports the results using days in months associated with the highest selling intensity of stock funds. The qualitative patterns remain the same as before.

6.4 Subsample in years 2007 and 2008

Given the still unfolding global financial crisis since 2007, there has been a prolonged exodus of investors from the stock market. According to the ICI, there are two months in 2007 and nine months in 2008 that see net outflows from stock mutual funds. The total net outflows for 2008 as a whole is $237.708 billion and this is the third time since 1984 that stock funds suffered net outflow on an annual basis, after a net outflow of $26.015 billion in 2002. Therefore, one may reasonably argue that these two years coincide with a flight-to-liquidity and flight-to-quality event of a large-scale in a sustained fashion. We run the same regression (9) over these two years and the results in Table XI are quite similar to the ones discussed earlier. Over these two years, the stock volatility is positive and significant at the 1 percent level for all 11 maturities. The stock illiquidity is not as a strong variable explaining

Table VII.
Analysis on weeks with extreme growth in money market funds (Fed data)

labels	premium3m		premium6m		premium1y		premium2y	
Illiq	86.1780	(2.13)**	85.3451	(1.68)*	46.4136	(1.15)	45.5019	(1.05)
retvol	0.2732	(2.29)**	0.3293	(1.98)**	0.3383	(2.25)**	0.2779	(1.64)
ewret	−2.7033	(−1.67)*	−2.3617	(−1.13)	−1.9277	(−1.25)	−2.5138	(−1.27)
dateid	0.0098	(3.08)***	0.0092	(2.46)**	0.0070	(2.46)**	0.0069	(2.41)**
constant	−12.7255	(−1.39)	−15.4862	(−1.64)	−12.4232	(−1.62)	−11.5008	(−1.15)
num. obs.	401		401		401		401	
adj. R^2	0.353		0.346		0.358		0.389	
labels	premium3y		premium4y		premium5y		premium7y	
illiq	47.4363	(1.29)	53.1921	(1.73)*	41.2500	(1.43)	53.2176	(1.90)*
retvol	0.2318	(1.54)	0.1684	(1.19)	0.1754	(1.27)	0.2013	(1.75)*
ewret	−2.6031	(−1.32)	−2.0591	(−1.22)	−1.6692	(−1.11)	−1.9059	(−1.20)
dateid	0.0076	(2.94)***	0.0069	(2.89)***	0.0062	(2.83)***	0.0074	(3.92)***
constant	−10.3421	(−1.22)	−9.2837	(−1.19)	−7.4499	(−1.00)	−8.2885	(−1.34)
num. obs.	401		401		401		401	
adj. R^2	0.419		0.414		0.388		0.526	
labels	premium10y		premium20y		premium30y			
illiq	40.6358	(1.72)*	35.3390	(1.37)	28.4270	(1.59)		
retvol	0.1289	(1.46)	0.1804	(1.83)*	0.0574	(1.79)*		
ewret	−1.4442	(−1.21)	−1.6668	(−1.29)	−0.0519	(−0.09)		
dateid	0.0062	(4.36)***	0.0059	(3.56)***	0.0083	(3.41)***		
constant	−2.5135	(−0.51)	−1.4310	(−0.26)	2.8785	(0.76)		
num. obs.	401		401		321			
adj. R^2	0.493		0.488		0.437			

Notes: Statistical significant at: *10, **5 and ***1 percent levels; this table reports the OLS regression results for the daily yield spread between the Refco agency bond and the Treasury bond; the dependent variable is the yield spread (premium) of bonds with matching maturity stripped of coupons and the estimation is done separately for different maturities, ranging from three-month to 30-year; in addition to a constant, the set of explanatory variables include a time trend (dateid), average Amihud measure of illiquidity (illiq), average of squared daily returns (retvol) and average stock return (ewret); when computing the aggregated stock measures of illiquidity, volatility and return, we use only common stocks listed on NYSE, AMEX and NASDAQ with the equal-weighting scheme; the analysis focuses on days associated with the highest decile of growth in money market funds according to non-seasonally adjusted weekly time series from the Fed (including retail investors and institutional investors); the table presents the estimated coefficients, the number of observations used and adjusted R^2; the *t*-stats (inside parentheses) are based on Newey-West standard errors adjusted for heteroskedasticity and autocorrelations

Table VIII. Analysis on months with extreme net inflows to money market funds (ICI data)

labels	premium3m		premium6m		premium1y		premium2y	
illiq	56.9853	(2.66)***	55.2475	(2.18)**	43.4723	(1.95)*	19.3996	(1.05)
retvol	0.9127	(7.53)***	0.9537	(9.05)***	0.7240	(6.61)***	0.6093	(8.13)***
ewret	−2.8047	(−2.09)**	−4.3765	(−3.13)***	−3.5269	(−3.89)***	−2.7351	(−4.30)***
dateid	0.0100	(1.02)	−0.0226	(−2.91)***	−0.0133	(−1.93)*	0.0106	(2.00)**
constant	−28.9998	(−0.80)	91.4780	(3.30)***	55.8053	(2.19)**	−32.5915	(−1.60)
num. obs.	231		231		231		231	
adj. R^2	0.559		0.664		0.606		0.653	
labels	premium3y		premium4y		premium5y		premium7y	
illiq	22.8773	(1.67)*	25.6490	(1.62)	21.7069	(1.86)*	19.0905	(1.14)
retvol	0.6603	(7.74)***	0.6362	(6.15)***	0.5933	(9.45)***	0.6735	(6.62)***
ewret	−2.3277	(−4.55)***	−2.3314	(−4.54)***	−1.7728	(−2.88)***	−2.3450	(−3.46)***
dateid	0.0130	(2.93)***	0.0197	(4.23)***	0.0157	(4.61)***	0.0175	(4.10)***
constant	−38.7799	(−2.61)***	−66.5758	(−4.15)***	−54.5349	(−4.97)***	−57.9852	(−4.06)***
num. obs.	231		231		231		231	
adj. R^2	0.705		0.724		0.768		0.720	
labels	premium10y		premium20y		premium30y			
illiq	24.3761	(1.94)*	14.5370	(1.06)	−24.7356	(−1.78)*		
retvol	0.5645	(5.07)***	0.4826	(8.23)***	−0.0647	(−2.88)***		
ewret	−1.1921	(−2.32)**	−1.7961	(−3.93)***	−0.3829	(−1.62)		
dateid	0.0134	(3.34)***	0.0039	(1.25)	0.3135	(15.12)***		
constant	−37.2792	(−2.80)***	1.4426	(0.14)	−785.8239	(−14.57)***		
num. obs.	231		231		82			
adj. R^2	0.658		0.659		0.769			

Notes: Statistical significant at: *10, **5 and ***1 percent levels; this table reports the OLS regression results for the daily yield spread between the Refco agency bond and the Treasury bond; the dependent variable is the yield spread (premium) of bonds with matching maturity stripped of coupons and the estimation is done separately for different maturities, ranging from three-month to 30-year; in addition to a constant, the set of explanatory variables include a time trend (dateid), average Amihud measure of illiquidity (illiq), average of squared daily returns (retvol) and average stock return (ewret); when computing the aggregated stock measures of illiquidity, volatility and return, we use only common stocks listed on NYSE, AMEX and NASDAQ with the equal-weighting scheme; the analysis focuses on days associated with the highest decile of net inflows to money market funds in percentage of total net assets according to monthly trends reported by the Investment Company Institute (ICI) since 1998; the table presents the estimated coefficients, the number of observations used and adjusted R^2; the *t*-stats (inside parentheses) are based on Newey-West standard errors adjusted for heteroskedasticity and autocorrelations

Table IX.
Analysis on months with extreme growth in TNA of money market funds (ICI data)

labels	premium3m		premium6m		premium1y		premium2y	
illiq	149.3139	(3.44)***	215.0462	(3.54)***	115.7444	(4.99)***	87.9890	(4.55)***
retvol	0.3885	(1.55)	0.3773	(1.50)	0.4947	(4.70)***	0.5069	(5.57)***
ewret	−3.3735	(−1.92)*	−4.5831	(−2.26)**	−2.5452	(−1.39)	−2.6576	(−1.96)*
dateid	0.0208	(3.27)***	0.0119	(2.03)**	0.0080	(2.07)**	0.0114	(3.98)***
constant	−65.5653	(−2.77)***	−42.4786	(−2.06)**	−28.2488	(−2.31)**	−34.8211	(−3.65)***
num. obs.	235		235		235		235	
adj. R^2	0.496		0.493		0.545		0.641	
labels	premium3y		premium4y		premium5y		premium7y	
illiq	46.7483	(2.17)**	47.5609	(2.19)**	54.8690	(3.06)***	71.9007	(2.23)**
retvol	0.4864	(5.07)***	0.4729	(4.17)***	0.4462	(4.59)***	0.4182	(3.16)***
ewret	−1.6869	(−1.67)*	−1.7556	(−2.04)**	−1.8565	(−1.86)*	−1.1764	(−1.15)
dateid	0.0159	(5.18)***	0.0134	(4.27)***	0.0103	(3.61)***	0.0133	(4.24)***
constant	−47.4709	(−4.41)***	−40.9660	(−3.49)***	−32.6961	(−3.18)***	−37.6880	(−3.37)***
num. obs.	235		235		235		235	
adj. R^2	0.640		0.620		0.630		0.651	
labels	premium10y		premium20y		premium30y			
illiq	43.6150	(2.04)**	70.0692	(3.72)***	26.8317	(1.07)		
retvol	0.3308	(3.39)***	0.2912	(3.20)***	0.0227	(0.34)		
ewret	−0.3324	(−0.53)	−1.3211	(−1.32)	0.8823	(1.96)*		
dateid	0.0131	(5.01)***	0.0106	(4.46)***	0.0215	(5.46)***		
constant	−34.1908	(−3.64)***	−25.3246	(−2.97)***	−30.2609	(−3.04)***		
num. obs.	235		235		124			
adj. R^2	0.651		0.671		0.726			

Notes: Statistical significant at: *10, **5 and ***1 percent levels; this table reports the OLS regression results for the daily yield spread between the Refco agency bond and the Treasury bond; the dependent variable is the yield spread (premium) of bonds with matching maturity stripped of coupons and the estimation is done separately for different maturities, ranging from three-month to 30-year; in addition to a constant, the set of explanatory variables include a time trend (dateid), average Amihud measure of illiquidity (illiq), average of squared daily returns (retvol) and average stock return (ewret); when computing the aggregated stock measures of illiquidity, volatility and return, we use only common stocks listed on NYSE, AMEX and NASDAQ with the equal-weighting scheme; the analysis focuses on days associated with the highest decile of monthly growth rate in total net assets of money market funds (both tax-free and taxable funds) according to the monthly trends reported by the Investment Company Institute (ICI) since 1998; the table presents the estimated coefficients, the number of observations used and adjusted R^2; the *t*-stats (inside parentheses) are based on Newey-West standard errors adjusted for heteroskedasticity and autocorrelations

Table X. Analysis on months with extreme stock funds selling intensity (ICI data)

labels	premium3m		premium6m		premium1y		premium2y	
illiq	56.0181	(1.84)*	53.8642	(1.74)*	37.5962	(1.49)	21.6861	(1.15)
retvol	0.7636	(6.17)***	0.7219	(5.21)***	0.5398	(4.84)***	0.4834	(5.99)***
ewret	−1.1089	(−1.11)	−1.8120	(−1.54)	−1.2773	(−1.54)	−1.1414	(−1.79)*
dateid	0.0294	(3.14)***	0.0182	(2.15)**	0.0183	(1.80)*	0.0244	(3.22)***
constant	−80.7826	(−2.75)***	−42.9362	(−1.79)*	−48.7415	(−1.32)	−76.5410	(−2.71)***
num. obs.	311		311		311		311	
adj. R^2	0.576		0.519		0.442		0.602	
labels	premium3y		premium4y		premium5y		premium7y	
Illiq	28.1688	(1.42)	37.3679	(1.67)*	30.3411	(1.39)	31.5432	(1.69)*
retvol	0.5426	(6.16)***	0.5612	(5.61)***	0.5195	(6.07)***	0.4203	(4.89)***
ewret	−0.8395	(−1.42)	−0.9347	(−1.68)*	−0.5916	(−1.01)	−0.8180	(−1.61)
dateid	0.0269	(3.76)***	0.0252	(4.19)***	0.0237	(3.90)***	0.0240	(4.33)***
constant	−81.4906	(−3.29)***	−76.2418	(−4.02)***	−72.0120	(−3.68)***	−64.2196	(−3.73)***
num. obs.	311		311		311		311	
adj. R^2	0.657		0.632		0.639		0.636	
labels	premium10y		premium20y		premium30y			
Illiq	39.0186	(1.87)*	28.4442	(1.51)	−16.4540	(−1.40)		
retvol	0.5050	(5.25)***	0.3681	(5.82)***	0.0060	(0.17)		
ewret	−0.4671	(−0.92)	−0.8263	(−1.91)*	−0.2261	(−1.35)		
dateid	0.0168	(3.02)***	0.0133	(3.38)***	0.0267	(5.66)***		
constant	−43.5344	(−2.76)***	−25.7778	(−2.70)***	−37.2940	(−2.87)***		
num. obs.	311		311		139			
adj. R^2	0.561		0.578		0.587			

Notes: Statistical significant at: *10, **5 and ***1 percent levels; this table reports the OLS regression results for the daily yield spread between the Refco agency bond and the Treasury bond; the dependent variable is the yield spread (premium) of bonds with matching maturity stripped of coupons and the estimation is done separately for different maturities, ranging from three-month to 30-year; in addition to a constant, the set of explanatory variables include a time trend (dateid), average Amihud measure of illiquidity (illiq), average of squared daily returns (retvol) and average stock return (ewret); when computing the aggregated stock measures of illiquidity, volatility and return, we use only common stocks listed on NYSE, AMEX and NASDAQ with the equal-weighting scheme; the analysis is focuses on days associated with the lowest decile of monthly net buying intensity of stock mutual funds (new sales net of redemptions divided by the total flow) according to the monthly trends reported by the Investment Company Institute (ICI) since 1998; the table presents the estimated coefficients, the number of observations used and adjusted R^2; the t -stats (inside parentheses) are based on Newey-West standard errors adjusted for heteroskedasticity and autocorrelations

Table XI.
Analysis in years 2007 and 2008

labels	premium3m		premium6m		premium1y		premium2y	
Illiq	46.6717	(2.12)**	43.1361	(1.96)*	39.4361	(1.90)*	25.5172	(1.38)
retvol	0.5786	(5.67)***	0.4671	(5.85)***	0.3795	(6.16)***	0.4275	(5.12)***
ewret	0.0250	(0.03)	−0.2997	(−0.33)	−0.4453	(−0.63)	−0.5715	(−0.92)
dateid	0.1962	(4.87)***	0.1844	(5.00)***	0.1343	(4.35)***	0.0831	(3.16)***
constant	−797.5369	(−4.82)***	−752.3577	(−4.92)***	−546.9684	(−4.27)***	−331.2904	(−3.08)***
num. obs.	504		504		504		504	
adj.R^2	0.791		0.780		0.768		0.743	
labels	premium3y		premium4y		premium5y		premium7y	
illiq	27.6482	(1.59)	35.6030	(1.73)*	32.7334	(1.54)	29.7364	(1.78)*
retvol	0.4254	(5.58)***	0.4615	(5.62)***	0.4229	(6.29)***	0.3849	(4.85)***
ewret	−0.2710	(−0.57)	−0.3647	(−0.74)	−0.0299	(−0.06)	−0.5035	(−1.13)
dateid	0.1119	(3.80)***	0.0947	(2.88)***	0.0865	(2.72)***	0.0957	(3.62)***
constant	−446.1748	(−3.69)***	−375.5237	(−2.77)***	−342.4890	(−2.60)***	−377.3136	(−3.46)***
num.obs.	504		504		504		504	
adj.R^2	0.781		0.718		0.688		0.754	
labels	premium10y		premium20y					
illiq	36.1895	(1.83)*	25.0193	(1.46)				
retvol	0.4794	(4.75)***	0.3413	(5.61)***				
ewret	−0.1730	(−0.37)	−0.4689	(−1.12)				
dateid	0.0575	(1.72)*	0.0637	(2.60)***				
constant	−221.4971	(−1.62)	−246.0883	(−2.45)**				
num.obs.	504		504					
adj.R^2	0.640		0.703					

Notes: Statistical significant at: *10, **5 and ***1 percent levels; this table reports the OLS regression results for the daily yield spread between the Refco agency bond and the Treasury bond; the dependent variable is the yield spread (premium) of bonds with matching maturity stripped of coupons and the estimation is done separately for different maturities, ranging from three-month to 20-year; in addition to a constant, the set of explanatory variables include a time trend (dateid), average Amihud measure of illiquidity (illiq), average of squared daily returns (retvol) and average stock return (ewret); when computing the aggregated stock measures of illiquidity, volatility and return, we use only common stocks listed on NYSE, AMEX and NASDAQ with the equal-weighting scheme; the analysis focuses on all trading days in years 2007 and 2008; the yield series for the Refco agency bond with 30-year maturity ceased on September 2, 2004, so we exclude the yield spread with 30-year maturity from this analysis; the table presents the estimated coefficients, the number of observations used and adjusted R^2; the *t*-stats (inside parentheses) are based on Newey-West standard errors adjusted for heteroskedasticity and autocorrelations the variation in yield spread as other methods of classifying subsamples. Nevertheless, the goodness of fit in this subsample is the highest among all designs.

7. Conclusion

In this paper, we build a one-period model to illustrate the intuition that the heterogeneity in investment horizon can contribute to the flight-to-liquidity and the flight-to-quality events. When the stock market deteriorates (with lower liquidity, higher volatility, or lower return), the existing marginal investor would prefer bonds to stocks instead of being indifferent between the two asset choices. There will be just enough stock investors moving into the bond market leading to a reduction of bond yield exactly offsetting the stock disadvantage. At the new equilibrium, there is a larger fraction of bond ownership and a higher average investment horizon among stock investors.

The finding that the investment horizon of the marginal investor (and thus the equilibrium fraction of bond ownership) can change under different market conditions contributes to the theoretical and empirical debate on whether transaction costs matter. Moreover, we directly model the price impact in the bond market in relation to changes in the stock market condition. Because of the collective move of many investors who choose to rebalance their portfolios in the same direction at the same time, the asset valuation has to change, sometimes dramatically, to reflect the supply and demand gap. Therefore, it is beneficial for investors to incorporate the price impact in the bond market as realistic costs for executing their portfolio rebalancing decisions. Even those investors who shift wealth from stocks to money market funds are not immune from this fallout as they would own Treasury securities indirectly through money market funds.

We use the yield spread between the Refcorp agency bond and Treasury bond of matching maturities as a natural proxy for the price impact in the bond market and find empirical evidence in strong support of the theoretical predictions. Days with high stock illiquidity, high stock volatility and low stock return are associated with high yield spread for the Refcorp bond. This contemporaneous linkage between the stock market and the bond market is even stronger during periods with strong net outflows from stock mutual funds and strong net inflows to money market funds.

The identification of a maturity effect in this paper constitutes another contribution to the literature. That is, the influence of stock market development on the flight to liquidity premium in the bond market is the strongest on the Treasury bonds with short maturities. It is quite natural that investors with longer investment horizon are less concerned about the day-to-day fluctuations in the stock market because they are better able to depreciate the transaction costs over time. This result confirms the model's predictions that investors with different investment horizons have different sensitivities to relative changes in transaction costs and that only a subset of investors with an investment horizon sandwiched between the old and new equilibrium outcomes would reallocate their wealth across the stock versus the bond market. This finding is entirely consistent with the maturity effects in Amihud and Mendelson (1991a), who argue that the excess yield investors demand as a compensation for transaction costs should be lower for longer maturities.

The flow evidence conditional on days with likely flights strengthens our understanding of the asset pricing implications of portfolio rebalancing decisions and the maturity pattern bolsters the case for flights to liquidity/quality due to heterogeneity in investment horizon without resorting to investor irrationality or behavioral attributes. In fact, it is arguably difficult to reconcile the maturity pattern with a behavioral explanation.

Notes

1. Amihud and Mendelson (1986) show in a theoretical model that the expected stock return should be an increasing function of spread. Brennan and Subrahmanyam (1996) report evidence for a positive relationship between required stock return and measures of illiquidity. Jones (2001) and Amihud (2002) demonstrate that stock liquidity predicts the expected stock return. Some authors promote the stock market liquidity risk as a pricing factor (Amihud, 2002; Pástor and Stambaugh, 2003; Acharya and Pedersen, 2005).
2. The popular press partially attributed the Long Term Capital Management (LTCM) failure to its engagement in so-called convergence trades. Newly issued Treasury bonds (on-the-run bonds) are often more liquid than older existing Treasury bonds (off-the-run bonds), so it seemed profitable to short the bonds on-the-run and buy the bonds off-the-run to reap the yield difference assuming that the difference will converge to zero by the next cycle of new issues. Following the Russia default in 1998, however, the spread actually widened as a result of surging public interest in government bonds, leading to substantial losses for LTCM.
3. At the peak of the LTCM debacle in 1998, traders at LTCM found it nearly impossible to unwind their positions. It seemed suddenly almost all the market participants preferred the most liquid asset to the less liquid ones even though the underlying credit risk had not changed. See Lowenstein (2000) for an easy-to-read coverage on the failure of the LTCM.
4. The Refcorp bond is issued by the government agency Resolution Funding Corporation (Refcorp). This agency was established by the Financial Institutions Reform, Recovery and Enforcement Act in 1989. Refer to Longstaff (2004) for the institutional details of this bond.
5. There is also a growing literature related to repo specialness in the context of Treasury bonds. Krishnamurthy (2002) builds on Duffie's (1996) theory of repo specialness and links the specialness premium to the yield spread between on-the-run and off-the-run Treasury bonds. More recently, Vayanos and Weill (2008) model liquidity as well as specialness endogenously by highlighting the role of short sellers. They find that facing search externalities short sellers can endogenously concentrate on one of two assets with identical cash flows, leading to different prices for these assets. On the empirical side, Krishnamurthy (2002) shows that the yield spread net of specialness is essentially zero for 30-year Treasury bond. On the contrary, Jordan and Jordan (1997) and Goldreich *et al.* (2005) show that the specialness premium is fairly small compared to the yield spread. Longstaff (2004) also makes the case that the specialness premium is negligible relative to the yield spread between Refcorp agency bond and Treasury bond.
6. We have not directly examined the flows in the Treasury bond market in this paper mainly due to the lack of access to the GovPX dataset, which would otherwise make it possible.
7. To the best of our knowledge, the news article by Vartan (1974) on *New York Times* had the earliest reference to "flight to quality"and Gramlich (1976) was the first one commenting "flight to quality" among academic journal articles. Note that Gramlich attributed this term to Treasury Secretary William E. Simon on a statement made on September 24, 1975. Also see Vartan (1975a, 1982), Phalon (1975) or Millham (1982) who indicated market participants as the originator of this and other similar phrases.
8. About one month earlier than Sloane (1987) and Holberton (1987) had described "flight to liquidity" as a "post-equity market slump reaction" and this was the earliest reference to the term "flight to liquidity" that we could find in news media.

9. Amihud and Mendelson (1991a) and Kamara (1994) study the yield spread between Treasury notes and bills. Krishnamurthy (2002) and Goldreich *et al.* (2005) study the yield spread between on-the-run and off-the-run Treasury bonds.
10. We use the mean-variance utility function here for modeling convenience. It has been shown that the mean-variance utility function is equivalent to a negative exponential utility function with normally distributed wealth (Sargent, 1987).
11. Note that Longstaff (2004) uses monthly data to study the relationship between the same yield spread and a set of variables intended for measuring the investor sentiment.
12. Another well-known proxy for the bond market price impact is the spread between on-the-run and off-the-run Treasury bonds. See Krishnamurthy (2002) and Goldreich *et al.* (2005) for detailed analysis of this spread. Amihud and Mendelson (1991) and Kamara (1994), among others, also study the liquidity effects on the yield spread between Treasury securities that are otherwise identical.
13. We only provide a few examples here. Amihud (2002) uses the dollar volume weighted absolute stock return as a measure of illiquidity and Pástor and Stambaugh (2003) use a regression-based liquidity measure reflecting the notion that for very liquid stocks order flow induces small return reversals. On the camp of finer liquidity measures using the transaction data, there are many proposals with different emphasis, including the bid-ask spread (Amihud and Mendelson, 1986), the amortized effective bid-ask spread (Chalmers and Kadlec, 1998), the measures involving the practice of signing volumes (Foster and Viswanathan, 1993 and Brennan and Subrahmanyam, 1996), the probability of information based trading (Easley *et al.*, 1996), and the order imbalance defined as the difference between the total number of buyer-initiated trades and the total number of seller-initiated trades (Blume *et al.*, 1989; Lauterbach and Ben-Zion, 1993; Chan and Fong, 2000; Hasbrouck and Seppi, 2001; Chordia *et al.*, 2002). Measures of transaction level bond liquidity have been used in Fleming (2003) and Chordia *et al.* (2005), but the GovPX data used in these two studies are not widely available for extended periods.
14. Though the Investment Company Institute (ICI) is the source of the Federal Reserve data in this regard, the ICI does not make available on its website the entire historical series. Also note that the weekly series by the Fed ends every Monday and the weekly series by the ICI ends every Wednesday.

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Corresponding author

Qin Lei can be contacted at: leiq@umich.edu