Understanding Returns to Short Selling Using Option-Implied Stock Borrowing Fees[☆]

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Abstract

Readily available measures of short selling and stock borrowing activity predict stock returns. It is difficult to identify the source of this return predictability. We partially resolve the puzzle by using portfolio sorts and measures of the stock borrowing costs paid by short-sellers to show that the returns to short selling net of stock borrowing costs are less than one-third of the gross returns to a typical strategy, and not significant. Option-implied borrowing fees, which reflect option market makers' borrowing costs and the risks of changes in those costs, are on average equal to quoted borrowing fees. This finding indicates that the risk of changes in borrowing fees is not systematically priced. Option-implied borrowing fees predict stock returns, including returns net of quoted borrowing costs. The option-implied fee drives out other return predictors in panel regressions.

JEL Classification: G12, G13, G14

Keywords: Short sales, borrowing fee, equity options

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1. Introduction

A large literature shows that measures of short selling activity including short interest, lending fees, utilization, days to cover, and the risk of changes in lending fees predict negative abnormal stock returns.[1] The persistence of this predictability based on readily available information is a puzzle. One possible explanation is that short selling is not profitable to the marginal short seller. For example, Hong, Li, Ni, Scheinkman and Yan (2016) present a model in which arbitrageurs short overvalued securities up to the point at which the marginal trading cost (price impact) of short covering is large enough to offset the marginal benefit of shorting overvalued securities; in equilibrium, a marginal short seller does not benefit. Alternatively, it might be that the returns to shorting are compensation for the special risks of holding short positions. One potentially important risk stems from the market practice that stock loans may be recalled at any time, forcing market participants either to cover their short positions and return the borrowed stock or else to reestablish their stock loans at a possibly much higher borrowing fee. Thus, the borrowing fee for any period longer than a day is uncertain. D'Avolio (2002, p. 279) emphasizes that "…a short seller is concerned not only with the level of fees, but also with fee variance," and Engelberg, Reed, and Ringgenberg (2017) argue that the risk of borrowing fee increases is an important impediment to short-selling and explains a large fraction of the returns to shorting.[2] Focusing on a different risk, Drechsler and Drechsler (2016) argue that short-sellers have concentrated portfolios and that the abnormal returns to stocks with high stock borrowing fees reflect the compensation that short sellers require for bearing the risk of concentrated short positions.

We present a number of results that address the returns to shorting and possible explanations. Using portfolio sorts and measures of the stock borrowing costs paid by short-sellers, we find that the returns to shorting net of stock borrowing costs are less than one-third of the gross returns, and not significantly different from zero at conventional levels. This partially resolves the puzzle of the persistence of predictability based on readily available information, but does not fully eliminate the puzzle because panel regressions show that some measures of short selling activity continue to predict returns net of borrowing costs. Next, we exploit the fact that stock borrowing costs are reflected in option prices to compute option-implied borrowing fees. Because the option-implied borrowing fee

[1] For example, Figlewski (1981), Desai, Ramesh, Thiagarajan, and Balachandran (2002), Jones and Lamont (2002), Ofek, Richardson, and Whitelaw (2004), Asquith, Pathak, and Ritter (2005), Boehme, Danielsen, and Sorescu (2006), Cohen, Diether, and Malloy (2007), Diether, Lee, andWerner (2009) Boehmer, Huszar, and Jordan (2010), Engelberg, Reed, and Ringgenberg (2012), Hong, Li, Ni, Scheinkman and Yan (2016), Drechsler and Drechsler (2016), Duong, Huszár, Tan, and Zhang (2017), Engelberg, Reed, and Ringgenberg (2017), and Henderson, Jostova, and Philipov (2017).

[2] Prado, Saffi, and Sturgess (2014) also interpret their results as being consistent with the hypothesis that the risk of changes in future borrowing fees is an impediment to shorting.

reflects the risk of borrowing fee changes as perceived by option market makers, the average difference between the option-implied borrowing fee and the average indicative quoted borrowing fee over the life of the option is an estimate of the risk premium for the risk of borrowing fee changes. Our results show that this risk premium is close to zero. Third, the option-implied borrowing fees we compute are excellent predictors of stock returns. When we include the option-implied borrowing fee in predictive regressions it (and utilization) predict returns, and short interest and short fee risk no longer do. The implied volatility spread (Cremers and Weinbaum 2010) and skew (Xing, Zhang, and Zhao 2010) also no longer predict returns once we include the option-implied borrowing fee and utilization in the predictive regressions. After we net out the costs of borrowing stock, the indicative fee also no longer negatively predicts returns but the option-implied borrowing fee still does.

In these analyses we use indicative fee data from Markit. This variable estimates the fees that would be paid by a hedge fund or other short seller to borrow a stock from surveys of participants on both sides of the market for stock loans. These fee data differ from those used in the existing literature. To understand how our fee data differ, one must recognize that prime brokers sit in the middle of the market for borrowing and lending stock (see, for example, Kolasinski, Reed, and Ringgenberg 2013), and that the fees paid by ultimate borrowers such as hedge funds and option market makers differ from the fees received by the ultimate lenders. In a typical case, a prime broker borrows from a lender, for example a mutual fund or pension fund, and lends to an ultimate borrower, for example a hedge fund or an option market maker who wants to short the stock, at a different fee. The existing literature often uses measures of the fees received by ultimate lenders, not the fees paid by short sellers.

We begin our analyses by using the measures of the borrowing costs paid by short sellers to show that the returns to shorting net of stock borrowing costs are much smaller than the gross returns to shorting that do not reflect borrowing costs. We sort stocks into decile portfolios based on various measures: indicative fees for new loans and the risk of fee changes. Doing this, we find equal-weighted gross returns to the decile ten minus decile one long-short portfolio of between 140 and 153 basis points per month, depending on the variable used to sort stocks into portfolios. However, the returns net of shorting costs are only 22% to 29% as large as the gross returns, and not statistically different from zero at conventional levels. These results do not eliminate the puzzle that available information about short selling activity predicts returns, since panel regressions discussed below show that the option-implied borrowing fee and utilization predict net-of-borrow-cost returns. However, these findings make the puzzle much less surprising, and the reduced magnitude of the predictability makes explanations in terms of the costs of short covering (Hong et al. 2016) and short fee risk (Engelberg et al. 2017) more likely to be viable. The findings also help explain why hedge funds that specialize in short selling earn abnormal returns of only 34 bps per month (Sadka 2010, Table 3) rather than more than 100 basis points per month suggested by the unadjusted portfolio returns.

Second, we exploit the fact that option market makers are an important group of short sellers to estimate the risk premium for bearing the risk of changes in the borrowing fee. Option market makers often borrow and short-sell stock to delta-hedge their options positions, and when stocks are hard to borrow their delta hedges typically involve shorting stock.[3] They bear the risk of changes in stock borrowing costs because they maintain their delta-hedges even if stock borrowing costs increase. As a result, the option prices they quote must reflect their expected borrowing costs over the options' lives plus any risk premium they require to compensate them for the risk of future fee changes. The option-implied borrowing fee, which reflects both the expected borrowing cost and the risk premium, can be computed from option prices using a version of the put-call parity relation that includes the borrowing cost. The average difference between option-implied and realized indicative borrowing fees over the options' lives provides an estimate of the risk premium for bearing the risk of borrowing fee changes. This idea is analogous to one in the interest rate literature, where the difference between say the three-month interest rate and the average overnight rate during the three-month term is an estimate of the risk premium for bearing interest rate risk. A similar idea appears in the literature on the variance risk premium, where the variance risk premium is the average difference between so-called "model-free" option-implied variances and realized variances over the option lives (Carr and Wu 2009).

We carry out this exercise and estimate the risk premium using option prices from OptionMetrics and the estimates of stock borrowing costs from Markit. The correlation between the option-implied borrowing fee and the indicative fee is 0.57, indicating that these fee measures are highly correlated. On average, they are close to the realized borrowing costs during the lives of the options from which the option-implied fees were computed. This approximate equality between the average option-implied and realized indicative borrowing fees means that the risks of borrowing stock are not severe enough to create an important risk premium reflected in the prices of exchange-traded options. As one should expect, the option-implied borrowing fees help predict changes in indicative borrowing fees over the lives of the options used to compute the option-implied fees even after

[3] This is shown in Internet Appendix Table 4.

controlling for current quoted fees. This is evidence that the option-implied borrowing fees are useful forward-looking estimates of indicative borrowing fees.

The lack of a risk premium embedded in option prices does not contradict the arguments in D'Avolio (2002) and Engelberg et al. (2017) that uncertainty about future stock borrowing fees might be an impediment to short sales. The risk of changes in the borrowing fee can still be an impediment to short-selling even if it does not carry a risk premium. However, while short fee risk predicts changes in the indicative fee, it does not predict stock returns once we include the option-implied fee and other variables in the predictive regressions, but the option-implied borrowing fee still predicts returns. Thus, while short fee risk predicts future fee changes and may impede arbitrage, the regression evidence indicates that its predictive effect is subsumed by the combination of the forward-looking option-implied fee that also captures expected future fee changes and the other variables included in the predictive regressions.

Third, if the option-implied borrowing fees are forward-looking estimates of quoted borrowing fees then they also should predict future stock returns. We estimate predictive regressions using the option-implied borrowing fee and other covariates and find that option-implied borrowing fees predict stock returns over one-week and one-month horizons in both the full sample and a subsample of hard-to-borrow stocks. The coefficient on the option-implied borrowing fee remains highly significant even when other variables such as the indicative borrowing fee, loan utilization, short interest, and short fee risk are included in the regressions. Of all of the variables we include, the option-implied borrowing fee is the most significant predictor of stock returns. In the subsample of hard-to-borrow stocks it is the only significant predictor of weekly returns, and the option-implied fee and utilization are the only significant predictors of monthly returns. The evidence from the hard-to-borrow sample is compelling because the other potential explanations should be particularly important in this sample, and yet, there is no evidence supporting these alternatives. Returns to portfolios sorted on the option-implied borrowing fee provide additional evidence that it predicts returns. Of course, since the option-implied fee is a non-linear transformation of apparent put-call parity violations, this last result is not particularly surprising. However, the fact that these apparent put-call parity violations are related to the expectation of future borrowing costs does cast these results in a different light.

Our regression results in which we use the option-implied borrowing fee to predict stock returns are closely related to the large literature that uses measures of lending fees to predict returns. For example, Geczy, Musto and Reed (2002), Ofek, Richardson, and Whitelaw (2004), Cohen, Diether, and Malloy (2007), and Drechsler and Drechsler (2016) present evidence that lending fees negatively predict stock returns. Our results are consistent with these papers, but suggest that the option-implied borrowing fee is a better measure of shorting costs than the fees used in the literature for two reasons. First, the option implied borrowing fee is measured from the borrower's perspective, and second, it is a proxy for expected future borrowing fees.

Fourth, we consider the literature showing that differences between certain option implied volatilities predict underlying stock returns. Cremers and Weinbaum (2010) find that the implied volatility spread, defined as the average difference between the implied volatilities of calls and puts with the same strike price and expiration date, positively predicts returns, while Xing et al. (2010) find that the implied volatility skew, defined as the difference between the implied volatility of an out-of-the-money put and an ATM call, is a negative predictor of returns. The returns to decile portfolios sorted on the volatility measures and univariate panel regressions confirm that these measures predict gross returns during our sample period. However, the returns net of stock borrowing costs of the decile ten minus decile one long-short portfolio are much smaller than the gross returns, and not significantly different from zero at conventional levels. When we include the option-implied fee and other predictors in the panel regressions we find that only the option-implied fee and utilization predict weekly stock returns. In panel regressions that predict monthly returns the option-implied fee, the indicative fee, and utilization are highly significant predictors, while the coefficient on the implied volatility skew is insignificant and that on the implied volatility spread is significant at only the 10% level. We obtain similar results when we predict returns net of stock borrowing costs, except that the coefficient on the indicative fee becomes insignificant.

There is a natural interpretation of our finding that the implied volatility spread and skew predict returns in portfolio sorts and univariate regressions but do not do so (or do at only the 10% level) once we include the option-implied fee in the panel regressions. The implied volatility spread and skew are computed from OptionMetrics implied volatilities, which OptionMetrics computes omitting stock borrowing fees, that is by assuming that borrowing fees are zero. Thus, for hard-to-borrow stocks the implied volatilities are computed with errors that depend on the omitted borrowing fees. As a result, in the cross-section of stocks the implied volatility spread and skew are correlated with the borrowing fee. The findings that they predict returns in univariate regressions but no longer predict returns once the option-implied borrowing fee is included in the regression specifications suggests that the implied volatility spread and skew predict returns because they are transformations of the omitted borrowing fee.

This interpretation differs from the current literature, which interprets the ability of the option-implied spread and skew to predict returns as evidence that informed trading occurs in the option market and impacts option prices as in demand-based option pricing (Gârleneau, Pedersen and Poteshman 2009). Although we cannot fully rule out this explanation for why option prices predict future returns, in the internet appendix we show that the results hold in the subsample of options with little trading volume, which presumably have little informed trading.

The balance of the paper is as follows. Section 2 describes the stock borrowing fee and option price data we use. Section 3 uses decile portfolio sorts to show that the returns to shorting net of the costs to borrow stock are much smaller than the gross returns, and not significantly different from zero. Section 4 introduces the option implied borrowing fee and describes how we compute it. This section also shows that the option-implied borrowing fee predicts future borrowing fees and that the borrowing fee risk premium is zero. Section 5 presents results of regressions in which we use the option-implied borrowing fee and other variables to predict stock returns. Section 6 presents the regression results regarding the implied volatility spread and skew. Section 7 briefly concludes.

2. Data and summary statistics

We use stock borrowing fees and other data about short selling from the Markit Securities Finance Buy Side Analytics Data Feed available from Markit, Ltd. The database includes daily data on securities borrowing and lending activity, including rebates and loan fees, the quantity on loan, the number of loans, the numbers of active brokers and lending agents, and other data. Markit obtains the information from more than 100 equity loan market participants, including beneficial owners, hedge funds, investment banks, lending agents, and prime brokers, who together account for approximately 85% of US securities loans (Markit 2012). While the Markit Securities Finance dataset includes a broader range of securities, the analysis in Section 3 is limited to U.S. equities, and the analyses in other sections are limited to the subset of U.S. equities that have exchange-traded options. Our sample begins in July 2006 because the data coverage expanded significantly around that time and the data are available at daily frequency beginning June 28, 2006. The sample ends with August 2015.

The market for borrowing stock is described in other papers, including D'Avolio (2002) and Kolasinski, Reed, and Ringgenberg (2013). It includes three groups of participants: (i) lenders such as mutual funds, pension funds, and insurance companies, some of which lend through agent lenders (custodians), (ii) ultimate borrowers, for example hedge funds, proprietary trading desks, and option market makers, and (iii) prime brokers. Typically hedge funds and option market makers borrow the securities from their prime brokers, who in turn borrow from the mutual funds, pension funds, and other ultimate lenders (Kolasinski, Reed, and Ringgenberg 2013, especially Figure 1). In this process the prime brokers "mark up" the fee, that is they borrow from the original lender and then relend to the hedge fund, option market maker, or other short seller at a higher fee, the ultimate borrowing fee.

Borrowing fees typically are not quoted directly but are derived from quoted rebate rates. The security borrower usually provides cash collateral to the security lender, and the security lender pays interest (the rebate rate) on the cash collateral that it holds. The borrowing fee is the difference between the market short-term interest rate and the rebate rate paid on the cash collateral.[4] The rebate rate can be negative when securities are hard to borrow and the borrowing fee is high. The borrowing fee can also be negative, which occurs when the rebate rate that the security lender pays on cash collateral exceeds the short-term interest rate.[5]

The market structure in which prime brokers are typically in the middle implies that there are two fees, a buy-side fee paid by the ultimate borrower (for example, a hedge fund or option market maker) and a lender-side fee received by the ultimate lender (for example, a mutual fund). The main borrowing fee variable we use is "IndicativeFee," which is a buy-side fee. Specifically, it is Markit's estimate of the "The expected borrow cost, in fee terms, for a hedge fund on a given day," based on "both borrow costs between Agent Lenders and Prime Brokers as well as rates from hedge funds to produce an indication of the current market rate" (Markit 2012).[6] The Markit database also includes

[4] When the security borrower provides Treasury securities as collateral the borrowing fee is quoted and the rebate rate is derived as the difference between the short-term interest rate and the borrowing fee. During our data period Markit used the Federal Funds Open rate as the short-term interest rate in these calculations.

[5] This can occur in financing transactions motivated by the security lender's desire to obtain access to the cash collateral posted by the security borrower in order to invest the cash in high-yielding assets. (Each security loan is simultaneously a loan of a security, collateralized by cash, and a loan of cash, collateralized by a security.) Pierce (2014) describes AIG's use of securities lending to obtain funds to invest in mortgage-backed securities prior to the financial crisis, and Foley-Fisher, Narajabad, and Verani (2016) provide evidence that other insurance companies continue to use securities lending to obtain funding. In both of these papers the securities being lent are bonds, which are better collateral for cash loans than are stocks because bond prices are less variable than stock prices. However, the summary statistics in Table I of Engelberg, Reed, and Ringgenberg (2017) indicate that the lending fees received by ultimate lenders of stock are occasionally negative, consistent with some stock loans being financing transactions.

[6] The full description of the data item is "The expected borrow cost, in fee terms, for a hedge fund on a given day. This is a derived rate using Data Explorers proprietary analytics and data set. The calculation uses both borrow costs between Agent Lenders and Prime Brokers as well as rates from hedge funds to produce an indication of the current market rate. It should not be assumed that the indicative rate is the actual rate a Prime Broker will quote or charge but rather an indication of the standard market cost" (Markit 2012).

another buy-side fee variable called Simple Average Fee (SAF) and a corresponding Simple Average Rebate (SAR), which are the simple averages of the actual borrowing fees paid and rebates received by ultimate borrowers for ongoing short positions as of a specific date. An important limitation of SAF is that this variable is not well populated in the database—as we show below, it is available for only about 43% of the stock-date pairs for which the indicative fee is available. In addition, SAF and SAR are subject to an important selection bias in that they tend to be unavailable when stocks are hard to borrow and the indicative fee is high.

The literature on stock shorting such as Drechsler and Drechsler (2016) or Engelberg, Reed, and Ringgenberg (2017) that uses lending fees generally uses one of the lender-side fee measures available in the Markit Securities Finance Database or a similar lender-side fee measure computed from a proprietary database (for example, DAvolio (2002), Geczy, Musto, and Reed (2002), Ofek, Richardson, and Whitelaw (2004), and Asquith, Au, Covert and Pathak (2013)). While such lender-side fee data are useful for many purposes, including predicting securities returns, they are not the fees paid by ultimate borrowers such as hedge funds and option market makers. As a result, using the lender-side fees to compute returns to short positions net of the fees paid to borrow stock would result in upward-biased estimates of the net of fee returns and downward-biased estimates of the borrowing costs of option market makers. This bias will be substantial if prime brokers receive significant compensation for their market making activities in the context of equity loans.

The Markit buy-side data also include the quantity on loan (QuantityOnLoan) and the utilization rate (Utilization), defined as the ratio of the quantity on loan to the lendable quantity (LendableQuantity), both of which we use. In addition to the Markit data, we also use end-of-day option price quotes from OptionMetrics. Stock prices, returns, and dividend information (amounts and ex-dividend dates) are from the files maintained by the Center for Research in Securities Prices (CRSP) files, and we address NASDAQ delisting returns as implemented Shumway and Warther (1999). Our main analyses use interest rates that we "imply" or back out from the prices of liquid options that are easy to borrow. While we think this approach provides a more accurate estimate of borrowing costs, the main findings do not change if the relevant LIBOR rates are used instead.

Table 1 Panel A reports various percentiles of the distributions of the Markit stock borrowing fee and rebate data, and also of several variables we compute from the Markit data, for the set of stock-dates for which the stock appears in CRSP and an indicative fee is available in the Markit data. The first row of the table reveals that the mean indicative fee is 2.25% per year, and that this variable is positively skewed. The indicative fee is 0.25% at the first percentile, 0.375% at both the tenth and 50th percentiles, and then reaches 6% at the 90th percentile and 30% at the 99th percentile. In the next row the rebate is negatively skewed, being –29.88% at the first percentile (note that large negative rebates correspond to large positive fees), –4.43% at the tenth percentile, and –0.25% at the 50th percentile, with a mean value of –1.03%.

The next two rows of the table contain information about the simple average fee (SAF) and rebate (SAR). These data are available for only about 43% (= 4,392,544/10,200,000) of the stock-date pairs for which the indicative fee is available. The mean is only 1.20%, less than the indicative fee mean of 2.25%, and the 90th and 99th percentiles are only 1.90% and 19.76%, much less than the corresponding percentiles of the indicative fee. These differences suggest a selection bias in which SAF and SAR are less likely to be available when the indicative fee is high. We provide more evidence regarding this issue in the next section of the paper.

The next two rows report information about utilization and short interest, both of which are also right-skewed. The mean of utilization is 19.14% compared to a median of 9.57%, and the 90th and 99th percentiles are 54.87% and 96.28%, respectively. Short interest is computed from the Markit data, and is defined as the quantity on loan divided by shares outstanding (from CRSP). After short interest comes information about the short fee risk measure introduced by Engelberg, Reed, and Ringgenberg (2017). This variable is defined as the natural log of the variance of the daily fee over the preceding 12 months, and has mean and median values of 5.59 and 4.45, respectively.[8]

The last two rows provide some information about the market capitalization of the underlying stocks in our sample. The typical stock is in the sixth NYSE size decile, with mean and median market capitalizations of $4.063 billion and $503 million, respectively. The sample is tilted a bit towards the larger stocks in CRSP because we exclude stocks with prices below $5 per share.

Panel B provides the same information and some additional information about the subset of the Panel A stocks that are optionable. The combined market capitalization of the optionable subset in Panel B is approximately 88% of the combined market capitalization of the stocks covered by Markit in Panel A. This sample consists of all combinations of optionable stocks and dates for which the stock

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[8] Our short fee risk measure is not exactly the same as that used in Engelberg, Reed, and Ringgenberg (2017), because their measure is computed from lender-side fees and ours is computed from buy-side indicative fees. We are unable to replicate the Engelberg, Reed, and Ringgenberg (2017) short fee risk measure because we do not have the lender-side fees—at the time we licensed the buy-side data Markit was unwilling to license both the buy and lender-side data to the same researcher or group of researchers.

price is greater than \$5, the dividend yield is less than or equal to 5%, and there was at least one call-put pair that satisfies the following criteria: (a) the put moneyness K/S is less than or equal to 1.1; (b) there are between 15 and 90 days remaining to expiration; and (c) and the sum of the call and put bid-ask spreads divided by the stock price is less than or equal to 5%. In addition, for each option in a put-call pair, open interest is positive, the absolute delta is between 0.01 and 0.99, implied volatility is between 0.03 and 2, the bid is greater than 0.1, and the bid is less than the ask. The optionable stocks tend to be larger than those in the sample used in Panel A—the mean and median market capitalizations in Panel B are approximately 2.4 and 5 times as large, respectively, as the corresponding values in Panel A. Not surprisingly, indicative borrowing fees and short fee risk are lower for the optionable stocks. The mean and median values of utilization are slightly larger for the optionable stocks, though the 90th and 99th percentiles are slightly smaller. All of the reported percentiles of short interest are greater for the optionable stocks as compared to the full sample in Panel A. This is perhaps not surprising, as option market makers will often short stocks to hedge their option positions.

Panel B also contains information about the option-implied borrowing fee. Section 4 below describes how it is computed from put-call pairs using a version of the put-call parity relation that includes the borrowing fee. We use the option data to compute the option-implied borrowing fee for each date and call-put pair with between 15 and 90 days remaining to expiration, and then for each date and stock we use the median option-implied fee across the call-put pairs on that date as the estimate of the option-implied fee. The row labeled "Option-implied fee, unadj." reports information about estimates of the option implied borrowing fee, without any adjustment for the bias caused by the use of a version of the European put-call parity relation with American option prices. The row labeled "Option-implied fee, adjusted" includes an adjustment to remove this bias, as described in Section 4.

The mean and median of the adjusted option-implied fee, 1.24% and 0.77%, are similar to the mean and median of the indicative borrowing fee reported in the first row of Panel B. However, the distribution of the option-implied fees exhibits more dispersion than the distribution of the indicative fees, the 90^{th} percentile is 4.88% and the 10^{th} percentile is actually negative, −2.38%. The statistics for the unadjusted option-implied fees are similar, though the mean and all percentiles are somewhat smaller, reflecting the adjustment for early exercise. The dispersion in the option-implied fees reflects the fact that they are estimated with error, some of which is microstructure "noise" stemming from the wide bid-ask spreads in the option market.[9] In the panel regressions we estimate below these measurement errors likely cause estimates of the coefficients on the option-implied fee to be biased toward zero as a result of the classic errors-in-variables bias. In general, this problem should make it more difficult to find evidence that the option-implied fee predicts changes in the subsequent indicative fees and or stock returns.

3. Impact of borrowing fees on the performance of portfolio strategies

The literature regarding short selling frictions includes several results in which a particular measure of the cost of maintaining a short position predicts subsequent stock returns. However, this type of analysis frequently does not include an adjustment for some measure of the fees paid to maintain such positions. Taking account of the fees that must be paid to borrow stock is necessary to measure correctly the returns to a short position, as omitting them is analogous to computing stock returns while omitting dividends. In this section, we evaluate the performance of several simple portfolio sorts using variables measuring short selling activity. This performance evaluation includes an analysis of the effectiveness of these strategies after incorporating borrowing fees.

In Table 2 we sort stocks into deciles based on the indicative borrowing fee. All stocks are sorted into portfolios based on the historical borrowing fee as of the close of trading day t. Stocks are held from the close of trading day t + 1 until the close of trading day t + 22, to mimic the length for a typical month with 21 trading days. The reported return for each portfolio for a specific date is the average of this return for all stocks in the portfolio. By construction, the return series for each portfolio is a moving average in which the horizon of the returns leads to 20 overlapping observations, and so, it is important to use Newey-West standard errors to adjust for this feature of the data. This approach ensures that there is a one day gap between the information used to sort stocks into the portfolios and the evaluation period for portfolio return. This gap is important for subsequent analyses using option-implied measures because the midpoint of the quotes for the underlying stock price that are used by option market participants can be different from the actual closing price reported by CRSP. This temporary price difference generates substantial stock return predictability the next trading day

[9] Despite these estimation errors, the option-implied fee is highly correlated (0.66) with the indicative fee (Internet Appendix, Table 1, Panel B). The fee measures are not as highly correlated with short interest and short fee risk. In the full sample the correlations between the indicative fee and short fee risk and short interest are only 0.2939 and 0.2474, respectively, while in the optionable sample the correlations between the option-implied fee and and short fee risk and short interest are only 0.3109 and 0.2191. Foreshadowing future results, despite the estimation errors, once we add the option-implied fee to panel regressions to predict stock returns most other predictors become insignificant.

according to the findings in Goncalves-Pinto, Grundy, Hameed, Heijden, and Zhu (2016). In addition, using the average portfolio return across all potential starting dates will eliminate any unusual results associated with end-of-month patterns.

We examine the performance of equal-weighted portfolios with the understanding that the abnormal performance results are almost always less pronounced for value-weighted portfolios (not reported). The first row of results for unadjusted returns shows that stocks with a high indicative fee have much lower returns than stocks with a low historical indicative fee. The unadjusted returns exhibit a monotonic pattern and the return differential between the top and bottom deciles is more than 1.5% per month. The magnitude of this estimate is similar to the 1.3% per month gross return differential reported by Drechsler and Drechsler (2016) for portfolios sorted using the 30-day value-weighted lending fee. Our estimate is associated with a t-statistic that is greater than 3 and is due largely to the low returns for stocks in the tenth decile compared to the performance of the other nine deciles. The differences between the abnormal performance for the top and bottom decile using the 4-factor model are virtually identical to the unadjusted return differentials reported in the column labeled 10-1 in Table 2. The risk-adjusted results are not reported for brevity.

The other sets of results report portfolio returns after adjusting for different versions of the borrowing fee. For the row labeled Historical fee adj., the cumulative indicative borrowing fee based on the daily historical fee measured by the simple average fee (SAF) from Markit from day t+1 to t+22 is added to the unadjusted stock return. This adjustment accounts for the decrease in the effective performance of a short position due to the borrowing fee. Applying the borrowing cost adjustment based on the historical fee only reduces the differential performance to a limited extent. However, the number of stocks with a valid adjustment in each portfolio reveals a selection problem. More than half of the stocks in the bottom decile have historical borrowing fees reported by Markit while less than one quarter of the stocks in the top decile have similar information. The stocks in the portfolio with high indicative fees are also stocks that are much less likely to have a historical borrowing fee reported by Markit. The historical fee adjustment is potentially problematic because the data from Markit includes a large number of stocks with an indicative fee based on quotes but no historical borrowing fee.

This concern is exacerbated by the next set of results using the indicative borrowing fee adjustment to reflect the cost of implementing short positions. By construction, the indicative fee must be reported for this sample because these stocks are sorted into portfolios based on this information. The performance differential following the indicative fee adjustment is approximately one-fifth of the unadjusted magnitude, −0.3% per month instead of −1.5% per month, and the estimate is not statistically significant. Thus, the performance of the portfolio strategy is largely not exploitable once borrowing fee used to form the portfolios in the first place are taken into account. The failure to include the true cost of implementing short positions in the performance evaluation overstates the performance of this type of strategy. Therefore, it is much less puzzling why investors do not attempt to take greater advantage of this apparent mispricing by establishing the necessary short positions. This attenuation in performance based on the indicative fee is more than twice as large as the attenuation found by Drechsler and Drechsler (2016) using the 30-day value-weighted lending fee. This difference appears to be driven by the difference between the average indicative borrowing fee for portfolio 10 in our sample of 12.4% and the analogous average lending fee in their sample of 5.7%. The importance of the selection issue related to the historical borrowing fee is confirmed in the next to last set of results in Table 2. In this analysis we restrict the portfolio analysis to stocks that have a historical borrowing fee but use the adjustment based on the indicative fee. These results are much closer to the second set of estimates based on the historical fee adjustment. The underlying cause of the difference in the attenuation of the strategy's performance due to the historical fee adjustment compared to the indicative fee adjustment is the role of selection in determining which stocks are included in the portfolio analysis when using the historical fee adjustment. Thus, the indicative borrowing fee has better properties than the historical fee in almost all situations.

This pattern of substantial attenuation of return differentials is not only associated with portfolios based on the level of borrowing fees. In Table 3 we examine the performance of portfolios sorted using short fee risk. This measure of indicative fee volatility is estimated using the daily indicative borrowing fee during the previous year for each stock. The first set of results in Table 3 show that the return of the portfolio of stocks with high short fee risk is 1.4% per month less than that of the portfolio of stocks with low short fee risk. The magnitude of this estimate is somewhat larger than 0.8% per month return differential reported by Engelberg, Reed, and Ringgenberg (2017) for portfolios formed using short fee risk sorted into quintiles. Again, this difference in performance is statistically significant and largely due to the very low returns of stocks in the tenth decile. The adjustment of stock returns using the historical borrowing fee does not reduce the performance differential substantially, but the adjustment based on the indicative fee attenuates the differential performance by more than two thirds. Again, most stocks with high short fee risk are missing data for the historical average fee in Markit and it is this selection issue that explains the difference in the impact of the two adjustments the performance differential.

Overall, the main message of these results is that proper adjustment for the cost of establishing short positions dramatically reduces the effective benefits of strategies based on measures of short selling activity. It is difficult for the marginal institutional investor facing the indicative borrowing fee to exploit these patterns by establishing short positions. A secondary message is that the Markit historical fee variable, SAF, is subject to a selection bias that limits its usefulness. The only remaining puzzle is the fact that retail and other institutional investors hold the stocks in this tenth decile in spite of the clear benefits to selling stocks exhibiting high short selling activity. It is important to note that institutional investors may receive an ultimate lending fee for these stocks, but this lending fee is typically smaller than the borrowing fee paid by ultimate borrowers such as hedge funds and option market makers.

4. Option-implied fees and the risk premium in the stock loan market

An option market maker quotes prices for call and put options. We are interested in analyzing how the stock borrowing fees that she must pay to borrow shares impact the option prices she quotes. For simplicity, we assume that the options are of the European type initially, the interest rate is constant, and the stock does not pay a dividend before the expiration of the options. The option market maker will delta-hedge by borrowing and short-selling the underlying stock, and thus must pay the stock borrowing fee. For hard-to-borrow stocks this is typically the case; that is, for hard-to-borrow stocks the option market maker's option position is usually such that she will need to short-sell stock in order to delta-hedge her option position. We also assume that the stock lender, typically the option market maker's prime broker, does not require the option market maker to overcollateralize the stock loan.[10]

4.1 Borrowing fee risk premium

Consider a discrete-time setting with risky borrowing payments that are made once each day from t to the expiration of the option pair $T = t + k$. Here S_t and h_t are the stock price and borrowing fee at date t, and an investor who buys the stock at date t at the price S_t can lend the stock and receive $h_t S_t$

[10] Hedge funds that borrow and short-sell shares are typically required to post collateral equal to at least 102% of the value of the borrowed shares, that is the prime broker keeps the proceeds of the short sale and requires the hedge fund to provide additional collateral equal to at least 2% of the value of the borrowed shares. We are told by option market makers that because their prime brokers hold all of their securities their liabilities to their prime brokers are routinely overcollaterized and they are not required to provide the additional 2%.

at time $t + 1$. Note that similar to an overnight interest rate, h_t is quoted at time t but $h_t S_t$ is paid at the end of the period, time $t + 1$. Define $R^{\sim h}_{t,t+j}$ as $(S_{t+j}/S_t) - 1$, which does not include the claim to any borrowing fee payments. Define $R_{t,t+j}$ for the same length of time as the return including the borrowing fee payments; this is the return received by representative investor that determines stock price and the stochastic discount factor. Of course, the risk of changes in the borrowing fee might be a priced risk because it covaries with the stochastic discount factor. Let M_{t+j} be the stochastic discount factor from period t to period $t + j$ and let V_{t+j} be the risk-adjusted present value of $h_{t+j-1}S_{t+j-1}$, which is the borrowing fee paid at date $t + j$ based on h_{t+j-1} quoted at $t+j-1$. Also let r be the one-day interest rate and let $\delta = 1/(1 + r)$ be the one-day discount factor.

The borrowing fee paid at date $t + j$ is $h_{t+j-1}S_{t+j-1}$ which is based on h_{t+j-1} quoted at date $t + j-1$ and the stock price at time $t + j - 1$. Consider the risk-adjusted value at t of this borrowing fee:

$$\begin{aligned} V_{t+j} &= E_t\left[M_{t+j}(S_{t+j-1}h_{t+j-1})\right] \\ &= E_t\left[(\delta M_{t+j-1}S_{t+j-1})h_{t+j-1}\right] \\ &= E_t\left[\delta M_{t+j-1}S_{t+j-1}\right]E_t\left[h_{t+j-1}\right] + Cov_t\left(\delta M_{t+j-1}S_{t+j-1}, h_{t+j-1}\right), \end{aligned} \tag{1}$$

where the second equality uses $M_{t+j} = \delta M_{t+j-1}$, reflecting the fact that the fee paid at time $t + j$ is known at time $t + j - 1$. Divide by $E_t[\delta M_{t+j-1}S_{t+j-1}]$ to simplify the resulting expression:

$$\frac{V_{t+j}}{E_t[\delta M_{t+j-1}S_{t+j-1}]} = E_t[h_{t+j-1}] + Cov_t\left(\frac{\delta M_{t+j-1}S_{t+j-1}}{E_t[\delta M_{t+j-1}S_{t+j-1}]}, h_{t+j-1}\right). \tag{2}$$

Note that $E_t[M_{t+j-1}S_{t+j-1}]$ is the present value of the underlying stock received at date $t + j - 1$ without any claim to borrowing fees (or dividends) before $t + j - 1$. If the borrowing fee is not included in the return to the representative investor then $E_t[M_{t+j-1}S_{t+j-1}] = S_t$. However, in this case the representative investor receives the borrowing fee, so the present value of the future stock price is lower than the current stock price, analogous to the situation in which there is a dividend payment.

Averaging the payments on k dates from $t + 1$ to $T = t + k$,

$$\frac{1}{T-t}\sum_{j=1}^{k}\frac{V_{t+j}}{E_t[\delta M_{t+j-1}S_{t+j-1}]} = \frac{1}{T-t}\sum_{j=1}^{k}\left(E_t[h_{t+j-1}] + Cov_t\left(\frac{\delta M_{t+j-1}S_{t+j-1}}{E_t[\delta M_{t+j-1}S_{t+j-1}]}, h_{t+j-1}\right)\right). \tag{3}$$

Define a risk-adjusted borrowing fee h_Q to be the constant risk-adjusted borrowing fee that results in the same present value of fees as the random fees h_{t+j-1} over the next k periods. That is, h_Q solves

$$\sum_{j=1}^{k} V_{t+j} = \sum_{j=1}^{k} E_t\left[\delta M_{t+j-1} h_{t+j-1} S_{t+j-1}\right] = \sum_{j=1}^{k} E_t\left[h_Q \delta M_{t+j-1} S_{t+j-1}\right]. \tag{4}$$

The right-hand side can be simplified to

$$\begin{aligned} \sum_{j=1}^{k} E_t\left[h_Q \delta M_{t+j-1} S_{t+j-1}\right] &= \delta h_Q S_t \sum_{j=1}^{k} (1-\delta h_Q)^{j-1} \\ &= \delta h_Q S_t \left(\frac{1}{\delta h_Q} - \frac{(1-\delta h_Q)^k}{\delta h_Q} \right). \\ &= S_t\left(1-(1-\delta h_Q)^k\right), \end{aligned} \tag{5}$$

where we used the fact that

$$E_t[\delta M_{t+j-1} S_{t+j-1}] = \delta S_t (1-\delta h_Q)^{j-1}. \tag{6}$$

The term $(1-\delta h_Q)^{j-1}$ adjusts the present value of the future stock price for the borrowing fee payments that are not received by the representative investor. Note that for a small number of time periods and/or small h_Q, the right-hand side of equation (5) is approximately $k\delta h_Q S_t$, and that this approximation is exact if the borrowing fee is not included in the return received by the representative investor.

Using the assumption that h_Q is constant from t to T and equation (6) we have $V_{t+j} = E_t[h_Q M_{t+j-1} S_{t+j-1}] = h_Q \delta S_t (1-\delta h_Q)^{j-1}$. Substituting into the left-hand side of (3) and using (6) again, the left-hand side of (3) becomes

$$\frac{1}{T-t} \sum_{j=1}^{k} \frac{V_{t+j}}{E_t[\delta M_{t+j-1} S_{t+j-1}]} = h_Q. \tag{7}$$

Thus (3) becomes

$$h_Q = \frac{1}{T-t} \sum_{j=1}^{k} \left(E_t[h_{t+j-1}] + Cov_t\left(\frac{\delta M_{t+j-1} S_{t+j-1}}{E_t[\delta M_{t+j-1} S_{t+j-1}]}, h_{t+j-1} \right) \right). \tag{8}$$

Moving the average of $E_t[h_{t+j-1}]$ to the left-hand side and slightly rearranging we have an expression for the risk premium for bearing the risk of changes in the borrowing fee:

$$\begin{aligned} h_Q - E_t\left[\frac{1}{T-t} \sum_{j=1}^{j} h_{t+j-1} \right] &= \frac{1}{T-t} \sum_{j=1}^{k} Cov_t\left(\frac{\delta M_{t+j-1} S_{t+j-1}}{E_t[\delta M_{t+j-1} S_{t+j-1}]}, h_{t+j-1} \right). \\ &= \frac{1}{T-t} \sum_{j=1}^{k} Cov_t\left(\frac{M_{t+j-1} S_{t+j-1}}{(1-\delta h_Q)^{j-1}}, h_{t+j-1} \right). \end{aligned} \tag{9}$$

If date T is the expiration date of an option then the constant risk-adjusted fee h_Q on left-hand side can be computed from option prices. The average borrowing fee can be computed from realized borrowing fees over the life of the option, and the risk premium can be estimated as the average value of the difference. This approach is similar to how the volatility risk premium is often measured as the difference between implied and future realized volatilities (e.g, in Carr and Wu 2009).

Using the constant risk-adjusted borrowing fee h_Q, the put-call parity relation for a put-call pair expiring at date $T = t + k$ is

$$S_t - \sum_{j=1}^{K} E_t[\delta h_Q M_{t+j-1} S_{t+j-1}] = C_t - P_t + PV(K). \tag{10}$$

From this, and using (6), the option-implied borrowing fee, h_Q^{imp}, is given by the solution of

$$S_t - S_t\left(1-(1-\delta h_Q^{imp})^k\right) = C_t - P_t + PV(K)\,, \tag{11}$$

where we have used the fact that the borrowing fee is part of the equilibrium return to the representative investor. Rearranging,

$$1-(1-\delta h_Q^{imp})^k = \frac{S_t - C_t + P_t - PV(K)}{S_t}\,. \tag{12}$$

In this equation h_Q^{imp} is a non-linear function of the put-call parity violation and k is the number of borrowing fee payments (or periods) remaining until expiration. The solution of this equation is

$$h_Q^{imp} = \frac{1}{\delta}\left(1-\left(1-\frac{S_t - C_t + P_t - PV(K)}{S_t}\right)^{1/k}\right). \tag{13}$$

This computation of the option-implied lending fee that takes account of the discrete nature of lending fee payments yields implied fees similar to an alternative simplified approach of treating the lending fee as a continuous flow analogous to the continuous dividend yield that appears in some versions of the Black-Scholes-Merton formula.

Turning back to the risk premium in equation (9), we can replace the first term on the left hand side with the option-implied borrowing fee based on options from t to T. We replace the second term on the left hand side, the expected average of daily borrowing fees, with the actual average of the daily borrowing fees from t to T. The difference on the left hand side should be positive if the stochastic discount factor covaries with the borrowing fee or if the stock return covaries with the borrowing fee to any significant extent. Of course, it is also possible that this covariance is zero because the actual borrowing fee is largely idiosyncratic.

4.2 Computation of the option-implied borrowing fee

In computing the option-implied borrowing fee we must take account of the dividends on the stocks. Thus, we compute the option-implied borrowing fee using the version of the put-call parity relation that incorporates dividends,

$$S_t - S_t\left(1-(1-\delta h_Q^{imp})^k\right) - PV(D) = C_t - P_t + PV(K). \tag{14}$$

Equation (13) becomes

$$h_Q^{imp} = \frac{1}{\delta}\left(1-\left(1-\frac{S_t - C_t + P_t - PV(D) - PV(K)}{S_t}\right)^{1/k}\right). \tag{15}$$

where $C(t)$ and $P(t)$ are the midpoints of quoted call and put quote prices, $PV(D)$ is the present value of dividends with ex-dividend dates before the expiration date, $T - t$ is the time to expiration, $S(t)$ is the current stock price, and K is the option strike price. For each stock and day, we use the median of the borrowing fee estimates from individual call-put pairs to reduce the impact of microstructure noise. We also restrict attention to options for which the sum of the call and put bid-ask spreads divided by the stock price is less than or equal to 5% and the stock price is greater than $5.

Actual equity options have American, not European, style exercise, and often their underlying stocks pay dividends. As described in Section 2, we minimize the impact of the biases created by the possible early exercise of American options and our use of the European put-call parity relation by restricting the sample to exclude in-the-money puts and options whose underlying stocks pay large dividends during the lives of the options. We also restrict attention to options with between 15 and 90 calendar days to expiration.

These sample restrictions do not address the fact that, when the borrowing fee is large, the fee itself can make early exercise of an American call optimal even when the stock does not pay any dividends during the life of the option. This impacts the value of an American call option, and causes the option-implied borrowing fees we compute using the European put-call parity relation to be downward-biased. We assess the magnitude of the bias by using the binomial model to compute American option prices for a grid of borrowing fees and option volatilities, using plausible values for the moneyness, time-to-expiration, and risk-free rate. For each put-call pair, we estimate the difference between the true borrowing fee and the option-implied fee computed using equation (15) above. Repeating this for many put-call pairs, we use a regression model to estimate how the difference betweeen the true and option-implied fees depends on the option parameters. We find that the bias due to the use of the European put-call parity relation can be important when the borrowing fee is large and the moneyness $\ln(K/S)$ is small so that call options are well in-the-money. The regression analysis shows that the bias is not sensitive to the option volatility and is well explained by a linear function of the interaction term $\min(h\times\ln(K/S), 0)$,where h is the indicative borrowing fee from Markit. We compute this linear function using the regression estimates and add the adjustment to the option-implied borrowing fees computed using the European put-call parity relation. We use these resulting adjusted option-implied borrowing fees to estimate the risk premium using equation (9) above.

However, we use the unadjusted option-implied fees to predict borrowing fee changes and stock returns because the adjustment uses the indicative fee. Due to this, using the adjusted fees in predictive regressions would make it difficult to conclude whether the predictive ability was due to the option-implied fee or the indicative fee component of the adjustment for early exercise. We obtain similar results using the adjusted borrowing fees in the regressions.

4.3 Option-implied borrowing fee predicts changes in borrowing fees

If the option-implied borrowing fee is a forward-looking estimate of the future borrowing fees then it should help predict changes in the indicative borrowing fee. Table 5 presents the results of regressions used to test this relation. We construct the estimates of the option-implied borrowing fees used in the regressions as follows.[11]

The unit of observation is a stock-date. For each combination of stock and date, we compute the option-implied borrowing fee from end-of-day price quotes for each call-put pair that satisfies the option filters used in constructing the optionable sample, yielding an estimate of the option-implied borrowing fee for each call-put pair.[12] For each stock and date we then take the median of the option-implied borrowing fees across the available call-put pairs, resulting in an estimate of the implied borrowing fee for each stock and date.[13] The current indicative borrowing fee for each stock and date is from the Market Securities Finance database, and the future borrowing fee is the average indicative fee

[11] Because the change in the borrowing fee is the difference between the future fee and the current indicative fee and our regressions control for the current indicative fee, the results in Table 5 also answer the question of whether the option-implied fee helps explain future fee levels. In untabulated results we regress future fee levels on the covariates used in Table 5 and obtain results in which (a) the estimated coefficient on the current indicative fee are equal to those reported in Table 5, plus one; and (b) coefficients on all other covariates are unchanged.
[12] The criteria are: (a) the put moneyness K/S is less than or equal to 1.1; (b) there are between 15 and 90 days remaining to expiration; and (c) and the sum of the call and put bid-ask spreads divided by the stock price is less than or equal to 5%. In addition, for each option in a put-call pair, open interest is positive, the absolute delta is between 0.01 and 0.99, rhw implied volatility is between 0.03 and 2, the bid is greater than 0.1, and the bid is less than the ask.
[13] Using the mean rather than the median yields similar results.

over the life of the option. The change in the indicative borrowing fee is the difference between the future borrowing fee and the current borrowing fee.

Table 4 reports the results of regressions in which the change in the borrowing fee over the next month is regressed on the indicative fee, the option-implied borrowing fee, and several other covariates. The results in the first three columns are for the full sample, while those in the last three columns are for the subset of stock-date combinations on which the stock is hard-to-borrow, where a stock is hard-to-borrow on a date if its utilization rate is greater than 60%.[14] The indicative borrowing fee by itself predicts a decrease in borrowing fees, indicating some mean reversion in borrowing fees (columns 1 and 4). The results in the other columns show that the option-implied borrowing fee helps predict the change in the borrowing fee, controlling for both the current indicative fee and other covariates, and that the estimated coefficients are highly significant. The coefficients on the option-implied borrowing fee are larger in the subsample of hard-to-borrow stocks, which is unsurprising because in this subsample the option-implied borrowing fee is larger relative to the errors in estimating it. When both variables are included in the regression specification the coefficient on the indicative borrowing fee is larger than the coefficient on the option-implied fee, though in the sample of hard-to-borrow stocks the coefficient on the option-implied borrowing fee is almost as large as that on the indicative fee.

4.4 Borrowing fee risk premium

Table 5 provides evidence about the magnitude of the borrowing fee risk premium by reporting the mean and median of the risk premium, defined as the difference between the option-implied borrowing fee and the realized indicative borrowing fee, for various samples. The unit of observation is a stock-date. For each combination of stock and date, we compute the option-implied borrowing fee for each call-put pair used in the regressions reported in Table 4, and then take the median across the options on the stock. We also adjust each of the option-implied fees for the early exercise premium as described above, and again use the median for each stock-date. For each option, we compute the average indicative borrowing fee over the remaining life of the option. The realized risk premium is the difference between the option-implied borrowing fee and this average indicative borrowing fee.

[14] The utilization rate of 60% is greater than the 90th percentile of utilization in Table 2, so the hard to borrow sample consists of fewer than 10% of the stock-dates. Stocks with high utilization are those for which constraints on supply are most likely to be binding, possibly leading to loan recalls, higher borrowing fees, and difficulties locating new shares to borrow when attempting to replace recalled stock loans. The possible alternative of defining a hard-to-borrow stock as one with a high lending fee is problematic, as the lending fee is used in computing the change in the lending fee that is the left-hand side variable.

The first row of Panel A labeled “Borrowing fee risk premium (adjusted)” reports the mean and median of the realized risk premium and also the standard deviation of the risk premium for the full sample and a subsample of hard-to-borrow stocks, where the risk premium is based on the adjusted option-implied fee. The standard error of the mean risk premium is in the next row. The table also reports the mean and median values of the risk premium computed from option-implied borrowing fees that are not adjusted for early exercise (“Borrowing fee risk premium (unadjusted)”), the adjusted and unadjusted option-implied borrowing fees, where the option-implied borrowing fees are computed as described above, and the indicative borrowing fee. The main message of the table is that the risk premium in the stock borrowing market, if there is one, is close to zero. In the full sample the mean and median risk premia are 0.17% and 0.23% per year, respectively. There are some extreme values of the realized risk premia, so the median is probably a better measure of location than the mean. In the subsample of hard-to-borrow stocks, defined as those with utilization greater than 60%, the mean and median values of the realized risk premium are −0.35% and −0.03% per year, respectively. The median of −0.03% is only −0.01% (= −0.03%/3.49%) of the median adjusted option-implied borrowing fee of 3.49% per year. The subsample of hard-to-borrow stocks is the place where we would expect to find a risk premium, if there is one, because this is the subsample for which constraints on supply are most likely to be binding, possibly leading to loan recalls, higher borrowing fees, and difficulties locating new shares to borrow when attempting to replace recalled stock loans. The fact that we do not find a risk premium in this subsample is compelling evidence that the risk premium in the stock borrowing market, if there is one, is quite small.

In Table 6 we revisit the estimates of the risk premium in the stock borrowing cost for several subsamples. First, we restrict the sample to observations in 2013 or later. Following SEC enforcement actions with respect to rule 204 of regulation SHO beginning in 2012, it became clear that failure-to-deliver is prohibited for all participants, including option market makers. The risk premium estimates for this subsample are close to zero or negative and are slightly smaller than those for the entire sample. Thus, any change in ability of market makers to fail-to-deliver appears unrelated to the observed absence of a risk premium. The second row restricts the sample to valid put-call pairs with greater time to expiration to measure the risk premium over longer time periods. Using the option-implied borrowing cost for longer horizons allows more time during which the indicative borrowing fee could change dramatically. Again, we find no evidence of a larger risk premium for this subsample.

The remaining rows of Table 6 restrict the sample based various option characteristics to ensure that option prices are more likely to be large relative to option trading costs and that the observed option prices are not simply stale quotes. The third row restricts the sample to observations the sum of the call and put bid-ask spreads divided by the stock price is less than or equal to 1%. The fourth row restricts the sample to observations to stocks with high average prices, and presumably, higher option prices and lower relative spreads.[15] The fifth row restricts the sample to observations of put-call pairs with higher implied volatility and the sixth row restricts the sample to observations with higher average option volume during the previous month. The magnitudes of these alternative risk premium estimates indicate that a borrowing cost risk premium does not explain the returns to short selling.

5. Cross-sectional return predictability

The results in Table 4 from the preceding section show that the implied borrowing fee is a strong predictor of the change in the indicative borrowing fee during the remaining life of the option pair. Since the expected cost of a short position is likely to be a key determinant of any limits to arbitrage associated with short sales, we analyze the predictability of stock returns based on the implied borrowing fee. Table 7 presents the results of these panel regressions for various specifications. The predictive relation between the implied borrowing fee and subsequent returns is negative and highly significant. While we initially focus our attention on the full sample using weekly stock returns, we also consider the subsample of stocks with high utilization that we label as hard-to-borrow (Columns 5 through 8) and stock returns during the subsequent month (Panel B). The subsample of hard-to-borrow stocks is the group where predictability due to differences in the cost of short selling may be the most relevant.

In Column 1, the *t*-statistic indicates overwhelming statistical significance of the predictive relation between the implied borrowing fee and stock returns during the next week in Panel A and during the next month in Panel B. Of course, it is possible that the implied borrowing fee only reflects the current cost determined by the market for short sales for a particular stock, that is, the current indicative borrowing fee. Column 2 indicates that the predictive relation between the implied borrowing fee and subsequent returns is clearly distinct from any role associated with the current indicative fee.

[15] Merton (1973) shows that option prices are linear homogenous in underlying stock prices. Thus, holding other option characteristics fixed, higher stock prices result in higher option prices and lower relative spreads.

Engelberg et al. (2017) argue that short selling risk is relevant for the cross-section of stock returns. Essentially, this hypothesis is motivated by the observation that shorting stocks with volatile borrowing fees incorporates another source of risk into the returns of short positions. In the theoretical setting of De Long et al. (1991), idiosyncratic risk precludes undiversified and risk averse arbitrageurs from fully correcting any potential mispricing. The ability of a risk averse and undiversified arbitrageur to move an asset's price toward its fundamental value degrades further in the presence of high idiosyncratic volatility and the findings of Wurgler and Zhuravskaya (2002) regarding index inclusions support this theory. The results of Engelberg et al. (2017) indicate that stocks with higher short selling risk, as measured by the estimates of fee volatility, tend to have lower subsequent stock returns. The authors suggest that the high volatility of the borrowing fee prevents short sellers from taking sufficiently large short positions to drive down the current stock price immediately and eliminate the subsequent low returns.

The estimate in Column 3 confirms that there is a strong univariate relation between short fee risk, as measured by the volatility of the indicative borrowing fee during the previous twelve months, and subsequent stock returns. [16] However, the estimates in Column 4 indicate that in our sample of optionable stocks the effect of short fee risk is subsumed by the other covariates. We include other characteristics of the securities borrowing market discussed in the existing literature along with the log of market capitalization for each particular stock. Once these other measures of short sales activity are incorporated, the estimated coefficient for short fee risk becomes statistically insignificant. The predictive relation between the implied borrowing fee and subsequent stock returns does not change noticeably in magnitude or statistical significance once the other variables introduced in Column 4 compared to the estimation results in Column 2.

In Columns 5 through 8, we repeat our analysis for the subsample of dates for which a specific stock is hard to borrow, that is, dates with high utilization (above 60%) for a particular stock. To the extent that the cross-section of subsequent stock returns is influenced by the limits to arbitrage created by the properties of the market for short positions, these considerations should be more important at times where relatively high demand is more likely to generate borrowing constraints now or in the near future. The predictability of stock returns using the implied borrowing fee in this subsample is quite similar to the evidence presented in Columns 1 through 4 even though these specifications include less

[16] Also, as explained in footnote 8 above, our short fee risk measure is not identical to that used in Engel, Reed, and Ringgenberg (2017) because their measure is computed from lender-side fees and ours is computed from buy-side indicative fees.

than 10% of the observations. In addition, with the exception of the estimated coefficients for implied borrowing fee, the other variables of interest in Column 8 are not significant for this subsample. Apparently, the other variables measuring activity in the short position market do not explain the cross-sectional pattern of expected returns in the subsample that should be the most relevant. Indeed, the negative relation between short fee risk and subsequent returns actually switches sign after controlling for variables related to the expected costs of a short position, such as the implied borrowing fee, the current borrowing fee, and utilization.

We also revisit all eight specifications for stock returns during the subsequent month in Panel B. The coefficient estimate for the implied borrowing fee is approximately three times larger compared to Panel A. The patterns of statistical significance for the same predictors of stock returns remain virtually unchanged compared to the analogous patterns for stock returns during the next week. With the exception of the implied borrowing fee and utilization, none of the other potential predictors are statistically significant when all predictors are included for the hard-to-borrow observations. The results of these specifications indicate that the relation between the implied borrowing fee and subsequent returns is statistically important even after controlling for other variables.

Since the preceding section of this paper indicates that the implied borrowing fee does not exhibit a positive risk premium, we interpret the implied borrowing fee as a proxy for the expected cost of holding a short position in the particular stock. The explanation of stock return predictability using the implied borrowing fee readily follows from this interpretation. Essentially, the level of the expected borrowing fee, rather than the risk properties of the borrowing fee, is responsible for the observed limit to arbitrage. This explanation is clearly consistent with the basic idea that short sellers should be less likely to take large short positions whenever doing so is expensive, e.g. Miller (1977). We generalize this concept because the expected cost of the short position during the subsequent week or month, rather than the current daily cost of the short position, creates the limit to arbitrage. This explanation of the findings is also consistent with the evidence that the current indicative borrowing fee is not significant predictor of returns in many specifications. The implied borrowing fee is a better proxy of the expected costs of short selling for the relevant horizon of typical short position. We conclude that the expected cost of the short position is the main limit to arbitrage. The potential riskiness of the borrowing fee may only be a second order consideration in terms of return predictability.

Thus, it appears that the expected cost of short selling as measured by the implied borrowing fee is the dominant limit to arbitrage. In general, this finding supports the existing literature that measures of borrowing market activity such as borrowing fees, short interest, and the relative demand for lendable shares are typically negatively related to stock returns. The implied borrowing fee is a better summary statistic of the various forces at work in the securities borrowing market compared to the other measures used in the literature. At the same time, the relation between short fee risk and returns in Engelberg et al. (2017) appears to be due to the omission of other variables related to the expected cost of maintaining short positions. The volatility of the fee does not have any predictive power after controlling appropriately for proxies related to the expected cost of short positions.

Next, we investigate the subsequent performance of portfolios formed using the implied borrowing fee. Following the performance evaluation approach described in Section 3, we sort stocks into portfolios each trading day based on the implied borrowing fee. We evaluate performance for each decile during the subsequent month after skipping one trading day. The first row of Panel A indicates that stocks with a lower implied borrowing fee have higher returns than stocks with high borrowing fee. This difference in performance is statistically significant. The differential performance is mostly due to the low stock returns in the tenth decile compared to the other portfolios, but there is also a clear monotonic performance pattern from decile 1 to decile 10 for these unadjusted returns. After adjusting for the indicative borrowing fee during the evaluation period in Panel A, the monotonic performance pattern across the deciles remains, but the estimate of the performance differential between the top and bottom deciles is attenuated and the corresponding *t*-statistic is only 1.5. Of course, this reduction in the performance differential estimate is unsurprising because the implied borrowing fee is an estimate of the expected costs associated with maintaining a short position in the near term, and so, the differences in performance associated with the implied fee should reflect future realized fees to some extent.

In Panel B, we revisit the same portfolio strategy using the implied borrowing fee and risk-adjust performance using the 4-factor model. The factor specification increases the precision of the estimate for the performance differential because there is a substantial differential loading on the SMB factor. Even though the differential estimates remains largely unchanged compared to Panel A, the corresponding *t*-statistics are roughly twice as large. After adjusting for the realization of fees during the next month, the abnormal performance differential remains statistically significant and there is a clear monotonic pattern across the deciles. The implied borrowing cost appears to contain some information about future performance even after adjusting for the indicative borrowing fees that are realized in the future.

6. Option-based predictors of stock returns

There is also an expanding literature investigating links between option markets and stock returns using various measures of implied volatility. For instance, Cremers and Weinbaum (2010) show that the average difference between the implied volatilities of calls and puts with the same strike price and expiration date, also known as the implied volatility spread, positively predicts stock returns. In addition, Xing et al. (2010) indicate that implied volatility skew, the difference between the implied volatility of an OTM put and an ATM call, is a negative predictor of stock returns. Both of these measures are transformations of option prices. Since the option-implied volatility used in both of these studies is not corrected for the effective dividend yield created by the borrowing fee, the underlying source of stock return predictability associated with these measures is an open question.

In Table 9 we analyze the stock returns during the subsequent month of portfolios formed using these transformations of option prices. All stocks are sorted into portfolios based on a particular option-implied measure as of the close of trading day t. Following the performance evaluation approach in previous sections, stocks are held from the close of trading day $t + 1$ until the close of trading day $t + 22$, to mimic the return for a typical month with 21 trading days. The first row of Panel A confirms that stocks with lower implied volatility spread have higher returns than stocks with high volatility spread. This difference is statistically significant and the differential performance is largely due to the low average return in the tenth decile compared to the other portfolios. While the reported estimates are not risk-adjusted, in unreported results the estimated abnormal performance differential using a four-factor model is virtually identical to the raw differential reported in the table. After adjusting for the indicative borrowing fee in the second set of results in Panel A, approximately half of the estimated performance differential disappears and this adjusted differential is not statistically significant. This pattern is due to the impact of the borrowing fee adjustment on the performance of the tenth portfolio. Therefore, the observed underperformance of stocks with a high implied volatility spread is concentrated amongst stocks that have high costs for short positions. Essentially, the differential performance observed before adjusting for borrowing fees is not exploitable through short positions because the costs of borrowing faced by the marginal institutional investor are high for these stocks.

Panel B of Table 9 conducts a similar analysis for implied skew instead of implied volatility spread. The first row of Panel B confirms that stocks with high implied skew have low returns compared to stocks with low implied skew. Once again, the difference in performance between the top and bottom decile is statistically significant and this difference is almost entirely associated with the poor performance of the tenth decile compared to all of the other deciles. In unreported results, the four-factor model yields a very similar pattern for all deciles as well as the difference in abnormal performance for the top and bottom deciles. The second set of results in Panel B incorporate the adjustment for the indicative borrowing fee. This correction reduces the performance differential to about half of its original magnitude and it is no longer statistically significant. The adjustment for the borrowing fee has a very large impact on the performance of the tenth decile and this indicates that low unadjusted stock returns for stocks with high implied skew are not exploitable by the marginal investor via short positions.

Table 10 analyzes the same implied measures using panel regressions. First, we confirm the existence of a strong univariate predictive relation between each of these implied volatility measures and subsequent stock returns. Column 1 indicates that the implied volatility spread is positively related to returns next week. Column 2 shows that implied volatility skew is negatively related to returns next week. However, when we augment this approach with the implied borrowing fee and other variables related to the market for short sales in Column 3, the only consistently significant predictors of stock returns related to short selling are the implied borrowing fee and utilization. The implied borrowing fee has a *t*-statistic of approximately 5. Neither the implied volatility spread measure from Cremers and Weinbaum (2010) nor the implied skew measure from Xing et al. (2010) are significant predictors of returns next week.

Following our typical practice, we revisit these specifications for stock returns during the next month. In Column 4 and Column 5 we verify the presence of a strong univariate relation between each implied volatility spread measure and stock returns next month. If we include the other variables of interest in Column 6, the three clearly significant predictors of returns related to short selling are the implied borrowing fee, the indicative borrowing fee, and utilization. The implied volatility spread measure is not significant in this specification and the coefficient estimate changes sign relative to the univariate relation. The implied skew measure from Xing et al. (2010) is not a significant predictor of returns and the *t*-statistic is almost identically zero.

In Table 11 we revisit the specifications in Table 10 while adjusting subsequent stock returns for the indicative borrowing fee. This adjustment dramatically reduces the strength of the univariate relation between implied volatility spread and subsequent stock returns, Columns 1 and 4, as well as the relation between implied skew and subsequent stock returns, Columns 2 and 5. While the univariate coefficients remain statistically significant, the magnitudes of theses coefficients decline by at least one half and in some cases more than two thirds. This pattern of attenuation indicates the stock return predictability associated with either of these transformations of option prices is due to the high costs of borrowing for a relatively modest number of stocks. Once other variables reflecting short sales activity are included, both implied volatility spread and implied skew are no longer significant predictors of stock returns during the next week. Instead, the implied borrowing fee, utilization, and market capitalization predict subsequent stock returns. These results reflect the same patterns of predictability for unadjusted returns that were present in Table 10. For returns during the subsequent month, the results are quite similar except the coefficient estimate for implied volatility spread changes sign once the other variables reflecting the short sales market are included. In general, these results indicate that stock return predictability related to these transformations of option prices is really a consequence of the cost to borrow stocks.

7. Conclusion

Readily available measures of short selling activity predict stock returns, which presents a puzzle. We use portfolio sorts and measures of the stock borrowing costs paid by short-sellers to show that the returns to shorting net of stock borrowing costs are less than one-third of the gross returns, and not significant. This partially resolves the puzzle of the persistence of predictability based on readily available information, but does not fully eliminate the puzzle because panel regressions show that the option-implied borrowing fee and utilization continue to predict returns net of borrowing costs. The smaller magnitude of the net of borrowing cost returns also makes explanations of the puzzle in terms of trading costs and risk of borrowing fee changes more likely to be viable. For example, it seems unlikely that borrowing fee risk could fully explain the decile ten minus decile one long-short spread of 140 basis points per month (≈17% per year) in Table 4, but can more plausibly explain the net of borrowing cost return of 40 basis points.

We also use option implied borrowing fees to estimate the risk premium to bearing the risk of borrowing fee changes. Specifically, the average difference between the option-implied borrowing fee and the average daily borrowing fee during the life of the option pair used to compute the option-implied borrowing fee is an estimate of the borrowing fee risk premium. We find that the option-implied borrowing fees are approximately equal to the relevant realized daily borrowing fees. This result implies that the risk of borrowing stock is not substantial enough to create a risk premium reflected in the prices of exchange-traded options. The finding is consistent with the possibility that borrowing fee risk for individual stocks is diversifiable and the options market is sufficiently competitive and well-capitalized to distribute this risk effectively.

In the absence of a risk premium, it should be the case that the option-implied borrowing fee predicts the changes in the daily borrowing fee during the life of the option. Indeed, we find that the option-implied borrowing fee is a strong predictor of changes in realized indicative borrowing fees. This finding is evidence that the option-implied borrowing fees we are useful forward-looking estimates of the borrowing fees during the lives of the options. Since option prices are public information, as compared to proprietary data about daily borrowing fees or short interest that could be considered private information, these results also indicate that one valid measure of the expected cost of short selling is public information.

If the option-implied borrowing fee is a forward-looking estimate of the actual borrowing fees and the expected cost of short selling is a limit to arbitrage, then this measure should predict future stock returns. We estimate predictive regressions using the option-implied borrowing fee and find that option-implied borrowing fees predict stock returns next week and next month. This relation is highly significant even when other variables such as the indicative borrowing fee, loan utilization, short interest, and the short fee risk are included. Indeed, aside from utilization, these other measures of borrowing market activity are typically not significant predictors especially for hard-to-borrow stocks. Our results suggest that the option-implied borrowing fee is a better measure of expected costs of shorting than the lending fee and short interest commonly used in the literature. In all likelihood, this superior performance is due to the fact that the option-implied borrowing fee is a better measure of future borrowing fees during the holding period of the typical short position.

We also find that the option-implied borrowing fee is related to the literature relating option-implied volatility measures to the subsequent stock returns. Cremers and Weinbaum (2010) find that the implied volatility spread is positively relate to stock returns and Xing et al. (2010) show that the implied volatility skew is negatively related to returns. If we include the option-implied borrowing fee and these other option-based predictors in predictive regressions, we obtain significant coefficients on the option-implied borrowing fee and insignificant coefficients on both the implied volatility spread and the implied volatility skew. This pattern suggests that the implied volatility measures only predict returns because they proxy for the option-implied borrowing fee. This result may have important implications for any potential explanations of these existing findings in the literature. For example, the explanation proposed by Xing et al. (2010) is that informed traders use out-of-the-money put options to exploit an informational advantage. This seems to be quite distinct from the limit to arbitrage explanation generated by the expected costs of short selling.

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Table 1

Summary Statistics

Panel A presents the summary statistics for stocks in CRSP that match to an indicative borrowing fee in Markit where the unit of observation is the combination of a stock and trading date. Panel B presents analogous statistics for the optionable stocks in CRSP that match to a valid put-call pair in Optionmetrics and an indicative borrowing fee in Markit. For each option in a valid put-call pair, open interest is positive, the absolute delta is between 0.01 and 0.99, implied volatility is between 0.03 and 2, the bid is greater than 0.1, and the bid is less than the ask. In addition, the sum of the call and put bid-ask spreads divided by the stock price is ≤ 5%, the put moneyness, K/S, is ≤ 1.1, and time to maturity is greater than 15 days and less than 90 days. Panel B is restricted to observations where the dividend yield is ≤ 5% and the stock price is greater than $5. The historical borrowing fee, measured using simple average fee (SAF), and utilization are from Markit. Short interest is the number of shares short in Markit divided by shares outstanding from CRSP. Short fee risk is the log of the variance of the indicative fee during the preceding 12 months. Market capitalization is from CRSP and NYSE size decile is assigned accordingly. The calculation of implied volatility spread follows Cremers and Weinbaum (2010) and the calculation of implied volatility skew follows Xing, Zhang, and Zhao (2010). The computation of the option-implied borrowing fee and the adjustment of this option-implied borrowing fee to take account of early exercise are described in Section 4. The sample period is July 2006 to August 2015.

	No. Obs.	Mean	Std. Dev.	Skewness	1%	10%	50%	90%	99%
Panel A: Summary statistics for CRSP stocks with an indicative borrowing fee in Markit									
Indicative borrowing fee	10,200,000	0.0225	0.0664	7.8807	0.0025	0.0038	0.0038	0.0600	0.3000
Indicative rebate	10,200,000	-0.0103	0.0701	-6.9687	-0.2988	-0.0443	-0.0025	0.0475	0.0494
Historical borrowing fee	4,392,544	0.0120	0.0430	8.9297	0.0004	0.0020	0.0029	0.0190	0.1976
Historical rebate	4,392,544	-0.0074	0.0446	-8.1013	-0.1950	-0.0159	-0.0015	0.0015	0.0500
Utilization	9,865,709	19.1397	23.1371	1.6163	0.0000	0.4379	9.5724	54.8720	96.2804
Short fee risk	10,100,000	5.5941	5.3504	-2.7018	-28.2801	1.1426	4.4460	11.5399	14.4885
Short interest	10,200,000	0.0363	0.0589	5.0031	0.0000	0.0003	0.0144	0.1016	0.2527
Market cap, $mn	10,100,000	4063	17173	13	8	46	503	7327	64725
NYSE size decile	9,796,131	6.0102	2.8137	-0.2132	1	2	6	10	10
Panel B: Summary statistics for the optionable subset of CRSP stocks with an indicative borrowing fee in Markit									
Indicative borrowing fee	3,656,397	0.0107	0.0393	12.2105	0.0025	0.0038	0.0038	0.0088	0.1600
Indicative rebate	3,656,397	0.0014	0.0440	-8.8851	-0.1485	-0.0059	-0.0023	0.0475	0.0494
Implied fee, adj.	3,656,397	0.0124	0.0494	3.4408	-0.0992	-0.0236	0.0077	0.0488	0.1952
Implied fee, unadj.	3,656,397	0.0105	0.0447	2.3720	-0.1003	-0.0244	0.0070	0.0466	0.1702
Utilization	3,651,961	20.5113	21.8736	1.3781	0.0784	1.0778	12.2455	54.3394	88.3012
Short fee risk	3,653,014	3.8246	4.9569	-3.5158	-28.2801	0.9163	3.7351	9.3214	13.8134
Short interest	3,656,397	0.0559	0.0661	2.0928	0.0003	0.0030	0.0310	0.1449	0.2966
Implied volatility spread	3,655,960	-0.0094	0.0466	-3.0683	-0.1690	-0.0489	-0.0048	0.0280	0.0915
Implied volatility skew	2,407,634	0.0609	0.0478	2.4422	-0.0259	0.0177	0.0536	0.1113	0.2232
Market cap, $mn	3,656,287	9871	27131	8	205	530	2545	21490	140747
NYSE size decile	3,586,441	8.4000	1.5897	-1.0119	4	6	9	10	10

Table 2

Portfolio returns based on the indicative borrowing fee reported by Markit

The table presents the returns for equal-weighted portfolios formed using the indicative borrowing fee. The sample includes stock returns from CRSP matched to indicative borrowing fee observations from Markit. Stocks are sorted into deciles using the indicative fee on trading date t and held in portfolios from the close of trading date t+1 until the close of trading date t+22. For the Historical fee adj., the cumulative historical borrowing fee based on the simple average fee (SAF) measured by Markit for each stock is added to the return. For the Indicative fee adj., the cumulative indicative borrowing fee during the evaluation period for each stock is added instead. For the Indicative conditional row, the cumulative indicative borrowing fee for each stock is added to the monthly stock return and the sample of stocks in each portfolio is restricted to those for which the historical borrowing fee is available from Markit. The sample period is July 2006 to August 2015. Each return series is a moving average with 20 overlapping observations. The t-statistics based on Newey-West standard errors with 30 lags adjust for this pattern and are reported in brackets below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Monthly performance using stocks sorted by indicative fee for equal-weighted portfolios											
	1 Low	2	3	4	5	6	7	8	9	10 High	10-1
Average return	0.0037**	0.0036**	0.0032*	0.0031*	0.0030	0.0026	0.0017	0.0014	-0.0013	-0.0117***	-0.0153***
(Unadjusted)	[2.1]	[2.0]	[1.8]	[1.7]	[1.6]	[1.3]	[0.7]	[0.5]	[-0.4]	[-2.7]	[-3.3]
Average # of stocks	441	441	441	441	441	441	441	441	441	441	
Average return	0.0029*	0.0027*	0.0027*	0.0022	0.0021	0.0022	0.0012	-0.0004	-0.0034	-0.0098*	-0.0127**
(Historical fee adj.)	[1.6]	[1.8]	[1.8]	[1.5]	[1.3]	[1.2]	[0.5]	[-0.2]	[-0.8]	[-1.9]	[-2.3]
Average # of stocks	252	254	253	250	244	237	212	154	113	98	
Average Return	0.0040**	0.0039**	0.0036**	0.0035*	0.0034*	0.0030	0.0022	0.0025	0.0017	0.0007	-0.0034
(Indicative fee adj.)	[2.3]	[2.2]	[2.0]	[1.9]	[1.8]	[1.5]	[1.0]	[0.9]	[0.6]	[0.2]	[-0.7]
Average # of stocks	441	441	441	441	441	441	441	441	441	441	
Average Return)	0.0030*	0.0028*	0.0028*	0.0023	0.0022	0.0023	0.0011	-0.0004	-0.0031	-0.0073	-0.0104*
(Indicative conditional)	[1.6]	[1.8]	[1.9]	[1.5]	[1.3]	[1.3]	[0.5]	[-0.2]	[-0.8]	[-1.4]	[-1.9]
Average # of stocks	252	254	253	250	244	237	212	154	113	98	

Table 3

Portfolio returns based on short fee risk

The table presents the returns for equal-weighted portfolios formed using short fee risk calculated from Markit. Short fee risk is the log of the variance of the daily indicative borrowing fee during the preceding 12 months. The sample includes stock returns from CRSP matched to short fee risk observations. Stocks are sorted into deciles using the short fee risk on trading date t and held in portfolios from the close of trading date t+1 until the close of trading date t+22. For the Historical fee adj., the cumulative historical borrowing fee based on the simple average fee (SAF) measured by Markit for each stock is added to the return. For the Indicative fee adj., the cumulative indicative borrowing fee during the evaluation period for each stock is added instead. For the Indicative conditional row, the cumulative indicative borrowing fee for each stock is added to the monthly stock return and the sample of stocks in each portfolio is restricted to those for which the historical borrowing fee measured by SAF is available from Markit. The sample period is July 2006 to August 2015. Each return series is a moving average with 20 overlapping observations. The t-statistics based on Newey-West standard errors with 30 lags adjust for this pattern and are reported in brackets below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Monthly performance using stocks sorted by short fee risk for equal-weighted portfolios											
	1 Low	2	3	4	5	6	7	8	9	10 High	10-1
Average Return	0.0031*	0.0032*	0.0033*	0.0040**	0.0041*	0.0029	0.0003	-0.0001	-0.0008	-0.0109***	-0.0140***
(Unadjusted)	[1.7]	[1.7]	[1.8]	[2.0]	[1.9]	[1.2]	[0.1]	[-0.0]	[-0.2]	[-3.7]	[-4.1]
Average # Of Stocks	440	440	440	440	440	440	440	440	440	440	
Average Return	0.0031*	0.0024	0.0023	0.0026	0.0021	0.0024	-0.0002	-0.0013	-0.0045	-0.0093**	-0.0124**
(Historical Fee Adj.)	[1.9]	[1.4]	[1.4]	[1.5]	[1.2]	[0.9]	[-0.1]	[-0.4]	[-0.9]	[-2.0]	[-2.5]
Average # Of Stocks	293	289	286	279	253	206	154	120	88	96	
Average Return	0.0035*	0.0035*	0.0037*	0.0044**	0.0044**	0.0034	0.0012	0.0019	0.0030	-0.0006	-0.0040
(Indicative Fee Adj)	[1.9]	[1.8]	[1.9]	[2.2]	[2.0]	[1.4]	[0.4]	[0.6]	[0.8]	[-0.2]	[-1.2]
Average # Of Stocks	440	440	440	440	440	440	440	440	440	440	
Average Return	0.0032*	0.0025	0.0024	0.0027	0.0022	0.0024	-0.0002	-0.0012	-0.0040	-0.0075	-0.0106**
(Indicative Conditional)	[1.9]	[1.5]	[1.4]	[1.6]	[1.2]	[0.9]	[-0.1]	[-0.3]	[-0.8]	[-1.6]	[-2.1]
Average # Of Stocks	293	289	286	279	253	206	154	120	88	96	

Table 4

Predicting the change in the indicative borrowing fee

This table presents the estimates from regressions that use the indicative fee and the option-implied borrowing fee to explain the subsequent change in the indicative fee. This change is the difference between the average indicative fee from trading day t+1 to trading day t+22, and the current indicative fee. This horizon mimics the length for a typical month with 21 trading days. The unit of observation is the combination of a stock and trading date for the optionable stocks in CRSP that match to a valid put-call pair in Optionmetrics and an indicative borrowing fee in Markit. For each option in a valid put-call pair, open interest is positive, the absolute delta is between 0.01 and 0.99, implied volatility is between 0.03 and 2, the bid is greater than 0.1, and the bid is less than the ask. In addition, the sum of the call and put bid-ask spreads divided by the stock price is ≤ 5%, the put moneyness, K/S, is ≤ 1.1, and time to maturity is greater than 15 days and less than 90 days. The sample is also restricted to observations where the dividend yield is ≤ 5% and the stock price is greater than $5. Short interest is the number of shares short from Markit divided by shares outstanding from the CRSP. Short fee risk is the log of the variance of the daily indicative borrowing fee during the preceding 12 months. Market capitalization is from CRSP. Utilization is from Markit. The sample period is July 2006 to August 2015. The computation of the option-implied borrowing fee is described in Section 4. The hard-to-borrow sample uses observations where utilization from Markit is greater than 60%. The t-statistics are based on robust standard errors clustered by stock and are reported in brackets below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	All Observations			Hard-to-borrow (Utilization > 60%)		
Model	1	2	3	4	5	6
Indicative fee	-0.0578***	-0.0758***	-0.0896***	-0.0684***	-0.1309***	-0.1552***
	[-11.7]	[-13.9]	[-14.3]	[-11.5]	[-15.0]	[-15.8]
Option-implied fee		0.0316***	0.0293***		0.1136***	0.1079***
		[12.0]	[11.8]		[12.5]	[12.4]
Short fee risk			0.0000***			0.0005***
			[4.2]			[5.1]
Utilization			0.0001***			0.0006***
			[12.7]			[15.1]
Short interest			-0.0109***			-0.0011
			[-6.7]			[-0.4]
Market capitalization			0.0000***			-0.0000***
			[6.7]			[-6.5]
Constant	0.0006***	0.0005***	-0.0006***	0.0058***	0.0043***	-0.0419***
	[13.5]	[11.7]	[-12.2]	[14.9]	[12.5]	[-14.5]
R^2	0.04	0.05	0.06	0.05	0.09	0.11
Number of Observations	3,650,742	3,650,742	3,642,862	290,610	290,610	286,032
Number of Clusters	4219	4219	4203	1795	1795	1768

Table 5

The risk premium for the borrowing fee

This table provides estimates of the borrowing fee risk premium based on adjusted and unadjusted option-implied fees. The borrowing fee risk premium is the difference between the adjusted (unadjusted) option-implied fee and the subsequent realized average indicative borrowing fee during the remaining life of the put-call pair associated with the option-implied fee (the median borrowing cost measured across put-call pairs for a stock on a trading date). The unit of observation is the combination of a stock and trading date for the optionable stocks in CRSP that match to a valid put-call pair in Optionmetrics and an indicative borrowing fee in Markit. For each option in a valid put-call pair, open interest is positive, the absolute delta is between 0.01 and 0.99, implied volatility is between 0.03 and 2, the bid is greater than 0.1, and the bid is less than the ask. In addition, the sum of the call and put bid-ask spreads divided by the stock price is ≤ 5%, the put moneyness, K/S, is ≤ 1.1, and time to maturity is greater than 15 days and less than 90 days. The sample is also restricted to observations where the dividend yield is ≤ 5% and the stock price is greater than $5. The computation of the option-implied borrowing fee and the adjustment of the option-implied borrowing fee to take account of early exercise are described in Section 4. The hard-to-borrow sample uses observations where utilization from Markit is greater than 60%. The sample period is July 2006 to August 2015. The t-statistics testing the hypothesis that the mean lending fee risk premium is zero are based on robust standard errors clustered by stock and are reported in brackets below the sample means. The table also reports the means, medians, and standard deviations of the adjusted implied fee, the unadjusted implied fee, and the current indicative fee.

	All Observations				Hard-to-borrow (Utilization > 60%)			
	N	Mean	Median	Std. Dev.	N	Mean	Median	Std. Dev.
Borrowing fee risk premium (adjusted)	3,656,397	0.17% [2.9]	0.23%	3.93%	291,239	-0.35% [-2.2]	-0.03%	6.76%
Borrowing fee risk premium (unadjusted)	3,656,397	-0.02% [-0.7]	0.15%	4.04%	291,239	-1.72% [-10.1]	-0.74%	7.22%
Implied borrowing fee (adjusted)	3,656,397	1.24%	0.77%	4.94%	291,239	6.61%	3.49%	10.74%
Implied borrowing fee (unadjusted)	3,656,397	1.05%	0.70%	4.47%	291,239	5.22%	2.93%	8.89%
Indicative borrowing fee (current)	3,656,397	1.07%	0.38%	3.93%	291,239	6.98%	3.00%	11.29%

Table 6

Subsample analysis of the risk premium for the borrowing fee

This table provides estimates of the borrowing fee risk premium based on adjusted option-implied fees for various subsamples of the data. The borrowing fee risk premium is the difference between the adjusted option-implied fee and the subsequent realized average indicative borrowing fee during the remaining life of the put-call pair associated with the option-implied fee (the median borrowing cost measured across put-call pairs for a stock on a trading date). The unit of observation is the combination of a stock and trading date for the optionable stocks in CRSP that match to a valid put-call pair in Optionmetrics and an indicative borrowing fee in Markit. For each option in a valid put-call pair, open interest is positive, the absolute delta is between 0.01 and 0.99, implied volatility is between 0.03 and 2, the bid is greater than 0.1, and the bid is less than the ask. In addition, the sum of the call and put bid-ask spreads divided by the stock price is ≤ 5%, the put moneyness, K/S, is ≤ 1.1, and time to maturity is greater than 15 days and less than 90 days. The sample is also restricted to observations where the dividend yield is ≤ 5% and the stock price is greater than $5. The computation of the option-implied borrowing fee and the adjustment of the option-implied borrowing fee to take account of early exercise are described in Section 4. The sample period is July 2006 to August 2015. The hard-to-borrow sample uses observations where utilization from Markit is greater than 60%. The first row restricts the sample to observations in 2013 or later when failure-to-deliver by all participants, including option market makers, is prohibited. The second row restricts the sample to valid put-call pairs with greater time to expiration to measure the risk premium over longer time periods. The third row restricts the sample to observations the sum of the call and put bid-ask spreads divided by the stock price is q 1%. The fourth row restricts the sample to observations to stocks with high average prices, and presumably, higher option prices. The fifth row restricts the sample to observations to put-call pairs with higher implied volatility. The sixth row restricts the sample to observations with higher average option volume during the previous month.

	All Observations				Hard-to-borrow (Utilization > 60%)			
Subsample	N	Mean	Median	Std. Dev.	N	Mean	Median	Std. Dev.
Year ≥ 2013	1,145,663	0.02%	0.21%	4.07%	73,155	-1.51%	-0.62%	8.17%
Days to expiration > 60	575,532	0.04%	0.14%	2.63%	35,303	-0.88%	-0.27%	5.38%
Scaled Option Bid-Ask Spread ≤ 1%	1,150,129	0.05%	0.16%	1.95%	38,331	-0.07%	0.18%	3.92%
Average Stock Price > $40	1,326,109	0.17%	0.22%	3.06%	51,719	0.04%	0.29%	6.19%
Implied Volatility > 40%	1,643,872	0.19%	0.27%	4.68%	218,787	-0.10%	0.08%	6.96%
Previous Month Option Volume > 1000	958,436	0.18%	0.18%	3.22%	92,315	0.55%	0.32%	7.02%

Table 7

Stock return predictability using the option-implied lending fee

This table presents regressions that use the option-implied borrowing fee to predict the stock return from the close of trading date t+1 to the close trading date t+6 in Panel A or from the close of trading date t+1 to the close trading date t+22 in Panel B. The unit of observation is the combination of a stock and trading date for the optionable stocks in CRSP that match to a valid put-call pair in Optionmetrics and an indicative borrowing fee in Markit. For each option in a valid put-call pair, open interest is positive, the absolute delta is between 0.01 and 0.99, implied volatility is between 0.03 and 2, the bid is greater than 0.1, and the bid is less than the ask. In addition, the sum of the call and put bid-ask spreads divided by the stock price is ≤ 5%, the put moneyness, K/S, is ≤ 1.1, and time to maturity is greater than 15 days and less than 90 days. The sample is also restricted to observations where the dividend yield is ≤ 5% and the stock price is greater than $5. Short interest is the number of shares short from Markit divided by shares outstanding from the CRSP. Short fee risk is the log of the variance of the daily indicative borrowing fee during the preceding 12 months. Market capitalization is from CRSP. Utilization is from Markit. The sample period is July 2006 to August 2015. The computation of the option-implied borrowing fee is described in Section 4. The hard-to-borrow sample uses observations where utilization from Markit is greater than 60%. The t-statistics are based on robust standard errors clustered by stock and are reported in brackets below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Stock returns for the next week (trading days t+2 through t+6)

	All Observations				Hard-to-borrow (Utilization > 60%)			
Model	1	2	3	4	5	6	7	8
Implied borrowing fee	-0.0189***	-0.0136***		-0.0129***	-0.0200***	-0.0181***		-0.0179***
	[-11.6]	[-9.7]		[-9.3]	[-5.2]	[-4.3]		[-4.3]
Indicative borrowing fee		-0.0120***		-0.0064*		-0.0022		0.0021
		[-3.8]		[-1.9]		[-0.5]		[0.4]
Short fee risk			-0.0001***	0.0000			-0.0004***	-0.0001
			[-5.8]	[1.0]			[-4.1]	[-1.3]
Utilization				-0.0000***				0.0000
				[-5.3]				[-1.0]
Short interest				0.0011				0.0011
				[0.6]				[0.3]
Market capitalization				-0.0000***				0.0000
				[-3.9]				[1.0]
Constant	0.0004***	0.0005***	0.0005***	0.0010***	-0.0013***	-0.0012***	0.0011	0.0018
	[7.5]	[8.2]	[7.5]	[11.9]	[-3.9]	[-3.5]	[1.3]	[0.7]
Number of Observations	3656287	3656287	3652904	3648469	291237	291237	291054	286637
Number of Clusters	4259	4259	4253	4244	1809	1809	1801	1782

Table 7 (continued)

Panel B: Stock returns for the next month (trading days t+2 through t+22)								
	All Observations				Hard-to-borrow (Utilization > 60%)			
Model	1	2	3	4	5	6	7	8
Implied borrowing fee	-0.0638***	-0.0312***		-0.0277***	-0.0747***	-0.0441***		-0.0422***
	[-10.2]	[-6.9]		[-6.2]	[-5.0]	[-2.9]		[-2.7]
Indicative borrowing fee		-0.0738***		-0.0532***		-0.0345**		-0.0221
		[-6.1]		[-4.1]		[-2.2]		[-1.2]
Short fee risk			-0.0003***	0.0000			-0.0015***	-0.0003
			[-6.3]	[0.7]			[-4.0]	[-0.6]
Utilization				-0.0001***				-0.0002**
				[-5.0]				[-2.0]
Short interest				0.0012				-0.0016
				[0.2]				[-0.1]
Market capitalization				-0.0000***				0.0000
				[-3.8]				[1.0]
Constant	0.0014***	0.0018***	0.0019***	0.0039***	-0.0068***	-0.0060***	0.0029	0.0125
	[6.0]	[7.6]	[7.3]	[11.6]	[-5.2]	[-4.3]	[0.8]	[1.4]
Number of Observations	3656287	3656287	3652904	3648469	291237	291237	291054	286637
Number of Clusters	4259	4259	4253	4244	1809	1809	1801	1782

Table 8

Portfolio returns using sorting by implied borrowing fee

Panel A presents the returns for equal-weighted portfolios formed using the option-implied borrowing fee described in Section 4. Panel B presents the abnormal returns for the same equal weighted portfolios based on the 4-factor model. The factors are from Kenneth French's website. The sample includes stock returns from CRSP matched to option-implied borrowing fee observations based on valid put-call pairs. For each option in a valid put-call pair, open interest is positive, the absolute delta is between 0.01 and 0.99, implied volatility is between 0.03 and 2, the bid is greater than 0.1, and the bid is less than the ask. In addition, the sum of the call and put bid-ask spreads divided by the stock price is ≤ 5%, the put moneyness, K/S, is ≤ 1.1, and time to maturity is greater than 15 days and less than 90 days. The sample is also restricted to observations where the dividend yield is ≤ 5% and the stock price is greater than $5. Stocks are sorted into deciles using the implied borrowing fee on trading date t and held in portfolios from the close of trading date t+1 until the close of trading date t+22. For the Indicative fee adj., the cumulative indicative borrowing fee during the evaluation period for each stock is added to the return. The sample period is July 2006 to August 2015. Each return series is a moving average with 20 overlapping observations. The t-statistics based on Newey-West standard errors with 30 lags adjust for this pattern and are reported in brackets below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Monthly performance using stocks sorted by implied borrowing fee for equal-weighted portfolios

	1 Low	2	3	4	5	6	7	8	9	10 High	10-1
Average return	0.0025*	0.0023*	0.0022*	0.0019*	0.0018	0.0014	0.0011	0.0011	0.0002	-0.0052**	-0.0077***
(Unadjusted)	[1.7]	[1.8]	[1.9]	[1.7]	[1.6]	[1.2]	[0.9]	[0.8]	[0.1]	[-2.3]	[-2.9]
Average # of stocks	159	159	159	159	158	159	159	159	159	158	
Average return	0.0033**	0.0028**	0.0027**	0.0023**	0.0023**	0.0019	0.0016	0.0017	0.0011	-0.0006	-0.0039
(Indicative fee adj.)	[2.3]	[2.2]	[2.3]	[2.1]	[2.0]	[1.6]	[1.3]	[1.2]	[0.6]	[-0.3]	[-1.5]
Average # of stocks	159	159	159	159	158	159	159	159	159	158	

Panel B: Monthly 4-factor abnormal performance using stocks sorted by implied borrowing fee for equal-weighted portfolios

	1 Low	2	3	4	5	6	7	8	9	10 High	10-1
Abnormal return	0.0017***	0.0014***	0.0013**	0.0010*	0.0008	0.0003	0.0000	-0.0001	-0.0012**	-0.0066***	-0.0083***
(Unadjusted)	[2.8]	[2.8]	[2.2]	[1.8]	[1.5]	[0.7]	[-0.1]	[-0.2]	[-2.1]	[-5.7]	[-6.3]
Average # of stocks	159	159	159	159	158	159	159	159	159	158	
Abnormal return	0.0025***	0.0019***	0.0017***	0.0014**	0.0013**	0.0008	0.0004	0.0005	-0.0003	-0.0020*	-0.0045***
(Indicative fee adj.)	[4.1]	[3.8]	[3.0]	[2.5]	[2.3]	[1.5]	[0.8]	[0.8]	[-0.5]	[-1.7]	[-3.4]
Average # of stocks	159	159	159	159	158	159	159	159	159	158	

Table 9

Portfolio returns based different option implied measures in the literature

Panel A presents the returns for equal-weighted portfolios formed using the implied volatility. Implied volatility spread is the difference between the implied volatilities of at-the-money calls and puts used in Cremers and Weinbaum (2010). Panel B presents the returns to equal-weighted portfolios formed using implied volatility skew. Implied volatility skew is the difference between the implied volatilities an out-of-the-money call and an at-the-money call used in Xing, Zhang, and Zhao (2010). For comparison purposes with the results for the implied borrowing fee, the sample includes stock returns from CRSP that match to option-implied borrowing fee observations based on valid put-call pairs. For each option, open interest is positive, the absolute delta is between 0.01 and 0.99, implied volatility is between 0.03 and 2, the bid is greater than 0.1, and the bid is less than the ask. In addition, the sum of the call and put bid-ask spreads divided by the stock price is ≤ 5%, the put moneyness, K/S, is ≤ 1.1, and time to maturity is greater than 15 days and less than 90 days. The sample is also restricted to observations where the dividend yield is ≤ 5% and the stock price is greater than $5. Stocks are sorted into deciles using the implied measure on trading date t and held in portfolios from the close of trading date t+1 until the close of trading date t+22. For the Indicative fee adj., the cumulative indicative borrowing fee during the evaluation period for each stock is added to the return. The sample period is July 2006 to August 2015. Each return series is a moving average with 20 overlapping observations. The t-statistics based on Newey-West standard errors with 30 lags adjust for this pattern and are reported in brackets below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Monthly performance using stocks sorted by option implied volatility spread for equal-weighted portfolios

	1 Low	2	3	4	5	6	7	8	9	10 High	10-1
Average return	0.0018	0.0021	0.0020*	0.0021*	0.0017	0.0015	0.0015	0.0010	0.0003	-0.0048**	-0.0066**
(Unadjusted)	[1.1]	[1.5]	[1.7]	[1.9]	[1.6]	[1.3]	[1.3]	[0.8]	[0.2]	[-2.2]	[-2.4]
Average # of stocks	159	159	159	159	158	159	159	159	159	159	
Average return	0.0025	0.0026*	0.0024**	0.0025**	0.0021**	0.0020*	0.0020*	0.0016	0.0012	-0.0002	-0.0027
(Indicative fee adj.)	[1.5]	[1.9]	[2.0]	[2.3]	[2.0]	[1.7]	[1.7]	[1.2]	[0.8]	[-0.1]	[-1.0]
Average # of stocks	159	159	159	159	158	159	159	159	159	159	

Panel B: Monthly performance using stocks sorted by option implied skew for equal-weighted portfolios

	1 Low	2	3	4	5	6	7	8	9	10 High	10-1
Average return	0.0008	0.0015	0.0020*	0.0016	0.0015	0.0016	0.001	0.0006	-0.0004	-0.0057**	-0.0066**
(Unadjusted)	[0.6]	[1.2]	[1.7]	[1.4]	[1.4]	[1.4]	[0.8]	[0.5]	[-0.3]	[-2.5]	[-2.4]
Average # of stocks	104	104	104	104	104	104	104	104	104	104	
Average return	0.0014	0.0019	0.0024**	0.0020*	0.0020*	0.0020*	0.0015	0.0012	0.0004	-0.0016	-0.0030
(Indicative fee adj.)	[0.9]	[1.6]	[2.1]	[1.8]	[1.8]	[1.8]	[1.2]	[0.9]	[0.3]	[-0.7]	[-1.1]
Average # of stocks	104	104	104	104	104	104	104	104	104	104	

Table 10

Unadjusted stock return predictability using other option implied measures

This table presents regressions that use the option-implied measures to predict the stock return from the close of trading date t+1 to the close trading date t+6 (the next week) in Columns 1 through 3 or from the close of trading date t+1 to the close trading date t+22 (the next month) in Columns 4 through 6. The unit of observation is the combination of a stock and trading date for the optionable stocks in CRSP that match to a valid put-call pair in Optionmetrics and an indicative borrowing fee in Markit. For each option in a valid put-call pair, open interest is positive, the absolute delta is between 0.01 and 0.99, implied volatility is between 0.03 and 2, the bid is greater than 0.1, and the bid is less than the ask. In addition, the sum of the call and put bid-ask spreads divided by the stock price is ≤ 5%, the put moneyness, K/S, is ≤ 1.1, and time to maturity is greater than 15 days and less than 90 days. The sample is also restricted to observations where the dividend yield is ≤ 5% and the stock price is greater than $5. Implied volatility spread is the difference between the implied volatilities of at-the-money calls and puts used in Cremers and Weinbaum (2010). Implied volatility skew is the difference between the implied volatilities an out-of-the-money call and an at-the-money call used in Xing, Zhang, and Zhao (2010). Short interest is the number of shares short from Markit divided by shares outstanding from the CRSP. Short fee risk is the log of the variance of the daily indicative borrowing fee during the preceding 12 months. Market capitalization is from CRSP. Utilization is from Markit. The sample period is July 2006 to August 2015. The computation of the option-implied borrowing fee is described in Section 4. The t-statistics are based on robust standard errors clustered by stock and are reported in brackets below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	Return for the next week			Return for the next month		
Model	1	2	3	4	5	6
Implied volatility spread	0.0164***		0.0021	0.0545***		-0.0143*
	[9.5]		[0.7]	[8.5]		[-1.7]
Implied volatility skew		-0.0131***	0.0009		-0.0451***	0.0007
		[-6.8]	[0.4]		[-6.5]	[0.1]
Implied borrowing fee			-0.0152***			-0.0435***
			[-4.8]			[-5.0]
Indicative borrowing fee			-0.0048			-0.0575***
			[-1.2]			[-4.0]
Utilization			-0.0000***			-0.0001***
			[-4.4]			[-3.8]
Short fee risk			0.0000			0.0000
			[0.2]			[-0.1]
Short interest			0.0016			-0.0004
			[0.7]			[-0.0]
Market capitalization			-0.0000***			-0.0000***
			[-3.3]			[-3.2]
Constant	0.0004***	0.0008***	0.0008***	0.0012***	0.0030***	0.0036***
	[6.6]	[6.7]	[5.7]	[5.3]	[6.5]	[6.7]
Number of Observations	3655850	2407569	2403792	3655850	2407569	2403792
Number of Clusters	4259	3769	3758	4259	3769	3758

Table 11

Adjusted stock return predictability using other option implied measures

This table presents regressions that use the option-implied measures to predict the stock return from the close of trading date t+1 to the close trading date t+6 (next week) in Columns 1 through 3 or from the close of trading date t+1 to the close trading date t+22 (next month) in Columns 4 through 6. The stock return is adjusted to reflect the cumulative indicative borrowing fee during the period for each stock. The unit of observation is the combination of a stock and trading date for the optionable stocks in CRSP that match to a valid put-call pair in Optionmetrics and an indicative borrowing fee in Markit. For each option in a valid put-call pair, open interest is positive, the absolute delta is between 0.01 and 0.99, implied volatility is between 0.03 and 2, the bid is greater than 0.1, and the bid is less than the ask. In addition, the sum of the call and put bid-ask spreads divided by the stock price is ≤ 5%, the put moneyness, K/S, is ≤ 1.1, and time to maturity is greater than 15 days and less than 90 days. The sample is also restricted to observations where the dividend yield is ≤ 5% and the stock price is greater than $5. Implied volatility spread is the difference between the implied volatilities of at-the-money calls and puts used in Cremers and Weinbaum (2010). Implied volatility skew is the difference between the implied volatilities an out-of-the-money call and an at-the-money call used in Xing, Zhang, and Zhao (2010). Short interest is the number of shares short from Markit divided by shares outstanding from the CRSP. Short fee risk is the log of the variance of the daily indicative borrowing fee during the preceding 12 months. Market capitalization is from CRSP. Utilization is from Markit. The sample period is July 2006 to August 2015. The computation of the option-implied borrowing fee is described in Section 4. The t-statistics are based on robust standard errors clustered by stock and are reported in brackets below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	Return for the next week			Return for the next month		
Model	1	2	3	4	5	6
Implied volatility spread	0.0071***		0.0016	0.0151**		-0.0158*
	[4.0]		[0.5]	[2.3]		[-1.8]
Implied volatility skew		-0.0059***	0.0011		-0.0144**	0.0016
		[-3.0]	[0.5]		[-2.1]	[0.2]
Implied borrowing fee			-0.0146***			-0.0414***
			[-4.6]			[-4.7]
Indicative borrowing fee			0.0125***			0.0185
			[3.3]			[1.3]
Utilization			-0.0000***			-0.0001***
			[-4.2]			[-3.5]
Short fee risk			0.0000			0.0000
			[0.2]			[-0.0]
Short interest			0.0014			-0.0013
			[0.6]			[-0.1]
Market capitalization			-0.0000***			-0.0000***
			[-3.3]			[-3.2]
Constant	0.0005***	0.0006***	0.0008***	0.0018***	0.0020***	0.0035***
	[9.4]	[4.8]	[5.6]	[8.0]	[4.3]	[6.5]
Number of Observations	3655850	2407569	2403792	3655850	2407569	2403792
Number of Clusters	4259	3769	3758	4259	3769	3758

Appendix Table 1

Correlation matrix

Panel A presents the correlation matrix for selected characteristics for stocks in CRSP that match to an indicative borrowing fee in Markit where the unit of observation is the combination of a stock and trading date. Panel B presents analogous correlation matrix for the optionable stocks in CRSP that match to a valid put-call pair in Optionmetrics and an indicative borrowing fee in Markit. For each option in a valid put-call pair, open interest is positive, the absolute delta is between 0.01 and 0.99, implied volatility is between 0.03 and 2, the bid is greater than 0.1, and the bid is less than the ask. In addition, the sum of the call and put bid-ask spreads divided by the stock price is ≤ 5%, the put moneyness, K/S, is ≤ 1.1, and time to maturity is greater than 15 days and less than 90 days. Panel B is also restricted to observations where the dividend yield is ≤ 5% and the stock price is greater than $5. Short interest is the number of shares short from Markit divided by shares outstanding from the CRSP. Short fee risk is the log of the variance of the daily indicative borrowing fee during the preceding 12 months. Market capitalization is from CRSP and NYSE size decile is assigned accordingly. Utilization is from Markit. The calculation of implied volatility spread follows Cremers and Weinbaum (2010) and the calculation of implied volatility skew follows Xing, Zhang, and Zhao (2010). The computation of the option-implied borrowing fee and the adjustment of the option-implied borrowing fee to take account of early exercise are described in Section 4. The sample period is July 2006 to August 2015.

Panel A: Correlation matrix for CRSP stocks with an indicative borrowing fee in Markit

	IBF	IR	HBF	HR	U	SFR	SI	MC
Indicative borrowing fee	1.0000							
Indicative rebate	-0.9610	1.0000						
Historical borrowing fee	0.9307	-0.8942	1.0000					
Historical rebate	-0.8829	0.9371	-0.9467	1.0000				
Utilization	0.4272	-0.3856	0.4443	-0.3924	1.0000			
Short fee risk	0.2939	-0.2603	0.3087	-0.2666	0.3801	1.0000		
Short interest	0.2474	-0.2021	0.2622	-0.2072	0.8063	0.2309	1.0000	
Market Cap, $mn	-0.0588	0.0701	-0.0630	0.0755	-0.2471	-0.0189	-0.2387	1.0000

Panel B: Correlation matrix for the optionable subset of CRSP stocks with an indicative borrowing fee in Markit

	IBF	IR	IFA	IFU	U	SFR	SI	IVSP	IVSK	MC
Indicative borrowing fee	1.0000									
Indicative rebate	-0.9066	1.0000								
Implied fee, adj.	0.6610	-0.5959	1.0000							
Implied fee, unadj.	0.5675	-0.5124	0.9848	1.0000						
Utilization	0.4182	-0.3114	0.3498	0.3116	1.0000					
Short fee risk	0.3109	-0.2262	0.2408	0.2122	0.3897	1.0000				
Short interest	0.2191	-0.1250	0.2245	0.2047	0.7827	0.2170	1.0000			
Implied Volatility Spread	-0.5693	0.5105	-0.8316	-0.8214	-0.3106	-0.2339	-0.1928	1.0000		
Implied Volatility Skew	0.4214	-0.4179	0.6029	0.5891	0.2564	0.1853	0.1808	-0.6639	1.0000	
Market Cap, $mn	-0.0590	0.0472	-0.0749	-0.0723	-0.2388	-0.0385	-0.2267	0.0596	-0.0111	1.0000

Appendix Table 2

The cost of indirectly short selling stocks using put-call pairs

This table estimates the cost of indirectly short selling stocks using put-call pairs traded in options markets. The unit of observation is the combination of a stock and trading date for the optionable subset of stocks in CRSP that match to a valid put-call pair in Optionmetrics and an indicative borrowing fee in Markit. The computation of the option-implied borrowing fee described in Section 4 uses the midpoint of the bid-ask spread for each option. The alternative measures below use the appropriate side of the bid-ask spread to estimate the cost of synthetically creating a short position through the option positions. In addition, different aggregation methods across put-call pairs for a given stock and trading date are considered. For each option in a valid put-call pair, open interest is positive, the absolute delta is between 0.01 and 0.99, implied volatility is between 0.03 and 2, the bid is greater than 0.1, and the bid is less than the ask. In addition, the sum of the call and put bid-ask spreads divided by the stock price is ≤ 5%, the put moneyness, K/S, is ≤ 1.1, and time to maturity is greater than 15 days and less than 90 days. The sample is also restricted to combinations of stocks and dates for which the dividend yield is ≤ 5% and the stock price is greater than $5. The sample period is July 2006 to August 2015. The hard-to-borrow sample uses observations for which utilization from Markit is greater than 60%. The table also reports the means, medians, and standard deviations for the various measures of the implied borrowing fee.

	All observations				Hard-to-borrow (Utilization > 60%)			
	N	Mean	Median	Std. Dev.	N	Mean	Median	Std. Dev.
Indicative borrowing fee	3656397	1.07%	0.38%	3.93%	291,239	6.98%	3.00%	11.3%
Implied borrowing fee (Median of pairs at midpoint)	3656397	1.05%	0.70%	4.46%	291,239	5.22%	2.93%	8.9%
Implied borrowing fee (Median of pairs at bid & ask)	3656397	9.34%	7.02%	8.53%	291,239	16.33%	12.95%	12.6%
Implied borrowing fee (Mean of pairs at bid & ask)	3656397	9.78%	7.55%	8.55%	291,239	16.86%	13.61%	12.6%
Implied borrowing fee (Min of pairs at bid & ask)	3656397	7.24%	5.12%	8.11%	291,239	13.14%	10.11%	11.6%
Implied borrowing fee (Max of pairs at bid & ask)	3656397	13.39%	10.47%	10.76%	291,239	21.68%	17.62%	15.4%

Appendix Table 3

The risk premium for the borrowing fee using different subsamples

This table provides estimates of the borrowing fee risk premium based on adjusted and unadjusted option-implied fees for different subsamples. The unit of observation is the combination of a stock and trading date for the optionable subset of stocks in CRSP that match to a valid put-call pair in Optionmetrics and an indicative borrowing fee in Markit. The borrowing fee risk premium for a given stock and date is the average, across put-call pairs, of difference between the option implied fee and the average realized indicative fee during the remaining life of the put-call pair. For each option in a valid put-call pair, open interest is positive, the absolute delta is between 0.01 and 0.99, implied volatility is between 0.03 and 2, the bid is greater than 0.1, and the bid is less than the ask. In addition, the sum of the call and put bid-ask spreads divided by the stock price is ≤ 5%, the put moneyness, K/S, is ≤ 1.1, and time to maturity is greater than 15 days and less than 90 days. The sample is also restricted to combinations of stocks and dates for which the dividend yield is ≤ 5% and the stock price is greater than $5. Market capitalization is the product of the stock price and shares outstanding from CRSP. The computation of the option-implied borrowing fee and the adjustment of the option-implied borrowing fee to take account of early exercise are described in Section 4. The sample period is July 2006 to August 2015. The table also reports the means, medians, and standard deviations of the adjusted and unadjusted implied fees and indicative fees. The first subsample uses observations from January 2013 to August 2015 during which failure-to-deliver by option market makers was no longer permitted. The second subsample only includes stocks with an average price during the sample period that is greater than $40. The third subsample uses the observations with a market capitalization greater than the cutoff for the ninth size decile of the NYSE. The fourth subsample uses put-call pairs where the sum of the call and put bid-ask spreads divided by the stock price is less than 1%. The fifth subsample uses put-call pairs with time-to-expiration greater than 60 days.

	All observations				Hard-to-borrow (Utilization > 60%)			
	N	Mean	Median	Std. Dev.	N	Mean	Median	Std. Dev.
Year >= 2013								
Borrowing fee risk premium (adjusted)	1145663	0.02%	0.21%	4.07%	73155	-1.51%	-0.62%	8.17%
Borrowing fee risk premium (unadjusted)	1145663	-0.14%	0.14%	4.23%	73155	-3.02%	-1.57%	8.80%
Implied borrowing fee (adjusted)	1145663	1.18%	0.77%	4.99%	73155	7.78%	4.79%	12.16%
Implied borrowing fee (unadjusted)	1145663	1.02%	0.72%	4.54%	73155	6.26%	4.03%	10.25%
Indicative borrowing fee	1145663	1.17%	0.38%	4.25%	73155	9.26%	5.00%	13.21%
Average Stock Price > $40								
Borrowing fee risk premium (adjusted)	1326109	0.17%	0.22%	3.06%	51719	0.04%	0.29%	6.19%
Borrowing fee risk premium (unadjusted)	1326109	0.07%	0.15%	3.09%	51719	-0.98%	-0.23%	6.42%
Implied borrowing fee (adjusted)	1326109	0.82%	0.66%	3.50%	51719	5.60%	3.06%	9.27%
Implied borrowing fee (unadjusted)	1326109	0.72%	0.60%	3.30%	51719	4.56%	2.61%	7.85%
Indicative borrowing fee	1326109	0.65%	0.38%	2.21%	51719	5.54%	2.50%	9.49%

Appendix Table 3 (continued)

	All observations				Hard-to-borrow (Utilization > 60%)			
	N	Mean	Median	Std. Dev.	N	Mean	Median	Std. Dev.
Option Bid-Ask Spread < 1%								
Borrowing fee risk premium (adjusted)	1150129	0.05%	0.16%	1.95%	38331	-0.07%	0.18%	3.92%
Borrowing fee risk premium (unadjusted)	1150129	-0.03%	0.10%	1.96%	38331	-0.88%	-0.24%	3.97%
Implied borrowing fee (adjusted)	1150129	0.60%	0.58%	2.29%	38331	4.16%	2.24%	6.59%
Implied borrowing fee (unadjusted)	1150129	0.52%	0.53%	2.14%	38331	3.36%	1.92%	5.47%
Indicative borrowing fee	1150129	0.54%	0.38%	1.45%	38331	4.19%	1.63%	6.56%
Days-to-expiration > 60								
Borrowing fee risk premium (adjusted)	575532	0.04%	0.14%	2.63%	35303	-0.88%	-0.27%	5.38%
Borrowing fee risk premium (unadjusted)	575532	-0.12%	0.05%	2.76%	35303	-2.11%	-0.93%	5.91%
Implied borrowing fee (adjusted)	575532	0.86%	0.64%	3.17%	35303	4.42%	2.38%	8.04%
Implied borrowing fee (unadjusted)	575532	0.70%	0.56%	2.76%	35303	3.19%	1.87%	6.09%
Indicative borrowing fee	575532	0.81%	0.38%	2.60%	35303	5.16%	2.00%	8.26%
Implied Volatility > 40%								
Borrowing fee risk premium (adjusted)	1643872	0.19%	0.27%	4.68%	218787	-0.10%	0.08%	6.96%
Borrowing fee risk premium (unadjusted)	1643872	-0.13%	0.11%	4.84%	218787	-1.75%	-0.79%	7.49%
Implied borrowing fee (adjusted)	1643872	1.73%	0.96%	6.27%	218787	7.33%	3.90%	11.37%
Implied borrowing fee (unadjusted)	1643872	1.40%	0.85%	5.53%	218787	5.68%	3.21%	9.28%
Indicative borrowing fee	1643872	1.54%	0.38%	5.26%	218787	7.42%	3.00%	11.91%
Average Option Volume During Previous Month > 1000								
Borrowing fee risk premium (adjusted)	958436	0.18%	0.18%	3.22%	92315	0.55%	0.32%	7.02%
Borrowing fee risk premium (unadjusted)	958436	-0.13%	0.07%	3.38%	92315	-1.71%	-0.75%	7.58%
Implied borrowing fee (adjusted)	958436	1.53%	0.68%	5.52%	92315	9.81%	5.32%	12.69%
Implied borrowing fee (unadjusted)	958436	1.22%	0.61%	4.56%	92315	7.55%	4.24%	10.12%
Indicative borrowing fee	958436	1.37%	0.38%	5.25%	92315	9.40%	4.50%	13.68%

Appendix Table 4

Average customer order imbalance in option markets by utilization

Panel A presents the average of cumulative monthly order imbalance for different option types for ISE customers based on equal-weighted portfolios of stocks sorted using utilization from Markit. Panel B presents the average indicative borrowing fee and the average implied borrowing fee for the same portfolios. The sample includes all stocks in optionable subset of CRSP that match to a valid put-call pair in Optionmetrics and an indicative borrowing fee in Markit. For each option in a valid put-call pair, open interest is positive, the absolute delta is between 0.01 and 0.99, implied volatility is between 0.03 and 2, the bid is greater than 0.1, and the bid is less than the ask. In addition, the sum of the call and put bid-ask spreads divided by the stock price is ≤ 5%, the put moneyness, K/S, is ≤ 1.1, and time to maturity is greater than 15 days and less than 90 days. The sample is also restricted to combinations of stocks and dates for which the dividend yield is ≤ 5% and the stock price is greater than $5. The sorting procedure groups stocks into deciles and assigns them to portfolios based on utilization from Markit measured on trading date t. Stocks are held in these portfolios from the close of trading date t+1 until the close of trading date t+22 to mimic the length for a typical month with 21 trading days. By construction, the average of cumulative order imbalance and the other statistics for the stocks in each portfolio is a moving average in which the horizon of evaluation leads to 20 overlapping trading days, and so, it is important to use Newey-West standard errors with 30 lags to adjust for this feature of the data. The sample period is July 2006 to August 2015. The computation of the option-implied borrowing fee is described in Section 4. The t-statistics based on Newey-West standard errors in brackets below the coefficient estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Average order imbalance for options on stocks sorted into portfolios by utilization

	1 Low	2	3	4	5	6	7	8	9	10 High
Order imbalance	218.87***	67.86**	58.97**	-19.31	9.64	-24.59	13.78	-25.49	-62.91***	-234.86***
Calls	[5.2]	[2.0]	[2.1]	[-0.8]	[0.4]	[-1.2]	[0.8]	[-1.6]	[-3.5]	[-11.1]
Order imbalance	-71.12	165.68***	148.15***	53.84***	111.36***	111.06***	94.91***	82.18***	92.63***	225.38***
Puts	[-1.7]	[5.3]	[5.8]	[2.6]	[4.7]	[5.9]	[5.0]	[5.4]	[6.2]	[12.5]
Order imbalance	289.99***	-97.81*	-89.18**	-73.14**	-101.72***	-135.64***	-81.13***	-107.67***	-155.54***	-460.24***
Calls minus puts	[4.6]	[-2.0]	[-2.1]	[-2.2]	[-2.8]	[-4.2]	[-2.8]	[-4.4]	[-6.1]	[-14.7]

Panel B: Average borrowing fee for stocks sorted into portfolios by utilization

	1 Low	2	3	4	5	6	7	8	9	10 High
Implied borrowing fee	0.0046***	0.0048***	0.0054***	0.0059***	0.0065***	0.0069***	0.0077***	0.0096***	0.0151***	0.0632***
	[48.5]	[51.0]	[48.2]	[51.0]	[49.2]	[53.6]	[54.2]	[59.7]	[63.6]	[79.7]
Indicative borrowing fee	0.0046***	0.0040***	0.0040***	0.0040***	0.0043***	0.0044***	0.0048***	0.0056***	0.0102***	0.0593***
	[47.9]	[74.4]	[43.2]	[39.3]	[17.9]	[25.4]	[28.8]	[30.6]	[24.6]	[38.5]