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ABSTRACT

We investigate short- and long-horizon effects of 237 option listings/relistings and 140 delistings in a short-sale-constrained market—specifically, India's National Stock Exchange from 2001 to 2012, when institutional short selling was either curtailed or banned outright. We find a strong positive impact on listings/relistings, signalling a favorable market perception of the event, but a negative impact on delistings. Over long horizons volatility is higher in both listed and delisted periods, especially the latter. We also find evidence to suggest that traders migrate from stock venues to (from) option venues following a listing (delisting), especially during short-sale bans.

JEL classifications: G14, G28

Keywords: Delisting, Relisting, Options, Short sales

1. Introduction

Several studies suggest that trading in equity options improves liquidity, stability, and the informativeness of the underlying market (e.g., Beber & Pagano, 2013; Easley, O'Hara, & Srinivas, 1998; Kumar, Sarin, & Shastri, 1998; Ross, 1976). For instance, Kumar, Sarin, and Shastri (1998) find that options listing is associated with lower bid-ask spreads, higher depth and volume, and increased transaction size in the spot market. Other studies also document a positive response to options listing (e.g., Branch & Finnerty, 1981; Conrad, 1989; Detemple & Jorion, 1990), with few exceptions (Sorescu, 1999).

A less explored argument revolves around the efficacy of equity options trading when an underlying market limits short sales (e.g., Figlewski & Webb, 1993; Miller, 1997). A ban on short sales effectively constrains bearish investors from trading on their information.[5] This potentially results in overvaluation and subsequent corrections (e.g., Bris, Goetzman, & Zhu, 2007; Chang, Cheng, & Yu, 2007; Fung & Dapper, 1999; Hong & Stein, 2003). Hong and Stein (2003) argue that a short-sale ban leads to underweighting of negative information, thus increasing the likelihood of crashes or extreme volatility. Bris and colleagues (2007) find that stock returns display significantly less negative skewing in the absence of short selling. Since options allow bearish trades, the listing of options may partially offset this illiquidity and instability brought on by short-sale constraints (e.g., Danielson & Sorescu, 2001); but there is little evidence about the role of option delistings in such markets. Additionally, it is hard to find evidence about the role of options listing/delisting for companies whose stocks

[5] Previous evidence from multiple countries indicates a sharp decline in liquidity following a short-selling ban (e.g., Beber & Pagano, 2013).

underperform, where factors such as price stability may be much more important. In this study, we provide evidence on these important issues by examining the Indian stock market.

There is a precedent to our investigation on the regulatory actions on leveraged trading in Indian markets. Before the introduction of derivative trading, the Securities and Exchange Board of India (henceforth SEBI) introduced an indigenous trading system called "Badla," allowing traders to buy stock with money borrowed from a stock exchange, under an agreement to repay the loan within 70 days, with interest. As with options, regulators banned and then later allowed Badla with the view that the contracts undermine market efficiency. The effects of those regulatory measures appear inconclusive.[6]

This study examines the immediate and long-horizon effects of listings/delistings (henceforth simply listings) of options in a short-sale-constrained market. The Indian equities market from January 2001 through 2012 presents an ideal laboratory for such an examination. During this period, under Indian securities law, options trading in a particular stock was suspended if that stock failed to meet certain trading and capitalization criteria. But the delisted options could be reinstated if certain (relisting) criteria were met. The eligibility

[6] Before December 1993, there were 91 stocks that were classified as "most liquid" and qualified to trade under Badla. The system was blamed for excessive speculation, and in December 1993 SEBI announced that it would be discontinued as of March 14, 1994. In October 1995, SEBI reintroduced Badla in a more restricted and refined form, and it was legalized in 1996. It was finally replaced by derivatives trading in 2001. Interestingly, the initial ban on Badla led to a 72 percent drop in the trading volume of its 91 stocks from April to December 1994; but also interestingly, the trading volume for non-Badla stocks increased 17 percent during the same period (for more see Berkman & Eleswaeapu, 1998).

criteria for the listing and delisting of options centered around price performance and trading volume (see https://www.nseindia.com/products/content/derivatives/equities /selection_criteria.htm). Over the same period, institutional short selling was either prohibited or deeply constrained for all companies—a reaction by regulators to the stock market crash of 2001. This ban was partially lifted in early 2008, when institutions were permitted to hold short positions up to but not beyond the close of a trading day.

The period from 2008 to 2012, when the ban was only partial, provided sufficient time for the market to adjust to the less stringent regulatory environment, and gives us a window to examine the effects following an easing of short-sale constraints.[7]

The Indian experience allows us to assess liquidity and volatility in a market with and without options trading in a short-sale-constrained environment. By contrast, short-sale

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[7] The regulators took the line that short selling may be destabilizing, although it may have its benefits:

> While international securities market regulators have recognized that short selling can exacerbate market falls and lead to manipulative activities, most of the jurisdictions have also recognized short selling as a legitimate investment activity that has contributed significantly to market liquidity. International securities market regulators have, therefore, permitted short selling with adequate safeguards to prevent any abusive/manipulative market practices. Similar issues may arise in the Indian context also. Genuine short selling could exacerbate price decline but that by itself may not be construed as a manipulative activity unless there are evidences of market misconduct (Discussion Paper on Short Selling and Securities Lending and Borrowing, Secondary Market Advisory Committee, SEBI, 2006).

constraints are rare in U.S. markets, so researchers examining U.S. data have had to use proxies for constraints to assess the effects of short selling. Figlewski and Webb (1993), among others, use the short-interest ratio; Asquith, Pathak, and Ritter (2005) use institutional ownership; Reed (2007) uses the rebate rate; and Diether and Werner (2010) employ a "threshold list." We are fortunate in that we can dispense with such indirect means, much like Chang, Cheng, and Yu (2007), who examine the Hong Kong market.

Our focus is threefold. First, we assess the market perceptions regarding option listings versus delistings. Detemple and Selden (1991) note that prices generally rise when options are introduced. On the other hand, there is insufficient evidence about option delistings. Given that a delisting of an option on the NSE follows months of relatively weak performance in the underlying stock (see https://www.nseindia.com/products/content/derivatives/equities/selection_criteria.htm), it remains unclear from theoretical arguments whether equity traders will view a delisting as good or bad news. From the Indian regulators' actions in setting short-sale rules and rules on derivatives in general, it follows that they likely view delisting options as a means to promote stock-price stability and deter trader manipulation,[8] and a positive response to delistings will suggest that the markets affirm this view. On the other hand, arguments such as those put forth by Figlewski and Webb (1993) predict that delistings will increase instability, and by extension will be viewed negatively by the market.

Second, and importantly from a regulatory perspective, we assess whether the listing and delisting of equity options are related to the long-horizon price stability of the underlying

[8] Regulators in India have a long history of attempting to curtail what they view as manipulation in the derivatives market. For reviews of the recent history of regulation, see Youssef (2000) and Adrangi et al. (2014).

stock. The Indian regulators appear to believe that options trading in a company with declining capitalization is destabilizing. After all, an optionable stock with a declining price can be expected to witness dynamic hedge-based selling.[9] To examine price stability, we examine whether return variability differs across the listing and delisting samples, while controlling for market volatility. Because listing and delisting events are unevenly spread throughout the sample, we face the possibility of confounding effects in the data. More specifically, we must deal with the relationship between the trading of options (or the lack thereof) and stock return volatility, while simultaneously dealing with the relationship between stock volatility and overall market volatility. Thus, we deploy a market volatility index to control our assessments of the stability of individual equities. A finding that volatility does not differ between listing and delisting periods would relieve the Indian regulators' concerns.

Third, we examine whether options listing promotes liquidity in the underlying stock. Our empirical work in this regard primarily assesses the frequency of trading (number of

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[9] We doubt that expiration-data effects play a major role in the Indian regulators' perceptions, since all derivatives are cash settled. A steady stream of research argues for or against the relationship between physical delivery in the derivatives market and volatility in the underlying market. In particular, the delivery of physical assets has often been associated with increased market distortions, impacting price discovery and hedging efficiency, and cash settlement is offered as the better alternative (see, e.g., Chan & Lien, 2002). Opposing arguments suggest that it is indeed cash settlement, rather than physical delivery, that facilitates manipulation in commodity markets (e.g., Kumar & Seppi, 1992). On balance, there appears to be more support for cash settlement among academics and regulators for both options and futures contracts (e.g., Lien & Tse, 2006; Lien & Yang, 2005; Miller, 1986).

transactions) over the listing and delisting intervals. Note that other well-accepted measures of liquidity, such as volume and shares traded, are themselves criteria for relisting and delisting (see https://www.nseindia.com/products/content/derivatives/equities/selection_criteria.htm). However, SEBI's decision to list or delist is likely taken many days before the announcement of the event or around the actual event itself, so our findings are not prone to simultaneity bias.

In assessing the short-term market perceptions about options listing and delisting, we examine the announcement of the event as well as the actual event, because the actual listing or delisting can take place several days after the announcement. We employ abnormal returns for these purposes. To assess whether listings or delistings have a bearing on the long-horizon price stability of the underlying stock, we examine daily volatility. We employ actual listing and delisting dates for these tests and also for our examination of liquidity. To assess liquidity changes, we examine primarily the frequency of trading (number of transactions). In additional tests, we also examine trading dynamics using share and option volume.

The next section lays out explanations for short- and long-horizon effects of options listing and delisting in a short-sale-constrained market. Section 3 reports the data and results, and Section 4 concludes.

2. Empirical evidence on the effects of options listing and delisting

2.1. Short-horizon effects with short-sale constraints

2.1.1. Listings/relistings

Intuitively, an options listing should be perceived as good news. Tse and Xiang (2005) find that derivatives trading increases market efficiency. Kumar and Tse (2009) demonstrate that in India single-stock futures contracts predict about 28% of information share. More to the point, Wilkens and Roder (2006) study transactions data for the DAX and Bund futures options and find implied volatility to be predictive, even while implied skewness and kurtosis are not.

Within the Indian context, at the very least, an options listing suggests (i) that regulators (after necessary scrutiny) have validated leveraged trading on that stock (see https://www.nseindia.com/products/content/derivatives/equities/selection_criteria.htm), and (ii) that traders can now take leveraged positions beyond what is currently offered, inviting more informational trading. Thus, options listing may be expected to elicit a positive response in the underlying market. In fact, several studies show positive abnormal returns around options listings in the U.S. (e.g., Branch & Finnerty, 1981; Conrad, 1989; Detemple & Jorion, 1990; Faff & Hillier, 2005).

However, the response to options listing also depends on the nature of the market and can be negative. Sorescu (1999) finds the price impact to be negative for options listed after 1980. While Sorescu (1999) is unable to explain the reasons for this shift, Danielsen and Sorescu (2001) find a significant positive correlation between constraints on short selling and the negative price impact. Thus, short-selling constraints may actually cause a negative short-term response to options listings. Chang, Cheng, and Yu (2007) appear to support this view. They employ data from the Hong Kong market, where only stocks on a "short-sales list" can be shorted. Much like Indian regulations on options listing, the Hong Kong short-sales list is revised from time to time on the basis of price performance of the underlying stocks. Chang, Cheng, and Yu find a negative response when stocks are added to this list, suggesting that negative information fails to get sufficiently incorporated when short-sale constraints are in effect. Thus, it is possible that if options listing represents a substitute for short-sale listing, the experience in India could mimic that of Hong Kong.

2.1.2. Delistings

The immediate effect of delisting is really an open question. In the Indian context, where delisting generally follows months of weak price performance, a positive response to delisting may arise from the perception that (i) options trading is a substitute for short selling, and (ii) a ban on options trading lessens the ability of bearish traders to take further leveraged positions against the stock. Both of these explanations point to a short-term positive response to delisting. This line of thought is supported by the widespread bans on short selling by financial institutions seen in 2008 (e.g., http://www.sec.gov/news/press/2008/2008-211.htm). The U.S. SEC banned short sales on 799 stocks in September of that year. The bans did result in a short-lived bounce for financial stocks, as short sellers were squeezed (see "Bank shares rise on ban on short selling," *Guardian*, August 12, 2011; "Short selling: Costs and benefits," CenFis, Federal Reserve Bank of Atlanta, November 2009; Battalio & Schultz, 2011).[10]

[10] Battalio and Shultz (2011) suggest that their sample is short-sale constrained in that traders are at times not able to short stocks cheaply (see also Ofec & Richardson, 2003). In essence, they argue that short selling is subject to "indirect constraints" such as borrowing constraints, and they propose a threshold of misalignment between stocks and options prices that constrains short selling. Fortunately, we do not have to make such an assumption, nor do we have to rely on any such thresholds, since during our sample period there was either a total ban or tight controls on short selling. Note that while Battalio and Shultz examine the relationship between options and stock prices to assess whether short-sale constraints are responsible for price bubbles, we examine the effects of options listing and delisting on volatility and liquidity.

The constraints put on short sellers in 2008 remain controversial, with SEC Chairman Coz himself admitting afterwards that the ban may have been a mistake, and that it did not

But, on the other hand, we cannot rule out the possibility that negative perceptions about delistings per se may simply overwhelm any positive effects. Following a delisting, informed traders, who prefer an options venue (see, e.g., Black, 1975; Easley, O'Hara, & Srinivas, 1998), will now have to migrate to equity markets. A bearish trend may thus be extended, at least in the very near term. Thus, the question about the immediate effects of options delisting in an underperforming stock is ultimately empirical and is examined using standard event-study methods.

2.2. Long-horizon effects with short-sale constraints

Our measure of long-term horizon effects is volatility, estimated using a GARCH framework. Black (1975) notes that the major attraction of options is their leverage, which enables informed traders to take large positions. Similarly, Easley, O'Hara, and Srinivas (1998) propose that informed traders would prefer options as long as the options market is sufficiently liquid.[11] An increase in informed trading should lower information asymmetry in

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ultimately prevent a further slide in financial stocks (SEC chief has regrets over short-selling ban, Reuters, Wednesday, December 31, 11:47 a.m. EST).

[11] Several studies indicate that options traders are informed. Pan and Poteshman (2006) provide strong evidence that options trading volume contains information about future stock prices. Amin and Lee (1997) find that options activity increases notably before quarterly earnings releases, and the direction of trading foreshadows earnings. Chan, Kot, and Ni (2011) find that options opening trades contain information about future stock returns, to horizons several months out. Kumar et al. (1998) find that, once options have been listed, specialists appear to pay more attention to the stock. This is taken as evidence that they regard options as important sources of price discovery.

the underlying stock market (see, e.g., Brennan & Cao, 1996), and in turn make returns less volatile (e.g., Detemple & Selden, 1991). It should be noted, however, that evidence about the effects of options trading on volatility is far from definitive. For instance, some studies find that volatility increases upon the introduction of index options (e.g., Chatrath et al., 1995) or index futures trading (e.g., Gulen & Mayhew, 2000), while others find decreases in volatility (e.g., Bansal, Pruitt, & Wei, 1989; Edwards, 1988; Skinner, 1989). Bansal and colleagues, who study individual options listing on the CBOE between 1973 and mid-1986, find that options listing reduces volatility and increases liquidity in a vast majority of stocks. Similarly, Skinner (1989) finds that the volatility of stock returns declines after options listing, and suggests that this may be due to informed trading. He also reports a rise in trading volume with the introduction of options.

2.2.1. Short-sale-constrained markets, listings, and delistings

If markets limit short selling, the benefits from options listing should be magnified. This can be explained by the following two points, considered together: (1) options represent a substitute vehicle for short traders, and (2) short-sales bans remove information and promote instability. The first point follows intuitively from the nature of options. For instance, the very foundation of options pricing models is built on the fact that the payoff of a put can be mimicked by trading $\Delta(-1<\Delta<0)$ quantity of stock and lending an appropriate amount. Purists might argue that while puts may be mimicked via delta-shorting, a static short position may not be mimicked via put strategies (because of the limited number of strike prices, for instance). Nevertheless, even if short sales are not perfectly replicated by options strategies, their partial substitutability is undeniable: bearish traders deploy a number of partially self-financing strategies using call and/or put options. The second point, regarding why we should expect larger benefits from options listing in the face of short-selling bans, is that a lack of short selling leads to market inefficiencies that options can help correct. Miller

(1986) argues that short-sale-constrained markets will be overvalued, since optimistic (pessimistic) opinions will be overrepresented (underrepresented) in prices. Duffie, Garleanu, and Pedersan (2002) derive a framework in support of Miller's overvaluation hypothesis, wherein short-sales constraints along with a divergence in opinion will result in mispricing. Similarly, Johnson (2004) suggests that constraining short sales will result in overshopping, with lower subsequent returns. Others, too, suggest that short-sale constraints may be destabilizing, though they do not necessarily suggest pricing bias. Diamond and Verecchia (1987) present a rational expectation framework in which bans on short sales may not lead to overvaluation, but will slow the incorporation of negative information into prices.

Miller's overvaluation hypothesis has a fair amount of empirical support (e.g., Berkman, Dimitrov, Jain, Koch, & Tice, 2009; Chang, Cheng, & Yu, 2007; Figlewski & Webb, 1993; Gousgounis, 2012; Jones & Lamont, 2002). Notably, Giannikos and Gousgounis study overpricing in the Indian Nifty index over the period 2001–2008, when the institutional trading ban was in place. Measuring overpricing by the difference between the present value of Nifty futures and the underlying index, they find that overpricing does exist, especially in the presence of divergent opinion. While there is much evidence bearing on the overvaluation hypothesis, the evidence on whether the overvaluation increases volatility is mixed. Chang, Cheng, and Yu (2007), using data from Hong Kong, document lower volatility when short sales are constrained, which may be an effect of informed trading.

To summarize, theory suggests that options listing (delisting) should have a stabilizing (destabilizing) influence on the underlying market, especially in a short-sale-constrained market such as the Indian market. However, given the evidence from short-sale listing and delisting in Hong Kong, the question about whether options listing and delisting decreases return volatility must be addressed empirically.

3. Data and results

Our study covers listings and delistings of options on individual equities on the National Stock Exchange of India (NSE) from 2001 to 2012. These options are traded at the NSE and the Bombay Stock Exchange (BSE) using an electronic platform. Equity options began trading at the NSE in 2001, with the number of contracts traded more than doubling in each of the first 10 subsequent years. Over the 2001–2012 interval, there are a total of 257 optionable stocks on the NSE, 237 events of listings (217 listings and 20 relistings), and 154 events of delistings.[12]

We obtain options listings and delistings dates from historical circulars available from the NSE. The stock information we use includes end-of-day prices, daily trading volume, and daily turnover, all from the Centre for Monitoring the Indian Economy (CMIE) Prowess database. We also employ the closing values of the NSE's CNX Nifty index (Nifty), which started trading in 1996 and represents a popular benchmark for Indian equities. We use the Nifty to capture daily market volatility, estimated with a GARCH (1,1) model using end-of-day index returns.

Table 1 reports listings and delistings of options by year. Notice that listings are mostly evenly spread, with some clustering between 2005 and 2008, a period that witnessed strong market performance. For two of the three years without listings—2002 and 2009—the previous year saw sharp drops in the major Indian stock indexes. On a related note, the Nifty and Sensex (India's other major stock exchange index) fell approximately 60% in the second half of 2008, and 30% in 2001. The listing criteria are based on moving-average performance (seehttps://www.nseindia.com/products/content/derivatives/equities/selection_criteria.htm).

[12] When we disaggregate listings from relistings, the findings remain substantively similar.

Delistings, as we expected, cluster in 2009 (40%), a year that experienced rising stock index values. In summary, we do find that delistings are sampled from both falling and rising markets. However, because there is no overlap between the listing and delisting samples, any comparative tests should exert controls for market movements and volatility.

Table 1 about here

3.1. Unconditional summary statistics

Table 2 provides distributional and autocorrelation statistics for our sample. For each stock, we compute return moments on the event date over the full sample period, the short-sale ban period (4/2001–6/2008), and the partial curtailment period (7/2008–12/2012).

We compute returns as the natural log of end-of-day dividend-adjusted prices: $R_t=\ln[P_t/P_{t-1}]*100$. The summary statistics are then pooled across stocks over listing and delisting days. The moment statistics in Table 2 should be considered "unconditional" and preliminary, because no controls for market trend or volatility are imposed in these calculations. In addition to statistics on all listings and delistings (Panel A), we provide statistics for companies that experienced either a listing or a delisting (Panel B) and for companies that experienced both a listing and a delisting (Panel C).

Panel A is very instructive. Average daily returns are higher after listings than after delistings. For instance, when short-selling constraints were most stringent (4/2001–6/2008), mean returns following listings were higher (0.074), more skewed (-1.719), and more kurtotic (14.495) than the corresponding moments following delistings (0.0594, -0.834, 10.064). Also, across the two subperiods, returns were more negatively skewed during 2001–2008 than during 2008–2012, a finding consistent with that of Bris and colleagues (2007), who find returns to be more negatively skewed in the presence of short sales. Similar findings appear in Panel B. In Panel C, for stocks that experienced both listing and delisting, there is preliminary evidence that volatility tends to be lower after listings than after delistings. Finally, the return autocorrelations are significant at three lags across all samples. Still, Table 2 provides only preliminary guidance.

Table 2 about here

3.2. Short-term responses to options listing and delisting

To assess short-term responses, we employ standard event-study methodology (see Brown & Warner, 1980), and as our benchmark portfolio we use the NSE's Nifty index. This index is capitalization weighted and comprises 50 stocks that represent 22 industries. The event date, for our purpose, can be either (a) the date of announcement of the listing or delisting, or (b) the actual listing or delisting date. For both approaches, we deploy a 21-day (-10 to +10) window to assess responses.

The estimated market model uses close-to-close returns for each stock, and is given by

$$R_{it}=\alpha_i + \beta_i R_{mt}+\varepsilon_{it}, \quad (1)$$

where $R_{mt} = \ln\left(\frac{I_t}{I_{t-1}}\right)$ is the log of the corresponding Nifty index, α_i and β_i are regression coefficients for stock i, and ε_{it} is the regression error. For stock i and day t, the abnormal return (AR) is computed as

$$AR_{it} = R_{it} - (\hat{\alpha}_i + \hat{\beta} R_{mt}), \quad (2)$$

from which we obtain the cross-sectional average abnormal return (AAR) for a sample of N stocks:

$$AAR_{it} = \sum_{i=1}^{N} \frac{AR_{it}}{N}, \quad (3)$$

as well as the associated cumulative average abnormal return (CAAR) for event days t_1 (-10 days) through t_2 (+10 days):

$$CAAR_t = \sum_{t=t_1}^{t_2} AAR_t . \quad (4)$$

To construct tests of significance relating to AARs and CAARs, we calculate, as is customary, the standard deviation of abnormal returns for the period -210 days to -11 days for each company, which we use to obtain the standardized abnormal returns (SAR) over days -10 ...+10 for each company. The test statistics for the average abnormal returns and cumulative average abnormal returns for N stock are given by $Z_{AAR,t} = \sum_{i=1}^{N} \frac{SAR_{it}}{\sqrt{N}}$ and $Z_{CAAR,t} = \sum_{i=t_{1i}}^{t_{2i}} \frac{SAR_{it}}{\sqrt{T * N}}$, respectively, for T= 1,...21.

We examine these events in two parts, the announcement of the listing or delisting versus the actual listing or delisting, for the following reasons. First, looking at the announcement helps us assess perceptions regarding permission to trade options, while the announcement itself formally expresses regulators' view of the underlying stock's performance and liquidity. Second, the listing or delisting announcement may precede actual listing or delisting by as much as several months, so that the actual listing or delisting provides additional information about short-term performance arising from traders gearing up for a listing or gearing down for a delisting.

Table 3A reports the first set of results, relating to abnormal returns around the announcement. The AARs in particular are worth attention. As we expected, the listing announcements elicit a strong positive response on day 0 (announcement day), and this becomes stronger in the next two days. The relatively prolonged positive response (see CAARs) may indicate substantial hedge trading. The AAR also provides evidence, albeit brief, of information leakage in day -1. In general, the market appears to perceive a listing announcement as good news.

The results for delisting announcements vary more. The abnormal returns leading up to the event day are mixed, although they appear to be positive on average. The AARs are strongly positive before the delisting announcement, but on the following day they turn sharply negative, especially on the first two days after the announcement. The negative response is consistent with the view that delisting may promote instability (Figlewski & Webb, 1993).

In Table 3B we report results relating to the actual listings and delistings. For listings, the abnormal returns are significant and positive from day -5 through day -1 (see the AARs), suggesting buying pressure on the underlying stock as traders anticipate hedgers and/or large institutions entering the options markets. Nonetheless, the strength of the returns is surprising given that there was a previous announcement. The AARs beyond day -1 are generally insignificant, suggesting that the introduction of options trading in itself does not elicit any noteworthy trading responses. This finding could also signal trading movement away from the options venue, a possibility that we explore below in more detail. Notice the negative and significant coefficient on day +4, signalling possible overreaction. Interestingly, the responses associated with delistings are a near-mirror image of the responses to listings. There is a significant negative response leading up to the delisting but little noteworthy pattern following it, although the positive and significant coefficient on day +3 signals a possible overreaction.

Table 3A and Table 3B about here

Even though SEBI's decision to list or delist is likely taken many days before an announcement, there may be concerns about endogeneity given that the variables used in our study are themselves requirements for a listing or a delisting. To address this issue we conduct tests similar to the tests noted above in Tables 3A and 3B on a control sample. For this purpose, we randomly sample a group of stocks matched by industry and asset size, and use t=0 as the announcement date of our listing/delisting (as in 3B). The results for the control sample fail to show any consistent pattern, suggesting that the effects we find in our listing and delisting samples are indeed due to the announcement or the actual event itself.[13]

Another issue is that the dynamics surrounding a relisting might differ from those surrounding a listing because traders are familiar with the stock. To examine this, we again conduct tests similar to tests reported in Tables 3A and 3B, and report these results in Table 3C (relisting announcement) and Table 3D (relisting event). Despite many similarities, the responses are weaker than those to listings. As with listings, we find evidence of information leakage before relistings (see AARs on Day +1). And again, the AARs are significant before the actual event, though the responses are less pronounced.

Table 3C and Table 3D about here

3.3. Volatility across listed and delisted periods

Tables 4A and 4B report volatility effects of option listings and delistings. We use the actual listing and delisting dates for this examination, as well as for the following examination of liquidity. The estimation framework is

$$\upsilon_{i,t} = c_i + \beta_{i,t}\upsilon_{I,t} + \psi_i L_t + \lambda_i D_t + e_{i,t}\,, \tag{5}$$

where υ_i represents a measure of conditional volatility, υ_I represents index volatility, and L and D are dichotomous (1,0) dummy variables for listed and delisted periods, respectively. We use an EGARCH approach to obtain conditional volatility.

The approach accounts for potential asymmetry in trader responses, given short-sale bans. The intercept, c_i, captures the volatility over periods preceding options introduction for a particular stock. In the interest of robustness, we employ four alternate specifications to

[13] These results are available from the authors upon request.

estimate volatility effects. These estimation frameworks are detailed in the Appendix, and include panel, cross-sectional (between effects), within-effects, and random-effects models.[14]

The evidence across the models is consistent and shows that volatility increases after both listings and delistings but is more pronounced after delistings (see, e.g., the random-effects model), as Wald tests confirm. At first blush, it might appear that the absence of options trading is associated with much greater volatility. This could be so. It is tempting to suggest that these results invalidate the regulatory rationale (of promoting stability). But the greater volatility may arise not simply from the absence of options trading in the underlying stock, but also from the fact that the delisting proxies weakness in that stock. We explore these issues further.

Table 4A about here

To further assess the potential role of short-sales constraints in the impact of options trading, we perform the above tests on listings and delistings, but only over the 2001–4/2008 interval, which witnessed a complete ban on institutional short selling. The results for this sample are reported in Table 4B. As we suspected, the increase in volatility after delisting is

[14] The test statistics are computed in the following manner. (i) We compute the redundant fixed-effect test (a) by restricting the cross-section fixed effects to zero to determine whether a model with cross-section fixed effects has more explanatory power than a pooled regression model and (b) by restricting period fixed effects (period chi-square) to zero to assess whether a period fixed-effect model has more explanatory power than one with cross-section fixed effects only. (ii) We use the Hausman test to assess whether random effects are uncorrelated with the explanatory variables, that is, whether a random-effects model has more explanatory power than a fixed-effects model.

significantly higher than after listing, suggesting that the regulatory curbs have a hand in these effects.

Table 4B about here

3.4. Number of daily trades across listed and delisted periods

To conduct a similar exercise for different measures of liquidity, we regress, alternatively, the logof the number of trades and the number of shares traded on the listing and delisting dummies over the sample period 2004–2012. Note that during 2001–2003, trade volume data is unavailable for most stocks. For brevity, Table 5 reports the results only for the number of trades variable. The findings show that options delisting significantly reduces trading frequency. Increases in trading after a listing are not significant at conventional levels. But in each of the four specifications, the coefficient of the listing dummy is statistically distinguishable from that of the delisting dummy, suggesting that the trading dynamics differ. Thus, we find that options trading is associated with significant changes in trading in the underlying stocks.[15]

[15] For robustness, we examine trading dynamics around the actual listing and delisting events using a standard event window (-10 to +10 days), using T-tests. More specifically, we examine potential increases (decreases) in stock volume and the number of trades before and after listings (delistings). The results are summarized below (*** implies significance at the 1% level). Once again, we note a significant increase in trading and volume after listings and a significant decrease in trading and volume after delistings.

H_0: Before(-10)=After(+10)	Volume	Number of Trades
Listings	2.200***	1.942***
Delistings	-4.618***	-2.874***

Table 5 about here

3.5. Short-sale constraint regimes and short-term stock volume dynamics

In the last part of this analysis, we examine the effects of differing short-sale regimes on stock volume. For ease of interpretation, we omit the intercept. Specifically, we conduct the following regression:

$$STV_{i,t} = \alpha_1 OTV_{i,2001-2008} + \alpha_2 OTV_{i,2008-2012} + \alpha_3 OTV_{i,2001-2008} * \text{Listing}_{2001\text{-}2008} + \alpha_4 OTV_{i,2001-2008} * \text{Delisting}_{2001\text{-}2008} + \alpha_5 OTV_{i,2008-2012} * \text{Listing}_{2008\text{-}2012} + \alpha_6 OTV_{i,2008-2012} * \text{Delisting}_{2008\text{-}2012} + \upsilon_{i,t}, \quad (6)$$

where STV and OTV represent stock trading volume and options trading volume respectively. The results are shown in Table 6. The subscript 2001–2008 covers the period 4/2001/–6/2008, while the subscript 2008–2012 covers the period 8/2007–2012. For this test we consider the announcement and event dates and the 10 days following these dates. For example, $\text{Listing}_{2001\text{-}2008}$ represents OTV trading on the day of the options listing announcement and the ten days that follow, as well as the day of the actual listing and the ten days that follow. Because there is no trading of options after an actual delisting, in the equation above the delisting dummy represents only the announcement day and the 10 days of OTV after that announcement.

Table 6 about here

The findings across all four models are consistent and provide two interesting insights. One, after a listing or a delisting there appears to be a shift in trading from one venue to another. Notice that the parameters β_3 and β_4 are both significant but have different signs. The negative coefficient on the former suggests that trading shifts away from stocks to options following a listing, and vice versa after a delisting (see, e.g., Easley, O'Hara, &

Srinivas, 1998). Two, during 2001–2008, when stringent controls were in place, the effects are magnified (see, e.g., β_3 versus β_5).

4. Summary and conclusions

We have attempted to answer three important related questions.

(1) How does the market respond, in the short term, to options listing and delisting? We find a strong positive response to listings on the announcement day and for the next two days, plus evidence of information leakage about a forthcoming listing on the preceding day. After a delisting announcement, we find sharply negative responses, especially on the first two days. In short, traders respond strongly to these announcements. They also respond significantly to actual listings and delistings. In the run-up to an actual listing abnormal returns are positive and significant; in the run-up to an actual delisting, negative and significant. But there is little evidence of abnormal returns after that. Taken together, the evidence on listings is consistent with a long line of studies that find positive abnormal returns associated with options listings (e.g., Branch & Finnerty, 1981; Conrad, 1989; Detemple & Jorion, 1990; Detemple & Selden, 1991; Faff & Hillier, 2005). The negative responses to delistings may point to informed traders having to migrate away from option venues (see, e.g., Black, 1975; Easley, O'Hara, & Srinivas, 1998). The effects of differing short-sale regimes on stock volume suggest that traders migrate to option venues from stock venues after a listing and vice versa after delisting, and these effects are magnified during short-sale bans.

(2) How do options listing and delisting affect daily volatility? We find that both listings and delistings elevate volatility, but this increase is significantly larger after delistings than after listings. During 2001–4/2008, when institutional short selling was completely banned, the increase after delistings was marginally larger. Other studies also find that

volatility rises after options listings or index futures listings (e.g., Chatrath, Ramchander, & Song, 1995; Gulen & Mayhew, 2000). Duffie, Garleanu, and Pedersen (2002) suggest that short-sales constraints combined with a divergence in opinion can result in mispricing. Our findings may reinforce this notion. It might be useful for the regulatory body, the Securities and Exchange Board of India, to take note of our evidence.

(3) Does options listing promote liquidity in the underlying stock? We find that options delisting significantly reduces the number of trades and that this effect differs significantly from that of listings. Robustness tests using a standard event window confirm that trading accelerates after listings but decelerates after delisting.

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Table 1

Option listings and delistings by year.

Year	Listing	%Listing	Delisting	%Delisting
2001	20	8%	0	
2002	0		2	3%
2003	22	9	0	
2004	0		0	
2005	49	21	6	4
2006	23	9	1	
2007	43	18	0	
2008	28	12	6	4
2009	0		55	40
2010	40	17	1	
2011	11	5	13	9
2012	1		56	40
Total	**237**		**140**	

The sample covers listings and delistings of options on individual equities on the National Stock Exchange of India (NSE) from 2001 to 2012. Over the 2001–2012 interval, there are a total of 257 optionable stocks on the NSE, 237 events of listings (217 listings and 20 relistings), and 140 events of delistings.

Table 2

Daily moment statistics averaged across listings and delistings.

Statistics	4/2001–2012		4/2001–07/2008		07/2008–2012	
Panel A	Listing [237]	Delisting [140]	Listing [157]	Delisting [9]	Listing [80]	Delisting [131]
Mean (%)	0.029***	0.0183	0.074***	0.0594	0.016	-0.028
Std deviation (%)	1.382	1.395	1.362	1.644	1.674	1.171
Skewness	-1.0003***	-1.174***	-1.719***	-0.834***	-0.380	-0.501***
Kurtosis	11.195***	12.564***	14.495***	10.064***	7.415***	8.056***
Autocorrelation						
Lag-1	0.263***	0.307***	0.276***	0.187***	0.286***	0.318***
Lag-2	0.051***	0.084***	-0.014***	-0.042***	0.126***	0.131***
Lag-3	0.059***	0.084***	0.015***	0.003***	0.107***	0.125***
Panel B	Only a Listing or Only a Delisting					
N	[97]	[115]	[62]	[5]	[35]	[110]
Mean (%)	0.0411	0.0216	0.082***	0.061	0.006	-0.0366
Std deviation (%)	1.411	1.381	1.453	1.736	1.666	1.682
Skewness	-0.816***	-1.141***	-1.394***	-0.422	-0.313*	-0.557***
Kurtosis	10.116***	11.768***	11.689***	7.54***	6.727***	8.53***
Autocorrelation						
Lag-1	0.218***	0.313***	0.236***	0.167***	0.193***	0.361***
Lag-2	0.019***	0.082***	-0.043***	-0.083***	-0.080***	0.152***
Lag-3	0.034***	0.081***	0.001***	-0.010***	0.081***	0.119***
Panel C	Both a Listing and a Delisting					
[N]	[140]		[9]		[55]	
Mean (%)	0.0183		0.0594		0.012	
Std deviation (%)	1.395		1.644		1.751	
Skewness	-1.174***		-0.834***		-0.531***	
Kurtosis	12.564***		10.064***		7.465***	
Autocorrelation						
Lag-1	0.304***		0.187***		0.353***	
Lag-2	0.080***		-0.042***		0.144***	
Lag-3	0.081***		0.003***		0.112***	

Daily statistics are calculated for each stock over listing and delisting event dates. The statistics are then arranged across stocks with listed options, and separately across stocks with delisted options. This is done for the full sample, 2001–2012, and the subsample, 7/2008–2012, during which short-selling restrictions were lifted to some degree. The sampling in this table includes only stocks that witnessed both listing and delisting of options during the sample period. The subscripts ***, **, * represents significance at the 1%, 5%, and 10% levels respectively, from tests of equality between listing and delisting samples.

Table 3A

Abnormal returns around options listing and delisting announcements.

	Listings				Delistings			
Event day	AAR	CAAR	test AAR	Test CAAR	AAR	CAAR	test AAR	Test CAAR
-10	-0.0003	-0.0003	-0.118	-0.118	0.006	0.006	1.992**	1.992**
-9	0.0028	0.002	1.1704	1.12	0.00008	0.007	0.742	1.934*
-8	0.003	0.005	1.616	1.848	0.018	0.025	5.812***	4.935***
-7	-0.003	0.002	-1.823	0.689	0.0166	0.0042	5.204***	6.876***
-6	0.001	0.003	0.597	0.883	0.003	0.045	0.881	6.544***
-5	0.0004	0.004	0.08	0.843	0.002	0.048	0.58	6.211***
-4	-0.003	0.001	-1.3	0.289	0.004	0.052	1.842	6.446***
-3	0.001	0.002	0.2	0.342	-0.007	0.044	-2.297**	5.218***
-2	0.002	0.006	1.52	0.832	0.008	0.053	2.881***	5.880***
-1	0.004	0.01	2.33**	1.528	0.009	0.062	2.941**	6.505***
0	0.007	0.02	3.95**	2.651***	0.0006	0.063	0.440	6.338**
1	0.01	0.027	4.56***	3.856***	-0.025	0.038	-8.351***	3.658***
2	0.001	0.029	0.926	3.962***	-0.007	0.031	-2.41***	2.742**
3	-0.0004	0.028	-0.31	3.736***	-0.006	0.024	-3.538***	1.903*
4	0.001	0.030	1.11	3.895***	-0.001	0.026	0.842	2.056**
5	0.005	0.035	2.580***	4.417***	0.0002	0.026	-0.081	1.970**
6	0.001	0.036	0.793	4.447***	-0.0012	0.025	-0.098	1.881*
7	0.0001	0.036	-0.166	4.31***	0.007	0.032	3.185***	2.585***
8	-0.003	0.033	-1.39	3.878***	0.005	0.038	1.631	2.890**
9	-0.002	0.0313	-1.35	3.477***	0.002	0.041	0.233	2.870**
10	-0.003	0.0285	-1.22	3.126***	0.008	0.049	-2.099**	3.258***

Average Abnormal Returns (AARs) and cumulative AARs are reported for days t_{-10} to t_{+10} with listing at t_0. The market model is used to compute abnormal returns: $AR_{it} = R_{it} - (\hat{\alpha}_i + \hat{\beta}_i R_{mt})$, where R_m is the daily return on the Nifty index. To construct tests of significance relating to AARs and CAARs, we calculate, as is standard, the standard deviation of abnormal returns for the period -210 days to -11 days for each company, which we use to obtain the standardized abnormal return (SAR) over days -10...+10 for each company. The test statistics for the average abnormal returns and cumulative average abnormal returns for N stock are given by, $Z_{AAR,t} = \sum_{i=1}^{N} \frac{SAR_{it}}{\sqrt{N}}$ and $Z_{CAAR,t} = \sum_{i=t_1}^{t2i} \frac{SAR_{it}}{\sqrt{T*N}}$, respectively, for T=1,...21. ***, **, * represent significance at the 1%, 5%, and 10% levels respectively.

Table 3B

Abnormal returns around options listing and delisting events.

	Listings				Delistings			
Event day	AAR	CAAR	test AAR	test CAAR	AAR	CAAR	test AAR	test CAAR
-10	-0.007	-0.0007	-0.342	-0.342	-0.0045	-0.00459	-0.807	-0.807
-9	0.0003	-0.0004	-0.023	-0.259	0.0007	-0.00382	-0.471	-904
-8	-0.002	-0.0026	-1.586	-1.127	-0.0005	-0.0044	-0.891	-1.252
-7	0.002	-0.0004	1.207	-0.372	0.002	-0.00167	0.565	-0.801
-6	-0.0018	-0.002	-1.254	-0.893	0.004	0.00229	1.132	-0.21
-5	-0.0056	0.0033	2.799***	0.326	-0.001	0.00085	-0.096	-0.231
-4	0.0027	0.0061	2.280***	1.164	0.001	0.00186	0.841	0.103
-3	0.0039	0.010	2.770***	2.068	0.003	0.00489	0.763	0.366
-2	0.014	0.0241	8.609***	4.82***	-0.011	-0.00622	-5.729***	-1.564
-1	0.006	0.03	3.376***	5.64***	-0.005	-0.01186	-2.318**	-2.217**
0	-0.001	0.028	-0.848	5.122***	-0.0037	-0.0156	-2.845***	-2.972***
1	0.001	0.03	-0.944	5.177**	0.0043	-0.01125	1.791*	-2.32**
2	0.003	0.033	1.818*	5.428***	-0.0012	-0.01246	-0.543	-2.301**
3	0.0009	0.034	0.721	5.471***	0.00415	-0.00831	2.691***	-1.581
4	-0.005	0.029	-2.518***	4.636***	-0.0022	-0.0105	0.137	-1.492
5	-0.0007	0.028	-0.66	4.323***	0.00274	-0.00776	0.270	-1.377
6	-0.0000	0.028	-0.019	4.198***	0.0002	-0.00752	-0.130	-1.367
7	0.0001	0.029	-0.426	3.979***	-0.0106	0.01812	-3.633***	-2.185**
8	0.001	0.029	0.944	4.019***	0.0065	-0.01163	1.627	-1.753*
9	0.0014	0.028	-1.094	3.742***	0.009	-0.00212	3.041***	-1.029
10	-0.0015	0.027	-1.301	3.368***	-0.0002	-0.0024	.134	-0.975

Average Abnormal Returns (AARs) and cumulative AARs are reported for days t_{-10} to t_{+10} with delisting at t_0. The market model is used to compute abnormal returns: $AR_{it} = R_{it} - (\widehat{\alpha}_i + \widehat{\beta}_i R_{mt})$, where R_m is the daily return on the Nifty index. To construct tests of significance relating to AARs and CAARs, we calculate, as is standard, the standard deviation of abnormal returns for the period -210 days to -11 days for each company, which we use to obtain the standardized abnormal return (SAR) over days -10...+10 for each company. The test statistics for the average abnormal returns and cumulative average abnormal returns for N stock are given by $Z_{AAR,t} = \sum_{i=1}^{N} \frac{SAR_{it}}{\sqrt{N}}$ and $Z_{CAAR,t} = \sum_{i=t_1}^{t2i} \frac{SAR_{it}}{\sqrt{T * N}}$, respectively, for T=1,...21. ***, **, * represent significance at the 1%, 5%, and 10% levels, respectively.

Table 3C

Abnormal returns around relisting announcements.

Relistings				
Event day	AAR	CAAR	test AAR	test CAAR
-10	0.0088	0.0088	1.5543	1.554
-9	0.0014	0.0102	0.1622	0.982
-8	-0.002	0.0082	-0.4463	0.897
-7	0.001	0.0092	0.3822	0.963
-6	0.0087	0.0005	-2.0162**	0.042
-5	0.0078	0.0083	1.3414	0.545
-4	0.0084	0.0004	-1.2546	-0.008
-3	0.0006	0.0007	-0.1429	-0.051
-2	0.0156	0.0149	2.1328**	0.930
-1	0.0027	0.0122	-0.5818	0.660
0	0.0034	0.0156	0.4333	0.689
1	0.0106	0.0262	2.5698***	1.148
2	0.0008	0.0254	-0.1729	1.102
3	0.0053	0.0307	0.9132	1.262
4	0.0051	0.0358	0.677	1.394
5	0.0037	0.0395	1.0676	1.558
6	0.0046	0.0441	0.8656	1.648
7	0.0106	0.0547	1.8672*	1.852*
8	0.0061	0.0486	-1.0181	1.526
9	0.0033	0.0453	-0.4569	1.372
10	0.0055	0.0398	-1.3084	1.152

Average Abnormal Returns (AARs) and cumulative AARs are reported for days t_{-10} to t_{+10} with relisting at t_0. The market model is used to compute abnormal returns: $AR_{it} = R_{it} - (\hat{\alpha}_i + \hat{\beta}_i R_{mt})$, where R_m is the daily return on the Nifty index. To construct tests of significance relating to AARs and CAARs, we calculate, as is standard, the standard deviation of abnormal returns for the period -210 days to -11 days for each company, which we use to obtain the standardized abnormal return (SAR) over days -10...+10 for each company. The test statistics for the average abnormal returns and cumulative average abnormal returns for N stock are given by $Z_{AAR,t} = \sum_{i=1}^{N} \frac{SAR_{it}}{\sqrt{N}}$ and $Z_{CAAR,t} = \sum_{i=t_1}^{t2i} \frac{SAR_{it}}{\sqrt{T*N}}$, respectively, for T=1,...21. ***, **, * represent significance at the 1%, 5%, and 10% levels, respectively.

Table 3D

Abnormal returns around relisting events.

Relistings				
Event day	AAR	CAAR	Test AAR	Test CAAR
-10	0.0058	0.0058	1.022	1.022
-9	-0.0078	-0.002	-1.376	-0.25
-8	0.0054	0.0034	0.962	0.351
-7	0.0115	0.0149	2.022**	1.315
-6	-0.0080	0.007	-1.404	0.548
-5	0.011	0.0179	1.936*	1.219
-4	0.0053	0.0233	0.936	1.549
-3	0.0035	0.0268	0.621	1.668
-2	0.0207	0.0476	3.646**	2.789***
-1	0.0113	0.059	1.996**	3.277***
0	-0.011	0.0481	-1.959**	2.533***
1	0.0045	0.0524	0.801	2.657***
2	-0.0003	0.0522	-0.067	2.534***
3	-0.0059	0.0462	-1.043	2.163**
4	-0.0112	0.0349	-1.971**	1.581
5	0.0008	0.0357	0.149	1.568
6	0.0026	0.0383	0.47	1.635
7	0.006	0.0444	1.062	1.839*
8	0.0092	0.0537	1.619	2.162**
9	0.0006	0.0543	0.114	2.133**
10	-0.0126	0.0418	-2.222***	1.596

Average Abnormal Returns (AARs) and cumulative AARs are reported for days t_{-10} to t_{+10} with relisting at t_0. The market model is used to compute abnormal returns: $AR_{it} = R_{it} - (\hat{\alpha}_i + \hat{\beta}_i R_{mt})$, where R_m is the daily return on the Nifty index. To construct tests of significance relating to AARs and CAARs, we calculate, as is standard, the standard deviation of abnormal returns for the period -210 days to -11 days for each company, which we use to obtain the standardized abnormal return (SAR) over days -10...+10 for each company. The test statistics for the average abnormal returns and cumulative average abnormal returns for N stock are given by $Z_{AAR,t} = \sum_{i=1}^{N} \frac{SAR_{it}}{\sqrt{N}}$ and $Z_{CAAR,t} = \sum_{i=t_1}^{t2i} \frac{SAR_{it}}{\sqrt{T * N}}$, respectively, for T=1,...21. ***, **, * represent significance at the 1%, 5%, and 10% levels, respectively.

Table 4A

GARCH volatility across listing and delisting events.

	Pooled	Between Effects	Within Effects	Random Effects
C	0.104***(18.68)	0.239***(9.915)	0.176***(17.05)	0.104***(3.885)
Index volatility	2.457***(26.16)	0.972*(1.760)	1.981***(14.27)	2.815***(7.775)
Options listed (L)	0.035***(3.959)	0.048***(5.568)	0.0253(1.452)	0.149***(3.113)
Options delisted (D)	0.093***(8.011)	0.084***(6.823)	0.081***(3.707)	0.230***(3.968)
Adjusted R2	0.24	0.30	0.08	0.037
Redundant fixed effects (F-stat)		1.739***		
Period fixed effects			1.18	
Cross-section random (rho)				0.00
Hausman (Cross-section random)				0.86
H0: L=D	16.954***	5.801**	4.261**	1.226

Four panel regressions are conducted over the period 2001–2012: pooled, fixed cross-section effects, and random effects. These models are detailed in the Appendix. Conditional volatility is obtained from an EGARCH framework that accounts for asymmetry in responses. Volatility is regressed on index volatility and dichotomous dummy variables for options listed (L) and delisted (D) for the dates listed or delisted. The intercept is permitted to capture periods before options were introduced for a particular stock. Each model is estimated via GLS. Adjusted R^2 tests whether the alternate model is superior to the pooled regression. ***,**,* represent significance at the 1%, 5%, and 10% levels, respectively.

Table 4B

Volatility across listing and delisting events with short-sale constraints: 2001–4/2008.

	Pooled	Between Effects	Within Effects	Random Effects
C	0.105***(16.29)	0.080(1.089)	0.169***(11.364)	0.141***(5.416)
Index volatility	2.382***(22.60)	3.369***(2.885)	2.170***(11.36)	2.227***(6.384)
Options listed (L)	0.033***(3.701)	0.043***(5.852)	0.004(0.195)	0.050(1.066)
Options delisted (D)	0.105***(5.988)	0.084***(6.823)	0.081***(3.707)	0.230***(3.968)
Adjusted R2	0.269	0.412	0.079	0.044
Redundant fixed effects (F-stat)		2.069***		
Period fixed effects			1.001	
Cross-section random (rho)				0.00
Hausman (Cross-section random)				0.86
H0: L=D	13.919***	15.010***	2.831	14.288***

Four panel regressions are conducted over the period 2001–4/2008, a period that saw a complete ban on short sales. The regression frameworks are pooled, fixed cross-section effects, within effects, and random effects. These models are detailed in the Appendix. Conditional volatility is obtained through an EGARCH framework that accounts for asymmetry in responses. Volatility is regressed on index volatility and dichotomous dummy variables for options listed (L) and delisted (D) for the dates listed or delisted. The intercept is permitted to capture periods before options were introduced for a particular stock. Each model is estimated via GLS. Adjusted R^2 tests whether the alternate model is superior to the pooled regression. ***,**,* represent significance at the 1%, 5%, and 10% levels, respectively.

Table 5

Number of trades on listing and delisting event dates.

	Pooled	Between Effects	Within Effects	Random Effects
C	8.337***(233.04)	8.35***(240.15)	8.337***(232.75)	0.141***(5.416)
Options listed (L)	0.141(1.234)	0.221 (1.841)	0.142 (1.239)	0.050(1.066)
Options delisted (D)	-0.266***(-2.019)	-0.570***(-3.963)	-0.269***(-2.030)	-0.365***(-2.750)
Adj R2	0.002	0.08	-0.000	0.003
Redundant fixed effects (F-stat)		1.718***		
Period fixed effects			0.443	
Cross-section random (rho)				0.07
Hausman (Cross-section random)				0.75
H0: L=D	5.947***	18.21***	6.009**	9.799***

The log of transactions for each company is regressed on dichotomous dummy variables for options listed (L) and delisted (D) days. Four panel regressions are conducted using data from 2001–2012: pooled, fixed cross-section effects, and random effects. These models are detailed in the Appendix. The intercept term is permitted to capture periods before options were introduced for a particular stock. Each model is estimated via GLS. Adjusted-R^2 tests whether the alternate model is superior to the pooled regression. ***,**,* represent significance at the 1%, 5%, and 10% levels, respectively.

Table 6

Trading dynamics: stock volume, options volume, and short-sale regimes.

Variable	Pooled	Individual	Two-Way	Random
β_1 [Options volume$_{2001\text{-}2008}$]	0.711***	-0.002	0.403***	0.008
β_2 [Options volume$_{2008\text{-}2012}$]	0.865***	0.003	0.688***	0.015***
β_3 [Options volume$_{2001\text{-}2008}$*Listing$_{2001\text{-}2008}$]	0.110***	-0.032***	-0.013***	-0.327***
β_4 [Options volume$_{2001\text{-}2008}$*Delisting$_{2001\text{-}2008}$]	0.288***	0.087***	0.027***	0.085***
β_5 [Options volume$_{2008\text{-}2012}$*Listing$_{2008\text{-}2012}$]	-0.226***	-0.063***	0.003	-0.08***
β_6 [Options volume$_{2008\text{-}2012}$*Delisting$_{2008\text{-}2012}$]	0.134***	-0.20***	-0.011***	-0.031***
Adjusted R^2	0.05	0.071	0.03	0.09
H0: $\beta_1 = \beta_2$	70.07***	1.01	46.68***	2.45
H0: $\beta_1 = \beta_3$	164.74***	12.94***	137.50***	22.33***
H0: $\beta_1 = \beta_4$	118.69***	212.18***	101.24***	164.90***
Tions	415.42***	23.15***	712.10***	40.44***
H0: $\beta_2 = \beta_6$	1744.74***	7.85***	740.50***	24.25***
H0: $\beta_3 = \beta_5$	26.34***	0.38	0.40	2.58*
H0: $\beta_4 = \beta_6$	23.02***	38.98***	18.10***	51.07***
H0: RE better than FE				34.02**
Cross-section random rho				0.77

Four panel regressions are conducted over the period 2001–2012: pooled, individual cross-section effects, two-way effects, and random effects. These models are detailed in the Appendix of this paper. Stock volume is regressed on options volume for the period 2001–2008, options volume for the period 2008–2012, and four interaction variables: options volume and listings during 2001–2008, options volume and delistings during 2001–2008, options volume and listings during 2008–2012, and options volume and delistings during 2008–2012. All models are estimated with heteroscedasticity-adjusted standard errors. T-statistics are reported in parentheses. ***,**,* represent significance at the 1%, 5%, and 10% levels, respectively. Note that the subscript 2001–2008 covers the period 4/2001–6/2008, while the subscript 2008–2012 covers the period 7/2008–2012. For this test, we consider the announcement and event date and the 10 days following a delisting (after the actual date). The delisting dummy represents only the announcement day and the 10 days of options trading after that announcement.

Appendix: Alternate specifications

A.1. Pooled regression model

The simplest approach, with which our analysis begins, is pooled OLS regression. This is expressed as follows: $y_{it} = \alpha_0 + \beta x_{it} + \varepsilon_{it}$, where i = 1,2,...N represents the number of entities, t = 1, 2,...T represents the time period, and x_{it} is a 1xk vector of explanatory variables. In pooled regressions the intercept and slope coefficients remain constant over time and entities.

A.2. Fixed (cross-sectional) effects model

We use the cross-sectional fixed effects model to capture heterogeneity across entities, represented by αi. The cross-sectional fixed effects model is expressed as follows: $y_{it} = \alpha_i + \beta x_{it} + \varepsilon_{it}$, where α_i, the intercept, is different for every firm but remains constant over time, and x_{it} is a 1xk vector of explanatory variables.

A.3. Fixed (time) effects model

We use the time fixed effects model to capture the heterogeneity of every individual over time, represented by αt. The time fixed effects model is expressed as follows: $y_{it} = \alpha_t + \beta x_{it} + \varepsilon_{it}$, where the intercept changes over time for every firm. x_{it} is a 1xk vector of explanatory variables.

A.4. Random effects model

The random effects model allows an intercept for each cross-sectional unit to arise from a common intercept term α (which remains the same for all cross-sectional units and over time) and a random variable ε_i, which measures the random standard deviation of each unit's intercept term from the overall intercept term α (Brooks, 2008).

$$y_{it} = \alpha_i + \beta_i x_{it} + w_{it},\ w_{it} = \varepsilon_i + v_{it},$$

where i = 1,2,...N represents the number of entities, and t = 1, 2,...T represents the time period. x_{it} is still a 1xk vector of explanatory variables, but unlike the fixed effects model, the random effects one has no dummy variables to capture the heterogeneity in the cross-sectional dimension. It is assumed that the new cross-sectional term, ε_i, has zero mean and constant variance. ε_i is independent of v_{it} and the explanatory variable, x_{it}. Generalized least squares is used to estimate the random effects panel.