

Institutional Investor Mandates, Securities Lending, and Short-Selling Constraints*

Taisiya Sikorskaya[†]

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Abstract

Institutions facilitate short-selling by lending from their holdings, but what they hold is endogenous. This paper examines how institutional demand, driven by investment mandates (benchmarking), affects short-selling. In a model where benchmarked managers lend from their holdings, both lending supply and equilibrium price are higher for the benchmark asset, and so is shorting demand (due to inflated price). A quasi-experiment using Russell index reconstitution shows that stocks with more benchmarked capital have greater lending supply and demand. Ultimately, such stocks are *costlier* to short. In theory and data, results are driven by incomplete pass-through from benchmarked capital to lending supply.

JEL Classification: G11, G12, G14, G15, G23

Keywords: Benchmark, lending supply, borrowing fee, short sales, index effect, Russell

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[†]University of Chicago Booth School of Business, Taisiya.Sikorskaya@chicagobooth.edu

1 Introduction

Short-selling is key to price discovery in financial markets. Yet, the securities lending market, in which most investors must first borrow assets to sell them short, is opaque (U.S. Securities and Exchange Commission (2021)). It is still an open question what determines the cost of short-selling despite nearly six decades of academic research in this area (Seneca (1967)). At the same time, an increasing number of studies are linking asset pricing anomalies to securities with binding short-selling constraints, or those that are expensive to borrow.¹

The conventional view in the literature is that institutional ownership alleviates short-selling constraints by increasing the supply of lendable shares (D’Avolio (2002) and Asquith, Pathak, and Ritter (2005)). According to S&P Global (2025), short-sellers borrowed an average value of over \$0.6 trillion per day in U.S. equities in 2024, where institutional investors were the primary lenders.² Institutions, with their long-term investment horizons, are well-suited to lend their holdings and generate significant revenue by doing so.³ At the same time, institutions can only lend what they own, and hence the same asset characteristics that drive institutional demand also influence the level of supply of the asset available to short-sellers in the lending market. For instance, one can expect larger and more liquid assets, which are typically held by institutions, to have a larger lending supply. However, if institutional demand affects asset prices, for example, by inflating them, it must change the short-selling demand as well. Therefore, it is not clear ex-ante how institutional ownership should affect the cost of short-selling, that is, the borrowing fee.

In this paper, I bring together the demand and supply effects of institutional ownership in the stock lending market, thereby shedding new light on the role of institutions in shaping short-selling constraints. In particular, I isolate changes in institutional holdings stemming from investment mandates and study the resulting changes in lending supply, shorting demand, and borrowing fees. Benchmarking, which involves evaluating fund manager performance against a market index (benchmark), is a key mechanism for enforcing investment mandates and has been shown to influence asset prices.⁴ Despite this, the potential of mandate-bound institutional in-

¹See, for example, Chen, Hong, and Stein (2002), Geczy, Musto, and Reed (2002), Stambaugh, Yu, and Yuan (2012), Drechsler and Drechsler (2016), and Muravyev, Pearson, and Pollet (2025).

²In the United States, over 90% of equity loans are sourced from institutions, as reported by the Federal Reserve (Baklanova, Caglio, Keane, and Porter, 2016) and The Investment Company Institute (2014).

³For instance, the 2022 N-CSR filing for Vanguard Index Funds reports net securities lending income of over \$0.57 billion, nearly 60% of net expenses. The Financial Times reports a 40% rebate of fees due to lending for selected BlackRock funds: <https://www.ft.com/content/866171e2-1916-4c55-bdc2-2d6c6cb56609>.

⁴See Ma, Tang, and Gómez (2019), who document that over 80% of manager compensation contracts in the United States are tied to an index such as the S&P 500 or the Russell 1000. Institutions tilt their portfolios toward stocks included in their benchmark indexes, raising these stocks’ prices and inducing excess correlations in returns (Basak and Pavlova, 2013). Tight mandates contribute to market segmentation and

vestors to inflate asset prices and hence increase short-selling demand has been largely overlooked in the literature on short sales. I explicitly incorporate this channel and show, theoretically and empirically, that it is strong enough to challenge the conventional view on the role of institutions in short-selling markets.

I build intuition using a tractable model with benchmarked fund managers who supply their risky holdings for lending. These managers optimally tilt their portfolios to the asset in their benchmark index, increasing both the price of the asset and its lending supply. Simple intuition suggests that a larger supply should alleviate short-selling constraints and reduce the borrowing fee (*supply effect* of benchmarking). However, the model shows that benchmarking may increase the fee because it inflates the asset price and hence also attracts higher shorting demand (*demand effect* of benchmarking). I test the model’s predictions using a quasi-experiment based on the Russell index reconstitution, in which there are shocks to how much capital is benchmarked against specific stocks. I find that the demand effect of benchmarking dominates the supply effect because it becomes costlier to short stocks that experience an increase in capital benchmarked against them due to index reconstitution. Finally, combined with my model, insights from novel regulatory filings suggest that both explicit lending limits and frictions in the lending market depress the pass-through from institutional holdings to lending supply, resulting in a weak supply effect of benchmarking.

The model allows me to characterize asset prices and borrowing fees in the presence of benchmarking and securities lending. It introduces a lending market to an economy with fund managers benchmarked to a market index. Other agents include direct investors, who are net long, and hedgers, who are net short. Because fund managers’ performance is evaluated relative to the index, they always allocate a fraction of their holdings to the benchmark asset, thereby inflating its price. This results in the asset being overvalued compared to an economy without benchmarking.

A unique aspect of the model is that the benchmark-induced holdings contribute to the lending supply. Fund managers can lend their risky holdings to hedgers, up to an exogenous lending limit,⁵ in exchange for a fee, while direct investors are not permitted to lend. The shorting demand of hedgers is upward-sloping in price so it is also higher for the benchmark asset due to its inflated price. Because both the supply and demand effects of benchmarking coexist, it is not immediately apparent how borrowing fees (short-selling costs) relate to benchmarking. By clearing the asset spot and lending markets at the same time, I demonstrate that this relationship in equilibrium

capital immobility (He and Xiong, 2013) and are closely related to preferred-habitat models of the term structure of interest rates (Vayanos and Vila, 2021).

⁵In the United States, there is a regulatory limit on the total value on loan relative to the fund value. I discuss this and other drivers of limited lending below. Furthermore, allowing funds to choose the lending limit endogenously to balance lending costs yields the same key findings. I explore this in Internet Appendix E.

depends on a simple condition related to the fund managers’ lending limit. When the managers are too constrained in lending (that is, when the lending limit is relatively tight), the demand effect prevails, resulting in a higher borrowing fee for the benchmark asset.

The model features different predictions for an asset that is free to short, referred to as a *general collateral* asset, and an asset that is costly to short, referred to as an asset on special (or simply as a *special* asset). For a general collateral asset, the lending market clearing condition is slack, which means that the equilibrium lending supply is higher than the shorting demand and the borrowing fee is zero. While benchmarking increases both lending supply and shorting demand for such an asset, the borrowing fee remains unchanged. For a special asset, the lending market clearing condition binds, resulting in a strictly positive borrowing fee. Whether this fee increases or decreases with benchmarking depends on the lending limit as described above.

The contribution of the paper is primarily empirical. An ideal test of the model would require variation in benchmarking that is independent of stock fundamentals. Obtaining such variation in data is challenging because index membership is typically related to factors like company size and liquidity of its shares. Additionally, as stocks in major indexes often attract more analyst coverage, index membership may be related to analyst disagreement, which the literature has associated with short-selling. I therefore turn to the following quasi-experiment.

To test predictions of my model, I exploit changes in the index membership of U.S. stocks due to the reconstitution of Russell indexes. Utilizing the composition of 34 U.S. equity indexes and the assets of mutual funds and exchange-traded funds (ETFs) benchmarked against them, I construct a comprehensive measure of the amount of capital benchmarked against a stock, expressed as a fraction of its market value. This measure is called *benchmarking intensity*, or BMI (Pavlova and Sikorskaya, 2023). I argue that the mechanical nature of the Russell reconstitution creates a plausibly exogenous change in BMI, allowing me to test the predictions of the model.⁶ I first confirm that a stock’s price goes up when the stock moves down from the Russell 1000 to the Russell 2000 index (see Chang, Hong, and Liskovich (2015)). Such stocks experience an average BMI increase of 8.6 percentage points (pp) because there is more capital benchmarked to the Russell 2000 index.

Using comprehensive S&P Global (Markit) buy-side data, I provide new insights into the securities lending market during the Russell reconstitutions. I find that both a stock’s lending supply (inventory) and shorting demand (short interest) go up with its BMI. This is true for both general collateral stocks and stocks on special, which I define empirically as those with annualized borrowing fees below and above 1%, respectively, following the literature (for example, Aggarwal,

⁶By using the proprietary ranking variable and constituent files from FTSE Russell, I circumvent certain known issues with the test design (see, for example, Appel, Gormley, and Keim (2021)). I provide the details in Section 5.2.6 and Internet Appendix A.5.

Saffi, and Sturgess (2015)).⁷ However, the pass-through to lending supply seems weak, as a dollar of new benchmarked capital translates only to around 18 cents of new lending inventory. I observe no change in borrowing fees for general collateral stocks, which is consistent with my model because the short-selling constraint does not bind for these stocks. Conversely, the fees of stocks on special increase, revealing that the demand effect of benchmarking is dominant. The magnitude is economically significant, with the borrowing fee increasing by 21 basis points (bps) for each pp increase in BMI. This means that, on average, it becomes 25% more expensive to short stocks added to the Russell 2000. Finally, using changes in BMI as an instrument for changes in institutional ownership (following Pavlova and Sikorskaya (2023)), I document that a 1 pp increase in institutional ownership leads to a 78 bps higher fee for special stocks.

These findings do not depend on how borrowing fees and special status are measured. While the main analysis uses a borrower-side measure of short-selling costs, the results hold for lender-side fees and option-implied short-selling costs. Importantly, I argue that a change in BMI shifts lending supply and shorting demand curves, rather than causing a movement along the supply curve. Potential changes in analyst disagreement and borrowing risk measures do not explain my findings, as demonstrated alongside other robustness tests in Section 5.2.6. Finally, I show that, even further away from the Russell cutoff, funds mostly lend stocks within their benchmark indexes, and provide additional evidence from the Japanese equity market supporting my model.

So why does the demand effect of benchmarking dominate in the Russell reconstitutions? In my model, this is primarily influenced by the lending limits that fund managers face. When these lending limits are too restrictive, managers tend to undersupply their holdings for lending. Meanwhile, shorting demand continues to rise due to the impact of benchmarking on asset prices.

To explore how restrictive lending limits are in the data, I collect lending information for U.S. investment management companies from their N-PORT and N-CEN filings, which are available from 2019. I find that the regulatory portfolio-level limit, set at one-third of total fund value by the regulators in the United States, is not binding. At the same time, position-level data from major investment managers like BlackRock, Fidelity, J.P. Morgan, State Street, T. Rowe Price, and Vanguard reveal soft explicit lending limits that are often at or above 80% of how much the manager holds in a given stock (see Figure 3).

The same regulatory filings allow me to study lending around the recent Russell reconstitutions by funds benchmarked to the Russell indexes. I find that these funds often lend out over 90%

⁷The borrowing fees in Markit data are typically derived from the quoted rebate rates. To borrow a stock, short-sellers usually provide cash collateral, on which lenders pay interest, called the rebate rate. The borrowing fee is the difference between the market short-term interest rate and the rebate rate paid on the cash collateral.

of their holdings in special stocks transitioning between Russell indexes. Hence, even if the explicit position-level lending limits bind for some managers, it is unlikely that these limits are strict enough to fully explain the weak pass-through from holdings to supply. At the same time, benchmarked funds seem to entirely forgo lending many special stocks, contrary to model predictions. I show that known frictions in the lending market, such as participation constraints and search costs, cannot fully explain this sparse lending. Instead, the data suggests the presence of lending specialization, as also observed in contemporaneous N-PORT studies (Chen, Tran, and Wang (2024) and Dong and Zhu (2024)). Consistent with this view, I show in the appendix that many special stocks not lent at reconstitution remain not lent over the following year, even at the fund family level, with only modest and heterogeneous increases in lending activity over time.

Finally, I show that limited lending has broader implications beyond its impact on borrowing fees. In my model, lending limits influence both the likelihood of an asset being classified as special (that is, how likely the lending market clearing constraint binds) and the special asset’s price sensitivity to benchmarking. As lending limits are relaxed, asset price sensitivity to benchmarking generally decreases. Without lending limits—when fund managers can lend the full value of their holdings—the model predicts that benchmarking has no effect on special asset prices. These findings underscore the significant and novel role of limited lending in designing and enforcing investment mandates, including central banks purchases and sustainable investing.

Related literature. This paper is related to several strands of the literature encompassing investment mandates and index effect, theoretical and empirical work on short-selling constraints, and, in general, empirical research on investment managers and securities lending.

A large body of empirical literature recognizes the importance of institutional ownership for lending markets. D’Avolio (2002) shows that the main suppliers of stock loans are institutional investors. So not surprisingly, the literature has used measures based on institutional ownership to proxy for short-selling constraints (Chen, Hong, and Stein (2002) and Nagel (2005)) and supply specifically (Asquith, Pathak, and Ritter, 2005).⁸ A classical result in this literature is that institutional ownership increases lending supply, while the concentration of ownership reduces it (Prado, Saffi, and Sturgess, 2016). The literature has also recognized that investment restrictions influence funds’ participation in lending markets (Evans, Ferreira, and Prado, 2017). I exploit exogenous changes in benchmarking-driven institutional ownership to offer a new perspective on

⁸Another approach is offered by Cohen, Diether, and Malloy (2007), who isolate directional shifts in supply and demand for shorting using proprietary data. They find that shorting demand predicts future returns while lending supply has only minor effects. Similarly, Kaplan, Moskowitz, and Sensoy (2013) use experimental evidence to argue for the limited importance of lending supply for stock prices and liquidity. At the same time, Beneish, Lee, and Nichols (2015) argue that shocks to supply are important when it is limited.

how that ownership can impact short-selling constraints. Although benchmarking increases supply, I find that borrowing fees rise when BMI increases. I provide position-level evidence of the weak pass-through from institutional ownership to supply around index reconstitutions and link it to the prevalence of the demand effect of benchmarking. My model takes into account the price pressure induced by institutional demand, which is typically not considered in the literature.

The literature suggests that passive fund ownership may influence the quality of lending supply. In independent and contemporaneous research, [Beschwitz, Honkanen, and Schmidt \(2025\)](#) examine Russell reconstitutions and argue that increased supply by passive owners reduces risks associated with stock borrowing, resulting in higher short-selling demand for all stocks.⁹ I test for this complementary channel using proxies suggested by the literature and find that demand and fees increase with BMI even without any observable improvements in short-selling risk measures. Specifically, in my sample of special stocks, I find no evidence of reduced borrowing fee volatility, loan utilization volatility, or failures to deliver.¹⁰ My model links changes in BMI to borrowing demand and fees without relying on the short-selling risk channel, and my findings for both special and not special stocks align closely with model predictions. My empirical tests exploit the intensity of Russell reconstitution shocks helping alleviate concerns related to the power of these tests and allowing me to study special stocks. While this group represents a small subset of stocks at any given time, over 80% of stocks in my U.S. sample become special at some point. Finally, I provide international evidence for the mechanism in the model using the central bank’s purchases of exchange-traded funds in Japan, where special stocks account for around a third of the market.

This paper naturally relates to the vast literature on short-selling constraints and securities lending markets. Short-selling constraints are recognized as a limit to arbitrage,¹¹ but they bind only for certain (special) stocks.¹² Furthermore, beginning with [Miller \(1977\)](#) and [Jarrow \(1980\)](#), the literature has predominantly relied on the differences of opinion to explain the coexistence of short-sellers and investors who hold a long position in the asset, with the latter group typically supplying securities for lending. This is also true for the search-based models of the securities lending markets that endogenize the specialness of securities (see [Duffie, Gârleanu, and Pedersen \(2002\)](#) and

⁹[Palia and Sokolinski \(2024\)](#) investigate the same hypothesis without an instrument and additionally show that higher passive ownership is correlated with larger borrowing fees for special stocks.

¹⁰Results for various proxies of short-selling risk are reported in Tables [A15–A16](#) in the Internet Appendix.

¹¹See, for example, [Diamond and Verrecchia \(1987\)](#), [Hong and Stein \(2003\)](#), [Dow and Gorton \(1994\)](#), and the reviews in [Gromb and Vayanos \(2010\)](#) and [Reed \(2013\)](#).

¹²The granular empirical evidence for that is first provided in [D’Avolio \(2002\)](#) and [Geczy, Musto, and Reed \(2002\)](#) and further extended in [Kolasinski, Reed, and Ringgenberg \(2013\)](#), all based on proprietary data from large lenders. [Jones and Lamont \(2002\)](#) document the same for U.S. stocks in 1926–1933. Studies of bond specialness include those of [Duffie \(1996\)](#), [Krishnamurthy \(2002\)](#), [Nashikkar and Pedersen \(2007\)](#), and [Asquith, Au, Covert, and Pathak \(2013\)](#). Also see the review in [Daniel, Klos, and Rottke \(2024\)](#).

Vayanos and Weill (2008)) and the recent theoretical literature with dynamic short-selling (Atmaz, Basak, and Ruan, 2024). Securities that are subject to more disagreement are usually more special in these models. Models in Blocher, Reed, and Van Wesep (2013) and Banerjee and Graveline (2013) are agnostic with respect to the trading rationale, and yet the prediction for specialness is similar. My model is first to provide a microfoundation for the effect of institutional incentives on lending supply. Furthermore, benchmarking generates short-selling demand by inflating the asset price (independent of disagreement). In contrast with the established mechanisms, its effect on asset specialness and borrowing fee is ambiguous and crucially depends on the lending limit.

There is extensive theoretical literature on the asset pricing effects of benchmarking, mandates, and investor habitats. The first equilibrium model with a benchmark is offered by Brennan (1993), while Cuoco and Kaniel (2011), Basak and Pavlova (2013), Buffa, Vayanos, and Woolley (2022), and Buffa and Hodor (2023) investigate equilibrium asset pricing effects in dynamic economies with benchmarks. Similarly, the literature considers the implications of investor styles (Barberis and Shleifer (2003)) and investment mandates in delegated asset management (for example, Binsbergen, Brandt, and Kojen (2008) and He and Xiong (2013)).¹³ None of these papers has examined how benchmarking or mandates affect the lending market. My model suggests that the feedback through this market has the potential to alter the effects of benchmarking on price.¹⁴

Finally, this paper is related to literature quantifying the effects of index membership for financial securities. Shleifer (1986) and Harris and Gurel (1986) were first to document abnormal returns to additions to the S&P 500 index. Index effects were later found in many other markets and asset classes.¹⁵ In this strand of literature, my paper is closest to Chang, Hong, and Liskovich (2015), who document the Russell index effect, or an average price increase of stocks added to the Russell 2000 index from the Russell 1000 index, and to Pavlova and Sikorskaya (2023), who propose BMI as a measure of how much capital is benchmarked against a stock. I show that index reconstitutions trigger large changes in both lending supply and shorting demand as well as changes in short-selling costs, which this literature typically abstracts away from.

¹³Closely related literature investigates preferred habitats in fixed income markets (for example, Greenwood and Vayanos (2014) and Vayanos and Vila (2021)). Jappelli, Subrahmanyam, and Pelizzon (2023) integrate a repo market into a preferred-habitat model.

¹⁴There is also developing literature that incorporates downward-sloping demand curves for stocks in the asset pricing and macro-finance models (Kojen and Yogo (2019) and Gabaix and Kojen (2024)). My results imply that the asset pricing effects of institutional investors' inelastic demand may be influenced by their role as major lenders in the securities lending market.

¹⁵For example, Greenwood (2005) explores index effects of a redefinition of the Nikkei 225 index in Japan. Further examples include Kaul, Mehrotra, and Morck (2000), Wurgler and Zhuravskaya (2002), Chakrabarti, Huang, Jayaraman, and Lee (2005), and Boyer (2011).

2 The Market for Lending and Borrowing Stock

The stock lending market plays a pivotal role by bridging the gap between short-sellers and stock owners willing to lend their shares in exchange for a fee. Four distinct groups of participants operate within this market: (i) beneficial owners such as institutional investors, (ii) professional lenders such as custodians or in-house lending agents of institutions, (iii) borrowers, comprising hedge funds, proprietary trading desks, and market makers, and (iv) prime brokers. Typically, hedge funds and market makers procure securities from their prime brokers, who subsequently borrow from lenders representing mutual funds, pension funds, and other beneficial owners. A comprehensive description of the U.S. market can be found in [D’Avolio \(2002\)](#), [Kolasinski, Reed, and Ringgenberg \(2013\)](#), and the recent Survey of Agent Securities Lending Activity by the Office of Financial Research, the Federal Reserve System, and staff from the SEC, summarized in [Baklanova, Caglio, Keane, and Porter \(2016\)](#).

Borrowing fees are typically not quoted directly but are derived from quoted rebate rates. For stock loans, the borrowers usually provide cash collateral to the lenders, who, in turn, pay interest (the rebate rate) on the held cash collateral. The borrowing fee is the difference between the market short-term interest rate and the rebate rate paid on the cash collateral. A high borrowing fee is observed when securities are difficult to borrow, which makes them special. A part of the fee paid by the borrower compensates lending agents and prime brokers for their services, although the predominant portion is retained by the beneficial owners. Specifically, approximately 80% of the securities lending income of investment companies in the United States accrues back to fund investors ([Johnson and Weitzner, 2024](#)).

3 Model with Benchmarking and Securities Lending

To illustrate the main mechanism, I develop a simple and tractable model of asset prices and borrowing fees in the presence of benchmarking. The model builds upon [Brennan \(1993\)](#) and [Banerjee and Graveline \(2013\)](#), introducing a market for asset lending to an economy with fund managers benchmarked to a market index. The distinguishing feature of the model is that fund managers’ holdings contribute to the lending supply available to short-sellers. The goal of the model is to characterize the relationship between benchmarking, asset prices, and borrowing fees.

3.1 Model setup

There are two dates, $t = \{0, 1\}$. The financial market consists of a riskless asset with an exogenous interest rate normalized to zero and unlimited net supply (for example, a storage technology) and one risky asset paying a cash flow $\bar{D}$ at $t = 1$, with $\bar{D} \sim N(\mu, \sigma^2)$. I focus on a one-asset case for brevity, and the intuition in an economy with multiple risky assets is similar (see Internet Appendix C). The shares of the risky asset are in fixed supply, which I denote by $\bar{\theta} > 0$. Let p denote the price of the risky asset. There exists a benchmark index, which is a portfolio of ω shares of the risky asset.

There are three types of investors: direct investors, fund managers, and hedgers. All investors have a constant absolute risk aversion (CARA) utility function over terminal wealth (or compensation), $U(W) = -\exp^{-\gamma W}$, where γ is the coefficient of absolute risk aversion. They trade at $t = 0$ and collect payoffs at $t = 1$.

Direct investors, whose mass in the population is λ_D , manage their own portfolios. The terminal wealth of a direct investor is given by

$$W^D = W_0^D + \theta_D(\bar{D} - p),$$

where θ_D denotes the number of shares held by the direct investor and W_0^D is the investor's initial wealth. The direct investor chooses holdings θ_D to maximize expected utility $U(W^D)$.

Fund managers, with a mass λ_M , allocate funds on behalf of fund investors in exchange for compensation. Each fund manager is evaluated relative to the benchmark and chooses a portfolio of θ_M shares to maximize expected utility from compensation $U(w)$. Furthermore, fund managers are permitted to engage in securities lending to earn the fee of Δ per share, with an exogenous (scalar) limit $l \in (0, 1]$ on the fraction of the risky asset in their portfolio that they can lend out.¹⁶

Fund managers' compensation w incorporates three payouts. The first one linearly depends on the absolute performance of the fund, the second is based on the performance of the fund relative to the benchmark index, and the third is independent of performance (for example, a fixed salary).¹⁷ Specifically,

$$\begin{aligned} w &= aR + b(R - B) + c, \quad a \geq 0, b > 0 \\ R &\equiv \theta_M(l\Delta + \bar{D} - p) \quad \text{and} \quad B \equiv \omega(\bar{D} - p), \end{aligned} \tag{1}$$

¹⁶There are various microfoundations for this parameter, which I discuss in Section 5.3.

¹⁷Ma, Tang, and Gómez (2019) and Evans, Gómez, Ma, and Tang (2024) analyze compensation of fund managers in the U.S. mutual fund industry and provide evidence supporting the specification I use here. Kashyap, Kovrijnykh, Li, and Pavlova (2023) derive such compensation as part of an optimal contract.

where R is the performance of the fund's portfolio and B is the performance of the benchmark index. The parameters a and b are the contract's sensitivities to absolute and relative performance, respectively, and c is the fixed payout size. This specification nests compensation of a passive fund manager, for whom b has to be very high to disincentivize any deviation from the benchmark. Because the fund's performance monotonically increases in securities lending, managers lend out their risky holdings up to the limit l .

Hedgers—the third type of investors—are endowed with $e\bar{D}$ units of consumption at $t = 1$ so that they engage in short-selling at $t = 0$ for hedging purposes. This is similar to how [Banerjee and Graveline \(2013\)](#) model short-selling. Each hedger chooses a portfolio θ_H to maximize expected utility $U(W^H)$. Their terminal wealth is given by

$$W^H = W_0^H + e\bar{D} + \theta_H(\bar{D} - p + \Delta \mathbf{1}_{\theta_H < 0}),$$

where θ_H denotes the number of shares held by the hedger and W_0^H is the hedger's initial wealth. Δ is the fee that the hedger pays on the short position, that is when θ_H is negative. Hedgers in my model are necessary to generate a certain level of shorting demand independent of benchmarking. In general, hedging has long been recognized as a rationale for selling short ([McDonald and Baron, 1973](#)). One can think of these hedgers as investors endowed with equity risk, such as those with risky labor income, displacement risk ([Gârleanu, Kogan, and Panageas, 2012](#)), or convertible debt ([Agarwal, Fung, Loon, and Naik, 2011](#)). I denote hedgers' mass in the population as λ_H .

3.2 Portfolio choice

In this section, I describe the optimal portfolio choice of each investor type. All proofs for this section are in Internet Appendix [B.1](#).

The portfolio demand of the direct investors is the standard mean-variance portfolio,

$$\theta_D = \frac{1}{\gamma\sigma^2} (\mu - p). \quad (2)$$

I focus on the case when the expected returns, $\mu - p$, are always positive so that the direct investors do not take part in the securities lending market, either as borrowers or lenders.

In contrast, fund managers do not face the same risk-return trade-off as direct investors, because of their compensation contracts and because they are allowed to lend securities. The

portfolio demand of a fund manager is given by

$$\theta_M = \frac{1}{\gamma\sigma^2(a+b)}(\mu - p) + \frac{b}{a+b}\omega + \frac{1}{\gamma\sigma^2(a+b)}l\Delta. \quad (3)$$

Hence, fund managers split their risky asset holdings across three portfolios: the mean-variance portfolio (the first term in (3)), the benchmark portfolio (the second term), and the return-augmenting portfolio (the last term). The middle portfolio arises because the compensation structure makes the managers hedge against underperforming their benchmarks. The last term in (3) arises because managers hold more assets on which they can earn higher borrowing fees.

Finally, a hedger's portfolio demand is

$$\theta_H = \frac{1}{\gamma\sigma^2}(\mu - p + \Delta) - e. \quad (4)$$

I focus on the case when the endowment e is so large that θ_H is negative. A hedger's shorting demand, $-\theta_H$, increases in asset price and decreases in the borrowing fee.

3.3 Equilibrium asset price and borrowing fee

Both the asset market and the securities lending market clear at the same time. The asset market clearing condition is

$$\lambda_D\theta_D + \lambda_M\theta_M + \lambda_H\theta_H = \bar{\theta}, \quad (5)$$

and the lending market clearing condition is

$$l\lambda_M\theta_M + \lambda_H\theta_H \geq 0. \quad (6)$$

If the price of the asset is such that the lending supply of this asset, $l\lambda_M\theta_M$, is larger than the shorting demand for it, $-\lambda_H\theta_H$, the latter condition is slack and the equilibrium borrowing fee is zero. If instead the shorting demand is higher than the lending supply, there will be a positive fee to borrow the asset. The fee increases the utility of fund managers, so they will lend the maximum possible amount (up to the limit l). At the same time, the fee will bring the demand of hedgers down. The equilibrium fee will be such that the condition (6) binds.

Below, I present solutions for both an economy with an asset on special (for which condition (6) is binding) and an economy with a general collateral asset (for which condition (6) is slack). All derivations are in Internet Appendix B.2. I also discuss explicitly how benchmarking affects specialness as well as demand and supply in the lending market.

3.3.1 Asset on special

The market clearing conditions together with the investors' optimal portfolio demands define the equilibrium of the model. The expression for the equilibrium asset price is

$$p = \mu + \gamma\sigma^2\bar{B}(B_e e - B_\theta \bar{\theta} + B_\omega \omega_\lambda), \quad (7)$$

where B_e , B_θ , B_ω , and $\bar{B}$ are nonnegative scalars because $l \in (0, 1]$,¹⁸

$$\begin{aligned} B_e &= l(1-l)\lambda_H \frac{\lambda_M}{a+b}, \\ B_\theta &= l^2 \frac{\lambda_M}{a+b} + \lambda_H, \\ B_\omega &= (1-l)\lambda_H, \\ \bar{B} &= \frac{1}{\frac{\lambda_M}{a+b}(l^2\lambda_D + (1-l)^2\lambda_H) + \lambda_D\lambda_H}, \\ \text{and } \omega_\lambda &\equiv \frac{b}{a+b}\lambda_M\omega. \end{aligned}$$

Term ω_λ above represents BMI because it reflects the cumulative demand of fund managers induced by the relative performance component in their compensation (1). It also motivates the measure I use in the empirical part of the paper.¹⁹

Equation (7) highlights that benchmarking is a source of price pressure, or overvaluation, in my model (induced through the term $B_\omega\omega_\lambda$). It implies that if an asset's BMI ω_λ increases, for example, due to an addition to a market index, its price goes up (known as the index effect).

The equilibrium price also increases in the endowment of hedgers, $B_e e$. This is an equilibrium effect, which arises because the price increases in the fee that the manager can earn when lending the asset to hedgers. Higher hedging demand e makes lending more attractive, so the managers hold more of the asset, pushing the price up.²⁰ This is in contrast to the case with slack in the securities lending market: When the equilibrium fee is zero, the price unambiguously decreases in the endowment of hedgers, as I show in Section 3.3.2.

¹⁸Because I am focusing on the case with positive expected returns, that is, $\mu - p > 0$, the scalars have to satisfy $B_\theta \bar{\theta} - B_e e - B_\omega \omega_\lambda > 0$.

¹⁹ ω_λ is an equivalent of the BMI introduced in Pavlova and Sikorskaya (2023), although here it is based on one benchmark index rather than multiple indexes. Extending to the case of multiple benchmark indexes does not change the key results in this paper.

²⁰In line with that, Johnson and Weitzner (2024) show that some active mutual fund managers overweight assets with high borrowing fees. Lending revenue accruing to price can be traced to the model in Duffie (1996).

The equilibrium borrowing fee is

$$\Delta = \gamma \sigma^2 \bar{B} \left(C_e e - C_\theta \bar{\theta} + C_\omega \omega_\lambda \right), \quad (8)$$

where C_e , C_θ , and C_ω are scalars,

$$\begin{aligned} C_e &= \lambda_H \left((1-l) \frac{\lambda_M}{a+b} + \lambda_D \right), \\ C_\theta &= l \frac{\lambda_M}{a+b} + \lambda_H, \\ C_\omega &= (1-l) \lambda_H - l \lambda_D. \end{aligned}$$

Because $l \in (0, 1]$ and $\bar{B} > 0$, the equilibrium borrowing fee unambiguously increases in the size of the endowment of hedgers, e , and decreases in asset supply, $\bar{\theta}$. In contrast, the effect of the asset's BMI ω_λ depends on the sign of C_ω . If the population masses of hedgers and direct investors satisfy the following condition,

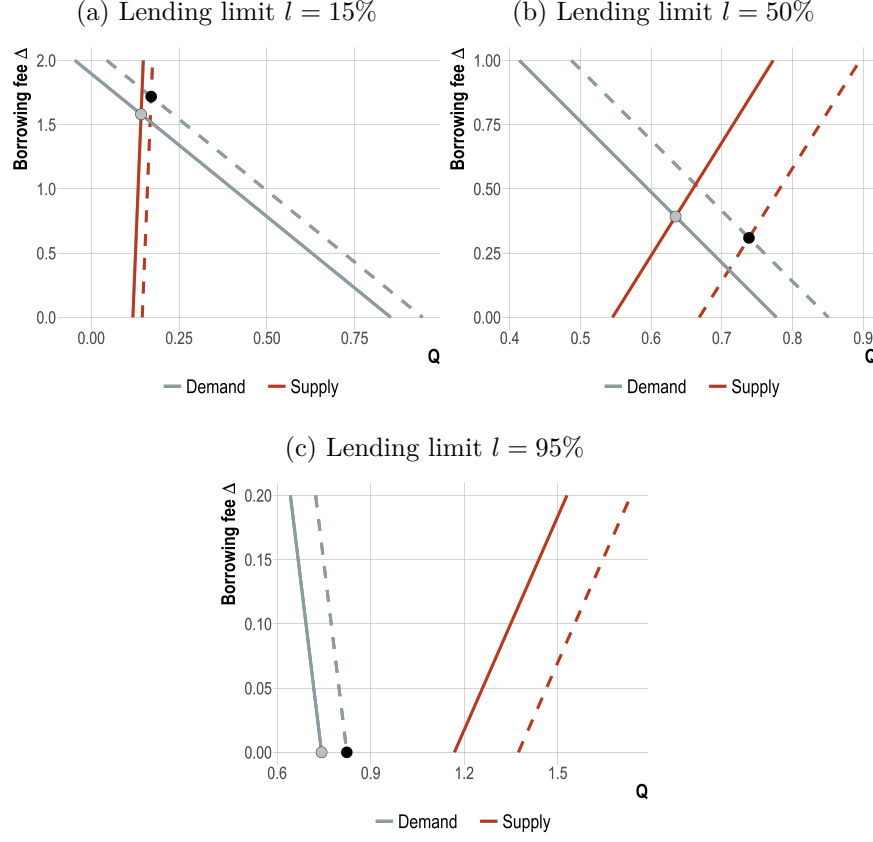
$$\frac{\lambda_H}{\lambda_D + \lambda_H} < l, \quad (9)$$

then $C_\omega < 0$ and the equilibrium borrowing fee decreases in BMI ω_λ . This condition compares the share of hedgers relative to direct investors with the lending limit l . When the limit is lenient enough, the supply effect of benchmarking dominates in the lending market.

This model prediction is novel because the literature typically assumes that all long investors can lend, or in my model, $\lambda_D = 0$. Such an assumption is restrictive because not all (even institutional) investors have access to lending in the data (as shown in Internet Appendix A.1). Furthermore, in Internet Appendix D, I show that the relationship between benchmarking and borrowing fees is still ambiguous if direct investors are allowed to lend with a limit different from l . Finally, the trade-off between the demand and supply effects of benchmarking prevails even if the limit l is endogenously chosen by agents. In Appendices E and F, I solve extensions of the model with costly lending by fund managers and costly search by hedgers, respectively, and show that, although less tractable, such models deliver the same key results.

I provide a numerical illustration for the role of condition (9) in Figure 1. Panel (a) depicts the shift in the lending market equilibrium due to an increase in the BMI when $C_\omega > 0$ (setting $l = 15\%$). In this case, the equilibrium borrowing fee is higher with a larger BMI, the demand shift being larger than the supply shift. Panel (b) illustrates how the fee changes when $C_\omega < 0$ (setting $l = 50\%$). In this case, the fee is lower when BMI is higher because the supply shift is larger.

Figure 1: Demand and supply in the lending market



This figure plots demand and supply curves in the lending market. Panel (a) depicts the case when $l = 15\%$ ($C_\omega > 0$), panel (b) when $l = 50\%$ ($C_\omega < 0$), and panel (c) when $l = 95\%$ (general collateral asset). Solid lines correspond to an off-benchmark asset ($\omega_\lambda = 0$), while dashed lines correspond to an identical asset that belongs to the benchmark index. The black (gray) dot marks the equilibrium for the (off-)benchmark asset. The curves represent the partial equilibrium quantity demanded or supplied Q for each level of the borrowing fee Δ (and the corresponding equilibrium price). Internet Appendix B.4 details all parameter values.

3.3.2 General collateral asset

For a general collateral asset, lending market condition (6) is slack at the asset price which satisfies the spot market clearing (5). So the lending fee is zero and the equilibrium asset price is

$$p = \mu + \frac{1}{\frac{\lambda_M}{(a+b)} + \lambda_D + \lambda_H} \gamma \sigma^2 (\omega_\lambda - \lambda_H e - \bar{\theta}). \quad (10)$$

Notice that, as for the asset on special, the price increases in BMI ω_λ (index effect) and decreases in supply $\bar{\theta}$. However, hedgers' endowment shocks e now reduce the price, because they increase shorting demand without triggering additional purchases from fund managers.

Panel (c) of Figure 1 illustrates the lending market for a general collateral asset, in which

supply is always larger than demand and both are positively related to BMI.

3.3.3 When do short-selling constraints bind?

The model explains how benchmarking contributes to short-selling constraints. From (8), there will be a strictly positive fee to borrow the asset if and only if

$$C_e e - C_\theta \bar{\theta} + C_\omega \omega_\lambda > 0. \quad (11)$$

That is, an asset for which (11) holds will be special. Notice that an asset is more likely to be on special when it has a lower supply $\bar{\theta}$ or when hedgers are more endowed with it (higher e). Naturally, an asset with a higher BMI ω_λ is less likely to be on special if $C_\omega < 0$, or if (9) holds, that is, if the supply effect of benchmarking dominates.

I can also rewrite (11) as a linear condition on l ,

$$l < \lambda_H \frac{\left(\frac{\lambda_M}{a+b} + \lambda_D\right) e - \bar{\theta} + \omega_\lambda}{\frac{\lambda_M}{a+b}(\lambda_H e + \bar{\theta}) + (\lambda_D + \lambda_H)\omega_\lambda}.$$

Naturally, in an economy with a tighter limit on lending, any asset is more likely to be special.

3.3.4 Price sensitivity to benchmarking

In an economy with both benchmarking and securities lending, asset pricing effects of benchmarking are co-determined with the outcomes in the lending market of a special asset. Hence, the price sensitivity to benchmarking depends on whether the demand or supply effect of benchmarking dominates. Furthermore, a general collateral asset and a special asset have different sensitivities of price to benchmarking.

If the supply effect of benchmarking dominates, that is, if condition (9) holds, the price sensitivity of a special asset to benchmarking is lower than that of a general collateral asset. In other words, if benchmarking-induced purchases reduce the borrowing fee, more of the benchmarking price pressure will be counteracted by the hedgers' increased shorting. In the limiting case when fund managers lend out any new purchase of a benchmark asset ($l = 1$), benchmarking does not affect asset prices. See B_ω becoming zero in (7) and further details in Internet Appendix B.3. On the other hand, if the demand effect of benchmarking dominates, it will become even costlier to sell the asset short and the index effect will be larger. I formally evaluate price sensitivity to benchmarking and provide the comparative statics for equilibrium price and borrowing fee in Internet Appendix B.5.

3.3.5 Demand and supply in the lending market

My model features a downward-sloping shorting demand and an upward-sloping lending supply for special assets.²¹ Demand is defined by the shorting needs of hedgers, whereas supply is sourced from the fund managers' holdings up to the limit l ,

$$Q^d = -\lambda_H \theta_H \quad \text{and} \quad Q^s = l \lambda_M \theta_M. \quad (12)$$

Only lending supply directly depends on BMI, while both shorting demand and lending supply are indirectly affected through equilibrium price and borrowing fee. Internet Appendix B.6 reports the total derivatives of the demand and supply in the lending market with respect to BMI and shows that both demand and supply always increase with BMI.

In the following sections, I use a quasi-experiment to test the predictions of my model. I also evaluate the assumption of limited lending using novel regulatory data.

4 Data and Summary Statistics

4.1 Data sources

I use data on stock borrowing and lending activity from the S&P Global Securities Finance Equities Buyside Analytics Premium Data Feed (also known as Markit Securities Finance Buyside Analytics Premium Data Feed). The dataset includes daily stock-level data on borrowing activity, such as borrow-side loan fees, the quantity on loan, the available lendable supply, and other data. S&P obtains the information from loan market participants, who together account for over 90% of the market. The daily data are available from July 2006.

My main U.S. equity sample is an annual panel of stocks that were members of the Russell 3000 index in 2006-2018. I obtain the stock-level BMI measure from Pavlova and Sikorskaya (2023), which is based on historical benchmark weights, primary prospectus benchmarks reported in historical fund prospectuses, and fund assets from the Center for Research in Securities Prices (CRSP) Survivor-Bias-Free U.S. Mutual Fund Database. Historical benchmark weights are from

²¹Empirically, Kolasinski, Reed, and Ringgenberg (2013) find that the supply curve is mostly flat and has a positive slope for very high levels of specialness. The positive slope in my model comes from the return-augmenting portfolio of fund managers, or the third term in their demand (3). Alternatively, I could assume that fund managers receive a windfall gain from their fund family or lending agent. In that case, their demand would not depend on the borrowing fee and the aggregate supply curve would be flat. To get a positive slope, one could define the lending limit as a nondecreasing function of borrowing fee, while the implications of benchmarking for the equilibrium borrowing fee would be qualitatively the same.

FTSE Russell, Morningstar, and CRSP. Importantly, Russell index data come from FTSE Russell directly. It includes proprietary total market values (capitalization) as of the Russell’s rank day in May and provisional constituent lists available before the reconstitution day in June for the Russell 3000E index. Other U.S. stock data are from CRSP and Compustat.

I also collect information on funds’ securities lending from N-PORT and N-CEN filings. Quarterly N-PORT filings, available from the third quarter of 2019, include the schedule of fund investments and the value of each holding on loan. Annual N-CEN filings, available from 2019, include fund-level information such as whether the fund is permitted to lend and its net income from lending. Further details are reported in Section A.2 in the Internet Appendix.

4.2 Key summary statistics

Table 1 describes the key data samples used in this paper. Panel A reveals that a typical general collateral stock next to the Russell cutoff has 28% of its shares in lending inventory and close to 5% loaned to short-sellers. On average, borrowing such a stock costs 39 bps per annum. Panel B shows that 5% of stocks next to the Russell cutoff are special. These stocks are costly to borrow, with an average borrowing fee of 5.6%. Special stocks have over 17% of their shares on loan, on average, which implies utilization of lending inventory of over 75%. I provide detailed definitions and descriptive statistics for all variables in Internet Appendix A.3. Throughout my analysis, all variables are winsorized at 0.5% and 99.5% (or at 99% if taking only positive values).

5 Russell Reconstitution

In this section, I use the changes in the amount of capital benchmarked against stocks around the Russell index reconstitutions to test the predictions of my model in the U.S. equity market.

5.1 Russell reconstitution, benchmarking, and lending supply

The Russell indexes undergo annual reconstitution in June. All eligible stocks are ranked based on their market capitalization values, and the stocks above the so-called Russell cutoff are assigned to the Russell 1000 index on the reconstitution day in June. This ranking is based on a fixed date in May, so any shock to a stock near the Russell cutoff can send it to one side or the other. The mechanical nature of this process makes the assignment of stocks to indexes next to

Table 1: Key sample summary statistics

Variable	No. obs.	Mean	Median	St. dev.	p1	p99
Panel A: General collateral stocks						
ΔBMI , % MV	13,047	0.09	-0.04	2.56	-9.03	9.46
Δ Lending inventory, % shares	13,047	-0.03	0.07	1.88	-6.09	5.25
Δ Shorting demand, % shares	13,047	0.21	0.06	1.86	-5.20	6.41
Δ Borrowing fee, %	13,047	0.01	0.00	0.21	-0.15	0.25
Stock return, %	13,047	-0.85	-0.60	9.18	-26.10	23.45
BMI in May, % MV	13,047	22.10	23.19	6.19	4.97	33.31
Lending inventory in May, % shares	13,047	28.46	28.81	8.57	6.34	48.71
Shorting demand in May, % shares	13,047	5.06	3.23	5.38	0.06	24.09
Borrowing fee in May, %	13,047	0.39	0.38	0.09	0.25	0.79
Active utilization in May, %	13,047	15.54	10.57	15.07	0.20	64.18
Market value, USD million	13,047	3,485.75	2,471.14	2,899.54	526.99	13,512.05
Panel B: Special stocks						
ΔBMI , % MV	638	0.96	0.24	3.50	-6.37	12.19
Δ Lending inventory, % shares	638	0.32	0.21	2.74	-7.54	8.22
Δ Shorting demand, % shares	638	-0.35	-0.29	3.10	-7.57	7.44
Δ Borrowing fee, %	638	0.19	-0.21	4.09	-10.48	16.15
Stock return, %	638	-0.50	-0.27	13.80	-36.93	34.25
BMI in May, % MV	638	18.46	18.88	7.28	2.67	31.53
Lending inventory in May, % shares	638	17.84	17.02	8.96	1.85	42.49
Shorting demand in May, % shares	638	17.06	15.74	8.88	1.75	41.36
Borrowing fee in May, %	638	5.61	3.12	6.26	1.02	31.82
Active utilization in May, %	638	75.75	80.02	17.29	31.41	98.64
Market value, USD million	638	2,187.51	1,670.28	1,589.00	499.47	7,984.77

This table reports the summary statistics for the key samples analyzed in the paper. Statistics for general collateral stocks are presented in panel A and those for special stocks are presented in panel B. All stocks have to be within 500 ranks around the Russell cutoff in 2007–2018, with changes in lending market variables computed as differences between July and May. Stock return is as of June. A stock is considered special if its average fee in May is above 1% and a general collateral stock otherwise. ΔBMI is the change in BMI (amount of capital benchmarked against a stock relative to its market value), as defined in Section 5.1. Lending inventory is active lendable quantity and shorting demand is short quantity on loan, both scaled by shares outstanding. Active utilization is short quantity on loan divided by active lendable quantity. Borrowing fee is Markit’s indicative fee.

the cutoff as good as random (Chang, Hong, and Liskovich, 2015).²²

When a stock crosses the Russell cutoff, it enters a benchmark index of a different group of funds so the amount of assets benchmarked to that stock changes. To measure this, I use the total benchmarking intensity (BMI) of Pavlova and Sikorskaya (2023), defined as

$$BMI_{it} = \frac{\sum_{j=1}^J \lambda_{jt} \omega_{ijt}}{MV_{it}}, \quad (13)$$

where λ_{jt} is the assets under management (AUM) of mutual funds and ETFs benchmarked to

²²I discuss this in more detail and also explain how my approach avoids common research design issues with the Russell cutoff in Section A.5 of the Internet Appendix.

index j in month t , ω_{ijt} is the weight of stock i in index j in month t , and MV_{it} is the market capitalization of stock i in month t . This BMI measure is based on data for the 34 most tracked U.S. equity indexes, coming from S&P Dow Jones, CRSP, and FTSE Russell index providers.

BMI has a large discontinuity around the Russell cutoff, due to stock membership in all nine Russell indexes that share this cutoff. These indexes include the Russell 1000 and the Russell Midcap to the left of the cutoff and the Russell 2000 to the right of it (blend, value, and growth in each case). On average, a stock moving from the Russell 1000 index to the Russell 2000 experiences a sizeable increase in BMI of 8.6 percentage points. Internet Appendix A.6 illustrates the discontinuity and discusses changes in BMI around the cutoff in more detail.

I use BMI rather than only the index membership in the main analysis for two reasons. First, it allows me to measure the strength of the pass-through to lending inventory and supply, which is an economically interesting figure. Specifically, this pass-through is related to the limit on lending in my model, see equation (12). Second, BMI offers more variation and hence higher precision of estimates in my regression analyses, which counteracts the small sample issues with having too few special stocks near the Russell cutoff. Nevertheless, Internet Appendix A.9 shows that using the index membership dummy results in the same key findings.

As long as the mechanical nature of Russell reconstitutions makes index membership exogenous, the change in BMI during the Russell reconstitution is not related to a given stock's fundamentals and can be used as a shock to the amount of capital benchmarked against the stock. The Russell reconstitution thus offers a quasi-experimental setup to study the effects of benchmarking on asset spot and lending markets.

Academic literature has documented discontinuities in mutual fund and ETF ownership around the Russell cutoff (see an overview in Glossner (2024)). Given that funds make their holdings available for lending, the increase in fund ownership is expected to increase the supply of shares in the lending market. I use funds' regulatory filings from 2020-2022 to illustrate that funds increase lending of stocks added to their benchmarks and reduce lending of stocks excluded from their benchmarks. Figure 2 shows that aggregate lending follows changes in funds' benchmarks. For example, there is a noticeable increase in lending by passive funds benchmarked to the Russell 2000 of stocks added to the index (panel (a)). Similarly, active funds benchmarked to the Russell 2000 lend more of stocks added to the index (panel (c)). Internet Appendix A.7 shows that these patterns are significant at a stock level and provides further details of this analysis.

Therefore, lending and borrowing of a stock are likely to be positively related to the amount of capital benchmarked against the stock, as my model predicts. I formally test the model predictions in the next section.

5.2 Benchmarking effects on spot and lending markets

The model in Section 3 predicts that an increase in BMI leads to increases in asset price, lending inventory, and shorting demand, whereas the prediction for the borrowing fee depends on the lending limit. In this section, I test these theoretical predictions using the change in BMI around Russell reconstitutions.

5.2.1 Regression specifications

To understand the effects of benchmarking on spot and lending market outcomes, I estimate the following specifications:

$$\Delta Y_{it} = \alpha \Delta BMI_{it} + \delta' \bar{X}_{it} + \mu_{st} + \varepsilon_{it}, \quad (14)$$

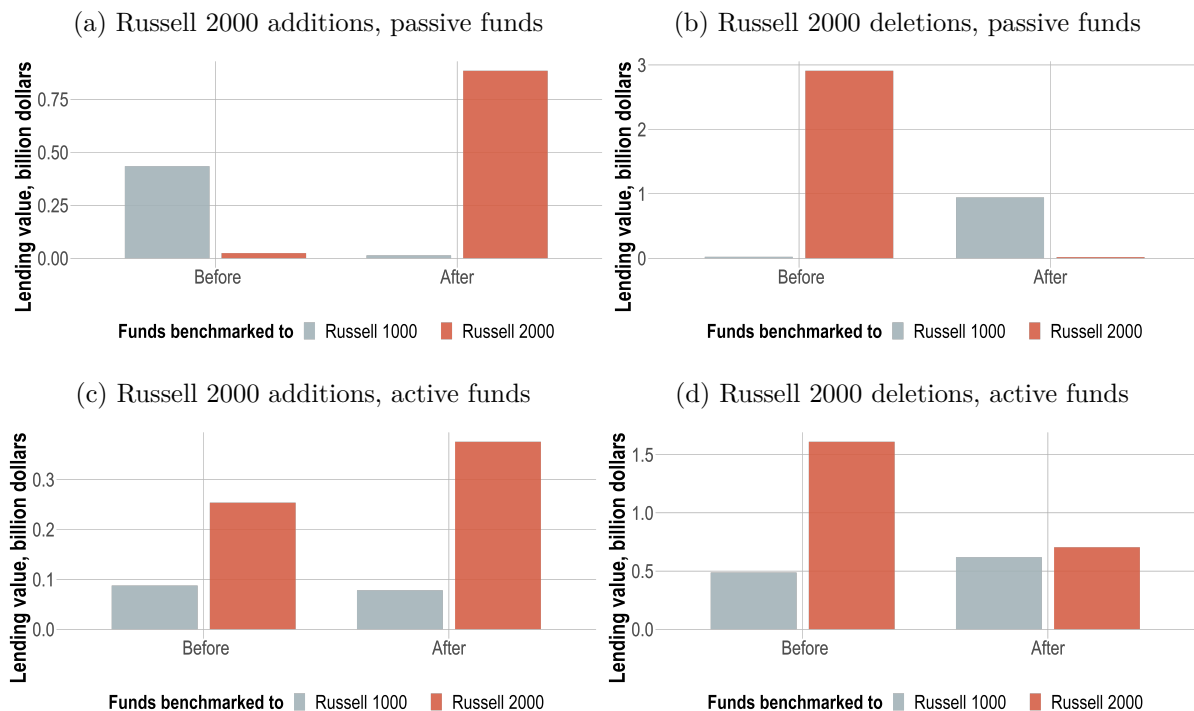
$$\Delta Y_{it} = \beta_1 \Delta BMI_{it} \times D(\text{special})_{it} + \beta_2 \Delta BMI_{it} \times D(\text{not special})_{it} + \zeta' \bar{X}_{it} + \nu_{st} + \epsilon_{it}. \quad (15)$$

The dependent variable, ΔY_{it} , is the change in the stock's lending inventory (active lendable quantity of shares), short quantity on loan (Markit's measure of short interest), borrowing fee, or the stock price. The changes in lending market variables are computed as the difference in means of daily observations for stock i between May and July of year t . Change in price is the return of stock i in June of year t (because June is the month when most of the price pressure due to the Russell reconstitution occurs, see the discussion in [Chang, Hong, and Liskovich \(2015\)](#)). ΔBMI_{it} is the difference between the BMI of stock i in May and June of year t , which effectively compares the pre- and post-reconstitution levels of BMI.

Specification (15) introduces interactions between ΔBMI_{it} and $D(\text{special})_{it}$ to allow the effect of BMI to be different for stocks on special and general collateral stocks, in line with my model. In all baseline analyses, I classify stock i as special, or $D(\text{special})_{it} = 1$, if its average borrowing fee exceeds 1% before the reconstitution month (specifically, in May of year t), and zero otherwise (following [D'Avolio \(2002\)](#) and [Aggarwal, Saffi, and Sturgess \(2015\)](#)).

In both specifications above, $\bar{X}_{it}$ is a vector of controls ensuring exogeneity of ΔBMI . $\log MV_{it}$ is the logarithm of total market value, the ranking variable as of May provided by Russell. $BandingControls_{it}$ include dummies for being in the band and being in the Russell 2000 as well as their interaction in May of year t . $Float_{it}$ is the Russell float factor, a proprietary liquidity measure affecting index weight. Conditional on $\log MV_{it}$, $BandingControls_{it}$ and $Float_{it}$ in May, the change in BMI due to the Russell reconstitution is exogenous. With these controls, I broadly follow [Appel, Gormley, and Keim \(2019\)](#). Other controls in vector $\bar{X}$ include a five-year monthly rolling β^{CRSP} computed using CRSP total market value-weighted index and a one-year monthly rolling average

Figure 2: Aggregate fund lending of the Russell 2000 index additions and deletions



This figure plots the aggregate fund lending of the Russell 2000 additions and deletions before (March–May) and after (July–September) the Russell reconstitutions of 2020–2022, according to funds’ N-PORT filings. Only funds with identified benchmarks and types (active or passive) are included. Russell 1000 group includes funds benchmarked to the Russell 1000 and Russell Midcap indexes (blend, value, or growth). Russell 2000 group includes funds benchmarked to the Russell 2000 indexes (blend, value, or growth). Further details are provided in Internet Appendix A.7.

bid-ask percentage spread. I supplement the controls with these variables to account for any stale information in the float factor (see Internet Appendix A.6). μ_{st} and ν_{st} are year by $D(\text{special})$ fixed effects, which allow for differences in trends for special and general collateral stocks. Finally, to ensure my results are robust to serial and cross-sectional correlation, as well as to account for the small number of time periods, I use the wild bootstrap procedure recommended by Cameron, Gelbach, and Miller (2008) to cluster standard errors by stock and time.

5.2.2 Results for the lending inventory and quantity on loan

Estimation results are presented in Table 2. Column (1) shows that a change in a stock’s BMI is indeed strongly positively related to the change in the lendable inventory of its shares. On average, a 1 pp increase in BMI is associated with an 18 bps increase in the lending inventory. This is consistent with the Russell case studies discussed in Section 5.1 and corroborates the assumption of my model that benchmarked funds supply their holdings for lending.

Table 2: Response of spot and lending variables to changes in benchmarking intensity (BMI)

	Δ Lending inventory, % shares (1)	Δ Quantity on loan, % shares (2)	Δ Borrowing fee, % (3)	Stock return, % (4)
Panel A: No interactions				
ΔBMI , % MV	0.175*** (10.18)	0.136*** (7.07)	0.013* (1.91)	0.122** (2.22)
Observations	13,685	13,685	13,685	13,685
Adjusted R-squared	0.144	0.089	0.078	0.202
Panel B: With specialness interactions				
ΔBMI , % MV $\times$ D(not special)	0.179*** (10.63)	0.129*** (6.86)	-0.004 (-1.28)	0.105** (2.15)
ΔBMI , % MV $\times$ D(special)	0.126** (2.61)	0.213*** (5.57)	0.206*** (3.01)	0.306* (1.91)
Observations	13,685	13,685	13,685	13,685
Adjusted R-squared	0.144	0.090	0.106	0.202
$\beta_1 - \beta_2$	-0.053 (-1.14)	0.083** (2.54)	0.210*** (3.12)	0.201 (1.49)

This table reports the estimates of specification (14) (panel A) and specification (15) (panel B) in the panel of stocks within 500 ranks around the Russell cutoff in 2007–2018. The last row reports the t -test for estimation results in panel B. Changes in lending market variables are computed as differences between July and May; stock return is measured in June. A stock is considered special, or $D(\text{special}) = 1$, if its fee in May is above 1%. All regressions include controls and D(special) by year fixed effects. t -statistics based on wild bootstrap with clustering by stock and year are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Column (2) of Table 2 documents the effect of a change in BMI on the quantity on loan (short interest). In line with the prediction of my model, quantity on loan significantly increases, for both general collateral and special stocks. The magnitude of the increase is economically significant and similar to that of the change in inventory, at 13 bps for general collateral stocks and 21 bps for special stocks per 1 pp increase in BMI.

These results imply a strong positive sensitivity of short-selling demand to the spot price. There are very few empirical estimates in the literature of the elasticity of short-seller demand with respect to the spot price. A notable exception is a negative estimate in Mainardi (2023), which, however, reflects the combined effect of a price change on both demand and the borrowing fee.

5.2.3 Results for the borrowing fee

Column (3) of Table 2 sheds light on the ex-ante ambiguous relationship between benchmarking intensity and borrowing fees. I find that the borrowing fee of special stocks increases in

response to the rise in BMI, which implies that the demand effect of benchmarking dominates in Russell reconstitutions. The increase is economically significant, with the fee rising by 21 bps for a 1 pp increase in BMI. This implies that special additions to the Russell 2000 see their borrowing fees increase by 1.5 pp (their average BMI change is 7.4 pp). This corresponds to an increase of over 25% relative to the level in May.

Importantly, column (3) of Table 2 shows that there is no change in the borrowing fee for general collateral stocks. In the language of my model, the lending market constraint is slack because the lending supply is abundant. Consistent with that, general collateral stocks have 28% of their shares in lending inventory, and only 5% of their shares are on loan to short-sellers, on average (see Table 1).

These results shed new light on the role of institutional ownership, and more specifically, benchmarking, in the formation of short-selling constraints. The literature has typically associated institutional ownership with a larger lending supply and lower borrowing fees. For example, Prado, Saffi, and Sturgess (2016) document that a one-standard-deviation increase in institutional ownership (equal to 30 pp in their sample) is associated with a decrease in fees of 5.6 bps, on average, for general collateral and special stocks in 2006-2010. Estimates in column (3) of Table 2 imply that a one-standard-deviation increase in BMI leads to a 3.2 bps (72.5 bps) increase in fees in the pooled (special) sample. In sum, I find that despite increasing the lending supply, an inflow of benchmarked capital leads to higher borrowing fees around Russell index reconstitutions.

Internet Appendix A.11 plots the average daily estimates of regression (14) in subsamples of special and not special stocks. Consistent with inelastic buying (and lending) by benchmarked fund managers, lending supply sharply increases at reconstitution (after accounting for the settlement of T+3 prevalent in my sample). Quantity on loan sees the largest increase then too. Yet, it takes the borrowing fees of special stocks around one month to reach the level corresponding to the estimate in Table 2, which likely reflects renegotiation of loans. Finally, none of these variables exhibits an imbalance before the reconstitution month.

The model in Section 3 also predicts that benchmarking may make an asset special if the demand effect dominates. In Internet Appendix A.14, I study changes in specialness following Russell reconstitutions. I document that a special stock with an increase in BMI is somewhat more likely to remain special and a general collateral stock is not significantly more likely to become special after the Russell reconstitution. At the same time, increases in BMI seem to slightly reduce the severity of specialness episodes as measured by their length and maximum borrowing fee. These results may be affected by the sparsity of the outcome variables, although they are similar in linear and non-linear specifications such as logit.

5.2.4 Results for the stock price

Consistent with my model’s prediction for the stock price, Table 2 confirms that price pressure is the highest for stocks experiencing the largest increase in BMI, all else equal. As per column (4) of Table 2, a 1 pp increase in BMI leads to a 12 bps higher return in June. This is not a new result, as there is a vast body of literature documenting the index effect. What is novel, however, is that the index effect is stronger for special stocks, with the magnitude of the coefficient on ΔBMI increasing threefold for these stocks (although not significantly in this specification). In my model that occurs when the demand effect of benchmarking dominates, so it is in line with the result in column (3).

Estimates in column (4) of Table 2 suggest that the price elasticity of demand for special stocks is lower than that of general collateral stocks. Because α in specification (14) is the sensitivity of the change in price to the change in quantity, the average estimate of the price elasticity of demand in my sample is $-1/0.12 = -8.3$. Panel B of Table 2 reveals that the elasticity estimate for special stocks is $-1/0.31 = -3.3$ and $-1/0.11 = -9.5$ for general collateral stocks.²³ The difference in these estimates is consistent with prior literature linking the size of index effect to arbitrage risk (for example, Wurgler and Zhuravskaya (2002)).

5.2.5 Pass-through from BMI to lending supply

Results thus far suggest that the pass-through from BMI to lending supply is rather weak. In this section, I argue that this reflects both the insufficient response of inventory and its limited utilization. Finally, I use changes in BMI as an instrument for changes in institutional ownership around the Russell cutoff to show that the pass-through from ownership to supply is also limited.

My estimates in column (1) of Table 2 imply that one dollar of new benchmarked capital translates into only 18 cents of new lending inventory. This coefficient is estimated quite precisely and stable across specifications. However, the estimated pass-through is likely a lower bound for the true pass-through because of how BMI is constructed. Specifically, when computing BMI, I assign equal weights to active and passive funds, while the true weight on active funds should reflect the strength of the relative performance component in their compensation ($b/(a+b)$ in the model). If I assume a lower weight on active funds, the estimate of the pass-through increases, as reported

²³My elasticity estimates are larger in magnitude than those in the literature (e.g., -1 in Koijen and Yogo (2019)), yet they should be viewed as upper bounds for two reasons. First, BMI treats active and passive fund assets equally while the model predicts that passive assets should enter with larger weight. Second, my tests assume that all rebalancing occurs in June and is not anticipated. If some of the price pressure occurs in May or July, the true price impact exceeds the estimate in Table 2. With a 50% weight on active assets and a 50% anticipatory pressure, elasticity estimates decrease to -1.2 and -2.8 for special and general collateral stocks, respectively.

Table 3: Response of lending inventory to changes in BMI for different levels of active funds' contribution

	Δ Lending inventory, % shares					
	(1)	(2)	(3)	(4)	(5)	(6)
ΔBMI , % (0% active)	0.591*** (7.26)					
ΔBMI , % (20% active)		0.452*** (8.80)				
ΔBMI , % (40% active)			0.329*** (9.61)			
ΔBMI , % (60% active)				0.254*** (10.04)		
ΔBMI , % (80% active)					0.205*** (10.31)	
ΔBMI , % (only active)						0.208*** (11.29)
Observations	13,685	13,685	13,685	13,685	13,685	13,685
Adjusted R-squared	0.123	0.137	0.142	0.144	0.144	0.146

This table reports the estimates of specification (14) for alternative definitions of BMI in the panel of stocks within 500 ranks around the Russell cutoff in 2007–2018. Changes in lending inventory are computed as differences between July and May. All regressions include controls and D(special) by year fixed effects. t -statistics based on wild bootstrap with clustering by stock and year are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

in Table 3. In the limit, if active funds' contribution to BMI (and the lending inventory) were zero, the pass-through becomes 59%. Therefore, the estimates in Tables 2 and 3 suggest that the true level of the pass-through from BMI to lending inventory lies in the range of 18% and 59%.

Furthermore, the response of lending supply to BMI is also weakened by the fact that only a fraction of lending inventory typically gets utilized. In my model, such utilization of inventory coincides with the lending limit (see Section 3.3.5). Stocks next to the Russell cutoff have pre-reconstitution utilization levels of 16% and 76% for general collateral and special stocks, respectively. Moreover, utilization increases by only around 0.3 percentage points in response to a 1 pp increase in BMI, as shown in Internet Appendix A.15.

To account for the potential differences between the ownership changes predicted by BMI and the actual changes in institutional ownership, I use changes in BMI as an instrument for changes in institutional ownership following Pavlova and Sikorskaya (2023). ΔBMI remains a valid instrument in my application because it affects all dependent variables only through changes in ownership. In particular, I estimate the following two-stage least squares regression:

$$\Delta IO_{it} = \kappa \Delta BMI_{it} + \delta' \bar{X}_{it} + \mu_{st} + \varepsilon_{it}, \quad (16)$$

$$\Delta Y_{it} = \alpha \widehat{\Delta IO}_{it} + \zeta' \bar{X}_{it} + \nu_{st} + \epsilon_{it}. \quad (17)$$

ΔIO_{it} is the change in institutional ownership of stock i implied by the quarterly 13F filings from March to June of year t . The rest of the specification is the same as in the baseline test.

Table 4 reports the estimates. The first-stage estimation results confirm that ΔBMI is a strong instrument for ΔIO , with an F -statistic of 49.5. Second-stage results show that the pass-through from institutional ownership to lending inventory is at 67% (44% for special stocks). Finally, I find that a 1 pp increase in institutional ownership of special stocks leads to a 78 bps increase in their borrowing fees.

5.2.6 Further discussion

This section addresses potential concerns about the research design and interpretation.

First, my results are robust to a number of permutations in the research design, such as changing the bandwidth to 200, 300, or 750 stocks, adding the interactions of control variables with specialness, or excluding liquidity controls. Using alternative definitions of specialness delivers same results as well. All these tests are reported in Internet Appendix A.10.

Second, the main threat to using changes in BMI in stock-level regressions is that index membership is potentially endogenous. However, there is a large body of literature that uses membership in the Russell 2000 index as an instrument for institutional ownership in a similar setting. This literature argues that, after controlling for factors that determine index inclusion, such as the ranking variable that Russell uses for index assignment at the end of May, the index membership is exogenous. Appel, Gormley, and Keim (2021), Heath, Macciocchi, Michaely, and Ringgenberg (2021) and Wei and Young (2021) discuss potential issues with the construction of the sample and controls, which I largely avoid by using the proprietary Russell ranking variable and Russell 3000E index files (see further details in Section A.5 of the Internet Appendix). Internet Appendix A.12 also confirms that the main results go through even if I exclude stocks that move across the Russell cutoff. The remaining stocks experience (smaller) changes in BMIs because their index weights get revised as *other* stocks are moving across the cutoff. Therefore, such variation is even less likely related to the unobserved fundamentals.²⁴

A potential concern with the Russell reconstitution setting is that it has been used many times in economic research, and hence a multiple testing problem may arise. Yet, the relevant t -statistics in Table 2 are well above the 5% critical value that accounts for multiple testing suggested

²⁴I thank Antonio Coppola and Matteo Maggiori for pointing this out.

in the literature specifically for the Russell setting (Heath, Ringgenberg, Samadi, and Werner, 2023).

Third, it may not be immediately clear from the empirical results that a change in BMI leads to a shift in lending supply. Given the observed increase in borrowing fees and quantity on loan for special stocks, a shift in demand must have occurred. However, the positive coefficient in column (1) of Table 2 may be due to both the shift in the supply curve and the movement along the supply curve. I argue that an increase in BMI leads to a shift in the lending supply curve for two reasons. First, lending inventory is slow-moving and unlikely responsive to fees at the horizon of my test. The inventory represents the total potential number of shares available for lending, not the number of shares available at current fee levels, as pointed out by Saffi and Sigurdsson (2011) and others.²⁵ Second, Internet Appendix A.13 formally shows that my reduced-form estimates imply a stronger pass-through to shorting demand than to lending supply. By relying on an instrument for demand for special stocks suggested by the literature, I identify a positive shift in inventory and supply curves due to BMI and confirm that my estimate of the pass-through is not sensitive to the simultaneity of supply and demand.

It is plausible that special stocks with large increases in BMIs (predominantly additions to the Russell 2000) have become special due to some form of distress, driving addition to the index and bringing about higher borrowing fees. However, my results are virtually the same if I exclude stocks that are likely to be in distress, as measured by Altman’s Z-score (Altman, 1968) or by a drastic decrease in market value rank in the previous year.

An underlying assumption in my analysis is that special and general collateral stocks are different across a dimension orthogonal to BMI, which is driving most of shorting demand. A large part of the literature takes disagreement—for example, measured by the dispersion of analyst forecasts (Diether, Malloy, and Scherbina, 2002)—as the key driver of short-selling and stock specialness. Given the mechanical nature of the Russell reconstitution, disagreement should not be related to changes in BMI. I validate this assumption in Internet Appendix A.16 and show that my estimates are virtually unaffected if concurrent changes in disagreement are included as controls.

²⁵This is Markit’s description of how lending inventory is constructed: “The lending pools are generally aggregated from underlying asset owners who have their assets in custody with the lending agents. The pool is not dependent on fee, it is more dependent on which instruments asset owners have a long-term positive view, as they are more likely to lend out an instrument they have a long-term positive view on.” See further discussion and suggestive evidence in Baklanova, Caglio, Keane, and Porter (2016).

Table 4: Response of lending variables to changes in institutional ownership (IO) instrumented by changes in BMI

	Δ Lending inventory, % shares			Δ Quantity on loan, % shares	Δ Borrowing fee, %	Stock return, %	Δ Lending inventory, % shares	Δ Quantity on loan, % shares	Δ Borrowing fee, %	Stock return, %
	OLS			2SLS			2SLS			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A: Second-stage estimates										
ΔIO , %	0.088*** (12.43)	0.805*** (6.05)	0.674*** (11.42)	0.524*** (8.84)	0.050* (1.80)	0.469** (2.16)				
ΔIO , % $\times$ D(not special)							0.695*** (10.57)	0.501*** (6.86)	-0.012 (-0.90)	0.417** (2.17)
ΔIO , % $\times$ D(special)							0.436** (2.74)	0.793*** (6.24)	0.776*** (3.44)	1.071* (1.86)
Panel B: First-stage estimates										
ΔBMI , %			0.259*** (7.04)							
D(in Russell 2000 in June)		2.740*** (5.98)								
Observations	13,685	13,685	13,685	13,685	13,685	13,685	13,685	13,685	13,685	13,685
F -stat. (excl. instruments)		35.7	49.5							

This table reports the estimates of specification (16) (panel A) and specification (17) (panel B) in the panel of stocks within 500 ranks around the Russell cutoff in 2007–2018. Column (1) reports an OLS estimate of the coefficient of lending inventory on the change in institutional ownership. Columns (2) and (3) report 2SLS estimates with Russell 2000 membership dummy and ΔBMI used as instruments, respectively. Columns (4)–(6) report 2SLS estimates for other dependent variables, for which I do not report first-stage estimates because they are the same as in column (3). In columns (7)–(10), I first compute values of IO predicted with ΔBMI , then use these predicted values, interacted with specialness, in the second stage. A stock is considered special, or $D(special) = 1$, if its average fee in May is above 1%. Changes in lending market variables are computed as differences between July and May; stock return is measured in June. All regressions include controls and D(special) by year fixed effects. t -statistics based on wild bootstrap with clustering by stock and year are in parentheses. F -statistics assume clustering by stock and year as well. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The literature has long debated whether index effects are transitory, which would suggest that the effects in Table 2 may also reverse over time. Motivated by this perspective, I extend the analysis in Section 5.2 to examine the dynamics of prices, shorting demand, lending supply, and borrowing fees over longer horizons. While slow-moving capital can, in principle, lead to reversals, existing evidence for Russell index reconstitutions does not support a systematic reversal pattern.²⁶

In my data, prices remain elevated through the post-reconstitution period, and while long-run returns are noisy and confidence intervals quickly widen, I find no statistically significant reversal. In fact, a substantial portion of the index effect emerges in anticipation of reconstitution, and when this pre-trend is accounted for, the total price impact appears even more persistent. These dynamics are especially clear for general collateral stocks: prices shift to a new equilibrium level, shorting demand initially spikes and then gradually declines as positions are covered, and borrowing fees remain near zero throughout, consistent with slack in the lending market. For special stocks, long-horizon price effects are of similar magnitude, but borrowing fees and shorting demand remain elevated, reflecting constrained supply and the dominant demand effect of benchmarking. Importantly, I find no evidence of delayed increases in lending inventory, either in market data or in regulatory filings at the fund and fund-family level, suggesting that lending supply does not respond slowly in this setting. The long-run results are documented in Internet Appendix A.17 and fund- and family-level evidence is presented in Internet Appendix A.19.

Finally, the literature has argued that market participants may perceive borrowing from passive funds as less risky (Palia and Sokolinski (2024) and Beschwitz, Honkanen, and Schmidt (2025)). This could be due to, for example, the less frequent recall of previously lent shares by lenders with longer investment horizons. Through this channel, the equilibrium shorting demand and borrowing fee could also increase with BMI as long as it reflects a more stable lending supply.

I test for this channel using several borrowing risk measures suggested by the literature, such as the borrowing fee volatility, utilization volatility, number of failures to deliver, and the option-implied fee risk premium. I find no change in fee risk premium and failures to deliver while fee volatility even increases in some specifications. Internet Appendix A.15 reports these results. Overall, BMI does not seem to increase shorting demand by reducing borrowing risk in my sample.

²⁶For example, Chang, Hong, and Liskovich (2015) find no return reversal after inclusion, and Pavlova and Sikorskaya (2023) show that stocks with increases in BMIs tend to underperform at long horizons—consistent with persistent overvaluation driven by the hedging benefits benchmarked investors derive from their holdings.

5.2.7 External validity and international evidence

With increasing size of the passive fund industry and decreasing tracking errors of active funds (Stambaugh, 2014), benchmark indexes should have an increasing influence on lending supply. Indeed, even further away from the Russell cutoff, funds mostly lend stocks that are inside their benchmarks. For example, within-benchmark stocks account for almost 99% of loan values of funds benchmarked to the Russell 1000 index. Similarly, above 83% of the loan value of Russell 2000 funds comes from stocks within this index. Percentages for other indexes are reported in Internet Appendix A.8.

My results extend to other settings with mandate-driven rebalancing, such as central bank purchases. In fact, the literature has argued that lending of bonds from a central bank’s balance sheet affects quantitative easing effectiveness (e.g., Pelizzon, Subrahmanyam, and Tomio (2025) and Roh (2022)), which is similar to how lending of institutions affects the role of investment mandates for asset prices. To gather further evidence outside of the Russell experiment, I study purchases of ETFs by the Bank of Japan (BoJ) in 2010–2022. I find that cross-sectional shocks to the size of the BoJ purchases lead to very similar results. Specifically, with an increase in the BoJ purchases, special stocks in Japan experience an increase in lending supply, shorting demand, and borrowing fees. This evidence suggests that the demand effect of benchmarking is dominant for Japanese stocks as well. Details of this test, identification assumptions, and the results are provided in Internet Appendix G.

Finally, even though the number of special stocks in my U.S. sample is limited, it is an important group of securities. An increasing number of studies are linking asset pricing anomalies to special stocks (see Introduction). Even though historically around 10% of U.S. stocks have been considered special at a given point in time, over 80% of stocks become special at some point in my sample. Daniel, Klos, and Rottke (2024) show that in recent years the share of U.S. stocks on special has grown closer to 30%. In other geographies, special stocks typically represent even a larger share of the market, for example, a third of the Japanese market (see Internet Appendix G).

5.3 What drives limited lending?

The previous section documents that borrowing fees of special stocks increase with BMI. In the model, it is the lending limit on fund managers’ holdings that is driving a wedge between the demand and supply effect of benchmarking. The dominant demand effect of benchmarking and the weak pass-through from BMI to lending inventory suggest that managers underprovide their holdings for lending.

Consistent with that, in this section, I uncover explicit position-level limits on lending set by investment companies in the United States. These explicit limits, however, cannot explain the small magnitude of the pass-through from benchmarking to lending supply, and I discuss other potential factors behind that in detail.

5.3.1 Evidence on explicit lending limits from regulatory filings

The recent modernization of fund regulatory reporting in the United States has provided more granular data on lending. I use N-PORT and N-CEN filings, available for the Russell reconstitutions from 2020, to shed light on position-level lending limits.

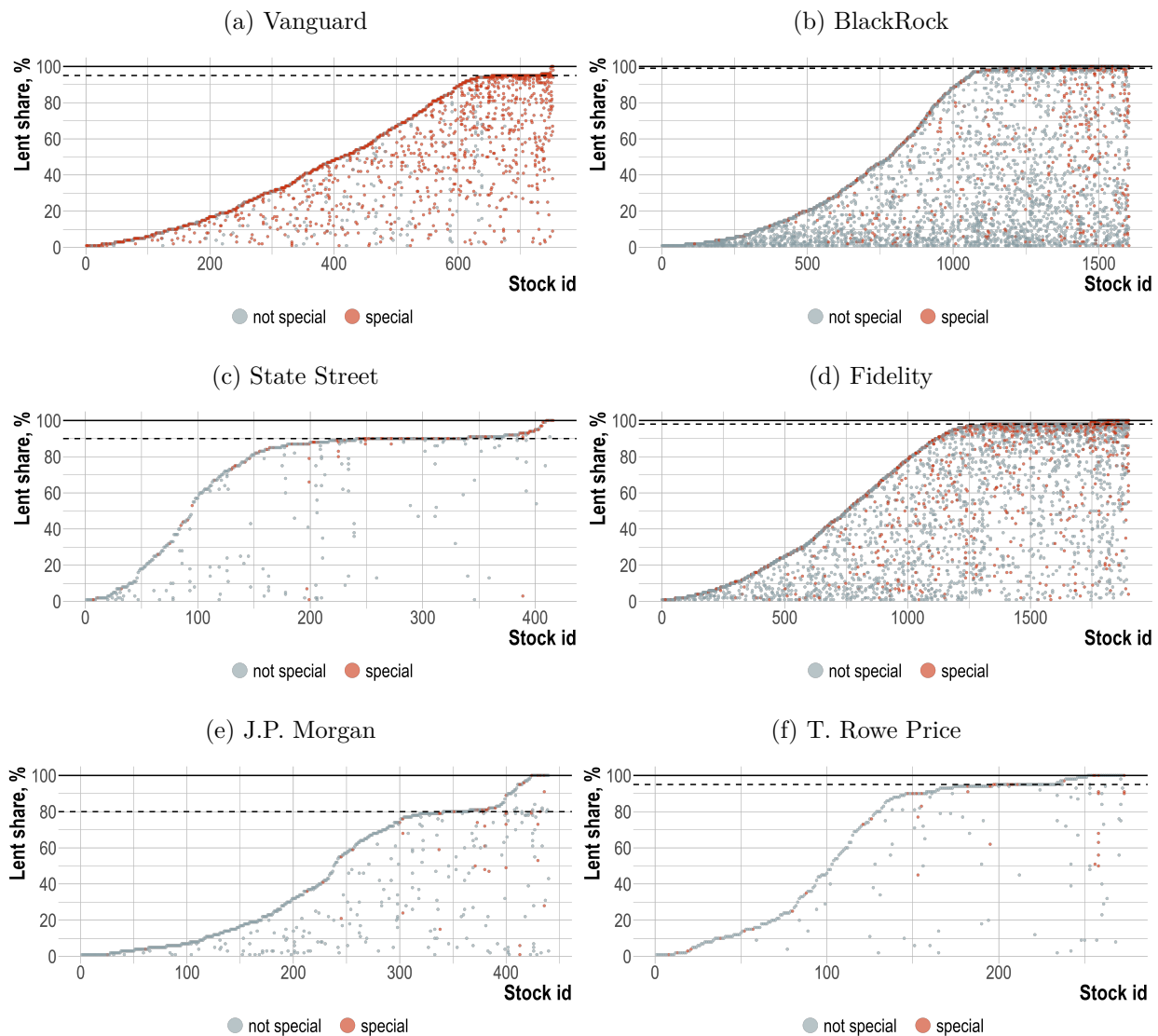
One of the well-known limits on lending is that regulators in the United States impose a total portfolio-level lending limit of $1/3$, which is often quoted in the literature. Because collateral may be counted as part of the total assets, this usually means that funds are allowed to lend up to 50% of their net assets. However, in the data, this limit does not bind. Internet Appendix [A.1](#) combines N-PORT and N-CEN filings to show that the value on loan represents only 1% of investment company assets (on average and conditional on lending). Even in the cross-section, the percentage of fund net assets on loan tends to be significantly below the regulatory limit.

Funds also set limits on lending at the position level, driven by their investment and lending policies. Figure [3](#) plots how much of each holding is on loan (lent share) for several prominent investment companies in the United States. Because lending also reflects demand, the lent shares can be anywhere between 0% and 100%. Yet, the bunching of lent shares reveals that investment managers impose position-level limits on securities lending. For example, Vanguard funds seem to have an effective limit of 95%, whereas State Street funds limit their lending to 90% of position values.²⁷ Fidelity funds show a limit of around 97.5%. A notable exception is BlackRock, which has the most lenient limit, at 99%, if any. Active fund managers also impose limits. For example, the plots for J.P. Morgan and T. Rowe Price in panels (e) and (f) reveal fuzzy limits at 80% and 95%, respectively.

These explicit lending limits get hit during Russell reconstitutions, yet they unlikely fully explain the weak passthrough of benchmarked capital to lending inventory. Lent share histograms in Figure [A6](#) in the Internet Appendix illustrate that many special stocks moving between indexes during the Russell reconstitutions are lent out at the levels of 90%–100% of how much funds hold. However, the same histograms also reveal that many funds do not lend these special stocks at all (lent share is 0%). This is puzzling in light of my model because funds seem to forgo income from

²⁷My conversations with representatives of State Street and Vanguard confirmed that these companies enforced lending “buffers” at these levels.

Figure 3: Illustration of lent shares at position level for prominent investment managers in the United States



This figure plots the share of each holding that is on loan for funds managed by Vanguard, BlackRock, State Street, Fidelity, J.P. Morgan, and T. Rowe Price. The data are as of the report date in the second quarter of 2021 and rounded to percentage points. I include only domestic equity funds with a defined active or passive type. On the x-axis is a unique ID assigned for each stock on loan within each investment manager. Each dashed line corresponds to the sample mode of lent shares, computed using all lent shares above 1% within the corresponding company. Observations with a lent share above 100% are set to 100%.

lending these high-fee stocks. Therefore, the next section discusses factors that can drive limited lending apart from portfolio-level and position-level limits.

5.3.2 Other drivers of limited lending

In addition to the explicit lending limits discussed in the previous section, other factors, such as lending market participation costs, concentration of lenders, and search frictions, could contribute to the limited pass-through from BMI to lending supply. In this section, I discuss these factors in more detail and argue that they can unlikely fully explain the sparse lending of special stocks around the Russell reconstitutions documented in the previous section.

First, my results above abstract away from the costs of lending. Not all funds are even permitted to engage in securities lending by their investment policies. Anecdotally, industry practitioners cite reputation concerns, fiduciary duty, and small investment scale as drivers of a decision not to lend. Internet Appendix A.1 shows that around 99% of passive funds and 73–86% of active funds are permitted to lend. Of those, around 99% of passive funds and 84–94% of active funds participate in lending activities. Funds that lend face the costs of running a lending program (whether in-house, through a custodian, or a third-party lending agent), and the observed limited lending may reflect such cost-benefit trade-offs. In Internet Appendix E, I introduce costly lending into the model in Section 3 and find that the effect of benchmarking on borrowing fee is still ambiguous even if the lending limit is endogenously determined.

Additionally, the literature has demonstrated that lender concentration can reduce lending supply (Prado, Saffi, and Sturgess (2016) and Chen, Kaniel, and Opp (2024)). Internet Appendix A.15 documents that the concentration of loan values across lenders, as computed by Markit, decreases for general collateral stocks and does not change for special stocks in response to an increase in BMI. Furthermore, I find that special stocks in my sample exhibit a relatively low lender concentration level of 19%. Hence, changes in lender concentration alone can unlikely account for my findings, and yet, it is plausible that its level could contribute to the limited pass-through from benchmarked capital to lending supply.

Finally, since most lending transactions happen over the counter, search frictions may contribute to the incomplete utilization of inventory (Duffie, Gârleanu, and Pedersen (2002)). Yet, these frictions should be alleviated with an increase in BMI, as benchmarked owners are widely known to supply their holdings for lending. I also find that even when short-sellers optimally choose the lending limit (search intensity), benchmarking may increase or decrease the equilibrium borrowing fee, consistent with the baseline model. This extension follows Banerjee and Graveline (2014) and is reported in Internet Appendix F.

Lending costs, lender concentration, and search costs are unlikely to fully explain limited lending in the data. To illustrate that, Figure 4 plots a histogram of lent shares in special stocks added to the Russell 2000 index in 2020–2022, based on the holdings of benchmarked funds in the

quarter after reconstitution. Over 40% of these stocks are not lent out, and even such prominent lenders as Vanguard and Schwab do not lend some special stocks (see panels (a) and (b)). For those stocks that are lent, funds mostly lend more than 75% of what they hold in these stocks. Moreover, the same special stock may be fully lent by some funds but not by others (e.g., TIAA-CREF’s lending of Sinclair Broadcast in panel (c)).

These lending patterns suggest that funds may specialize in lending only a subset of stocks. To formalize this, Table A18 in the Internet Appendix reports conditional correlation coefficients between lent shares and several stock characteristics. It shows that fund-by-stock fixed effects account for over half of the variation in the extensive margin (whether a fund lends a special stock) and 40% of the variation in the intensive margin (how much is lent). In contrast, stock characteristics explain only about 3% of the variation in lending on both margins. The importance of fund-by-stock fixed effects strongly suggests specialization in the securities lending market, consistent with findings in contemporaneous N-PORT studies, such as [Dong and Zhu \(2024\)](#).

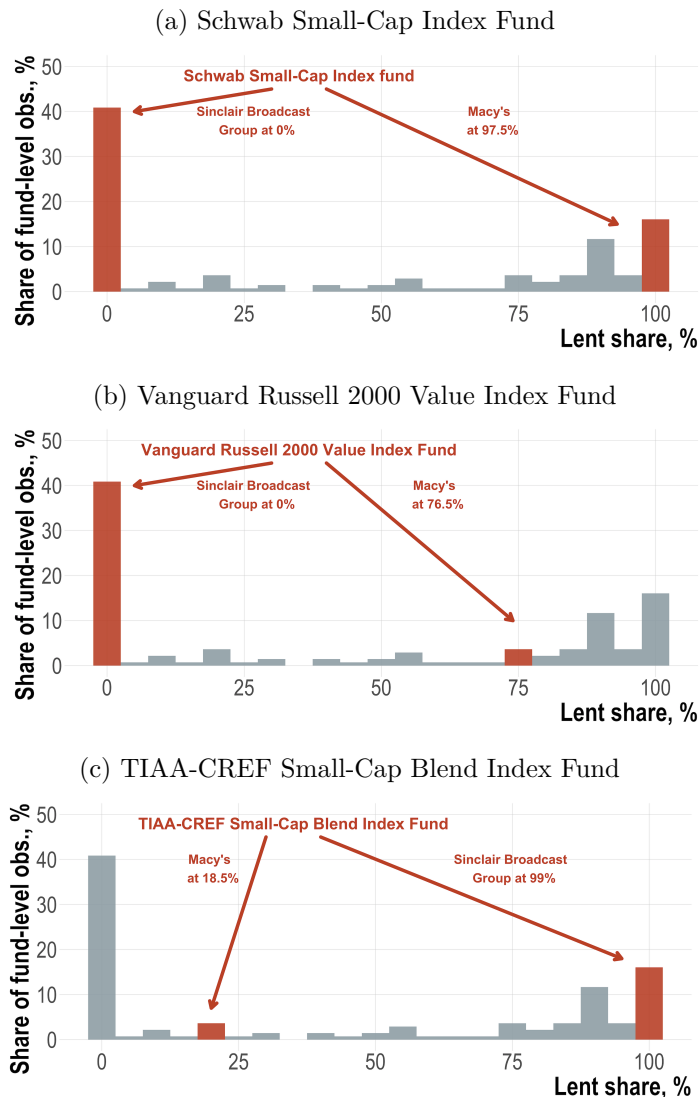
6 Concluding Remarks

Short-selling plays a crucial role in price discovery within financial markets. At the same time, the cost of short-selling is determined in the securities lending and borrowing market, where institutional investors act as key lenders.

In this paper, I exploit variation in institutional mandates to provide new insights into how institutions influence the formation of short-selling constraints. I propose a simple model with benchmarked fund managers who can also lend their holdings to short-sellers. In this model, benchmarking has an ambiguous effect on the equilibrium borrowing fee. An asset included in a benchmark index will generally have a larger lending supply but also attract greater shorting demand because its price is inflated relative to an asset outside of the index. By exploiting plausibly exogenous variation in how much capital is benchmarked against stocks, I find that borrowing fees tend to increase with benchmarking-induced purchases around Russell index reconstitutions. This is consistent with the dominant demand effect, or overvaluation effect, of benchmarking. In the model, the demand effect of benchmarking dominates if fund managers undersupply their holdings for lending due to lending limits. Using the evidence from novel regulatory filings of investment companies in the United States, I discuss several drivers of limited lending in the data.

I find that the weak pass-through of benchmarked capital to lending supply contributes to the asset pricing effects of investment mandates. To facilitate price discovery, it may be beneficial to address supply-side frictions, such as those stemming from market participation or lending costs,

Figure 4: Lending in special stocks added to the Russell 2000 index in 2020-2022 by benchmarked funds



This figure plots a histogram of lent shares in special stocks added to the Russell 2000 index in 2020-2022 of active and passive funds benchmarked to the Russell 2000 index (blend, value, or growth). Each panel highlights lending of two stocks by a specific index fund, all captured in the third quarter of 2020. Observations with a lent share above 100% are set to 100%.

lender concentration, and search costs. This paper abstracts away from strategic actions or active rebalancing in response to shorting demand that may also limit lending (for example, [Greppmair, Jank, Saffi, and Sturgess \(2024\)](#) and [Honkanen \(2025\)](#)). Nevertheless, formulating an optimal policy action depends on which friction is key and requires further research. The new data collection effort announced by the SEC is likely to facilitate inquiry in this direction.

The magnitude of the index effect might have decreased over time, particularly for the S&P

500 index reconstitutions, as argued by [Bennett, Stulz, and Wang \(2020\)](#), [Aghaee Shahrababaki \(2024\)](#), and [Greenwood and Sammon \(2025\)](#). The model in this paper implies that relaxing limits on lending counteracts benchmarking price pressures. [Evans, Ferreira, and Prado \(2017\)](#) document a strong increase in funds’ participation in lending in 1996-2008 and my analysis of the regulatory filings for 2020-2022 confirms this trend. Therefore, the dynamics in the index effect may be affected by the lending policies of benchmarked fund managers becoming more accommodating over time. A dynamic extension of the model could help capture these evolving patterns by allowing lending limits and participation rates to adjust over time.

My findings may have implications for the design of unconventional monetary policies. Literature on bond quantitative easing has shown that central bank purchases can depress the repo rates through the so-called scarcity channel (e.g., [D’Amico, Fan, and Kitsul \(2018\)](#)). [Pelizzon, Subrahmanyam, and Tomio \(2025\)](#) demonstrate that the introduction of lending of bonds from the central bank’s portfolio mitigates scarcity effects. My findings for equity markets emphasize the potential role of lending limits in influencing the effectiveness of quantitative easing, an aspect not previously considered in the literature. Therefore, by adjusting the lending program and its lending limits, central banks may transition more smoothly into a tightening regime, prior to unwinding their holdings. I see it as a promising avenue for future research.

The intuition in this paper can be applied to any investment mandate. Although my model features benchmarking, adding a preference for certain assets directly into a lender’s utility function would yield very similar results. This could include a preference for safe assets ([Krishnamurthy and Vissing-Jorgensen, 2012](#)), ESG assets ([Pástor, Stambaugh, and Taylor, 2021](#)) or correspond to any type of taste ([Fama and French, 2007](#)). My results suggest that by introducing lending limits specific to ESG assets, regulators may achieve stronger effects on the cost of capital at the same level of investment. Understanding this requires more research into the lending policies of investment companies and a careful analysis of distributional effects because the primary beneficiaries of securities lending revenues are fund investors.

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A Internet Appendix: Additional U.S. Evidence

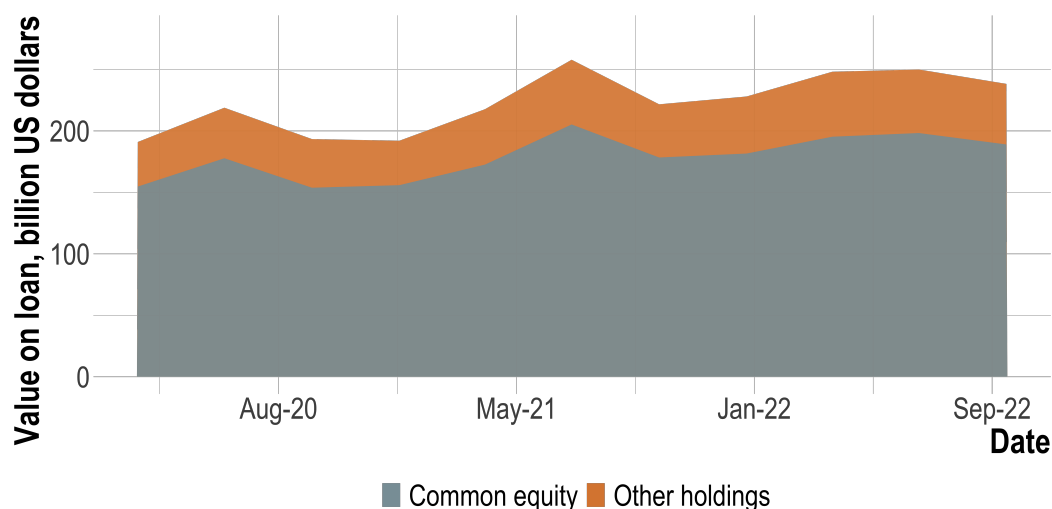
A.1 Aggregate insights into the lending activity of U.S. investment companies from regulatory filings

This section provides aggregate descriptive statistics using N-PORT and N-CEN filings. The parsing of both types of filings is described in Appendix [A.2.5](#).

A.1.1 Aggregate value on loan

The aggregate quarterly value on loan between Q1 2020 and Q3 2022 is plotted in Figure [A1](#). Lending of common equity holdings contributes 80% or more to the aggregate value on loan in each quarter.

Figure A1: Aggregate value on loan as reported in N-PORT filings

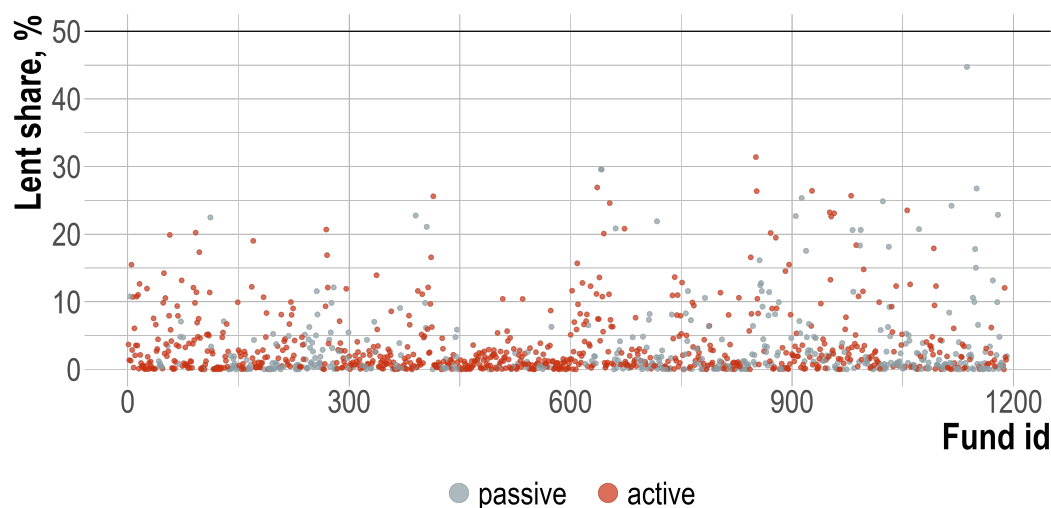


This figure plots the aggregate value on loan as reported in N-PORT filings for all investment companies in the United States. Common equity value is the total of loan values with the asset category ‘EC’ and the ‘Long’ payoff profile.

A.1.2 Aggregate lending descriptive statistics

Table [A1](#) reports descriptive statistics on the lending activity of investment companies in the United States.

Figure A2: Fund-level value on loan as reported in N-PORT filings



This figure plots the value on loan relative to fund net assets as reported in N-PORT filings for all investment companies in the United States in the second quarter of 2021. Only funds permitted to lend securities by their investment policies are included. The horizontal line marks the regulatory limit of 50%.

Table A1: Key descriptive statistics on securities lending by year

	Net assets, \$ billion	Value on loan, \$ billion	Securities lending income, \$ billion	Share of funds permitted to lend, %	Share of funds lending, %	Share of fund assets on loan, %
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Domestic equity index mutual funds and ETFs						
2019	3,886.88	51.38	0.69	98.52	97.29	1.32
2020	4,375.83	55.46	0.75	98.74	98.08	1.27
2021	5,595.14	51.83	0.69	99.07	98.20	0.93
Panel B: Domestic equity active mutual funds						
2019	5,003.81	53.15	0.41	72.83	61.42	1.06
2020	5,258.05	47.96	0.42	86.01	72.39	0.91
2021	6,223.62	46.74	0.30	85.02	80.32	0.75
Panel C: All funds of U.S. investment companies						
2019	21,884.28	218.96	2.61	70.17	62.99	1.00
2020	23,517.93	212.93	2.54	77.36	68.69	0.91
2021	27,990.66	217.00	2.25	77.55	73.73	0.78

This table reports descriptive statistics on lending activity of domestic equity funds of U.S. investment companies according to their annual N-CEN filings in 2019–2021. Fund observation is attributed to a given year when the report date is within that year. Net assets are the total of average monthly net assets. Value on loan is the average value of lent out securities. Share of assets on loan is computed as a fund-level ratio of average value of securities on loan to the average monthly net assets. Shares in columns (4)–(6) are asset-weighted averages across funds in a given year. Share in column (6) is conditional on lending. In panels A and B, I include only funds with a defined type. Panel C reports statistics for all funds submitting N-CEN forms.

A.2 Data

A.2.1 U.S. stock data

U.S. stock data come from standard sources. I take daily returns, prices, adjustment factors, bid and ask prices, and historical stock identifiers from CRSP. Returns are adjusted for delisting, following [Shumway \(1997\)](#). Market, risk-free rate, and factor returns are from Ken French’s database at Dartmouth. These data are merged with S&P securities lending data using CUSIP and date. All fundamental accounting data, such as book values, come from Compustat. I use a CRSP-Compustat linking table and take into account release dates to ensure that the variables are available to the public by the Russell rank date in May. Finally, to compute institutional ownership ratios, I follow the WRDS-hosted code of Luis Palacios, Rabih Moussawi, and Denys Glushkov and run it on Thomson Reuters s34 regenerated data that avoids errors identified in 2010–2016.

A.2.2 Historical benchmark weights data

I obtain benchmark weights data from the following sources. All the constituent weights for 22 Russell benchmark indexes are from the FTSE Russell (London Stock Exchange Group). The Russell indexes include (all total return in USD): Russell 1000, 2000, 2500, 3000, 3000E, Top 200, Midcap, Small Cap Completeness (blend), and their growth and value counterparts. Constituent weights for the S&P 500 TR USD and S&P MidCap 400 TR USD are from Morningstar and are available from September 1989 and September 2001, respectively, to October 2015. I construct constituent weights for S&P 500 after October 2015 manually from constituent lists and prices available through CRSP. I generate the S&P 400 weights from holdings of index funds (Dreyfus and iShares).²⁸ The constituent weights for the CRSP U.S. indexes are from Morningstar and are available from 2012. These indexes include (all total return in USD): Total Market, Large Cap, Mid Cap, Small Cap (blend), and their growth and value counterparts.

A.2.3 U.S. funds data

U.S. fund data are from the CRSP Survivor-Bias-Free U.S. Mutual Fund Database. In particular, I use fund total net assets, fund returns, and investment style information.

Active and Passive Domestic Equity Funds. I follow the major steps of the procedure described in [Doshi, Elkamhi, and Simutin \(2015\)](#) to select active domestic equity funds and modify it to identify passive funds. In particular, I use *crsp_obj_cd* (CRSP objective code) to identify ‘equity’, ‘domestic’, ‘cap-based or style’ and exclude ‘hedged’ and ‘short’ and remove

²⁸Because the S&P 400 index is relatively small, these weights do not contribute much to the analysis.

those funds that changed their objectives. I also keep only funds with ‘ioc’ variable in Thomson Reuters S12 file (investment objective) not in (1,5,6,7). Active funds are identified as those without *Index_fund_flag* or with ‘B’ (index-based funds) and without *et_flag*. I also exclude funds that have a range of words in their names, as per the list below.

1. Generic and index provider names: index, indx, ‘ idx ‘, s&p, ‘ sp ‘ (with spaces), nasdaq, msci, crsp, ftse, barclays, ‘ dj ‘, ‘ dow ‘, jones, russell, ‘ nyse ‘, wilshire, 400, 500, 600, 1000, 1500, 2000, 2500, 3000, 5000
2. Passive management names: ishares, spdr, trackers, holdrs, powershares, streettracks, ‘ dfa ‘, ‘program’, etf, exchange traded, exchange-traded
3. Target fund names: target, retirement, pension, 2005, 2010, 2015, 2020, 2025, 2030, 2035, 2040, 2045, 2050, 2055, 2060, 2065, 2070, 2075.

Similarly, the sample of passive funds consists of index funds and ETFs available on CRSP. Index funds are those with *index_fund_flag* equal to *D* or *E* and those that include any of the following words in their name:

1. Generic and index provider names: index, indx, ‘ idx ‘, s&p, ‘ sp ‘ (with spaces), nasdaq, msci, crsp, ftse, barclays, ‘ dj ‘, ‘ dow ‘, jones, russell, ‘ nyse ‘, wilshire, 400, 500, 600, 1000, 1500, 2000, 2500, 3000, 5000
2. Passive management names: ishares, ‘dfa’, ‘program’.

ETFs are identified as funds that have *et_flag* or have one of the following words in their name:

1. Passive management names: spdr, trackers, holdrs, powershares, streettracks, etf, exchange traded, exchange-traded.

Furthermore, I exclude all leverage and inverse funds by identifying the following in their names: leverage, inverse, 2x, 1.5x, 1.25x, 2.5x, 3x, 4x. Finally, I clean the resulting sample of funds with share classes of different types as per the rule: (a) Put ETF share classes of index funds as ETFs. (b) When missing the flag for otherwise index funds and *portno* is the same, set to index. (c) If *cl_grp* is different, exclude.

A.2.4 Construction of the historical fund benchmark data

Construction of the historical fund benchmark data follows [Pavlova and Sikorskaya \(2023\)](#).

A.2.5 U.S. funds securities lending data

Using R package ‘edgarWebR’, I download the full history of N-PORT, N-PORT/A, N-CEN, and N-CEN/A filings for each unique CIK (central index key, SEC fund company identifying number) in the *crsp_fundno*-CIK mapping from CRSP (table *crsp_cik_map*). My sample includes reports filed up to March 1, 2023. N-PORT filings are quarterly (holdings schedule), and N-CEN filings are annual. If there are amended filings for the same report date (N-PORT/A and N-CEN/A), I use the last available filing. The filings are machine-readable so I simply extract the relevant data, as follows.

1. Fields from N-PORT and N-PORT/A filings

- Filing information: CIK, series ID, series name, report date, filing date
- Fund information: series ID, total assets, and net assets
- Fund borrower information: series ID, borrower name, borrower legal entity identifier (LEI), and borrower aggregate loan value
- Fund holdings: series ID, investment name, CUSIP, ISIN, ticker, number of shares, value of shares in USD, weight in portfolio, long or short position indicator, asset category, investment country, indicator whether any amount of this investment represents reinvestment of cash collateral received for loaned securities, whether any portion of this investment is treated as a fund asset and received for loaned securities (i.e., a non-cash collateral), whether any portion of this investment is on loan by the fund, and loan value.

2. Fields from N-CEN and N-CEN/A filings

- Filing information: CIK, series ID, series name, report date, filing date
- Fund information: series ID, fund type (ETF, inverse, fund of funds, etc.), monthly average net assets, whether the fund is permitted to lend, whether the fund lent, average value of securities on loan, net income from securities lending
- Fund lending agent information: series ID, agent name, agent legal entity identifier (LEI), and whether lending agent is affiliated with the investment company

In my sample, the number of unique funds (series ID level) in N-PORT data is 13,267, and the number of funds that have a merged type from CRSP is 2,988 (including 2,261 active and 727 passive funds). The latter sample includes only domestic equity funds identified as described in Section [A.2.3](#).

A.3 Variable definitions and descriptive statistics

Table A2: Key variable definitions and descriptive statistics

Variable	Definition	Units	Source (field)	Mean	Median	St. dev.	p1	p99
Panel A: U.S. data (sample around the Russell cutoff)								
ΔBMI	Change in BMI as defined in equation (13) from May to June	% MV	FTSE Russell, Morningstar, CRSP, CRSP MFDB, SEC	0.13	-0.03	2.62	-8.90	9.79
Δ Lending inventory	Difference between the average daily active inventory (ActiveLendableQuantity) as a share of shares outstanding (SHROUT*1000) in July and May.	% shares	Markit (ActiveLendableQuantity) and CRSP (SHROUT)	-0.01	0.07	1.93	-6.13	5.57
Δ Quantity on loan	Difference between the average daily short quantity on loan (ShortLoanQuantity) as a share of shares outstanding (SHROUT*1000) in July and May.	% shares	Markit (ShortLoanQuantity) and CRSP (SHROUT)	0.19	0.05	1.94	-5.66	6.54
Δ Borrowing fee	Difference between the average daily borrowing fee (IndicativeFee) in July and May.	%	Markit (IndicativeFee)	0.02	0.00	0.91	-1.41	1.84
Stock return	Stock return in June, adjusted for delisting, not annualized.	%	CRSP	-0.83	-0.59	9.44	-26.75	24.78
Lending inventory in May	Average daily active inventory (ActiveLendableQuantity) in May	% shares	Markit (ActiveLendableQuantity)	27.97	28.44	8.88	5.52	48.54
Quantity on loan in May	Average daily short quantity on loan (ShortLoanQuantity) in May	% shares	Markit (ShortLoanQuantity)	5.62	3.49	6.14	0.06	27.82
Borrowing fee in May	Average daily borrowing fee (IndicativeFee) in May	%	Markit (IndicativeFee)	0.63	0.38	1.74	0.25	8.14
D(special)	1 if IndicativeFee in May >1%, 0 otherwise	Boolean		0.05	0.00	0.21	0.00	1.00
Markit score in May	Average Markit's Daily Cost of Borrow Score in May, where 1 is cheapest and 10 is most expensive	1-10		1.12	1.00	0.66	1.00	4.83
(Total) Market value	Proprietary log market value (ranking variable).	Million dollars	FTSE Russell	3,425.3	2,404.1	2,865.0	526.9	13,487.6
Float	Proprietary float factor (fraction of shares floated)	Fraction	FTSE Russell	0.11	0.00	0.19	0.00	0.78
β^{CRSP}	CAPM beta as of May, 5-year monthly rolling, computed using CRSP total market value-weighted index		CRSP	1.28	1.20	0.63	0.19	3.38
Bid-ask spread	1-year monthly rolling average bid-ask percentage spread	%	CRSP	0.13	0.10	0.13	0.02	0.53
Band	1 if stock is in the Russell band in May	Boolean		0.29	0.00	0.46	0.00	1.00
D(in Russell 2000)	1 if stock is in the Russell 2000 index in May	Boolean		0.51	1.00	0.50	0.00	1.00
M/B	Market-to-book ratio (EV/Assets - Total, or EV/AT)	Fraction	Compustat	2.05	1.57	1.57	0.85	8.39
Value ratio	Fraction of stock shares assigned to value indices	Fraction	FTSE Russell	0.50	0.49	0.45	0.00	1.00
Panel B: U.S. data (N-PORT sample)								
Change in fee	The fee after the reconstitution of year t minus the fee before the reconstitution, as of fund report dates.	%	Markit (IndicativeFee)	0.11	0.00	2.22	-1.19	0.96
Change in fee (aggregated)	The fee after the reconstitution of year t minus the fee before the reconstitution, as of fund report dates, average across all funds.	%	Markit (IndicativeFee)	0.10	0.00	1.82	-3.20	1.04
LentShare	Share of fund holding on loan, or loanVal/ValUSD, after the Russell reconstitution (not conditional on lending).	%	SEC	7.52	0.00	23.93	0.00	100.00
LentShare (aggregated)	Share of fund holding on loan, or loanVal/ValUSD, averaged across funds after the Russell reconstitution (not conditional on lending).	%	SEC	6.69	2.46	10.57	0.00	57.69
D(special)	1 if IndicativeFee in the three months before the reconstitution >1%, 0 otherwise, as of fund report dates.	Boolean		0.03	0.00	0.17	0.00	1.00
Change in quantity on loan	The shorting demand after the reconstitution of year t minus the fee before the reconstitution, as of fund report dates.	% shares	Markit (ShortLoanQuantity)	-0.56	-0.36	4.30	-18.71	10.17
Change in quantity on loan (aggregated)	The shorting demand after the reconstitution of year t minus the fee before the reconstitution, as of fund report dates, average across all funds.	% shares	Markit (ShortLoanQuantity)	-0.65	-0.56	3.95	-9.38	9.40

A.4 Details on “Active” Inventory and Utilisation in Markit data

Throughout the paper, I use Markit’s “active” lendable quantity as a measure of lending inventory. All results are qualitatively the same if I use the total lendable quantity instead, yet the active field should better reflect the level of inventory available to market participants. Below are the details from Markit’s data FAQ.

Figure A3: Markit’s calculation of active fields

What are the “Active” Fields?

Active fields look at the depth of the stock borrow market with more sophistication - drawing on uniquely granular inventory files that are received each day from all major global custodians and large institutional asset managers.

Securities Finance collects inventory from the securities lending market however, there is sometimes a difference between the total amount that could be borrowed from this pool and the actual amount on offer (i.e. where securities are held in too small parcels or have been restricted by the beneficial owner – see below for the full methodology). It is important to understand what is “actively” available in the market. Securities Finance have developed a methodology for calculating this active availability using its unique market knowledge and understanding of market conventions.

What is the methodology used to calculate active inventory?

1. If a stock has a Markit Securities Finance proprietary benchmark fee of less than 100bp then all inventory will be considered active.
2. If a given fund has inventory in a stock but has no current trades, then all inventory of that stock in that fund will be considered inactive.
3. If a given fund has trades in a stock but none of them started within the last 30 calendar days, then only the quantity/value that is currently out on loan will be considered active.
4. If the fund has trades in a stock and some of them start within the last 30 days, and there is less than £500,000 inventory that is NOT currently out on loan, only the quantity/value that is currently out on loan will be considered active.
5. If the fund has trades in a stock, and some of them start within the last 30 days, and there is more than £500,000 inventory that is NOT currently out on loan, then all lendable will be considered active.

Excerpt from S&P’s (Markit’s) Global Securities Finance Equities Buyside Analytics Data Feed FAQ (2022).

A.5 Russell Reconstitution

Russell indexes undergo a reconstitution at the end of June each year. The reconstitution is a two-step process: assigning a stock to an index and determining the weight of the stock in that index. The first step is solely based on the ranking of all eligible securities by their total market capitalization on the rank day in May. For most of the years in my sample, the rank day falls on the last trading day in May and the reconstitution day falls on the last Friday of June.²⁹ Russell uses its broadest Russell 3000E index as the universe of eligible securities together with newly admitted stocks. The details on the methodology are provided in the official and publicly available guide.³⁰ Ranks are computed based on the proprietary measure of the total market capitalization of eligible securities. In the second step of the reconstitution, each stock in the index is assigned a weight based on its float-adjusted market capitalization in June. To define the adjustment, Russell uses proprietary float factors, which I infer from total and float-adjusted market capitalization.

FTSE Russell has shared with me their proprietary market capitalization measure, Russell 3000E constituent lists as well as the preliminary constituent lists from June. These proprietary

²⁹Exceptions are the rank days 05/27/2016, 05/12/2017, and 05/11/2018 and the reconstitution days 06/22/2007 and 06/23/17.

³⁰See <https://research.ftserussell.com/products/downloads/Russell-US-indexes.pdf>.

data allow me to replicate the index assignment rule very closely.³¹ Finally, by restricting my analysis to stocks that are next to the Russell cutoff in May rather than in June, I avoid selection in sample construction, which is discussed in detail in [Wei and Young \(2021\)](#).

Because of the availability of securities lending data, I include Russell reconstitutions starting from 2007, when FTSE Russell introduced a “banding” policy. According to this policy, a stock is assigned to the Russell 2000 index, if and only if:

- it was in the Russell 2000 in the previous year and its total market value rank in May falls between the left cutoff ($1000 - c_1$) and 3000,
- it was in the Russell 1000 and its total market value rank in May falls between the right cutoff ($1000 + c_2$) and 3000.

The band, that is, the range of ranks between $(1000 - c_1)$ and $(1000 + c_2)$, is based on a mechanical rule, but it changes each year with the distribution of firm sizes around the cutoff. Specifically, it is a 5% band around the cumulated market cap of the stock ranked 1000 in the Russell 3000E universe on the rank date. Because the assignment is based on ranks, firms cannot manipulate it. This suggests that within a window around the left and the right cutoff in each year, whether a stock ranks above or below the cutoff – and therefore switches indexes or stays – is as good as randomly assigned.

A.6 What drives variation in BMI?

Figure [A4](#) plots the average values of BMIs around the Russell cutoffs immediately after the reconstitution. The figure reveals the sizeable discontinuity at both left and right cutoffs. There is a 5%–8% gap in BMIs for stocks within the Russell band. See Section [A.5](#) for the details on the band and how cutoffs are defined.

Changes in a stock’s BMI are driven by the stock’s membership in benchmark indexes, assets benchmarked to these indexes, and index total market values. To see that, use a definition

³¹Around 40 bps of observations are incorrectly assigned even when using the proprietary data (including 10 special stocks). The presence of measurement error in the running variable may pose a challenge to treatment effect identification, which is discussed in the context of the Russell reconstitution by [Wei and Young \(2021\)](#), [Appel, Gormley, and Keim \(2021\)](#), and [Heath, Macciocchi, Michaely, and Ringgenberg \(2021\)](#). Therefore, to alleviate the concern that my findings are affected by this error, I implement a “doughnut trimming” design suggested by the literature. In particular, [Dong and Kolesár \(2023\)](#) point out that when misclassification happens right next to the cutoff (which is the case in my data), this approach yields an estimate with a causal interpretation. When trimming 10–30 observations right next to the cutoff, I observe virtually identical estimates. Finally, my results are unchanged if I use ranks based on public data, constructed following [Ben-David, Franzoni, and Moussawi \(2019\)](#).

of a stock weight in any value-weighted index j ,

$$\omega_{ijt} = \frac{MV_{it}\mathbf{1}_{ijt}}{\sum_{k=1}^N MV_{kt}\mathbf{1}_{kjt}} = \frac{MV_{it}\mathbf{1}_{ijt}}{\text{IndexMV}_{jt}}, \quad (18)$$

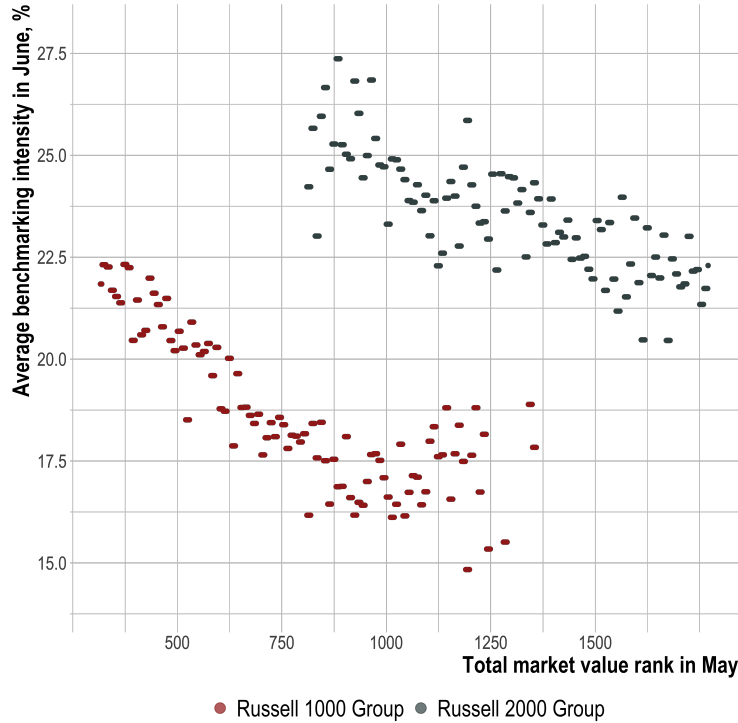
where the index membership dummy $\mathbf{1}_{ijt}$ is equal to one if stock i belongs to index j at time t and IndexMV_{jt} is the total market cap of all stocks in index j at time t , and rewrite BMI defined in (13) as

$$BMI_{it} = \sum_{j=1}^J \frac{\lambda_{jt}\mathbf{1}_{ijt}}{\sum_{k=1}^N MV_{kt}\mathbf{1}_{kjt}} = \sum_{j=1}^J \frac{\lambda_{jt}\mathbf{1}_{ijt}}{\text{IndexMV}_{jt}}. \quad (19)$$

There are two potential caveats. First, some index providers use the float-adjusted market cap rather than the total market cap. That is, strictly speaking, (19) should be

$$BMI_{it} = \sum_{j=1}^J \frac{\lambda_{jt}FF_{ijt}\mathbf{1}_{ijt}}{\sum_{k=1}^N MV_{kt}FF_{kjt}\mathbf{1}_{kjt}},$$

Figure A4: BMI after the Russell reconstitution



This figure plots the average BMI of stocks to the left and to the right of the Russell cutoff in the reconstitutions of 2007–2018. Russell 1000 group includes funds benchmarked to the Russell 1000 and Russell Midcap indexes (blend, value, or growth). Russell 2000 group includes funds benchmarked to the Russell 2000 indexes (blend, value, or growth).

where FF_{ijt} denotes the float factor of stock i in index j at time t (the float factors are often index-specific and therefore proprietary). Because the float factor reflects stock liquidity, it could be a potential source of endogeneity. Russell primarily uses companies' SEC filings to compute their free float. In my regression analysis, I use the free float factors, implied by the data provided by Russell, as one of the control variables and supplement it with bid-ask spread to account for any stale information in the float factor. The second caveat concerns value and growth indexes. They typically include only a fraction of the market value of the stock that they deem related to value or growth style (this classification is based on index providers' proprietary classification algorithms). In my sample, this split of shares between Russell value and growth indexes does not strongly affect changes in BMI around the Russell cutoff. Furthermore, additions to the Russell 2000 have similar pre-reconstitution proprietary value ratios and Compustat-based market-to-book ratios, and my results are robust to controlling for them.

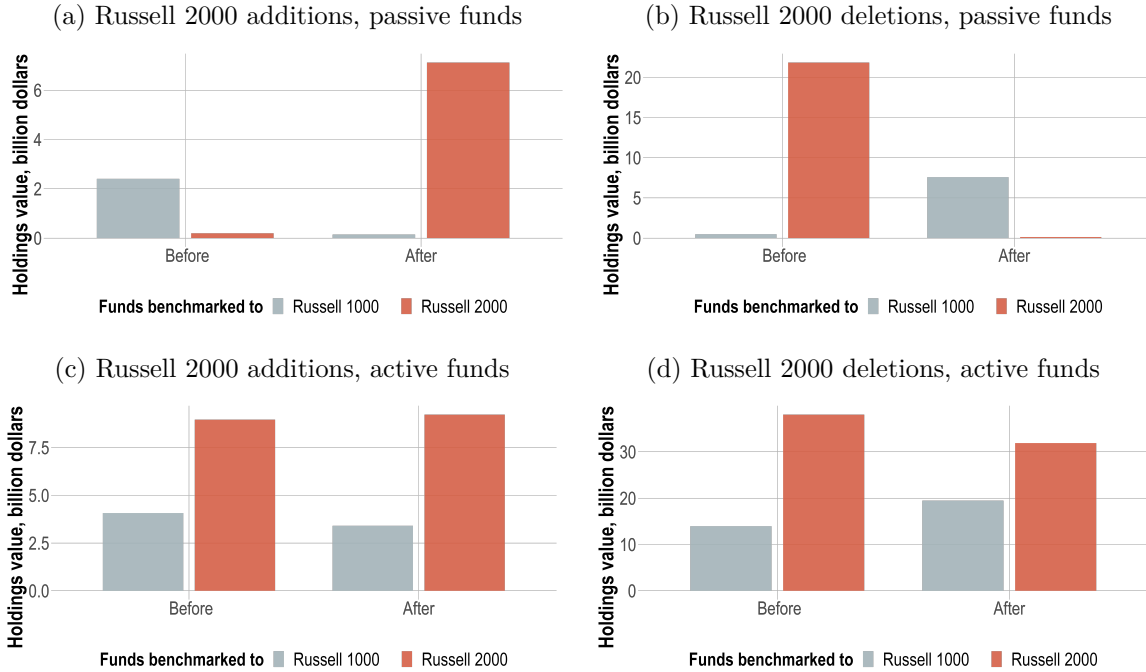
A.7 Case studies on funds' lending around the Russell reconstitutions

In this section, I illustrate changes in the lending supply of stocks whose index membership changed in the Russell reconstitutions of 2020–2022. My sample is limited to these years because the loan value data by fund comes from N-PORT filings, available from the last quarter of 2019. I identify additions and deletions with the official FTSE Russell index composition files and arrive at a sample of 212 stocks, for 211 of which I have data in N-PORT.

First, I confirm that the aggregate holdings of funds follow changes in their benchmarks. For example, Figure A5 (a) illustrates that stocks added to the Russell 2000 experience an increase in holdings by passive funds benchmarked to the index. Similarly, panel (c) shows that the aggregate holdings of active funds benchmarked to the Russell 2000 also increase. As funds lend what they own, Figure 2 in the main text confirms that aggregate lending is a mirror image of aggregate ownership.

These aggregate changes in ownership and lending are also detectable at a stock level. Table A3 reports changes in the ownership of funds with different benchmarks and changes in their contribution to the total amount on loan for additions and deletions to the Russell 2000 index. In general, additions see an increase in the ownership of domestic equity funds of around 1% and a similar-sized increase in their lending share. Deletions see a decrease in domestic equity fund ownership of 6% and a decrease of 5% in their lending share. The table shows that these changes are driven not only by passive funds. Active funds also change their holding and lending mostly

Figure A5: Aggregate fund holdings of the Russell 2000 index additions and deletions



This figure plots the aggregate fund holdings of the Russell 2000 additions and deletions before (March–May) and after (July–September) the reconstitutions of 2020–2022, according to their N-PORT filings. Only funds with an identified benchmarks and types are included. Russell 1000 group includes Russell Midcap funds.

in line with their benchmarks. For example, for an average stock deleted from the Russell 2000 index, passive funds benchmarked to Russell 2000 decrease their share in lending by 3.2%, and active funds benchmarked to Russell 2000 decrease their share in lending by 1.7%.

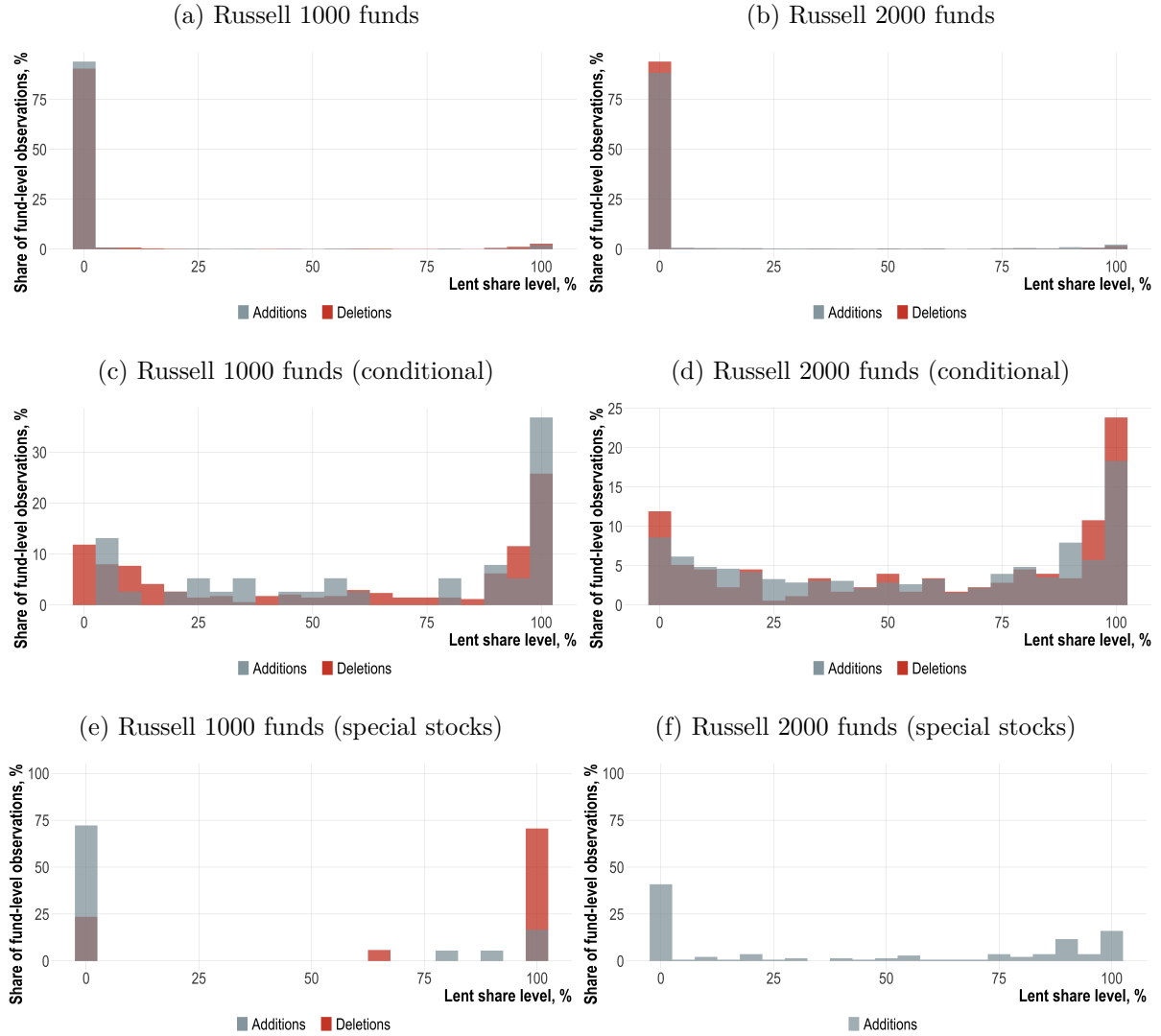
Second, I study the lending behavior of funds benchmarked to the indexes around the Russell cutoff immediately after the reconstitution. In particular, I examine what fraction of additions' and deletions' position value is on loan (lent share). As Figure A6 illustrates, the majority of stocks that moved indexes in the Russell reconstitutions are not on loan (panels (a) and (b)). However, conditional on lending, most of them have lent shares close to 100% (panels (c) and (d)). Panels (e) and (f) show the same patterns within special stocks. Many of them are not on loan, and conditional on lending, lent shares are close to 100%. However, it is puzzling why funds do not lend out many special stocks, albeit the model predicts that they should.

Table A3: Stock-level fund holding and lending of the Russell 2000 index additions and deletions

Group of funds														
Total N-PORT	Additions to Russell 2000						Total N-PORT	Deletions from Russell 2000						
	Russell 1000		Russell Midcap		Russell 2000			Russell 1000		Russell Midcap		Russell 2000		
	Active	Passive	Active	Passive	Active	Passive		Active	Passive	Active	Passive	Active	Passive	
Panel A: Fund ownership relative to stock market value, %														
Mean	1.04	-1.20	-1.35	-0.10	-1.15	0.10	4.47	-6.09	0.20	1.14	-0.16	1.39	-0.95	-6.01
t-stat	(7.24)	(-11.4)	(-66.6)	(-9.78)	(-56.24)	(5.8)	(73.54)	(-44.43)	(19.07)	(30.57)	(-6.69)	(52.61)	(-24.89)	(-83.03)
Panel B: Fund lending relative to the total value on loan, %														
Mean	1.09	-0.16	-0.33	-0.12	-0.37	-0.23	2.27	-4.94	0.02	0.43	0.27	0.52	-1.69	-3.16
t-stat	(18.21)	(-32.54)	(-178.09)	(-14.26)	(-176.16)	(-15.68)	(194.99)	(-77.06)	(1.58)	(268.4)	(26.39)	(266.59)	(-73.29)	(-313.65)

This table compares the average ownership (panel A) and lending share (panel B) of each group of funds from before the Russell reconstitution (March–May) to after (July–September) in 2020–2022. The sample includes 126 additions to the Russell 2000 and 85 deletions from it. “Total N-PORT” column includes only domestic equity funds.

Figure A6: Lent share frequency for the Russell 2000 additions and deletions



This figure plots the frequency shares of the fund-level lent share for the Russell 2000 additions and deletions. Panels (a) and (b) include data on all stocks, panels (c) and (d) plot shares conditional on lending (within observations with lent share above 0), and panels (e) and (f) plot shares for special stocks only (average fee of above 1% before the reconstitution). Panels (a), (c), and (e) include data of funds benchmarked to the Russell 1000 or Russell Midcap indexes (blend, value, or growth) and panels (b), (d), and (f) include data of funds benchmarked to the Russell 2000 indexes (blend, value, or growth). The data are as of the report date within three months after the respective reconstitution month (that is, the first available quarterly filing per fund). I include only domestic equity funds with a defined active or passive type. Binwidth is 5%. Observations with lent share above 100% are set to 100%.

A.8 Funds' lending across the largest Russell indexes

In this section, I report the average values of funds' lending of stocks inside and outside their benchmark indexes in 2020–2022. My sample is limited to these years because the loan value data by fund comes from N-PORT filings, available from the last quarter of 2019. I also only have the official FTSE Russell index composition files for this period of time and hence only consider the key Russell benchmark indexes.

Table A4: Share of value on loan coming from within-benchmark lending and not

Benchmark index	Mean value on loan, billion US dollars	% within-benchmark	% not within-benchmark
Russell 1000	1,665.3	98.6	1.4
Russell 1000 Growth	2,467.2	92.3	7.7
Russell 1000 Value	1,366.3	75.3	24.7
Russell 2000	746.7	83.7	16.3
Russell 2000 Growth	351.5	65.9	34.1
Russell 2000 Value	219.5	67.5	32.5
Russell Midcap	522	81.1	18.9
Russell Midcap Growth	553.5	64.8	35.2
Russell Midcap Value	275.1	81.8	18.2

This table reports the average monthly loan values of stocks in major Russell benchmark indexes in 2020–2022 as well as the share of that value that comes from funds benchmarked to a given index and not. Loan values are from N-PORT filings of funds with any of the nine indexes identified as a benchmark.

A.9 U.S. regressions with index membership dummy

Table A5: Response of spot and lending variables to the Russell index membership

	Δ Lending inventory, % shares (1)	Δ Quantity on loan, % shares (2)	Δ Borrowing fee, % (3)	Stock return, % (4)
Panel A: No interactions				
D(in Russell 2000)	2.101*** (11.17)	2.029*** (8.84)	0.285 (1.48)	1.354 (1.48)
Observations	9,659	9,659	9,659	9,659
Adjusted R-squared	0.175	0.129	0.163	0.240
Panel B: With specialness interactions				
D(in Russell 2000) $\times$ D(not special)	2.154*** (11.40)	2.045*** (8.81)	0.178 (0.97)	1.178 (1.30)
D(in Russell 2000) $\times$ D(special)	1.501*** (5.70)	1.855*** (5.16)	1.486*** (2.88)	3.341** (1.99)
Observations	9,659	9,659	9,659	9,659
Adjusted R-squared	0.176	0.129	0.178	0.241
$\beta_1 - \beta_2$	-0.653*** (-3.89)	-0.189 (-0.61)	1.308*** (2.87)	2.163 (1.45)

This table reports the estimates of specification (14) (panel A) and specification (15) (panel B) in the panel of stocks within 300 ranks around the Russell cutoff in 2007–2018. I use Russell 2000 index membership dummy instead of ΔBMI as the main independent variable (similar to Appel, Gormley, and Keim (2019)). The last row reports the t -test for estimation results in panel B. Changes in lending market variables are computed as differences between July and May; stock return is measured in June. A stock is considered special, or $D(special) = 1$, if its fee in May is above 1%. All regressions include controls, stock and D(special) by year fixed effects. t -statistics based on wild bootstrap with clustering by stock and year are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

A.10 Alternative specifications for U.S. regressions

A.10.1 Alternative definitions of specialness

Table A6: Response of lending variables to changes in BMI

	Δ Lending inventory, % shares (1)	Δ Quantity on loan, % shares (2)	Δ Borrowing fee, % (3)	Stock return, % (4)
Panel A: Top tercile				
ΔBMI , % $\times$ D(not special)	0.185*** (11.24)	0.129*** (6.21)	-0.006* (-1.79)	0.097** (2.34)
ΔBMI , % $\times$ D(special)	0.138*** (3.95)	0.166*** (6.67)	0.079** (2.73)	0.204 (1.59)
Observations	13,685	13,685	13,685	13,685
Adjusted R-squared	0.143	0.088	0.042	0.203
Panel B: Top quintile				
ΔBMI , % $\times$ D(not special)	0.176*** (10.29)	0.128*** (6.64)	-0.004 (-1.40)	0.115** (2.65)
ΔBMI , % $\times$ D(special)	0.168*** (3.89)	0.195*** (5.58)	0.134** (2.56)	0.175 (0.97)
Observations	13,685	13,685	13,685	13,685
Adjusted R-squared	0.143	0.088	0.069	0.201
Panel C: Top decile				
ΔBMI , % $\times$ D(not special)	0.176*** (10.33)	0.132*** (6.96)	-0.001 (-0.36)	0.117** (2.46)
ΔBMI , % $\times$ D(special)	0.159*** (3.52)	0.211*** (4.07)	0.288*** (3.13)	0.240 (0.92)
Observations	13,685	13,685	13,685	13,685
Adjusted R-squared	0.144	0.087	0.138	0.200
Panel D: Markit score above 1				
ΔBMI , % $\times$ D(not special)	0.178*** (10.53)	0.127*** (6.63)	-0.004 (-1.34)	0.107** (2.34)
ΔBMI , % $\times$ D(special)	0.147** (2.77)	0.212*** (6.10)	0.159*** (3.04)	0.247 (1.56)
Observations	13,685	13,685	13,685	13,685
Adjusted R-squared	0.144	0.090	0.088	0.202

This table reports the estimates of specification (15) in the panel of stocks within 500 ranks around the Russell cutoff in 2007–2018. Changes in lending market variables are computed as differences between July and May; stock return is measured in June. A stock is considered special, or $D(\text{special}) = 1$, if its fee in May is in the top tercile (panel A), top quintile (panel B), or top decile (panel C) of fee distribution in that year (across all Russell 3000 constituents). In panel D, I use Markit’s proprietary Daily Cost of Borrow Score, averaged over May, to classify stocks as special. All regressions include controls and D(special) by year fixed effects. t -statistics based on wild bootstrap with clustering by stock and year are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

A.10.2 Alternative controls

Table A7: Response of lending variables to changes in BMI

	Δ Lending inventory, % shares (1)	Δ Quantity on loan, % shares (2)	Δ Borrowing fee, % (3)	Stock return, % (4)
Panel A: Removing liquidity controls				
ΔBMI , % $\times$ D(not special)	0.179*** (10.58)	0.129*** (6.91)	-0.003 (-1.13)	0.080* (1.78)
ΔBMI , % $\times$ D(special)	0.126** (2.63)	0.213*** (5.65)	0.207*** (3.02)	0.275* (1.79)
Observations	13,685	13,685	13,685	13,685
Adjusted R-squared	0.144	0.088	0.105	0.194
Panel B: Adding interactions of controls with stock specialness				
ΔBMI , % $\times$ D(not special)	0.177*** (10.71)	0.133*** (7.07)	-0.000 (-0.33)	0.102** (2.12)
ΔBMI , % $\times$ D(special)	0.135*** (2.69)	0.172*** (3.86)	0.184** (1.96)	0.369* (1.90)
Observations	13,685	13,685	13,685	13,685
Adjusted R-squared	0.145	0.091	0.120	0.203

This table reports the estimates of changes in specification (15) in the panel of stocks within 500 ranks around the Russell cutoff in 2007–2018. Specification in panel A removes β^{CAPM} and the bid-ask spread. Panel B includes baseline controls and their interactions with D(special). Both panels include D(special) by year fixed effects. Changes in lending market variables are computed as differences between July and May; stock return is measured in June. A stock is considered special, or $D(special) = 1$, if its average fee in May is above 1%. t -statistics based on wild bootstrap with clustering by stock and year are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

A.10.3 Alternative band widths

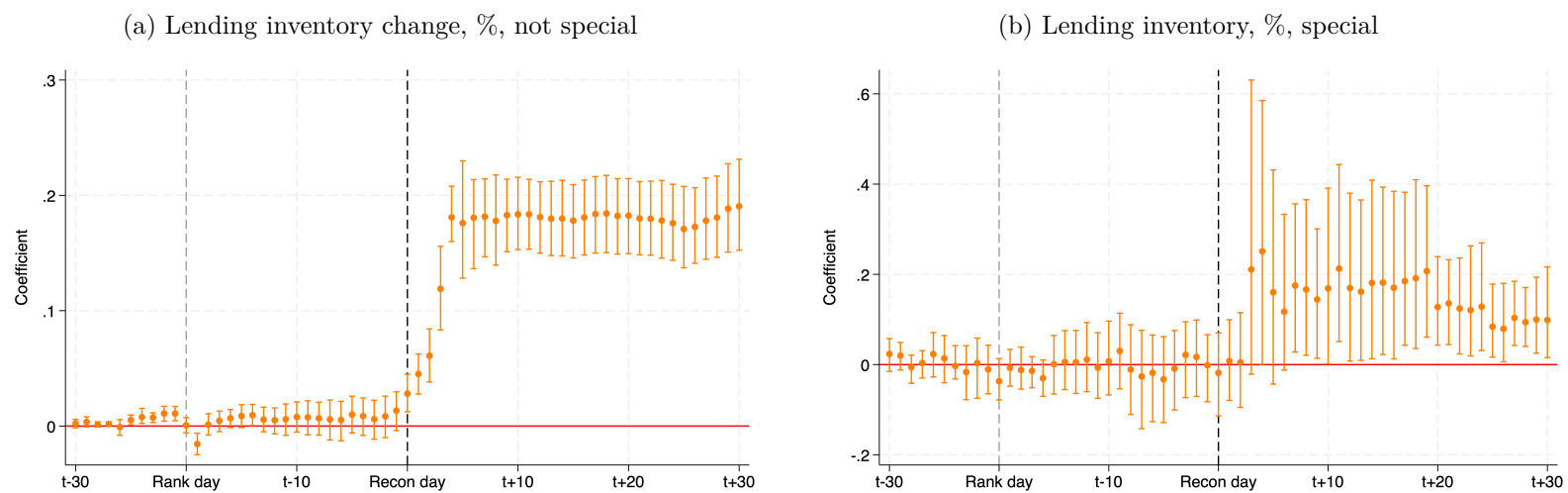
Table A8: Response of lending variables to changes in BMI

	Δ Lending inventory, % shares (1)	Δ Quantity on loan, % shares (2)	Δ Borrowing fee, % (3)	Stock return, % (4)
Panel A: Band width of 200				
ΔBMI , % $\times$ D(not special)	0.202*** (11.86)	0.136*** (6.16)	-0.005 (-1.20)	0.217*** (3.37)
ΔBMI , % $\times$ D(special)	0.167*** (3.15)	0.240*** (3.98)	0.204** (2.17)	0.180 (1.03)
Observations	7,766	7,766	7,766	7,766
Adjusted R-squared	0.174	0.111	0.097	0.209
Panel B: Band width of 300				
ΔBMI , % $\times$ D(not special)	0.191*** (11.37)	0.128*** (6.53)	-0.008 (-1.57)	0.141** (2.65)
ΔBMI , % $\times$ D(special)	0.132*** (3.05)	0.223*** (4.74)	0.223** (2.60)	0.479** (2.50)
Observations	9,853	9,853	9,853	9,853
Adjusted R-squared	0.161	0.104	0.102	0.209
Panel C: Band width of 750				
ΔBMI , % $\times$ D(not special)	0.177*** (11.24)	0.126*** (7.26)	-0.001 (-0.68)	0.068* (1.78)
ΔBMI , % $\times$ D(special)	0.150*** (3.29)	0.215*** (6.33)	0.157*** (2.96)	0.216 (1.49)
Observations	18,781	18,781	18,781	18,781
Adjusted R-squared	0.137	0.077	0.085	0.194

This table reports the estimates of specification (15) in the panel of stocks within 200 (panel A), 300 (panel B), or 750 (panel C) ranks around the Russell cutoff in 2007–2018. Changes in lending market variables are computed as differences between July and May; stock return is measured in June. A stock is considered special, or $D(special) = 1$, if its fee in May is above 1%. All regressions include controls and D(special) by year fixed effects. t -statistics based on wild bootstrap with clustering by stock and year are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

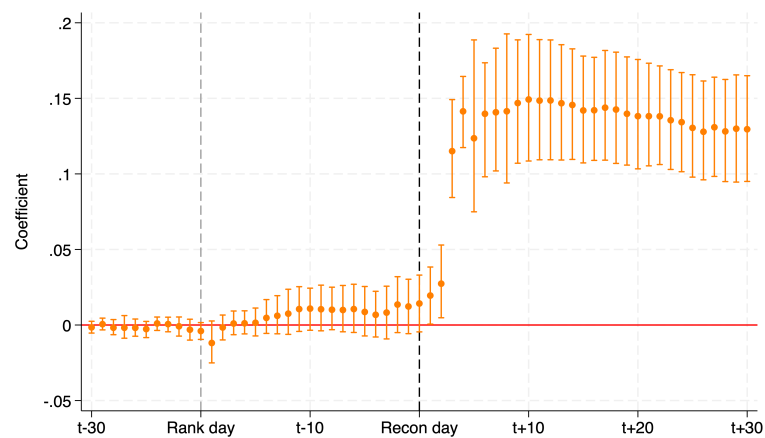
A.11 Daily changes in lending market variables

Figure A7: Daily estimates of changes in lending market variables on ΔBMI

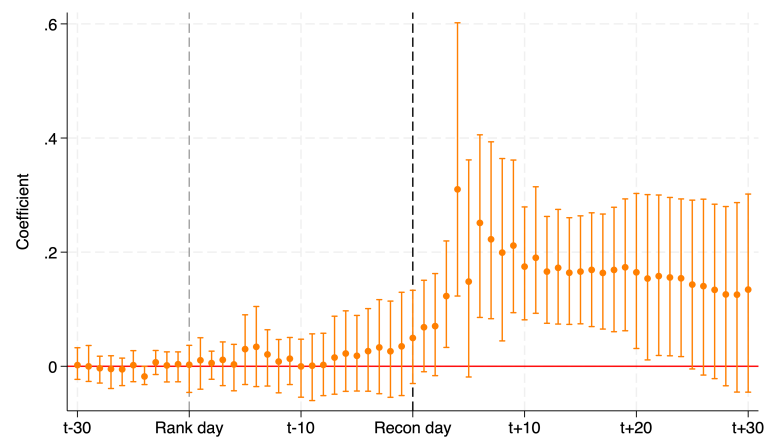


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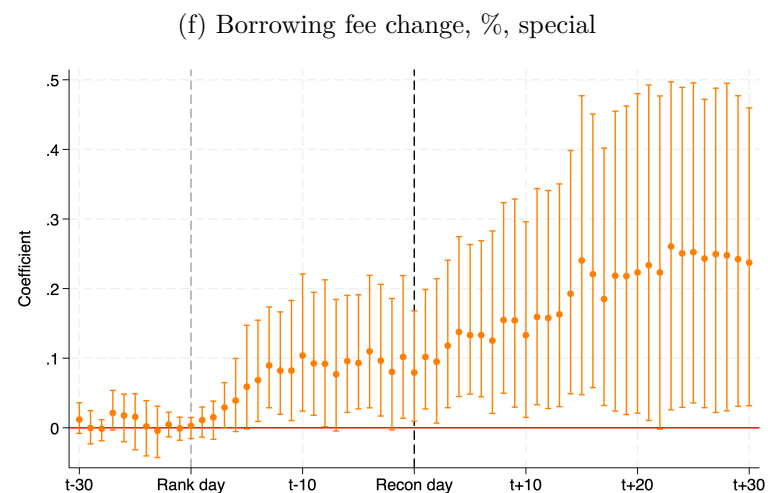
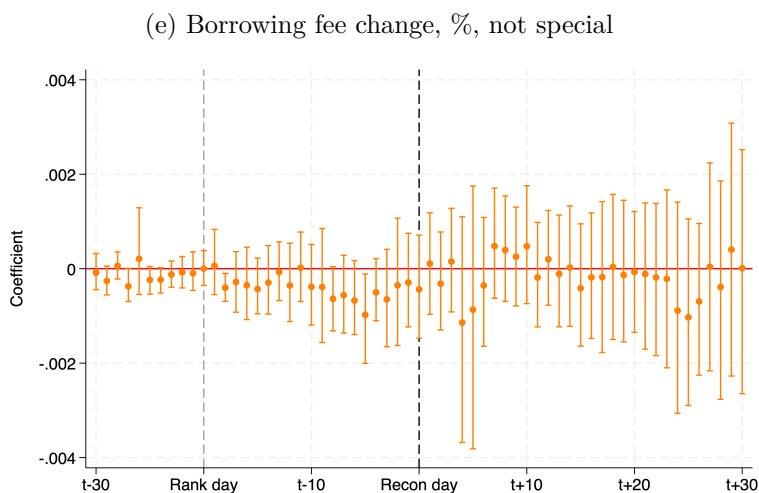
(c) Quantity on loan change, %, not special



(d) Quantity on loan change, %, special



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This figure plots the daily estimates of the loading on ΔBMI and the corresponding wild bootstrap 90% confidence intervals from regression (14), estimated separately for special (panels (b), (d), (f)) and not special stocks (panels (a), (c), (e)). The estimation window covers all trading days from mid-May to mid-August each year. Changes in variables are computed relative to the value at the end of May each year. The reconstitution day (recon day) is the actual historical reconstitution date, and the rank day is assumed to be on the last trading day in May.

A.12 Baseline results in the sample of stocks not switching indexes

Table A9: Response of spot and lending variables to changes in BMI in a sample of stocks that did not move indexes

	Δ Lending inventory, % shares (1)	Δ Quantity on loan, % shares (2)	Δ Borrowing fee, % (3)	Stock return, % (4)
$\Delta BMI, \% \times D(\text{not special})$	0.135*** (6.85)	0.076*** (4.55)	-0.005*** (-3.75)	0.217*** (2.94)
$\Delta BMI, \% \times D(\text{special})$	0.112* (1.81)	0.158** (2.12)	0.178** (2.34)	0.429* (1.74)
Observations	13,098	13,098	13,098	13,098
Adjusted R-squared	0.104	0.053	0.091	0.208
$\beta_1 - \beta_2$	-0.022 (-0.39)	0.082 (1.14)	0.183** (2.38)	0.212 (0.77)

This table reports the estimates of specification (15) in the panel of stocks within 500 ranks around the Russell cutoff in 2007-2018 excluding stocks that moved across the cutoff in a given year. Changes in lending market variables are computed as differences between May of year t and May of year $t + 1$ and otherwise consistent with the main text. A stock is considered special, or $D(\text{special}) = 1$, if its fee in May is above 1%. All regressions include controls and $D(\text{special})$ by year fixed effects. t -statistics based on wild bootstrap with clustering by stock and year are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

A.13 More evidence on the shift in supply

If supply in the lending market moves in response to changes in borrowing fees, the findings in the main text may represent a movement along the supply curve rather than a shift in the supply curve. In this section, I show that it is not the case for Russell reconstitutions. First, I argue that under the assumption of downward-sloping shorting demand and upward-sloping supply, my estimates imply that BMI shifts demand more than it shifts supply. Then, I use an instrumental variable for shorting demand suggested by the literature to identify the lending supply and lending inventory curve parameters. Overall, results in this section confirm that BMI leads to a shift in both lending supply and shorting demand.

A.13.1 Identification without an instrument for demand (as in the main text)

The model in Section 3 can be written as the following system of structural equations for the lending market:

$$Q^{supply} = b_0 + b_1\Delta + b_2w + v, \quad (20)$$

$$Q^{demand} = a_0 + a_1\Delta + a_2w + u, \quad (21)$$

where w denotes BMI.

By equating them the supply and demand equations, I get a reduced-form equation for the borrowing fee Δ . Then I plug it into the supply equation to get a reduced-form representation for the quantity on loan Q .

$$\begin{aligned} \Delta &= \frac{b_2 - a_2}{a_1 - b_1}w + \frac{b_0 - a_0}{a_1 - b_1} + \frac{v - u}{a_1 - b_1} \\ &= \pi_{\Delta,w}w + \pi_{\Delta,0} + \epsilon, \end{aligned} \quad (22)$$

$$\begin{aligned} Q &= \frac{a_1b_2 - a_2b_1}{a_1 - b_1}w + \frac{b_0a_1 - a_0b_1}{a_1 - b_1} + \frac{a_1v - b_1u}{a_1 - b_1} \\ &= \pi_{Q,w}w + \pi_{Q,0} + \nu. \end{aligned} \quad (23)$$

Because these reduced-form equations provide 4 estimates, the system of structural equations above is not identified (it has 6 parameters).

In the main text, I estimate (22) and (23) in changes, which only influences interpretation of the constant terms. Therefore, I keep all equations in levels here for a better exposition. The corresponding reduced-form estimates are

$$\pi_{\Delta,w} > 0,$$

$$\pi_{Q,w} > 0.$$

They imply that either $b_2 > a_2$ and $a_1 > b_1$ or $b_2 < a_2$ and $a_1 < b_1$. Under the theoretical sign restrictions of $a_1 < 0$ and $b_1 > 0$ (downward-sloping shorting demand and upward-sloping lending supply), $a_1 - b_1 < 0$, so empirical estimates imply that $b_2 < a_2$ (pass-through from BMI to demand is stronger).

In sum, even though the structural parameters are not strictly identified, the reduced-form estimates together with theoretical sign restrictions suggest that an increase in BMI shifts shorting demand more than it shifts lending supply.

A.13.2 Identification with a demand shift

In order to identify the shift in lending supply around Russell reconstitutions and to support my assumptions for lending inventory, I rely on an exogenous demand shifter. Specifically, I follow [Kolasinski, Reed, and Ringgenberg \(2013\)](#), who use discretionary accruals, among other variables, as an instrument for shorting demand. Due to the slow-moving nature of lending inventory, it is unlikely that short-term shorting signals such as high discretionary accruals affect lending supply, although they strongly predict shorting demand.

First, I estimate the following 2SLS regression for special stocks:

$$\begin{aligned} \text{Change in } fee_{it} &= \gamma \text{Accruals}_{it} + \kappa \Delta BMI_{it} + \delta' \bar{X}_{it} + \mu_{st} + \varepsilon_{it}, \\ \Delta Y_{it} &= \alpha \widehat{\text{Change in } fee_{it}} + \beta \Delta BMI_{it} + \zeta' \bar{X}_{it} + \nu_{st} + \epsilon_{it}. \end{aligned}$$

Accruals_{it} are computed for stock i in May of year t , in line with [Sloan \(1996\)](#). I use both the change in inventory (active lendable shares) and the shorting quantity variable (short quantity on loan) as the dependent variable ΔY_{it} . The rest of the specification is the same as in the baseline test, described near equation (14).

Results are reported in Table [A10](#). Columns (1) and (4) report the estimates of the coefficient on change in BMI β without including *Change in fee* to show that the estimates are virtually the same as in the main text (because the specification here is estimated in the subsample of special stocks as opposed to using interactions). Columns (2) and (5) include *Change in fee* and report OLS estimates. The OLS estimate for the quantity on loan is significant and positive, consistent with the prevailing demand shocks in my sample. The OLS estimate for inventory is insignificantly negative. Finally, columns (3) and (6) report 2SLS estimates with *Change in fee* around the Russell reconstitution instrumented by *Accruals*. The first-stage estimates in panel B highlight that *Accruals* is a strong instrument for the change in borrowing fee, with the effective F-statistic above 27. For quantity on loan, the second-stage estimate for the change in fee is positive but close to zero and insignificant. This implies a rather unresponsive supply at least at the two-month horizon of my tests.³² Importantly, the coefficients on ΔBMI are almost the same as the baseline estimates. Finally, inventory appears not sensitive to fees, consistent with the discussion in Section [5.2.6](#).

Next, I discuss what structural parameters these estimates identify. With a demand shifter,

³²I get $\hat{\alpha} \approx 0.3$ if I use one-year changes while the loading of inventory on fees remains close to zero.

Table A10: Sensitivity of coefficient on BMI to simultaneity in lending supply and shorting demand

	Change in quantity on loan, %			Change in inventory, %		
	Baseline (1)	OLS (2)	2SLS (3)	Baseline (4)	OLS (5)	2SLS (6)
Panel A: Second-stage estimates						
<i>Change in fee, %</i>		0.12** (3.26)	0.04 (0.34)		-0.05 (-1.48)	-0.01 (-0.08)
ΔBMI , %	0.17*** (3.51)	0.15*** (3.07)	0.16*** (2.94)	0.13*** (3.00)	0.14*** (3.16)	0.13*** (2.69)
Panel B: First-stage estimates						
<i>Accruals</i>			1.75*** (5.21)			1.75*** (5.21)
F-Stat (excl. instruments)			27.10			27.10
Observations	613	613	613	613	613	613

This table reports the estimates of specification described in Section A.13 in the panel of special stocks within 500 ranks around the Russell cutoff in 2007–2018. Panel A reports the second-stage and OLS estimates, whereas panel B reports the first-stage estimates. Changes in lending market variables are computed as differences between July and May. A stock is considered special, or $D(special) = 1$, if its fee in May is above 1%. All regressions include controls and year fixed effects. t -statistics based on standard errors clustered by stock are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

structural equations for the lending market are as follows,

$$\begin{aligned}
Q^{supply} &= b_0 + b_1 \Delta + b_2 w + v, \\
Q^{demand} &= a_0 + a_1 \Delta + a_2 w + a_3 A + u, \\
Inv &= c_0 + c_1 \Delta + c_2 w + e,
\end{aligned}$$

where A is accruals. The corresponding reduced-form equations are

$$\begin{aligned}
\Delta &= \frac{b_2 - a_2}{a_1 - b_1} w - \frac{a_3}{a_1 - b_1} A + \frac{b_0 - a_0}{a_1 - b_1} + \frac{v - u}{a_1 - b_1} \\
&= \pi_{\Delta, w} w + \pi_{\Delta, A} A + \pi_{\Delta, 0} + \epsilon,
\end{aligned} \tag{24}$$

$$\begin{aligned}
Q &= \frac{a_1 b_2 - a_2 b_1}{a_1 - b_1} w - \frac{b_1 a_3}{a_1 - b_1} A + \frac{b_0 a_1 - a_0 b_1}{a_1 - b_1} + \frac{a_1 v - b_1 u}{a_1 - b_1} \\
&= \pi_{Q, w} w + \pi_{Q, A} A + \pi_{Q, 0} + \nu,
\end{aligned} \tag{25}$$

$$\begin{aligned}
Inv &= \left(\frac{c_1 b_2 - c_1 a_2}{a_1 - b_1} + c_2 \right) w - \frac{c_1 a_3}{a_1 - b_1} A + \left(\frac{c_1 b_0 - c_1 a_0}{a_1 - b_1} + c_0 \right) + \left(\frac{c_1 v - c_1 u}{a_1 - b_1} + e \right) \\
&= \pi_{Inv, w} w + \pi_{Inv, A} A + \pi_{Inv, 0} + \xi,
\end{aligned} \tag{26}$$

These allow to me identify the supply and inventory equations. However, because I have 9 reduced-

form estimates and 10 structural parameters, the parameters of the demand equation are not identified.

I estimate (24) – (26) equation by equation on a sample of special stocks around the Russell cutoff and get the estimates below (robust t-statistics in parentheses):³³

$$\begin{aligned}\pi_{Q,w} &= 0.171(3.50), \\ \pi_{Q,A} &= 0.065(0.33), \\ \pi_{\Delta,w} &= 0.188(2.52), \\ \pi_{\Delta,A} &= 1.749(5.21), \\ \pi_{Inv,w} &= 0.131(3.00), \\ \pi_{Inv,A} &= -0.012(-0.08).\end{aligned}$$

Using these reduced-form estimates, I can recover the structural parameters of supply and inventory equations:

$$\begin{aligned}b_1 &= 0.037, & b_2 &= 0.164, \\ c_1 &= -0.007, & c_2 &= 0.133.\end{aligned}$$

Therefore, I find that the pass-through from BMI to both inventory and supply is positive ($b_2 > 0$ and $c_2 > 0$). The sensitivity of supply to fee is weakly positive, and it is virtually zero for inventory. Together with the sign restrictions from the previous section, these estimates imply that the pass-through from BMI to shorting demand is positive and above $b_2 = 0.164$.

A.14 Changes in specialness and BMI

In this section, I analyze changes in stock specialness around Russell reconstitutions. I document transition probabilities at one-month and one-year horizons and show how changes in specialness are related to changes in BMI.

Table A11 documents that the specialness of stocks in my sample is quite persistent. A total of 87% of stocks next to the Russell cutoff that are special in May (prior to the reconstitution) remain special in July (after the reconstitution). At a one-year horizon, 54% of stocks remain special. These probabilities are similar in the full sample of Russell 3000 constituents, at 89% and 66% in July and May of the following year, respectively.

³³I omit all constants because I estimate (24) – (26) in changes, so I cannot recover b_0 and c_0 .

Table A11: Short- and long-term transition probabilities in specialness

	D(not special in July)	D(special in July)	D(not special in May next year)	D(special in May next year)
Panel A: Stocks around the Russell cutoff				
D(not special in May)	99%	1%	97%	3%
D(special in May)	13%	87%	46%	54%
Panel B: Full sample				
D(not special in May)	97%	3%	95%	5%
D(special in May)	11%	89%	34%	66%

This table reports specialness transition probabilities in the panel of stocks within 500 ranks around the Russell cutoff (panel A) and for all Russell 3000 constituents (panel B) in 2007–2018. A stock is considered special, or $D(\text{special}) = 1$, if its fee in May is above 1%.

Table A12 reports the estimates of linear probability and logit models of future stock specialness using specialness in May, change in BMI, and their interaction as main predictors:

$$\begin{aligned}
D(\text{special})_{it+h} = & \alpha D(\text{special})_{it} + \beta \Delta BMI_{it} + \gamma \Delta BMI_{it} \times D(\text{special})_{it} \\
& + \zeta' \bar{X}_{it} + \nu_t + \epsilon_{it+h},
\end{aligned} \tag{27}$$

where $D(\text{special})_{it+h} = 1$ if stock i has an average borrowing fee of over 1% in either July of year t or in May of year $t + 1$, and all other variables are defined in Section 5.2.

Table A12 confirms that stock specialness is highly persistent even conditional on controls and year fixed effects. If a stock is special in May, it has a 85% higher chance of being special in July of the same year and 49% higher chance of being special in May of the next year. Furthermore, Table A12 shows that a change in BMI has limited predictive power for future specialness. Immediately after the reconstitution, a special stock is more likely to remain special if its BMI has increased; however, the economic magnitude is very small (at 60 bps larger probability for each 1 percentage point increase in BMI). At a one-year horizon, this estimate is 80 bps yet statistically insignificant. Both coefficients are not statistically significant if estimated with logit.

Since the specification above may lack power and may not capture dimensions of specialness beyond the average fee, I use alternative dependent variables and specifications to examine whether exogenous increases in BMI reduce the likelihood or severity of future special episodes within the sample of not special stocks. I first construct an indicator equal to one if a stock that is not on special at the time of reconstitution enters special status at any point during the year until the next Russell reconstitution (from July of year t to May of year $t + 1$). Logit and linear probability

Table A12: Specialness and changes in BMI

	D(special in July)		D(special in May next year)	
	(1)	(2)	(3)	(4)
D(special)	0.849*** (30.67)	6.815*** (9.21)	0.489*** (10.05)	3.637*** (8.50)
ΔBMI , %	-0.000 (-1.13)	0.025 (1.00)	-0.001 (-1.01)	0.000 (0.00)
ΔBMI , % $\times$ D(special)	0.006** (2.50)	-0.006 (-0.14)	0.008 (1.03)	0.014 (0.33)
Observations	13,692	13,692	12,171	12,171
Adjusted R-squared	0.735		0.267	
Estimator	FE	Logit	FE	Logit

This table reports the estimates of specification (27) in the panel of stocks within 500 ranks around the Russell cutoff in 2007–2018. A stock is considered special, or $D(\text{special}) = 1$, if its average fee in May is above 1%. All regressions include controls and year fixed effects. Columns (1) and (3) are estimated using a linear regression specification with fixed effects (FE). t -statistics based on wild bootstrap with clustering by stock and year are in parentheses. Columns (2) and (4) report logit regression estimates with bootstrap z -statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

estimates in Table A13 show that increases in BMI are associated with a slightly lower probability of becoming special, although this effect is not statistically significant. Results are similar regardless of whether the independent variable is an absolute change in BMI (as in the baseline case) or the proportional change in BMI, measured as the log ratio.

To further address potential sparsity of the binary outcome, I also estimate specifications in which the dependent variable is either the log number of days the stock is on special until the next Russell reconstitution or its maximum borrowing fee over the same period. I again use two measures of the BMI change, absolute (baseline) and proportional (log ratio). Although all these specifications use more variation in the outcome, we see statistically significant estimates only for the proportional change in BMI. To gauge magnitudes, a 10% increase in BMI—approximately the 90th percentile of BMI changes among non-special stocks—reduces the maximum borrowing fee by about 4–5 basis points and lowers the number of days on special by roughly 1–2%. While modest in levels, these effects reflect a compression of the right tail of lending fees and special episodes, consistent with benchmarking reducing the severity of fee spikes.

Table A13: Likelihood and severity of specialness and changes in BMI

	D(Ever special)				Log. days on special		Max. fee (%)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔBMI , %	−0.002* (−1.94)		−0.025 (−1.73)		−0.006* (−1.86)		−0.010 (−1.23)	
$\ln(BMI_{t+1}/BMI_t)$		−0.038 (−1.50)		−0.420 (−1.68)		−0.161** (−2.46)		−0.436*** (−3.70)
Observations	11,585	11,584	11,585	11,585	11,585	11,584	11,585	11,584
Estimator	FE	FE	Logit	Logit	FE	FE	FE	FE

This table relates the likelihood and severity of specialness with changes in BMI in the panel of general collateral stocks within 500 ranks around the Russell cutoff in 2007–2018. A stock is considered special if its fee in May is above 1%. The dependent variable in Columns (1)–(4) equals one if a stock that is not special in May enters special status at any point during the following Russell year (July–May). Columns (5)–(6) use $\ln(1 + \text{days on special})$ over the same window. Columns (7)–(8) use the maximum borrowing fee over the next Russell year. All specifications include the baseline set of control variables used in the main analysis and year fixed effects. Columns (1), (2), (5)–(8) are estimated using a linear regression specification with fixed effects (FE). Numbers in parentheses are wild bootstrap t -statistics with clustering by stock and year. Columns (3) and (4) report logit regression estimates with bootstrap z -statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

A.15 Response of other lending features to BMI

In this section, in order to provide further support for the mechanism in my model, I analyze how changes in other lending market variables are related to changes in BMI around Russell reconstitutions. Specifically, I show that special stocks do not experience economically significant changes in utilization, loan tenure, or concentration of borrower, lender, or inventory shares. Furthermore, I document increases in option-implied borrowing fees of the same size as those reported in the main text and find no evidence of changes in fee risk premia or riskiness of short-selling.

Table A14 reports the estimates of specifications (14) and (15) for additional dependent variables, namely, active utilization, active utilization (short), Markit score, loan tenure, lender concentration, borrower concentration, and inventory concentration. Active utilization is quantity on loan relative to active lendable quantity (active inventory). Active utilization (short) is short quantity on loan relative to active lendable quantity. Markit score is Markit’s proprietary Daily Cost of Borrow Score which measures how expensive it is to borrow a stock, based on the wholesale segment (agent lenders lending to intermediaries, e.g. prime brokers). Loan tenure is the loan-size-weighted average number of days from the start date to present for all transactions. Lender and borrower concentration levels are computed by Markit and represent Herfindahl-Hirschman indexes

Table A14: Response of additional lending variables to changes in BMI

	Change in						
	active utilization, % (1)	active utilization (short), % (2)	loan tenure, days (3)	Markit score (4)	lender con- centration, % (5)	borrower concentra- tion, % (6)	inventory concentra- tion, % (7)
Panel A: No interactions							
ΔBMI , % MV	0.287*** (6.62)	0.337*** (6.71)	-0.531*** (-4.09)	0.350** (2.17)	-0.275*** (-5.47)	-0.270*** (-5.22)	-0.012 (-1.33)
Observations	13,685	13,371	13,685	13,684	7,963	7,963	13,692
Adjusted R-squared	0.078	0.090	0.023	0.101	0.019	0.006	0.083
Panel B: With specialness interactions							
ΔBMI , % MV $\times$ D(not special)	0.274*** (6.85)	0.328*** (7.15)	-0.558*** (-4.00)	-0.151** (-2.13)	-0.298*** (-4.21)	-0.285*** (-5.39)	-0.007 (-0.91)
ΔBMI , % MV $\times$ D(special)	0.436*** (3.33)	0.512** (2.23)	-0.220 (-0.88)	6.063*** (3.88)	-0.005 (-0.12)	-0.097** (-2.23)	-0.063 (-1.63)
Observations	13,685	13,371	13,685	13,684	7,963	7,963	13,692
Adjusted R-squared	0.078	0.091	0.023	0.126	0.019	0.006	0.083
$\beta_1 - \beta_2$	0.162 (1.37)	0.185 (0.89)	0.338 (1.24)	6.214*** (4.06)	0.293*** (3.10)	0.188** (2.71)	-0.056 (-1.47)

This table reports the estimates of specification (14) (panel A) and specification (15) (panel B) in the panel of stocks within 500 ranks around the Russell cutoff in 2007–2018. Lender and borrower concentration levels are available from 2012 onwards, resulting in a lower number of observations in columns (4) and (5). The last row reports the t -test for estimation results in panel B. Changes in lending market variables are computed as differences between July and May, see details in Appendix A.3. A stock is considered special, or $D(\text{special}) = 1$, if its fee in May is above 1%. All regressions include controls and $D(\text{special})$ by year fixed effects. t -statistics based on wild bootstrap with clustering by stock and year are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. In columns (5) and (6), because the number of clusters is lower (7), the bootstrap uses Webb weights instead of Rademacher weights.

for the lender and borrower shares in the value on loan, respectively. Inventory concentration is also computed by Markit and represents a Herfindahl-Hirschman index for the lender share in lendable quantity. I use changes in level variables computed as in the main text, and results are very similar if I use differences in logarithms instead.

Table A15 reports the estimates of specifications (14) and (15) for dependent variables related to borrowing fee risk, namely, changes in borrowing fee volatility and changes in borrowing fee risk premium implied by option prices (adjusted). I compute fee volatility as a sample variance of daily borrowing fees in a given month (annualized, in %) and compare its value in May (before the reconstitution) to several months after the reconstitution – July, August, September, and October. I document that borrowing fee volatility for special stocks increases immediately after the reconstitution and tapers off with time. Therefore, the short-term increase in volatility is likely driven not by an increase in the riskiness of short-selling but rather by the renegotiation of loans (consistent with fee dynamics discussed in Section 5.2 and Appendix A.11). I also show that changes in option-implied borrowing fee (adjusted for early exercise) are very similar to those in

Table A15: Response of borrowing fee risk measures to changes in BMI

	Change in						
	borrowing fee, %	option- implied borrowing fee, %	option- implied fee risk premium, %	fee volatility (Jul-May), %	fee volatility (Aug- May), %	fee volatility (Sep- May), %	fee volatility (Oct- May), %
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: No interactions							
ΔBMI , %	0.010 (1.48)	0.003 (0.20)	-0.005 (-0.44)	0.070 (1.67)	0.011 (0.66)	0.007 (0.36)	-0.021 (-1.30)
Observations	7,684	7,684	7,684	13,689	13,687	13,678	13,625
Adjusted R-squared	0.103	0.049	0.034	0.055	0.026	0.053	0.077
Panel B: With specialness interactions							
ΔBMI , % $\times$ D(not special)	-0.004 (-1.37)	-0.015 (-1.38)	-0.010 (-0.97)	-0.001 (-0.05)	-0.022*** (-3.55)	-0.017 (-1.17)	-0.028** (-2.25)
ΔBMI , % $\times$ D(special)	0.188** (2.73)	0.220*** (3.62)	0.058 (1.25)	0.882* (1.80)	0.393* (1.73)	0.281* (1.79)	0.065 (0.53)
Observations	7,684	7,684	7,684	13,689	13,687	13,678	13,625
Adjusted R-squared	0.126	0.056	0.035	0.064	0.034	0.057	0.077
$\beta_1 - \beta_2$	0.192** (2.86)	0.234*** (3.91)	0.068 (1.48)	0.883* (1.81)	0.416* (1.82)	0.298* (1.92)	0.093 (0.78)

This table reports the estimates of specification (14) (panel A) and specification (15) (panel B) in the panel of stocks within 500 ranks around the Russell cutoff. Columns (1)–(3) only include optionable stocks in 2007–2015 (as in Muravyev, Pearson, and Pollet (2022)), while columns (4)–(7) use the baseline sample. The last row reports the t -test for estimation results in panel B. Changes in variables in columns (1)–(3) are computed as differences between July and May. Changes in fee volatility are computed between May and July, August, September, and October in columns (4), (5), (6), and (7), respectively. A stock is considered special, or $D(\text{special}) = 1$, if its fee in May is above 1%. t -statistics based on wild bootstrap with clustering by stock and year are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. In columns (1)–(3), because the number of clusters is lower (8), the bootstrap uses Webb weights instead of Rademacher weights.

Markit’s borrowing fee used in the main text.³⁴

Table A16 reports the estimates of specifications (14) and (15) for more dependent variables related to borrowing fee risk following Engelberg, Reed, and Ringgenberg (2018) and Palia and Sokolinski (2024). Specifically, I investigate whether the changes in utilization volatility (often used as a measure of recall risk), lending inventory (active supply) volatility, quantity on loan (short interest) volatility, and failures to deliver are related to changes in BMI around the Russell reconstitutions. For special stocks, none of these variables significantly decrease in BMI. Therefore, my main results do not seem to be driven by a decrease in the borrowing risk.

³⁴The computational details for the option-implied borrowing fee and borrowing fee risk premium are provided in Muravyev, Pearson, and Pollet (2022) and Muravyev, Pearson, and Pollet (2018). I thank Dmitriy Muravyev for sharing the data.

Table A16: Response of other short-selling risk measures to changes in BMI

	Change in					
	utilization volatility, %	utilization (short) volatility, %	lending inventory volatility, %	quantity on loan volatility, %	number of failures to deliver, bps	new number of failures to deliver, bps
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: No interactions						
ΔBMI , %	-0.975** (-2.46)	-1.466** (-2.30)	-0.001 (-1.32)	0.001 (0.92)	-0.004 (-0.23)	-0.002 (-0.73)
Observations	12,168	12,150	12,168	12,168	12,168	12,168
Adjusted R-squared	0.035	0.034	0.114	0.052	0.186	0.186
Panel B: With specialness interactions						
ΔBMI , % $\times$ D(not special)	-0.946* (-2.04)	-1.222* (-2.02)	-0.001* (-1.95)	0.000 (0.40)	-0.014 (-0.75)	-0.004 (-1.44)
ΔBMI , % $\times$ D(special)	-1.312 (-0.95)	-4.290 (-1.59)	0.004 (1.41)	0.006 (1.44)	0.108 (1.05)	0.015 (1.06)
Observations	12,168	12,150	12,168	12,168	12,168	12,168
Adjusted R-squared	0.035	0.034	0.115	0.053	0.186	0.186
$\beta_1 - \beta_2$	-0.366 (-0.23)	-3.068 (-1.17)	0.005 (1.76)	0.005 (1.43)	0.122 (1.17)	0.019 (1.46)

This table reports the estimates of specification (14) (panel A) and specification (15) (panel B) in the panel of stocks within 500 ranks around the Russell cutoff. The last row reports the t -test for estimation results in panel B. Changes in all variables are computed as differences between one year after the Russell reconstitution and one year before the reconstitution. Failures to deliver are taken from the U.S. SEC website and scaled by shares outstanding. New failures to deliver are computed as change in the number of failures to deliver relative to the previous observation.^a A stock is considered special, or $D(special) = 1$, if its fee in May is above 1%. All regressions include controls and D(special) by year fixed effects. t -statistics based on wild bootstrap with clustering by stock and year are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

^aThis change technically cannot be interpreted as the number of new failures to deliver. I use it simply to capture potential jumps in the number of failures. See all caveats of the data at <https://www.sec.gov/data-research/sec-markets-data/fails-deliver-data>.

A.16 Disagreement and BMI

In this section, I show that changes in disagreement as measured by the dispersion in analyst forecasts are not driving the main results.

I define disagreement in line with the literature. Specifically, I use the standard deviation of EPS estimates scaled by the absolute value of the mean estimate (Diether, Malloy, and Scherbina (2002)). The change in dispersion is computed from the last available summary date prior to June to the first available date after June. I use the summary estimate table from I/B/E/S following

the discussion of different vintage issues in WRDS.³⁵

Table A17 shows that for September EPS forecasts, there is a negative relationship between the level of disagreement and BMI in May. Intuitively, stocks that belong to major benchmark indexes may exhibit less information asymmetry resulting in analysts disagreeing less about these stocks' prospects. Columns (2) and (3) further document no significant relationship between BMI and disagreement in changes, for the full sample of stocks and special stocks only. Nevertheless, to ensure that the contemporaneous changes in disagreement are not driving my findings, I add the change in disagreement interacted with specialness to the baseline regressions. Columns (4) to (7) show that the estimates are virtually unaffected.

Table A17: Disagreement and changes in BMI

	EPS dispersion in May	Δ EPS dispersion	Δ EPS dispersion	Δ Lending inventory, % shares	Δ Quantity on loan, % shares	Δ Borrowing fee, %	Stock return, %
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
BMI in May, %	-0.340* (-1.72)						
ΔBMI , %		0.104 (0.64)	2.093 (1.24)				
ΔBMI , % $\times$ D(not special)				0.175*** (9.98)	0.119*** (6.56)	-0.003 (-1.03)	0.098** (2.49)
ΔBMI , % $\times$ D(special)				0.119** (2.27)	0.216*** (5.94)	0.191*** (2.88)	0.341** (2.45)
ΔEPS dispersion $\times$ D(not special)				-0.001** (-2.46)	0.000 (0.41)	0.000 (1.28)	-0.016*** (-7.17)
ΔEPS dispersion $\times$ D(special)				-0.006* (-2.45)	0.001 (0.84)	0.004 (1.89)	-0.028* (-1.72)
Observations	11,421	11,421	502	11,421	11,421	11,421	11,421
Adjusted R-squared	0.044	0.001	-0.011	0.150	0.093	0.124	0.208
$\beta_1 - \beta_2$				-0.056 (-1.13)	0.096** (2.77)	0.194** (2.96)	0.242 (1.77)

This table reports the estimates of specification (15) with added Δ EPS dispersion controls in the panel of stocks within 500 ranks around the Russell cutoff in 2007–2018. Column (3) includes only special stocks. EPS dispersion is computed as standard deviation in September EPS forecasts scaled by the absolute value of the mean EPS forecast, as reported in the forecast summary table of I/B/E/S. Change in dispersion is computed as the difference between the last available summary date prior to June and the first available summary date after June. Changes in lending market variables are computed as differences between July and May; stock return is measured in June. A stock is considered special, or $D(special) = 1$, if its average fee in May is above 1%. The last row reports the t -test for no difference in loading on ΔBMI for special and not special stocks. All regressions include controls and D(special) by year fixed effects. t -statistics based on wild bootstrap with clustering by stock and year are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

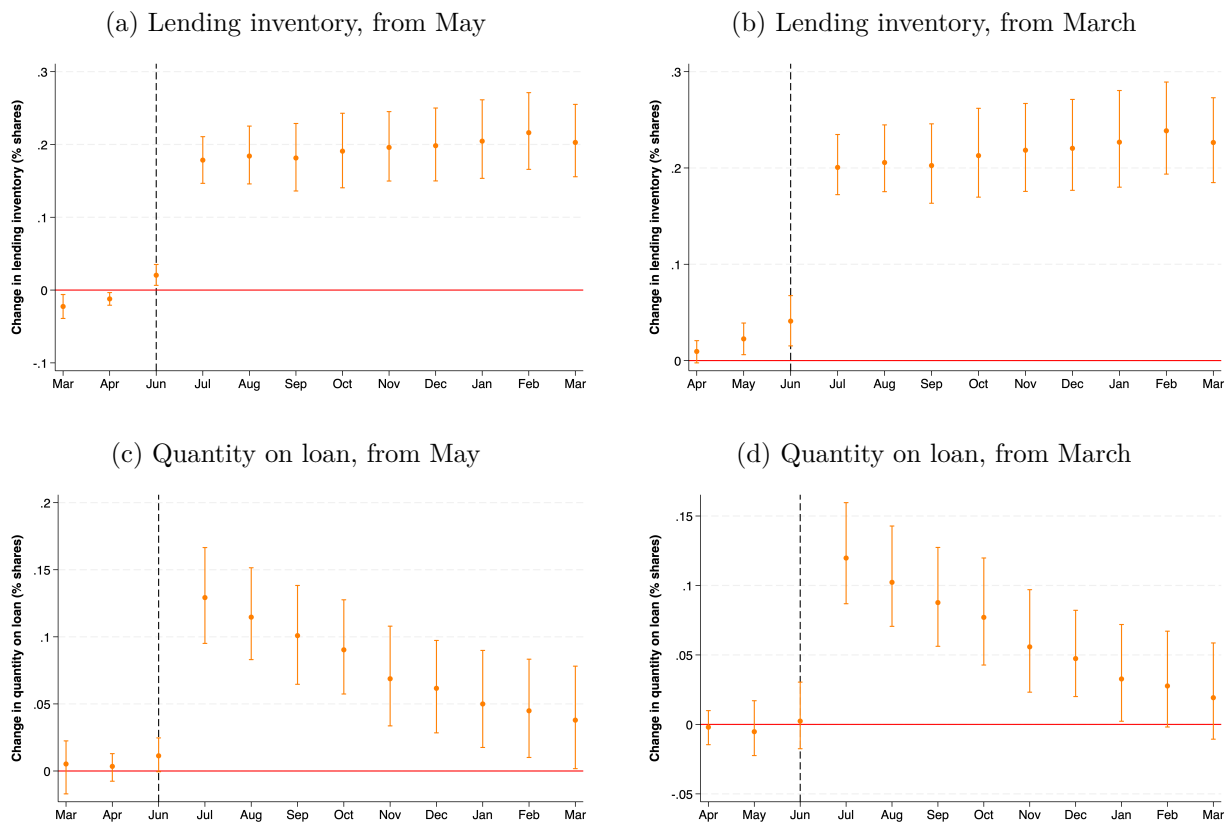
³⁵See WRDS research guide to I/B/E/S: <https://wrds-www.wharton.upenn.edu/pages/grid-items/ibes-wrds-101-introduction-and-research-guide/>.

A.17 BMI effects on spot and lending markets in the long run

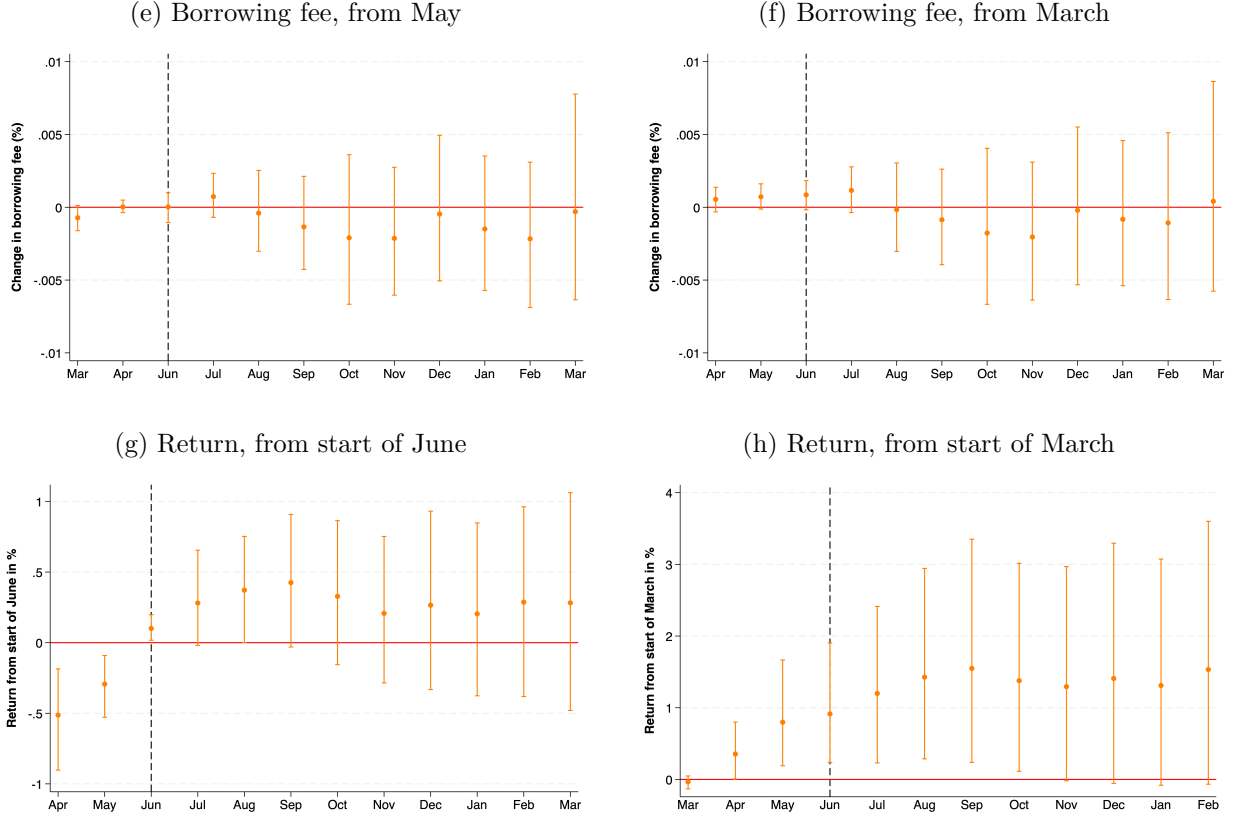
In this section, I analyze longer-horizon changes in spot and lending markets around Russell reconstitutions. Specifically, I estimate regression (14) in samples of general collateral and special stocks for different horizons of the dependent variables, reporting changes from March and May of the reconstitution year. So that this analysis can cover both reference months, a stock is classified as special if its fee in March–May is above 1%. Figures A8 and A9 report the estimates and the corresponding 90% confidence intervals based on wild cluster bootstrapped standard errors.

A.17.1 General collateral stocks

Figure A8: Monthly estimates of changes in lending and spot market variables on ΔBMI (general collateral stocks)



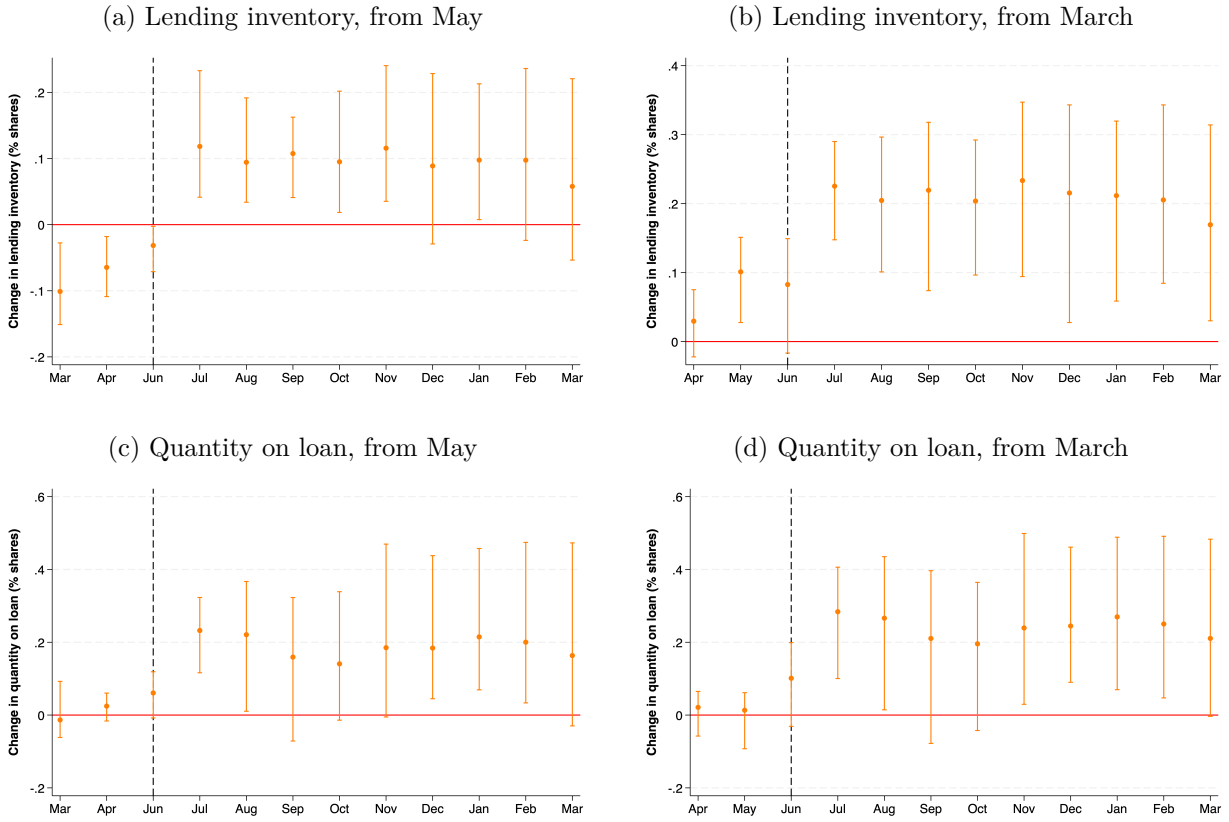
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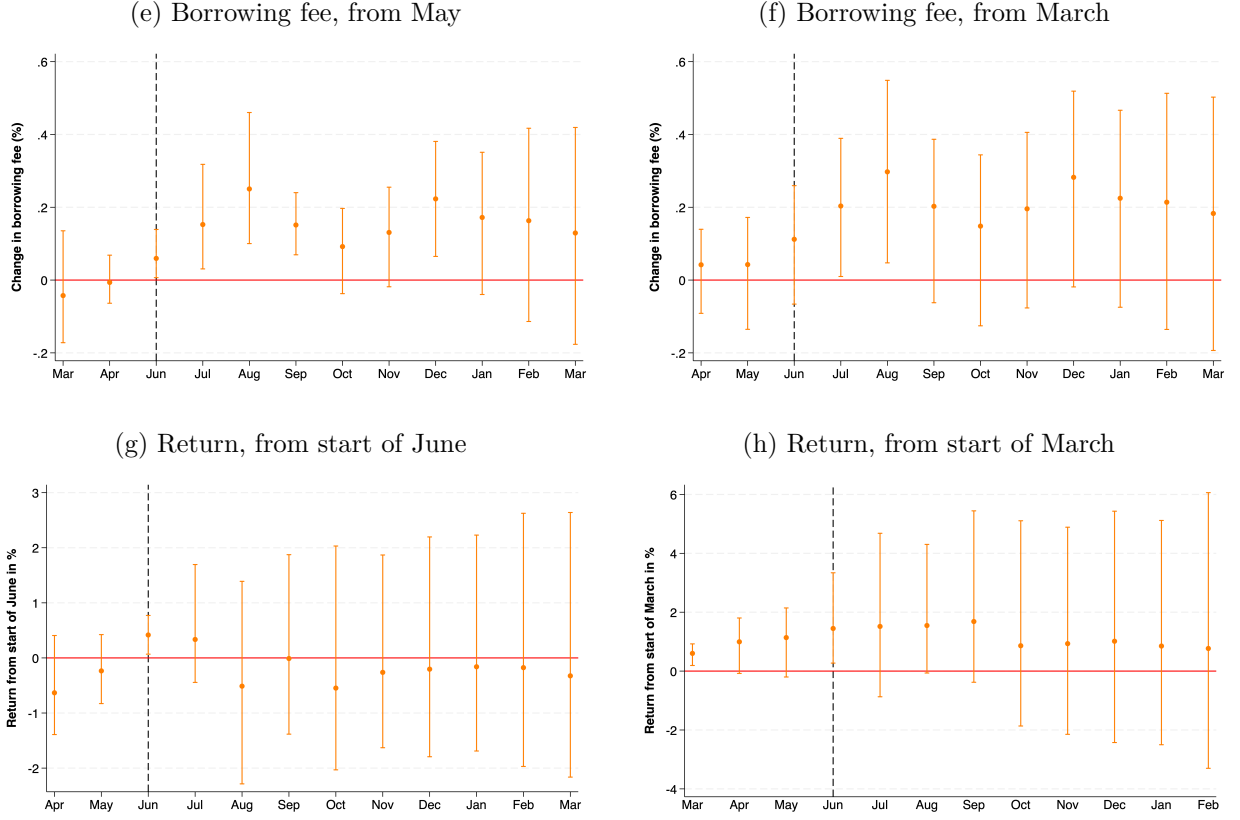
This figure plots the monthly estimates of the loading on ΔBMI and the corresponding 90% confidence intervals from regression (14), estimated within a panel of not special stocks with year fixed effects. Panels (a), (c), (e) and (g) consider changes from May (baseline), while panels (b), (d), (f) and (h) from March. June is the reconstitution month. Changes in lending variables are computed using average monthly levels. Returns are cumulative total returns from either start of June (baseline) or March.

A.17.2 Special stocks

Figure A9: Monthly estimates of changes in lending and spot market variables on ΔBMI (special stocks)



continued on the next page



This figure plots the monthly estimates of the loading on ΔBMI and the corresponding 90% confidence intervals from regression (14), estimated within a panel of special stocks with year fixed effects. Panels (a), (c), (e) and (g) consider changes from May (baseline), while panels (b), (d), (f) and (h) from March. June is the reconstitution month. Changes in lending variables are computed using average monthly levels. Returns are cumulative total returns from either start of June (baseline) or March.

A.18 Stock fundamentals and lending shares

Table A18: Conditional correlation between fund-level stock lending share and stock characteristics

	Stock-level lending by funds						
	All stocks		Special stocks				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Extensive margin, $D(\text{Lent Share} > 0)$							
D(special)	0.407*** (39.86)	0.158*** (19.02)					
Size decile			0.033*** (13.53)	0.012*** (3.79)	0.016*** (4.86)	0.011*** (3.47)	0.012*** (4.16)
Volatility, 1y rolling					7.060*** (4.18)	8.476*** (4.86)	5.127*** (3.05)
Beta, 1y rolling					0.028*** (4.26)	0.015** (2.53)	0.018*** (3.11)
Bid-ask spread, 1y rolling						-12.752*** (-17.08)	-13.419*** (-18.95)
Borrowing fee							0.923*** (9.61)
Observations	4,778,953	4,675,790	263,414	222,925	210,223	208,069	208,069
Adjusted R-squared	0.108	0.508	0.021	0.533	0.541	0.542	0.546
Panel B: Intensive margin, Lent Share							
D(special)	0.163*** (27.45)	0.081*** (23.87)					
Size decile			0.024*** (12.09)	0.005** (2.10)	0.005* (1.90)	0.003 (1.36)	0.005* (2.02)
Beta, 1y rolling					0.013*** (3.05)	0.008* (1.89)	0.010** (2.23)
Volatility, 1y rolling					5.945*** (3.56)	6.736*** (3.81)	4.227*** (2.83)
Bid-ask spread, 1y rolling						-5.298*** (-5.22)	-5.923*** (-5.92)
Borrowing fee							0.751*** (13.87)
Observations	417,905	351,070	124,351	100,525	96,131	95,839	95,839
Adjusted R-squared	0.040	0.481	0.027	0.397	0.403	0.402	0.408
FE	N	Fund x Stock and Date	N	Fund x Stock and Date	Fund x Stock and Date	Fund x Stock and Date	Fund x Stock and Date

This table reports the estimates of regressing fund-level stock lending share on stock characteristics in the panel of fund holdings in 2020–2022. In columns (1)–(2), I use the full fund-stock-quarter panel of holdings, whereas in columns (3)–(7) I include only special stocks. Included fixed effects are specified in each column. Lent share is the share of holdings in a given stock on loan. A stock is considered special, or $D(\text{special}) = 1$, if its fee on the report date is above 1%. Size decile is computed daily over the sample of stocks in fund holdings. Volatility is one-year rolling sum of daily squared returns. Beta is the estimate of stock return sensitivity to CRSP value-weighted index return, computed over one year of daily data with a minimum of three trading months of data. Bid-ask spread is the one-year rolling average quoted bid-ask spread scaled by the close price. Borrowing fee is Markit's indicative fee used in the baseline analysis. All characteristics, except for size decile and beta, are winsorized daily at 99%. Beta is winsorized daily at 0.5% and 99.5%. t -statistics based on standard errors clustered by fund-stock and date are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

A.19 Dynamics in fund- and family-level lending following Russell reconstitutions

In this Appendix, Tables A19 and A20 examine whether fund- and family-level lending of newly added (or deleted) stocks increases gradually following index reconstitution. These tables report transition rates, or propensities, at the fund-series and CIK (fund family) levels, respectively.³⁶ For each stock held in the fiscal quarter covering the reconstitution (quarter 0), positions are classified based on whether the fund/family was lending the stock at that time and whether stock was special before the reconstitution (i.e., had borrowing fee above 100 bps). Lending activity is then tracked over the next four quarters (+1 to +4), and the share of positions that go on loan in each quarter is reported, along with an “Ever Lent” column indicating whether lending occurred at any point post-reconstitution. Standard errors are computed based on stock-fund-quarter or stock-family-quarter samples. At the CIK level, holdings and lending values are aggregated across all funds managed by a given family.

First, fund-level results suggest a gradual but modest increase in lending activity over time. Table A19 reports lending probabilities for individual fund-series holdings of newly added and deleted stocks. The data suggest a gradual increase in lending activity over time, which is, however, small and short-lived:

- For newly added non-special stocks that were not lent at reconstitution, lending increases slightly from 4.4% in Q+1 to 5.4% in Q+4. On average, only 10.8% of these stocks are ever lent after reconstitution.
- For special stocks not lent at reconstitution, 18.7% go on loan in Q+1, but this increase quickly flattens. On average, only about 24% are ever lent.
- Stocks already lent at reconstitution show high and persistent lending propensities, with modest declines over time, likely reflecting inventory turnover or changing demand.
- Patterns for deleted stocks mirror these results, albeit at slightly lower levels.
- Standard errors are reported throughout to shed some light on heterogeneity across funds.

Second, Table A20 aggregates holdings and lending behavior to the family (CIK) level and confirms similar dynamics:

³⁶CIK is the effective fund management company identifier used by the U.S. SEC EDGAR system and corresponds to families of funds, such as Vanguard Admiral Funds or Vanguard Index Funds.

- For CIKs not lending a given addition at reconstitution, lending increases from 4.7% in Q+1 to 6.2% in Q+4. On average, only 11.5% of non-special stocks are ever lent after the reconstitution.
- As at the fund level, a subset of special stocks not lent at reconstitution begins lending in Q+1 (13.4%) and Q+2 (14.5%), but the overall share ever lent remains modest (around 20%).
- CIKs already lending a stock at reconstitution maintain relatively high and persistent lending propensities.

Overall, these results suggest that while some lending activity ramps up after reconstitution, the magnitude is modest, and the majority of stocks (importantly, the special ones) remain not lent if not already on loan at reconstitution.

To shed some more light on the heterogeneity across families and investment companies, Tables A21 and A22 report CIK-level transition propensities for four major investment companies (Vanguard, BlackRock, SSGA, and Fidelity) for additions and deletions:

- At Vanguard, previously not lent non-special stocks are rarely lent even months later (only 2.6% ever), while stocks lent at reconstitution remain active in lending (30%).
- In contrast, BlackRock, SSGA, and Fidelity show much higher transition rates. For example, Fidelity reaches 35.6% for non-special stocks not lent at reconstitution and 83.3% for those already lent.
- Special stocks generally elicit more lending (e.g., >80% ever for lent-at-reconstitution stocks), but the transition from not lending to lending is limited and firm-specific. While Vanguard and SSGA show a smaller and short-lived increase in lending, BlackRock and Fidelity take longer but eventually lend out more stocks (25% and 29%, respectively, as opposed to 7% and 15% for Vanguard and SSGA). Still, many special stocks remain not lent entirely.
- Importantly, these companies also differ in their initial lending propensities. For example, in the reconstitution quarter, Vanguard funds do not lend 57% of special stocks they hold,³⁷ compared to 56% for SSGA, 34% for BlackRock, and only 17% for Fidelity.

To summarize, these results suggest that, even though funds do begin lending special stocks that were not lent out at reconstitution, many of these stocks remain not lent at all, consistent with persistent specialization in the lending markets.

³⁷Computed as $53/(53+39)$.

Table A19: Fund-Level Lending Propensities (Series Level)

Recon Quarter Status	Specialness	+1	+2	+3	+4	Ever	Obs.
Panel A: Additions							
Not lent	Non-Special	4.4 (0.14)	4.7 (0.16)	5.0 (0.18)	5.4 (0.20)	10.8 (0.20)	24,736
Lent	Non-Special	59.2 (1.06)	48.3 (1.23)	41.7 (1.33)	40.3 (1.41)	71.3 (0.92)	2,397
Not lent	Special	18.7 (1.23)	14.4 (1.31)	7.3 (1.16)	8.6 (1.33)	23.9 (1.22)	1,227
Lent	Special	79.7 (1.34)	58.8 (2.00)	19.8 (2.14)	20.6 (2.28)	83.6 (1.15)	1,031
Panel B: Deletions							
Not lent	Non-Special	3.6 (0.11)	4.4 (0.14)	5.5 (0.18)	6.3 (0.20)	10.5 (0.18)	30,458
Lent	Non-Special	59.4 (1.08)	51.6 (1.20)	40.8 (1.31)	43.6 (1.42)	73.9 (0.88)	2,478
Not lent	Special	10.3 (1.61)	4.7 (1.47)	1.1 (0.76)	7.8 (2.17)	16.4 (1.71)	470
Lent	Special	71.6 (3.41)	94.4 (3.15)	50.0 (18.90)	44.4 (17.57)	75.0 (2.89)	226

This table reports the percentage of fund-level holdings of stocks that were lent in each post-reconstitution quarter (+1 to +4) or ever after. Panel A considers stocks added to the Russell 2000 from the Russell 1000, while panel B considers stocks added to the Russell 1000 from the Russell 2000. Results are shown separately by whether the stock was lent in quarter 0 and whether it was special at reconstitution. Observations are reported in the final column. Quarters are aligned to fund fiscal calendars. Standard errors are reported in parentheses.

Table A20: Family-Level Lending Propensities (CIK Level)

Recon Quarter Status	Specialness	+1	+2	+3	+4	Ever	Obs.
Panel A: Additions							
Not lent at 0	Non-Special at 0	4.7 (0.3)	6.0 (0.4)	5.7 (0.3)	6.2 (0.4)	11.5 (0.3)	9,012
Lent at 0	Non-Special at 0	61.7 (1.7)	51.2 (2.1)	46.2 (1.9)	46.5 (2.1)	72.6 (1.4)	1,044
Not lent at 0	Special at 0	13.4 (1.8)	14.5 (2.8)	7.4 (1.6)	11.0 (2.2)	19.5 (1.7)	563
Lent at 0	Special at 0	80.6 (2.2)	68.3 (4.6)	26.6 (3.3)	25.0 (3.7)	79.1 (1.9)	463
Panel B: Deletions							
Not lent at 0	Non-Special at 0	3.7 (0.2)	4.8 (0.3)	5.4 (0.3)	6.0 (0.3)	10.1 (0.3)	11,750
Lent at 0	Non-Special at 0	64.0 (1.5)	53.8 (1.8)	44.2 (1.7)	43.2 (1.9)	75.0 (1.2)	1,256
Not lent at 0	Special at 0	7.9 (2.4)	1.4 (1.4)	0.0 (0.0)	3.2 (2.2)	10.9 (2.2)	198
Lent at 0	Special at 0	54.5 (6.2)	75.0 (16.4)	50.0 (18.9)	37.5 (18.3)	60.6 (4.6)	113

This table reports the percentage of CIK-level holdings of stocks that were lent in each post-reconstitution quarter (+1 to +4) or ever after. Panel A considers stocks added to the Russell 2000 from the Russell 1000, while panel B considers stocks added to the Russell 1000 from the Russell 2000. Results are shown separately by whether the stock was lent in quarter 0 and whether it was special at reconstitution. Observations are reported in the final column. Quarters are aligned to fund fiscal calendars. Standard errors are reported in parentheses.

Table A21: CIK-Level Lending Propensities for Additions by Investment Company

Status at Quarter 0	Specialness	+1	+2	+3	+4	Ever	Obs.
Panel A: Vanguard							
Not lent at 0	Non-Special	1.3	1.9	1.7	1.9	2.6	766
Lent at 0	Non-Special	30.0	10.0	10.0	10.0	30.0	10
Not lent at 0	Special	5.4	6.7	0.0	0.0	7.1	53
Lent at 0	Special	93.5	76.9	6.3	31.3	93.5	39
Panel B: BlackRock							
Not lent at 0	Non-Special	10.3	13.7	11.2	15.1	32.6	259
Lent at 0	Non-Special	77.9	72.0	73.6	74.5	86.4	88
Not lent at 0	Special	9.1	0.0	0.0	0.0	25.0	16
Lent at 0	Special	84.2	71.4	40.0	50.0	87.0	30
Panel C: SSGA							
Not lent at 0	Non-Special	3.2	2.9	3.4	4.6	9.5	343
Lent at 0	Non-Special	68.4	66.7	55.9	45.5	83.3	48
Not lent at 0	Special	11.1	12.5	0.0	12.5	14.8	28
Lent at 0	Special	81.0	100.0	0.0	16.7	81.0	22
Panel D: Fidelity							
Not lent at 0	Non-Special	22.1	11.9	14.0	19.6	35.6	264
Lent at 0	Non-Special	69.9	63.6	57.7	57.9	83.3	136
Not lent at 0	Special	0.0	–	20.0	0.0	28.6	8
Lent at 0	Special	84.2	50.0	45.5	50.0	95.0	37

This table reports the percentage of CIK-level holdings of newly added stocks that were lent in each post-reconstitution quarter (+1 to +4) or ever after for four major investment companies. Results are shown separately by whether the stock was lent in quarter 0 and whether it was special at reconstitution. Observations are reported in the final column. Quarters are aligned to fund fiscal calendars. Cells with missing holdings are marked with –.

Table A22: CIK-Level Lending Propensities for Deletions by Investment Company

Status at Quarter 0	Specialness	+1	+2	+3	+4	Ever	Obs.
Panel A: Vanguard							
Not lent at 0	Non-Special	0.4	0.9	1.2	1.7	1.8	721
Lent at 0	Non-Special	16.7	30.0	44.4	44.4	50.0	12
Not lent at 0	Special	16.7	25.0	0.0	50.0	28.6	9
Lent at 0	Special	80.0	–	–	–	80.0	7
Panel B: BlackRock							
Not lent at 0	Non-Special	8.5	8.1	7.6	20.2	18.0	349
Lent at 0	Non-Special	82.8	80.0	76.9	86.2	91.2	106
Not lent at 0	Special	12.5	0.0	0.0	16.7	25.0	13
Lent at 0	Special	100.0	–	–	–	100.0	5
Panel C: SSGA							
Not lent at 0	Non-Special	3.5	5.6	7.1	8.1	10.9	303
Lent at 0	Non-Special	45.0	61.1	44.4	37.1	73.3	47
Not lent at 0	Special	0.0	0.0	0.0	0.0	12.5	8
Lent at 0	Special	100.0	–	–	–	100.0	3
Panel D: Fidelity							
Not lent at 0	Non-Special	11.9	18.1	15.3	19.9	29.4	475
Lent at 0	Non-Special	73.0	71.0	60.0	50.0	87.1	88
Not lent at 0	Special	0.0	0.0	0.0	0.0	0.0	4
Lent at 0	Special	28.6	100.0	100.0	66.7	57.1	11

This table reports the percentage of CIK-level holdings of deleted stocks that were lent in each post-reconstitution quarter (+1 to +4) or ever after. Results are shown separately by whether the stock was lent in quarter 0 and whether it was special at reconstitution. Observations are reported in the final column. Quarters are aligned to fund fiscal calendars. Cells with missing holdings are marked with –.

B Baseline model details and proofs

B.1 Portfolio choice

B.1.1 Solution to the direct investor's problem.

The direct investor chooses a portfolio θ_D to maximize his expected utility $U(W^D)$:

$$\max_{\theta_D} E_0[-\exp\{-\gamma W^D\}]. \quad (28)$$

To evaluate the expectation in (28), I need the following property. Suppose $Y \sim N(E[Y], Var[Y])$ is an $N \times 1$ random vector, α is a (constant) scalar and x is a constant vector. Then

$$E e^{\alpha x' Y} = e^{\alpha x' E[Y] + \frac{\alpha^2}{2} x' Var[Y] x}. \quad (29)$$

Substituting in the terminal wealth $W^D = W_0^D + \theta_D(\bar{D} - p)$ and using property (29), I can equivalently represent the direct investor's problem as

$$\max_{\theta_D} \left[-\exp\{-\gamma[W_0^D + \theta_D(\mu - p) - \frac{\gamma}{2}\sigma^2\theta_D^2]\} \right].$$

The first order condition (FOC) with respect to θ_D yields the demand function (2):

$$\begin{aligned} -\gamma(\mu - p) + \gamma^2\sigma^2\theta_D &= 0, \\ \theta_D &= \frac{1}{\gamma\sigma^2}(\mu - p). \end{aligned}$$

B.1.2 Solution to the fund manager's problem

A fund manager chooses risky holdings θ_M to maximize his expected utility from compensation $U(w)$. The optimization problem of the fund manager is

$$\max_{\theta_M} E_0[-\exp\{-\gamma(aR + b(R - B) + c)\}],$$

or equivalently,

$$\max_{\theta_M} E_0[-\exp\{-\gamma((a + b)\theta_M(l\Delta + \bar{D} - p) - b\omega(\bar{D} - p))\}].$$

Again using property (29), I can write the fund manager's problem as

$$\max_{\theta_M} \left[-\exp\{-\gamma \left((a + b)\theta_M(l\Delta + \mu - p) - b\omega(\mu - p) - \frac{\gamma}{2}\sigma^2((a + b)\theta_M - b\omega)^2 \right)\} \right].$$

The FOC with respect to θ_M yields the demand function (3):

$$\begin{aligned} -\gamma(a+b)(l\Delta + \mu - p) + \gamma^2(a+b)\sigma^2((a+b)\theta_M - b\omega) &= 0, \\ (a+b)\theta_M - b\omega &= \frac{1}{\gamma\sigma^2}(l\Delta + \mu - p), \\ \theta_M &= \frac{1}{\gamma\sigma^2(a+b)}(l\Delta + \mu - p) + \frac{b}{a+b}\omega. \end{aligned}$$

B.1.3 Solution to the hedger's problem

The hedger chooses risky holdings θ_H to maximize his expected utility $U(W^H)$. After substituting in $W^H = W_0^H + e\bar{D} + \theta_H(\bar{D} - p + \Delta\mathbf{1}_{\theta_H < 0})$, I can write the hedger's problem as

$$\max_{\theta_H} E_0[-\exp\{-\gamma(W_0^H + e\bar{D} + \theta_H(\bar{D} - p + \Delta\mathbf{1}_{\theta_H < 0}))\}]. \quad (30)$$

As discussed in the main text, I focus on the case when $\mathbf{1}_{\theta_H < 0} = 1$ (endowment is large enough). With that and using property (29), I can rewrite (30) as

$$\max_{\theta_H} \left[-\exp\left\{-\gamma[W_0^H + e\mu + \theta_H(\mu - p + \Delta) - \frac{\gamma}{2}\sigma^2(e + \theta_H)^2]\right\} \right].$$

The FOC with respect to θ_H yields the demand function (4):

$$\begin{aligned} -\gamma(\mu - p + \Delta) + \gamma^2\sigma^2(e + \theta_H) &= 0, \\ \theta_H &= \frac{1}{\gamma\sigma^2}(\mu - p + \Delta) - e. \end{aligned}$$

B.2 Equilibrium price and borrowing fee

B.2.1 Asset on special

I use market clearing conditions (5) and (6) as well as the optimal portfolio choice of the investors (2)–(4) to solve for the equilibrium asset price and borrowing fee. First, substitute the demand functions (3), and (4) into the market clearing condition in the lending market (6):

$$\begin{aligned} l\lambda_M\theta_M + \lambda_H\theta_H &= 0, \\ l\lambda_M \left(\frac{1}{\gamma\sigma^2(a+b)}(l\Delta + \mu - p) + \frac{b}{a+b}\omega \right) + \lambda_H \left(\frac{1}{\gamma\sigma^2}(\mu - p + \Delta) - e \right) &= 0, \\ (\mu - p) \left(\frac{l\lambda_M}{a+b} + \lambda_H \right) + l\Delta \left(\frac{l\lambda_M}{a+b} + \lambda_H \right) + (1-l)\lambda_H\Delta + \gamma\sigma^2 l\lambda_M \frac{b}{a+b}\omega - \gamma\sigma^2 \lambda_H e &= 0. \end{aligned}$$

which yields an expression for $p - l\Delta$:

$$p - l\Delta = \mu + \frac{1}{l\lambda_M/(a+b) + \lambda_H} \left[(1-l)\lambda_H\Delta + \gamma\sigma^2 l\lambda_M b/(a+b)\omega - \gamma\sigma^2 \lambda_H e \right]. \quad (31)$$

Then, combine the market clearing conditions in the lending market (6) and in the asset market (5) to get

$$\lambda_D \theta_D + (1-l)\lambda_M \theta_M = \bar{\theta}.$$

If I substitute the demand functions (2) and (3) into the expression above, then

$$\begin{aligned} \lambda_D \frac{1}{\gamma\sigma^2} (\mu - p) + (1-l)\lambda_M \left(\frac{1}{\gamma\sigma^2(a+b)} (l\Delta + \mu - p) + \frac{b}{a+b} \omega \right) &= \bar{\theta}, \\ (\mu - p + l\Delta)(\lambda_D + (1-l)\lambda_M/(a+b)) - \lambda_D l\Delta + (1-l)\gamma\sigma^2 \lambda_M b/(a+b)\omega &= \gamma\sigma^2 \bar{\theta}, \end{aligned}$$

which yields another expression for $p - l\Delta$:

$$p - l\Delta = \mu - \frac{1}{(1-l)\lambda_M/(a+b) + \lambda_D} \left[\lambda_D l\Delta + \gamma\sigma^2 \bar{\theta} - \gamma\sigma^2 (1-l)\lambda_M b/(a+b)\omega \right]. \quad (32)$$

Subtract (32) from (31) and rearrange:

$$\begin{aligned} \frac{1}{l\lambda_M/(a+b) + \lambda_H} \left[(1-l)\lambda_H\Delta + \gamma\sigma^2 l\lambda_M b/(a+b)\omega - \gamma\sigma^2 \lambda_H e \right] + \\ \frac{1}{(1-l)\lambda_M/(a+b) + \lambda_D} \left[\lambda_D l\Delta + \gamma\sigma^2 \bar{\theta} - \gamma\sigma^2 (1-l)\lambda_M b/(a+b)\omega \right] &= 0, \\ \Delta[\lambda_M/(a+b)(l^2\lambda_D + (1-l)^2\lambda_H) + \lambda_D\lambda_H] + \gamma\sigma^2(\bar{\theta}[l\lambda_M/(a+b) + \lambda_H] - e[(1-l)\lambda_M/(a+b) + \lambda_D]\lambda_H + \\ \omega\lambda_M b/(a+b)[l\lambda_D - (1-l)\lambda_H]) &= 0. \end{aligned}$$

Further rearranging yields the expression for the equilibrium borrowing fee Δ (8).

Next, rearrange (32) to get

$$\begin{aligned} p - l\Delta &= \mu - \frac{1}{(1-l)\lambda_M/(a+b) + \lambda_D} \left[\lambda_D l\Delta + \gamma\sigma^2 \bar{\theta} - \gamma\sigma^2 (1-l)\lambda_M b/(a+b)\omega \right], \\ p &= \mu - \frac{1}{(1-l)\lambda_M/(a+b) + \lambda_D} \gamma\sigma^2 \left[\bar{\theta} - (1-l)\lambda_M b/(a+b)\omega \right] \\ &\quad + l\Delta \frac{(1-l)\lambda_M/(a+b)}{(1-l)\lambda_M/(a+b) + \lambda_D}. \end{aligned} \quad (33)$$

Substituting in the equilibrium borrowing fee Δ (8) and rearranging yields

$$\begin{aligned}
p = & \mu + \frac{l(1-l)\lambda_H}{l^2\lambda_D + (1-l)^2\lambda_H + (a+b)\lambda_D\lambda_H/\lambda_M} \gamma\sigma^2 e \\
& - \frac{1}{(1-l)\frac{\lambda_M}{a+b} + \lambda_D} \left(1 + \frac{l(1-l)(l\frac{\lambda_M}{a+b} + \lambda_H)}{l^2\lambda_D + (1-l)^2\lambda_H + (a+b)\lambda_D\lambda_H/\lambda_M} \right) \gamma\sigma^2 \bar{\theta} \\
& + \frac{(1-l)\frac{b\lambda_M}{a+b}\lambda_H}{\frac{\lambda_M}{a+b}(l^2\lambda_D + (1-l)^2\lambda_H) + \lambda_D\lambda_H} \gamma\sigma^2 \omega.
\end{aligned}$$

This yields the expression for the equilibrium asset price (7).

B.2.2 General collateral asset

If the securities lending market clearing condition (6) holds with a strict inequality,

$$l\lambda_M\theta_M + \lambda_H\theta_H > 0,$$

or, in other words, if the lending supply from the fund managers is higher than the shorting demand from hedgers, then the equilibrium borrowing fee is zero. In this case, $-\lambda_H\theta_H$ in the model corresponds to the shorting demand observed in the data and $l\lambda_M\theta_M$ corresponds to the available lending supply which is higher than the demand. Because the fee is zero, the fund manager has no incentive to lend the asset and his portfolio demand is

$$\theta_M = \frac{1}{\gamma\sigma^2(a+b)} (\mu - p) + \frac{b}{a+b} \omega.$$

The portfolio demand of a hedger is $\theta_H = \frac{1}{\gamma\sigma^2} (\mu - p) - e$, and the direct investor's demand function is the same.

The equilibrium asset price is defined by the market clearing condition (5). Plugging in the demand functions with a zero borrowing fee, I get

$$\begin{aligned}
& \lambda_D\theta_D + \lambda_M\theta_M + \lambda_H\theta_H = \bar{\theta}, \\
& \lambda_D \frac{1}{\gamma\sigma} (\mu - p) + \lambda_M \left(\frac{1}{\gamma\sigma^2(a+b)} (\mu - p) + \frac{b}{a+b} \omega \right) + \lambda_H \left(\frac{1}{\gamma\sigma^2} (\mu - p) - e \right) = \bar{\theta}, \\
& (\mu - p) \left[\lambda_D + \lambda_M \frac{1}{(a+b)} + \lambda_H \right] + \gamma\sigma^2 (\omega_\lambda - \lambda_H e - \bar{\theta}) = 0,
\end{aligned}$$

where $\omega_\lambda = \frac{b\lambda^A}{a+b}\omega$, as earlier. Rearranging, I get the equilibrium asset price in (10).

B.3 Economy with full lending

The presence of direct investors in my model ensures the existence of equilibrium even in the full lending economy, that is, when $l = 1$. Under full lending, the equilibrium asset price and borrowing fee for an asset on special are simplified to

$$p = \mu - \frac{1}{\lambda_D} \gamma \sigma^2 \bar{\theta},$$

$$\Delta = \gamma \sigma^2 \left(\frac{\lambda_H}{\frac{\lambda_M}{a+b} + \lambda_H} e - \frac{1}{\lambda_D} \bar{\theta} - \frac{1}{\frac{\lambda_M}{a+b} + \lambda_H} \omega_\lambda \right).$$

Under full lending, changes in endowment and benchmarking are fully balanced in the lending market and no longer passed to the equilibrium prices. Endowment e is a demand shifter, and the equilibrium fee increases with it. In contrast, ω_λ is a supply shifter and the equilibrium fee unambiguously decreases with it.

For a general collateral asset, the borrowing fee is zero and the price is still defined by (10) in the main text.

In an economy with full lending, the specialness condition becomes

$$\lambda_H \lambda_D e - \left(\frac{\lambda_M}{a+b} + \lambda_H \right) \bar{\theta} - \lambda_D \omega_\lambda > 0.$$

Therefore, an asset with a higher BMI is always less likely to be on special.

B.4 Numerical illustration

I use the following parameter values for the numerical illustration of the model:

$$\begin{aligned} \mu &= 2, \\ \gamma &= 2, \\ \sigma^2 &= 0.15, \\ a &= 0.1, \\ b &= 0.9, \\ \lambda_M &= 0.6, \\ \lambda_D &= 0.25, \\ \lambda_H &= 0.15, \end{aligned}$$

$$\begin{aligned}
e &= 7, \\
\bar{\theta} &= 1, \\
\omega &= 1 \quad (\text{for a benchmark asset}), \\
\omega &= 0 \quad (\text{for an off-benchmark asset}).
\end{aligned}$$

These parameter values correspond to the equilibrium with positive holdings of direct investors (positive expected return), negative holdings of hedgers (large enough endowment), and positive equilibrium price.

In Figure 1 in the main text, panel (a) uses $l = 0.50$ and panel (b) uses $l = 0.15$. These values yield a positive borrowing fee (asset is on special). Panel (c) in Figure 1 uses $l = 0.95$, which corresponds to the general collateral case with a zero borrowing fee. In the figure, equilibrium price is recomputed at each level of fee Δ and the given parameters to account for the fact that they are jointly determined.

B.5 Price sensitivity to benchmarking

An asset on special and a general collateral asset have different price sensitivities to benchmarking. Compare the price sensitivity of a general collateral asset,

$$\frac{\partial p}{\partial \omega_\lambda} = \frac{1}{\frac{\lambda_M}{(a+b)} + \lambda_D + \lambda_H} \gamma \sigma^2,$$

to that of a special asset,

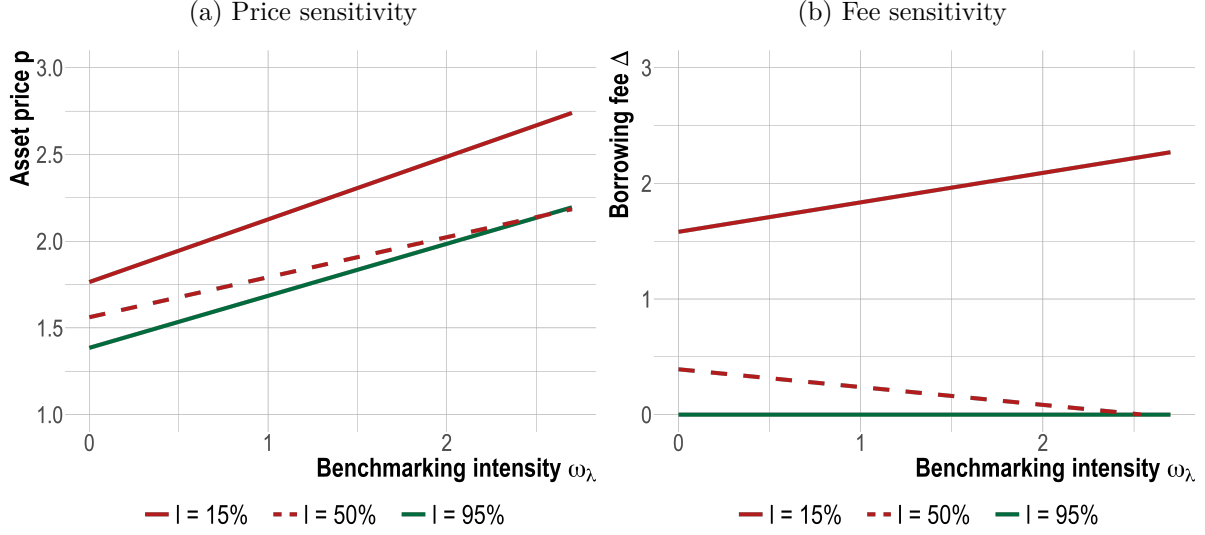
$$\frac{\partial p}{\partial \omega_\lambda} = \gamma \sigma^2 \bar{B} B_\omega = \frac{(1-l)\lambda_H}{\frac{\lambda_M}{a+b}(l^2\lambda_D + (1-l)^2\lambda_H) + \lambda_D\lambda_H} \gamma \sigma^2.$$

The latter is lower if and only if

$$\begin{aligned}
\frac{(1-l)\lambda_H}{\frac{\lambda_M}{a+b}(l^2\lambda_D + (1-l)^2\lambda_H) + \lambda_D\lambda_H} - \frac{1}{\frac{\lambda_M}{(a+b)} + \lambda_D + \lambda_H} < 0, \\
\text{or equivalently, } \frac{\lambda_H}{\lambda_H + \lambda_D} < l,
\end{aligned}$$

which is the same as condition (9), which defines equilibrium fee sensitivity to BMI for the asset on special. In this comparison, the asset on special is ex-ante different from the general collateral asset on other dimensions, for example, because hedgers are more endowed with it, that is, it has a higher e . I also assume that the change in benchmarking intensity is not large enough to make a

Figure B1: Sensitivity of equilibrium prices and fees to benchmarking



This figure plots the changes in equilibrium quantities due to changes in BMI in the model: equilibrium price in panel (a) and equilibrium borrowing fee in panel (b). In each panel, the two red lines correspond to special assets – one with the lending limit $l = 15\%$ ($C_\omega > 0$) and the other with $l = 50\%$ ($C_\omega < 0$), whereas the green line corresponds to a general collateral asset with $l = 95\%$. Appendix B.4 details all parameter values.

general collateral asset special, or the other way around.

In other words, asset pricing effects of investment mandates (or more specifically, benchmarking) are co-determined with the outcomes in the lending market of a special asset. In an economy with dominating demand effect of benchmarking in the lending market (if condition (9) does not hold), price sensitivity to BMI is higher for an asset on special or lower for a general collateral asset. This is illustrated in panel (a) of Figure B1: for the same change in BMI, an increase in the equilibrium asset price is smaller (larger) if condition (9) holds (does not hold) than the increase in the price of a general collateral asset. The equilibrium borrowing fees corresponding to these cases are plotted in panel (b).

B.6 Total derivatives of lending supply and demand with respect to BMI

B.6.1 Asset on special

For an asset on special, I find that both demand and supply always increase with benchmarking intensity ω_λ . Their sensitivity to it is the same because the lending market clearing condition is binding. Specifically, the general equilibrium responses of the shorting demand and

the lending supply are given by

$$\begin{aligned}
\frac{dQ^d}{d\omega_\lambda} &= \lambda_H \frac{1}{\gamma\sigma^2} \left(\frac{\partial p}{\partial \omega_\lambda} - \frac{\partial \Delta}{\partial \omega_\lambda} \right) \\
&= \bar{B}l\lambda_D\lambda_H, \\
\frac{dQ^s}{d\omega_\lambda} &= \frac{\partial Q^s}{\partial \omega_\lambda} + \frac{l\lambda_M}{\gamma\sigma^2(a+b)} \left(l \frac{\partial \Delta}{\partial \omega_\lambda} - \frac{\partial p}{\partial \omega_\lambda} \right) \\
&= \bar{B}l\lambda_D\lambda_H,
\end{aligned} \tag{34}$$

where the response of the supply includes the direct effect of benchmarking on supply, $\frac{\partial Q^s}{\partial \omega_\lambda}$, and the indirect effects through asset price and borrowing fee. Benchmarking-induced increase in shorting demand pushes the borrowing fee up and incentivizes fund managers to hold more of the asset despite the index effect.

B.6.2 General collateral asset

For a general collateral asset, the equilibrium lending supply and shorting demand also increase in BMI. However, since condition (6) is slack, their sensitivities are not the same.

The general equilibrium response of the shorting demand is

$$\begin{aligned}
\frac{dQ^d}{d\omega_\lambda} &= \frac{\partial Q^d}{\partial \omega_\lambda} + \lambda_H \frac{1}{\gamma\sigma^2} \frac{\partial p}{\partial \omega_\lambda} \\
&= \frac{\lambda_H}{\frac{\lambda_M}{(a+b)} + \lambda_D + \lambda_H} > 0.
\end{aligned}$$

The index effect implies that the shorting demand is positively related to BMI in equilibrium, whereas the strength of the relationship is defined by the share of hedgers in the population of price-elastic investors.

The general equilibrium response of the lending supply is

$$\begin{aligned}
\frac{dQ^s}{d\omega_\lambda} &= \frac{\partial Q^s}{\partial \omega_\lambda} - \frac{l\lambda_M}{\gamma\sigma^2(a+b)} \frac{\partial p}{\partial \omega_\lambda} \\
&= l \left(1 - \frac{\frac{\lambda_M}{(a+b)}}{\frac{\lambda_M}{(a+b)} + \lambda_D + \lambda_H} \right) \\
&= l \frac{\lambda_D + \lambda_H}{\frac{\lambda_M}{(a+b)} + \lambda_D + \lambda_H} > 0,
\end{aligned} \tag{35}$$

Benchmarking-induced increase in fund managers' holdings still translates to larger supply, although the increase is not necessarily the same as that of the shorting demand: It depends on

how $l(\lambda_D + \lambda_H)$ compares to λ_H . The response of the lending supply is larger if condition (9) holds.

C Economy with multiple assets

In this section, I verify robustness of my results for the risky asset with a positive borrowing fee in the presence of either a risky asset with a zero fee or another risky asset with a positive fee. I demonstrate that all key results remain valid in such more elaborate economies.

C.1 Economy with additional costless-to-short asset

I consider a simple extension of the baseline model by introducing a risky asset for which the lending market constraint is not binding.

The setup of the model is the same as in the main text, with one exception. There are now two risky assets paying cash flows D_i , $i = \{1, 2\}$, in period 1. The cash flows of the risky assets are given by

$$D_i = \bar{D}_i + \beta_i Z + \epsilon_i, \quad \beta_i > 0, \quad i = \{1, 2\},$$

where $Z \sim N(0, \sigma_z^2)$ is a common shock and $\epsilon_i \sim N(0, \sigma_\epsilon^2)$ is an idiosyncratic one. The vectors $D \equiv (D_1, D_2)'$ and $p \equiv (p_1, p_2)'$ denote vectors of period-1 cash flows and period-0 risky asset prices, respectively. The risky assets are in fixed supply of $\bar{\theta} \equiv (\bar{\theta}_1, \bar{\theta}_2)'$ shares. The variance-covariance matrix of cash flows D can be conveniently written as

$$\Sigma = \begin{pmatrix} \beta_1^2 \sigma_z^2 + \sigma_\epsilon^2 & \beta_1 \beta_2 \sigma_z^2 \\ \beta_1 \beta_2 \sigma_z^2 & \beta_2^2 \sigma_z^2 + \sigma_\epsilon^2 \end{pmatrix} = \begin{pmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{12} & \sigma_2^2 \end{pmatrix}$$

I also set $\bar{D} \equiv \mu = (\mu_1, \mu_2)'$ and $\beta \equiv (\beta_1, \beta_2)'$. Borrowing fees are also represented by the vector $\Delta \equiv (\Delta_1, \Delta_2)'$, with $\Delta_2 = 0$. Finally, the benchmark index is now a portfolio of $\omega = (\omega_1, \omega_2)'$, in which individual components ω_i , $i = \{1, 2\}$, may be zero.

Below I will use an analytical expression for the inverse of Σ ,

$$\Sigma^{-1} = \frac{1}{\underbrace{\sigma_1^2 \sigma_2^2 - \sigma_{12}^2}_A} \begin{pmatrix} \sigma_2^2 & -\sigma_{12} \\ -\sigma_{12} & \sigma_1^2 \end{pmatrix} = \begin{pmatrix} A\sigma_2^2 & -A\sigma_{12} \\ -A\sigma_{12} & A\sigma_1^2 \end{pmatrix}.$$

C.1.1 Portfolio choice

Solutions to investors' problems are equivalent to the baseline model. In particular, the direct investors choose the demand function:

$$\begin{aligned} \theta_D &= \frac{1}{\gamma} \Sigma^{-1} (\mu - p), \\ \text{i.e.} \quad \theta_D &= \frac{1}{\gamma} \begin{pmatrix} A\sigma_2^2 & -A\sigma_{12} \\ -A\sigma_{12} & A\sigma_1^2 \end{pmatrix} \begin{pmatrix} \mu_1 - p_1 \\ \mu_2 - p_2 \end{pmatrix}, \\ \begin{pmatrix} \theta_{D1} \\ \theta_{D2} \end{pmatrix} &= \frac{1}{\gamma} \begin{pmatrix} A\sigma_2^2(\mu_1 - p_1) - A\sigma_{12}(\mu_2 - p_2) \\ -A\sigma_{12}(\mu_1 - p_1) + A\sigma_1^2(\mu_2 - p_2) \end{pmatrix} \end{aligned} \quad (36)$$

Fund managers' demand is given by

$$\begin{aligned} \theta_M &= \frac{1}{\gamma(a+b)} \Sigma^{-1} (l\Delta + \mu - p) + \frac{b}{a+b} \omega, \\ \text{i.e.} \quad \theta_M &= \frac{1}{\gamma(a+b)} \begin{pmatrix} A\sigma_2^2 & -A\sigma_{12} \\ -A\sigma_{12} & A\sigma_1^2 \end{pmatrix} \begin{pmatrix} l\Delta_1 + \mu_1 - p_1 \\ \mu_2 - p_2 \end{pmatrix} + \frac{b}{a+b} \begin{pmatrix} \omega_1 \\ \omega_2 \end{pmatrix}, \\ \begin{pmatrix} \theta_{M1} \\ \theta_{M2} \end{pmatrix} &= \frac{1}{\gamma(a+b)} \begin{pmatrix} A\sigma_2^2(l\Delta_1 + \mu_1 - p_1) - A\sigma_{12}(\mu_2 - p_2) \\ -A\sigma_{12}(l\Delta_1 + \mu_1 - p_1) + A\sigma_1^2(\mu_2 - p_2) \end{pmatrix} + \frac{b}{a+b} \begin{pmatrix} \omega_1 \\ \omega_2 \end{pmatrix} \end{aligned} \quad (37)$$

Note that $l \in (0, 1]$ is still a scalar of the same size across all risky assets.

Lastly, hedgers' demand function is

$$\begin{aligned} \theta_H &= \frac{1}{\gamma} \Sigma^{-1} (\mu - p + \Delta) - e, \\ \begin{pmatrix} \theta_{H1} \\ \theta_{H2} \end{pmatrix} &= \frac{1}{\gamma} \begin{pmatrix} A\sigma_2^2(\Delta_1 + \mu_1 - p_1) - A\sigma_{12}(\mu_2 - p_2) \\ -A\sigma_{12}(\Delta_1 + \mu_1 - p_1) + A\sigma_1^2(\mu_2 - p_2) \end{pmatrix} - \begin{pmatrix} e_1 \\ e_2 \end{pmatrix} \end{aligned} \quad (38)$$

where $e \equiv (e_1, e_2)'$ is a vector of endowment shocks. Similar to the main text, I assume that they are large enough so that all holdings of hedgers are negative in equilibrium (net short in all risky assets).

C.1.2 Equilibrium prices and borrowing fees

I use the market clearing conditions (5) and (6) as well as the optimal portfolio choice of the investors (36)–(38) to solve for the equilibrium asset price and the borrowing fee of asset 1. To solve for the price of asset 2, I use only the asset market clearing condition (5) and set the fee to zero.

The expression for the equilibrium borrowing fee for asset 1 is

$$\Delta_1 = \frac{\gamma}{\sigma_2^2 A} \bar{B} \left(C_e e_1 - C_\theta \bar{\theta}_1 + C_\omega \omega_{\lambda 1} \right), \quad (39)$$

where C_e , C_θ , C_ω , and $\bar{B}$ are scalars defined in the main text,

$$\omega_{\lambda 1} = \frac{b}{a+b} \lambda_M \omega_1,$$

and $A = 1/(\sigma_1^2 \sigma_2^2 - \sigma_{12}^2) > 0$ if the correlation between the assets is not perfect. Notice that the equilibrium borrowing fee in the presence of asset 2, given by (39), is almost the same as the equilibrium borrowing fee in one-asset economy, given by (8) in the main text. The only difference is in the effective risk aversion. Therefore, the presence of asset 2 does not affect the key predictions of the baseline model, including the ambiguous relationship between benchmarking with either asset borrowing fee or its specialness.

The expression for the equilibrium price of asset 2 is

$$p_2 = \mu_2 + \bar{C} \frac{\gamma}{A} \left[\omega_{\lambda 2} - \bar{\theta}_2 - \lambda_H e_2 - \frac{\sigma_{12}}{\sigma_2^2} \left(\lambda_H e_1 + \bar{\theta}_1 - \omega_{\lambda 1} \right) \right], \quad (40)$$

where $\bar{C}$ is a positive scalar,

$$\bar{C} = \frac{1}{\left(\lambda_D + \frac{\lambda_M}{a+b} + \lambda_H \right) (\sigma_1^2 - \sigma_{12}^2 / \sigma_2^2)}.$$

The key intuition from the expression for equilibrium price of asset 2 (40) is the same as for the general collateral asset in the main text (see discussion near (10)). There are two differences. First, the presence of the second asset alters effective risk aversion through A and $\bar{C}$. Second, features of asset 1 affect the price of asset 2 through the covariance σ_{12} .

Finally, the equilibrium price for asset 1.

$$p_1 = \mu_1 + \frac{\gamma}{\sigma_2^2 A} \left[D_e e_1 - D_\theta \bar{\theta}_1 + D_\omega \omega_{\lambda 1} + \sigma_{12} \bar{C} \left(\omega_{\lambda 2} - \bar{\theta}_2 - \lambda_H e_2 \right) \right], \quad (41)$$

where D_e , D_θ , and D_ω are scalars:

$$\begin{aligned} D_e &= B_e - \frac{\sigma_{12}^2}{\sigma_2^2} \bar{C}, \\ D_\theta &= B_\theta + \frac{\sigma_{12}^2}{\sigma_2^2} \bar{C}, \\ D_\omega &= B_\omega + \frac{\sigma_{12}^2}{\sigma_2^2} \bar{C}, \end{aligned}$$

with scalars B_e , B_θ , and B_ω defined in the main text.

In sum, the predictions of this model are very similar to the baseline economy without the second asset. In particular, the equilibrium price of asset 1 always decreases in supply and increases in its own BMI, as well as the BMI of asset 2 if they are positively correlated.

C.2 Economy with additional costly-to-short asset

In this section, I consider a version of the economy in which both assets are on special at the same time. The setup is as in C.1 except for the binding lending market clearing for asset 2.

I use market clearing conditions (5) and (6) as well as the optimal portfolio choice of the investors (36)–(38) to solve for the equilibrium asset price and borrowing fee (in vector forms).

The expression for the equilibrium borrowing fee Δ is

$$\Delta = \gamma \Sigma \bar{B} (C_e e - C_\theta \bar{\theta} + C_\omega \omega_\lambda), \quad (42)$$

where C_e , C_θ , C_ω , and $\bar{B}$ are as in the main text. It is the exact counterpart of the expression in the main text in vector form, except for one conceptual difference – specialness of an asset (whether $\Delta > 0$) is affected by the specialness of another correlated asset. Intuitively, if assets are close substitutes, hedgers may be able to use asset 2 to hedge endowment shock in asset 1 or the other way around.

The expression for the equilibrium asset price is

$$p = \mu + \gamma \Sigma \bar{B} (B_e e - B_\theta \bar{\theta} + B_\omega \omega_\lambda), \quad (43)$$

where B_e , B_θ , B_ω , and $\bar{B}$ are exactly the same as in the main text.

In sum, the predictions of this model are virtually the same as in the baseline economy without the second asset.

D Economy with other (not benchmarked) lenders

In this section, I describe the equilibrium in an economy in which direct investors are allowed to lend up to a limit $\varphi \in (0, 1)$. All other assumptions are the same as in the baseline model in Section 3.

Direct investor's demand function is

$$\theta_D = \frac{1}{\gamma\sigma^2}(\mu - p + \varphi\Delta),$$

whereas the demand functions of the other investors are as in the main text. Intuitively, the direct investor deviates from the mean-variance portfolio to earn income from lending.

Direct investor's supply now contributes to the market condition in the lending market,

$$l\lambda_M\theta_M + \lambda_H\theta_H + \varphi\lambda_D\theta_D \geq 0.$$

Market clearing condition in the asset market is the same as in the baseline model (see (5)), so the solution for a general collateral asset is the same as in the main text.

D.1 Equilibrium asset price and borrowing fee

Using the updated market clearing conditions and demand functions, I arrive at the equilibrium borrowing fee for a special asset,

$$\Delta = \gamma\sigma^2\bar{B} \left(C_e e - C_\theta \bar{\theta} + C_\omega \omega_\lambda \right), \quad (44)$$

where C_e , C_θ , C_ω , and $\bar{C}$ are scalars:

$$\begin{aligned} C_e &= \lambda_H \left((1-l) \frac{\lambda_M}{a+b} + (1-\varphi)\lambda_D \right), \\ C_\theta &= l \frac{\lambda_M}{a+b} + \lambda_H + \varphi\lambda_D, \\ C_\omega &= (1-l)\lambda_H - (l-\varphi)\lambda_D, \\ \bar{B} &= \frac{1}{\frac{\lambda_M}{a+b}((l-\varphi)^2\lambda_D + (1-l)^2\lambda_H) + (1-\varphi)^2\lambda_D\lambda_H}. \end{aligned}$$

As in the baseline model, $C_e > 0$ and $C_\theta > 0$ because $l \in (0, 1)$ and $\varphi \in (0, 1)$, whereas $C_\omega < 0$ if and only if

$$l > \frac{\lambda_H + \varphi\lambda_D}{\lambda_H + \lambda_D},$$

as opposed to condition (9) in the main text. This means that the supply effect of benchmarking is less likely dominant when direct investors are allowed to lend. This is because fund managers now constitute only a part of the overall supply.

Similarly, I can get the equilibrium price for a special asset,

$$p = \mu + \gamma\sigma^2(B_e e - B_\theta \bar{\theta} + B_\omega \omega_\lambda), \quad (45)$$

where B_e , B_θ , and B_ω are scalars:

$$\begin{aligned} B_e &= \bar{B}\lambda_H \left(\frac{\lambda_M}{a+b} + \lambda_H + \lambda_D \right) \left[(1-l)l \frac{\lambda_M}{a+b} + (1-\varphi)\varphi\lambda_D \right], \\ B_\theta &= \bar{B} \left(\left[l \frac{\lambda_M}{a+b} + \lambda_H + \varphi\lambda_D \right]^2 + \frac{1}{\bar{B}} \right), \\ B_\omega &= 1 + \bar{B}C_\theta C_\omega. \end{aligned}$$

$B_e > 0$ and $B_\theta > 0$ as in the baseline case. In contrast, B_ω may be positive or negative. When $C_\omega > 0$, that is, the demand effect of benchmarking dominates, $B_\omega > 0$, or the price increases in BMI. When $C_\omega < 0$, that is, the supply effect of benchmarking dominates, B_ω may become negative. The index effect may be negative in an economy where both direct and benchmarked investors are allowed to lend. At the same time, in the case when benchmarked investors' lending limit is stricter than or equal to the direct investors' lending limit, that is, $l \leq \varphi$, it is easy to show that $B_\omega > 0$ and C_ω may be negative or positive.

Finally, the asset is special if and only if the equilibrium fee is positive, or $C_e e - C_\theta \bar{\theta} + C_\omega \omega_\lambda > 0$, which can be written as a condition on lending limit l :

$$l < \lambda_H \frac{\left(\frac{\lambda_M}{a+b} + \lambda_D \right) e - \bar{\theta} + \omega_\lambda}{\frac{\lambda_M}{a+b}(\lambda_H e + \bar{\theta}) + (\lambda_D + \lambda_H)\omega_\lambda} - \varphi\lambda_D \frac{\lambda_H e + \bar{\theta} - \omega_\lambda}{\frac{\lambda_M}{a+b}(\lambda_H e + \bar{\theta}) + (\lambda_D + \lambda_H)\omega_\lambda}.$$

The first fraction in the condition above is the same as in the main text (see Section 3.3.3). Furthermore, because the BMI cannot be larger than the asset supply, i.e., $\omega_\lambda \leq \bar{\theta}$, it is easier for an asset to become a general collateral asset in this economy. This is intuitive because the additional supply from direct investors relaxes the market clearing condition in the lending market.

E Economy with costly lending

E.1 Model setup

The model setup is the same as in the main text except for how the lending limit is set. Rather than being exogenous, it is now optimally chosen by fund managers, who face a per-unit cost $c(l)$ to lend a fraction l of their risky holding, where $c(l)$ is nonnegative, non-decreasing, convex, $c(0) = 0$, and $c'(0) = 0$. I use the same notation as lending limit in the baseline model l for simplicity.

In other words, fund managers' optimization problem now depends on the cost, and they choose the level of lending:

$$\max_{\theta_M, l} E_0[-\exp\{-\gamma((a+b)\theta_M(l\Delta + \bar{D} - p - c(l)) - b\omega(\bar{D} - p))\}]. \quad (46)$$

Other investors' optimization problems remain the same.

The market clearing conditions both in the long market and in the lending market are the same as in the main text.

E.2 Portfolio choice

The portfolio demands of the direct investors and hedgers are the same. In contrast, a fund manager's demand is given by

$$\theta_M = \frac{1}{\gamma\sigma^2(a+b)}(\mu - p) + \frac{b}{a+b}\omega + \frac{1}{\gamma\sigma^2(a+b)}(l\Delta - c(l)). \quad (47)$$

Intuitively, the costs enter the return-augmenting part of the fund manager's portfolio.

The chosen lending limit has to simply satisfy

$$\Delta = c'(l), \quad (48)$$

where the marginal increase in lending limit equates the marginal cost, Δ .

If I assume a certain form for the cost function, for example, quadratic costs $c(l) = \varphi + \kappa \frac{l^2}{2}$, I can get an explicit solution for l ,

$$l = \frac{\Delta}{\kappa}. \quad (49)$$

E.3 Equilibrium price and borrowing fee

I use market clearing conditions (5) and (6) as well as the optimal portfolio choice of the investors (2), (4), and (47) to solve for the equilibrium asset price and borrowing fee. First, substitute the demand functions (47) and (4) into the market clearing condition in the lending market (6),

$$l\lambda_M\theta_M + \lambda_H\theta_H = 0,$$

$$l\lambda_M \left(\frac{1}{\gamma\sigma^2(a+b)}(l\Delta + \mu - p - c(l)) + \frac{b}{a+b}\omega \right) + \lambda_H \left(\frac{1}{\gamma\sigma^2}(\mu - p + \Delta) - e \right) = 0,$$

which yields the following expression for $p - l\Delta$:

$$p - l\Delta = \mu + \frac{1}{l\lambda_M/(a+b) + \lambda_H} \left[(1-l)\lambda_H\Delta + \gamma\sigma^2 l\lambda_M b/(a+b)\omega - \gamma\sigma^2 \lambda_H e - \frac{l\lambda_M}{a+b}c(l) \right]. \quad (50)$$

Then, combine the market clearing conditions in the lending market (6) and in the asset market (5) to get

$$\lambda_D\theta_D + (1-l)\lambda_M\theta_M = \bar{\theta}.$$

Substituting the demand functions (2) and (47) into the expression above yields another expression for $p - l\Delta$,

$$p - l\Delta = \mu - \frac{1}{(1-l)\lambda_M/(a+b) + \lambda_D} \left[\lambda_D l\Delta + (1-l)\frac{\lambda_M}{a+b}c(l) + \gamma\sigma^2 \bar{\theta} - \gamma\sigma^2 (1-l)\lambda_M b/(a+b)\omega \right]. \quad (51)$$

Subtract (51) from (50) and rearrange to get the expression for the equilibrium borrowing fee Δ ,

$$\Delta = \gamma\sigma^2 \bar{B} \left(C_e e - C_\theta \bar{\theta} + C_\omega \omega \right) - \bar{B} C_\omega \frac{\lambda_M}{a+b} c(l), \quad (52)$$

where C_e , C_θ , C_ω , and $\bar{B}$ are scalars:

$$C_e = \lambda_H \left((1-l)\frac{\lambda_M}{a+b} + \lambda_D \right),$$

$$C_\theta = l\frac{\lambda_M}{a+b} + \lambda_H,$$

$$C_\omega = (1-l)\lambda_H - l\lambda_D,$$

$$\bar{B} = \frac{1}{\frac{\lambda_M}{a+b}(l^2\lambda_D + (1-l)^2\lambda_H) + \lambda_D\lambda_H},$$

and the last term in (52) means that the fee incorporates the costs that the fund managers have to incur. If the demand effect of benchmarking dominates, or $C_\omega > 0$, the fee is negatively related to the costs.

To solve for Δ and l , need to plug in the solution for $\Delta = c'(l)$ and solve the nonlinear equation in l . In the case of quadratic costs, $l = \frac{\Delta}{\kappa}$ and this nonlinear equation becomes

$$\left(\frac{\lambda_M}{a+b} (l^2 \lambda_D + (1-l)^2 \lambda_H) + \lambda_D \lambda_H \right) \kappa l = \gamma \sigma^2 \left(C_e e - C_\theta \bar{\theta} + C_\omega \omega_\lambda \right) - C_\omega \frac{\lambda_M}{a+b} \left(\varphi + \kappa \frac{l^2}{2} \right).$$

It has three roots and I focus on the solution with a positive and real equilibrium borrowing fee. This solution can then be plugged into expression (51) to compute the corresponding equilibrium price.

Maintaining the assumption of quadratic costs, I verify numerically that there exist solutions with the positive price, positive fee, positive expected return, and $l \in (0, 1)$. Because the presence of endogenous l makes the expression for p less interpretable, I also verify that the price sensitivity to ω_λ is unambiguously positive in this model. I also find that, under admissible parameter values, C_ω may take both positive and negative values. In other words, the model with costly lending and endogenous lending limit still delivers both the demand and supply effects of benchmarking.

F Economy with costly search by borrowers

F.1 Model setup

The model setup is the same as in the main text except for how the lending limit is set. Rather than being exogenous, it is now optimally defined by the search intensity of hedgers. Hedgers are assumed to incur a utility cost $c(l)$ to search for lenders, and l is the search intensity, or the probability of meeting a long investor who lends (i.e., a fund manager). If a hedger meets a lender, they submit a demand schedule $\theta_{H1} = \theta_H$, if not, they submit $\theta_{H0} = 0$.

Hedger's problem is therefore

$$\begin{aligned} \max_{l, \theta_H} \quad & l E_0[-\exp\{-\gamma(W_0^H + e\bar{D} + \theta_H(\bar{D} - p + \Delta \mathbf{1}_{\theta_H < 0}))\}] \\ & + (1-l) E_0[-\exp\{-\gamma(W_0^H + e\bar{D})\}] - c(l), \end{aligned} \tag{53}$$

or, equivalently,

$$\begin{aligned} \max_{l, \theta_H} \quad & -l \exp\{-\gamma[W_0^H + e\mu + \theta_H(\mu - p + \Delta) - \frac{\gamma}{2}\sigma^2(e + \theta_H)^2]\} \\ & - (1-l) \exp\{-\gamma(W_0^H + e\mu - \frac{\gamma}{2}\sigma^2 e^2)\} - c(l). \end{aligned} \quad (54)$$

Similarly, fund manager's problem now depends on whether they meet a hedger or not.

$$\begin{aligned} \max_{\theta_1^M, \theta_0^M} \quad & lE_0[-\exp\{-\gamma((a+b)\theta_1^M(\Delta + \bar{D} - p) - b\omega(\bar{D} - p))\}] \\ & + (1-l)E_0[-\exp\{-\gamma((a+b)\theta_0^M(\bar{D} - p) - b\omega(\bar{D} - p))\}]. \end{aligned} \quad (55)$$

The market clearing condition in the asset market becomes

$$\lambda_D \theta_D + l(\lambda^M \theta_1^M + \lambda_H \theta_H) + (1-l)\lambda^M \theta_0^M = \bar{\theta}. \quad (56)$$

The lending market clearing condition is

$$l(\lambda^M \theta_1^M + \lambda_H \theta_H) \geq 0. \quad (57)$$

F.2 Portfolio choice

The portfolio demand of the direct investors is the same. In contrast, a fund manager's demand is given by

$$\theta_1^M = \frac{1}{\gamma\sigma^2(a+b)}(\mu - p) + \frac{b}{a+b}\omega + \frac{1}{\gamma\sigma^2(a+b)}\Delta \quad (58)$$

if they meet a hedger and

$$\theta_0^M = \frac{1}{\gamma\sigma^2(a+b)}(\mu - p) + \frac{b}{a+b}\omega, \quad (59)$$

if they do not.

Finally, a hedger's portfolio demand, if they meet a lender, is

$$\theta_H = \frac{1}{\gamma\sigma^2}(\mu - p + \Delta) - e. \quad (60)$$

The search intensity is a unique solution to

$$-\exp\{-\gamma[W_0^H + e\mu + \theta_H(\mu - p + \Delta) - \frac{\gamma}{2}\sigma^2(e + \theta_H)^2]\} + \exp\{-\gamma(W_0^H + e\mu - \frac{\gamma}{2}\sigma^2 e^2)\} = c'(l). \quad (61)$$

It exists because the term on the left is a difference in expected utility under hedging and not hedging and $c(l)$ is nonnegative, strictly increasing and convex (ensuring uniqueness of the solution for search intensity l).

F.3 Equilibrium price and borrowing fee

For a positive fee to arise, lending market clearing has to bind. Therefore,

$$\lambda_H \theta_H = -l^M \theta_1^M.$$

Plugging this into the asset market clearing condition (56) and substituting demand functions,

$$\begin{aligned} \lambda_D \theta_D + (1-l)\lambda^M \theta_0^M &= \bar{\theta}, \\ \lambda_D \frac{1}{\gamma\sigma^2} (\mu - p) + (1-l)\lambda^M \left[\frac{1}{\gamma\sigma^2(a+b)} (\mu - p) + \frac{b}{a+b} \omega \right] &= \bar{\theta}. \end{aligned}$$

This gives an expression for the equilibrium asset price

$$p = \mu + \gamma\sigma^2 A \left[(1-l)\lambda^M \frac{b}{a+b} \omega - \bar{\theta} \right],$$

where $A = \frac{1}{\lambda_D + (1-l)\lambda^M \frac{1}{(a+b)}}$. Notice that the price does not depend on the hedger's endowment shock directly. It depends on it only through the relationship between the search intensity l and the equilibrium fee Δ .

Solve for the fee using the lending market clearing, demand functions, and the equilibrium

price.

$$\begin{aligned}
\lambda_H \theta_H &= -\lambda^M \theta_1^M, \\
\lambda_H \left[\frac{1}{\gamma \sigma^2} (\mu - p + \Delta) - e \right] &= -\lambda^M \left[\frac{1}{\gamma \sigma^2 (a+b)} (\mu - p) + \frac{b}{a+b} \omega + \frac{1}{\gamma \sigma^2 (a+b)} \Delta \right], \\
\left(\lambda_H + \frac{\lambda^M}{a+b} \right) \Delta &= \gamma \sigma^2 \lambda_H e \\
&\quad + \gamma \sigma^2 \left(A(1-l) \left[\lambda_H + \lambda^M \frac{1}{(a+b)} \right] - 1 \right) \omega_\lambda - \gamma \sigma^2 A \bar{\theta} \left[\lambda_H + \lambda^M \frac{1}{a+b} \right],
\end{aligned}$$

where I used $\mu - p = \gamma \sigma^2 A \left[\bar{\theta} - (1-l) \lambda^M \frac{b}{a+b} \omega \right]$ and $\omega_\lambda = \lambda^M \frac{b}{a+b} \omega$. The coefficient on e and $\bar{\theta}$ is unambiguously positive and negative, respectively. Simplifying the coefficient on ω_λ using A , I get

$$A(1-l) \left[\lambda_H + \lambda^M \frac{1}{(a+b)} \right] - 1 = \frac{(1-l) \lambda_H - \lambda_D}{\lambda_D + (1-l) \lambda^M \frac{1}{(a+b)}},$$

which is positive iff

$$\frac{\lambda_H - \lambda_D}{\lambda_H} > l. \quad (62)$$

Thus, the demand effect of benchmarking dominates if the search intensity is small enough. Similar to the main text, the prediction is ambiguous. If there are no direct investors, or $\lambda_D = 0$, the demand effect always dominates, also in line with the main text.

The final expression for the equilibrium fee is

$$\Delta = \frac{\gamma \sigma^2}{\lambda_H + \frac{\lambda^M}{a+b}} \left(\lambda_H e + A [(1-l) \lambda_H - \lambda_D] \omega_\lambda - A \left[\lambda_H + \lambda^M \frac{1}{a+b} \right] \bar{\theta} \right),$$

which intuitively is quite similar to that in the main text.

F.4 Equilibrium search intensity

Because search intensity is chosen by hedgers, I need to solve for it to understand the condition (62). To do so, I plug the equilibrium quantities into (61)

$$\begin{aligned}
c'(l) &= -\exp\{-\gamma[W_0^H + e\mu + \theta_H(\mu - p + \Delta) - \frac{\gamma}{2}\sigma^2(e + \theta_H)^2]\} + \exp\{-\gamma(W_0^H + e\mu - \frac{\gamma}{2}\sigma^2 e^2)\} \\
&= \mathcal{E} \left[-\exp\{-\gamma[\theta_H(\mu - p + \Delta) - \frac{\gamma}{2}\sigma^2(\theta_H^2 + 2e\theta_H)]\} + 1 \right],
\end{aligned}$$

where $\mathcal{E} = \exp\{-\gamma(W_0^H + e\mu - \frac{\gamma}{2}\sigma^2 e^2)\}$. Simplifying the part in the exponent using equilibrium quantities, I get

$$-\gamma[\theta_H(\mu - p + \Delta) - \frac{\gamma}{2}\sigma^2\theta_H^2 - \gamma\sigma^2 e\theta_H] = -\frac{1}{2\sigma^2} \left[(\mu - p + \Delta - \gamma\sigma^2 e)^2 \right].$$

Therefore, the equation for the equilibrium search intensity becomes

$$c'(l) = \mathcal{E} \left[1 - e^{-\frac{1}{2\sigma^2} \left(\frac{\gamma\sigma^2}{\lambda_H + \frac{\lambda M}{a+b}} \left[\frac{\lambda M}{a+b} e + \omega_\lambda \right] \right)^2} \right],$$

which is an expression in model parameters. Intuitively, the marginal cost of searching is equal to the increase in hedger's expected utility from being able to trade in the asset (i.e., from locating a lender).

In the case of quadratic costs, $c(l) = \varphi + \kappa \frac{l^2}{2}$ for some positive constants $\kappa > 0$ and $\varphi \geq 0$, the equilibrium search intensity is defined by

$$\kappa l = \mathcal{E} \left[1 - e^{-\frac{1}{2\sigma^2} \left(\frac{\gamma\sigma^2}{\lambda_H + \frac{\lambda M}{a+b}} \left[\frac{\lambda M}{a+b} e + \omega_\lambda \right] \right)^2} \right],$$

where $\mathcal{E} = \exp\{-\gamma(W_0^H + e\mu - \frac{\gamma}{2}\sigma^2 e^2)\}$.

Maintaining the assumption of quadratic costs, I verify numerically that there exist solutions with the positive price, positive fee, positive expected return, and $l \in (0, 1)$. Because the presence of endogenous l makes the expression for p less interpretable, I also verify that the price sensitivity to ω_λ is unambiguously positive in this model. Finally, I find that, under admissible parameter values, condition (62) is sometimes satisfied and sometimes it is not. In other words, the model with costly search and endogenous lending limit still delivers both the demand and supply effects of benchmarking.

G Evidence from the BoJ ETF purchase program

In this section, I test the predictions of my model in the Japanese equity market using the ETF purchases of the BoJ as shocks to BMI. In addition to index reconstitutions, the amount of capital benchmarked against securities is also affected by investment flows. The Japanese monetary easing program has been unique in its purchases of equity funds and its impact on benchmarking intensities of domestic stocks. The literature has shown that the purchases reduced risk premium (Barbon and Gianinazzi (2019)) while their real effects are debated (Charoenwong, Morck, and Wiwattanakantang (2021)). Maeda, Shino, and Takahashi (2022) study the securities lending market and document that the BoJ's purchases increased lending supply. They also use the annual reports of investment companies to document position-level lending limits ranging from 40% to 80%.³⁸ None of the papers has explored how the program affected borrowing fees.³⁹

G.1 The structure of the BoJ ETF purchase program

Since 2010, the BoJ has engaged in programs known as comprehensive monetary easing and quantitative and qualitative easing, aimed at combating deflation. As part of both programs, the BoJ has increased its domestic equity holdings through purchases of ETFs linked to Japanese market indexes. Aggressive purchases led to the BoJ becoming the majority owner of those ETFs.

Within the ETF purchase program, the BoJ has bought funds tracking three major Japanese equity market indexes, namely the TOPIX, Nikkei 225, and JPX-Nikkei 400. I report the list of ETFs tracking these indexes in Table C2 of this Internet Appendix. Importantly, the BoJ's purchases have been virtually the only source of flows in the target ETFs, and Figure C1 demonstrates that the cumulative flows are closely in line with the cumulative BoJ purchases. Figure C1 also indicates the announcement dates of the major policy changes, such as the announcement of the first purchases in 2010, the introduction of the qualitative and quantitative easing program in 2013, multiple expansions of its size and changes in its composition. I provide more details on each of the announcements in Table C3 in the Internet Appendix.

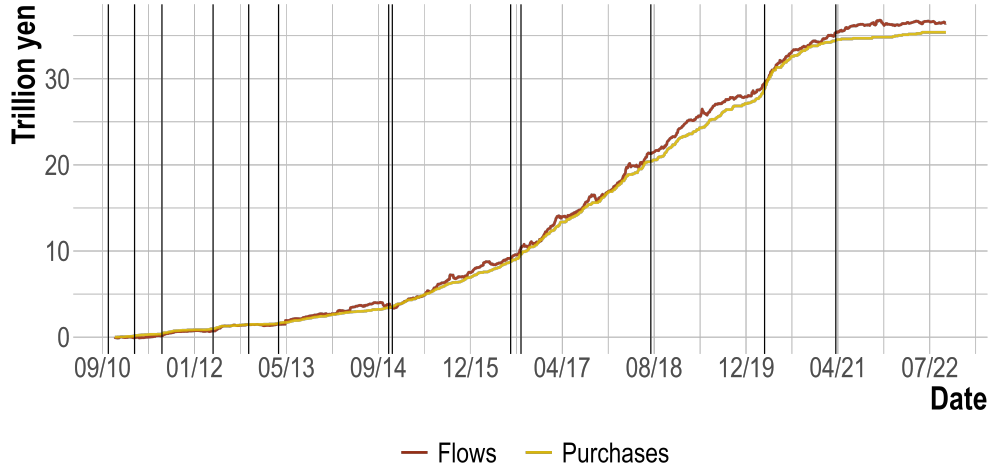
In the language of my model, the BoJ's purchases of ETFs increased the share of selected benchmarked funds in the economy and hence affected the benchmarking intensities of stocks in the major market indexes.⁴⁰ Due to the unprecedented size of the program, these changes in

³⁸Japanese regulators do not impose any portfolio-level limits.

³⁹An exception is contemporaneous and independent work by Katagiri, Shino, and Takahashi (2025), who use a different identification strategy to study borrowing fees and also highlight the importance of linking the spot and lending market effects of the BoJ's purchases.

⁴⁰An important assumption behind my analysis is that ETFs are closely tracking their benchmarks. First, tracking errors are indeed low across the relevant ETFs. Morningstar reports one-year annualized tracking

Figure C1: The BoJ purchases and flows in the target ETFs



This figure plots cumulative ETF purchases of the BoJ and cumulative ETF flows (in trillion yen). Solid vertical lines indicate the BoJ announcement dates related to ETF purchases, splitting the sample into 13 policy periods used in the tests below.

benchmarking intensities are economically large, with the BoJ's ownership reaching 30% of the market value of certain stocks and buying as much as 12% in a given policy period. Furthermore, the design of the program allows me to isolate changes in benchmarking intensities that are arguably exogenous, as discussed below.

G.2 The effects of the BoJ's purchases on spot and lending markets

In this section, I use the BoJ's purchases of ETFs as a shock to BMI to test predictions of my model in the Japanese stock market. Even though the academic literature has studied the risk premium effects of the BoJ's ETF purchases, the program's impact on the lending markets has received only limited attention.

G.2.1 Changes in benchmarked capital due to the BoJ's purchases

I focus on key policy periods that followed the BoJ announcements that either expanded the program size or changed the allocation between indexes. Table C3 in the Internet Appendix lists

errors of around 115 bps for ETFs tracking the TOPIX and JPX-Nikkei 400 indexes and around 284 bps for ETFs tracking the Nikkei 225 index, with very little variation within a benchmark (all values are as of November 2022). Second, any noise in the investment of ETF flows works against finding any relationship between the BoJ's purchases and lending supply.

all announcements related to the BoJ's ETF program and classifies policy periods into reallocative and expansive ones. My analysis covers the entire history of the BoJ's holdings of ETFs.

The test is designed at the level of each policy period so that the estimates combine the announcement effects with the flow effects of the actual purchases. This is to preserve consistency with my (static) model, in which the announcement and implementation of a change in BMI occur at the same time.

For each policy period, I compute the total stock-level purchases implied by the BoJ-driven ETF flows. Specifically,

$$BoJ\ purchase_{ip} = \sum_{t \in p} BoJ\ purchase_t \times (\omega_{it}^{TOPIX} \times S_t^{TOPIX} + \omega_{it}^{Nikkei225} \times S_t^{Nikkei225} + \omega_{it}^{JPXNikkei400} \times S_t^{JPXNikkei400}), \quad (63)$$

where S_t^j is the share of BoJ purchases allocated to index j on day t , ω_{it}^j is the weight of stock i in index j on day t , $BoJ\ purchase_t$ is the total size of the BoJ's purchase in JPY on day t reported on the BoJ's website. The shares S_t^j are computed using ETF assets and allocation rules as defined by the BoJ's announcement for period p . I assume that the allocation rule holds not only on aggregate but also at each purchase.

Purchases defined in (63) measure the actual ownership of the BoJ, yet they cannot be used as shocks to BMI because of their expected component. Because the BoJ's policy was not bounded to a single policy period, market participants expected it to continue purchasing ETFs (e.g., at the previously announced pace). For this reason, if I were to use purchases in definition (63) as shocks, I would be assuming that expected purchases were zero. See, for example, the studies of cross-sectional effects of the Federal Reserve's quantitative easing programs (D'Amico and King (2013)).

Therefore, I construct the shocks to BMIs as changes in BoJ's purchases relative to the market value of each stock, specifically,

$$\Delta BMI_{ip}^{BoJ} = \frac{1}{MV_{ip-1}} \left(BoJ\ purchase_{ip} - BoJ\ purchase_{ip-1} \frac{Days_p}{Days_{p-1}} \right), \quad (64)$$

where MV_{ip-1} is stock i 's market value in JPY based on Compustat Global price and number of shares as of the last day of period $p - 1$, i.e., immediately prior to period p , $BoJ\ purchase_{ip}$ is defined above, and $\frac{Days_p}{Days_{p-1}}$ is an adjustment for duration, with $Days_p$ being the number of days in period p . In brackets, the second term is how large the purchases would have been in period p if no policy change was announced at the beginning of period p . ΔBMI_{ip}^{BoJ} takes into account both

reallocative and expansive changes to the program and, consistent with my model, assumes that market participants correctly impute the size of stock-level purchases in each policy period.

There is a body of literature on the pricing effects of the program that argues for the cross-sectional exogeneity of the BoJ’s purchases (see, e.g., [Barbon and Gianinazzi \(2019\)](#)). There are two reasons why the change in BMI, as measured by ΔBMI^{BoJ} , is plausibly exogenous. The first reason is that the Nikkei 225 index is a price-weighted index, which makes $\omega^{Nikkei225}$ unrelated to the size of the stock.⁴¹ Second, the allocation across indexes (i.e., shares S^j) was not related to the fundamentals of a given stock.

G.2.2 Regression specifications

To study how the changes in BMI affected lending market variables, I compute changes during each policy period in the following way:

$$\Delta Y_{ip} = Y_{ip}^{end} - Y_{ip-1}^{end},$$

where Y_{ip}^{end} is the borrowing fee, active lending inventory, or short quantity on loan of stock i on the last trading day of period p .⁴² Finally, to measure the change in stock price, I take stock cumulative return over the entire policy period.

To test the predictions of my model, I estimate the following specification in a period-stock panel:

$$\begin{aligned} \Delta Y_{ip} = & \beta_1 \Delta BMI_{ip}^{BoJ} \times D(special)_{ip} + \beta_2 \Delta BMI_{ip}^{BoJ} \times D(not\ special)_{ip} \\ & + \zeta' \bar{X}_{ip-1} + \nu_{sp} + \mu_i + \epsilon_{ip}. \end{aligned} \quad (65)$$

The dependent variable, ΔY_{ip} , represents the change in the stock’s lending inventory (active lendable quantity of shares), short quantity on loan (Markit’s measure of short interest), borrowing fee, or stock return, constructed as explained above. $D(special)_{ip} = 1$ if stock i can be considered special at the beginning of the policy period p , that is, if its average borrowing fee exceeds 1% in the month preceding the policy period p , and zero otherwise. Similarly, $D(not\ special)_{ip} = 1$ if stock i has an average borrowing fee of up to 1% in the month preceding the policy period p , and

⁴¹Anecdotally, market participants saw the BoJ’s purchases as distorting valuations due to this feature of the Nikkei 225 index. See, for example, <https://corporate.quick.co.jp/en/japanmarketsview/equity/the-market-accepted-bojs-topix-etfs-purchase-plan-quick-monthly-survey-equity-in-april-2021/>.

⁴²Importantly, I exclude stock-period observations when a stock has an ex-dividend date two weeks before or after the period start date, as tax-related lending around those dates significantly affects my measures of shorting demand and borrowing fees. The results are not sensitive to this filter.

zero otherwise. $\bar{X}_{ip-1}$ is a vector of controls, including log market value, log shares outstanding, log trading volume, Amihud’s illiquidity, and the stock beta with respect to TOPIX return – all measured at the end of the preceding period. I include these controls to alleviate the concern that variation in ΔBMI^{BoJ} picks up stale information on stock size or liquidity due to how Japanese indexes are constructed. The estimates are virtually the same without these controls. ν_{sp} are period by $D(\text{special})$ fixed effects, which allow for differences in trends for special and general collateral stocks, and μ_i are stock fixed effects.

G.2.3 Regression results

Table C1 reports the estimation results. Column (1) documents that the lending inventory in Japan strongly reacts to the shocks to BMI. Furthermore, Column (2) of Table C1 documents that short quantity on loan also increases in response to the change in BMI, in line with my model.⁴³

Column (3) of Table C1 reports how the borrowing fee changes in response to the shock to BMI. I find a statistically strong and economically large increase in borrowing fees for special stocks, with a 1 percentage point larger shock leading to a 41 bps higher borrowing fee, or a one-standard-deviation larger shock increasing the lending fee by 13 bps. This increase in borrowing fee in response to the shock to BMI means that the demand effect of benchmarking dominates in the Japanese stock market.

Consistent with the existing literature on the impact of Japanese monetary easing on stock prices and risk premia, I find that increases in BMIs lead to considerably higher prices. As column (4) shows, a one-standard-deviation larger shock results in a 8.4% higher return for general collateral stocks and a 10.5% higher return for specials over a policy period.⁴⁴ The difference in coefficients is not statistically significant, yet its sign is consistent with the prediction of my model for the dominant demand effect of benchmarking.

The lending market in Japan has a larger number of stocks with economically significant fees (summarized in Table C5 of this Internet Appendix). Given the prevalence of the demand effect of benchmarking, any misclassification of special stocks is likely to attenuate the coefficient on the fee for special stocks and increase the coefficient for general collateral stocks. Nevertheless,

⁴³Weak response for general collateral stocks is due to both how I construct ΔBMI^{BoJ} and my definition of specialness. In unreported tests, I compare estimates of sensitivity to the change in BMI in subsamples of specialness as outlined by the JSDA. There is no increase in short quantity on loan only for stocks that are extremely cheap to lend, that is, with fees below 50 bps (annualized).

⁴⁴These estimates are upper-bound measures of price impact because of how I construct ΔBMI^{BoJ} . The average duration of a policy period in my sample is 207 days, so if the markets typically expected the program to last for 10 years, the estimates in column (4) should be divided by around $10 * 252/207 \approx 12$ to get an interpretation of price impact.

Table C1: Response of spot and lending market variables to changes in BMI due to the BoJ's ETF purchases

	Δ Lending inventory, % shares (1)	Δ Quantity on loan, % shares (2)	Δ Borrowing fee, % (3)	Stock return, % (4)
Panel A: No interactions				
ΔBMI^{BoJ} , % MV	0.414*** (2.99)	0.301*** (3.04)	0.162*** (2.63)	28.248*** (13.16)
Observations	17,298	17,298	17,298	17,298
Adjusted R-squared	0.093	0.037	0.115	0.373
Panel B: With specialness interactions				
ΔBMI^{BoJ} , % MV $\times$ D(not special)	0.050 (0.35)	0.017 (0.19)	0.037 (1.00)	26.942*** (10.04)
ΔBMI^{BoJ} , % MV $\times$ D(special)	1.140*** (4.27)	0.867*** (4.00)	0.411** (2.51)	33.847*** (9.59)
Observations	17,298	17,298	17,298	17,298
Adjusted R-squared	0.097	0.041	0.116	0.373
$\beta_1 - \beta_2$	1.090*** (3.61)	0.850*** (3.67)	0.374** (2.23)	6.904 (1.58)

This table reports the estimates of specification (65) in the panel of TOPIX constituents across 13 policy periods. Panel A removes interactions with specialness. Panel B uses the full specification. The last row reports the t-test for estimation results in panel B. ΔBMI^{BoJ} is a shock to BMI in a given policy period, as defined in (64). Changes in lending market variables are computed as differences between the end of the current policy period and the preceding one; see further details in Internet Appendix G.5. A stock is considered special, or $D(special) = 1$, if its average fee prior to the policy period is above 1%. All regressions include D(special) by date and stock fixed effects. t-statistics based on standard errors clustered by stock are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

in untabulated analyses, I confirm that the findings are qualitatively the same under alternative definitions of specialness.

The prevalence of the demand effect of benchmarking suggests that there are binding lending limits in the Japanese market, similar to my results for the United States presented in Section 5. At the same time, I see that the pass-through coefficient for the changes in BMI to inventory for special stocks is very high, at around 1.1. Furthermore, I estimate the pass-through of total purchases (as opposed to changes in BMI) to special stocks and find that for general collateral stocks it is over 40%. Overall, these results suggest that lending supply in Japan may be more responsive to fees than in the United States. To address that, similar to Appendix A.13, I use an instrument for shorting demand to isolate the shift in inventory and supply due to the change in BMI from their elastic response to higher fees. I find that the pass-through from BMI to inventory is 0.79, consistent with limited lending. I do not have the micro-data on securities lending by ETFs and other institutions in Japan that would allow me to characterize the effective lending limits.

However, [Maeda, Shino, and Takahashi \(2022\)](#) have analyzed the financial statements of the ETF managers in Japan and found evidence of such limits. They document that the ETFs increased their position-level lending shares from 40% to over 80% between 2015 and 2019, potentially in response to the purchases by the BoJ. Overall, the evidence for the Japanese market suggests a weak pass-through from institutional holdings to lending supply, similar to my baseline results for the United States.

G.3 Additional details on Japanese setting

G.3.1 Japanese stock data

Japanese stock data come from Compustat Global, table *g_sec*. These data include stock identifiers (gvkey, SEDOL, and ISIN), date, number of shares outstanding (*csnoc*), trading volume (*cshtd*), stock close price (*prccd*), dividend per share (*div*), and stock split ratio (*split*). I include only securities with ISO currency code (*curcdd*) of ‘JPY’ and that ever belonged to TOPIX or Nikkei 225 after 2006 according to Compustat Global (table *g_idxcst_his*). These data are merged with S&P securities lending data using SEDOL and date.

Table C2: Japanese ETFs tracking TOPIX, Nikkei 225, or JPX-Nikkei 400

Name	Ticker	ISIN	Inception Date	SecId	Primary Prospectus Benchmark
Nikko Exchange Traded Index Fund TOPIX	1308	JP3039100007	20/12/2001	F000000MDI	TOPIX PR JPY
iShares Core Nikkei 225 ETF	1329	JP3027710007	04/09/2001	F000000MRG	Nikkei 225 Average PR JPY
Daiwa ETF-TOPIX	1305	JP3027620008	11/07/2001	F000000NAO	TOPIX PR JPY
Daiwa ETF-Nikkei 225	1320	JP3027640006	09/07/2001	F000000NAZ	Nikkei 225 Average PR JPY
Nikko Exchange Traded Index Fund 225	1330	JP3027660004	09/07/2001	F000000NIZ	Nikkei 225 Average TR JPY
NEXT FUNDS TOPIX ETF	1306	JP3027630007	11/07/2001	F000000NOS	TOPIX PR JPY
NEXT FUNDS Nikkei 225 ETF	1321	JP3027650005	09/07/2001	F000000NQ6	Nikkei 225 Average PR JPY
MAXIS NIKKEI225 ETF	1346	JP3047040005	24/02/2009	F000002O43	Nikkei 225 Average TR JPY
MAXIS TOPIX ETF	1348	JP3047060003	14/05/2009	F000002T80	TOPIX PR JPY
Listed Index Fund Nikkei 225 (Mini)	1578	JP3047570001	22/03/2013	F000000POB4	Nikkei 225 Average PR JPY
NEXT FUNDS JPX-Nikkei Index 400 ETF	1591	JP3047670009	24/01/2014	F000000SGED	JPX-Nikkei Index 400 TR JPY
Listed Index Fund JPX-Nikkei Index 400	1592	JP3047680008	27/01/2014	F000000SGUR	JPX-Nikkei Index 400 TR JPY
MAXIS JPX-Nikkei Index 400 ETF	1593	JP3047690007	05/02/2014	F000000SIOI	JPX-Nikkei Index 400 TR JPY
Daiwa ETF JPX-Nikkei 400	1599	JP3047740000	26/03/2014	F000000SZ7B	JPX-Nikkei Index 400 TR JPY
iShares JPX-Nikkei 400 ETF	1364	JP3047840008	01/12/2014	F000000V1W6	JPX-Nikkei Index 400 TR JPY
One ETF Nikkei225	1369	JP3047890003	14/01/2015	F000000V7EK	Nikkei 225 Average PR JPY
SMDAM NIKKEI225 ETF	1397	JP3047920008	24/03/2015	F000000VHEG	Nikkei 225 Average PR JPY
One ETF TOPIX	1473	JP3048090009	04/09/2015	F000000W9HA	TOPIX PR JPY
One ETF JPX-Nikkei 400	1474	JP3048100006	04/09/2015	F000000W9HB	JPX-Nikkei Index 400 TR JPY
iShares Core TOPIX ETF	1475	JP3048120004	19/10/2015	F000000WFFL	TOPIX PR JPY
NZAM ETF TOPIX	2524	JP3048830008	05/02/2019	F000011UX8	TOPIX PR JPY
NZAM ETF Nikkei 225	2525	JP3048840007	05/02/2019	F000011UX9	Nikkei 225 Average PR JPY
NZAM ETF JPX-Nikkei400	2526	JP3048850006	05/02/2019	F000011UXA	JPX-Nikkei Index 400 PR JPY
SMDAM TOPIX ETF	2557	JP3048970002	13/12/2019	F000014YK	TOPIX PR JPY
iFreeETF-TOPIX(Quarterly Div Type)	2625	JP3049170008	09/11/2020	F000015YMI	TOPIX PR JPY
iFreeETF-Nikkei225(Quarterly Div Type)	2624	JP3049160009	09/11/2020	F000015YMJ	Nikkei 225 Average PR JPY

G.3.2 Japanese ETF data

I extract Japanese ETF net assets, primary prospectus benchmarks, net asset value (NAV) returns, and tracking errors from Morningstar. I include only ETFs with ‘Equity’ as Global Broad Category Group and TOPIX, Nikkei 225, or JPX-Nikkei 400 as Primary Prospectus Benchmark (I include net return, price return, and total return indexes). The resultant sample of funds is reported in Table C2.

G.4 BoJ announcements

Table C3: Announcements of the BoJ pertaining to the purchases of ETFs

Date	Key change	Announcement type
28 October 2010	Announcement of first ETF purchases of 0.45 trillion yen	Expansive
14 March 2011	Increase of the total amount to 0.9 trillion yen	Expansive
04 August 2011	Increase of the total amount to 1.4 trillion yen	Expansive
27 April 2012	Increase of the total amount to 1.6 trillion yen	Expansive
30 October 2012	Increase of the total amount to 2.1 trillion yen	Expansive
04 April 2013	Increase of the total amount to 1 trillion yen per year	Expansive
31 October 2014	Increase of the total amount to 2 trillion yen per year	Expansive
19 November 2014	Inclusion of the JPX-Nikkei 400 ETFs	Reallocative
15 March 2016	Addition of human capital supporting purchases at 0.3 trillion yen per year	
29 July 2016	Increase of the total amount to 6 trillion yen per year	Expansive
21 September 2016	Change in purchases allocation with 2.7 trillion per year dedicated to TOPIX-tracking ETFs and the other 3 trillion per year split across three indexes as before	Reallocative
31 July 2018	Change in purchases allocation with 4.2 trillion yen per year dedicated to TOPIX-tracking ETFs and the other 1.5 trillion yen per year split across three indexes as before	Reallocative
19 December 2019	Establishing lending ETF shares from BoJ holdings	
16 March 2020	Increase of the total amount to 12 trillion yen per year	Expansive
31 March 2020	Establishment of the amount of cash collateral for lending of ETFs	
01 May 2020	Change in allocation from total market value to the amount outstanding in circulation	
19 March 2021	Revision to the lending program	
23 March 2021	Change in purchases allocation with 11.7 trillion yen per year dedicated to TOPIX-tracking ETFs only	Reallocative

This table is based on the official BoJ announcement documents, publicly available at https://www.boj.or.jp/en/mopo/measures/mkt_ope/ope_t/index.htm. Horizontal lines separate policy periods used in the regression analysis.

G.5 Variable definitions and descriptive statistics

Table C4: Key variable definitions and descriptive statistics (Japan)

Variable	Definition	Units	Source (field)	Mean	Median	St. dev.	p1	p99
ΔBMI^{BoJ}	Change in BoJ purchases as fraction of stock market value relative to the expected pace, adjusting for the difference in period duration. See definition in (64).	% MV		0.01	0.01	0.30	-1.08	1.01
BoJ purchase	Fraction of stock market value purchased by the Bank of Japan in a given policy period. JPY purchases are defined in (63).	% MV	BoJ website, Refinitiv, Morningstar, Compustat Global	0.30	0.07	0.53	0.00	2.19
Δ Lending inventory	Difference between the average daily active inventory (ActiveLendableQuantity) as a share of shares outstanding (cshoc) in the last month of the period and the last month of the preceding period.	% shares	Markit (ActiveLendableQuantity) and Compustat Global (cshoc)	0.33	0.10	1.79	-4.86	6.66
Δ Quantity on loan	Difference between the average daily short quantity on loan (ShortLoanQuantity) as a share of shares outstanding (cshoc) in the last month of the period and the last month of the preceding period.	% shares	Markit (ShortLoanQuantity) and Compustat Global (cshoc)	0.23	0.05	1.59	-4.23	5.71
Δ Borrowing fee	Difference between the average daily borrowing fee (IndicativeFee) in the last month of the period and the last month of the preceding period.	%	Markit (IndicativeFee)	-0.10	0.00	1.31	-4.58	4.38
Stock return	Cumulative return over the policy period. Daily total return is computed as $(prcd + div) * split / lag(prcd)$.	%	Compustat Global	5.79	2.14	36.80	-62.39	135.37
Lending inventory	Active inventory on announcement date.	% shares	Markit (ActiveLendableQuantity)	5.10	4.09	4.57	0.00	18.19
Quantity on loan	Shorting demand on announcement date.	% shares	Markit (ShortLoanQuantity)	1.12	0.50	1.73	0.00	8.58
Borrowing fee	IndicativeFee averaged over the month preceding the announcement date.	%	Markit (IndicativeFee)	1.56	0.62	1.86	0.32	8.25
D(special)	1 if IndicativeFee > 1%, 0 otherwise	Boolean		0.36	0.00	0.48	0.00	1.00
Markit score	Markit's Daily Cost of Borrow Score, where 1 is cheapest and 10 is most expensive, averaged over the month preceding the announcement date.	1-10		1.69	1.00	1.06	1.00	5.05
Log shares outstanding	Logarithm of shares outstanding	Log shares	Compustat Global (cshoc)	17.84	17.76	1.54	12.60	21.56
Amihud's illiquidity	Module of return divided by dollar trading volume, or $abs(ret)/(cshtd * prcd)$, scaled by 10^9 .		Compustat Global	0.60	0.15	1.25	0.00	5.92
Log trading volume	Logarithm of trading volume	Log shares	Compustat Global (cshtd)	12.01	11.98	2.12	6.75	16.96
Market value	Logarithm of market capitalization value, or $\ln(prcd * cshoc / 10^6)$	Million yen	Compustat Global	202.8	40.4	664.2	2.9	2,968.4
β^{TOPIX}	Stock beta with respect to TOPIX index, computed on a one-year rolling window of daily total stock returns, with at least three months of data.		Compustat Global, Morningstar	0.93	0.92	0.35	0.20	1.81

Table C5: Key sample summary statistics (Japan)

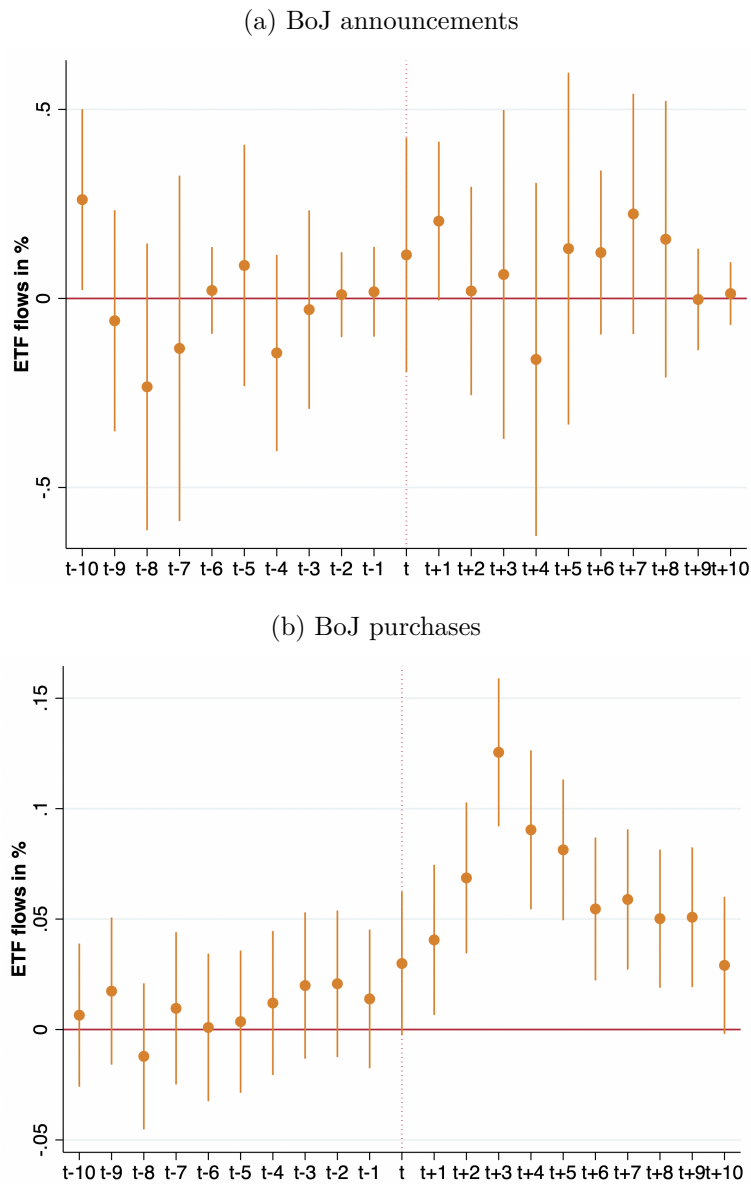
Variable	I. General collateral stocks						II. Special stocks					
	No. obs.	Mean	Median	St. dev.	p1	p99	No. obs.	Mean	Median	St. dev.	p1	p99
ΔBMI^{BoJ} , % MV	11,006	-0.00	0.01	0.29	-1.13	0.92	6,292	0.03	0.01	0.31	-0.98	1.13
Bank of Japan purchase, % MV	11,006	0.31	0.07	0.56	0.00	2.38	6,292	0.29	0.06	0.47	0.00	1.97
Δ Lending inventory, % shares	11,006	0.23	0.14	1.62	-4.91	5.23	6,292	0.50	0.05	2.03	-4.75	8.09
Δ Shorting demand, % shares	11,006	0.29	0.07	1.39	-3.02	5.24	6,292	0.13	0.01	1.89	-5.98	6.26
Δ Borrowing fee, %	11,006	0.13	0.00	0.75	-0.75	3.50	6,292	-0.50	-0.29	1.86	-6.25	5.00
Stock return, %	11,006	5.16	2.64	31.58	-58.42	108.83	6,292	6.91	1.32	44.46	-67.97	170.04
Lending inventory, % shares	11,006	7.06	6.39	4.39	0.22	19.24	6,292	1.67	0.74	2.25	0.00	9.96
Shorting demand, % shares	11,006	0.94	0.45	1.40	0.00	6.73	6,292	1.44	0.63	2.17	0.00	11.19
Borrowing fee, %	11,006	0.54	0.51	0.13	0.30	0.96	6,292	3.35	2.88	2.12	1.00	10.21
D(special)	17,298	0.36	0.00	0.48	0.00	1.00						
Active utilization, %	11,006	7.96	3.49	12.51	0.00	64.19	6,292	66.18	100.00	41.23	0.00	100.00
Market value, JPY billion	11,006	300.31	77.96	813.70	5.14	3,653.92	6,292	32.16	15.37	94.52	2.14	279.65

This table reports the summary statistics for the key samples analyzed in this Internet Appendix. Statistics for general collateral stocks are presented in panel I and those for special stocks are presented in panel II. The full sample includes stocks that were TOPIX constituents in 2010–2022. Changes in all variables are computed from the end of one policy period to the other, over the 13 periods outlined in Internet Appendix G. A stock is considered special if its average fee in the month preceding the policy period is above 1% and a general collateral stock otherwise. All variables are defined in Table C4.

G.6 Reaction of ETF flows to BoJ announcements and purchases

Figure C2 illustrates that the combined eligible ETF flows do not react to the BoJ announcements and strongly react to the purchases.

Figure C2: BoJ purchases and aggregate eligible ETF flows



This figure plots estimates of univariate regressions of eligible ETF flows onto $D(\text{BoJ announcement})$ in panel (a) and $D(\text{BoJ purchase})$ in panel (b). $D(\text{BoJ announcement}) = 1$ if there was a BoJ announcement on day t , and zero otherwise. Similarly, $D(\text{BoJ purchase}) = 1$ if there was a BoJ purchase on day t , and zero otherwise. The 99%-confidence bands are based on HAC-robust standard errors. Flows are winsorized at 99%.