

Strategic Order Flow in the On-The-Run and Off-The-Run Bond Markets

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September 19, 2006

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Abstract

We study the determinants of liquidity and price differentials between on-the-run and off-the-run U.S. Treasury bond markets. To guide our analysis, we develop a parsimonious model of multi-asset speculative trading in which endowment shocks separate the on-the-run security from an otherwise identical off-the-run security. We then explore the equilibrium implications of these shocks on both off/on-the-run price and liquidity differentials in the presence of two realistic market frictions — information heterogeneity and imperfect competition among informed traders — and a public signal. We test these implications by analyzing daily differences in market liquidity and yields for on-the-run and off-the-run three-month, six-month, and one-year U.S. Treasury bills and two-year, five-year, and ten-year U.S. Treasury notes. Our evidence suggests that *i*) off/on-the-run bid-ask spread differentials are economically and statistically significant, even after controlling for differences in several of the bonds' intrinsic characteristics (such as duration, convexity, or repo rates); *ii*) their corresponding yield differentials are neither, inconsistent with the illiquidity premium hypothesis; and *iii*) off/on-the-run liquidity differentials are larger for bonds of shorter maturity, immediately following bond auction dates, when the uncertainty surrounding the ensuing auction allocations is high, when the dispersion of beliefs across informed traders is high, and when macroeconomic announcements are noisy, consistent with our stylized model.

JEL classification: E44; G14

Keywords: Treasury Bond Markets; Strategic Trading; Market Microstructure; Liquidity; Order Flow; On-The-Run Bonds; Off-The-Run Bonds; Macroeconomic News Announcements; Expectations; Dispersion of Beliefs

1 Introduction

The *on-the-run phenomenon* refers to the stylized fact that, in fixed income markets, securities with nearly identical cash flows trade at different yields and with different liquidity. In particular, most recently issued (i.e., *on-the-run*, *new*, or *benchmark*) government bonds of a certain maturity are generally more expensive and liquid than previously issued (i.e., *off-the-run* or *old*) bonds maturing on similar dates.

Ample evidence of this phenomenon has been reported both in the U.S. Treasury market (e.g., Amihud and Mendelson, 1991; Kamara, 1994; Furfine and Remolona, 2002; Krishnamurthy, 2002; Strebulaev, 2002; Fleming, 2003; Goldreich et al., 2005) and in other countries (e.g., for Japan, Mason, 1987; Boudouck and Whitelaw, 1991, 1993). Accordingly, several explanations have also been provided by practitioners and academics. The most popular one attributes the on-the-run yield phenomenon to liquidity — the extent to which an asset can be traded cheaply, quickly, and with limited price impact. The illiquidity premium hypothesis of Amihud and Mendelson (1986) states that since investors value liquidity, more liquid securities should trade at a premium over otherwise similar, yet less liquid ones. Most existing literature concentrates on testing this prediction. Early studies find support for it (e.g., Amihud and Mendelson, 1991; Warga, 1992; Kamara, 1994). However, more recent research suggests that, even in the presence of off/on-the-run liquidity differentials, the corresponding yield differentials may be explained away by such considerations as differing tax treatments (Strebulaev, 2002), specialness in the repo markets (i.e., the cost of shorting, as in Duffie, 1996; Krishnamurthy, 2002), search costs (Vayanos and Weill, 2005), or the value of future liquidity (Goldreich et al., 2005).

In spite of this debate on the relative importance of liquidity as a factor driving off/on-the-run price differentials, there is little or no disagreement in the literature that off/on-the-run liquidity differentials in fixed income markets are both economically and statistically relevant. Nonetheless, we are aware of no theoretical and empirical study of the determinants of those liquidity differentials.¹ Performing such analysis is the objective of this paper.² To that purpose, we develop a parsimonious model of multi-asset trading. This model — in the spirit of Kyle

¹Amihud and Mendelson (1991) and Vayanos and Weill (2005) report anecdotal evidence that off-the-run bonds are in smaller effective supply — hence less liquid — because they become locked away in institutional investors' portfolios. Yet, since the econometrician does not observe when the off-the-run bonds become unavailable, their explanation cannot be empirically tested.

²A related literature studies price discrepancies among substantially identical securities or portfolios (e.g., Lee, Schleifer, and Thaler, 1990, 1991; Daves and Ehrhardt, 1993; Bodurtha, Kim, and Lee, 1995; Froot and Dabora, 1999; Grinblatt and Longstaff, 2000). Many of these papers use liquidity differentials to explain observed mispricings, yet none examines directly the determinants of those differentials.

(1985), Foster and Viswanathan (1996), and Pasquariello and Vega (2006) — builds upon two realistic market frictions: information heterogeneity and imperfect competition among informed traders (henceforth, speculators). In this basic setting, more diverse information among speculators makes their trading activity more cautious and market-makers more vulnerable to adverse selection, thus leading to lower equilibrium market liquidity. Pasquariello and Vega (2006) find strong empirical support for the main implications of this model in the U.S. Treasury market.³

By design, we use this setting to identify a novel mechanism explaining the on-the-run phenomenon, rather than comprehensively allowing for the several alternative explanations mentioned above. Specifically, we explore the role of government auctions in discriminating among two asset types of identical terminal payoff — off-the-run and on-the-run bonds — since by definition the latter are those most recently auctioned to sophisticated traders. In addition, although the total amount sold by the government is known to all market participants, the individual allocations may not. We capture these features of government bond markets by further assuming that each speculator receives a privately observed endowment in the latter asset type and cares about the interim as well as the liquidation value of his portfolio.

In this amended setting, we show that *i*) equilibrium market liquidity in the on-the-run asset is greater than in the off-the-run asset, the more so the greater the uncertainty about endowment shocks. Intuitively, speculators deviate from their informationally optimal trading strategies in the on-the-run asset to distort its interim price in the direction of their endowments. In these circumstances, uninformed market-makers perceive the threat of adverse selection in that asset as less serious, hence making its market more liquid. As interestingly, the equilibrium off/on-the-run liquidity spread is sensitive to the information environment in which trading takes place. In particular, we find that *ii*) such spread is generally lower the more correlated is speculators' private fundamental information, for that attenuates their incentives to trade cautiously with it in both markets yet alleviates adverse selection the most where the latter is most severe (i.e., in the off-the-run market). Consistently, we also show that *iii*) the equilibrium off/on-the-run price spread is driven exclusively by noise trading and endowment shocks but that, *ceteris paribus*, *iv*) both price and liquidity spreads are decreased by the availability of public fundamental news — a trade-free source of information — reducing the adverse selection risk for the market-makers, the more so the greater that signal's precision.

The contribution of the model is twofold. Other papers have studied the properties of a financial market in which strategic traders receive privately observable endowment shocks, most

³Consistently, Sadka and Scherbina (2006) find a positive relationship between analyst disagreement and both the permanent price impact of trades and the effective percentage bid-ask spread in the U.S. equity market.

notably Bhattacharyya and Nanda (1999) and Vayanos (1999, 2001). Yet, to our knowledge, our model is the first to relate the on-the-run phenomenon to auction-driven endowment shocks. Furthermore, our model is the first to generate explicit and empirically testable implications on the impact of both the heterogeneity of private signals and the presence and quality of public signals on the nature of that relationship.

Our empirical results strongly support the main implications of our model. We start by providing evidence of a systematic decoupling of the on-the-run liquidity phenomenon from the on-the-run yield phenomenon in the U.S. Treasury market. Specifically, we show that off/on-the-run bid-ask spread differentials for three-month, six-month, and one-year Treasury bills, and two-year, five-year, and ten-year Treasury notes are positive, economically significant — averaging more than half of the corresponding mean off-the-run spread — and cannot be explained by differences in such fundamental characteristics of the underlying securities as modified duration and convexity. Off/on-the-run yield differentials are instead neither uniformly positive nor uniformly significant, inconsistent with the illiquidity premium hypothesis.⁴

Our analysis suggests that those off/on-the-run liquidity differentials are affected by uncertainty about speculators' endowments in the on-the-run securities, consistent with our model. For instance, we find that those differentials are greater for bills than notes, as well as increasing in the notes' maturity, for speculators are likely to be less sensitive to fluctuations in the interim value of portfolios of the latter. In addition, we show that in the days immediately following Treasury “new bond” auctions — when on-the-run endowment uncertainty is arguably the highest — off/on-the-run bid-ask spread differentials decline, often significantly so, while the corresponding yield differentials either widen or are unchanged, even after controlling for relative duration, convexity, repo specialness, and supply effects. Accordingly, we also find that off/on-the-run liquidity differentials are positively related to the competitive yield range (high minus low divided by average auction bid yield), a more direct proxy for auction-driven endowment uncertainty.

Further investigation reveals that the magnitude and dynamics of these spread differentials are also crucially related to the informational role of trading in the U.S. Treasury market, again consistent with our model. In particular, we find that off/on-the-run liquidity differentials are positively related to perceived, market-wide uncertainty surrounding U.S. monetary policy — measured by Eurodollar implied volatility — and to the degree of information heterogeneity about

⁴Accordingly, Krishnamurthy (2002) shows that yield differentials between old and new thirty-year Treasury bonds are too small to make convergence trades profitable when accounting for the corresponding repo rate differentials; Strebulaev (2002) finds no significant price difference between Treasury notes maturing on the same day.

U.S. macroeconomic fundamentals among market participants — measured by the standard deviation of professional forecasts of macroeconomic news releases (as in Pasquariello and Vega, 2006) — albeit more weakly so. Correspondingly, we show that the availability of macroeconomic news — a trade-free source of information about assets’ payoffs attenuating adverse selection among market participants — lowers both off/on-the-run yield and spread differentials, the more so when those signals are less noisy and/or when speculators’ private information is more heterogeneous.

We proceed as follows. In Section 2, we construct a stylized model of trading to guide our empirical analysis. In Section 3, we describe the data. In Section 4, we present the empirical results. We conclude in Section 5.

2 A Model of the On-The-Run Phenomenon

In this section we motivate our investigation of the process of price formation in on-the-run and off-the-run Treasury bond markets. We do so by studying the impact of endowment shocks on the informational role of trading in the presence of dispersion of beliefs among sophisticated market participants and macroeconomic news. Specifically, we first describe a parsimonious model of trading in both securities in the spirit of Foster and Viswanathan (1996) and Pasquariello and Vega (2006), and derive a closed-form solution for the equilibrium depth differential between the two markets. Then, we enrich the model by introducing a public signal and consider its implications for the market equilibrium. We test for the empirical relevance and economic significance of our argument in the next section. All proofs are in the Appendix unless otherwise noted.

2.1 The Basic Model

The basic model is a three-date, two-period economy in which two identical risky assets ($i = 1, 2$) are exchanged. Trading occurs only at the end of the first period ($t = 1$). At the end of the second period ($t = 2$), the identical payoff of the risky assets — a normally distributed random variable v with mean p_0 and variance σ_v^2 — is realized. The economy is populated by three types of risk-neutral traders: a discrete number (M) of informed traders (that we label speculators), liquidity traders, and perfectly competitive market-makers (MMs) in each asset i . All traders know the structure of the economy and the decision process leading to order flow and prices. At time $t = 0$ there is no information asymmetry about v , and the price of both risky assets is p_0 .

In fixed income markets, just-issued, on-the-run government bonds (e.g., asset 2) routinely trade at different prices and with different liquidity than previously issued, off-the-run bonds

with (almost) identical cash flows (e.g., asset 1). In this section, we propose a theory of this puzzling phenomenon which focuses on the crucial role of government auctions in discriminating among these assets. Indeed, by definition, on-the-run bonds are so by having been most recently auctioned to sophisticated traders in a primary market. Interestingly, although the total amount sold by the government is known to all market participants, the individual allocations may not. We capture this feature of government bond markets by assuming that, at time $t = 0$, each speculator k receives an initial endowment of risky asset 2 whose magnitude e_{k2} — a normally distributed random variable with mean zero and variance σ_e^2 — is known exclusively to him. Because of this assumption, we label asset 2 the on-the-run security in our setting. For simplicity, we also assume that each endowment is unrelated to any other ($\text{cov}(e_{k2}, e_{j2}) = 0$) and uninformative about v ($\text{cov}(e_{k2}, v) = 0$), hence so is each speculator's initial wealth $W_{0k} = e_{k2}p_0$.⁵

Sometime between $t = 0$ and $t = 1$, each speculator k also receives a private and noisy signal of v , S_{vk} . We assume that each signal S_{vk} is drawn from a normal distribution with mean p_0 and variance σ_s^2 and that, for any two S_{vk} and S_{vj} , $\text{cov}(v, S_{vk}) = \text{cov}(S_{vk}, S_{vj}) = \sigma_v^2$ and $\text{cov}(e_{k2}, S_{vk}) = \text{cov}(e_{k2}, S_{vj}) = 0$. These assumptions imply that $E(v|S_{vk}) - p_0 = \delta_{vk} = \rho(S_{vk} - p_0)$, where $\rho = \frac{\sigma_v^2}{\sigma_s^2}$ is the correlation between any two information endowments δ_{vk} and δ_{vj} . We parametrize the degree of diversity among speculators' signals by imposing that $\sigma_s^2 = \frac{\sigma_v^2}{\rho}$ and $\rho \in (0, 1]$. If $\rho = 1$, speculators' private information is *homogeneous*, i.e., all speculators receive the same signal $S_{vk} = S_v$. If $\rho < 1$, speculators' information is *heterogeneous*, i.e., less than perfectly correlated, the more so the lower is ρ .

2.1.1 Market Participants and Trading

At time $t = 1$, both speculators and liquidity traders submit their orders in assets 1 and 2 to the MMs, before these assets' equilibrium prices p_{11} and p_{12} have been set. We define the market order of speculator k in asset i to be x_{ki} . Liquidity traders generate random, normally distributed demands z_1 and z_2 , with mean zero and variance σ_z^2 . For simplicity, we assume that z_1 and z_2 are identical ($z_1 = z_2 = z$) and independent from all other random variables. By the same token, we also impose that MMs in each asset i do not receive any information about its terminal payoff v , but observe only that asset's aggregate order flow $\omega_{1i} = \sum_{k=1}^M x_{ki} + z$ from all market participants before setting the market-clearing price $p_{1i} = p_{1i}(\omega_{1i})$, as in Subrahmanyam (1991). This latter assumption can be relaxed to allow for the MMs to observe the aggregate

⁵Vayanos (2001) studies the strategic trading activity of a risk-averse speculator endowed with a privately observed inventory but no private information about payoffs. Similar, yet more involved results ensue if $\text{cov}(e_{k2}, v) \neq 0$.

order flow for *all* securities (as in Pasquariello, 2003) if their terminal payoffs are similar yet not identical. The ensuing setting, albeit more complex, yields similar equilibrium implications.

In Kyle (1985) and Pasquariello and Vega (2006), speculators are risk-neutral, hence indifferent to their intermediate wealth and endowment of risky assets. However, we intend to explore the impact of specific endowment shocks on the process of price formation of otherwise identical assets. To that purpose, we further assume that our speculators, albeit risk-neutral, care about the interim as well as the terminal value of their portfolios. Specifically, we assume that each speculator's optimal demands x_{k1} and x_{k2} maximize the expected value of the following separable utility function U_k of his wealth at $t = 1$ and $t = 2$:

$$U_k = \gamma W_{1k} + (1 - \gamma) W_{2k}, \quad (1)$$

where $\gamma \in [0, 1]$, $W_{1k} = W_{0k} + e_{k2}(p_{12} - p_0)$, and $W_{2k} = W_{0k} + e_{k2}(v - p_0) + x_{k1}(v - p_{11}) + x_{k2}(v - p_{12})$. W_{1k} is known at the end of the first period, after the MMs set p_{11} and p_{12} , while W_{2k} is known at the end of the second period, after v is realized. We interpret the ratio $\frac{\gamma}{1-\gamma}$ as their intertemporal marginal rate of substitution between short and long-term wealth. If $\gamma = 0$, each speculator k reduces to a (long-term) profit-maximizing trader, as in Kyle (1985) and Pasquariello and Vega (2006). If $\gamma > 0$, his expected utility at $t = 1$, before trading occurs, is given by

$$\begin{aligned} E_1^k(U_k) &= W_{0k} + \gamma e_{k2} [E_1^k(p_{12}) - p_0] + (1 - \gamma) \{ e_{k2} [E_1^k(v) - p_0] \\ &\quad + x_{k1} [E_1^k(v) - E_1^k(p_{11})] + x_{k2} [E_1^k(v) - E_1^k(p_{12})] \}. \end{aligned} \quad (2)$$

At both dates $t = 1$ and $t = 2$ the change in wealth with respect to W_{0k} depends on two components: the change in value of the existing endowment of asset 2 and the profits from trading in both assets 1 and 2 at $t = 1$. However, because the MMs set p_{11} and p_{12} after having observed the order flow, the value of the net position accumulated at $t = 1$ is equal to zero in W_{1k} . This objective function, introduced by Bhattacharya and Nanda (1999) in a single-security framework, can be motivated by wealth constraints, solvency issues, agency and reputation problems, or cash redemptions and injections affecting the interim life of sophisticated market participants such as (open-end) mutual funds.

2.1.2 Equilibrium

Consistently with Kyle (1985), we define a Bayesian Nash equilibrium as a set of $2(M + 1)$ functions $x_{1i}(\cdot), \dots, x_{Mi}(\cdot)$, and $p_{1i}(\cdot)$ such that the following two conditions hold:

1. *Profit maximization*: $x_{ki}(\delta_{vk}, e_{k2}) = \arg \max E_1^k(U_k)$;

2. *Semi-strong market efficiency*: $p_{1i} = E(v|\omega_{1i})$.

We restrict our attention to linear equilibria. We first conjecture general linear functions for the pricing rule and speculators' demands. We then solve for their parameters satisfying conditions 1 and 2. Finally, we show that these parameters and those functions represent a rational expectations equilibrium. The following proposition accomplishes this task.

Proposition 1 *There exists a unique linear equilibrium given by the price functions*

$$p_{11} = p_0 + \lambda_1 \omega_{11} \quad (3)$$

$$p_{12} = p_0 + \lambda_2 \omega_{12} \quad (4)$$

and by the k^{th} speculator's demand strategies

$$x_{k1} = \frac{\sigma_z}{\sqrt{M\rho\sigma_v}} \delta_{vk} \quad (5)$$

$$x_{k2} = \frac{\sigma_n}{\sqrt{M\rho\sigma_v}} \delta_{vk} + \frac{1}{2} \frac{\gamma}{1-\gamma} e_{k2} \quad (6)$$

where $\sigma_n^2 = \sigma_z^2 + \frac{M}{4} \left(\frac{\gamma}{1-\gamma} \right)^2 \sigma_e^2$, $\lambda_1 = \frac{\sqrt{M\rho\sigma_v}}{\sigma_z[2+(M-1)\rho]} > 0$, and $\lambda_2 = \frac{\sqrt{M\rho\sigma_v}}{\sigma_n[2+(M-1)\rho]} > 0$.

In equilibrium, each speculator, albeit risk-neutral, exploits his private information cautiously ($|x_{ki}| < \infty$) and in both assets to limit dissipating his informational advantage with his trades. Both optimal trading strategies x_{ki} depend on his information endowment about the asset payoff (δ_{vk}) and on the corresponding market's depth (λ_i^{-1}), as in Kyle, (1985). Further, as in Pasquariello and Vega (2006), both x_{k1} (Eq. (5)) and x_{k2} (Eq. (6)) depend on the number of speculators (M) and the correlation among their information endowments (ρ). Intuitively, the intensity of competition among speculators affects their ability to maintain the informativeness of the order flow as low as possible. A greater number of speculators trade more aggressively — i.e., their aggregate amount of trading is higher — since (imperfect) competition among them precludes any collusive trading strategy. The heterogeneity of speculators' signals attenuates their trading aggressiveness. When information is less correlated (ρ closer to zero), each speculator has some monopoly power on his signal, because at least part of it is known exclusively to him. Hence, as a group, they trade more cautiously — i.e., their aggregate amount of trading is lower — to reveal less of their own information endowments δ_{vk} . Thus, either higher M or ρ leads to higher equilibrium liquidity in both markets, i.e., lower λ_1 and λ_2 . This reflects MMs' attempt to be compensated for the losses they anticipate from trading with speculators, as λ_1 and λ_2 affect their profits from liquidity trading.

2.1.3 Testable Implications

In the equilibrium of Proposition 1, only the market for asset 2 is affected by the presence of speculators' endowments of that asset and only when their interim wealth (W_{1k}) is relevant in their objective function ($\gamma > 0$). When $\gamma = 0$, the market equilibrium is the same in both markets: $p_{11} = p_{12}$, $\lambda_1 = \lambda_2$, and $x_{k1} = x_{k2} = \frac{\sigma_z}{\sqrt{M\rho\sigma_v}}\delta_{vk}$ of Eq. (5) is the optimal informational demand schedule of Kyle (1985) and Pasquariello and Vega (2006). When $\gamma > 0$, the latter is true only in the off-the-run market (asset 1), while the optimal trades in the on-the-run security (x_{k2}) also depend on speculators' endowments. This stems from the resolution of a trade-off between short and long-term profits: Each speculator trades in the on-the-run asset more (or less) than in the off-the run asset — i.e., more (or less) than he otherwise would if $\gamma = 0$ — to distort prices in the direction of his endowment e_{k2} and so increase W_{1k} , regardless of his private signal.

In equilibrium, these efforts are successful and create a wedge between off-the-run and on-the run asset prices,

$$\Delta p_1 = p_{11} - p_{12} = \frac{\sqrt{M\rho\sigma_v}}{\sigma_n [2 + (M-1)\rho]} \left[\frac{1}{2} \frac{\gamma}{1-\gamma} \sum_{k=1}^M e_{k2} + \frac{\sigma_n - \sigma_z}{\sigma_z} z \right] \neq 0, \quad (7)$$

yet at the cost of smaller expected long-term profits (since $x_{k2} \neq x_{k1}$).⁶ The expected price differential Δp_1 is zero by construction since $E(e_{k2}) = E(z) = 0$.⁷ Yet, its realizations may be either positive or negative depending on those for $\sum_{k=1}^M e_{k2}$ and z .

Remark 1 *The off/on-the run price differential can be either positive or negative. Its magnitude depends on realized noise trading and endowment shocks but not on realized private information shocks.*

Further, in these circumstances, a portion of speculators' trades x_{k2} is uninformative about fundamentals (v). Hence, the MMs perceive the threat of adverse selection in the market for asset 2 as less serious than in the market for asset 1, so penalize less their counterparts in the former by making it more liquid than the latter:

$$\Delta \lambda = \lambda_1 - \lambda_2 = \frac{\sqrt{M\rho\sigma_v}(\sigma_n - \sigma_z)}{\sigma_z \sigma_n [2 + (M-1)\rho]} > 0 \quad (8)$$

⁶Indeed, $cov(p_{12}, e_{k2}) = \frac{1}{2} \left(\frac{\gamma}{1-\gamma} \right) \lambda_2 \sigma_e^2$ is positive and identical to the expected short-term change in the value of that speculator's endowment $E[e_{k2}(p_{12} - p_0)]$.

⁷Accordingly, it can be shown that $var(p_{11}) = var(p_{12}) = \frac{M\rho}{[2+(M-1)\rho]} \sigma_v^2$, i.e., speculators' endowment-motivated trading in asset 2 ($\gamma > 0$) does not affect the relative informativeness of that market. Intuitively, more uninformative trading in asset 2 increases informed trading aggressiveness in that market, hence does not destabilize its equilibrium price, as in Kyle (1985).

since $\sigma_z^2 < \sigma_n^2$. Accordingly, the greater γ and σ_e , the greater is the perceived intensity of uninformative trading in the aggregate order flow for asset 2 (i.e., the greater is σ_n^2), the less severe is adverse selection for the MMs in that market, thus the greater is the liquidity differential between asset 1 and asset 2. Similarly, greater ex ante uncertainty about both assets' common terminal value v (σ_v^2) makes speculators' private information about it more valuable and adverse selection for the MMs in both markets more severe, yet the less so in the market for asset 2 (where uninformative trading is more intense: $\sigma_n^2 > \sigma_z^2$), thus increasing their liquidity differential. The following corollary summarizes the first set of empirical implications of our model.

Corollary 1 *Equilibrium market liquidity in the on-the-run asset is greater than in the off-the-run asset, the more so the greater the relevance of and uncertainty about endowment shocks and the greater the uncertainty about both assets' common fundamentals.*

To gain further insight on the liquidity differential between on-the-run and off-the-run securities, we construct a simple numerical example by setting $\sigma_v = \sigma_z = \sigma_e = 1$ and $\gamma = 0.5$. We then vary the private signal correlation ρ to study the impact of different degrees of information heterogeneity on the liquidity differential between asset 2 and asset 1 when $M = 2, 4, 8,$ and 200 .⁸ We plot the resulting $\Delta\lambda$ in Figure 1A. In the presence of numerous speculators (high M), the plot for $\Delta\lambda$ is negatively sloped. Intuitively, more homogeneous private signals (higher ρ) attenuate their incentives to behave cautiously when trading. This leads to greater market liquidity in both asset markets, yet the more so in the market for the off-the-run security, where adverse selection is the most severe. Hence, the liquidity differential decreases. However, in the presence of few — thus already less competitive — speculators (low M), the plot for $\Delta\lambda$ is instead positively sloped. Specifically, the equilibrium liquidity differential is lower when those speculators are heterogeneously informed (low ρ), since their marginally more cautious use of private information has a smaller impact on their trading activity in the off-the-run market than in the on-the-run market. The following remark formalizes this result.

Remark 2 *In the presence of many (few) speculators, the off/on-the-run liquidity differential is generally increasing (decreasing) in the heterogeneity of their private signals.*

2.2 Extension: A Public Signal

The basic model of Section 2.1 identifies a novel explanation for the on-the-run phenomenon that relies on the uncertainty surrounding auction outcomes for just-issued securities. Within

⁸When $M = 1$, the plot for $\Delta\lambda$ is not flat since the precision of the single speculator's signal, $\sigma_s^2 = \frac{\sigma_v^2}{\rho}$, is decreasing in ρ .

this setting, we relate the magnitude of the liquidity differential between cash-flow-equivalent assets to the heterogeneity of sophisticated speculators' private signals (and resulting trading activity). To our knowledge, this analysis is novel to the literature. In this section, we investigate the impact of public disclosure on the on-the-run phenomenon. Many recent studies investigate the functioning of government bond markets in proximity of the release of macroeconomic news (e.g., Brandt and Kavajecz, 2004; Green, 2004; Pasquariello and Vega, 2006). Yet, the impact of the availability of public signals on the relation between on-the-run and off-the-run securities has never been previously explored.

To that purpose, we extend the basic economy by providing each player with an additional, common source of information about the liquidation value of assets 1 and 2 before trading takes place. Specifically, we assume that, sometime between $t = 0$ and $t = 1$, both the speculators and the MMs receive a public and noisy signal S_p of assets 1 and 2's payoff v . This signal is normally distributed with mean p_0 and variance $\sigma_p^2 > \sigma_v^2$. We further impose that $cov(S_p, v) = cov(S_p, S_{vk}) = \sigma_v^2$, so that the parameter σ_p^2 controls for the quality of the public signal, and that $cov(S_p, e_{k2}) = 0$.

The availability of S_p affects the level and improves the precision of the information endowments of all market participants prior to trading at time $t = 1$, with respect to the economy of Section 2.1. In particular, the MMs' revised beliefs about v are now given by $p_0^* = E(v|S_p) = p_0 + \frac{\sigma_v^2}{\sigma_p^2}(S_p - p_0)$ and $\sigma_v^{2*} = var(v|S_p) = \sigma_v^2 \left(1 - \frac{\sigma_v^2}{\sigma_p^2}\right) < \sigma_v^2$. The new information endowment of each speculator is $\delta_{vk}^* = E(v|S_{vk}, S_p) - p_0^* = \rho^* (S_{vk} - p_0^*)$, where $\rho^* = \rho \left(\frac{\sigma_p^2 - \sigma_v^2}{\sigma_p^2 - \rho\sigma_v^2}\right) \leq \rho$ is the correlation between any two δ_{vk}^* and δ_{vj}^* . Hence, we can interpret δ_{vk}^* as the truly private (hence less correlated) component of speculator k 's original private information endowment (δ_{vk}) in the presence of a public signal of v . The resulting unique linear equilibrium of this amended economy mirrors that of Proposition 1, and is obtained by replacing p_0 , σ_v^2 , ρ , and δ_{vk} with p_0^* , σ_v^{2*} , ρ^* , and δ_{vk}^* , respectively, in Eqs. (3) to (6).

2.2.1 Additional Testable Implications

Pasquariello and Vega (2006) show that, in a Kyle (1985) setting similar to ours, introducing a public signal improves market liquidity. This is the case in our economy as well. Intuitively, the availability of a public signal of v — by making the speculators' private information less valuable and their trading activity less cautious — reduces the adverse selection risk for the MMs in both the markets for asset 1 and 2, thus increasing their depth.⁹ In this study, we are interested in the

⁹It can in fact be shown that $\lambda_1^* = \frac{\sqrt{M\rho^*\sigma_v^*}}{\sigma_z[2+(M-1)\rho^*]} < \lambda_1$ and $\lambda_2^* = \frac{\sqrt{M\rho^*\sigma_v^*}}{\sigma_n[2+(M-1)\rho^*]} < \lambda_2$, consistent with Pasquariello and Vega (2006).

impact of the availability of S_p on both the price and liquidity differentials between on-the-run (2) and off-the-run (1) assets.

We begin by comparing the off/on-the-run price differential in the presence of a public signal to the one in its absence (Eq. (7)) as follows:

$$\Delta p_1^* - \Delta p_1 = \left\{ \frac{(\sigma_p^2 - \sigma_v^2) [2 + (M - 1) \rho]}{\sigma_p \sqrt{\sigma_p^2 - \rho \sigma_v^2} [2 + (M - 1) \rho^*]} - 1 \right\} \Delta p_1. \quad (9)$$

According to Eq. (9), and *ceteris paribus* for the set of realized shocks driving Δp_1 , the availability of a public signal lowers the price differential between asset 1 and asset 2. Intuitively, an additional source of information about those assets' terminal payoff (v) pushes both their prices closer to it, the more so the better is the quality of the information (lower σ_p^2).

Remark 3 *Ceteris paribus, the availability of a public signal decreases the off/on-the-run price differential, the more so the lower is that signal's volatility.*

The availability of a public signal also lowers the off/on-the-run liquidity differential:

$$\Delta \lambda^* - \Delta \lambda = \left\{ \frac{(\sigma_p^2 - \sigma_v^2) [2 + (M - 1) \rho]}{\sigma_p \sqrt{\sigma_p^2 - \rho \sigma_v^2} [2 + (M - 1) \rho^*]} - 1 \right\} \Delta \lambda < 0, \quad (10)$$

since it reduces the perceived adverse selection risk for the MMs in both markets, yet the most in the market for the off-the-run asset (1) where — in absence of endowment-motivated trades — that risk was the greatest in the equilibrium of Proposition 1. Again, this effect is stronger when the available public signal is more precise (lower σ_p^2), i.e., when the speculators' original private information endowments are less valuable and their trading activity is less cautious.

Corollary 2 *The availability of a public signal decreases the off/on-the-run liquidity differential, the more so the lower is that signal's volatility.*

The impact of those endowments' heterogeneity on $\Delta \lambda^* - \Delta \lambda$ is however less obvious, as the following remark illustrates.

Remark 4 *In the presence of many (few) speculators and a public signal, the ensuing decrease in the off/on-the-run liquidity differential is generally increasing (decreasing) in the heterogeneity of their private signals.*

In Figure 1B, we plot $\Delta \lambda^* - \Delta \lambda$, the decline in the off/on-the-run liquidity differential due to the availability of a public signal, as a function of ρ , the correlation of speculators' private signals

S_{vk} , when $\sigma_p = 1.5$, $\gamma = 0.5$, and $M = 2, 4, 8$, and 200 . In the presence of numerous speculators (high M), that decline is larger when speculators’ private signals are weakly correlated (low ρ), since then the impact of ρ on the aggressiveness of their trading activity is greater, hence so is the impact of the availability of a public signal on the perceived severity of adverse selection risk in the off-the-run market (asset 1). Fewer speculators (low M) trade more cautiously with their information endowments, and especially so in the off-the-run asset where they suffer no endowment shocks, making that market less liquid (Figure 1A). Thus, the availability of a public signal reduces the off/on-the-run liquidity differential the most when their incentive to trade cautiously is the lowest (high ρ).

3 Data Description

We test the implications of the model presented in the previous section using U.S. Treasury bond market data and U.S. macroeconomic announcements.

3.1 Bond Market Data

We are interested in studying the informational role of bond trading in explaining on/off-the-run liquidity differentials. To that purpose, we use intraday U.S. Treasury bond yields, quotes, transactions, and signed trades for the most recently issued — *on-the-run* — and the second most recently issued — i.e., *just off-the-run* — three-month, six-month, one-year, two-year, five-year, and ten-year Treasury bills and notes. We focus on these bonds because, according to Fleming (1997), Brandt and Kavajecz (2004), and Goldreich et al. (2005), those are the securities with the greatest liquidity and where the majority of informed trading takes place.

We obtain the data from GovPX, a firm that collects quote and trade information from six of the seven main interdealer brokers (with the notable exception of Cantor Fitzgerald).¹⁰ Fleming (1997) argues that these six brokers account for approximately two-thirds of the interdealer-broker market, which in turn translates into approximately 45% of the trading volume in the secondary market for Treasury securities. Our sample includes every transaction taking place during “regular trading hours,” from 7:30 a.m. to 5:00 p.m. Eastern Standard Time (EST),

¹⁰Over our sample period (between 1992 and 2000), the major interdealer brokers in the U.S. Treasury market are Cantor Fitzgerald Inc., Garban Ltd., Hilliard Farber & Co. Inc., Liberty Brokerage Inc., RMJ Securities Corp., and Tullet and Tokyo Securities Inc. During that time, Cantor Fitzgerald’s share of the interdealer Treasury market was about 30%, according to Goldreich et al. (2005). Nevertheless, Cantor Fitzgerald is a dominant player only in the “long end” of the Treasury yield curve, which we do not analyze in this paper.

between January 2, 1992 and December 29, 2000. GovPX stopped recording intraday volume afterward. Strictly speaking, the U.S. Treasury market is open 24 hours a day; yet, 95% of the trading volume occurs during those hours. Thus, to remove fluctuations in bond yields due to illiquidity, we ignore trades outside that narrower interval. Finally, the data contains some interdealer brokers' posting errors not previously filtered out by GovPX. We eliminate these errors following the procedure described in Fleming's (2003) appendix.

We complement the GovPX data with information on those bills and notes' fundamental characteristics (daily modified duration and convexity) from Morgan Markets, and with official data on the history of those bonds' routinely scheduled Treasury auctions: the date of the auction, the amount of competitive, noncompetitive, and System Open Market Account (SOMA) tenders (a measure of government debt demand), the amount of tenders accepted by the U.S. Treasury (a measure of government debt supply), and high, low, and average accepted competitive yield bids. This information is publicly available on the U.S. Treasury website.¹¹

We report summary statistics for the following variables in Table 1A (Treasury bills) and Table 1B (Treasury notes): end-of-the day bond yields (Y_t), average daily *quoted* bid-ask price spreads (S_t),¹² modified duration (D_t), modified convexity (C_t), average amount tendered at the auction, average amount accepted at the auction, and range of competitive yield bids at the auction (highest bid minus lowest bid divided by average accepted competitive bid, HL_t). Bond yields are in percentage, i.e., were multiplied by 100; bid-ask spreads are in basis points, i.e., were multiplied by 10,000; total amount tendered and accepted are in billions of U.S. dollars; modified durations are in fractions of 365 days. Not surprisingly, given the prevalence of an upward-sloping yield curve during the sample period, mean Treasury bond yields are increasing with maturity and duration. Lastly, we compute average daily off/on-the-run bid-ask spread differentials as $\Delta S_t = S_t^{off} - S_t^{on}$ and the corresponding yield differentials as $\Delta Y_t = Y_t^{off} - Y_t^{on}$ for each of the bills and notes in our sample, consistent with both existing literature (e.g., Krishnamurthy, 2002; Goldreich et al., 2005) and widespread market practices. We plot the resulting time series of ΔS_t and ΔY_t in Figure 2 by week to smooth daily variability, as in Fleming (2003). Notably, these graphs reveal occasional gaps in GovPX market coverage, especially among six-month bills and ten-year notes in the earlier and latter parts of the sample period, respectively.¹³

There is clear, economically significant evidence of the on-the-run liquidity phenomenon in

¹¹<http://www.publicdebt.treas.gov/of/ofaicqry.htm>.

¹²The analysis that follows is nonetheless robust to employing average daily *effective* bid-ask spreads (e.g., as in Goldreich et al., 2005) or bid-ask *yield* spreads.

¹³For a discussion of the incompleteness of GovPX coverage of the U.S. Treasury market, see Boni and Leach (2002) and Fleming (2003).

the U.S. Treasury bond market between 1992 and 2000: Off/on-the-run spread differentials ΔS_t are large (e.g., on average, never less than 50% of the corresponding off-the-run spreads), always positive (solid line, left axis in Figures 2A to 2F), and statistically significant across all maturities (at the 1% level, in Tables 1A and 1B). Mean daily spread differentials range from less than one basis point (two-year, Figure 2D) to more than 17 basis points (three-month, Figure 2A). Interestingly, the evidence is instead mixed for off/on-the-run yield differentials ΔY_t : Albeit always statistically significant (again at the 1% level, in Tables 1A and 1B), average daily ΔY_t are large and steadily positive only for five-year and ten-year notes (gray line, right axis in Figures 2E and 2F), while negative (and often largely so) for all the other securities in the sample, as also reported in Fleming (2003). Accordingly, the correlation between daily yield and spread differentials — $\rho(\Delta Y_t, \Delta S_t)$ in Tables 1A and 1B — is positive and statistically significant only for two-year and five-year notes, either insignificant or negative otherwise, and small (i.e., never beyond ± 0.25) in all cases.

This preliminary evidence suggests that *i*) off/on-the-run liquidity differentials are consistently economically significant, while yield differentials are often much less so and *ii*) off/on-the-run yield and bid-ask spread differentials often decouple, i.e., cannot be interpreted as perfect substitutes, as implied by the illiquidity premium hypothesis of Amihud and Mendelson (1986, 1991) and by most of the subsequent empirical and theoretical research on the on-the-run phenomenon. Thus, this evidence further motivates our study of the determinants of the off/on-the-run liquidity differentials in fixed income markets.

3.2 Macroeconomic Data

The model of Section 2 relates the off/on-the-run liquidity differential to the heterogeneity of private information about fundamentals among sophisticated market participants, as well as to the release of public information about those fundamentals. In this paper, we use the International Money Market Services (MMS) Inc. real-time data on the expectations and realizations of 25 of the most relevant U.S. macroeconomic fundamentals to estimate announcement surprises and heterogeneity of speculators' signals about them.¹⁴ Specifically, we use the MMS standard deviation across those professional forecasts as a measure of the dispersion of beliefs across speculators. This measure of information heterogeneity is widely adopted in the literature on investors' reaction to information releases in the stock market (e.g., Diether et al., 2002; Kallberg and Pasquariello, 2004); Green (2004) and Pasquariello and Vega (2006) recently use

¹⁴Detailed discussions of the properties of this dataset can be found in Fleming and Remolona (1997), Andersen et al. (2003), and Pasquariello and Vega (2006).

it in a bond market context. The 18 macroeconomic news for which this variable is available in our sample, the corresponding number of announcements, and the reporting agency are listed in Table 2.

The dispersion of beliefs is positively correlated across the macroeconomic announcements in our sample, yet not strongly so. For instance, Pasquariello and Vega (2006) report that the pairwise correlation between each announcement and arguably the most important of them, the Nonfarm Payroll report (e.g., Andersen and Bollerslev, 1998; Andersen et al., 2004; Brenner et al., 2005), is positive, albeit not statistically significant for most of the announcements in the sample ($\rho(\textit{payroll})$ in Table 2). Thus, we follow Pasquariello and Vega (2006) and construct three alternative measures of dispersion of beliefs during announcement and non-announcement days: one based exclusively on the Payroll announcement, another based on 7 “influential” announcements (Nonfarm Payroll Employment, Retail Sales, New Home Sales, Consumer Confidence Index, NAPM Index, Index of Leading Indicators, and Initial Unemployment Claims.), and the last one based on the 18 announcements in Table 2. Pasquariello and Vega (2006) label those macroeconomic announcements “influential” for they are the only ones having a statistically significant impact on day-to-day bond yield changes over our sample period.

We then define a monthly proxy for the aggregate degree of information heterogeneity about macroeconomic fundamentals as a weighted sum of monthly dispersions across announcements,

$$SSD_{Pt} = \sum_{j=1}^P \frac{SD_{jt} - \hat{\mu}(SD_{jt})}{\hat{\sigma}(SD_{jt})}, \quad (11)$$

where SD_{jt} is the standard deviation of announcement j across professional forecasts, $\hat{\mu}(SD_{jt})$ and $\hat{\sigma}(SD_{jt})$ are its sample mean and standard deviation, respectively, and P is equal to either 1 (Nonfarm Payroll Employment), 7 (the “influential” announcements listed above), or 18 (i.e., those in Table 2). The standardization in Eq. (11) is necessary because units of measurement differ across economic variables. We use the monthly dispersion estimates from these three methodologies to classify days in which the corresponding monthly variable SSD_{Pt} is above (below) the top (bottom) 70th (30th) percentile of its empirical distribution as days with high (low) information heterogeneity. The resulting time series of high (+1) and low (−1) dispersion days are positively correlated: Their correlations range from 0.37 (between the Payroll-based series, $P = 1$, and the series constructed with the influential announcements, $P = 7$) to 0.70 (between the series using all announcements, $P = 18$, and the one based only on the influential news releases, $P = 7$).

4 Empirical Analysis

The model of Section 2 generates several implications for both off/on-the-run liquidity and yield differentials in bond markets that we now test in this section. The database described in Section 3 allows us to compute directly the daily off/on-the-run yield differentials, $\Delta Y_t = Y_t^{off} - Y_t^{on}$, for each of the bills and notes in our sample. Computing off/on-the-run liquidity differentials is a more challenging task. In the context of our model, and consistent with Kyle (1985), market liquidity for a traded asset i is defined as the marginal impact of an unexpected trade on the equilibrium price of that asset, λ_i . This measure of liquidity is typically estimated as the slope λ_t of the regression of yield or price changes on the observed aggregate order flow (net volume) over either intraday or daily time intervals. Hence, when transaction data is available, this procedure allows for a direct assessment of our model's implications for off/on-the-run liquidity differentials $\Delta\lambda$. The GovPX dataset contains such data, i.e., allows for the direct estimation of λ_t^{off} and λ_t^{on} .

Unfortunately, this procedure also suffers from several shortcomings. In particular, it requires the econometrician *i*) to specify a model for the prior estimation of the unobserved portion of the aggregate order flow, as well as *ii*) to control for many additional microstructure imperfections which, together with informed and liquidity trading, may affect its dynamics (e.g., Hasbrouck, 2004).¹⁵ Hence, any inference from such an effort is subject to potential misspecification, as well as to the potential biases stemming from measurement errors in the dependent variable. The latter are likely to be severe if any independent variable explaining λ_t is also not measured properly (e.g., see the discussion in Greene, 1997, p. 436). In addition, the relative scarcity of trades in off-the-run bonds often makes the estimation of λ_t^{off} problematic (e.g., Pasquariello and Vega, 2006).

In light of these considerations, in this paper we measure each market's liquidity using its daily average quoted bid-ask spread, S_t , for several reasons. First, off-the-run and on-the-run spreads (S_t^{on} and S_t^{off}) and spread differentials ($\Delta S_t = S_t^{off} - S_t^{on}$) are virtually privy of measurement error. Further, there is an extensive literature relating their magnitude and dynamics to the informational role of trading (see O'Hara, 1995, for a review). Lastly, when comparing several alternative measures of liquidity in the U.S. Treasury market, Fleming (2003) finds that the simple bid-ask spread is the most highly correlated with both direct estimates of price impact and well-known episodes of poor liquidity in those markets.¹⁶ The inference that follows is

¹⁵Green (2004), Brandt and Kavajecz (2004), and Pasquariello and Vega (2006) are recent examples of such efforts in the U.S. Treasury market.

¹⁶In this paper we do not pursue any of the techniques available in the literature to separate the portion of

nonetheless robust to replacing ΔS_t with $\Delta \lambda_t = \lambda_t^{off} - \lambda_t^{on}$ estimated using various intraday time intervals.

4.1 The Benchmark On-The-Run Phenomenon

The main objective of this paper is to identify and measure the informational role of trading for off/on-the-run liquidity differentials in fixed income markets. We start by assessing the economic and statistical significance of the on-the-run liquidity and yield phenomenon in the three-month, six-month, one-year, two-year, five-year, and ten-year Treasury bills and notes between 1992 and 2000. This is a necessary step in our analysis, for recent studies (e.g., Krishnamurthy, 2002; Strebulaev, 2002) argue that off/on-the-run yield differentials may either disappear or considerably diminish once controlling for these bonds' fundamental characteristics.

Some of those fundamental characteristics are in fact likely to differ for on-the-run bonds and their closest off-the-run securities, although these securities' liquidation values are assumed to be identical in our model. In particular, Table 1 suggests that duration and convexity differentials between them may be large. For instance, both off/on-the-run modified duration and convexity differentials ($\Delta D_t = D_t^{off} - D_t^{on}$ and $\Delta C_t = C_t^{off} - C_t^{on}$, respectively) are always negative and significant at the 1% level. Hence, on-the-run bonds are on average less sensitive to parallel shifts of the yield curve and to large, sudden yield jumps than corresponding off-the-run securities at each maturity. Investors' expectations and risk aversion may then affect their relative preferences toward these assets, i.e., may ultimately affect these assets' relative prices and liquidity in a systematic fashion.

To assess the empirical relevance of these considerations, we specify the following two *benchmark* models of off/on-the-run spread and yield differentials:

$$\Delta S_t = \beta_{s0} + \beta_{s1} \Delta D_t + \beta_{s2} \Delta C_t + \varepsilon_t \quad (12)$$

$$\Delta Y_t = \beta_{y0} + \beta_{y1} \Delta D_t + \beta_{y2} \Delta C_t + \varepsilon_t \quad (13)$$

for each of the bills and notes in our sample. We estimate these regressions by OLS and evaluate the statistical significance of the coefficients' estimates, reported in Table 3, with Newey-West standard errors to correct for heteroskedasticity and serial correlation. The results in Panel A

the bid-ask spread due to adverse selection from those due to order processing costs or inventory control (e.g., Stoll, 1989; George et al., 1991). Execution costs are in fact likely to be similar across Treasury bonds, hence to cancel out when computing average daily off/on-the-run spread differentials ΔS_t . Further, we find (and discuss in Section 4.1) that those differentials are insensitive to the corresponding repo rate differentials, which may proxy for the relative cost of unwinding undesired inventory positions in the off-the-run and on-the-run markets.

of Table 3 provide strong evidence of the on-the-run *liquidity* phenomenon in the U.S. Treasury market. For all maturities, both the magnitude and significance of estimates for the average off/on-the-run liquidity differentials (β_{s0} in Eq. (12)) are virtually unaffected — or even amplified — by the inclusion of duration and convexity differentials. However, those differentials explain a large portion of off/on-the-run yield differentials: After controlling for ΔD_t and ΔC_t , estimates for the average yield differentials ΔY_t (β_{y0} in Eq. (13)), in Panel B of Table 3, either are positive but decline by more than 50% (for ten-year notes), become statistically insignificant (for one-year bills and two-year notes), or turn out to be negative (for three-month and six-month bills and five-year notes), contrary to the illiquidity premium hypothesis of Amihud and Mendelson (1986, 1991).¹⁷ Ceteris paribus, in most cases it is greater duration ($\beta_{y1} < 0$) and lower convexity ($\beta_{y2} > 0$) that make on-the-run bonds more expensive than their off-the-run counterparts.¹⁸

Existing research also suggests that off/on-the-run yield differentials may be driven by the relative degree of specialness of the corresponding on-the-run and off-the-run Treasury securities (e.g., Krishnamurthy, 2002).¹⁹ Comprehensive data on repo rates for all the securities in our sample and over its entire length is unavailable to us. We attempt to account for the role of repo specialness for the on-the-run phenomenon by using the (limited) information on these rates provided by Morgan Markets only from 1997 onward. We do so by amending Eqs. (12) and (13) to include off/on-the-run repo rate differentials as well. The estimation of these amended regressions, not reported here, suggests that our inference above is robust to the inclusion of those repo differentials and that their impact on both ΔS_t and ΔY_t is in all cases statistically insignificant.

Overall, these results indicate that off/on-the-run bid-ask spread differentials are positive, economically significant — averaging more than half of the corresponding mean off-the-run spread — and cannot be explained by differences in the fundamental characteristics of the underlying securities. Off/on-the-run yield differentials are instead neither uniformly positive nor uniformly significant. Together with Table 1, this preliminary evidence is inconsistent with a common premise to much of the existing empirical and theoretical literature on this issue, for it sug-

¹⁷Consistently, Goldreich et al. (2005) find that, after adjusting for coupon and maturity differentials with prices of hypothetical Treasury notes, the resulting average daily two-year off/on-the-run yield differential between 1994 and 2000 is small (i.e., never larger than 1.5 basis points at its peak) and rapidly declining to zero during the monthly auction cycle until a newer note is issued (Figure 2, p 13). Goldreich et al. (2005) do not report information on the statistical significance of that yield differential over their sample period.

¹⁸We obtain similar results (not reported here) when replacing ΔD_t and ΔC_t with D_t^{off} , D_t^{on} , C_t^{off} , and C_t^{on} in Eqs. (12) and (13).

¹⁹For a detailed description of the functioning of the repo market for U.S. Treasury securities, see also Fleming and Garbade (2006).

gests a systematic decoupling of the on-the-run liquidity phenomenon from the on-the-run yield phenomenon.

4.2 Endowment Shocks and the On-The-Run Phenomenon

The analysis so far reveals that *i)* off/on-the-run liquidity differentials in the U.S. Treasury market are both economically and statistically significant, *ii)* off/on-the-run yield differentials are not so, and *iii)* the two phenomena are neither uniquely related to each other nor explained away by differences in fundamentals. The latter two facts provide indirect support for our model since, in that stylized market setting, equilibrium off/on-the-run price differentials between securities with identical terminal payoffs can be either positive or negative (Remark 1). We are now ready to test directly the model’s main implication for the former fact, namely that off/on-the-run liquidity differentials are driven by uncertainty about speculators’ endowments in the on-the-run securities (Corollary 1).

According to our theory, government auctions are the critical events discriminating among those otherwise identical assets, for they lead sophisticated speculators to acquire undisclosed amounts of just-issued — hence by definition on-the-run — securities (e_{k2}). When sensitive to both their short- and long-term wealth, these speculators’ subsequent trades in the on-the-run security are informationally suboptimal. This attenuates market makers’ adverse selection in that market, the more so the more short-term wealth matters to speculators (γ) and the greater is the uncertainty surrounding their endowments (σ_e^2), ultimately improving the market’s liquidity with respect to the one for the off-the-run asset.

These results, summarized in Corollary 1, translate naturally into two testable conjectures in fixed income markets. The first one stems from the observation that the time when assets 1 and 2’s identical payoffs v are realized in our model ($t = 2$) can be thought of as the time when two identical bonds mature. *Ceteris paribus*, it is then reasonable to conjecture that the distinction between short- and long-term should be more relevant for Treasury notes than for bills, i.e., $\gamma \approx 1 - \gamma$ and greater off/on-the-run liquidity wedge ΔS_t for the latter but $\gamma < 1 - \gamma$ and smaller ΔS_t for the former. Accordingly, Panel B of Table 3 shows that the average off/on-the-run liquidity differential after controlling for those bonds’ fundamental characteristics — β_{s0} of Eq. (12) — is greater (both economically and statistically) for Treasury bills (averaging 0.17 basis points) than for Treasury notes (less than 0.02 basis points on average).

The second conjecture stems from the observation that uncertainty about speculators’ endowments (σ_e^2) is likely to be the greatest — hence the on-the-run liquidity phenomenon the most intense — at the completion of an auction and declining afterward, i.e., when market participants

can learn from observed price movements about those endowments. We test for this possibility by estimating, for every bill and note in our sample, the following amended specifications of Eqs. (12) and (13):

$$\Delta S_t = \beta_{s0} + \sum_{i=1}^N \beta_{s0i} Auction_{t-i} + \beta_{s1} \Delta D_t + \beta_{s2} \Delta C_t + \varepsilon_t \quad (14)$$

$$\Delta Y_t = \beta_{y0} + \sum_{i=1}^N \beta_{y0i} Auction_{t-i} + \beta_{y1} \Delta D_t + \beta_{y2} \Delta C_t + \varepsilon_t \quad (15)$$

where $Auction_{t-i}$ is a dummy variable equal to one on day t if day $t-i$ is the most recent auction date for the corresponding bond and equal to zero otherwise. We choose $N = 4$ for three-month and six-month bills and $N = 10$ for all other bonds to prevent each post-auction window to overlap with the window of subsequent regular and *ad hoc* auction reopenings.²⁰ Yet, similar inference ensues from either bigger or smaller N . We cannot estimate the contemporaneous impact of the auction on ΔS_t and ΔY_t ($i = 0$) since GovPX reports transaction data on the auctioned on-the-run and the just off-the-run bonds only from the first business day *after* the auction date ($t - 1$) onward. Hence, we interpret estimates of β_{s0} and β_{y0} — the mean spread and yield differentials over the unaccounted portion of the prior auction cycle ending *on* day t — as a proxy for the extent of the on-the-run phenomenon immediately before trading on the new bond begins. We report estimates of Eqs. (14) and (15) in Tables 4A and 4B, respectively.

Table 4A indicates that, consistent with our conjecture, the off/on-the-run bid-ask spread differential ΔS_t is *lower* immediately following on-the-run auction dates: Estimated coefficients β_{s0i} in Eq. (14) are negative and significant for both bills and notes, albeit often first increasing and then decreasing in absolute magnitude. Hence, average liquidity differentials $\beta_{s0} + \beta_{si}$ generally decline in the immediate aftermath of Treasury auctions, albeit often either flat or slowly increasing toward β_{s0} thereafter.²¹ According to the illiquidity premium hypothesis of Amihud and Mendelson (1986, 1991), this should translate into lower off/on-the-run yield differentials (yet increasingly less so at greater lags i). Table 4B suggests otherwise: Conditional on $\beta_{y0} > 0$ ($\beta_{y0} < 0$), the coefficients β_{y0i} in Eq. (15) are negative and significant only for five-year (one-year) notes, while instead either insignificant or positive and significant for the other bills and notes in the sample.²² Equivalently, Tables 4A and 4B suggest that, immediately following

²⁰See Fabozzi and Fleming (2004) for a detailed description of the functioning of U.S. Treasury auctions.

²¹Consistently, Goldreich et al. (2005) show that average daily quoted and effective bid-ask spreads over the first 100 trading days of newly-issued two-year Treasury notes (Figure 1A) are first declining, then flat, and eventually steadily widening afterward.

²²Krishnamurthy (2002) finds that off/on-the-run yield differentials for 30-year Treasury bonds generally narrow following auction dates. We do not include the *long bond* in our sample for the GovPX database coverage of that market is poor. Nonetheless, when estimating Eq. (15) for the 30-year bond using available GovPX data,

Treasury auctions, off/on-the-run liquidity differentials decline, consistent with Corollary 1, yet the off/on-the-run yield differentials either remain negative or turn positive and widen in the secondary markets for government bonds, inconsistent with liquidity-based explanations.

The range of competitive yield bids at an auction HL_t — defined in Section 3.1 as the ratio of the difference between the highest and lowest bid at the auction and the average accepted competitive bid — represents an additional proxy for endowment uncertainty induced by a Treasury auction. This information is announced by the Treasury at around 1 p.m. on the auction date. It can be argued that, *ceteris paribus*, the greater is that ratio the greater is the uncertainty among uninformed market participants about the final outcome of the auction for each of the sophisticated speculators, the greater is the uncertainty about their endowments of on-the-run bonds (σ_e^2), hence the greater is the resulting off/on-the-run liquidity differential. We test for this possibility by amending Eq. (14) as follows:

$$\Delta S_t = \beta_{s0} + \sum_{i=1}^N \beta_{s0i} Auction_{t-i} + \beta_{s1} \Delta D_t + \beta_{s2} \Delta C_t + \beta_{s3} X_t + \varepsilon_t \quad (16)$$

where $X_t = HL_t$. We report estimates of β_{s3} in Table 5 for each of the securities in our sample. Estimates of all other coefficients are both qualitatively and quantitatively similar to those in Table 4A, hence are not reported here. Table 5 shows that the competitive yield range HL_t is strongly positively related to the liquidity differential of Treasury bills, even after controlling for supply effects and fundamental volatility (see the discussion next), yet is mostly unrelated to that of Treasury notes. This evidence is consistent with Corollary 1, for it suggests that the effect of uncertainty about speculators' endowments of the on-the-run asset (e_{k2}) on ΔS_t is greater (and in the direction of the theory) for the markets in which those speculators are more likely to be indifferent between the short- and long-term value of their wealth ($\gamma \approx 1 - \gamma$), i.e., for the Treasury securities of shorter maturity, as previously argued.²³

The relative supply of new and old Treasury securities in the secondary market, as well as the demand for the new ones in the primary market, do not play any role in the stylized model of trading à la Kyle (1985) of Section 2. Nonetheless, these effects may intuitively contribute to the dynamics of the bid-ask spread differentials reported in Table 4A. For instance, according to Vayanos and Weill (2005), the ensuing search costs — such as the additional time it may take a trader to locate a scarce off-the-run issue over its abundant on-the-run bond — may translate into liquidity wedges and no-arbitrage price premia. We assess the relevance of these

the ensuing coefficients β_{y0i} (not reported here) are negative (consistent with Krishnamurthy, 2002) but not statistically significant.

²³The same inference can be drawn when accounting for the interaction of HL_t with the auction dummies $Auction_{t-i}$ in Eq. (16).

considerations by amending the above regression to include either the amount tendered at the Treasury auctions ($X_t = Ten_t$), the amount eventually accepted by the investors ($X_t = Acc_t$), or both.²⁴ The resulting estimated parameters, not reported here, indicate that our inference is robust to the inclusion of supply and demand effects: Sign, magnitude, and significance of the coefficients β_{s0i} and β_{y0i} are very similar to those displayed in Tables 4A and 4B. Consistent with the intuition above, estimates of β_{s3} (in Table 5) are in most cases negative and significant: Tendered and accepted amounts lower bid-ask spread differentials in the Treasury market. Yet, their inclusion improves only marginally the overall fit — i.e., the adjusted R^2 , R_a^2 — of the regressions in Table 4A.²⁵

4.3 The Informational Role of Trading and the On-The-Run Phenomenon

The evidence reported in Section 4.2 provides further, more direct support for the basic premise of our model, i.e., that uncertainty surrounding speculators' endowments of new, just-auctioned securities creates a liquidity wedge between those securities and otherwise identical, old securities. Given this crucial premise, we now test two additional implications of our theory that stem from the informational role of trading in our stylized model.

The first one — again from Corollary 1 — states that *ceteris paribus* greater uncertainty surrounding both on-the-run and off-the-run assets' terminal payoffs (higher σ_v^2) leads to greater liquidity differentials between them, for adverse selection risk becomes more severe for uninformed market makers in both assets, yet the more so in the off-the-run security (asset 1) where noise trading is less intense ($\sigma_z^2 < \sigma_n^2$). To evaluate this argument, we amend Eq. (16) by imposing that $X_t = Vol_t$, the daily Eurodollar implied volatility from Bloomberg, a commonly used proxy for the market's perceived uncertainty surrounding U.S. monetary policy. We report estimates of the corresponding coefficients β_{s3} in Table 5. Consistent with Corollary 1 and the discussion in the previous section, greater Eurodollar implied volatility translates into greater off/on-the-run liquidity differentials: Estimated β_{s3} are always positive, always statistically significant at the 5% level or better (with the exception of three-month bills), and larger for bills than notes, i.e., when σ_n^2 is greater than σ_z^2 (see Section 2.1.3). These coefficients are even larger after controlling

²⁴Similar inference, not reported here, ensues from the inclusion of the interaction of both variables with auction dummies $Auction_{t-i}$, in Eq. (16).

²⁵According to Vayanos and Weill (2005), the ensuing search costs, such as the additional time it may take a trader to locate a scarce off-the-run issue over its abundant on-the-run bond, may translate into no-arbitrage price premia.

for supply effects and endowment uncertainty, in the bottom panel of Table 5.

The second implication — from Remark 2 — states that because of the informational role of trading in the markets for asset 1 and asset 2, the degree of heterogeneity of speculators’ private information has an impact on the equilibrium liquidity differential between those markets whose sign depends on speculators’ relative numerosity (M in Eq. (8)). We test for this argument by amending Eq. (14) as follows:

$$\begin{aligned} \Delta S_t = & \beta_{sh} \times D_{ht} + \beta_{sl} \times D_{lt} + \beta_{sm} \times (1 - D_{ht} - D_{lt}) + \beta_{s1}(D_t^{off} - D_t^{on}) + \\ & \beta_{s2}(C_t^{off} - C_t^{on}) + \sum_{i=1}^N \beta_{shi} Auction_{t-i} \times D_{ht} + \\ & \sum_{i=1}^N \beta_{sli} Auction_{t-i} \times D_{lt} + \sum_{i=1}^N \beta_{smi} Auction_{t-i} \times (1 - D_{ht} - D_{lt}) + \varepsilon_t \end{aligned} \quad (17)$$

where D_{ht} (D_{lt}) is a dummy variable equal to one on days with high (low) information heterogeneity, defined in Section 3.2 as days in which the monthly variable SSD_{Pt} of Eq. (11) is above (below) the top (bottom) 70th (30th) percentile of its empirical distribution, and equal to zero otherwise. We compute SSD_{Pt} using all the announcements listed in Table 2 (i.e., $P = 18$ in Eq. (11)). We obtain qualitatively similar results for $P = 1$ (Nonfarm Payroll) or $P = 7$ (the influential announcements listed in Section 3.2).

For conciseness’ sake, we only show plots of the resulting estimated average liquidity differentials $\beta_{sh} + \beta_{shi}$, $\beta_{sm} + \beta_{smi}$, and $\beta_{sl} + \beta_{sli}$ for $i = 1, 2, 3$, and 4 and for each of the bills and notes in our sample in Figure 3. As already suggested by Table 4A, off/on-the-run bid-ask spread wedges are positive and generally declining in the lags from the Treasury auction dates regardless of the degree of information heterogeneity among speculators, again consistent with Corollary 1. Figure 3 also suggests that those liquidity differentials are generally sensitive to the degree of information heterogeneity about macroeconomic fundamentals among sophisticated market participants, consistent with Remark 2. In particular, average ΔS_t is generally increasing (i.e., $\beta_{shi} > \beta_{sli}$) in the heterogeneity of speculators’ beliefs (i.e., decreasing in ρ in Figure 1A), often statistically significantly so, for issues of longer maturity (one-year bills to ten-year notes). This is intuitive since, according to our model, more heterogeneously informed speculators trade more cautiously to protect their perceived private information monopoly, the more so in the less liquid market (off-the-run), thus widening its liquidity gap with the on-the-run market. Yet, average spread differentials are either insensitive to or even weakly increasing in ρ (i.e., $\beta_{shi} \lesssim \beta_{sli}$) for short-term bills. According to our model (see Figure 1A), this dichotomy may be explained by Treasury bills’ markets being populated by fewer, hence less competitive sophisticated speculators. Anecdotal evidence, the significantly wider bid-ask spreads and lower aggregate daily trading volume and trading frequency in bills than in notes (e.g., our Tables 1A and 1B, and

Tables 1 and 2 in Fleming, 2003), as well as the observation that informed investors may be more active in more liquid trading venues (e.g., Chowdhry and Nanda, 1991) suggest that this may indeed be the case.

Overall, the above results provide additional support for our model, for they indicate that the magnitude and dynamics of off/on-the-run liquidity differentials — which we have showed to be related to endowment uncertainty following on-the-run auctions in Section 4.2 — are also crucially related to the informational role of trading in the U.S. Treasury market.

4.4 Announcement Days and the On-The-Run Phenomenon

Macroeconomic news are frequently released to the public in the U.S. financial markets. For instance, more than 2,000 of the news items listed in Table 2 were announced, often on the same day, over our sample period. These news releases are especially relevant for the U.S. Treasury market since their potential information content is deemed to play a crucial role for the valuation of the bonds there traded. Consistently, Pasquariello and Vega (2006) find that the release of macroeconomic information (weakly) improve liquidity in the Treasury note market. According to our model, these news releases may be relevant for the on-the-run phenomenon as well. In particular, we showed in Section 2.2 that the availability of a public signal of the identical terminal payoff of both the off-the-run and the on-the-run securities (v) reduces both their price and liquidity differentials — the more so the better is the quality of that signal— for it pushes both prices closer to v and attenuates both markets’ adverse selection risk, yet mainly where most severe (the off-the-run market).

We assess the empirical relevance of these considerations by using the database of macroeconomic announcements described in Section 3.2. Specifically, the above implications translate into observing a negative difference between each β_{s0w}^{ann} and β_{s0w}^{noann} and between each β_{y0w}^{ann} and β_{y0w}^{noann} in the following amended specifications of Eqs. (12) and (13):

$$\Delta S_t = Ann_t \sum_{w=1}^5 \beta_{s0w}^{ann} d_{tw} + (1 - Ann_t) \sum_{w=1}^5 \beta_{s0w}^{noann} d_{tw} + \beta_{s1} \Delta D_t + \beta_{s2} \Delta C_t + \varepsilon_t \quad (18)$$

$$\Delta Y_t = Ann_t \sum_{w=1}^5 \beta_{y0w}^{ann} d_{tw} + (1 - Ann_t) \sum_{w=1}^5 \beta_{y0w}^{noann} d_{tw} + \beta_{y1} \Delta D_t + \beta_{y2} \Delta C_t + \varepsilon_t \quad (19)$$

where Ann_t is a dummy variable equal to one if either the Nonfarm Payroll Employment report ($P = 1$), any of the 7 influential announcements listed in Section 3.2 ($P = 7$), or any of the 18 announcements listed in Table 2 ($P = 18$) is released on day t and equal to zero otherwise, while d_{tw} are day-of-the-week dummy variables, from $w = 1$ (Monday) to 5 (Friday), to control for event-day clustering. We report the resulting estimates of day-specific differences in Table 6 for

each of the bonds in our sample when $P = 7$.²⁶ We discuss the estimates for $P = 1$ or 18 below.

Consistent with our model (Remark 3), the difference of differences $\beta_{y0w}^{ann} - \beta_{y0w}^{noann}$ is more often negative when statistically significant. Hence, off/on-the-run yield differentials ΔY_t are generally lower during important announcement days. The evidence in Table 6 is however less supportive of Corollary 2: Estimates of $\beta_{s0w}^{ann} - \beta_{s0w}^{noann}$ are not only negative much less frequently than positive but also most often statistically indistinguishable from zero. Not surprisingly, public news releases are accompanied by lower off/on-the-run liquidity and yield differentials (albeit rarely in a statistically significant fashion) primarily in the market for Treasury bills, where we conjectured that the distinction between short- and long-term would be less relevant ($\gamma \approx 1 - \gamma$), hence the liquidity wedge induced by auction-driven endowment shock uncertainty of greater magnitude (see Section 4.2).

In short, the evidence presented in Table 6 is mixed. This can be due to several factors. Extant theories suggest alternative mechanisms mitigating the impact of the availability of public signals on ΔS_t . For instance, according to Chowdhry and Nanda (1991) sophisticated investors may divert much of their trading activity to the most liquid venue to maximize their expected profits. In such a setting, the release of high-quality public information, by devaluing those investors' private signals, may make that migration even more intense, thus *widening* — rather than tightening, as instead argued in Section 2.2.1 — the equilibrium liquidity differentials among markets. In addition, both the dispersion of beliefs among market participants and the quality of available public signals might vary across announcements. According to our model (Remarks 3 and 4 and Corollary 2), both factors may affect sign and significance of the relation between the availability of public signals and the on-the-run phenomenon. The weaker statistical significance of estimates for $\beta_{s0w}^{ann} - \beta_{s0w}^{noann}$ and $\beta_{y0w}^{ann} - \beta_{y0w}^{noann}$ for the narrowest and broadest — hence of possibly the highest and lowest quality — sets of macroeconomic news (i.e., for $P = 1$ and 18, not reported here) provides preliminary support to both sets of arguments above, respectively.

To test for the relevance of these considerations, we proceed in two directions. First, we focus on the impact of public signal noise (σ_p^2 of Section 2.2) on $\Delta p_1^* - \Delta p_1$ and $\Delta \lambda^* - \Delta \lambda$. We measure σ_p^2 using the U.S. government's frequent revisions of previously released macroeconomic information, as in Aruoba (2004) and Pasquariello and Vega (2006). Specifically, we augment our database with the Federal Reserve Bank of Philadelphia “Real Time Data Set” (RTDS) of all “informative” monthly data revisions (i.e., those due to newly available information).²⁷ These

²⁶As a word of caution, we observe that one of the 7 influential news in the MMS database, the Initial Unemployment Claims report, is released weekly in all but 24 Thursdays in our sample. Hence, when $P = 7$ or 18, both β_{s04}^{noann} and β_{y04}^{noann} are estimated with only 24 observations.

²⁷Occasionally, the U.S. government performs “uninformative” revisions of its previously announced data, i.e.,

revisions are available to us only for Capacity Utilization, Industrial Production, and Nonfarm Payroll Employment, among the 18 news releases listed in Table 2. We then compute those public signals’ noise as the absolute difference between each initial announcement and its last revision and label the corresponding announcement days as characterized by high (low) noise σ_p^2 when that difference is in the top (bottom) 70th (30th) percentile of its empirical distribution.²⁸ Lastly, we estimate Eqs. (18) and (19) for each of the RTDS announcements in either of their corresponding subsets of high and low σ_p^2 days in our sample. We report the ensuing differences $\beta_{s0w}^{ann} - \beta_{s0w}^{noann}$ and $\beta_{y0w}^{ann} - \beta_{y0w}^{noann}$ for Industrial Production in Table 7.

The resulting estimates are striking: Both average ΔS_t and ΔY_t during Industrial Production announcement days (Panels B and D) are lower than during nonannouncement days (Panels A and C) more often, more so, and more significantly so when the quality of that announcement is higher. For instance, $\beta_{s0w}^{ann} - \beta_{s0w}^{noann}$ are often negative and/or significant in Panel B but mostly either positive and/or insignificant in Panel A, especially for Treasury bills — i.e., where we expect the underlying adverse selection differential between on-the-run and off-the-run securities to be most severe ($\gamma \approx 1 - \gamma$). The inference drawn upon Capacity Utilization announcement days (not reported here) is qualitatively and quantitatively similar. However, we did not find any meaningful differences in $\beta_{s0w}^{ann} - \beta_{s0w}^{noann}$ and $\beta_{y0w}^{ann} - \beta_{y0w}^{noann}$ when estimated in correspondence with Nonfarm Payroll announcement days (also not reported here). This is not surprising, in light of the potentially offsetting liquidity-migration effect discussed in Chowdhry and Nanda (1991), since those news releases are commonly characterized as of the highest and most homogeneous quality.²⁹ Thus, Table 7 suggests that the decline in off/on-the-run bid-ask spread and yield differentials in the presence of a public signal is both more economically and statistically significant when σ_p^2 is low than when σ_p^2 is high, consistent with our theory.

Second, Remark 4 states (and Figure 1B shows) that in the presence of a public signal of the

due to definitional changes (such as changes in the base-year or changes in seasonal weights). Over our sample period, Industrial Production was the only announcement undergoing one such “uninformative” change, a base-year revision in February 1998. For a more detailed description of the RTDS dataset and its properties, see Croushore and Stark (2001).

²⁸By definition, the final published revision of an announcement represents the most accurate measure for the corresponding macroeconomic variable. The above procedure is motivated by the observation that these revisions can be interpreted as noise since they are predictable based on past information (e.g., Mork, 1987; Faust, Rogers, and Wright, 2003; Aruoba, 2004). Pasquariello and Vega (2006) find a more pronounced improvement in Treasury notes’ market liquidity when low noise announcements are released to the public.

²⁹E.g., Andersen and Bollerslev (1998), among others, label the Nonfarm Payroll report the “king” of announcements for its release has the most significant impact on most asset markets. For more on the special role played by Nonfarm Payroll announcements in financial markets, see Piazzesi et al. (2006).

traded assets' fundamentals (S_p), the decline in the resulting off/on-the-run liquidity differential is the greatest when information heterogeneity is the highest (ρ is lowest) among sophisticated investors in the venues when the latter are most numerous, i.e., in the Treasury notes' markets (as argued in Section 4.3). Intuitively, adverse selection is most severe in the off-the-run market (asset 1) when many speculators are most cautious (low ρ), hence the benefit of S_p 's availability for the market-makers is the greatest. We assess this argument by estimating Eq. (18) over the subset of days in our sample characterized by high (low) information heterogeneity, defined in Section 3.2 as days in which the average dispersion of professional forecasts of P announcements from the MMS database — SSD_{Pt} of Eq. (11) — is above (below) the top (bottom) 70th (30th) percentile of its empirical distribution. We then report the ensuing differences $\beta_{s0w}^{ann} - \beta_{s0w}^{noann}$ in Table 8 when $P = 7$ and ρ is either low (Panel A) or high (Panel B). Consistent with Remark 4 and Figure 1B, the estimated $\beta_{s0w}^{ann} - \beta_{s0w}^{noann}$ are larger and more often negative — i.e., off/on-the-run bid-ask spread differentials ΔS_t decline during announcement days — when speculators' beliefs are more heterogeneous (SSD_{Pt} is high, in Panel A), especially for longer-term bills and notes. Yet, since we are not cross-sorting announcement days by public signal noise (as in Table 7), most of these differences are again not statistically significant (as in Table 6). Qualitatively similar inference (not reported here) stems from $P = 1$ or 18.

Overall, the above evidence indicates that, as postulated by our theory, the availability of public signals of assets' terminal payoffs mitigates the on-the-run phenomenon in the Treasury market — which we model as and show to be related to auction-driven endowment uncertainty in Sections 2.1 and 4.2, respectively — by alleviating adverse selection among market participants.

5 Conclusions and Future Research

The existence of a negative liquidity differential between on-the-run and off-the-run securities is a pervasive and not fully understood feature of both domestic and international fixed income markets. The main goal of this paper is to deepen our understanding of the links between this important aspect of the on-the-run phenomenon, news about fundamentals, and order flow conditional on the investors' dispersion of beliefs and the public signals' noise.

To that end, we develop a parsimonious model of speculative trading in multiple assets in the presence of heterogeneously informed, imperfectly competitive traders, auction-driven endowment shocks identifying the on-the-run security from the off-the-run security, and a public signal of their identical terminal value. We then test its equilibrium implications by studying the determinants of daily differences in yields and in bid-ask spreads — a common and effective

measure of bond market liquidity — for on-the-run and off-the-run three-month, six-month, and one-year U.S. Treasury bills and two-year, five-year, and ten-year U.S. Treasury notes.

Our evidence indicates that *i*) the resulting off/on-the-run liquidity differentials are large, even after controlling for several differences in their intrinsic characteristics (such as duration, convexity, or repo rates), *ii*) their corresponding yield differentials are instead neither economically nor statistically significant, inconsistent with the illiquidity premium hypothesis, and *iii*) an economically meaningful portion of those liquidity differentials is linked to strategic trading activity in both security types. The nature of this linkage is sensitive to the uncertainty surrounding auction shocks and the economy, the intensity of investors' dispersion of beliefs, and the noise of the public announcement. In particular, and consistent with our model, off/on-the-run liquidity differentials are larger for bonds of shorter maturity, immediately following bond auction dates, when the dispersion of auction bids is higher, when fundamental uncertainty is greater, when the beliefs of sophisticated traders are more heterogeneous, in the absence of macroeconomic announcements or when the latter are noisier.

These findings suggest that any analysis of the on-the-run phenomenon, whether theoretical or empirical, cannot prescind from the endogenous determination of market liquidity in both the on-the-run and the off-the-run bonds. We believe this is an important implication for future research on this topic.

6 Appendix

Proof of Proposition 1. As noted in Section 2.1.2, the proof is by construction. We start by guessing that equilibrium p_{1i} and x_{ki} are given by $p_{1i} = A_{0i} + A_{1i}\omega_{1i}$ and $x_{ki} = B_{0i} + B_{1i}\delta_{vk} + C_{1i}e_{k2}$, respectively, where $A_{1i} > 0$ and $i = \{1, 2\}$. Those expressions and the definition of ω_{1i} imply that, for the k^{th} speculator,

$$E(p_{1i}|\delta_{vk}, e_{k2}) = A_{0i} + A_{1i}x_{ki} + A_{1i}B_{0i}(M-1) + A_{1i}B_{1i}(M-1)\rho\delta_{vk}. \quad (\text{A-1})$$

Using Eq. (A-1), the first order conditions of the maximization of the k^{th} speculator's expected utility $E_1^k(U_k)$ with respect to x_{k1} and x_{k2} are given by

$$p_0 + \delta_{vk} - A_{01} - (M+1)A_{11}B_{01} - 2A_{11}B_{11}\delta_{vk} - (M-1)A_{11}B_{11}\rho\delta_{vk} - 2A_{11}C_{11}e_{k2} = 0 \quad (\text{A-2})$$

$$p_0 + \frac{\gamma}{1-\gamma}A_{12}e_{k2} + \delta_{vk} - A_{02} - (M+1)A_{12}B_{02} \quad (\text{A-3})$$

$$-2A_{12}B_{12}\delta_{vk} - (M-1)A_{12}B_{12}\rho\delta_{vk} - 2A_{12}C_{12}e_{k2} = 0,$$

respectively. The second order conditions are satisfied, since $2A_{1i} > 0$. For Eqs. (A-2) and (A-3) to be true, it must be that

$$p_0 - A_{01} = (M + 1) A_{11} B_{01} \quad (\text{A-4})$$

$$2A_{11} B_{11} = 1 - (M - 1) A_{11} B_{11} \rho \quad (\text{A-5})$$

$$2A_{11} C_{11} = 0 \quad (\text{A-6})$$

$$p_0 - A_{02} = (M + 1) A_{12} B_{02} \quad (\text{A-7})$$

$$2A_{12} B_{12} = 1 - (M - 1) A_{12} B_{12} \rho \quad (\text{A-8})$$

$$2A_{12} C_{12} = \frac{\gamma}{1 - \gamma} A_{12}. \quad (\text{A-9})$$

Eqs. (A-6) and (A-9) imply that $C_{11} = 0$ and $C_{12} = \frac{1}{2} \frac{\gamma}{1 - \gamma}$. The distributional assumptions of Section 2.1 imply that the order flows ω_{11} and ω_{12} are normally distributed with means $E(\omega_{11}) = MB_{01}$ and $E(\omega_{12}) = MB_{02}$, and variances $var(\omega_{11}) = MB_{11}^2 \rho \sigma_v^2 [1 + (M - 1) \rho] + \sigma_z^2$ and $var(\omega_{12}) = MB_{12}^2 \rho \sigma_v^2 [1 + (M - 1) \rho] + \sigma_n^2$, respectively. Since $cov(v, \omega_{1i}) = MB_{1i} \rho \sigma_v^2$, it ensues that

$$E(v|\omega_{11}) = p_0 + \frac{MB_{11} \rho \sigma_v^2}{MB_{11}^2 \rho \sigma_v^2 [1 + (M - 1) \rho] + \sigma_z^2} (\omega_{11} - MB_{01}) \quad (\text{A-10})$$

$$E(v|\omega_{12}) = p_0 + \frac{MB_{12} \rho \sigma_v^2}{MB_{12}^2 \rho \sigma_v^2 [1 + (M - 1) \rho] + \sigma_n^2} (\omega_{12} - MB_{02}). \quad (\text{A-11})$$

According to the definition of a Bayesian-Nash equilibrium in this economy (Section 2.1.1), $p_{1i} = E(v|\omega_{1i})$. Therefore, our conjectures for p_{11} and p_{12} imply that

$$A_{01} = p_0 - MA_{11} B_{01} \quad (\text{A-12})$$

$$A_{11} = \frac{MB_{11} \rho \sigma_v^2}{MB_{11}^2 \rho \sigma_v^2 [1 + (M - 1) \rho] + \sigma_z^2} \quad (\text{A-13})$$

$$A_{02} = p_0 - MA_{12} B_{02} \quad (\text{A-14})$$

$$A_{12} = \frac{MB_{12} \rho \sigma_v^2}{MB_{12}^2 \rho \sigma_v^2 [1 + (M - 1) \rho] + \sigma_n^2}. \quad (\text{A-15})$$

The expressions for A_{0i} , A_{1i} , B_{0i} , and B_{1i} in Proposition 1 must solve the system made of Eqs. (A-4), (A-5), (A-7), (A-8), and (A12) to (A15) to represent a linear equilibrium. Defining $A_{11} B_{01}$ from Eq. (A-4) and $A_{12} B_{02}$ from Eq. (A-7), and plugging them into Eqs. (A-12) and (A-14), respectively, leads us to $A_{01} = A_{02} = p_0$. Thus, it must be that $B_{01} = B_{02} = 0$ to satisfy Eqs. (A-4) and (A-7). We are left with the task of finding A_{1i} and B_{1i} . Solving Eqs. (A-5) and (A-8) for A_{11} and A_{12} , respectively, we get

$$A_{11} = \frac{1}{B_{11} [2 + (M - 1) \rho]} \quad (\text{A-16})$$

$$A_{12} = \frac{1}{B_{12} [2 + (M - 1) \rho]}. \quad (\text{A-17})$$

Equating Eqs. (A-16) and (A-17) to Eqs. (A-13) and (A-15) respectively, it follows that $B_{11}^2 = \frac{\sigma_z^2}{M\rho\sigma_v^2}$ and $B_{12}^2 = \frac{\sigma_n^2}{M\rho\sigma_v^2}$, i.e. that $B_{11} = \frac{\sigma_z}{\sqrt{M\rho\sigma_v}}$ and $B_{12} = \frac{\sigma_n}{\sqrt{M\rho\sigma_v}}$. Substituting these expressions back into Eqs. (A-16) and (A-17) implies that $A_{11} = \frac{\sqrt{M\rho\sigma_v}}{\sigma_z[2+(M-1)\rho]}$ and $A_{12} = \frac{\sqrt{M\rho\sigma_v}}{\sigma_n[2+(M-1)\rho]}$. Finally, we observe that Proposition 1 is equivalent to a symmetric Cournot equilibrium with M speculators. Therefore, the “backward reaction mapping” introduced by Novshek (1984) to find n -firm Cournot equilibria proves that, given any linear pricing rule, the symmetric linear strategies x_{ki} of Eqs. (5) and (6) indeed represent the unique Bayesian Nash equilibrium of the Bayesian game among speculators. ■

Proof of Remark 1. The statement is immediate from the observation of Eq. (7). ■

Proof of Corollary 1. The on/off-the run liquidity spread $\Delta\lambda$ of Eq. (8) is positive since $\sigma_z^2 < \sigma_n^2$ for any $\gamma > 0$. Furthermore, $\frac{\partial\Delta\lambda}{\partial\gamma} = \frac{\sqrt{M\rho\sigma_v}\sigma_z^2}{\sigma_n^2\sigma_z^2[2+(M-1)\rho]^2} \frac{M\sigma_e^2\gamma}{4\sigma_n^2(1-\gamma)^3} > 0$, $\frac{\partial\Delta\lambda}{\partial\sigma_e} = \frac{\sqrt{M\rho\sigma_v}\sigma_z^2}{\sigma_n^2\sigma_z^2[2+(M-1)\rho]^2} \frac{M\gamma^2\sigma_e}{4\sigma_n(1-\gamma)^2} > 0$, and $\frac{\partial\Delta\lambda}{\partial\sigma_v} = \frac{\sqrt{M\rho}(\sigma_n-\sigma_z)}{\sigma_n\sigma_z[2+(M-1)\rho]} > 0$. ■

Proof of Remark 2. The statement stems from the fact that $\frac{\partial\Delta\lambda}{\partial\rho} = \frac{\sigma_v\sigma_n(\sigma_n-\sigma_z)[2-(M-1)\rho]}{2\sqrt{\rho}\sigma_n^2\sigma_z^2[2+(M-1)\rho]^2} \geq 0$ when $\rho \leq \frac{2}{M-1}$ and is negative otherwise. In particular, $\frac{\partial\Delta\lambda}{\partial\rho}$ is always positive when $M = 2$ or 3 since $\rho \in (0, 1]$. Furthermore, the greater is M the smaller is the subset of $\rho \in (0, 1]$ such that $\frac{\partial\Delta\lambda}{\partial\rho} > 0$. ■

Proof of Remark 3. The statement follows from the observation that, ceteris paribus for information, endowment, and liquidity shocks (i.e., such that both Δp_1^* and Δp_1 have the same sign), the sign of $\Delta p_1^* - \Delta p_1$ of Eq. (9) is equal to the sign of $-\Delta p_1$ — hence $|\Delta p_1^*| < |\Delta p_1|$ — since $\sigma_p^2 > \sigma_v^2$, $\rho^* \leq \rho$, and $\frac{\sqrt{\sigma_p^2 - \rho\sigma_v^2}}{\sigma_p} < 1$ imply that $\frac{\Delta p_1^*}{\Delta p_1} = \frac{[2\frac{\rho^*}{\rho} + (M-1)\rho^*]}{[2+(M-1)\rho^*]} \frac{\sqrt{\sigma_p^2 - \rho\sigma_v^2}}{\sigma_p} < 1$. Furthermore, it can be shown that $\frac{\partial\Delta p_1^* - \Delta p_1}{\partial\sigma_p}$ is of the same sign as Δp_1 for $\frac{\partial\rho^*}{\partial\sigma_p} = \frac{2\rho\sigma_p\sigma_v^2(1-\rho)}{(\sigma_p^2 - \rho\sigma_v^2)^2} \geq 0$, $\frac{\partial\sqrt{\sigma_p^2 - \rho\sigma_v^2}}{\partial\sigma_p} = \frac{\rho\sigma_v^2}{\sigma_p^2\sqrt{\sigma_p^2 - \rho\sigma_v^2}} > 0$, and $\frac{\partial\Delta p_1}{\partial\sigma_p} = 0$, i.e., that, again ceteris paribus for the shocks driving Δp_1 , $|\Delta p_1^* - \Delta p_1|$ is greater the smaller is σ_p . ■

Proof of Corollary 2. The first part of the statement stems from the fact that $\Delta\lambda^* - \Delta\lambda$ of Eq. (10) is negative since $\Delta\lambda^* = \frac{[2\frac{\rho^*}{\rho} + (M-1)\rho^*]}{[2+(M-1)\rho^*]} \frac{\sqrt{\sigma_p^2 - \rho\sigma_v^2}}{\sigma_p} \Delta\lambda$, $\Delta\lambda > 0$ (see the proof of Corollary 1), $\sigma_p^2 > \sigma_v^2$, $\rho^* \leq \rho$, and $\frac{\sqrt{\sigma_p^2 - \rho\sigma_v^2}}{\sigma_p} < 1$. Furthermore, it can be shown that $\frac{\partial\Delta\lambda^* - \Delta\lambda}{\partial\sigma_p} > 0$ for $\frac{\partial\rho^*}{\partial\sigma_p} = \frac{2\rho\sigma_p\sigma_v^2(1-\rho)}{(\sigma_p^2 - \rho\sigma_v^2)^2} \geq 0$, $\frac{\partial\sqrt{\sigma_p^2 - \rho\sigma_v^2}}{\partial\sigma_p} = \frac{\rho\sigma_v^2}{\sigma_p^2\sqrt{\sigma_p^2 - \rho\sigma_v^2}} > 0$, and $\frac{\partial\Delta\lambda}{\partial\sigma_p} = 0$. Lastly, $\lim_{\sigma_p \rightarrow \infty} \rho^* = \rho$ and $\lim_{\sigma_p \rightarrow \infty} \Delta\lambda^* = \Delta\lambda$. ■

Proof of Remark 4. The statement stems from the fact that $\frac{\partial \Delta \lambda^* - \Delta \lambda}{\partial \rho}$ can be shown to be a complex rational function of ρ whose highest nonnegative-integer power in the numerator (denominator) is 4 (2) and whose critical values are complex functions of M . In particular, algebraic analysis of $\frac{\partial \Delta \lambda^* - \Delta \lambda}{\partial \rho}$ shows that there exists only one stationary value $\rho \in (0, 1]$ for $\Delta \lambda^* - \Delta \lambda$ when M is either large or small ($M = 2$ or 3 , as in the proof of Remark 2), and an additional critical — either stationary or inflection (depending on M and σ_p^2) — value otherwise.

■

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Table 1A. U.S. Treasury Bills: Summary Statistics

This table presents the mean and standard deviation for several variables in the GovPX database of transactions in three-month, six-month, and one-year on-the-run and off-the-run Treasury bills between January 2, 1992 and December 29, 2000, their difference in means, and the correlation between daily yield and spread differentials, $\rho(\Delta Y_t, \Delta S_t)$. Yields are in percentage, bid-ask spreads are in basis points, and amounts auctioned are in billions of U.S. dollars. A “ * ”, “ ** ”, or “ *** ” indicates statistical significance at the 10%, 5%, or 1% level.

	Off-the-Run		On-the-Run		Difference in Mean
	Mean	Stdev.	Mean	Stdev.	
Three-Month					
Daily yield x 100: Y_t	5.166	0.606	5.193	0.609	-0.027***
Bid-ask spread x 10,000: S_t	0.291	0.240	0.120	0.067	0.171***
Convexity: C_t	0.0010	0.0001	0.0012	0.0001	-0.0002***
Duration: D_t	0.221	0.007	0.240	0.009	-0.019***
Total amount tendered			40.850	10.867	
Total amount accepted			12.308	1.689	
Range of competitive bids: HL_t			0.005	0.003	
$\rho(\Delta Y_t, \Delta S_t)$					-0.2454***
Six-Month					
Daily yield x 100: Y_t	5.388	0.578	5.402	0.581	-0.015***
Bid-ask spread x 10,000: S_t	0.260	0.172	0.130	0.057	0.130***
Convexity: C_t	0.0041	0.0005	0.0045	0.0004	-0.0004***
Duration: D_t	0.452	0.030	0.473	0.027	-0.021***
Total amount tendered			38.924	10.185	
Total amount accepted			12.332	1.277	
Range of competitive bids: HL_t			0.004	0.002	
$\rho(\Delta Y_t, \Delta S_t)$					-0.1729***
One-Year					
Daily yield x 100: Y_t	5.381	0.758	5.406	0.755	-0.025***
Bid-ask spread x 10,000: S_t	0.275	0.168	0.110	0.047	0.165***
Convexity: C_t	0.010	0.003	0.012	0.003	-0.002***
Duration: D_t	0.789	0.164	0.892	0.147	-0.102***
Total amount tendered			47.086	11.855	
Total amount accepted			17.266	2.056	
Range of competitive bids: HL_t			0.004	0.002	
$\rho(\Delta Y_t, \Delta S_t)$					-0.0546*

Table 1B. U.S. Treasury Notes: Summary Statistics

This table presents the mean and standard deviation for several variables in the GovPX database of transactions in two-year, five-year, and ten-year on-the-run and off-the-run Treasury notes between January 2, 1992 and December 29, 2000, their difference in means, and the correlation between daily yield and spread differentials, $\rho(\Delta Y_t, \Delta S_t)$. Yields are in percentage, bid-ask spreads are in basis points, and amounts auctioned are in billions of U.S. dollars. A “ * ”, “ ** ”, or “ *** ” indicates statistical significance at the 10%, 5%, or 1% level.

	Off-the-Run		On-the-Run		Difference in Mean
	Mean	Stdev.	Mean	Stdev.	
	Two-Year				
Daily yield x 100: Y_t	5.483	0.888	5.489	0.882	-0.006***
Bid-ask spread x 10,000: S_t	0.017	0.005	0.008	0.002	0.009***
Convexity: C_t	0.040	0.001	0.044	0.001	-0.003***
Duration: D_t	1.763	0.035	1.842	0.034	-0.080***
Total amount tendered			41.802	6.341	
Total amount accepted			18.300	1.844	
Range of competitive bids: HL_t			0.013	0.006	
$\rho(\Delta Y_t, \Delta S_t)$			0.150***		
	Five-Year				
Daily yield x 100: Y_t	5.974	0.747	5.960	0.754	0.014***
Bid-ask spread x 10,000: S_t	0.030	0.009	0.014	0.004	0.016***
Convexity: C_t	0.204	0.010	0.214	0.007	-0.010***
Duration: D_t	4.110	0.113	4.223	0.087	-0.113***
Total amount tendered			30.679	3.736	
Total amount accepted			12.914	1.830	
Range of competitive bids: HL_t			0.015	0.018	
$\rho(\Delta Y_t, \Delta S_t)$			0.2399***		
	Ten-Year				
Daily yield x 100: Y_t	6.525	0.688	6.497	0.687	0.027***
Bid-ask spread x 10,000: S_t	0.054	0.014	0.024	0.005	0.030***
Convexity: C_t	0.596	0.027	0.641	0.033	-0.045***
Duration: D_t	6.824	0.203	7.106	0.244	-0.283***
Total amount tendered			30.676	4.244	
Total amount accepted			13.385	2.093	
Range of competitive bids: HL_t			0.008	0.018	
$\rho(\Delta Y_t, \Delta S_t)$			0.055		

Table 2. Dispersion of Beliefs: Summary Statistics

This table presents summary statistics for the 18 MMS announcements in our sample (number of observations and source) and the standard deviation across the corresponding professional forecasts (mean, standard deviation, maximum, minimum, Spearman rank correlation with the Nonfarm Payroll standard deviation, $\rho(Payroll)$, and the first-order autocorrelation coefficient, $\rho(1)$). The sources are: Bureau of Labor Statistics (BLS), Bureau of the Census (BC), Bureau of Economic Analysis (BEA), Federal Reserve Board (FRB), National Association of Purchasing Managers (NAPM), Conference Board (CB), and Employment and Training Administration (ETA). A “ * ”, “ ** ”, or “ *** ” indicate the correlations’ significance at 10%, 5%, or 1% level, respectively.

	Obs.	Source	Mean	Stdev.	Max.	Min	$\rho(Payroll)$	$\rho(1)$
Quarterly Announcements								
1- GDP Advance	36	BEA	0.480	0.170	1.100	0.320	0.162*	-0.181
2- GDP Preliminary	34	BEA	0.313	0.178	1.290	0.120	0.014	0.192
3- GDP Final	35	BEA	0.128	0.051	0.240	0.040	0.083	0.250
Monthly Announcements								
<u>Real Activity</u>								
4- Nonfarm Payroll	108	BLS	41.814	14.212	103.190	17.496	1.000	0.424***
5- Retail Sales	107	BC	0.302	0.158	1.390	0.106	0.109	0.047
6- Industrial Production	107	FRB	0.183	0.135	1.700	0.087	0.236**	0.358***
<u>Consumption</u>								
7- New Home Sales	106	BC	19.270	10.235	96.225	7.840	0.151	0.099
<u>Investment</u>								
8- Durable Goods Orders	106	BC	1.034	0.333	2.583	0.450	0.077	0.412***
9- Factory Orders	105	BC	0.587	0.577	7.249	0.239	0.219**	0.015
10- Construction Spending	105	BC	0.499	0.253	1.270	0.158	0.176*	0.192***
<u>Net Exports</u>								
11- Trade Balance	107	BEA	0.790	0.851	11.480	0.400	0.122	0.018
<u>Prices</u>								
12- Producer Price Index	108	BLS	0.130	0.049	0.380	0.060	0.186*	0.287***
13- Consumer Price Index	107	BLS	0.086	0.051	0.580	0.040	0.146	0.221**
<u>Forward-Looking</u>								
14- Consumer Conf. Index	106	CB	1.646	0.609	4.026	0.663	0.079	0.230**
15- NAPM Index	107	NAPM	0.961	0.303	2.680	0.441	0.242**	0.382***
16- Housing Starts	106	BC	0.045	0.038	0.430	0.016	0.160	0.246***
17- Index of Leading Ind.	108	CB	0.202	0.137	0.920	0.044	0.134	0.480***
Weekly Announcements								
18- Initial Unemp. Claims	459	ETA	7.973	5.440	53.400	2.100	0.069	0.578***

Table 3. Benchmark On-The-Run Phenomenon

Panels A and B of this table report OLS estimates of the following regression models (Eqs. (12) and (13), respectively):

$$\Delta S_t = \beta_{s0} + \beta_{s1} \Delta D_t + \beta_{s2} \Delta C_t + \varepsilon_t$$

$$\Delta Y_t = \beta_{y0} + \beta_{y1} \Delta D_t + \beta_{y2} \Delta C_t + \varepsilon_t$$

where $\Delta S_t = S_t^{off} - S_t^{on}$ and $\Delta Y_t = Y_t^{off} - Y_t^{on}$ are the daily average off/on-the-run bid-ask spread and yield differentials, respectively, $\Delta D_t = D_t^{off} - D_t^{on}$ is the off/on-the-run modified duration differential, and $\Delta C_t = C_t^{off} - C_t^{on}$ is the off/on-the-run convexity differential. R_a^2 is the adjusted R^2 from the estimation of the fully specified regression above. A “*”, “**”, or “***” indicate significance at the 10%, 5%, or 1% level, respectively, using Newey-West standard errors.

	Panel A: ΔS_t					Panel B: ΔY_t				
	$\beta_{s0} \times 100$	β_{s1}	β_{s2}	R_a^2		$\beta_{y0} \times 100$	β_{y1}	β_{y2}	R_a^2	
Three-Month	0.1708***	0.2034***	0.0220	-0.5002	0.12%	-2.6925***	-1.2382***	0.7324	4.6170	1.26%
Six-Month	0.1297***	0.1375***	-0.0287	1.7725	-0.07%	-1.4654***	-0.7004***	-1.1089**	80.610*	0.87%
One-Year	0.1646***	0.1794***	-0.0113***	0.547***	2.81%	-2.4802***	0.8895	-0.8062**	48.698**	4.40%
Two-Year	0.0087***	0.0040	0.0005	-0.0267	1.13%	-0.6253***	-1.1613	-5.4738***	131.93***	12.36%
Five-Year	0.0161***	0.0126***	0.0005**	-0.0095***	14.80%	1.4494***	-1.5909***	-0.3509***	0.9313	52.43%
Ten-Year	0.0298***	0.0362***	0.0004***	-0.0014*	6.18%	2.7305***	1.3247***	-0.0911**	0.2598	5.32%

Table 4A. Auction Effect: Off/On-The-Run Bid-Ask Spread Differential

This table reports OLS estimates of the following regression model (Eq. (14)):

$$\Delta S_t = \beta_{s0} + \sum_{i=1}^N \beta_{s0i} Auction_{t-i} + \beta_{s1} \Delta D_t + \beta_{s2} \Delta C_t + \varepsilon_t$$

where $\Delta S_t = S_t^{off} - S_t^{on}$ is the daily average off/on-the-run bid-ask spread differential, $\Delta D_t = D_t^{off} - D_t^{on}$ is the off/on-the-run modified duration differential, and $\Delta C_t = C_t^{off} - C_t^{on}$ is the off/on-the-run convexity differential, $Auction_{t-i}$ is a dummy variable equal to one on day t if day $t - i$ is the most recent auction date for the corresponding bond and equal to zero otherwise. We assume $N = 4$ for three-month and six-month bills and $N = 10$ for all other bonds. R_a^2 is the adjusted R^2 from the estimation of the fully specified regression above. A “*” , “**” , or “***” indicate significance at the 10%, 5%, or 1% level, respectively, using Newey-West standard errors.

	Three-Month	Six-Month	One-Year	Two-Year	Five-Year	Ten-Year
β_{s0} x 100	0.2521***	0.1499***	0.1970***	0.0064**	0.0145***	0.0365***
β_{s01} x 100	-0.0894***	-0.057***	-0.0750***	-0.004***	-0.0051***	-0.0105***
β_{s02} x 100	-0.0514***	-0.0264***	-0.0714***	-0.0024***	-0.0035***	-0.0048**
β_{s03} x 100	0.0033	-0.0073	-0.053***	-0.002***	-0.0046***	-0.0085***
β_{s04} x 100	0.045***	0.0312***	-0.0595***	-0.0028***	-0.0039***	-0.0017
β_{s05} x 100			-0.0472***	-0.0023***	-0.0033***	-0.0005
β_{s06} x 100			-0.0376***	-0.0021***	-0.0024***	0.0005
β_{s07} x 100			-0.0293**	-0.001**	-0.0005	-0.0052***
β_{s08} x 100			-0.0178	-0.0003	-0.0027***	-0.0046**
β_{s09} x 100			-0.0114	-0.0011***	-0.0031***	-0.0042
β_{s10} x 100			-0.0095	-0.001***	-0.0023***	-0.0052**
β_{s1}	0.0861	-0.0265	-0.0093***	0.0027***	0.0006**	0.0004***
β_{s2}	-5.8171	1.6171	0.4509**	-0.0748***	-0.0099***	-0.0012
R_a^2	4.89%	3.04%	5.32%	10.20%	21.36%	7.93%

Table 4B. Auction Effect: Off/On-The-Run Yield Differential

This table reports OLS estimates of the following regression model (Eq. (14)):

$$\Delta Y_t = \beta_{y0} + \sum_{i=1}^N \beta_{yi} Auction_{t-i} + \beta_{y1} \Delta D_t + \beta_{y2} \Delta C_t + \varepsilon_t$$

where $\Delta Y_t = Y_t^{off} - Y_t^{on}$ is the daily average off/on-the-run yield differential, $\Delta D_t = D_t^{off} - D_t^{on}$ is the off/on-the-run modified duration differential, $\Delta C_t = C_t^{off} - C_t^{on}$ is the off/on-the-run convexity differential, and $Auction_{t-i}$ is a dummy variable equal to one on day t if day $t - i$ is the most recent auction date for the corresponding bond and equal to zero otherwise. We assume $N = 4$ for three-month and six-month bills and $N = 10$ for all other bonds. R_a^2 is the adjusted R^2 from the estimation of the fully specified regression above. A “*” , “**” , or “***” indicate significance at the 10%, 5%, or 1% level, respectively, using Newey-West standard errors.

	Three-Month	Six-Month	One-Year	Two-Year	Five-Year	Ten-Year
$\beta_{y0} \times 100$	-2.1232**	-0.9429**	1.5334	-1.3362	-1.254***	0.4819
$\beta_{y01} \times 100$	-0.1153	-0.0675	-1.9533***	0.9717**	-0.6525***	-1.0921**
$\beta_{y02} \times 100$	-0.326	-0.2113	-1.9222***	1.1793***	-0.5864***	-0.6409
$\beta_{y03} \times 100$	-0.2828	-0.3378	-1.8576**	0.9721**	-0.4862**	-0.5795
$\beta_{y04} \times 100$	-0.1849	-0.5548***	-1.4656*	1.3509***	-0.4703**	-0.6425
$\beta_{y05} \times 100$			-1.1884	1.2485***	-0.4415**	-0.6396
$\beta_{y06} \times 100$			-1.2204*	1.2703***	-0.4026*	-0.5471
$\beta_{y07} \times 100$			-1.3029*	1.2555***	-0.2346	-0.5307
$\beta_{y08} \times 100$			-1.2639*	1.1268***	-0.1757	-0.6042
$\beta_{y09} \times 100$			-1.1038	1.183***	-0.1931	-0.4715
$\beta_{y10} \times 100$			-1.4632**	1.0196***	-0.1763	-0.452
β_{y1}	-0.7409	0.6593	-0.7275**	-6.6487***	-0.3563***	0.2062***
β_{y2}	104.91	-26.886	44.643**	161.71***	1.2279	-2.0834***
R_a^2	0.54%	0.58%	4.96%	14.82%	57.96%	18.10%

Table 5. Further Determinants of the Off/On-The-Run Bid-Ask Spread Differential

This table reports OLS estimates of the coefficient β_{s3} from the following regression model (Eq. (16)):

$$\Delta S_t = \beta_{s0} + \sum_{i=1}^N \beta_{s0i} Auction_{t-i} + \beta_{s1} \Delta D_t + \beta_{s2} \Delta C_t + \beta_{s3} X_t + \varepsilon_t$$

where $\Delta S_t = S_t^{off} - S_t^{on}$ is the daily average off/on-the-run bid-ask spread differential, $\Delta D_t = D_t^{off} - D_t^{on}$ is the off/on-the-run modified duration differential, $\Delta C_t = C_t^{off} - C_t^{on}$ is the off/on-the-run convexity differential, $Auction_{t-i}$ is a dummy variable equal to one on day t if day $t - i$ is the most recent auction date for the corresponding bond and equal to zero otherwise, and $X_t = HL_t$, the competitive yield range, Ten_t , the amount tendered in the corresponding auction, Acc_t , the amount accepted at that auction, or Vol_t , the Eurodollar implied volatility. We assume $N = 4$ for three-month and six-month bills and $N = 10$ for all other bonds. R_a^2 is the adjusted R^2 from the estimation of the fully specified regression above. A “*” , “**” , or “***” indicate significance at the 10%, 5%, or 1% level, respectively, using Newey-West standard errors.

	Three-Month	Six-Month	One-Year	Two-Year	Five-Year	Ten-Year
X_t	β_{s3}	β_{s3}	β_{s3}	β_{s3}	β_{s3}	β_{s3}
HL_t	3.0594***	12.545***	12.109***	0.0227	-0.0057	-0.0634**
R_a^2	6.61%	5.41%	10.02%	10.45%	22.01%	8.50%
Ten_t	-0.0050***	-0.0012**	-0.0027***	-0.0001***	-0.0003***	-0.0002**
R_a^2	12.07%	3.64%	9.66%	14.05%	24.35%	8.33%
Acc_t	-0.0201***	-0.0079**	-0.0162***	-0.0004***	0.0005**	0.0005**
R_a^2	7.70%	3.45%	9.62%	15.27%	23.55%	8.32%
Vol_t	0.0041	0.0043**	0.0024**	0.0002***	0.0003***	0.0003***
R_a^2	5.44%	3.99%	5.66%	16.34%	30.69%	8.86%
HL_t	-1.2610	10.232**	9.7235***	-0.0284	-0.0159**	0.0387
Ten_t	-0.0062***	-0.0007	0.0002	-0.0002***	-0.0003***	-0.0001
Acc_t	-0.0147***	-0.0092**	-0.0110***	-0.0002**	0.0010***	0.0008***
Vol_t	0.0087***	0.0059***	0.0032***	0.0003***	0.0004***	0.0003***
R_a^2	16.07%	7.13%	12.33%	27.87%	37.74%	9.49%

Table 6. Macroeconomic Announcements and the On-The-Run Phenomenon

Panels A and B of this table report OLS estimates of the differences $(\beta_{s0w}^{ann} - \beta_{s0w}^{noann}) \times 100$ and $(\beta_{y0w}^{ann} - \beta_{y0w}^{noann})$ from the following regression models (Eqs. (18) and (19), respectively):

$$\begin{aligned} \Delta S_t &= Ann_t \sum_{w=1}^5 \beta_{s0w}^{ann} d_{tw} + (1 - Ann_t) \sum_{d=1}^5 \beta_{s0w}^{noann} d_{tw} + \beta_{s1} \Delta D_t + \beta_{s2} \Delta C_t + \varepsilon_t \\ \Delta Y_t &= Ann_t \sum_{w=1}^5 \beta_{y0w}^{ann} d_{tw} + (1 - Ann_t) \sum_{w=1}^5 \beta_{y0w}^{noann} d_{tw} + \beta_{y1} \Delta D_t + \beta_{y2} \Delta C_t + \varepsilon_t \end{aligned}$$

where Ann_t is a dummy variable equal to one if any of the 7 influential announcements listed in Section 3.2 ($P = 7$) is released on day t and equal to zero otherwise, d_{tw} are day-of-the-week dummy variables, from $w = 1$ (Monday) to 5 (Friday), $\Delta S_t = S_t^{off} - S_t^{on}$ and $\Delta Y_t = Y_t^{off} - Y_t^{on}$ are the daily average off/on-the-run bid-ask spread and yield differentials, respectively, $\Delta D_t = D_t^{off} - D_t^{on}$ is the off/on-the-run modified duration differential, and $\Delta C_t = C_t^{off} - C_t^{on}$ is the off/on-the-run convexity differential. A “*” , “**” , or “***” indicate significance of the F -statistic for the corresponding difference at the 10%, 5%, or 1% level, respectively, using Newey-West standard errors.

	Panel A: $(\beta_{s0w}^{ann} - \beta_{s0w}^{noann}) \times 100$					Panel B: $(\beta_{y0w}^{ann} - \beta_{y0w}^{noann})$				
	Monday	Tuesday	Wednesday	Thursday	Friday	Monday	Tuesday	Wednesday	Thursday	Friday
Three-Month	2.589	-3.357*	1.158	8.652***	1.277	1.007	0.515	0.775	-0.364	-0.303
Six-Month	0.843	-0.784	1.401	6.570***	5.233***	2.909***	-0.103	0.501	-0.596	-1.434***
One-Year	0.876	-0.468	-0.444	5.705***	-0.024	-0.448	-0.429	0.146	-4.226***	0.251
Two-Year	-0.116***	-0.002	-0.013	0.066	0.054	0.943**	-0.568**	-0.043	-2.066***	0.506*
Five-Year	0.016	0.044	0.093*	0.106	0.070	0.114	-0.257	0.043	-0.709**	0.128
Ten-Year	0.111	0.042	0.086	0.478**	0.181	0.705	0.370	0.333	1.005	-0.152

Table 7. Public Signal Noise and the On-The-Run Phenomenon

This table reports OLS estimates of the differences $(\beta_{s0w}^{ann} - \beta_{s0w}^{noann}) \times 100$ and $(\beta_{y0w}^{ann} - \beta_{y0w}^{noann})$ from the following regression models (Eqs. (18) and (19)):

$$\begin{aligned} \Delta S_t &= Ann_t \sum_{w=1}^5 \beta_{s0w}^{ann} d_{tw} + (1 - Ann_t) \sum_{d=1}^5 \beta_{s0d}^{noann} d_{tw} + \beta_{s1} \Delta D_t + \beta_{s2} \Delta C_t + \varepsilon_t \\ \Delta Y_t &= Ann_t \sum_{w=1}^5 \beta_{y0w}^{ann} d_{tw} + (1 - Ann_t) \sum_{d=1}^5 \beta_{y0d}^{noann} d_{tw} + \beta_{y1} \Delta D_t + \beta_{y2} \Delta C_t + \varepsilon_t \end{aligned}$$

where Ann_t is a dummy variable equal to one if Industrial Production news are released on day t and equal to zero otherwise, d_{tw} are day-of-the-week dummy variables, from $w = 1$ (Monday) to 5 (Friday), $\Delta S_t = S_t^{off} - S_t^{on}$ and $\Delta Y_t = Y_t^{off} - Y_t^{on}$ are the daily average off/on-the-run bid-ask spread and yield differentials, respectively, $\Delta D_t = D_t^{off} - D_t^{on}$ is the off/on-the-run modified duration differential, and $\Delta C_t = C_t^{off} - C_t^{on}$ is the off/on-the-run convexity differential. Both Eqs. (18) and (19) are estimated separately in days in which the noise surrounding the announcements listed above is high (Panels A and C) and low (Panels B and D) for each of the bills and notes in our sample. Specifically, we measure public signal noise as the absolute difference between each initial announcement and its last revision. We then label the corresponding announcement days as characterized by high (low) noise when that difference is in the top (bottom) 70th (30th) percentile of its empirical distribution. A “*”, “**”, or “***” indicate significance of the F -statistic for the corresponding difference at the 10%, 5%, or 1% level, respectively, using Newey-West standard errors.

Table 7 (Continued).

	Panel A: $(\beta_{s0w}^{ann} - \beta_{s0w}^{noann}) \times 100$ when σ_p^2 is high					Panel B: $(\beta_{s0w}^{ann} - \beta_{s0w}^{noann}) \times 100$ when σ_p^2 is low				
	Monday	Tuesday	Wednesday	Thursday	Friday	Monday	Tuesday	Wednesday	Thursday	Friday
Three-Month	27.815***	-3.043	-7.649***	-5.276	-3.811	-16.532***	-1.546	2.225	-20.171***	3.786
Six-Month	-10.239***	-2.192	-5.855***	-6.201***	-5.387	-10.552***	1.982	-1.144	-4.905***	3.369
One-Year	12.470***	10.802	8.390	7.178**	8.518*	-6.378***	-1.793	0.853	-10.333***	5.423
Two-Year	0.129	-0.127	0.385***	-0.255***	-0.005	0.010	0.150	-0.112	-0.097***	-0.072
Five-Year	0.209	0.095	0.343	-0.078	-0.007	0.036	-0.030	-0.290*	-0.190***	0.063
Ten-Year	-1.022**	0.307	1.283	0.204	-0.360	-0.459	-0.021	0.417	-0.757***	0.422
	Panel C: $(\beta_{y0w}^{ann} - \beta_{s0w}^{noann})$ when σ_p^2 is high					Panel D: $(\beta_{y0w}^{ann} - \beta_{s0w}^{noann})$ when σ_p^2 is low				
	Monday	Tuesday	Wednesday	Thursday	Friday	Monday	Tuesday	Wednesday	Thursday	Friday
Three-Month	0.215	1.183	0.531	-1.759**	-0.026	5.180***	1.928*	-1.429	0.755**	0.412
Six-Month	0.213	-0.170	0.232	2.362***	-1.102*	0.832***	-0.402	0.714	-0.504	0.869
One-Year	-4.369***	5.916	2.032	-1.868	-3.037	-1.743**	-1.269	0.188	-1.878**	-1.664
Two-Year	-0.392	2.197**	-0.249	0.381	0.396	-1.869***	-0.381	0.737	-0.338	-0.737
Five-Year	-1.213	-0.301	0.853	2.185***	1.890*	-1.626*	-0.266	0.521	-1.273**	-0.138
Ten-Year	0.471	0.112	0.785	2.098	0.568	0.221	1.132	0.570	-0.406	-0.829

Table 8. Public Signal, Information Heterogeneity, and the On-The-Run Phenomenon

This table reports OLS estimates of the differences $(\beta_{s0w}^{ann} - \beta_{s0w}^{noann}) \times 100$ from the following regression model (Eq. (18)):

$$\Delta S_t = Ann_t \sum_{w=1}^5 \beta_{s0w}^{ann} d_{tw} + (1 - Ann_t) \sum_{d=1}^5 \beta_{s0w}^{noann} d_{tw} + \beta_{s1} \Delta D_t + \beta_{s2} \Delta C_t + \varepsilon_t$$

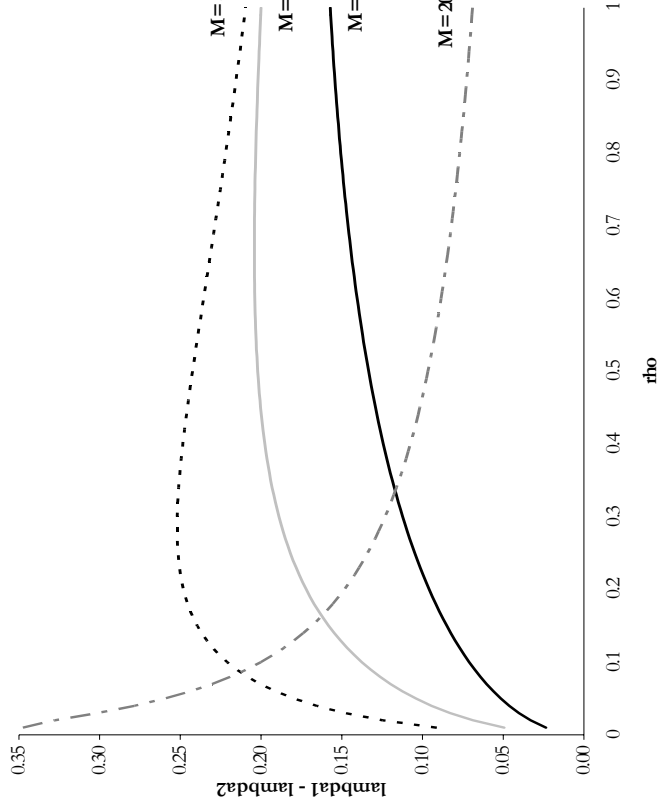
where Ann_t is a dummy variable equal to one if either Capacity Utilization, Industrial Production, or Nonfarm Payroll Employment is released on day t and equal to zero otherwise, d_{tw} are day-of-the-week dummy variables, from $w = 1$ (Monday) to 5 (Friday), $\Delta S_t = S_t^{off} - S_t^{on}$ is the daily average off/on-the-run bid-ask spread differential, $\Delta D_t = D_t^{off} - D_t^{on}$ is the off/on-the-run modified duration differential, and $\Delta C_t = C_t^{off} - C_t^{on}$ is the off/on-the-run convexity differential. Eq. (18) is estimated separately in days in which information heterogeneity among speculators is high (ρ is low, in Panels A and C) and low (ρ is high, in Panels B and D) for each of the bills and notes in our sample. Specifically, we define high (low) information heterogeneity days as days in which the monthly variable $SSDP_t$ of Eq. (11) is above (below) the top (bottom) 70th (30th) percentile of its empirical distribution when $P = 7$ (see Section 3.2). A “*”, “**”, or “***” indicate significance of the F -statistic for the corresponding difference at the 10%, 5%, or 1% level, respectively, using Newey-West standard errors.

	Panel A: $(\beta_{s0w}^{ann} - \beta_{s0w}^{noann}) \times 100$ when ρ is low					Panel B: $(\beta_{s0w}^{ann} - \beta_{s0w}^{noann}) \times 100$ when ρ is high				
	Monday	Tuesday	Wednesday	Thursday	Friday	Monday	Tuesday	Wednesday	Thursday	Friday
Three-Month	-2.826	-2.423	3.974	2.041	-2.748	2.869	-5.990	1.307	-0.030	-5.410
Six-Month	13.643	-1.528	1.023	2.674	-7.876	-2.224	-0.479	2.130	3.994	3.944
One-Year	-6.519	-0.670	-0.521	-2.585	-4.158	2.154	-1.284	0.702	0.082	0.229
Two-Year	-0.176**	0.082	-0.117	0.026	0.114	-0.070	0.046	0.026	0.058	0.023
Five-Year	0.000	0.189*	0.064	0.005	0.216*	0.074	-0.015	0.210*	0.032	-0.200
Ten-Year	-0.001	-0.057	-0.113	-0.255	0.070	0.326	0.473	0.097	-0.007	0.277

Figure 1. On/Off-The-Run Liquidity Differential without and with a Public Signal

Figure 1A plots the off/on-the-run liquidity differential $\Delta\lambda = \lambda_1 - \lambda_2$ in the equilibrium of Proposition 1, in the absence of a public signal of both asset 1 and 2's liquidation value v , defined in Eq. (8), as a function of ρ , the degree of correlation of the speculators' private signals, when $M = 2, 4, 8, \text{ or } 200$, $\sigma_v = \sigma_u = \sigma_e = 1$, and $\gamma = 0.5$. Figure 1B plots the difference between the on/off-the-run liquidity differential in the presence of a public signal of v and the differential plotted in Figure 1A, i.e., $\Delta\lambda^* - \Delta\lambda$ of Eq. (10), again as a function of ρ , when, in addition to the parametrization in Figure 1A, $\sigma_p = 1.5$.

A) $\Delta\lambda$



B) $\Delta\lambda^* - \Delta\lambda$

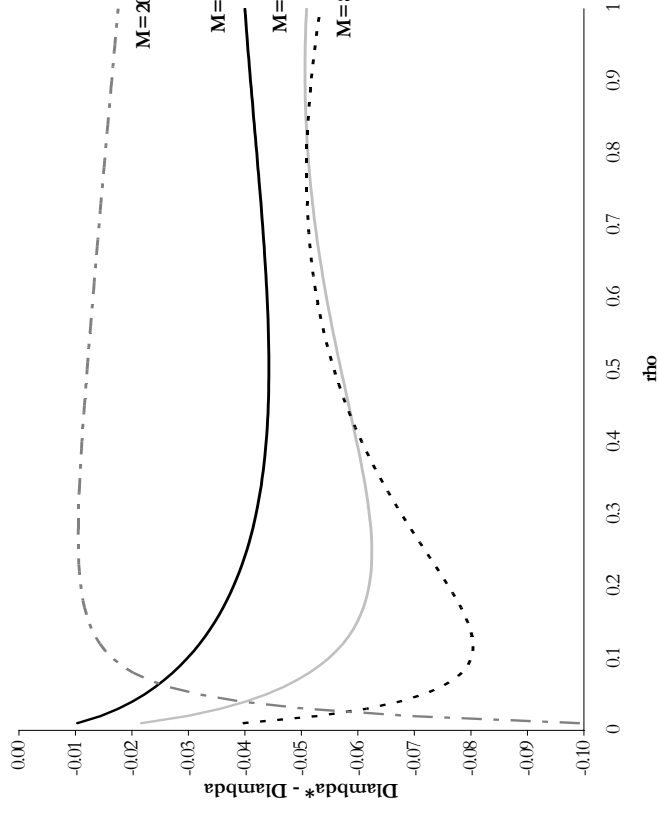


Figure 2. Historical On/Off-The-Run Bid-Ask Spread and Yield Differentials

In this figure, we plot weekly averages of daily off/on-the-run bid-ask spread differentials ($\Delta S_t = S_t^{off} - S_t^{on}$, solid line, left axis) and yield differentials ($\Delta Y_t = Y_t^{off} - Y_t^{on}$, gray line, right axis) over the sample period 1992-2000 for three-month, six-month, and one-year bills, and two-year, five-year, and ten-year notes.

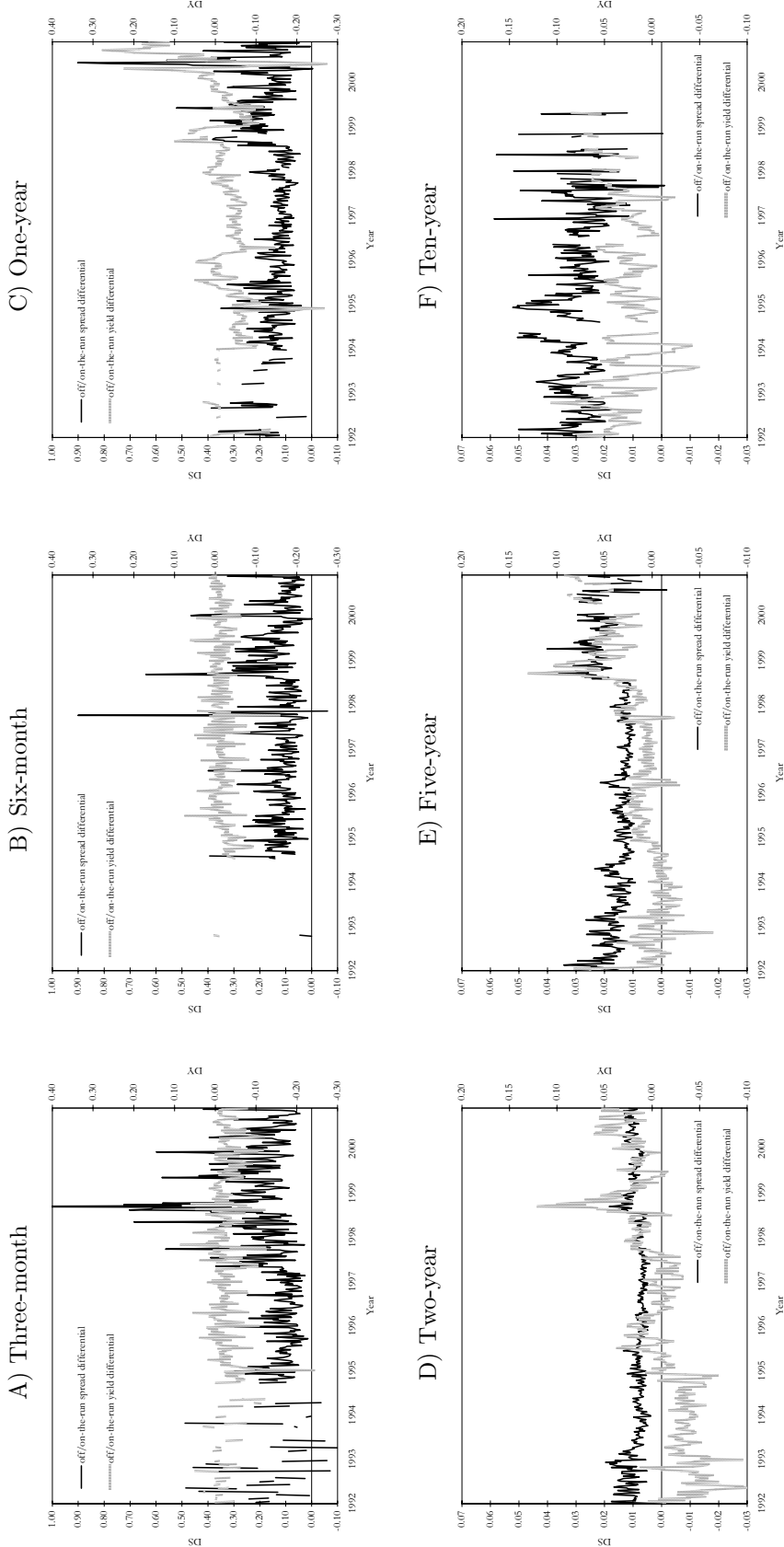


Figure 3. Information Heterogeneity and the Off/On-The-Run Bid-Ask Spread Differential

In this figure, we plot sums of coefficients $\beta_{sh} + \beta_{shi} \times 100$ (solid line), $\beta_{sm} + \beta_{smi} \times 100$ (gray line), and $\beta_{sl} + \beta_{sli} \times 100$ (dotted line) from the estimation of the following regression model (Eq. (17)):

$$\begin{aligned} \Delta S_t = & \beta_{sh} \times D_{ht} + \beta_{sl} \times D_{lt} + \beta_{sm} \times (1 - D_{ht} - D_{lt}) + \beta_{s1}(D_t^{off} - D_t^{on}) + \\ & \beta_{s2}(C_t^{off} - C_t^{on}) + \sum_{i=1}^N \beta_{shi} Auction_{t-i} \times D_{ht} + \\ & \sum_{i=1}^N \beta_{sli} Auction_{t-i} \times D_{lt} + \sum_{i=1}^N \beta_{smi} Auction_{t-i} \times (1 - D_{ht} - D_{lt}) + \varepsilon_t \end{aligned}$$

where $\Delta S_t = S_t^{off} - S_t^{on}$ is the daily average off/on-the-run bid-ask spread differential, $\Delta D_t = D_t^{off} - D_t^{on}$ is the off/on-the-run modified duration differential, $\Delta C_t = C_t^{off} - C_t^{on}$ is the off/on-the-run convexity differential, $Auction_{t-i}$ is a dummy variable equal to one on day t if day $t - i$ is the most recent auction date for the corresponding bond and equal to zero otherwise, D_{ht} (D_{lt}) is a dummy variable equal to one on days with high (low) information heterogeneity, defined in Section 3.2 as days in which the monthly variable SSD_{Pt} of Eq. (11) is above (below) the top (bottom) 70th (30th) percentile of its empirical distribution, and equal to zero otherwise, and $P = 18$, for each of the bills and notes in our sample. We assume $N = 4$ for three-month and six-month bills and $N = 10$ for all other bonds.

