A Preferred-Habitat Model of Term Structure with Dealer Market Power

Percy (Xuhui) Chen *

December 10, 2025

ABSTRACT

The repo market finances approximately 90% of Dealers' Treasury holdings. Recent evidence documents substantial dealer market power in this market. This paper examines how this market power shapes the term structure of interest rates and monetary policy transmission. I develop a preferred-habitat model in which dealers monopolistically compete for short-term funding to finance carry trades in long-term bonds. Market power in the funding market enables dealers to strategically restrict their carry positions and extract higher spreads between bond returns and funding costs, thereby generating elevated bond risk premia. I show analytically that this mechanism amplifies the sensitivity of risk premia to the yield curve slope and strengthens the transmission of monetary policy shocks to long-term yields. Empirically, I construct a measure of dealer market power using the Herfindahl-Hirschman Index (HHI) of repo borrowing concentration from money market funds. Consistent with the model's predictions, higher repo market concentration is positively associated with elevated term premia (both in ex-ante expectations and in ex-post realized bond returns), larger Fama-Bliss coefficients, and greater sensitivity of long-term yields to short-rate shocks. These findings reveal that dealer market power in the repo market plays a crucial role in shaping bond risk premia and the transmission of monetary policy through the yield curve.

Keywords: Monetary Policy, Market Power, Bond Risk Premia, Term Structure of Interest Rates

*xuhui.chen@sauder.ubc.ca, Sauder School of Business, University of British Columbia. I am deeply grateful to Adlai Fisher and Lorenzo Garlappi for their invaluable guidance and long-standing support. I am also sincerely thankful to Isha Agarwal, Paul Beaudry, Jack Favilukis, and Kai Li for their excellent advice.

I. Introduction

The preferred-habitat framework of Vayanos and Vila (2021), which has emerged as the leading theory of the term structure, explains bond prices and monetary policy transmission through dealers' carry trades from short-term funding markets to long-term bonds. A standard assumption is that dealers take funding costs as given, unaffected by their own trading. This assumption holds only under perfect competition where dealers are price-takers. However, growing evidence shows that financial intermediaries exhibit substantial market power in funding markets and strategically internalize how their borrowing affects rates to maximize profits (Drechsler, Savov, and Schnabl, 2017; Huber, 2023).

Violating the price-taking assumption fundamentally changes monetary policy transmission. The deposit channel (Drechsler et al., 2017) shows that banks with market power optimally restrict deposit-taking and widen loan-deposit spreads when rates rise, amplifying monetary transmission. Treasury markets exhibit similar features: dealers exhibit market power over money market funds in repurchase agreement (repo) borrowing (Huber, 2023) and finance most Treasury holdings through repos (Fleming, Nguyen, and Rosenberg, 2008). Similarly to the deposit channel, market power in repo markets may affect how dealers adjust their carry trade positions to monetary policy changes, propagating shocks through the term structure. Yet while this market power has been shown crucial for bank lending, its role in shaping the term structure remains unexplored.

I develop a preferred-habitat model that incorporates monopolistic competition among dealers in repo markets, endogenizing an upward-sloping supply curve for repo financing. The model delivers a tractable affine term structure while introducing a novel rent extraction channel. In line with Drechsler et al. (2017), dealers with market power strategically restrict their carry trades to avoid higher funding costs, extracting rents proportional to the policy rate. Dealers' carry trade decisions thus incorporate this rent opportunity. When the short rate moves, the rent opportunity changes proportionally, inducing dealers to adjust positions more aggressively than under perfect competition. This mechanism has three main implications for bond markets and monetary policy transmission.

First, dealer market power predicts higher bond risk premia. Just as banks with market power strategically restrict deposit taking to widen loan-deposit spreads, dealers with market power optimally restrict their carry trades to earn higher spreads between bond returns and funding costs, that is, higher bond risk premia. The magnitude of this rent extraction effect increases in market power.

Empirically, I measure dealer market power using the Herfindahl-Hirschman Index of repo borrowing concentration from money market funds. HHI exhibits a correlation of 0.72 with the 10-year term premium from Adrian, Crump, and Moench (2013), explaining over half the variation with an adjusted R^2 of 0.51. In predictive regressions of bond excess returns, a one standard deviation increase in dealer concentration predicts 3.2 percentage point higher one-year excess returns on 10-year bonds.

Second, dealer market power amplifies the sensitivity of bond returns to the yield curve slope (Fama and Bliss, 1987). In the standard preferred-habitat model, a steeper yield curve predicts higher excess returns because dealers must absorb more long-term bonds from preferred-habitat investors. Market power strengthens this channel: when short rates fall and the yield curve steepens, the rent opportunity from restricting trades diminishes proportionally, inducing dealers to expand positions more aggressively than under perfect competition. This amplifies the term premium response to yield curve slope changes. Empirically, I estimate Fama-Bliss regressions with interactions between dealer market power and yield curve slope. Moving up one decile in dealer concentration raises the Fama-Bliss coefficient by approximately 0.3 to 1 depending on maturity. Controlling for dealer market power substantially improves model fit, increasing adjusted R^2 by around 0.2 across maturities.

Third, dealer market power amplifies forward rate sensitivity to short-rate shocks. When policy rates rise, the rent opportunity increases proportionally with the short rate, strengthening dealers' incentive to cut carry positions beyond what standard duration risk considerations alone would imply. This leads to larger declines in long-term bond prices, corresponding to higher sensitivity of forward rates to short rate changes and generating excess sensitivity of long-term yields to policy shocks, particularly at modest maturities. The maturity profile of this amplification either declines monotonically or exhibits a U-shape, depending on the demand elasticity of preferred-habitat investors. Using daily Treasury data, I find that forward rates exhibit significantly greater sensitivity to short rate changes during periods of high dealer concentration, with patterns closely matching the model's predictions. This pattern proves robust across multiple specifications, including analyses based on all trading days, FOMC announcement days only, and monetary policy surprises identified from Fed funds futures.

Finally, I use the calibrated model to analyze implications for monetary policy effectiveness. Dealer market power amplifies both forward guidance and quantitative easing effects on the term structure. In the case of forward guidance, the standard preferred-habitat model predicts yield underreaction because dealers demand higher risk premia when absorbing additional bonds as rates fall. Market

power substantially reduces this underreaction: as the rent opportunity diminishes with declining short rates, dealers expand carry trades more aggressively, strengthening policy pass-through to long rates. Similarly, quantitative easing becomes more effective under market power. When the central bank reduces bond supply through asset purchases, dealers face lower funding costs due to reduced repo borrowing, providing an additional incentive to expand carry trades. This amplifies the upward pressure on bond prices and generates larger yield declines than under perfect competition.

This paper contributes to several strands of literature. First, it extends the preferred-habitat framework for understanding the term structure of interest rates. The canonical model of Vayanos and Vila (2021) provides a tractable equilibrium framework in which risk-averse arbitrageurs intermediate between segmented markets, generating rich implications for how shocks propagate through the yield curve. This framework has proven remarkably successful beyond Treasury markets, providing a foundation for analyzing asset pricing in mortgage-backed securities (e.g., Hanson, 2014; Malkhozov, Mueller, Vedolin, and Venter, 2016), foreign exchange (Gourinchas, Ray, and Vayanos, 2025), corporate bonds (Cavaleri, 2023), and interest rate swaps (Khetan, Li, Neamțu, and Sen, 2023). Within the repo market context, He, Nagel, and Song (2022) employ this framework to examine how frictions affect Treasury prices during the COVID-19 crisis. However, none of these studies incorporate dealer market power in funding markets. My contribution is to introduce this empirically well-documented feature into the preferred-habitat framework and analyze its implications for bond pricing and monetary policy transmission. Importantly, by preserving the affine structure of bond prices, the model maintains analytical tractability while incorporating a realistic intermediary friction. I expect this framework to prove useful for broader applications, as researchers could readily adopt this market power mechanism to understand how the market power shapes asset prices in their respective contexts.

Second, the idea of this paper connects to prior research on imperfect competition in financial intermediation. The deposit channel of Drechsler et al. (2017) demonstrates that intermediary market power fundamentally shapes monetary policy transmission: banks with market power optimally restrict deposit taking to widen loan-deposit spreads when policy rates rise, amplifying transmission to the real economy. This pioneering insight has inspired extensive research on banking market power and monetary policy (e.g., Xiao, 2020; Wang, Whited, Wu, and Xiao, 2022). However, these studies focus on deposit and lending markets, leaving unexplored how intermediary market power affects the term structure of interest rates. Motivating this extension, Huber (2023) document substantial dealer

market power in repo markets, arising from money market funds' concentration aversion when allocating cash across dealers. As repo markets serve as the primary funding source for dealers' Treasury holdings (Fleming et al., 2008), this finding suggests a natural parallel to the deposit channel in bond markets: just as banks intermediate between depositors and borrowers, dealers intermediate between money market funds and bond markets through repo financing. My contribution is to integrate this market power mechanism from the banking literature into term structure theory and show that it has important implications for bond pricing and monetary policy transmission.

Third, the paper contributes to understanding the oversensitivity of long-term rates to short rate changes, a well-documented puzzle (e.g., Hanson and Stein, 2015; Hanson, Lucca, and Wright, 2021). A growing literature explains this within the preferred-habitat framework by assuming short-rate shocks positively correlate with supply shocks from preferred-habitat investors (e.g., Hanson, 2014; Malkhozov et al., 2016; Hanson et al., 2021; Carboni and Ellison, 2022). However, as Greenwood, Hanson, and Vayanos (2023) note, this mechanism is equivalent to assuming that preferred-habitat investors have downward-sloping demand curves with respect to yields, that is, $\alpha(\tau) < 0$ in my model. This conflicts with the positive relationship between bond risk premia and yield curve slope (Fama and Bliss, 1987), which requires $\alpha(\tau) > 0$. My model bridges this gap by introducing dealer market power as a complementary mechanism that generates yield oversensitivity while preserving $\alpha(\tau) > 0$. The rent extraction channel amplifies dealers' response to short-rate shocks: when policy rates rise, the rent opportunity increases proportionally, inducing dealers to cut positions more aggressively than under perfect competition. This generates excess sensitivity at modest maturities while maintaining the positive relation between term premia and yield curve slope. The model predicts that both forward rate sensitivity and Fama-Bliss coefficients increase with dealer market power, a pattern strongly supported by the data.

The rest of the paper proceeds as follows. Section II presents the model. Section III tests the model's predictions. Section IV examines implications for monetary policy effectiveness. Section V concludes.

II. Model

A. Setup

Money market. To provide institutional context, I begin by describing the key features of the repo market. A repurchase agreement (repo) is a collateralized short-term loan where one party temporarily sells Treasury securities to another with an agreement to repurchase them at a specified price, with the price difference determining the repo rate. Treasury dealers are the main cash borrowers, using repo financing to fund their bond inventories, while money market funds (MMFs) are the dominant cash lenders. Importantly, Huber (2023) document that MMFs exhibit concentration aversion when allocating cash across dealers. Consequently, MMFs simultaneously accept different repo rates from different dealers, with dealer identity driving persistent cross-sectional rate dispersion. This concentration aversion gives dealers market power. The Federal Reserve's Overnight Reverse Repurchase Agreement (ON-RRP) facility serves as a crucial outside option for MMFs. Through this facility, the Fed stands ready to borrow cash overnight at a pre-announced rate with Treasury collateral, effectively setting a floor on repo rates since MMFs would not lend to dealers below this risk-free rate.

I now turn to the formal model. Time t is continuous and infinite, $t \in [0, \infty)$. There are overlapping generations of repo market lenders and repo-financing arbitrageurs that live for a period of length dt. For convenience, I refer to these repo market lenders as *lenders* and the repo-financing arbitrageurs as *dealers* in the rest of the paper. At each point in time, there is one lender generation and continuum of dealers indexed by $i \in [0,1]$. At each time t, the lender chooses the amount of investment $D_{i,t}$ that goes to the dealer $i \in [0,1]$, with the interest rate $r_{i,t}$ determined endogenously in equilibrium. The opportunity cost of cash investment is r_t, which is the return of the outside option that is directly under the control of the Federal Reserve. Following Huber (2023), I assume the lender has concentration aversion for investments in dealers but not for investment in the outside option. The lender's problem at time t is given by:

$$\max_{\{D_{i,t}\}} \left(\int_0^1 (D_{i,t} r_{i,t} dt)^{1-\frac{1}{\eta}} di \right)^{\frac{1}{1-\frac{1}{\eta}}} - D_t r_t dt, \text{ where } D_t = \int_0^1 D_{i,t} di \tag{1}$$

where $D_{i,t} r_{i,t} dt$ is the payoff from cash investment to dealer i at time $t + dt$. Similar to Drechsler et al. (2017), lenders' utility from repo investment is given by a constant elasticity of substitution (CES)

aggregator across payoffs from different dealers, with $\eta \in (0,\infty)$ the elasticity of substitution. The substitution elasticity parameter η captures the strength of concentration aversion and plays a crucial role in determining dealers' market power. As $\eta \to 0$, concentration aversion becomes extreme: lenders have near-Leontief preferences and must allocate cash nearly evenly across dealers regardless of rates, making them unresponsive to rate competition and giving dealers strong market power. A higher η implies lenders are more willing to tilt investment toward dealers offering higher rates. In the limit $\eta \to \infty$, investments become perfectly substitutable, lenders concentrate all funds with the highest-rate dealer, and the repo market becomes perfectly competitive. Following the financial intermediation literature (e.g., Drechsler et al., 2017), I assume $1 < \eta < \infty$ so that lendings to different dealers are imperfect substitutes.

To solve the lender's optimization problem, I proceed in two steps. First, given the total investment D_t, the lender determines the optimal allocation of cash across dealers to maximize utility from private repo investments. Second, given the interest rates $\{r_{i,t}\}$ and r_t, the lender selects the optimal total investment D_t to maximize overall utility. In the first step, the lender takes the interest rates $\{r_{i,t}\}$ and total investment D_t as given and solves the following optimization problem:

$$\max_{\{D_{i,t}\}} \left(\int_0^1 (D_{i,t} r_{i,t})^{1-\frac{1}{\eta}} di \right)^{\frac{1}{1-\frac{1}{\eta}}}, \quad \text{subject to } \int_0^1 D_{i,t} di = D_t. \tag{2}$$

The following proposition characterizes the optimal allocation across dealers.

Proposition 1 (**Optimal Allocation Across Dealers**): *Given the total investment D_t and private repo rates $\{r_{i,t}\}$, the optimal cash investment to dealer i is*

$$D_{i,t} = \left(\frac{r_{i,t}}{r_{d,t}} \right)^{\eta-1} D_t, \tag{3}$$

where $r_{d,t}$ is the aggregate private repo rate given by the CES average of individual repo rates $\{r_{i,t}\}$:

$$r_{d,t} \equiv \left(\int_0^1 r_{i,t}^{\eta-1} di \right)^{\frac{1}{\eta-1}}. \tag{4}$$

The elasticity of repo funding supply with respect to repo rate $r_{i,t}$ is

$$\nu_i \equiv \frac{\partial \ln D_{i,t}}{\partial \ln r_{i,t}} = \eta - 1 \equiv \frac{1}{\mathscr{M}}. \tag{5}$$

The proof of Proposition 1 is provided in Appendix A.1. The parameter ν_i measures the elasticity of repo funding supply to dealer i with respect to his repo rate $r_{i,t}$. A lower η leads to a lower elasticity ν_i, indicating that the lender is less responsive to rate competition among dealers. Therefore, I define $\mathscr{M} \equiv \frac{1}{\eta-1}$ to measure dealers' market power in setting repo rates, as a higher $\mathscr{M}$ indicates the lender is less sensitive to rate competition among dealers. The aggregate private repo rate $r_{d,t}$ represents the effective return of the total investment D_t in the private repo market. The lender's problem in equation (1) can hence be rewritten as

$$\max_{D_t} D_t r_{d,t} - D_t r_t. \tag{6}$$

The first-order condition implies that the aggregate private repo rate $r_{d,t}$ must equal the outside option rate r_t, i.e., $r_{d,t} = r_t$. The lender is willing to invest any amount of cash D_t in the private repo market as long as dealers offer an aggregate repo rate $r_{d,t}$ that equals the outside option rate r_t. Finally, to close the money market, I assume the outside option return r_t follows an exogenous process:

$$dr_t = \kappa_r(\bar{r} - r_t)dt + \sigma_r dB_{r,t} \tag{7}$$

where $\kappa_r > 0$ is the speed of mean reversion, $\bar{r}$ is the long-run mean, $\sigma_r > 0$ is the volatility, and $\{B_{r,t} : 0 \le t < \infty\}$ is a standard Brownian motion.

Bond market. The bond market follows a standard one-demand-factor version of the preferred-habitat model in Vayanos and Vila (2021). To cleanly highlight the role of dealer market power in the repo market, I consider a parsimonious specification with only interest rate risk. At each time t, there is a continuum of zero-coupon, default-free bonds with face value one that mature at time $t+\tau$ where $\tau \in (0, T]$. I denote the time-t price of the bond that matures at $t+\tau$ by $P_t^{(\tau)}$. The yield of the bond with maturity τ at time t is

$$y_t^{(\tau)} \equiv -\frac{\log\left(P_t^{(\tau)}\right)}{\tau}, \tag{8}$$

and the forward rate between maturities $\tau - \Delta\tau$ and τ at time t is

$$f_t^{(\tau-\Delta\tau,\tau)} \equiv \frac{\log P_t^{(\tau-\Delta\tau)} - \log P_t^{(\tau)}}{\Delta\tau}. \tag{9}$$

Following Vayanos and Vila (2021), I consider an exogenous demand curve from preferred-habitat investors for bonds with different maturities. The dollar value of bond holdings by preferred-habitat investors with maturity τ at time t is denoted by $H_t^{(\tau)}$, given by

$$H_t^{(\tau)} = -\alpha(\tau)\log P_t^{(\tau)} - \theta_0(\tau), \tag{10}$$

where $\alpha(\tau) > 0$ is a maturity-dependent constant that captures the price elasticity of habitat investors for bonds with maturity τ, and $\theta_0(\tau)$ is the demand intercept.

Dealers' problem. The dealer sector consists of a continuum of dealers indexed by $i \in [0,1]$. Following Vayanos and Vila (2021) and He et al. (2022), there are overlapping generations of dealers living over infinitesimal periods. The generation born at time t engages in repo-financed carry trades from t to $t+dt$. Specifically, they borrow short-term funds through repos at rate $r_{i,t}$ and invest in longer-term bonds, consume at $t+dt$, and then die. Therefore, they maximize a mean–variance objective over instantaneous changes in wealth:

$$\max_{\{X_{i,t}^{(\tau)}\}_{\tau\in[0,T]}} \mathbb{E}_t\left[dW_{i,t}\right] - \frac{\gamma}{2}\mathrm{Var}_t\left[dW_{i,t}\right] \tag{11}$$

where the wealth change over the period $[t, t+dt]$ is

$$dW_{i,t} = \int_0^T X_{i,t}^{(\tau)}\left(\frac{dP_t^{(\tau)}}{P_t^{(\tau)}} - r_{i,t}dt\right)d\tau \tag{12}$$

where $X_{i,t}^{(\tau)}$ is the dollar amount borrowed through repos at rate $r_{i,t}$ to invest in bonds with maturity τ. Notably, the dealer's repo rate $r_{i,t}$ endogenously depends on his bond holdings through an upward-sloping supply curve of repo funding derived from the lender's optimal allocation in Proposition 1.

B. Equilibrium

I focus on the symmetric monopolistic competition equilibrium in which individual dealers employ the same strategy. In aggregate, the dealer sector has $X_t^{(\tau)} = X_{i,t}^{(\tau)}$ amount of direct Treasury holdings with maturity τ and finances the total bond holding $X_t = \int_0^T X_t^{(\tau)} d\tau$ by borrowing $D_t = D_{i,t}$ from the money market lender at the repo rate $r_{d,t} = r_{i,t}$.

Definition 1 (**Symmetric Monopolistic Competition Equilibrium**): *A symmetric monopolistic competition equilibrium is an allocation* $\{D_t, X_t^{(\tau)}, \{D_{i,t}, X_{i,t}^{(\tau)}\}_{i\in[0,1]}\}_{\tau\in[0,T]}$ *and prices* $\{P_t^{(\tau)}, r_{d,t}, \{r_{i,t}\}_{i\in[0,1]}\}_{\tau\in[0,T]}$ *such that the following conditions hold:*

1. *The allocation and repo rate setting are symmetric across dealers:* $D_{i,t} = D_t$, $X_{i,t}^{(\tau)} = X_t^{(\tau)}$, *and* $r_{i,t} = r_{d,t}$ *for all* $i \in [0,1]$.
2. *Given the prices and bond holdings of all other dealers (hence the aggregate dealer bond holding* $X_t^{(\tau)}$ *and repo rate* $r_{d,t}$*), for each dealer* $i \in [0,1]$*, the bond holding* $X_{i,t}^{(\tau)} = X_t^{(\tau)}$ *solves the dealer's problem in equation* (11).
3. *The aggregate repo rate* $r_{d,t}$ *solves the lender's problem, i.e.,* $r_{d,t} = r_t$.
4. *The repo market clears:* $D_t = \int_0^T X_t^{(\tau)} d\tau$.
5. *The bond market clears:* $X_t^{(\tau)} + H_t^{(\tau)} = 0$.

Under this equilibrium definition, I can solve for the equilibrium bond prices $\{P_t^{(\tau)}\}_{\tau=0}^T$. The rational expectation of each dealer i is that all other dealers follow a symmetric strategy $r_{i',t} = r_{d,t} = r_t$, $X_{i',t}^{(\tau)} = X_t^{(\tau)}$ for all $i' \neq i$, and hence the aggregate dealer bond holding is $X_t \equiv \int_0^T X_t^{(\tau)} d\tau$.

The key innovation of this paper is to incorporate dealers' market power in setting repo borrowing rates through the lender's optimal allocation in Proposition 1. Therefore, different from the standard preferred-habitat model in Vayanos and Vila (2021) where dealers take short rates as given, here the funding cost for dealer i endogenously depends on his bond holding $X_{i,t} = \int_0^T X_{i,t}^{(\tau)} d\tau$. I first characterize the supply curve of repo funding for an individual dealer i. Substituting symmetric equilibrium conditions $r_{d,t} = r_t$, $D_t = X_t$, and the repo market clearing condition $D_{i,t} = X_{i,t}$ into equation (3), I obtain the funding cost for dealer i as a function of his bond holding:

$$r_{i,t} = r_t \left(\frac{X_{i,t}}{X_t}\right)^{\frac{1}{\eta-1}}, \tag{13}$$

where r_t and X_t are taken as given by dealer i. This implies that the elasticity of dealer i's repo rate with respect to his bond holding is

$$\frac{\partial \ln r_{i,t}}{\partial \ln X_{i,t}} = \frac{1}{\eta - 1} = \mathscr{M}. \tag{14}$$

I then conjecture that equilibrium yields are affine in the risk factor r_t. That is, there exist two functions $A_r(\tau)$ and $C(\tau)$ that depend only on τ such that the time-t price of the bond with maturity τ is

$$P_t^{(\tau)} = e^{-[A_r(\tau) r_t + C(\tau)]}. \tag{15}$$

Ito's lemma implies

$$\frac{dP_t^{(\tau)}}{P_t^{(\tau)}} = \mu_t^{(\tau)} dt - A_r(\tau) \sigma_r dB_{r,t} \tag{16}$$

where $\mu_t^{(\tau)}$ is the expected return of bonds with maturity τ at time t, given by

$$\mu_t^{(\tau)} \equiv A_r'(\tau) r_t + A_r(\tau) \kappa_r (r_t - \bar{r}) + \frac{1}{2} A_r(\tau)^2 \sigma_r^2 + C'(\tau). \tag{17}$$

Dealer i's problem can be rewritten as

$$\max_{\{X_{i,t}^{(\tau)}\}_{\tau \in [0,T]}} \int_0^T X_{i,t}^{(\tau)} \left(\mu_t^{(\tau)} - r_{i,t} \right) d\tau - \frac{1}{2} \gamma \sigma_r^2 \left(\int_0^T X_{i,t}^{(\tau)} A_r(\tau) d\tau \right)^2 \tag{18}$$

where dealer i's repo rate $r_{i,t}$ is endogenously determined by his bond holding through the supply curve in equation (13). The first-order condition of the dealer's problem in equation (18) is

$$\mu_t^{(\tau)} - r_{i,t} = \gamma \sigma_r^2 A_r(\tau) \int_0^T X_{i,t}^{(u)} A_r(u) du + \frac{\partial r_{i,t}}{\partial X_{i,t}^{(\tau)}} \int_0^T X_{i,t}^{(u)} du. \tag{19}$$

This condition generalizes the first-order condition in the standard preferred-habitat model by incorporating the dealer's market power in setting repo rates. The left-hand side is the expected excess return of bonds with maturity τ. The right-hand side consists of two components. The first component captures the risk compensation for interest rate risk. The second component captures the rent that dealers extract from their market power in setting the repo rate. To hold bonds with maturity τ, the

dealer has to pay a higher repo rate due to his larger bond holding, leading to an additional funding cost. Using equation (13), this rent term becomes

$$\frac{\partial r_{i,t}}{\partial X_{i,t}^{(\tau)}} \int_0^T X_{i,t}^{(u)} du = \frac{\partial r_{i,t}}{\partial X_{i,t}} X_{i,t} = \mathscr{M} r_{i,t}, \tag{20}$$

which is proportional to the market power $\mathscr{M}$ and the current repo rate $r_{i,t}$. When $\mathscr{M} = 0$, this rent term vanishes, as dealers are price takers in the repo market. Finally, applying the symmetric equilibrium conditions $r_{i,t} = r_t$ and $X_{i,t}^{(\tau)} = X_t^{(\tau)}$ for all $i \in [0,1]$ yields the first-order condition in symmetric equilibrium.

Lemma 1 (**Dealer's First-Order Condition in Symmetric Equilibrium**): *The dealer's first-order condition in symmetric equilibrium is*

$$\mu_t^{(\tau)} - r_t = -A_r(\tau)\lambda_{r,t} + \mathscr{M} r_t \tag{21}$$

where $\lambda_{r,t}$ is the price of interest rate risk, given by

$$\lambda_{r,t} \equiv -\gamma \sigma_r^2 \int_0^T X_t^{(u)} A_r(u) du \tag{22}$$

and $\mathscr{M} \equiv \frac{1}{\eta - 1}$ measures dealers' market power in setting repo rates.

The coefficient $-A_r(\tau)$ represents the sensitivity of bond returns to short rate risk. In this sense, it can be interpreted as the factor loading (or beta) of the τ-maturity bond with respect to interest rate risk. The term $\lambda_{r,t}$ is the corresponding price of risk, which is endogenously determined by the aggregate dealer sector's bond holdings. The left-hand side of the first-order condition in Lemma 1 captures the expected marginal payoff from carrying one additional unit of the τ-year bond, while the right-hand side represents the associated marginal cost. The first component on the right-hand side, $-A_r(\tau)\lambda_{r,t}$, corresponds to the risk compensation required for bearing interest rate risk. The second term, $\mathscr{M} r_t$, is the increased funding cost when dealers borrow more cash to finance their bond holdings. In other words, this is the "avoided cost" (hence benefit, or rent) by reducing the carry position. Therefore, this term in the term premium captures the rent arising from dealers' market power in the funding market. Moreover, this rent is increasing in both dealers' market power $\mathscr{M}$ and the policy rate r_t. This is consistent with Drechsler et al. (2017), where banks in the deposit market

with market power strategically reduce deposit supply to extract rents from loan-deposit spreads, with the magnitude of rent increasing in both market power and the fed funds rate. In my model, dealers with market power optimally channel less funding from the money market to the bond market and hence earn a higher spread between the bond's expected return and their funding cost. The effect is more pronounced when dealers have greater market power (higher $\mathscr{M}$) or when the policy rate r_t is elevated. The market clearing condition in the bond market requires that dealers' bond holdings equal the negative of habitat investors' demand in equation (10):

$$X_t^{(\tau)} = \theta_0(\tau) - \alpha(\tau)(A_r(\tau)r_t + C(\tau)). \tag{23}$$

Substituting the expected bond return in equation (17) and the bond market clearing condition in equation (23) into the dealer's first-order condition in Lemma 1, I obtain the following equation that must hold for all r_t:

$$\begin{aligned} A_r'(\tau)r_t + A_r(\tau)\kappa_r(r_t - \bar{r}) + \frac{1}{2}A_r(\tau)^2\sigma_r^2 + C'(\tau) - (1+\mathscr{M})r_t \\ - A_r(\tau)\left[\gamma\sigma_r^2\int_0^T (\theta_0(u) - \alpha(u)[A_r(u)r_t + C(u)])A_r(u)du\right] = 0 \end{aligned} \tag{24}$$

As this equation is affine in r_t, equating the coefficients on both sides of equation (24) yields a system of ordinary differential equations (ODEs) for $A_r(\tau)$ and $C(\tau)$:

$$A_r(\tau)(\kappa_r + \Omega_{rr}) + A_r'(\tau) = (1+\mathscr{M}) \tag{25}$$

$$C'(\tau) + \frac{1}{2}\sigma_r^2 A_r(\tau)^2 - A_r(\tau)\kappa_r\bar{r} - A_r(\tau)\Omega_r = 0 \tag{26}$$

where

$$\Omega_{rr} \equiv \gamma\sigma_r^2\int_0^T \alpha(u)A_r^2(u)du \tag{27}$$

$$\Omega_r \equiv \gamma\sigma_r^2\int_0^T (\theta_0(u) - \alpha(u)C(u))A_r(u)du. \tag{28}$$

The boundary conditions are $A_r(0) = 0$ and $C(0) = 0$ since the price of a bond that matures immediately must be one. The following proposition solves for the equilibrium yield curve analytically.

Proposition 2 (**Equilibrium Yield Curve**): *The functions $A_r(\tau)$ and $C(\tau)$ are*

$$A_r(\tau) = \frac{(1+\mathscr{M})(1-e^{-\kappa_r^*\tau})}{\kappa_r^*} \tag{29}$$

$$C(\tau) = \kappa_r^*\bar{r}^* \int_0^\tau A_r(u)du - \frac{\sigma_r^2}{2}\int_0^\tau A_r(u)^2 du \tag{30}$$

where the scalars κ_r^* and $\bar{r}^*$ are the risk-neutral counterparts of the speed of mean reversion and long-run mean of the short rate process respectively, given by the solutions to the following fixed point equations:

$$\kappa_r^* = \kappa_r + \gamma\sigma_r^2(1+\mathscr{M})^2 \int_0^T \alpha(\tau)\left(\frac{1-e^{-\kappa_r^*\tau}}{\kappa_r^*}\right)^2 d\tau \tag{31}$$

$$\begin{aligned}\bar{r}^* = \bar{r} + \gamma\sigma_r^2 \Bigg(& (1+\mathscr{M})\int_0^\infty [\theta_0(\tau) - (1+\mathscr{M})\bar{r}\alpha(\tau)\tau]\frac{1-e^{-\kappa_r^*\tau}}{\kappa_r^*}d\tau \\ & + \frac{\sigma_r^2}{2}(1+\mathscr{M})^3 \int_0^\infty \alpha(\tau)\left[\int_0^\tau \left(\frac{1-e^{-\kappa_r^* u}}{\kappa_r^*}\right)^2 du\right]\frac{1-e^{-\kappa_r^*\tau}}{\kappa_r^*}d\tau\Bigg) \\ & \Bigg/\left(\kappa_r^*\left[1+\gamma\sigma_r^2(1+\mathscr{M})^2\int_0^\infty \alpha(\tau)\left[\int_0^\tau \frac{1-e^{-\kappa_r^* u}}{\kappa_r^*}du\right]\frac{1-e^{-\kappa_r^*\tau}}{\kappa_r^*}d\tau\right]\right).\end{aligned} \tag{32}$$

The proof of Proposition 2 is provided in Appendix A.2.

C. Results

I now discuss the main results of the model. To illustrate these results, I complement the analytical findings with numerical analysis. I first calibrate the model in Section II.C.1, then discuss the model's core mechanism in Section II.C.2, examine its implications for bond risk premia in Section II.C.3, and finally analyze its effects on monetary policy transmission in Section II.C.4.

C.1. Calibration

I calibrate the model to match key moments of the U.S. Treasury nominal yield curve over the period from January 2011 to September 2025. To establish a benchmark, I first calibrate the model with $\mathscr{M} = 0$, corresponding to the classical preferred-habitat model of Vayanos and Vila (2021) under perfect competition. I then analyze how variations in dealer market power $\mathscr{M}$ affect the yield curve, term premium, and other key equilibrium outcomes.

The calibration proceeds in three stages. First, I specify the demand structure of preferred-habitat investors following Vayanos and Vila (2021). I adopt their functional form $\alpha(\tau) = \alpha e^{-\delta_\alpha \tau}$ for the demand

slope and use their parameter values: $\delta_\alpha = 0.297$ and $\alpha = 5.21$, where the latter is based on the estimate from Krishnamurthy and Vissing-Jorgensen (2012). Following standard practice in the literature, I assume the demand intercept is proportional to the demand slope, $\theta_0(\tau) = \theta_0 \alpha(\tau)$, where θ_0 is a scalar to be calibrated.

Second, I calibrate the parameters governing short-rate dynamics ($\bar{r}$, σ_r, κ_r) using moments of the 1-year yield, which is most sensitive to short-rate fluctuations. Specifically, I set the mean short rate $\bar{r}$ to match the average 1-year yield $\mathbb{E}[y_t^{(1)}]$ in the data. The volatility parameter σ_r is chosen to match the monthly standard deviation of the 1-year yield $\sigma(y_t^{(1)})$. The mean-reversion parameter κ_r is calibrated to match the volatility of the annual change in the 1-year yield $\sigma(\Delta y_t^{(1)})$.

Finally, I jointly calibrate the bond supply intercept θ_0 and arbitrageur risk aversion γ to match the slope of the yield curve. I target two key term spread moments: the 20-year spread $\mathbb{E}[y_t^{(20)} - y_t^{(1)}]$ and the 30-year spread $\mathbb{E}[y_t^{(30)} - y_t^{(1)}]$. The identification strategy exploits the fact that the slope of the yield curve primarily reflects the risk premia demanded by arbitrageurs for bearing duration risk, which depends on both the overall bond supply θ_0 and the risk aversion parameter γ (Greenwood and Vayanos, 2014). Table 1 presents the calibrated parameter values and the model's performance in matching the targeted moments.

Table 1. Benchmark Model Calibration

	Description	Value	Moment	Target	Model
$\bar{r}$	mean short rate	0.012	$\mathbb{E}[y_t^{(1)}]$	1.59%	1.60%
σ_r	std. dev. short rate	0.03	$\sigma(y_t^{(1)})$	1.74%	1.73%
κ_r	mean rev. short rate	0.131	$\sigma(\Delta y_t^{(1)})$	1.23%	1.25%
θ_0	intercept of bond supply	1.712	$\mathbb{E}[y_t^{(20)} - y_t^{(1)}]$	1.53%	1.55%
γ	arb. risk aversion	1.275	$\mathbb{E}[y_t^{(30)} - y_t^{(1)}]$	1.72%	1.69%
α	habitat price elast.	5.21	KVJ (2012)	–	–
δ_α	habitat price elast. slope	0.297	VV(2021)	–	–
$\mathscr{M}$	market power	0	–	–	–

Notes: This table reports the calibrated parameter values and the model's fit to targeted moments. Δ denotes annual change and σ denotes monthly standard deviation. KVJ (2012) and VV(2021) refer to Krishnamurthy and Vissing-Jorgensen (2012) and Vayanos and Vila (2021), respectively.

C.2. Rent Extraction and Dealers' Carry Trade

The core mechanism through which market power affects the yield curve operates through strategic rent extraction by dealers. To understand this mechanism, recall from equation (21) that dealers' equilibrium condition equates the marginal revenue from carry trading, $\mu_t^{(\tau)} - r_t$, to the marginal cost

of holding bonds, which comprises duration risk compensation $-A_r(\tau)\lambda_{r,t}$ and the rent term $\mathscr{M} r_t$.

The rent term $\mathscr{M} r_t$ captures a distinctive feature of imperfect competition: by restricting their carry positions, dealers can earn profits beyond the compensation for bearing duration risk. Specifically, this term represents the marginal increase in funding costs dealers would incur by expanding their carry positions. Equivalently, it reflects the profit margin they obtain by strategically limiting their bond holdings. Under perfect competition ($\mathscr{M} = 0$), dealers take prices as given and this margin vanishes. With market power ($\mathscr{M} > 0$), however, dealers internalize that expanding their positions raises their borrowing costs. By strategically restricting carry trades, they capture rents in the form of avoided funding cost escalation. The magnitude of these rents, measured by $\mathscr{M} r_t$, therefore quantifies dealers' incentive to limit their carry trading activity. When this rent increases, dealers optimally reduce their bond holdings to extract higher profits.

To build intuition for this mechanism, I rearrange the dealer's first-order condition in equation (21):

$$\underbrace{\mu_t^{(\tau)} - r_t}_{\text{risk premia}} - \underbrace{\left(-A_r(\tau)\lambda_{r,t}\right)}_{\text{duration risk compensation}} = \underbrace{\mathscr{M} r_t}_{\text{funding rent}} . \tag{33}$$

Consider a partial equilibrium setting where market power $\mathscr{M}$ increases and dealers must rebalance their carry positions $X_t^{(\tau)}$ accordingly, holding all other variables fixed. When market power $\mathscr{M}$ rises, the funding rent on the right-hand side increases, strengthening dealers' incentive to restrict carry trading. To satisfy this equilibrium condition with higher rent, the left-hand side must also increase. Dealers respond by reducing their carry positions, which depresses bond prices and raises expected returns $\mu_t^{(\tau)}$, thereby widening the spread between bond returns and funding costs. This directly increases the first term on the left-hand side. Moreover, by reducing carry positions, dealers lower the price of interest rate risk $\lambda_{r,t}$ through the holdings channel, which decreases the duration risk compensation component $-A_r(\tau)\lambda_{r,t}$ and further raises the left-hand side. Dealers optimally reduce their carry positions until the increase in the left-hand side exactly matches the increase in the funding rent on the right-hand side. Therefore, an increase in market power $\mathscr{M}$ leads to a new equilibrium characterized by higher rents $\mathscr{M} r_t$, lower carry positions $X_t^{(\tau)}$, higher risk premia $\mu_t^{(\tau)} - r_t$, and lower compensation for duration risk $-A_r(\tau)\lambda_{r,t}$.

Figure 1, Panel A illustrates this mechanism by plotting the marginal effect of market power on dealers' carry positions, $\frac{\partial X_t^{(\tau)}}{\partial \mathscr{M}}$, across different maturities and demand slope parameters. The figure

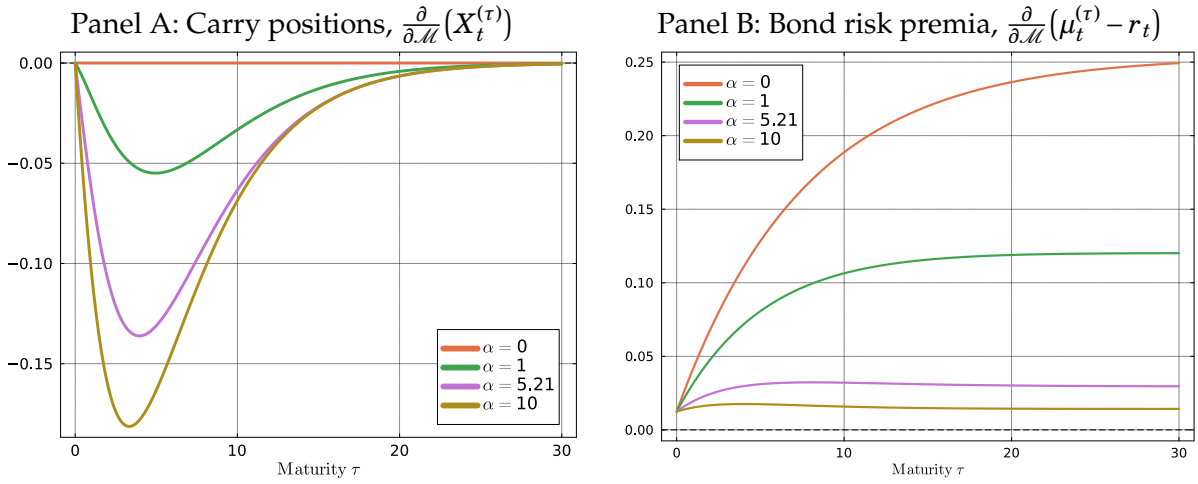


Figure 1. Effect of Market Power: Carry Positions and Bond Risk Premia

Notes: Panel A plots the marginal effect of market power on carry positions across maturities. Panel B plots the marginal effect of market power on equilibrium bond risk premia across maturities. Parameters follow Table 1.

reveals that when $\alpha > 0$, greater market power systematically reduces dealers' carry positions across all maturities, with this reduction intensifying as the demand slope parameter α increases.

This is because the magnitude of dealers' position adjustment depends critically on their price impact. Market clearing implies $\frac{\partial \log P_t^{(\tau)}}{\partial X_t^{(\tau)}} = \frac{1}{\alpha(\tau)}$. A higher $\alpha(\tau)$ reduces the price sensitivity to quantity changes: a given reduction in dealers' positions induces a smaller decline in bond prices and hence a smaller increase in expected returns. Consequently, to generate the necessary equilibrium adjustment in risk premia when market power rises, dealers must reduce positions more aggressively when α is larger. This explains the monotonic relationship between α and $|\frac{\partial X_t^{(\tau)}}{\partial \mathcal{M}}|$ observed in Panel A.

This rent extraction mechanism has profound implications for both bond risk premia and monetary policy transmission, which I analyze in the following subsections.

C.3. Bond Risk Premia

Effect of Market Power on Bond Risk Premia How does dealer market power affect bond risk premia? Figure 1, Panel B plots the marginal effect of market power on bond risk premia, $\frac{\partial(\mu_t^{(\tau)} - r_t)}{\partial \mathcal{M}}$ at steady state, that is, when $r_t = \bar{r}$. The figure reveals three key patterns.

First, the marginal effect of market power on bond risk premia is uniformly positive across all maturities and demand slope parameters, demonstrating that dealer market power is a fundamental

determinant of risk premia in bond markets. This reflects the rent extraction mechanism established above: dealers with greater market power optimally adjust carry positions to capture higher rents, thereby earning higher spreads between bond returns and funding costs.

Second, the marginal effect tends to be larger for longer maturities. To understand this pattern, consider the limiting case where $\alpha = 0$ in Panel B. In this benchmark, preferred-habitat investors have perfectly inelastic demand, so dealers' bond holdings $X_t^{(\tau)}$ remain fixed regardless of market power. The impact of $\mathscr{M}$ through the rent extraction channel contributes $\bar{r}$, which is uniform across maturities. Consequently, the increasing effect of market power on bond risk premia with maturity arises solely through the duration risk compensation channel. Since the price of interest rate risk is $\lambda_{r,t} = -\gamma\sigma_r^2 \int_0^T X_t^{(u)} A_r(u) du$, market power must increase $|\lambda_{r,t}|$ by raising the bond price sensitivity $A_r(\tau)$ in this integral. The increase in $|\lambda_{r,t}|$ has global effects on bond risk premia across all maturities, but its impact is amplified at longer maturities due to the higher interest rate exposure $|A_r(\tau)|$.

Finally, the marginal effect of market power on bond risk premia decreases with the demand slope parameter α. This pattern arises because larger α amplifies the position adjustment effect described in Panel A. The larger reductions in carry positions lower the price of interest rate risk $\lambda_{r,t}$ through the holdings channel, dampening the duration risk compensation component $-A_r(\tau)\lambda_{r,t}$ in equation (21). When α is higher, this negative effect on risk premia through the duration risk channel partially offsets the positive effect through the rent extraction channel $\mathscr{M} r_t$, explaining why the marginal effect of market power on bond risk premia, $\frac{\partial(\mu_t^{(\tau)} - r_t)}{\partial \mathscr{M}}$, declines with α in Panel B.

Effect of Market Power on Fama-Bliss Coefficient A large empirical literature on bond pricing, starting from Fama and Bliss (1987), has documented that the slope of the yield curve is a strong predictor of bond risk premia. One prominent explanation for this predictability is the preferred-habitat model of the term structure with demand slope of preferred-habitat investors $\alpha(\tau) > 0$, as in Vayanos and Vila (2021). In this section, I show that my model preserves this key empirical regularity. Moreover, the market power channel enriches the standard preferred-habitat explanation by providing a novel mechanism through which dealers' market power amplifies the relation between bond risk premia and the slope of the yield curve. Specifically, I show that the coefficient on the slope of the yield curve in predicting bond risk premia increases with dealers' market power.

Fama and Bliss (1987) run the following predictive regression:

$$\frac{1}{\Delta\tau}\log\left(\frac{P_{t+\Delta\tau}^{(\tau-\Delta\tau)}}{P_t^{(\tau)}}\right) - y_t^{(\Delta\tau)} = a_{\text{FB}} + b_{\text{FB}}\left(f_t^{(\tau-\Delta\tau,\tau)} - y_t^{(\Delta\tau)}\right) + e_{t+\Delta\tau} \tag{34}$$

Proposition 3 characterizes the Fama-Bliss coefficient b_{FB} in equation (34) as a function of dealers' market power $\mathscr{M}$.

Proposition 3 (**Slope of the Yield Curve and Bond Risk Premia**): *For $\Delta\tau \to 0$ and for all τ, the coefficient b_{FB} in FB regression in equation (34) is given by*

$$b_{\text{FB}} = \frac{\kappa_r^* - \kappa_r}{\kappa_r^*} \tag{35}$$

where κ_r^* is implicitly defined as a function of $\mathscr{M}$ in equation (31). When $\gamma > 0$ and $\alpha(\tau) > 0$, $\kappa_r^* > \kappa_r$ and $\frac{\partial \kappa_r^*}{\partial \mathscr{M}} > 0$ and therefore b_{FB} is positive and strictly increasing in dealers' market power $\mathscr{M}$, i.e., $b_{\text{FB}} > 0$ and $\frac{\partial b_{\text{FB}}}{\partial \mathscr{M}} > 0$.

The proof of Proposition 3 is provided in Appendix A.3. When $\alpha(\tau) > 0$ and $\gamma > 0$, the model preserves the central implication of Vayanos and Vila (2021): a steeper yield curve predicts higher bond risk premia, so that $b_{\text{FB}} > 0$. The novel contribution of this paper is to show that dealers' market power amplifies this mechanism. Figure 2 plots the marginal effect of market power on the Fama-Bliss coefficient, $\frac{\partial b_{\text{FB}}}{\partial \mathscr{M}}$, as a function of the demand slope parameter α. Consistent with Proposition 3, market power exerts a positive impact on the Fama-Bliss coefficient when $\alpha > 0$.

To understand this result, recall the mechanism in the standard preferred-habitat model. When the short rate falls, the yield curve steepens and long-term bond prices rise. Given $\alpha(\tau) > 0$, this price increase induces preferred-habitat investors to supply more long-maturity bonds. Dealers must absorb this additional supply, increasing their exposure to interest rate risk and therefore requiring higher risk premia. This bond-holding adjustment channel generates the well-known positive relationship between the yield curve slope and bond excess returns documented in Fama and Bliss (1987).

Market power amplifies this mechanism through the rent extraction channel. When short rates r_t decline, the rent opportunity $\mathscr{M} r_t$ diminishes proportionally, weakening dealers' incentive to restrict carry positions. Consequently, dealers expand their bond holdings more aggressively than under perfect competition, amplifying the term premium response to short-rate cuts. This stronger sensitivity of bond risk premia to yield curve fluctuations translates into a higher Fama-Bliss coefficient.

The magnitude of this amplification depends critically on the demand slope parameter α, which governs dealers' price impact. As explained earlier, a higher $\alpha(\tau)$ reduces the price sensitivity to quantity changes: $\frac{\partial \log P_t^{(\tau)}}{\partial X_t^{(\tau)}} = \frac{1}{\alpha(\tau)}$. When dealers expand positions in response to declining rent opportunities, a higher α requires more aggressive quantity adjustments to achieve the necessary equilibrium price change. Consequently, higher α leads to a stronger bond-holding response to short-rate cuts, strengthening the term premium sensitivity to yield curve slope. This explains the positive relationship between α and $\frac{\partial b_{\text{FB}}}{\partial \mathcal{M}}$ observed in Figure 2.

This finding has important implications for empirical bond pricing. The predictability of bond returns by the yield curve slope represents one of the most important empirical facts in fixed income markets, serving as regularity for asset pricing theories. My analysis reveals that dealer market power critically determines the strength of this relationship. Specifically, the model implies a conditional forecasting framework: during periods of elevated dealer market power, bond excess returns exhibit stronger loadings on the yield curve slope, resulting in a larger Fama-Bliss coefficient. Conversely, when competitive pressures reduce market power, the slope loading weakens. I test this conditional prediction empirically in Section III.

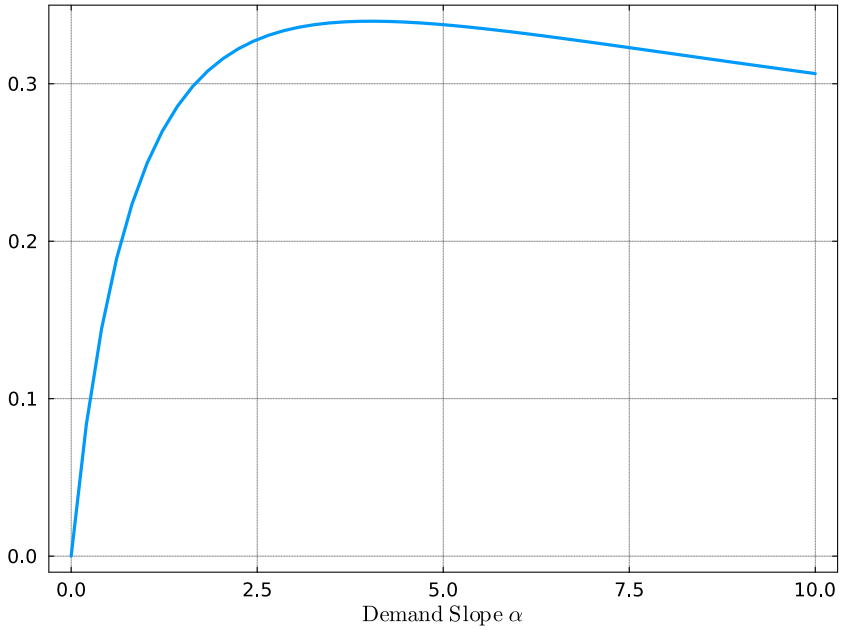


Figure 2. Effect of Market Power on Fama-Bliss Coefficient, $\frac{\partial b_{\text{FB}}}{\partial \mathcal{M}}$

Notes: This figure plots the marginal effect of market power on the Fama-Bliss regression coefficient, $\frac{\partial b_{\text{FB}}}{\partial \mathcal{M}}$, as a function of demand slope parameter α. All other parameters are calibrated as reported in Table 1.

C.4. Monetary Policy Transmission

The Federal Reserve implements its monetary policy by adjusting the short rate r_t that shapes repo borrowing rate for dealers. Dealers borrow short-term funds through repos and investment in longer-term bonds. Therefore, dealers transmit short-rate shocks to bond yields through their carry trades. When there is a shock to the short rate r_t, the impact on the long bond yield can be decomposed into two channels. The first is the effect through the expected future short rate, as described by the expectations hypothesis (EH) of the term structure. The second is the effect through the term premium, which depends on how dealers adjust their bond holdings in response to short-rate shocks.

Following Vayanos and Vila (2021) and Kekre, Lenel, and Mainardi (2024), I measure the impact of short-rate shocks on long end of the yield curve by analyzing the reaction of forward rates. The advantage of using forward rates is that it is easy to decompose the effect of short-rate shocks into the expectations and term-premium channels. I evaluate how a time-t shock to the short rate r_t affects the expected τ-period-ahead short rate $E_t(r_{t+\tau})$ at time $t+1$ and the instantaneous forward rate for maturity τ, $f_t^{(\tau)}$. The latter rate is defined as

$$f_t^{(\tau)} \equiv \lim_{\Delta\tau \to 0} f_t^{(\tau-\Delta\tau,\tau)} = -\frac{\partial \log P_t^{(\tau)}}{\partial \tau} = A_r'(\tau) r_t + C'(\tau). \tag{36}$$

where the second equality follows from taking the limit of $\Delta\tau \to 0$ of forward rate definition in equation (9) and the last equality follows from the bond price conjecture in equation (15). It follows that the sensitivity of the instantaneous forward rate and expected future short rate to a unit shock to the short rate r_t are given by

$$\frac{\partial f_t^{(\tau)}}{\partial r_t} = A_r'(\tau) = (1+\mathscr{M}) e^{-\kappa_r^* \tau}, \quad \frac{\partial E_t(r_{t+\tau})}{\partial r_t} = e^{-\kappa_r \tau} \tag{37}$$

When the expectations hypothesis (EH) of the term structure holds, forward rates move one-to-one with expected future short rates, i.e., $\frac{\partial f_t^{(\tau)}}{\partial r_t} = \frac{\partial E_t(r_{t+\tau})}{\partial r_t} = e^{-\kappa_r \tau}$. In the benchmark of no market power in the repo market ($\mathscr{M} = 0$) and no risk aversion ($\gamma = 0$ and hence $\kappa_r^* = \kappa_r$), this is indeed the case. If I introduce the risk-aversion ($\gamma > 0$ and hence $\kappa_r^* > \kappa_r$) but keep the market power channel muted ($\mathscr{M} = 0$), the sensitivity of the forward rate to the short rate becomes $\frac{\partial f_t^{(\tau)}}{\partial r_t} = e^{-\kappa_r^* \tau} < e^{-\kappa_r \tau}$. In this case, I replicate the result in Vayanos and Vila (2021) that the forward rate underreacts to short-rate shocks

because of a negative term premium response. With demand slope from preferred-habitat investors $\alpha(\tau) > 0$, the price decline in bond prices following a short-rate hike induces lower bond supply from preferred-habitat investors, and hence lower term premium as dealers take less quantity of interest-rate risk.

If I further introduce the market-power channel ($\mathscr{M} > 0$), I obtain the novel result that the forward rate sensitivity is affected by dealers' market power. The following proposition shows that the forward rate sensitivity could be increasing in dealers' market power $\mathscr{M}$, in particular for modest maturities.

Proposition 4 (**Market Power and Reaction of Forward Rates**): *A unit shock to the short rate r_t raises the forward rate $f_t^{(\tau)}$ for maturity τ by*

$$\frac{\partial f_t^{(\tau)}}{\partial r_t} = (1 + \mathscr{M}) e^{-\kappa_r^* \tau}. \tag{38}$$

Let $\mathscr{S}_t^{(\tau)} \equiv \frac{\partial}{\partial \mathscr{M}} \left(\frac{\partial f_t^{(\tau)}}{\partial r_t} \right)$ denote the impact of dealers' market power $\mathscr{M}$ on the forward rate sensitivity to short-rate shocks. It satisfies the following properties:

1. *There exists a threshold level of maturity $\hat{\tau} \in (0, \infty)$ such that $\mathscr{S}_t^{(\tau)} > 0$ if and only if $\tau \in (0, \hat{\tau})$. Therefore, the effect of market power $\mathscr{M}$ on the forward rate sensitivity is positive for all maturities if $T \leq \hat{\tau}$.*
2. *There exists a threshold level of maturity $\bar{\tau} \in (0, \infty)$ such that $\frac{\partial}{\partial \tau} \mathscr{S}_t^{(\tau)} < 0$ if and only if $\tau < \bar{\tau}$. Therefore, the effect of market power $\mathscr{M}$ on the forward rate sensitivity monotonically decreasing in $\tau \in [0, T]$ if $T \leq \bar{\tau}$, and exhibits a U-shape in $\tau \in [0, T]$ if $T > \bar{\tau}$.*
3. *The above two properties jointly imply there exists a threshold level of maturity $\tau^* = \min\{\hat{\tau}, \bar{\tau}\}$ such that $\mathscr{S}_t^{(\tau)} > 0$ and $\frac{\partial}{\partial \tau} \mathscr{S}_t^{(\tau)} < 0$ for all $\tau \in (0, \tau^*)$. Therefore, for short maturities, the effect of market power $\mathscr{M}$ on the forward rate sensitivity is always positive and decreasing in maturity.*

The proof of Proposition 4 is provided in Appendix A.4. Figure 3, Panel A plots the marginal effect of market power on forward rate sensitivity to short-rate shocks as a function of maturity τ for different levels of the demand slope parameter α. The figure reveals patterns consistent with Proposition 4. Across all values of α, market power amplifies forward rate sensitivity at short maturities: $\mathscr{S}_t^{(\tau)} > 0$ for sufficiently modest τ. The maturity profile of this amplification, however, depends critically on α. For low values ($\alpha = 0$ or 1), the marginal effect declines monotonically with maturity. For higher values ($\alpha = 5.21$ in the benchmark calibration, or $\alpha = 10$), the effect exhibits a U-shape, turning negative at intermediate maturities before potentially rising again at very long maturities.

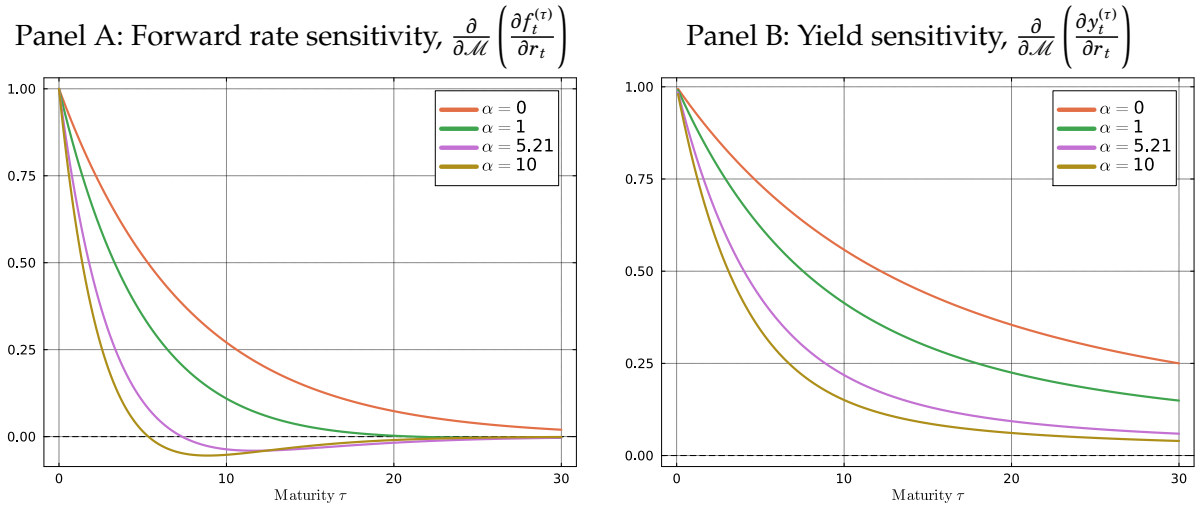


Figure 3. Effect of Market Power on Forward Rate and Yield Sensitivity

Notes: Panel A plots the marginal effect of market power on forward rate sensitivity to the short rate, $\mathscr{S}_t^{(\tau)} \equiv \frac{\partial}{\partial \mathscr{M}}\left(\frac{\partial f_t^{(\tau)}}{\partial r_t}\right)$, as a function of maturity τ. Panel B plots the marginal effect of market power on yield sensitivity to the short rate, $\frac{\partial}{\partial \mathscr{M}}\left(\frac{\partial y_t^{(\tau)}}{\partial r_t}\right)$, as a function of maturity τ. Each curve corresponds to a different level of the demand slope parameter α. All other parameters are calibrated as reported in Table 1.

There are two opposite channels through which market power affects forward rate sensitivity. Recall from equation (37) that forward rate sensitivity to short-rate shocks is given by $\frac{\partial f_t^{(\tau)}}{\partial r_t} = (1+\mathscr{M})e^{-\kappa_r^* \tau}$. Market power $\mathscr{M}$ influences this sensitivity through both the direct multiplier $(1+\mathscr{M})$ and the risk-neutral mean reversion speed κ_r^*.

The direct channel operates through the multiplier $(1+\mathscr{M})$ via rent extraction and is independent of α. When the short rate increases by one unit, the rent opportunity rises by $\mathscr{M}$ units, amplifying dealers' term premium response. This channel exerts a positive effect on forward rate sensitivity and the magnitude of this effect is independent of α.

The indirect channel operates through the risk-neutral mean reversion parameter κ_r^* in the exponential term $e^{-\kappa_r^* \tau}$, exerting a negative effect on forward rate sensitivity. As shown in Proposition 3, an increase in market power raises κ_r^*, which dampens forward rate sensitivity. Crucially, the magnitude of this negative indirect effect increases with α. To see this, note that Proposition 3 establishes that the Fama-Bliss coefficient $b_{\text{FB}} = \frac{\kappa_r^* - \kappa_r}{\kappa_r^*}$ is a monotonic transformation of κ_r^*. Figure 2 shows that $\frac{\partial b_{\text{FB}}}{\partial \mathscr{M}}$ tends to increase with α, implying that κ_r^* becomes more responsive to market power when α is larger. The net effect of market power on forward rate sensitivity thus depends on which channel dominates in

magnitude.

Panel A of Figure 3 reveals that the relative dominance of these two channels depends critically on the demand slope parameter α. The economic mechanism underlying this α-dependence operates through the carry-position adjustment channel discussed earlier. When market power increases, dealers optimally reduce bond holdings to extract rents, with the magnitude of these reductions governed by their price impact parameter α. In the limiting case where $\alpha = 0$, dealers' bond holdings remain fixed regardless of market power, so the indirect channel vanishes. Consequently, market power unambiguously amplifies forward rate sensitivity, with the magnitude decreasing in maturity according to the exponential decay $e^{-\kappa_r \tau}$. As α increases, dealers cut positions more aggressively in response to higher market power, as documented in Panel A of Figure 1. These holding adjustments lower the price of interest rate risk $\lambda_{r,t}$, dampening the term premium component of forward rates. Consequently, the indirect channel exerts a stronger offsetting effect when α is larger, explaining why the net effect of market power on forward rate sensitivity, $\mathscr{S}_t^{(\tau)}$, declines with α.

Panel B plots the marginal effect of market power on yield sensitivity to short-rate shocks, $\frac{\partial}{\partial \mathscr{M}}\left(\frac{\partial y_t^{(\tau)}}{\partial r_t}\right)$, as a function of maturity τ. While Panel A shows that market power amplifies forward rate sensitivity only up to a certain threshold maturity (approximately 10 years under the benchmark calibration with $\alpha = 5.21$), Panel B demonstrates that market power exerts a positive effect on yield sensitivity across all maturities $\tau \in [0, 30]$ for all values of α. This difference arises because yields represent averages of forward rates across maturities. Specifically, the yield $y_t^{(\tau)} = \frac{1}{\tau}\int_0^\tau f_t^{(s)} ds$ integrates forward rates over the interval $[0, \tau]$. Even though the marginal effect on forward rate sensitivity may turn negative at long maturities due to the indirect channel, the integration smooths out this effect, ensuring that the cumulative impact on yield sensitivity remains positive. Therefore, dealer market power strengthens the pass-through of policy rate changes to market rates over the entire yield curve. When dealers have greater market power, a given policy rate shock generates a larger response in long-term yields, thereby amplifying monetary policy transmission to the broader economy through the yield curve.

C.5. Remarks and Empirical Implications

Proposition 4 highlights that dealer market power provides a novel explanation for the empirical oversensitivity of long-term yields to short-rate shocks documented in the literature (e.g., Hanson and Stein, 2015; Hanson et al., 2021). A growing body of literature has made significant progress in under-

standing this phenomenon within the preferred-habitat framework (e.g., Hanson, 2014; Malkhozov et al., 2016; Domanski, Shin, and Sushko, 2017; Hanson et al., 2021; Carboni and Ellison, 2022). The key insight in these papers is that the short rate shocks are, through different channels, positively correlated with the supply shocks from preferred-habitat investors. When short rates rise, preferred-habitat investors tend to supply more long-term bonds, forcing dealers to absorb more duration risk and thereby raising term premia. This mechanism is consistent with assuming a negative demand slope parameter $\alpha(\tau) < 0$ in the preferred-habitat framework.

However, such an assumption conflicts with the positive relationship between bond risk premia and the slope of the yield curve documented empirically (e.g., Fama and Bliss, 1987). Greenwood et al. (2023) effectively show this tension, noting that *"When $\eta^{(\tau)} > 0$ (corresponding to $\alpha(\tau)$ in my model), bond risk premia are positively related to the slope of the yield curve... Naturally, all of these results are reversed when $\eta^{(\tau)} < 0$. Specifically, when the supply from preferred-habitat agents is decreasing in bond prices, bond yields overreact to movements in short rates relative to the expectations hypothesis. As a result, versions of the VV model (Vayanos and Vila (2021)) in which $\eta^{(\tau)} < 0$ have proven useful in understanding the excess sensitivity of long-term yields to changes in short rates that has been documented at higher frequencies."*

While the "VV model" has been very successful in explaining either yield oversensitivity or the positive relationship between bond risk premia and yield curve slope, reconciling both empirical facts within a unified framework has been challenging. My model bridges this gap by introducing dealer market power into this framework, motivated by well-documented evidence of market power in funding markets (e.g., Drechsler et al., 2017; Huber, 2023). I show that even a parsimonious version of the "VV model", when augmented with dealer market power, can jointly account for both empirical patterns with $\alpha(\tau) > 0$.

Beyond reconciling these stylized facts, my model generates novel empirical predictions that distinguish the market power channel from alternative mechanisms. These predictions provide testable implications for understanding how dealer market power shapes bond market dynamics:

1. **Prediction 1 (Market Power and Bond Risk Premia):** Dealer market power in funding markets predicts higher bond risk premia. Specifically, measures of dealer market power should positively forecast excess bond returns across maturities, with magnitudes increasing with maturity.
2. **Prediction 2 (Market Power and Fama-Bliss Coefficient):** The sensitivity of bond excess returns to the yield curve slope increases with dealer market power. Formally, in a Fama-Bliss regression

of excess returns on the yield curve slope, the coefficient b_{FB} should be larger during periods of elevated dealer market power.

3. **Prediction 3 (Market Power and Forward Rate Sensitivity):** For maturities below a certain threshold, forward rates exhibit greater sensitivity to short rate changes when dealer market power is high. The magnitude of this sensitivity difference either decreases monotonically or exhibits a U-shape with maturity.

III. Empirical Evidence

This section tests the empirical predictions of my model using U.S. Treasury market data. Following Vayanos and Vila (2021), I adopt the nominal interpretation of the preferred-habitat model, where the short rate is set by central bank policy rather than determined by production technology. Most empirical studies on bond risk premia and monetary policy transmission focus on maturities up to 5 to 10 years (e.g., Cochrane and Piazzesi, 2005; Fama and Bliss, 1987; Greenwood and Vayanos, 2014; Malkhozov et al., 2016; Haddad and Sraer, 2020; Hanson and Stein, 2015; Hanson et al., 2021), so my analysis concentrates on yields with maturities up to 10 years. The sample runs from January 2011 to September 2025, limited by the availability of repo market data from money market funds, which begins in late 2010.

This section is organized as follows. Section III.A describes the data sources and construction of key variables, including measures of dealer market power in the repo market. Section III.B validates the core mechanism of the model by examining how dealer market power affects their repo market activities. Section III.C tests Prediction 1 regarding the relationship between dealer market power and bond risk premia and Prediction 2 on how dealer market power affects the Fama-Bliss coefficient. Section III.D tests Prediction 3 concerning the sensitivity of forward rates to short rate changes under varying levels of dealer market power.

A. Data Description

Repo Market Data and Dealer Market Power Measure. I construct measures of dealer market power using data on repo market activities from money market funds, the major cash lenders in the U.S. repo market. Since October 2010, money market funds have been required to report their portfolio holdings monthly to the SEC via Form N-MFP. I obtain repo lending data from the Money Market Monitor

dataset maintained by the Office of Financial Research (OFR). The OFR aggregates fund-level N-MFP data to provide total repo lending to major counterparties at the end of each month. Following Huber (2023), my sample begins in January 2011, allowing funds three months to adjust to the new reporting requirements.

My measure of dealer market power is the Herfindahl-Hirschman Index (HHI) of dealers' repo borrowing from money market funds, calculated as:

$$HHI_t = \sum_{i=1}^{N} \left(\frac{\text{RepoBorrowing}_{i,t}}{\sum_{j=1}^{N} \text{RepoBorrowing}_{j,t}} \right)^2 \times 100 \tag{39}$$

This measure captures concentration in the repo market, with higher HHI indicating greater dealer market power.

The model's core mechanism is dealers' rent extraction through repo market activities. When dealers have greater market power, they optimally restrict their repo borrowing to avoid high borrowing costs. To validate this mechanism, I use two measures to capture dealers' activities in the repo market.

First, the *private repo ratio* measures the share of MMF repo lending to private dealers in their total portfolio. It equals one minus the proportion of repo lending to the Federal Reserve's ON-RRP program. Calculated from the OFR data, this ratio mirrors dealers' carry position in my model, that is, the quantity of bonds they finance through repos. When dealers have greater market power, they restrict their carry trades, which lowers the private repo ratio.

Second, the *tri-party repo spread* measures the difference between the tri-party repo rate and the overnight reverse repo rate. The tri-party repo rate represents dealers' borrowing cost in repo markets, while the ON-RRP rate represents the outside option for money market funds provided by the Federal Reserve. For the tri-party repo rate, I follow He et al. (2022): from August 2014 onward, I use the daily tri-party general collateral rate (TGCR) computed by the Federal Reserve Bank of New York, which is the volume-weighted median of transaction level tri-party repo data excluding General Collateral Finance (GCF) repo transactions and Federal Reserve transactions. From August 2012 to August 2014, I use tri-party repo rates calculated by the Bank of New York Mellon, one of the two primary clearing banks for U.S. tri-party repos.[1] These rates are volume-weighted medians of overnight repo transactions collateralized by U.S. Treasuries (excluding Strips). The model predicts that when

[1] In the U.S., tri-party repo services have historically been provided by the Bank of New York Mellon and JPMorgan Chase. In 2019, JPMorgan Chase announced its exit from this business.

dealers have greater market power, they reduce their repo borrowing, which mechanically compresses the tri-party repo spread.[2]

Term Premium Measures. I employ two widely used ex-ante term premium measures: the Adrian et al. (2013) measure and the Kim and Wright (2011) measure. Both are available at daily frequency from the Federal Reserve for my sample period of January 2011 to September 2025.

Bond Yield Data. To compute yields, forward rates, and bond returns, I use the nominal yield curve data constructed by Gürkaynak, Sack, and Wright (2007), provided by the Federal Reserve.

Monetary Policy Surprises Data. My model's core mechanism operates through shocks to the short rate r_t that the central bank controls in the repo market. Ideally, I would measure monetary policy surprises using high-frequency changes in market expectations of the ON-RRP rate around FOMC announcements. However, such data are not available for my sample period. As a practical alternative, I rely on the event-study measures constructed by Jarocinski and Karadi (2020), which isolate monetary policy surprises through changes in the three-month-ahead federal funds futures rate within a 30-minute window around FOMC announcements. Given the close relationship between the federal funds rate and the ON-RRP rate in the post-2008 monetary policy framework—where the ON-RRP facility serves as a key tool for implementing the target federal funds rate—these futures-based measures provide a reasonable proxy for the monetary policy shock on the short rate in my model.

B. Dealers' Market Power and Repo Market Activities

My model implies a rent extraction mechanism whereby dealers with greater market power strategically restrict their repo borrowing to avoid high borrowing costs. Figure 4 tests this mechanism empirically. Panel A displays the mean private repo ratio across HHI tertiles with 90% confidence intervals. The declining pattern from low to high concentration tertiles demonstrates that greater dealer

[2]Though the model does not explicitly feature the repo spread for tractability, a more realistic extension incorporates a regulatory cost $\psi > 0$ in the money market fund manager's problem (Equation (6)), yielding:

$$\max_{D_t} D_t r_{d,t} - D_t r_t - \frac{\psi}{2} D_t^2,$$

which implies the equilibrium repo spread $r_{d,t} - r_t = \psi D_t$. The tri-party repo spread is therefore proportional to total repo borrowing D_t. When dealers reduce their repo borrowing D_t due to greater market power, the tri-party repo spread compresses.

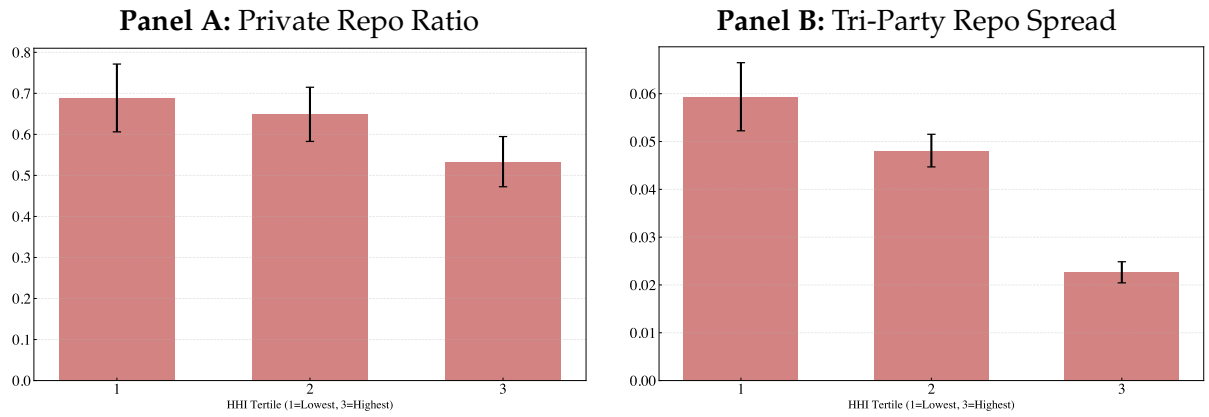


Figure 4. Dealer Market Power and Repo Market Activities

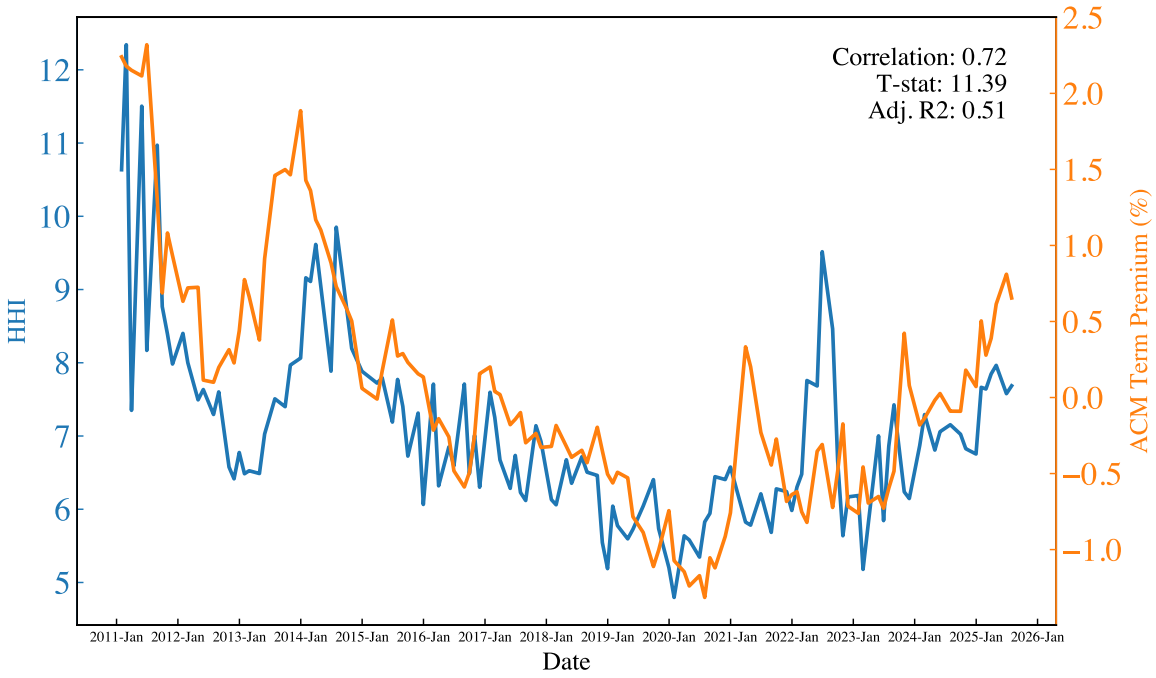
Notes: This figure examines the relationship between dealer market power and repo market activities. Panel A and B plot the mean private repo ratio and tri-party repo spread by HHI tertile with 90% confidence intervals. Sample period: September 2013 to July 2025.

market power is associated with lower repo borrowing. Using the underlying monthly data without binning into tertiles, I find a correlation of $\rho = -0.29$ with a t-statistic of -3.56, confirming that greater dealer market power significantly reduces private repo activity. Panel B shows the mean tri-party repo spread across HHI tertiles with 90% confidence intervals. The pattern reveals that higher dealer market power is associated with compressed repo spreads, with a correlation of $\rho = -0.28$ and a t-statistic of -3.54 from the unbinned data. Both patterns are statistically significant and economically meaningful, consistent with the rent extraction mechanism in which dealers with greater market power strategically restrict private repo borrowing to secure lower funding costs.

C. Bond Risk Premia

Market Power and Bond Risk Premia. I now test Prediction 1: dealer market power predicts higher bond risk premia. I test this prediction using both ex-ante term premium measures and predictive regressions of bond excess returns. Figure 5 presents time-series evidence using ex-ante term premium measures. Panel A plots my HHI measure alongside the 10-year term premium from Adrian et al. (2013). The two series exhibit a positive correlation of 0.72, which is statistically significant. When dealer market power rises, term premia increase substantially, consistent with the model's rent extraction mechanism. Panel B shows similar results using the Kim and Wright (2011) term premium measure, confirming the robustness of this relation.

Panel A: Adrian et al. (2013) 10-year Term Premium



Panel B: Kim and Wright (2011) 10-year Term Premium

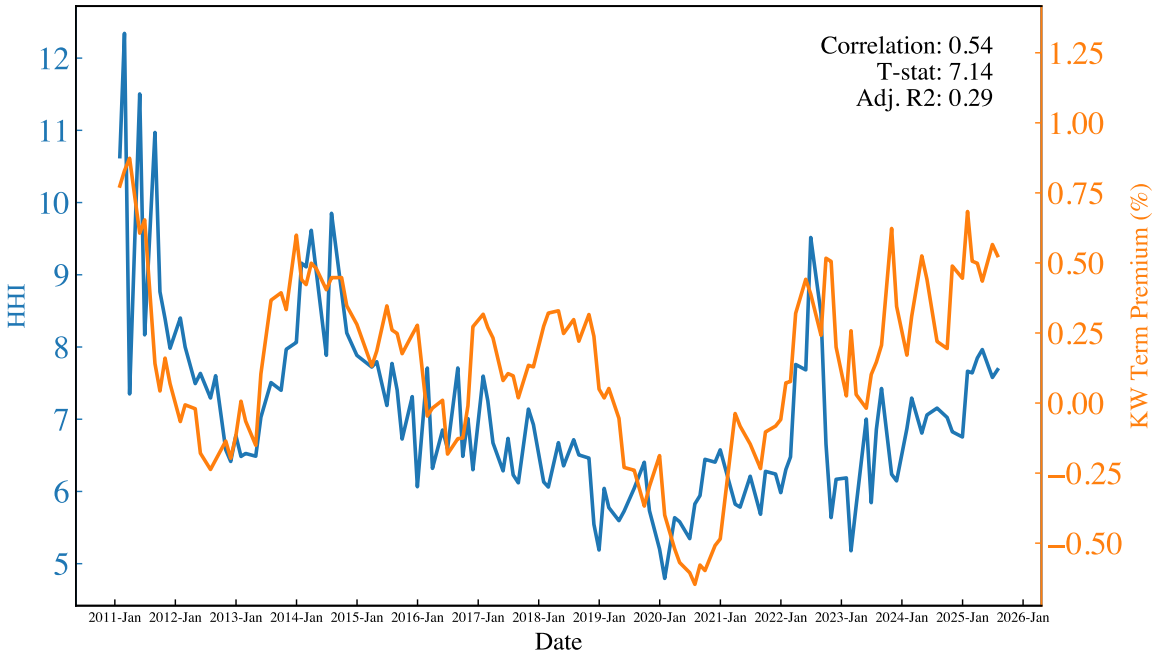


Figure 5. Dealer Market Power and Ex-Ante Term Premium

Notes: This figure plots the Herfindahl-Hirschman Index (HHI) of dealers' repo borrowing from money market funds and ex-ante measures of the 10-year nominal term premium over the sample period from January 2011 to September 2025. The blue line represents the HHI (left axis), and the orange line represents the term premium (right axis). Panel A uses the term premium measure from Adrian et al. (2013), and Panel B uses the measure from Kim and Wright (2011). Term premium values are plotted at the monthly frequency corresponding to the repo data reporting dates.

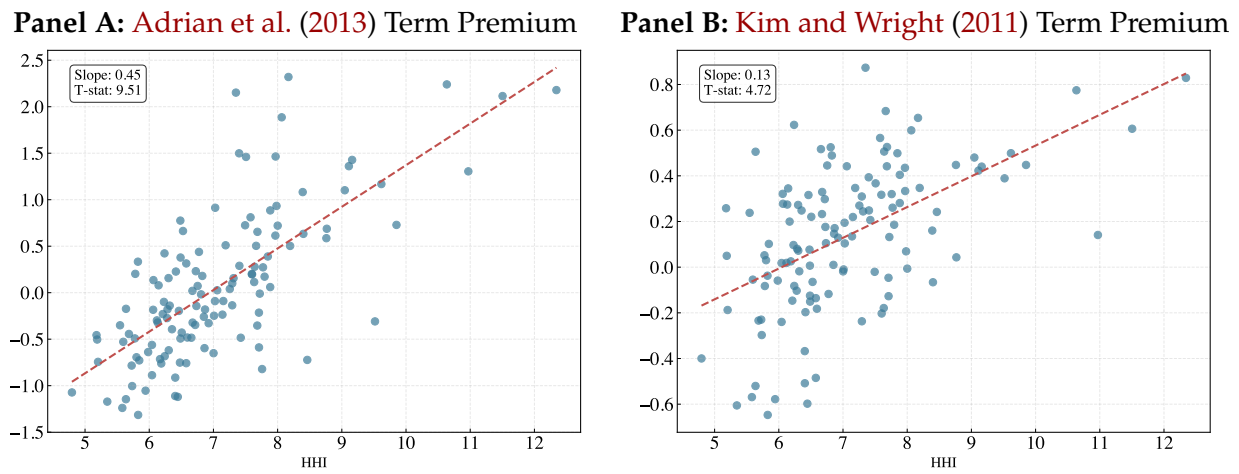


Figure 6. Dealer Market Power and 10-Year Term Premium: Scatter Plots

Notes: This figure presents scatter plots of the 10-year term premium against the HHI of dealers' repo borrowing from money market funds. Panel A uses the term premium measure from Adrian et al. (2013), showing a slope coefficient of 0.45 (t-statistic = 9.51). Panel B uses the term premium measure from Kim and Wright (2011), showing a slope coefficient of 0.13 (t-statistic = 4.72). The fitted lines represent OLS regressions with Newey-West standard errors (4 lags). Sample period: January 2011 to September 2025.

To quantify this relationship more formally, I run the following regression:

$$TP_t^{(10)} = \alpha + \beta HHI_t + \varepsilon_t, \tag{40}$$

where HHI_t is the repo market concentration at month t and $TP_t^{(10)}$ is the 10-year term premium on the reporting date of month t. I estimate this regression using Newey-West standard errors with 4 lags to account for potential autocorrelation in the term premium series.[3] Figure 6 presents scatter plots of the 10-year term premium against HHI for both measures. Panel A shows the estimates using the Adrian et al. (2013) term premium. The estimated slope coefficient is 0.45 with a t-statistic of 9.51. Panel B presents the corresponding relationship using the Kim and Wright (2011) term premium, yielding a slope coefficient of 0.13 with a t-statistic of 4.72. With a standard deviation of 1.25 for HHI, the slope coefficients imply that a one standard deviation increase in HHI is associated with a $45 \times 1.25 = 56$ basis point increase in the 10-year term premium using the Adrian et al. (2013) measure and a $13 \times 1.25 = 16$ basis point increase using the Kim and Wright (2011) measure. Both estimates are statistically significant and economically meaningful, demonstrating that dealer market power is a strong predictor of bond risk premia.

[3] Allowing for more lags does not affect the results.

To further validate Prediction 1, I also run predictive regressions of bond excess returns on lagged dealer market power. Specifically, for each maturity τ in 1 to 10 years, I estimate the following regression:

$$rx_{t+1}^{(\tau)} = \alpha^{(\tau)} + \beta^{(\tau)} HHI_t + \varepsilon_{t+1}^{(\tau)}, \tag{41}$$

where $rx_{t+1}^{(\tau)}$ is the 1-year log return on a τ-year bond from year t to $t+1$ minus the 1-year yield at time t. The coefficient $\beta^{(\tau)}$ captures the predictive power of dealer market power for excess returns at maturity τ. Figure 7, Panel A plots the estimated $\hat{\beta}^{(\tau)}$ across maturities. Standard errors are Newey–West adjusted with 36 lags, following Greenwood and Vayanos (2014). The pattern closely aligns with the model's prediction in Panel B of Figure 1: dealer market power positively predicts excess returns, with coefficient magnitudes rising with maturity and reaching 2.56 for 10-year bonds (t-statistic = 2.33). Quantitatively, a one-standard-deviation increase in HHI raises the predicted one-year excess return on 10-year bonds by $2.56 \times 1.25 = 3.2$ percentage points.

Taken together, these results provide strong support for Prediction 1: dealer market power positively predicts bond risk premia, both in ex-ante measures and in excess return regressions.

Market Power and Fama-Bliss Coefficient. I next test Prediction 2: dealer market power amplifies the sensitivity of bond excess returns to the yield curve slope. I estimate the following Fama-Bliss regression with an interaction term:

$$rx_{t+1}^{(\tau)} = a^{(\tau)} \left(f_t^{(\tau-1,\tau)} - y_t^{(1)} \right) + b^{(\tau)} HHI_t + c^{(\tau)} HHI_t \times \left(f_t^{(\tau-1,\tau)} - y_t^{(1)} \right) + d^{(\tau)} + \varepsilon_{t+1}^{(\tau)}, \tag{42}$$

where $rx_{t+1}^{(\tau)}$ is the 1-year log return on a τ-year bond from year t to $t+1$ minus the 1-year yield at time t, $y_t^{(1)}$ is the 1-year yield at time t, and $f_t^{(\tau-1,\tau)}$ is the forward rate from $\tau-1$ to τ years at time t. The coefficient $b^{(\tau)}$ captures the direct effect of dealer market power on excess returns, while $c^{(\tau)}$ measures how dealer market power affects the sensitivity of excess returns to the yield curve slope. Prediction 1 implies that $b^{(\tau)} > 0$, meaning higher dealer market power predicts higher excess returns. Prediction 2 implies that $c^{(\tau)} > 0$, meaning higher dealer market power amplifies the sensitivity of excess returns to the yield curve slope. For interpretability of the interaction term $c^{(\tau)}$, I transform HHI into decile rankings before estimation; however, this transformation does not affect the significance of

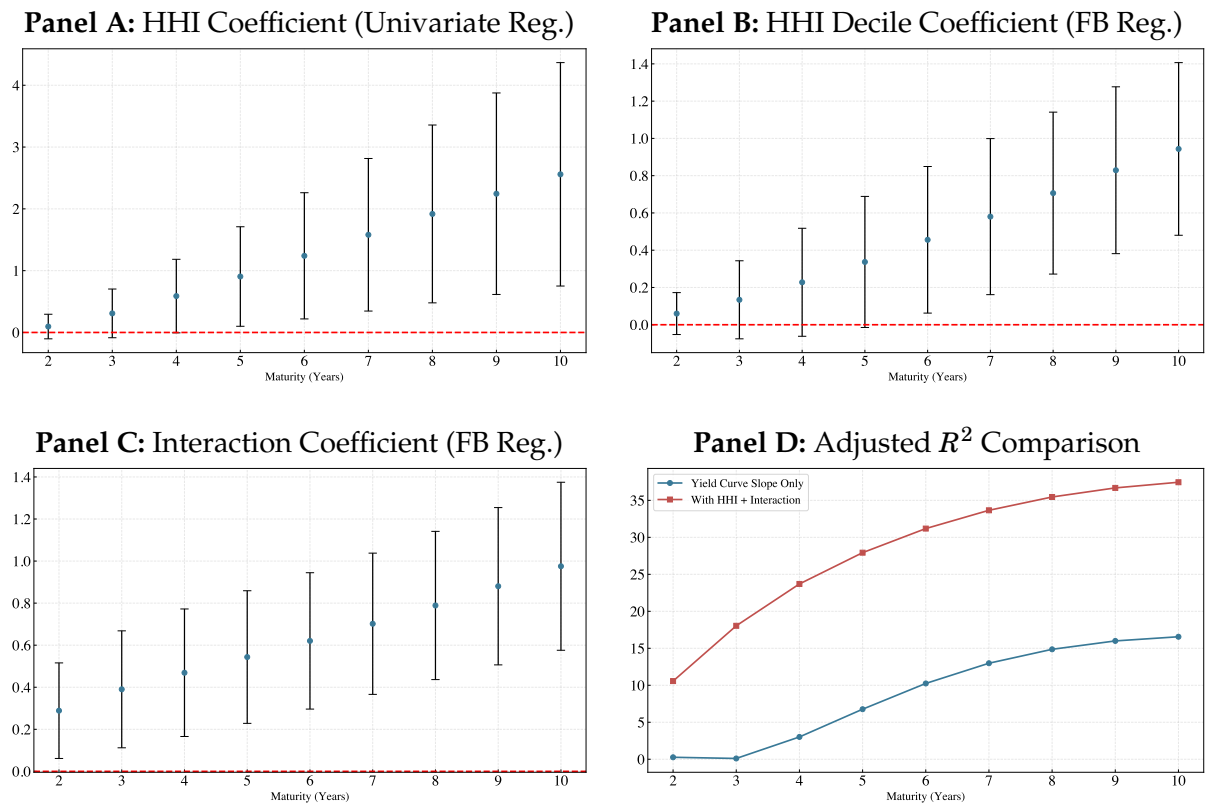


Figure 7. Dealer Market Power and Bond Excess Returns

Notes: This figure examines how dealer market power predicts bond excess returns across maturities. Panel A plots coefficients from univariate regressions of 1-year excess returns on lagged HHI (Equation (41)). Panel B and C plot the HHI coefficients $\hat{b}^{(\tau)}$ and the interaction coefficients $\hat{c}^{(\tau)}$ from the extended Fama-Bliss regression (Equation (42)). Panel D compares the adjusted R^2 of Fama-Bliss regressions with and without market power controls. All standard errors are Newey-West adjusted with 36 lags. Confidence bars indicate 90% confidence intervals. Sample period: January 2011 to September 2025.

$c^{(\tau)}$. Standard errors are Newey-West adjusted with 36 lags.

Panel B and C in Figure 7 present the estimation results. Panel B plots the estimates $\hat{b}^{(\tau)}$ across maturities, confirming that dealer market power has positive predictive power for excess returns, with coefficients increasing in maturity. Panel C plots the interaction coefficients $\hat{c}^{(\tau)}$, which are significantly positive across all maturities. The impact of dealer market power on the Fama-Bliss coefficient is economically meaningful: moving up one HHI decile increases the Fama-Bliss coefficient by approximately 0.3 to 1, depending on maturity. This supports Prediction 2 that dealer market power amplifies the sensitivity of bond excess returns to the yield curve slope.

Panel D compares the adjusted R^2 of the Fama-Bliss regression with and without controlling for dealer market power. Including dealer market power and its interaction with the yield curve slope

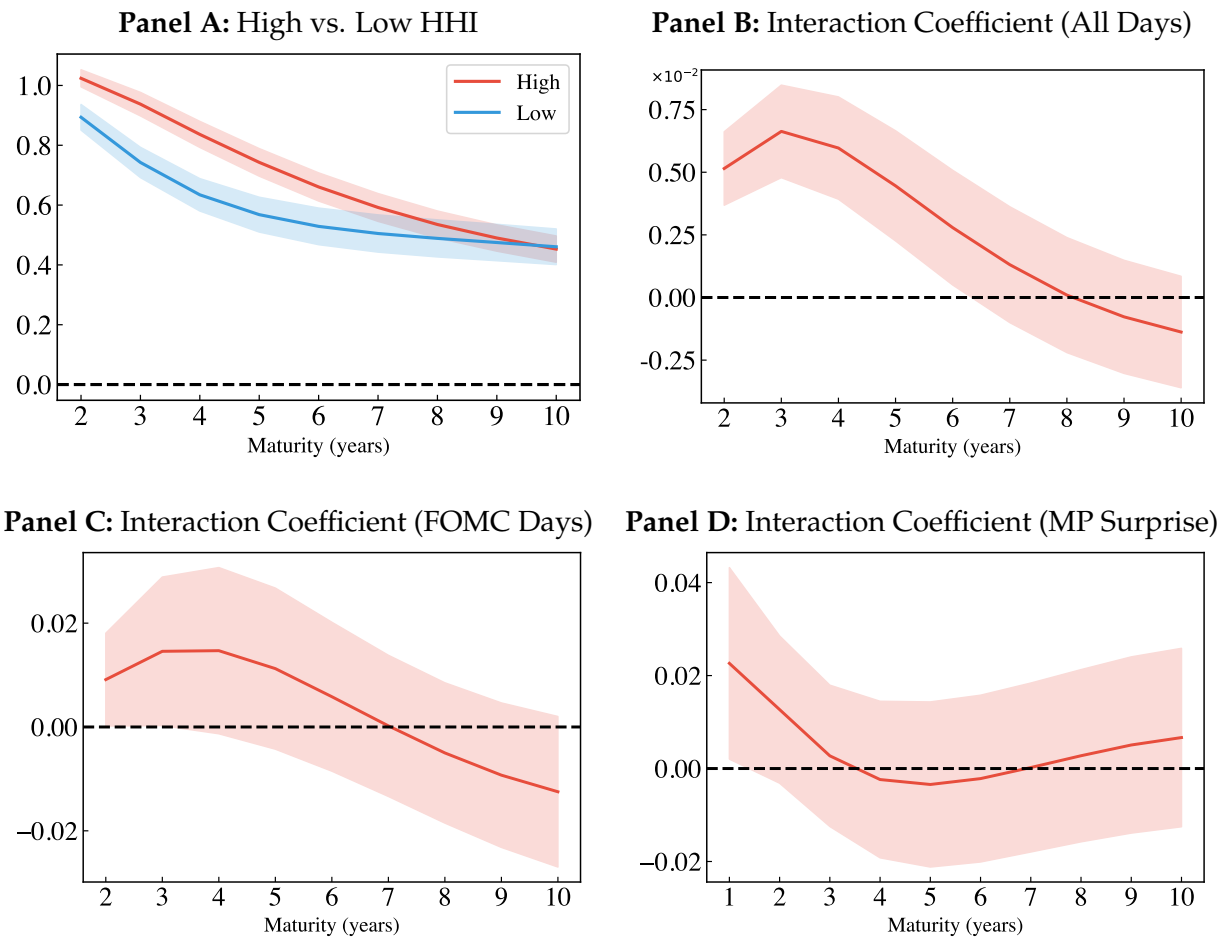


Figure 8. Dealer Market Power and Forward Rate Sensitivity

Notes: This figure examines how dealer market power affects forward rate sensitivity to short rate changes. Panel A plots estimated forward rate sensitivities $\beta_t^{(\tau)}$ from Equation (43) on high HHI days, defined as above median, and low HHI days across maturities. Panel B plots the interaction coefficients $\hat{\varphi}^{(\tau)}$ from Equation (44) using all trading days. Panel C repeats the analysis from Panel B using only FOMC announcement days. Panel D repeats the analysis from Panel C but uses monetary policy surprises measured by changes in 3-month-ahead Fed funds futures around FOMC announcements as the measure of short-rate shocks. Shaded regions indicate 90% confidence intervals. Sample period: January 2011 to September 2025.

substantially improves the model fit across all maturities, underscoring the role of dealer market power in explaining bond excess returns.

D. Market Power and Forward Rate Sensitivity

I now test Prediction 3: dealer market power amplifies forward rate sensitivity to short-rate shocks at short maturities. There are two ways to interpret long rate sensitivity in preferred habitat models. The first is a broad interpretation where short-rate shocks encompass all factors that move the short

rate, not just monetary policy shocks. For example, macroeconomic news can influence market expectations of the central bank's future short-rate path, thereby affecting repo market dynamics and bond pricing immediately even without explicit FOMC announcements. Under this interpretation, the model's predictions apply to any shock that moves the short rate, regardless of its origin. The literature runs daily regressions of changes in forward rates against changes in short-term rates to test long rate sensitivity (e.g., Hanson et al., 2021). The second interpretation focuses specifically on monetary policy shocks, where short rate changes are primarily driven by central bank policy decisions and communications. The literature examines forward rate sensitivity specifically around FOMC announcement days (e.g., Hanson and Stein, 2015). I conduct empirical tests under both interpretations to comprehensively validate Prediction 3.

I first group the daily data into high and low HHI days based on the median HHI value. Then, I run univariate regressions of daily changes in forward rates against daily changes in 1-year forward rates:

$$\Delta f_t^{(\tau)} = \alpha^{(\tau)} + \beta_t^{(\tau)} \Delta f_t^{(1)} + \varepsilon_t^{(\tau)}, \tag{43}$$

separately for high and low HHI days. Here, $\Delta f_t^{(\tau)}$ is the daily change in the τ-year forward rate, and $\beta_t^{(\tau)}$ captures the sensitivity of the τ-year forward rate to changes in the 1-year forward rate. Panel A of Figure 8 presents the estimated coefficients for high and low HHI days across maturities. Consistent with Prediction 3, forward rates exhibit greater sensitivity to short rate changes on high HHI days compared to low HHI days, particularly at shorter maturities. The gap between high and low HHI sensitivities decreases with maturity. To test the statistical significance of this difference more formally, I estimate the following regression with an interaction term:

$$\Delta f_t^{(\tau)} = \alpha^{(\tau)} + \beta^{(\tau)} \Delta f_t^{(1)} + \varphi^{(\tau)} HHI_t \times \Delta f_t^{(1)} + \varepsilon_t^{(\tau)}, \tag{44}$$

where HHI_t is the most recent monthly HHI value at day t. The coefficient $\varphi^{(\tau)}$ is the empirical counterpart of $\mathscr{S}_t^{(\tau)}$ in the model, capturing how forward rate sensitivity to short rate changes varies with dealer market power. According to Prediction 3, I expect $\varphi^{(\tau)} > 0$ for short maturities, with the magnitude of $\varphi^{(\tau)}$ either decreasing monotonically or exhibiting a U-shape with maturity.

Panel B of Figure 8 plots the estimated interaction coefficients $\hat{\varphi}^{(\tau)}$ across maturities. The estimates

are significantly positive for maturities up to 6 years and exhibit a declining pattern with maturity, consistent with the model's predictions. This pattern mirrors the benchmark case of $\alpha = 5.21$ in Panel A of Figure 3, providing strong empirical support for Prediction 3.

To capture monetary policy shocks more precisely, I also estimate the regression in Equation (44) using only FOMC announcement days and present the results in Panel C of Figure 8. Finally, Panel D repeats the analysis but replaces the dependent variable with monetary policy surprises measured by changes in 3-month-ahead Fed funds futures around FOMC announcements. Though statistical significance weakens due to the smaller sample size of 121 FOMC days, the results are qualitatively similar, exhibiting positive interaction coefficients at short maturities that decline with maturity or exhibit a U-shape, further validating Prediction 3. Interestingly, the U-shape pattern in Panel D resembles the case of $\alpha = 10$ in Panel A of Figure 3. A possible explanation guided by the model is that the preferred habitat investors may exhibit higher demand elasticities during FOMC days. Overall, the four panels of Figure 8 mirror the theoretical patterns in Figure 3, providing strong empirical support for Prediction 3.

IV. Policy Analysis

In this section, I discuss the implications of dealer market power in repo markets for monetary policy effectiveness. Following Vayanos and Vila (2021), I conduct two quantitative experiments to examine how the term structure responds to forward guidance announcements and quantitative easing (QE) programs. I compare outcomes under three scenarios: the expectations hypothesis benchmark ($\gamma = 0$), the standard preferred-habitat model without market power ($\mathscr{M} = 0$), and the model with market power ($\mathscr{M} = 0.5$). My analysis reveals that dealer market power amplifies the effectiveness of both forward guidance and QE policies on the term structure of interest rates.

Forward Guidance. I first analyze the effect of forward guidance announcements about the future path of short rates. A forward guidance announcement is modeled as an unexpected revision to the long-run mean of the short rate, $\bar{r}$. Specifically, I set $\Delta\bar{r} = -0.04$, a 400 basis point reduction, that reverts to zero exponentially at rate $\kappa_{\bar{r}} = 0.2$, corresponding to a half-life of 3.47 years. Figure 9 plots the yield curve responses across maturities for three cases: the expectations hypothesis with $\gamma = 0$, the standard preferred-habitat model with $\mathscr{M} = 0$, and the model with market power at $\mathscr{M} = 0.5$.

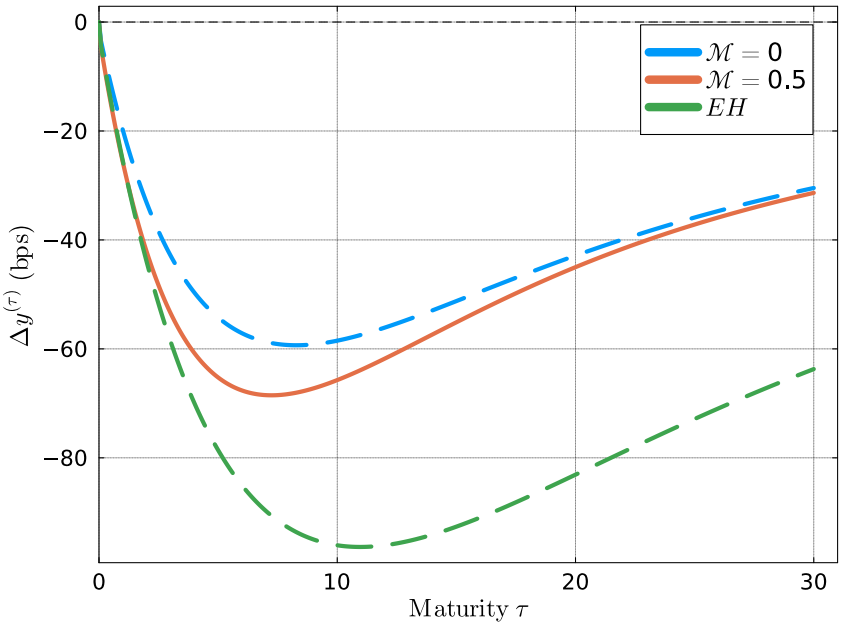


Figure 9. Forward Guidance: Yield Curve Response

Notes: This figure plots the yield curve response to a forward guidance announcement that reduces the long-run mean of the short rate by 400 basis points ($\Delta\bar{r} = -0.04$), reverting at rate $\kappa_{\bar{r}} = 0.2$ (half-life of 3.47 years). Three scenarios are shown: the expectations hypothesis benchmark (green dashed line, $\gamma = 0$), the standard preferred-habitat model without market power (blue solid line, $\mathscr{M} = 0$), and the model with market power (red dash-dot line, $\mathscr{M} = 0.5$). All other parameters are calibrated as reported in Table 1.

In the standard preferred-habitat model without market power, yields underreact to the forward guidance announcement, consistent with Vayanos and Vila (2021). This underreaction arises because dealers absorb the increased supply of long-term bonds from preferred-habitat investors when the short rate falls. As dealers take on more duration risk, they demand higher risk premia, which partially offsets the direct effect of lower expected future short rates on long-term yields. When I introduce dealer market power, the underreaction becomes substantially less severe. This result follows the same intuition from my earlier finding that market power amplifies the sensitivity of long-term yields to short rate changes. Yields decline more in response to the same forward guidance shock than they would without market power, indicating that market power channel enhances the pass-through of policy announcements to long-term rates.

Quantitative Easing. I next analyze the effects of quantitative easing on the term structure. I model QE as an unanticipated purchase of government bonds by the central bank that reduces the supply of bonds available to private markets. Following Vayanos and Vila (2021), I implement this as an unanticipated decrease in the intercept of preferred-habitat demand $\theta_0(\tau)$ such that $\int_0^\infty \Delta\theta_0(\tau)d\tau = -0.12$. The

shock occurs at time zero and reverts to zero at rate $\kappa_\theta = 0.1$, corresponding to a half-life of 6.93 years. Figure 10 presents the yield curve responses at time zero for bond purchases targeting four different maturities: 2-year, 10-year, 20-year, and 30-year bonds.

Consistent with Vayanos and Vila (2021), I find that in a single-factor preferred-habitat model without demand risk, QE exhibits no localized effect. The maturity of bond purchases does not significantly affect the shape of the term structure response. The yield curve responses are U-shaped, reaching their minimum around 10 years, regardless of the maturity targeted by QE. This absence of localization arises because all supply effects operate through the price of interest rate risk $\lambda_{r,t}$, which has a global impact across the term structure through the loading coefficient $A_r(\tau)$. Since $A_r(\tau)$ is independent of the maturity targeted by QE, the shape of the yield curve response remains similar regardless of which maturity the central bank purchases. This pattern remains even when I introduce dealer market power.

However, dealer market power substantially amplifies the overall magnitude of QE effects. Comparing the blue lines with $\mathscr{M} = 0$ to the red lines with $\mathscr{M} = 0.5$ across all four panels, yields decline significantly more under market power. The economic mechanism operates through dealers' funding cost considerations. When dealers possess market power, they internalize that their repo borrowing costs decline when they hold fewer bonds. This strategic consideration is absent in the standard preferred-habitat model and strengthens with higher market power. Consequently, when QE reduces the supply of bonds to private markets, it shifts the equilibrium to a state where dealers face substantially lower funding costs. This reduction in funding costs provides an additional incentive for dealers to expand their carry trades, further pushing bond prices up and yields down. Dealer market power therefore amplifies the effectiveness of QE programs in lowering long-term interest rates.

V. Conclusion

This paper examines how dealer market power in repo markets affects bond pricing and monetary policy transmission. I develop a tractable extension of the preferred-habitat model that incorporates an upward-sloping supply curve for repo financing, motivated by well-documented market power in funding markets. The model introduces a rent extraction channel: dealers with market power strategically restrict carry trades to avoid higher funding costs, earning rents proportional to both their market power and the policy rate.

The model generates three main predictions. First, dealer market power predicts higher bond

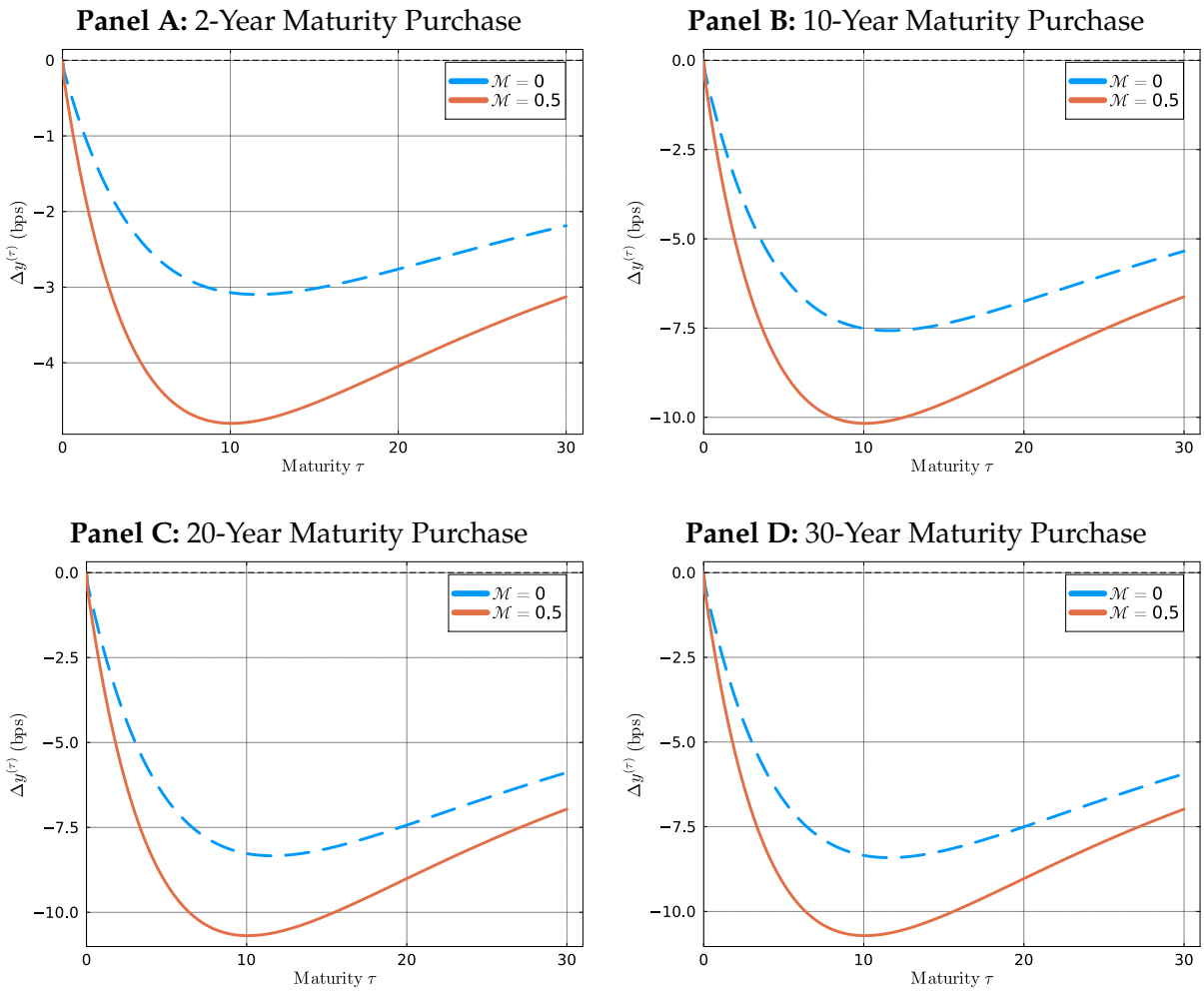


Figure 10. Quantitative Easing: Yield Curve Response by Purchase Maturity

Notes: This figure plots the yield curve response at time zero to a quantitative easing program that reduces bond supply by 12% of GDP, reverting at rate $\kappa_\theta = 0.1$ (half-life of 6.93 years). Each panel shows the effect of purchasing bonds at a specific maturity: 2-year (Panel A), 10-year (Panel B), 20-year (Panel C), and 30-year (Panel D). Two scenarios are shown in each panel: the standard preferred-habitat model without market power (blue solid line, $\mathcal{M} = 0$) and the model with market power (red dashed line, $\mathcal{M} = 0.5$). All other parameters are calibrated as reported in Table 1.

risk premia across all maturities. Second, it amplifies the sensitivity of bond excess returns to the yield curve slope, strengthening the well-known Fama-Bliss predictability pattern. Third, it amplifies forward rate sensitivity to short-rate shocks at modest maturities, with the amplification either declining monotonically or exhibiting a U-shape with maturity. Using U.S. Treasury market data from January 2011 to September 2025, I find strong empirical support for all three predictions. A measure of dealer concentration constructed from money market fund repo lending data successfully predicts term premia, amplifies return predictability by yield curve slope, and generates the predicted patterns in forward rate sensitivity to monetary policy shocks.

Beyond these empirical validations, the calibrated model reveals important implications for monetary policy effectiveness. Dealer market power amplifies the impact of both forward guidance announcements and quantitative easing programs on the term structure through the rent extraction channel, which strengthens policy pass-through to long-term rates. These findings underscore the crucial role of funding market structure in determining monetary policy effectiveness.

The analysis speaks directly to financial regulation. Recent years have seen heightened interest in repo market reforms aimed at enhancing liquidity and competition. A prominent example is the expansion of central clearing: in December 2023, the Securities and Exchange Commission adopted rules requiring central clearing for certain U.S. Treasury securities transactions, including repos. SEC Chair Gary Gensler emphasized that these reforms *"will help to make the Treasury market more efficient, competitive, and resilient."*[4] My findings reveal that such regulatory reforms may influence monetary policy effectiveness. When regulations reduce barriers to entry and lower dealer concentration, they weaken the rent extraction channel, potentially flattening the term structure and dampening the pass through of monetary policy shocks to long rates. This paper therefore highlights that policymakers should consider not only the direct effects of repo market reforms on market structure but also their broader implications for the entire yield curve through changes in dealer market power. Understanding these broader interactions between regulation, market structure, and monetary transmission remains an important area for future research.

[4]See https://www.sec.gov/newsroom/press-releases/2023-247

REFERENCES

Adrian, Tobias, Richard K Crump, and Emanuel Moench, 2013, Pricing the term structure with linear regressions, *Journal of Financial Economics* 110, 110–138.

Carboni, Giacomo, and Martin Ellison, 2022, *Preferred habitat and monetary policy through the looking-glass*, number 2697 (ECB Working Paper).

Cavaleri, Filippo, 2023, A preferred-habitat model with a corporate sector, *Available at SSRN 4603103* .

Cochrane, John H, and Monika Piazzesi, 2005, Bond risk premia, *American economic review* 95, 138–160.

Domanski, Dietrich, Hyun Song Shin, and Vladyslav Sushko, 2017, The hunt for duration: not waving but drowning?, *IMF Economic Review* 65, 113–153.

Drechsler, Itamar, Alexi Savov, and Philipp Schnabl, 2017, The deposits channel of monetary policy, *The Quarterly Journal of Economics* 132, 1819–1876.

Fama, Eugene F, and Robert R Bliss, 1987, The information in long-maturity forward rates, *The American Economic Review* 680–692.

Fleming, Michael J, Giang Nguyen, and Joshua V Rosenberg, 2008, How do treasury dealers manage their positions?, *FRB of New York Staff Report* .

Gourinchas, Pierre-Olivier, Walker Ray, and Dimitri Vayanos, 2025, A preferred-habitat model of term premia, exchange rates, and monetary policy spillovers, *American Economic Review* 115, 3788–3824.

Greenwood, Robin, Samuel Hanson, and Dimitri Vayanos, 2023, Supply and Demand and the Term Structure of Interest Rates, Technical Report w31879, National Bureau of Economic Research, Cambridge, MA.

Greenwood, Robin, and Dimitri Vayanos, 2014, Bond supply and excess bond returns, *The Review of Financial Studies* 27, 663–713.

Gürkaynak, Refet S, Brian Sack, and Jonathan H Wright, 2007, The us treasury yield curve: 1961 to the present, *Journal of monetary Economics* 54, 2291–2304.

Haddad, Valentin, and David Sraer, 2020, The Banking View of Bond Risk Premia, *The Journal of Finance* 75, 2465–2502.

Hanson, Samuel G., 2014, Mortgage convexity, *Journal of Financial Economics* 113, 270–299.

Hanson, Samuel G, David O Lucca, and Jonathan H Wright, 2021, Rate-amplifying demand and the excess sensitivity of long-term rates, *The Quarterly Journal of Economics* 136, 1719–1781.

Hanson, Samuel G, and Jeremy C Stein, 2015, Monetary policy and long-term real rates, *Journal of Financial Economics* 115, 429–448.

He, Zhiguo, Stefan Nagel, and Zhaogang Song, 2022, Treasury inconvenience yields during the COVID-19 crisis, *Journal of Financial Economics* 143, 57–79.

Huber, Amy Wang, 2023, Market power in wholesale funding: A structural perspective from the tri-party repo market, *Journal of Financial Economics* .

Jarocinski, Marek, and Peter Karadi, 2020, Deconstructing monetary policy surprises—the role of information shocks, *American Economic Journal: Macroeconomics* 12, 1–43.

Kekre, Rohan, Moritz Lenel, and Federico Mainardi, 2024, Monetary policy, segmentation, and the term structure, Technical report, National Bureau of Economic Research.

Khetan, Umang, Jian Li, Ioana Neamțu, and Ishita Sen, 2023, The market for sharing interest rate risk: Quantities and asset prices, *Available at SSRN 4517795* .

Kim, Don H, and Jonathan H Wright, 2011, An arbitrage-free three-factor term structure model and the recent behavior of long-term yields and distant-horizon forward rates .

Krishnamurthy, Arvind, and Annette Vissing-Jorgensen, 2012, The aggregate demand for treasury debt, *Journal of Political Economy* 120, 233–267.

Malkhozov, Aytek, Philippe Mueller, Andrea Vedolin, and Gyuri Venter, 2016, Mortgage risk and the yield curve, *The Review of Financial Studies* 29, 1220–1253.

Vayanos, Dimitri, and Jean-Luc Vila, 2021, A Preferred-Habitat Model of the Term Structure of Interest Rates, *Econometrica* 89, 77–112.

Wang, Yifei, Toni M Whited, Yufeng Wu, and Kairong Xiao, 2022, Bank market power and monetary policy transmission: Evidence from a structural estimation, *The Journal of Finance* 77, 2093–2141.

Xiao, Kairong, 2020, Monetary transmission through shadow banks, *The Review of Financial Studies* 33, 2379–2420.

A Proofs of Propositions

1. Proof of Proposition 1

Proof. The lender solves the following optimization problem

$$\max_{\{D_{i,t}\}} U_D = \left(\int_0^1 (D_{i,t} r_{i,t})^{1-\frac{1}{\eta}} di\right)^{\frac{1}{1-\frac{1}{\eta}}}, \quad \text{s.t.} \int_0^1 D_{i,t} di = D_t. \tag{A1}$$

The Lagrangean of the above problem is given by

$$\mathscr{L} = \left(\int_0^1 (D_{i,t} r_{i,t})^{1-\frac{1}{\eta}} di\right)^{\frac{1}{1-\frac{1}{\eta}}} + \lambda \left(D_t - \int_0^1 D_{i,t} di\right), \tag{A2}$$

where λ denotes the Lagrange multiplier associated with the constraint. The first-order conditions with respect to $D_{i,t}$ yield

$$\frac{\partial \mathscr{L}}{\partial D_{i,t}} = 0 \Longrightarrow U_D^{\frac{1}{\eta}} D_{i,t}^{-\frac{1}{\eta}} r_{i,t}^{1-\frac{1}{\eta}} = \lambda \tag{A3}$$

Multiplying both sides of equation (A3) by $D_{i,t}$ and integrating over i from 0 to 1, we obtain

$$U_D^{\frac{1}{\eta}} \underbrace{\int_0^1 D_{i,t}^{1-\frac{1}{\eta}} r_{i,t}^{1-\frac{1}{\eta}} di}_{=U_D^{1-\frac{1}{\eta}}} = \lambda \underbrace{\int_0^1 D_{i,t} di}_{D_t} \Longrightarrow U_D = \lambda D_t \tag{A4}$$

Hence, λ is the aggregate return from investing on private dealer sectors. We let $r_d \equiv \lambda$ denote the return of the dealer sector. Replacing U_D with λD_t in equation (A3), we obtain the optimal allocation

$$D_{i,t} = \left(\frac{r_{i,t}}{r_d}\right)^{\eta-1} D_t. \tag{A5}$$

Finally, replacing the above expression into the budget constraint, we obtain the expression of r_d

$$r_d = \left(\int_0^1 r_{i,t}^{\eta-1} di\right)^{\frac{1}{\eta-1}}. \tag{A6}$$

□

2. Proof of Proposition 2

Proof. First, I define

$$\kappa_r^* \equiv \kappa_r + \Omega_{rr} = \kappa_r + \gamma\sigma_r^2 \int_0^T \alpha(\tau) A_r(\tau)^2 d\tau. \tag{A7}$$

and rewrite the ODE for $A_r(\tau)$ in equation (25) as

$$A_r(\tau)\kappa_r^* + A_r'(\tau) - (1 + \mathscr{M}) = 0. \tag{A8}$$

With the boundary condition $A_r(0) = 0$, this ODE has the solution in equation (29). Substituting this solution back into the definition of κ_r^* in equation (A7), I obtain the fixed point equation for κ_r^* in equation (31). Next, taking the integral from 0 to τ on both sides of the ODE for $C(\tau)$ in equation (26), using the boundary condition $C(0) = 0$, and defining $\bar{r}^*$ to satisfy

$$\kappa_r^* \bar{r}^* = \kappa_r \bar{r} + \Omega_r = \kappa_r \bar{r} + \gamma\sigma_r^2 \int_0^T (\theta_0(\tau) - \alpha(\tau) C(\tau)) A_r(\tau) d\tau, \tag{A9}$$

this ODE has the solution in equation (30). Now, substituting the solution for $C(\tau)$ back into the definition of $\bar{r}^*$ in equation (A9), we obtain

$$\begin{aligned} &\kappa_r^* \bar{r}^* \left[1 + \gamma\sigma_r^2 \int_0^\infty \alpha(\tau) \left[\int_0^\tau A_r(u) du \right] A_r(\tau) d\tau \right] \\ &= \kappa_r \bar{r} + \gamma\sigma_r^2 \int_0^\infty \theta_0(\tau) A_r(\tau) d\tau + \frac{\gamma\sigma_r^4}{2} \int_0^\infty \alpha(\tau) \left[\int_0^\tau A_r(u)^2 du \right] A_r(\tau) d\tau \end{aligned} \tag{A10}$$

Notice that

$$\kappa_r \bar{r} = \kappa_r^* \bar{r} + \left(\kappa_r - \kappa_r^*\right) \bar{r} + \kappa_r^* \bar{r} \gamma\sigma_r^2 \int_0^\infty \alpha(\tau) \left[\int_0^\tau A_r(u) du \right] A_r(\tau) d\tau - \kappa_r^* \bar{r} \gamma\sigma_r^2 \int_0^\infty \alpha(\tau) \left[\int_0^\tau A_r(u) du \right] A_r(\tau) d\tau \tag{A11}$$

where the equation holds because first two terms on the right-hand side equal to the left-hand side and the last two terms cancel out. Merging the first and third terms on the right-hand side, I have

$$\begin{aligned} \kappa_r \bar{r} =& \kappa_r^* \bar{r} \left[1 + \gamma\sigma_r^2 \int_0^\infty \alpha(\tau) \left[\int_0^\tau A_r(u) du \right] A_r(\tau) d\tau \right] \\ &+ \left(\kappa_r - \kappa_r^*\right) \bar{r} - \kappa_r^* \bar{r} \gamma\sigma_r^2 \int_0^\infty \alpha(\tau) \left[\int_0^\tau A_r(u) du \right] A_r(\tau) d\tau. \end{aligned} \tag{A12}$$

Next, I simplify the last two terms on the right-hand side above:

$$\begin{aligned}
&\left(\kappa_r - \kappa_r^*\right)\bar{r} - \kappa_r^*\bar{r}\gamma\sigma_r^2\int_0^\infty \alpha(\tau)\left[\int_0^\tau A_r(u)du\right]A_r(\tau)d\tau \\
&= -\bar{r}\gamma\sigma_r^2\int_0^\infty \alpha(\tau)A_r(\tau)^2 d\tau - \kappa_r^*\bar{r}\gamma\sigma_r^2\int_0^\infty \alpha(\tau)\left[\int_0^\tau A_r(u)du\right]A_r(\tau)d\tau \\
&= -\bar{r}\gamma\sigma_r^2\int_0^\infty \alpha(\tau)\left[A_r(\tau) + \kappa_r^*\int_0^\tau A_r(u)du\right]A_r(\tau)d\tau
\end{aligned} \tag{A13}$$

where the first step follows from substituting $\kappa_r - \kappa_r^*$ in equation (A7) and the second step is rearranging the terms. Moreover, notice that

$$A_r(\tau) + \kappa_r^*\int_0^\tau A_r(u)du = \int_0^\tau \left[A_r'(u) + \kappa_r^* A_r(u)\right]du = \int_0^\tau (1+\mathscr{M})du = (1+\mathscr{M})\tau \tag{A14}$$

where the second last step follows from the ODE for $A_r(\tau)$ in equation (A8). Therefore, substituting this into equation (A13), I have

$$\left(\kappa_r - \kappa_r^*\right)\bar{r} - \kappa_r^*\bar{r}\gamma\sigma_r^2\int_0^\infty \alpha(\tau)\left[\int_0^\tau A_r(u)du\right]A_r(\tau)d\tau = -\bar{r}\gamma\sigma_r^2(1+\mathscr{M})\int_0^\infty \alpha(\tau)\tau A_r(\tau)d\tau \tag{A15}$$

Substituting this back into equation (A12), I find

$$\kappa_r\bar{r} = \kappa_r^*\bar{r}\left[1 + \gamma\sigma_r^2\int_0^\infty \alpha(\tau)\left[\int_0^\tau A_r(u)du\right]A_r(\tau)d\tau\right] - \bar{r}\gamma\sigma_r^2(1+\mathscr{M})\int_0^\infty \alpha(\tau)\tau A_r(\tau)d\tau \tag{A16}$$

Substituting this back into equation (A10), we obtain

$$\begin{aligned}
&\kappa_r^*\bar{r}^*\left[1 + \gamma\sigma_r^2\int_0^\infty \alpha(\tau)\left[\int_0^\tau A_r(u)du\right]A_r(\tau)d\tau\right] \\
&= \kappa_r^*\bar{r}\left[1 + \gamma\sigma_r^2\int_0^\infty \alpha(\tau)\left[\int_0^\tau A_r(u)du\right]A_r(\tau)d\tau\right] - \bar{r}\gamma\sigma_r^2(1+\mathscr{M})\int_0^\infty \alpha(\tau)\tau A_r(\tau)d\tau \\
&\quad + \gamma\sigma_r^2\int_0^\infty \theta_0(\tau)A_r(\tau)d\tau + \frac{\gamma\sigma_r^4}{2}\int_0^\infty \alpha(\tau)\left[\int_0^\tau A_r(u)^2 du\right]A_r(\tau)d\tau
\end{aligned} \tag{A17}$$

Finally, substituting the solution for $A_r(\tau)$ in equation (29) into the above equation and rearranging the terms yield the fixed point equation for $\bar{r}^*$ in equation (32). □

3. Proof of Proposition 3

Proof. For convenience, I denote the dependent variable in the FB regression in equation (34) by Y_t^τ and the independent variable by X_t. Using equations (8), (9), and (15), I can rewrite the dependent and independent variables in the FB regression in equation (34) as follows:

$$Y_t^\tau = \frac{1}{\Delta\tau}\Big(A_r(\tau)r_t + C(\tau) - \big[A_r(\tau-\Delta\tau)r_{t+\Delta\tau} + C(\tau-\Delta\tau)\big] - \big[A_r(\Delta\tau)r_t + C(\Delta\tau)\big]\Big) \tag{A18}$$

$$X_t = \frac{1}{\Delta\tau}\Big(A_r(\tau)r_t + C(\tau) - \big[A_r(\tau-\Delta\tau)r_t + C(\tau-\Delta\tau)\big] - \big[A_r(\Delta\tau)r_t + C(\Delta\tau)\big]\Big) \tag{A19}$$

Substituting these expressions into $b_{\text{FB}} \equiv \lim_{\Delta\tau\to 0}\frac{\text{Cov}(Y_t^\tau, X_t)}{\text{Var}(X_t)}$, I obtain

$$b_{\text{FB}} = \lim_{\Delta\tau\to 0}\frac{[A_r(\tau)-A_r(\Delta\tau)]\text{Var}(r_t) - A_r(\tau-\Delta\tau)\text{Cov}(r_{t+\Delta\tau}, r_t)}{[A_r(\tau)-A_r(\tau-\Delta\tau)-A_r(\Delta\tau)]\text{Var}(r_t)} \tag{A20}$$

Next, I calculate $\text{Cov}(r_{t+\Delta\tau}, r_t)$. I first calculate $r_{t+\Delta\tau}$. I define $X_s := r_s - \bar{r}$ and it satisfies

$$dX_s = -\kappa_r X_s\, ds + \sigma_r\, dB_{r,s}. \tag{A21}$$

Multiply both sides by the integrating factor $e^{\kappa_r s}$ and apply Itô's lemma to $e^{\kappa_r s}X_s$:

$$d\big(e^{\kappa_r s}X_s\big) = e^{\kappa_r s}dX_s + \kappa_r e^{\kappa_r s}X_s\, ds = \sigma_r e^{\kappa_r s}dB_{r,s}. \tag{A22}$$

Integrating from $s = t$ to $s = t+\Delta\tau$ yields

$$e^{\kappa_r(t+\Delta\tau)}X_{t+\Delta\tau} - e^{\kappa_r t}X_t = \sigma_r\int_t^{t+\Delta\tau} e^{\kappa_r s}\, dB_{r,s}. \tag{A23}$$

Rearranging gives

$$X_{t+\Delta\tau} = e^{-\kappa_r\Delta\tau}X_t + \sigma_r\int_t^{t+\Delta\tau} e^{-\kappa_r(t+\Delta\tau-s)}dB_{r,s}. \tag{A24}$$

Substituting back $X_s = r_s - \bar{r}$, we obtain

$$r_{t+\Delta\tau} = \bar{r}(1-e^{-\kappa_r\Delta\tau}) + r_t e^{-\kappa_r\Delta\tau} + \sigma_r\int_t^{t+\Delta\tau} e^{-\kappa_r(t+\Delta\tau-s)}dB_{r,s}. \tag{A25}$$

As the first term and the last term are independent of r_t, I have

$$\text{Cov}(r_{t+\Delta\tau}, r_t) = \text{Var}(r_t)e^{-\kappa_r\Delta\tau}, \tag{A26}$$

Substituting this expression back into the expression for b_{FB}, I obtain

$$b_{\text{FB}} = \lim_{\Delta\tau\to 0}\frac{A_r(\tau) - A_r(\tau-\Delta\tau)e^{-\kappa_r\Delta\tau} - A_r(\Delta\tau)}{A_r(\tau)-A_r(\tau-\Delta\tau)-A_r(\Delta\tau)}. \tag{A27}$$

Deviding the numerator and denominator of b_{FB} by $\Delta\tau$ and rearranging terms, I obtain

$$b_{\text{FB}} = \lim_{\Delta\tau\to 0} \frac{\frac{A_r(\tau)-A_r(\tau-\Delta\tau)}{\Delta\tau} - \frac{A_r(\Delta\tau)}{\Delta\tau} + \frac{A_r(\tau-\Delta\tau)(1-e^{-\kappa_r\Delta\tau})}{\Delta\tau}}{\frac{A_r(\tau)-A_r(\tau-\Delta\tau)}{\Delta\tau} - \frac{A_r(\Delta\tau)}{\Delta\tau}}. \tag{A28}$$

Applying L'Hôpital's rule, I have

$$\lim_{\Delta\tau\to 0} \frac{A_r(\tau)-A_r(\tau-\Delta\tau)}{\Delta\tau} = A_r'(\tau) \tag{A29}$$

$$\lim_{\Delta\tau\to 0} \frac{A_r(\tau-\Delta\tau)(1-e^{-\kappa_r\Delta\tau})}{\Delta\tau} = \kappa_r A_r(\tau) \tag{A30}$$

$$\lim_{\Delta\tau\to 0} \frac{A_r(\Delta\tau)}{\Delta\tau} = \lim_{\Delta\tau\to 0} \frac{(1+\mathscr{M})(1-e^{-\kappa_r^*\Delta\tau})}{\kappa_r^*\Delta\tau} = 1+\mathscr{M}, \tag{A31}$$

Substituting these limits back into the expression for b_{FB}, I obtain

$$b_{\text{FB}} = \frac{A_r'(\tau) - (1+\mathscr{M}) + \kappa_r A_r(\tau)}{A_r'(\tau) - (1+\mathscr{M})}. \tag{A32}$$

Finally, substituting $A_r(\tau) = \frac{(1+\mathscr{M})(1-e^{-\kappa_r^*\tau})}{\kappa_r^*}$ in equation (29), and its derivative $A_r'(\tau) = (1+\mathscr{M})e^{-\kappa_r^*\tau}$ into the above expression yields

$$b_{\text{FB}} = \frac{(1+\mathscr{M})(e^{-\kappa_r^*\tau}-1)\left(\frac{\kappa_r^*-\kappa_r}{\kappa_r^*}\right)}{(1+\mathscr{M})(e^{-\kappa_r^*\tau}-1)} = \frac{\kappa_r^*-\kappa_r}{\kappa_r^*}. \tag{A33}$$

I first show that $b_{\text{FB}} > 0$. From equation (31), I have

$$\kappa_r^* = \kappa_r + \gamma\sigma_r^2(1+\mathscr{M})^2 \int_0^T \alpha(\tau)\left(\frac{1-e^{-\kappa_r^*\tau}}{\kappa_r^*}\right)^2 d\tau. \tag{A34}$$

Since $\gamma > 0$, $\sigma_r^2 > 0$, $\alpha(\tau) > 0$, and $(1+\mathscr{M}) > 1$, the integral term is strictly positive. Therefore, $\kappa_r^* > \kappa_r$, which implies that $b_{\text{FB}} > 0$. I then show that b_{FB} is strictly increasing in $\mathscr{M}$. As $\frac{\partial b_{\text{FB}}}{\partial \mathscr{M}} = \frac{\kappa_r}{\kappa_r^{*2}}\frac{d\kappa_r^*}{d\mathscr{M}}$, it suffices to show that κ_r^* is strictly increasing in $\mathscr{M}$. Define the implicit function $\Phi : \mathbb{R}^+ \times \mathbb{R}^+ \to \mathbb{R}$ by:

$$\Phi(\kappa_r^*, \mathscr{M}) = \kappa_r^* - \kappa_r - \gamma\sigma_r^2(1+\mathscr{M})^2 \int_0^T \alpha(\tau)\left(\frac{1-e^{-\kappa_r^*\tau}}{\kappa_r^*}\right)^2 d\tau = 0. \tag{A35}$$

By the implicit function theorem:

$$\frac{d\kappa_r^*}{d\mathscr{M}} = -\frac{\frac{\partial\Phi}{\partial\mathscr{M}}}{\frac{\partial\Phi}{\partial\kappa_r^*}}. \tag{A36}$$

I now compute $\frac{\partial \Phi}{\partial \mathscr{M}}$:

$$\frac{\partial \Phi}{\partial \mathscr{M}} = -2\gamma\sigma_r^2(1+\mathscr{M})\int_0^T \alpha(\tau)\left(\frac{1-e^{-\kappa_r^*\tau}}{\kappa_r^*}\right)^2 d\tau < 0, \tag{A37}$$

where the inequality holds since all parameters are positive. Next, I compute $\frac{\partial \Phi}{\partial \kappa_r^*}$:

$$\frac{\partial \Phi}{\partial \kappa_r^*} = 1 - 2\gamma\sigma_r^2(1+\mathscr{M})^2\int_0^T \alpha(\tau)\frac{1-e^{-\kappa_r^*\tau}}{\kappa_r^*}\frac{\partial}{\partial \kappa_r^*}\left[\frac{1-e^{-\kappa_r^*\tau}}{\kappa_r^*}\right] d\tau. \tag{A38}$$

I have:

$$\frac{\partial}{\partial \kappa_r^*}\left[\frac{1-e^{-\kappa_r^*\tau}}{\kappa_r^*}\right] = \frac{\tau\kappa_r^* e^{-\kappa_r^*\tau} - (1-e^{-\kappa_r^*\tau})}{\kappa_r^{*2}} = \frac{\psi(\kappa_r^*\tau)}{\kappa_r^{*2}}, \tag{A39}$$

where $\psi(x) = xe^{-x} - (1-e^{-x})$. For $x > 0$, we have $\psi'(x) = -xe^{-x} < 0$ and $\psi(0) = 0$, so $\psi(x) < 0$ for all $x > 0$. Therefore:

$$\frac{\partial \Phi}{\partial \kappa_r^*} = 1 - \frac{2\gamma\sigma_r^2(1+\mathscr{M})^2}{\kappa_r^{*3}}\int_0^T \alpha(\tau)(1-e^{-\kappa_r^*\tau})\psi(\kappa_r^*\tau)d\tau. \tag{A40}$$

Since $(1-e^{-\kappa_r^*\tau}) > 0$ and $\psi(\kappa_r^*\tau) < 0$, the integral is negative. Hence:

$$\frac{\partial \Phi}{\partial \kappa_r^*} > 1 > 0. \tag{A41}$$

Combining the results above, we have $\frac{\partial \Phi}{\partial \mathscr{M}} < 0$ and $\frac{\partial \Phi}{\partial \kappa_r^*} > 0$, which implies:

$$\frac{d\kappa_r^*}{d\mathscr{M}} = -\frac{\frac{\partial \Phi}{\partial \mathscr{M}}}{\frac{\partial \Phi}{\partial \kappa_r^*}} > 0. \tag{A42}$$

Therefore, κ_r^* is strictly increasing in $\mathscr{M}$ and hence b_{FB} is strictly increasing in $\mathscr{M}$:

$$\frac{\partial b_{\text{FB}}}{\partial \mathscr{M}} = \frac{\kappa_r}{\kappa_r^{*2}}\frac{d\kappa_r^*}{d\mathscr{M}} > 0. \tag{A43}$$

□

4. Proof of Proposition 4

Proof. I establish the properties of $\mathscr{S}_t^{(\tau)} \equiv \frac{\partial}{\partial \mathscr{M}}\left(\frac{\partial f_t^{(\tau)}}{\partial r_t}\right)$ through a series of steps. I first verify equation (38). From the bond pricing formula $P_t^{(\tau)} = e^{-A_r(\tau)r_t - C(\tau)}$, the forward rate is given by:

$$f_t^{(\tau)} = -\frac{\partial \log P_t^{(\tau)}}{\partial \tau} = A_r'(\tau)r_t + C'(\tau) \tag{A44}$$

Taking the derivative with respect to r_t:

$$\frac{\partial f_t^{(\tau)}}{\partial r_t} = A_r'(\tau) = (1+\mathscr{M})e^{-\kappa_r^*\tau} \tag{A45}$$

This establishes equation (38).

I now derive the expression for $\mathscr{S}_t^{(\tau)}$. From equation (38):

$$\mathscr{S}_t^{(\tau)} = \frac{\partial}{\partial \mathscr{M}}\left[(1+\mathscr{M})e^{-\kappa_r^*\tau}\right] = e^{-\kappa_r^*\tau} + (1+\mathscr{M})e^{-\kappa_r^*\tau}\left(-\tau\frac{d\kappa_r^*}{d\mathscr{M}}\right) \tag{A46}$$

Factoring out $e^{-\kappa_r^*\tau} > 0$:

$$\mathscr{S}_t^{(\tau)} = e^{-\kappa_r^*\tau}\left[1 - (1+\mathscr{M})\tau\frac{d\kappa_r^*}{d\mathscr{M}}\right] \tag{A47}$$

To establish Property 1, we define:

$$\phi(\tau) \equiv 1 - (1+\mathscr{M})\tau\frac{d\kappa_r^*}{d\mathscr{M}} \tag{A48}$$

Since κ_r^* is independent of τ (it depends on the entire function $A_r(\cdot)$ over $[0,T]$ but not on the specific point τ), we have:

$$\frac{d\phi}{d\tau} = -(1+\mathscr{M})\frac{d\kappa_r^*}{d\mathscr{M}} < 0 \tag{A49}$$

Therefore, $\phi(\tau)$ is a strictly decreasing linear function of τ with $\phi(0) = 1 > 0$ and $\frac{d\phi}{d\tau} < 0$ for all $\tau \geq 0$. This implies there exists a unique $\hat{\tau} > 0$ such that $\phi(\hat{\tau}) = 0$:

$$\hat{\tau} = \frac{1}{(1+\mathscr{M})\frac{d\kappa_r^*}{d\mathscr{M}}} \tag{A50}$$

Since $\phi(\tau) > 0$ for $\tau < \hat{\tau}$ and $\phi(\tau) < 0$ for $\tau > \hat{\tau}$, and since $e^{-\kappa_r^*\tau} > 0$ for all τ, I have from equation (A47):

$$\mathscr{S}_t^{(\tau)} > 0 \text{ for all } \tau \in (0,\hat{\tau}) \quad \text{and} \quad \mathscr{S}_t^{(\tau)} < 0 \text{ for all } \tau \in (\hat{\tau},\infty)$$

This establishes Property 1. In particular, if $T \leq \hat{\tau}$, then $\mathscr{S}_t^{(\tau)} > 0$ for all $\tau \in (0,T]$, implying that market power increases the forward rate sensitivity for all maturities. I next establish Property 2 by analyzing the monotonicity of $\mathscr{S}_t^{(\tau)}$ with respect to τ. I compute the derivative:

$$\frac{\partial \mathscr{S}_t^{(\tau)}}{\partial \tau} = \frac{\partial}{\partial \tau}\left[e^{-\kappa_r^*\tau}\phi(\tau)\right] = e^{-\kappa_r^*\tau}\left[-\kappa_r^*\phi(\tau) - (1+\mathscr{M})\frac{d\kappa_r^*}{d\mathscr{M}}\right] \tag{A51}$$

Since $e^{-\kappa_r^* \tau} > 0$, the sign of $\frac{\partial \mathscr{S}_t^{(\tau)}}{\partial \tau}$ is determined by:

$$-\kappa_r^* \phi(\tau) - (1+\mathscr{M}) \frac{d\kappa_r^*}{d\mathscr{M}} = -\kappa_r^* + (1+\mathscr{M}) \frac{d\kappa_r^*}{d\mathscr{M}} (\kappa_r^* \tau - 1) \tag{A52}$$

Define:

$$h(\tau) \equiv -\kappa_r^* + (1+\mathscr{M}) \frac{d\kappa_r^*}{d\mathscr{M}} (\kappa_r^* \tau - 1) \tag{A53}$$

This is a linear function of τ with:

$$h(0) = -\kappa_r^* - (1+\mathscr{M}) \frac{d\kappa_r^*}{d\mathscr{M}} < 0 \tag{A54}$$

$$\frac{dh}{d\tau} = (1+\mathscr{M}) \kappa_r^* \frac{d\kappa_r^*}{d\mathscr{M}} > 0 \tag{A55}$$

Therefore, there exists a unique threshold $\bar{\tau} > 0$ such that $h(\bar{\tau}) = 0$:

$$\bar{\tau} = \frac{1}{\kappa_r^*} + \frac{1}{(1+\mathscr{M}) \kappa_r^* \frac{d\kappa_r^*}{d\mathscr{M}}} \tag{A56}$$

For $\tau < \bar{\tau}$, I have $h(\tau) < 0$, hence $\frac{\partial \mathscr{S}_t^{(\tau)}}{\partial \tau} < 0$. For $\tau > \bar{\tau}$, I have $h(\tau) > 0$, hence $\frac{\partial \mathscr{S}_t^{(\tau)}}{\partial \tau} > 0$. This establishes that $\mathscr{S}_t^{(\tau)}$ is strictly decreasing on $[0, \bar{\tau})$ and strictly increasing on $(\bar{\tau}, \infty)$, reaching its minimum at $\tau = \bar{\tau}$. Therefore, if $T \leq \bar{\tau}$, then $\mathscr{S}_t^{(\tau)}$ is monotonically decreasing on $[0, T]$. If $T > \bar{\tau}$, then $\mathscr{S}_t^{(\tau)}$ exhibits a U-shape on $[0, T]$. This establishes Property 2.

Finally, I establish Property 3. From Properties 1 and 2, I know $\mathscr{S}_t^{(\tau)} > 0$ for all $\tau \in (0, \hat{\tau})$ and $\frac{\partial \mathscr{S}_t^{(\tau)}}{\partial \tau} < 0$ for all $\tau \in (0, \bar{\tau})$. Define $\tau^* \equiv \min\{\hat{\tau}, \bar{\tau}\}$. For any $\tau \in (0, \tau^*)$, I have $\tau < \hat{\tau}$ and $\tau < \bar{\tau}$, which implies both $\mathscr{S}_t^{(\tau)} > 0$ and $\frac{\partial \mathscr{S}_t^{(\tau)}}{\partial \tau} < 0$. This establishes Property 3, showing that for short maturities (up to τ^*), market power always increases the forward rate sensitivity, and this positive impact is decreasing in maturity. □