The IPO Lock-Up Period: Implications for Market Efficiency And Downward Sloping Demand Curves

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Abstract

After an initial public offering, most existing shareholders are subject to a lock-up period in which they cannot sell their shares for a prespecified time. At the end of the lock-up, there is a permanent and large shift in the supply of shares. The lock-up expiration is a particularly interesting event to study because it is (i) completely known and observable, and (ii) potentially meaningful economically given the existing literature on supply shocks. This paper investigates volume and price patterns around this period, and documents several interesting results. Specifically, even though the event is totally anticipated, there is a 1% – 3% drop in the stock price, and a 40% increase in volume, when the lock-up ends. Various explanations are considered and rejected, suggesting a new anomalous fact against market efficiency. However, convincing evidence is provided which shows that this inefficiency is not exploitable, i.e., arbitrage is not violated. This aside, the evidence points to a downward sloping demand curve for shares, with the most likely explanation pointing to a permanent, long-run effect.

1 Introduction

Are stock prices affected by either demand or supply shifts in the quantity of shares? This question has been of paramount importance to financial economists over the past twenty-five years due to its implications for whether markets are efficient or demand curves downward slope. Numerous papers have looked at these implications in a variety of different situations (see Scholes' (1972) block-trade study and Shleifer's (1986) S&P index inclusion analysis for two particular examples). The evidence from this literature is for the most part mixed. Specifically, questions about the information content of the event (e.g., block trade or inclusion in index, respectively), or the exact timing, nature or length of the demand/supply shock tend to obscure the results.

This paper adds to the current literature by focusing on a particularly interesting characteristic of all initial public offerings (IPOs). Typically, upon a firm going public, the owners tend to sell roughly 15-20% of the company. As part of the IPO process, the remaining 80-85% of the shareholders are almost always subject to a lock-up period, usually (but not always) 180 days, in which they have agreed not to sell any of their shares. Upon completion of this period, these shareholders are then free to sell their existing shares. Thus, there is a completely observable event which results in a permanent shift in the amount of available shares in the marketplace.

A careful analysis of the lock-up period's effect has several advantages over the previous literature. First, the event itself is completely expected with the lock-up period length being spelled out in the IPO prospectus. Thus, we are able to form stronger conclusions about market efficiency in this context. Second, in contrast to existing studies, the event (i.e., the end of the lock-up period) is clearly not information-based. In fact, almost all IPOs are subject to lock-up agreements. Third, because the end of the lock-up period represents a permanent shift in the supply of shares in the market, this allows us a clean way of studying the effect of a known, long-run positive shift in one of the quantities of interest.

Our results are somewhat surprising. At the end of the lock-up period, there is a permanent drop in the stock price in the range of 1.15–3.29%, with a corresponding 38% increase in the volume of shares traded. This is anomalous evidence as it pertains to market efficiency in the sense that the markets are not rationally incorporating an anticipated price decline. Because the lock-up period event is known with certainty, the price drop should have been built into the price well before, in fact, during the first day of the IPO trading. We explore several *plausible* explanations, including (i) bid-ask bounce, (ii) liquidity effects, and (iii) biased expectations of supply shocks, but find they have little support. Given that prices do not reflect all available information, we ask the question: why does the inefficiency not get arbitraged away? Using data on bid-ask quotes and short interest, coupled with investor's tax considerations, we argue that the inefficiency is difficult to exploit in practice. For example, the price fall is larger for stocks that are harder to short and for stocks with bigger bid ask spread.

Nevertheless, given that there is in fact an anomalous price effect at the end of the lock-up period, this is strong evidence in favor of demand curves for stocks being downward sloping. With a positive shift in supply and a downward sloping demand curve, the price would be expected to fall. We explore two popular economic hypotheses of this result, namely price pressure (i.e., temporarily downward sloping demand curve) versus long-run demand effects. We find the evidence supportive of the latter theory, but not perfectly, as some results are inconsistent with implications from long-run downward sloping demand curves. On a different note, we provide some interesting evidence about the predictability of the price drop. Perhaps, most interesting, the magnitude of the price drop is related to the the stock's underlying volatility. We hypothesize that this variable is a good proxy for existing shareholders' desire to diversify their asset risk.

The paper is organized as follows. In Section 2, we describe the lock-up period for IPOs, and the underlying economics related to the end of this period. This section also describes the data used in this study, and the methodology and finance theories associated with our analysis. Section 3 provides the main empirical results, with special emphasis on trying to explain and understand the evidence against market efficiency. Section 4 analyzes what the price effects of the supply shock represent. Section 5 makes some concluding remarks.

2 Preliminaries

2.1 The Lock-up Period

At an initial public offering (IPO), the existing shareholders rarely sell the entire company. Instead, approximately 15-20% of the shares are issued to the public. Though not a legal requirement, it is a standard arrangement for the underwriters to insist upon the shares of the remaining 80-85% shareholders to be restricted from sale for a certain period of time. This period, the so-called *lock-up* period, is one way of aligning the incentives of the current owners and new owners, at least during the initial stages of the company being public. There are no rules regarding the length of the lock-up period; however, the majority of lock-up periods last 180 days, or approximately 6 months.

As an illustration of the lock-up language, consider the following excerpt from a typical IPO prospectus: *Holders of at least approximately 96% of all outstanding Common Stock, as well as the Company, have agreed that, during a period of 180 days from the date of this Prospectus, the Company and such holders will not, without the prior written consent of the U.S. and International Representatives, directly or indirectly, sell, offer to sell, grant any option for the sale of or otherwise dispose of any Common Stock or any security convertible or exchangeable into or exercisable for Common Stock (except for Common*

Stock issued as part of the Offerings) or, in the case of any holder of Common Stock, exercise any right to have securities of the Company registered by the Company under the Securities Act.

The Prospectus, and in particular the lock-up agreement spelled out above, is a legally enforceable contract. For existing shareholders to be able to sell their shares prior to the lock-up expiration, they must receive permission from the underwriters. From time to time, the underwriting group does grant permission and allow early sales of shares by locked-up shareholders; however, the percentage of sales that are unlocked prior to expiration is generally small. While the insiders of the firm, especially management and active investors (such as the venture capitalists), are subject to additional vesting agreements, most of the existing shareholders are free to sell the shares after the lock-up period. These shareholders often have strong reason to do so. In general, these shares represent significant fractions of their wealth, subjecting them to significant asset risk. From a diversification point of view, it is natural that after the lock-up period there is significant selling pressure on these stocks.

From an economic viewpoint, this period is interesting for several reasons. First, after the lock-up period, it is reasonable to expect certain characteristics of trading in the stock. In particular, due to the shift in the supply of available shares, we would expect trading volume to rise. This is because the quantity of liquidity trading (i.e., non information-based) increases in proportion to the supply shift, which is often three to four times the number of IPO issued shares. Second, and related, some of this new volume will more likely reflect seller-motivated trades as shareholders diversify their asset price risk. While the exact quantity of selling is an empirical question, there is little doubt it takes place. Third, there have been a number of papers documenting the effect of demand/supply shifts of shares, and buyer/seller-motivated trading. In this paper, the lock-up period is unique because, ex ante, it is not an information-based event. Though one might argue that excessive (or lack of) sales of insiders suggest bad (good) news about the company's prospects, it is important to note that these excessive sales are not known during the lock-up period. In addition, informed selling is somewhat mitigated by additional vesting periods which are standard for insiders. Fourth, the event, i.e., the end of the lock-up period, is known at the time of the IPO. In fact, it is spelled out in the underwriting section of the prospectus. Thus, rationally, markets should incorporate the economic impact (if any) of either price pressure or permanent shocks to share supply. In other words, the price impact should be built into the IPO traded price long before the end of the lock-up period.

2.2 Existing Literature

Analysis of the lock-up period allows us to study how stock prices and volume behave when there is a significant increase in the supply of shares a set number of days in advance. This analysis is relevant for two distinct areas of the current finance literature, namely (i) tests of market efficiency, and (ii) the question of whether demand curves slope downward.

With respect to whether demand curves slope downward, there are a plethora of papers that look at this question. Perhaps, the best known literature studies block trades, i.e., temporary shifts in supply, and finds ambiguous evidence. (See, for example, Scholes (1972), Mikkelson and Partch (1985), Holthausen, Leftwich and Mayers (1991) and Keim and Madhavan (1996).) The reason for the ambiguity relates to the difficulty of separating the information effect of seller-motivated trading from possible price pressure induced by downward sloping demand for shares. In response to this work, but only partially successful, are the papers on demand shifts for shares via an analysis of stocks that are added to a commonly traded index. (See, for example, the different conclusions reached by Shleifer (1986), Dhillon and Johnson (1991) and Lynch and Mendenhall (1997).) A related paper by Kaul, Mehrotra and Morck (1999), which studies weights adjustments for stocks already included in an index, finds evidence supporting a downward sloping demand curve. Their analysis is like ours in the sense that the event, i.e., weights adjustment, is clearly not information-based.[1]

Here, there is an unequivocal increase in the supply of shares available for trading in the secondary market.[2] This supply shock is permanent to the extent that the lock-up period no longer governs a significant fraction of the shareholders' holdings. If the demand curve is in fact downward sloping, then a permanent shift in supply lowers the stock price. Whether this price decrease is permanent or not depends on one's view of whether demand curves are temporarily or permanently downward sloping. The concept of downward sloping demand curves are an anathema to many financial economists, but do not necessarily imply market inefficiency. For example, divergences of opinion about share prices can lead to demand schedules (e.g., Varian (1985)), as can the lack of substitutability across assets (e.g., Scholes (1972)). In either case, the IPO market maybe an especially appropriate event for analysis of downward sloping demand curves for shares.

While downward sloping demand curves are not inconsistent with market efficiency, our paper does provide a clean, powerful test of whether prices rationally incorporate public information. The event, i.e., the end of the lock-up period, is (i) completely

[1]Hodrick (1992,1999) provides evidence that supply curves are upward sloping using a sample of Dutch auction tender offers, which can be viewed as the mirror image of the demand curve cases. The later paper is also relevant to the extent that it focuses on the interaction of corporate financial decisions and demand elasticity.

[2]There are a number of papers which look at permanent shifts in the supply of shares, such as stock repurchases (Comment and Jarrell (1991)), seasoned equity offerings (Asquith and Mullins (1986), Kalay and Shimrat (1987), and Barclay and Litzenberger (1988)), and the forced conversion of bonds (e.g., Mikkelson (1981)), among others. The focus of these papers is for the most part the impact of information on market prices; nevertheless, this literature provides an early motivation for the analysis in this paper. Relative to these papers, two unique characteristics for the expiration of the lock-up period are (i) the sheer size of the supply shift in the number of shares to be traded, and (ii) the event is clearly not information-based. In fact, as mentioned previously, almost all firms are subject to lock-up arrangements, so the inclusion of one in the prospectus is not even a surprise.

known and observable, (ii) potentially meaningful economically given the literature on supply shocks, and (iii) related to a complex vehicle, namely that of IPO pricing. Clearly, because the end of the lock-up period is known in advance, and there is possibly significant price effects from the event, the price impact should be incorporated immediately into price. In particular, the IPO price upon trading should adjust for the price impact implied by the event discounted at the required return on the stock. While it is difficult to test how much of the price impact is incorporated into the IPO price, on average, there should be no meaningful price impact around the end of the lock-up period. Our analysis falls into the category of papers that document calendar-day *anomalous* effects (such as the January effect, Keim (1983)), or look at price responses on announcement versus implementation dates (as in, for example, Lynch and Mendenhall (1997)).

2.3 Sample Description

Our study is based on a sample of all IPOs during the 1996-1998 period. The data on IPOs collected from SDC, while stock return and volume data was gathered from CRSP.[3] The sample consists of 1662 firms which went public on one of the three major U.S. stock exchanges, i.e., the New York Stock Exchange (NYSE), the American Stock Exchange (AMEX), and the NASDAQ market. Of these 1662 firms, 1056 had lock-up periods of 180 days, 327 had greater than, 88 less than, and 131 had no lock-up period at all. We dropped all firms with either no lock-up period or long lock-up periods (i.e., greater than 365 days). In addition, all firms without the lock-up ending in 1998, or with stock prices less than $4 (to avoid price discreteness), were also deleted from the sample. This left us with 1053 firms in our sample.[4]

For each IPO, we calculate the following characteristics: (i) daily returns, (ii) daily

[3]A random sample of IPO prospectuses were examined to check the SDC data on lock-ups.

[4]For out-of-sample purposes, the sample extends to include all firms that went public during the 1990-1995 period. This leads to an additional 1785 observations under the above characteristics.

volume, (iii) closing ask, bid and transaction prices at the lock-up end, (iv) short interest on the stock prior to the lock-up expiration, (v) the standard deviation of analyst's earnings forecast, (vi) the stock's estimated volatility over the lock-up period, and (vii) firm descriptive information (such as stock price level and size). Along with these data, aggregate data on stock indices were also calculated, including the CRSP equal- and value-weighted stock indices, as well as an IPO constructed index return. The IPO constructed index return includes all IPOs of less than one year, represents an equal-weighted index of each IPO, and thus hopefully matches better with the individual firms. This created a portfolio of approximately 250-300 firms on any given day.

2.4 Methodology

Our estimates of abnormal returns on stocks are based on market-adjusted prediction errors. In particular, we write

$$AR_{it} = R_{it} - R_{It}, \tag{1}$$

where AR_{it} is the abnormal return on stock i on day t, R_{it} is the return on stock i on day t, and R_{It} is the return on the index I on day t.[5] For each of the 1053 firms in our sample and 1785 firms in the extended sample, we calculate the cumulative abnormal return (CAR), starting from 20 trading days prior to the end of the lock-up period to 20 days after. That is, we look at windows of one month in either direction. Cross-sectional averages of CARs are then estimated and evaluated for their economic and statistical significance.

The lock-up expiration itself is analyzed in two ways. The first way looks at just the event date, which is defined as day 0 or day -1 in terms of the number of locked up days

[5] The index chosen was either the CRSP equal-weighted index, CRSP value-weighted index, or an IPO-adjusted index. The results were essentially the same for all three indices. The results reported in the tables refer to the IPO-adjusted index.

after the IPO.[6] The second way includes the entire prior week, i.e., day 0 to day -4, as a further investigation of how well markets incorporate the lock-up event. Of course, as previously mentioned, because the lock-up expiration is completely anticipated, there should be no real price effects on or before this date.

Excess volume is also calculated for each stock. In particular, from day -60 to day -21 relative to the end of the lock-up period, we estimate the average volumes of each stock. For day -20 to +20, we calculate the ratio of daily volume to its mean.[7] These volumes are then averaged cross-sectionally to get an estimate of the excess volume across each day surrounding the end of the lock-up period. That is, for each day, we estimate an average excess volume. This statistic, and the CAR mentioned above, are the basis for the empirical analysis of Sections 3 and 4.

3 Results

3.1 Summary Statistics

Table 1 provides summary statistics on the characteristics of the firms in our sample. Though these companies did an IPO, and thus tend to be smaller and clearly younger firms, their volume during the lock-up period is relatively high. For example, during the pre-event period as defined in Section 2.4 above, the average volume was 73,729 shares traded per day. Even accounting for the obvious skewness in volume, the 25th percentile, median and 75th percentiles are 22,549, 41,725 and 77,381 shares, respectively. These firms clearly trade.

Of particular interest to whether the lock-up effect is exploitable, Table 1 provides

[6] Observationally, choosing the lock-up expiration is difficult because it depends on whether the prospectus is viewed as being effective on the IPO date or the night before when the underwriter purchases the shares. In our random test of the sample, every lock-up expiration came on either day 0 or day -1. Hence, for the analysis to follow, these days are combined.

[7] To reduce the impact of outliers, that is, extraordinarily high volume days, we truncate the ratio at 50 times normal average volume.

statistics for the bid-ask spread, as well as the short interest. Though these firms trade frequently, the spreads are on average 3.3% of the firm's price. Even though the effective cost of trading is much smaller than the spread itself, nevertheless, this transaction cost is sizeable.[8] With respect to the short interest held in the stock, it tends to be relatively small as a fraction of the shares issued in the IPO, e.g., 3.1%. The standard deviation, however, is 7.5%, which suggests that there exist some stocks with large short positions. Generally, the arbitrage opportunity prior to the lock-up expiration rests on the ability to short the stock. Whether this has an important economic impact on the stock price is studied later in Section 3.

With respect to the lock-up period, Table 1 shows that the majority of shares outstanding, i.e., 59%, get unlocked at the end of the period. However, due to additional stock vesting agreements among managers and insiders, there is some variation in the amount unlocked.[9] Just as important a priori for understanding the lock-up effect are two additional facts. First, these firms tended on average to have run-ups in their stock price during this sample period. Second, the average volatility of these stocks is on the order of 4% per day, which translates to an astounding 60% plus on an annualized basis. If the first fact suggests that these stocks are an important part of investor's portfolios at the end of the lock-up period, the second fact surely points to strong diversification motives.

3.2 Main Empirical Findings

Figure 1 graphs the mean excess volume across the sample, relative to the end of the lock-up period. As expected, there is a large jump in volume on this date, with the mean

[8]For a breakdown and explanation of the bid-ask spread versus effective spreads, see Madhavan, Richardson and Roomans (1997), among others.

[9]Information about the number of shares unlocked is available for roughly half the sample (i.e., 423 firms). Thus, the various statistics in the table should be interpreted in this context.

being 61% larger than its pre-event average. While volume subsides over the following few days, there is a permanent shift in volume of around 38%. (See Table 2B for the exact numbers.) Of course, the increase in volume is not surprising given the lock-up period releases a significant number of shares to the secondary market. If liquidity trading is at all a motivation for buying/selling on the part of investors, then we would expect a permanent shift in volume. Moreover, the higher volume at the end of the lock-up period is consistent with shareholders selling their positions for diversification reasons.

Given the evidence (albeit mixed) on downward sloping demand curves for shares, the supply shift is clearly an important economic event. It is, however, completely anticipated. Thus, from an expectational point of view, there should be no impact on the stock prices of these firms. Figures 2A and 2B show that this is not the case. For example, on the lock-up expiration (which we have defined as day 0/-1), there is a 1.15% average drop in the price. Extending this period an additional three days surrounding the end of the lock-up period (i.e., day -4 to 0), the drop increases to 2.03% for the price of stocks that have gone through IPOs. In theory, if this result is driven by downward sloping demand for stocks, we would expect it to be incorporated on the offering date some 180 days earlier.

Several observations are in order. First, Figure 2B graphs the average CAR for these stocks, and, while there is an overall drop of around 2.5% during the entire period, it is permanent. That is, there is no bounce back even though there is significantly heavier volume on day 0 relative to the days following the lock-up end.[10] Interestingly, the permanent drop in stock price is consistent with a permanent increase in the volume of shares traded. The coincident event is the end of the lock-up period.

Second, Table 2A documents the statistical significance and impact of these results.

[10]In case one month is not sufficient to determine the end of the selling pressure to the lock-up day, we also checked volume and CARs for an additional month. There was essentially no change in either of these variables, giving further evidence of a permanent effect.

With a sample of 1053 firms, and a relatively small standard deviation, it should not be surprising that the t-statistics for the drops in stock prices are 5.81 and 6.61 using day 0/-1 and day 0/-4, respectively. There are two additional pointed empirical results which emerge from the analysis. Note that approximatley 60% of the stocks see their stock price fall at the end of the lock-up period. Not only is this percentage highly significant, but also suggestive that the result is not being driven by a few outliers. In addition, there is suggestive evidence that this fall is highly predictable. Separating the stocks into high and low volatility on an ex ante basis provides an additional 1% drop in the stock price at the lock-up end.

Third, Table 2C provides an analysis of the correlation between the CAR (at the lock-up end) and excess volume measures. In particular, the correlation between the CAR and excess volume during this period is -0.17, which is highly significant at the 1% level. Thus, the results are strongly supportive of a negative relation between permanent price changes and excess volume. This result is consistent with excess volume at the lock-up expiration being highly correlated with the permanent shift in volume from the unlocking of shares. In fact, this excess volume has 0.37 correlation with excess volume after the lock-up end. However, somewhat puzzling, the correlation between the permanent price drop and permanent excess volume is only mildly negative (i.e., -0.03). Alternatively, suppose that there exists a number of informed traders who wish to sell on or after the lock-up day. If this informed trading leads to greater excess volume, then one would expect the price to fall as volume increases.[11] Although it is difficult to entangle these effects, the overall result is discussed in more detail in Section 4 with respect to downward sloping demand curves.

In any event, the results in Table 2A have important implications for market effi-

[11]We thank the referee for pointing out this alternative explanation of the correlation between contemporaneous excess volume and price changes.

ciency. Here is an event (i.e., the lock-up) which *almost every* IPO is subject to, which is completely specified and anticipated, yet produces negative excess returns of roughly 2% over a short time interval. In theory, given the permanence of the stock price drop, arbitrageurs, or even just existing shareholders, should have an incredible incentive to sell the shares prior to the run down. Is there an alternative explanation of these findings?

In the next two subsections, we explore two areas. First, are these results in any way spurious? We look at three possibilities: (i) enhanced liquidity due to the higher volume, (ii) bid-ask bounce effects due to more trades being seller motivated, and (iii) biased, or ex post incorrect, expectations about the size of the supply shock. Second, given the inefficiency exists, why is it not arbitraged away in practice? We explore the effect of the bid-ask spread, short interest on the stock and tax considerations on the ability of investors to arbitrage the lock-up effect.

3.3 Plausible Explanations

3.3.1 A Liquidity Effect

There is growing evidence in the finance literature that investors require a liquidity premium for assets. For example, Amihud and Mendelson (1986), Brennan and Subrahmanyam (1996), and Brennan, Chordia and Subrahmanyam (1998), among others, all find evidence that the required rate of return increases with measures of illiquidity.

Here, there is a significant increase in volume (and permanently so) around the lock-up period. Putting aside the fact that these stocks trade frequently (see Table 1), previous research suggests that liquidity should increase in this environment. If liquidity increases, however, the stock price should rise, not fall. A cursory look at Figures 2A and 2B does not bode well for any type of liquidity story. In fact, there is a clear downward movement in the stock price around the lock-up expiration.

As an additional check, we regress the stock's two CAR measures on the daily dollar trading volume in the pre-event period. Thus, the volume variable is completely predetermined. In addition, this regression is performed in the context of a multiple regression, thus, holding fixed a number of related effects. (See Table 4.) Firms with low volume prior to the lock-up expiration should enjoy greater liquidity (i.e., increased volume) as a result of the lock-up end and thus suffer a smaller price drop. However, evidence favors a smaller price drop for higher dollar volume stocks, which is in contrast to the liquidity story. For example, for a one standard deviation increase in dollar volume, there is a corresponding 0.77% and 1.29% increase in the stock price at the lock-up end respectively measured by day 0/-1 and day 0/-4.

3.3.2 Bid-Ask Bounce

There is a large literature on the effect of bid-ask bounce on the distributional patterns of stock returns. For example, Lease, Masulis and Page (1991) argue that buy-sell order imbalance, and thus bid-ask bias, around seasoned equity offerings partially explain the negative price effects found in the literature. (See also Lakonishok and Smidt (1984), Dopuch, Holthausen and Leftwich (1986), and Keim (1989) for similar examples.) The bid-ask effect may be relevant here because we know that, at the end of the lock-up period, there is an incentive for many existing stockholders to sell their shares for diversification reasons. Thus, it is expected that, throughout this event, it is more likely a trade is seller- than buyer-motivated. Of course, whether the last recorded price is a buy or sell, and furthermore at the ask or bid, is an empirical question. Before addressing the empirics, it is informative to consider the underlying microstructure effects and implications.

Suppose the asset's recorded price, V^M, is equal to its true price V^T plus an adjustment due to the bid-ask spread, θ (see, for example, Blume and Stambaugh (1980)). In particular, let

$$V_t^m = V_t^T + \theta_t, \tag{2}$$

where θ_t equals $\frac{s}{2}$ with probability $\frac{p}{2}$, $\frac{-s}{2}$ with probability $\frac{p}{2}$, and 0 with probability $1-p$. Clearly, s represents the spread here, and above we have defined the ask, bid and midpoint of the stock price, respectively. At the end of the lock-up period, as shareholders are more likely to sell, suppose there is a shift δ increase in the probability of being at the bid. The probability decrease is assumed to be spread proportionately between the ask and midpoint.

For this model, the expected price change will be the true price change (i.e., a constant if prices follow a random walk) minus an adjustment due to the spread:

$$\Delta V^m = K - \frac{\delta S}{2-p}. \tag{3}$$

The price drop is a function of (i) the increase in probability of being at the bid, δ, (ii) the size of the spread, S, and (iii) the probability of a transaction occurring at the midpoint, $1-p$. For example, given a stock price of \$20 (which represents 320 sixteenths), and a 2% drop, the implication is a drop of 6-7 sixteenths. This means the spread would need to equal $\frac{3(2-p)}{8\delta}$, or, for $p = .25$ and $\delta = .25$, 21 sixteenths or approximately 6.56%. Of course, this spread is artificially too high for the types of liquid stocks that are found in our sample, and exceed the 3.32% spread documented in Table 1.

From an empirical point of view, there is not much evidence supporting the bid-ask bounce effect. First, on average, the stock price does not bounce back the days following the lock-up event. If there was a systematic effect, the drop should be temporary as all bid-ask effects should be diversified away across the portfolio of stocks. Figures 2A and 2B show that the stock price effect is clearly permanent, which contradicts this implication.

Second, Figure 3 presents a graph of what we call the *Closing Price Ratio* against event time. Note that the closing price ratio is defined as:

$$\frac{V^m - V^b}{V^a - V^b},$$

where V^m is the transaction price as described above, V^a is the ask price, and V^b is the bid price. If transactions were equally divided between the ask and the bid (or alternatively at the midpoint), then we would expect this ratio to equal 0.5. The figure shows that the closing transactions tend to be close to the 0.5 level, or at least, far away from a value of 0.0 which is what you would expect if the closing trades took place at the bid price. In fact, in the context of the above model, Figure 3 allows us to estimate δ, the shift in the probability of being at the bid. After some calculations, a value of .48 (which is the closing price ratio at the lock-up expiration) is consistent with a 2.67% increase in the probability of being at the bid. Thus, the bid-ask bias in our sample is small relative to the price effect. In particular, using the example from equation (3), the spread would need to be approximately 24.58% to explain the price drop, which is unreasonable.

3.3.3 Unanticipated Supply Shocks

If markets are efficient, and anticipated supply shocks to shares had price impact, we would expect these to get incorporated during the first day of IPO trading. What happens if these supply shocks were underestimated by market participants?

In theory, if on average the supply shocks across the 1053 firms were greater than anticipated, we could get an average drop in price on the lock-up day. Of course, in order to address this question, one would need a theory of expected volume. Since this theory is beyond the scope of our paper, one empirical way of addressing the issue is to break the sample by years. If underestimated supply shocks are an important determinant of price, one might expect variation from year to year in the price drop. In particular, the probability that the market participants made the same systematic errors each year is ceteris paribus less likely.

Table 2A and 2B reports the results for the CAR and excess volume year by year. Table 2A shows that the price drop around the lock-up period (i.e., day 0/-1) is surprisingly stable, yielding statistically significant drops of 1.31%, 1.03% and 1.16%, respectively over the three samples. Since each sample contains approximately 300-350 firms, the chances that these are sampling error are remote. As an additional check, Table 2B estimates the average excess volume during the lock-up end for each year. The excess volumes are large, and similar in magnitude for each year; moreover, if anything, there has been a tendency for excess volume to drop across the sample. Could the market have continually been surprised by the amount of shares traded after the lock-up period ended? Clearly, the fact that the price drops have not fallen over the sample, and excess volume has persisted on these days, suggests little learning has taken place.

As additional evidence, we also extend the sample to an earlier subperiod from 1990 to 1995 (see footnote 4). These results are given in Table 2A. While the magnitude of the drop is somewhat smaller, both the day 0/-1 and day -4/0 CARs are statistically significant at the 1% level, with drops of -0.63% and -1.28% respectively. Moreover, the probability that these CARs are positive across the IPO firms is significantly less than 0.5, with numbers very similar to the 1996-1998 period. Though not shown here, the regression results to be described in Section 4.1 are also consistent across time periods. The lock-up effect, therefore, is a consistent phenomenon through time.

3.4 Why Is the Lock-Up Effect Not Arbitraged Away?

Section 3 so far has provided strong evidence that the lock-up effect is not spurious. That is, given that the lock-up expiration is anticipated, the market is not rationally incorporating all public information into stock prices. If the lock-up effect is so persistent as shown in Section 3.1.3 above, why has it not been driven away by arbitrageurs and the like?

While it is difficult to answer this question fully, it is possible to consider the limitations of arbitrage in the lock-up context, and whether these limitations can explain the stock price response. There are two types of individuals/institutions who could take account of the anticipated price response prior to the lock-up expiration: (I) those who hold shares, then sell them say a week prior to the lock-up end, and then repurchase the shares after the lock-up period, and (II) those who short the shares prior to the lock-up period then close out their position afterwards. Outside of the market risks of holding the stock short-term, in theory the status of both investors (I) and (II) ends up being the same prior to and post the lock-up period.

First, consider investor I. This investor has purchased the stocks either at the IPO, or afterwards; otherwise, they are locked-up. Under current tax law, their gains are subject to short-term capital gains. By holding the stock an additional six months, their gains will be subject to long-term capital gains. Hence, unless the 1%–2% drop around the lock-up expiration is enough to compensate the investor for the higher tax liability, these investors have little incentive to take advantage of the lock-up effect. Of course, this analysis is dependent on the marginal investor's tax bracket.

Second, consider investor I or II's actual arbitrage strategy. At worst, the strategy involves buying at the ask and selling at the bid price. Given the summary statistics in Table 1, this would immediately eradicate any profit from the lock-up effect. In practice, however, investors' effective cost of trading is much less than the bid-ask spread (see, among others, Madhavan, Richardson and Roomans (1997) and Huang and Stoll (1997)). This is for several reasons, including the fact that not all trades occur at the quotes and that informed trading has permanent impact on price movements. Nevertheless, in all of the microstructure studies, there is a relation between trading costs and quoted spreads. Table 3 provides a regression of the two CAR measures against the bid-ask spread. The coefficient is significantly negative and economically important. For example, for day 0/-1, a one standard deviation decrease (increase) in the spread leads to an increase (decrease) in the stock price of 0.95%. This result has a clear interpretation. When spreads are high, it is difficult to arbitrage the lock-up effect and it remains in full force. However, as spreads narrow, the lock-up effect diminishes. The obvious reason is that arbitrage only takes place outside transactions costs bounds.[12]

Third, although investor II's strategy is not subject to the same tax issue as investor I, there is the additional requirement of shorting the stock. In practice, shorting stocks can be a nontrivial exercise. One crude measure of this difficulty is the amount of short interest in the stock relative to the number of shares outstanding. In our case, the relevant number of shares outstanding are those issued in the IPO, which are not subject to the lock-up agreement. Intuitively, if short interest is relatively high, then both locating the shares to short and the cost of shorting tend to be greater. Table 3 provides a regression of our two CAR measures against the ratio of short interest to the number of IPO issued shares. Consistent with the theory, the higher (lower) the short interest in the stock, the greater (smaller) the price drop. In other words, if the stock is difficult to short and therefore arbitrage, then the transactions costs bound is less tight and the lock-up effect is greater. For example, a one standard deviation increase in short interest is associated with a drop of 1.34% in the stock price at the lock-up expiration.

The results of this section cannot explain the existence of the lock-up effect. However, these results provide strong evidence that the magnitude of the effect is directly related to the investor's ability to conduct arbitrage. Therefore, a reasonable inference is that the lock-up effect represents a stock price drop consistent with no arbitrage, though not market efficiency.

[12]The result here is in contrast to that of Section 3.1.2, which shows that the bid-ask bounce cannot explain the stock price drop. The bid-ask bounce analysis tested whether the effect is spurious; this analysis tests the extent to which it is arbitrageable.

4 On Downward Sloping Demand Curves for Shares

The results of Section 3 provide an anomalous finding of market inefficiency. Conditional on this finding, however, it is interesting to analyze the underlying economics of the result. Specifically, conditional on the price falling around the end of the lock-up period, what are the possible reasons for this decline? Three explanations of similar phenomena have been discussed in the literature, namely information effects, price pressure and long-run downward sloping demand for shares. We take these possibilities in turn.

First, there are no information effects here per se. At the time of the IPO, almost all shareholders enter into a lock-up agreement with the underwriters and new shareholders. While there is potential information in who sells at the end of the period, from an ex ante viewpoint, the event itself contains no information. The anticipated information is that the supply of shares increase substantially in the secondary market after the lock-up period. Outside of some story related to biased expectations about the supply (see Section 3.1.3), information-based theories are not relevant.

With respect to price pressure, the evidence is not very supportive. While the price drop and negative correlation between price and volume on the day of the lock-up end is consistent with price pressure, it is also consistent with other explanations. For example, the price-volume effects could be driven by informed trading. More problematic are the several empirical facts which do not support this hypothesis. First, and foremost, the price drop is permanent. Price pressure would predict a temporary drop induced by selling pressure from shareholders around the lock-up day. In contrast, Figure 2B and Table 2A show that there is no meaningful bounce back in the price within one month of the lock-up period ending. Second, and related, even if price pressure takes place for many months following the lock-up period, the largest pressure is on the actual day. Figure 1 and Table 2B show that volume is 23% greater on that day, yet there is no measurable bounce back the very next day when volume somewhat subsides. Moreover, as mentioned in footnote 10, there is no real change in these results even when we go beyond one month after the lock-up end.

The evidence is more favorable to the hypothesis that demand curves for shares are downward sloping in the long run. As Figures 1 and 2 demonstrate, the shift in supply corresponds to a permanent drop in the stock price. If demand curves are downward sloping in the long run, and supply permanently shifts out, this is the exact result one would expect. However, this is not completely substantiated by Table 2C, which documents only a mild negative correlation between the CAR (i.e., the permanent drop) and the long-run shift in volume.

Nevertheless, we posit the following: stocks that have just gone through IPOs are arguably the most attractive firms in terms of the downward sloping demand curve explanation. First, newly-public stocks expand asset payoffs in ways which are not easily duplicated by existing assets. In other words, on average, stocks that have just gone through IPOs do not have clear asset substitutes. If IPOs represent an important part of the economy, yet cannot be duplicated by existing assets, investors will sacrifice the *arbitrage* price to access these assets. Second, heterogeneity across investors can lead to downward sloping demand curves. In particular, if economic agents have differences of opinion about asset prices, then in equilibrium the asset price may not be a sufficient statistic for convergence of these opinions (e.g., Varian (1985) and Harris and Raviv (1993)). Third, and related, if there is not unanimity about firm value maximization, then this too can create downward sloping demand curves for shares (e.g., Grossman and Stiglitz (1977)). One might argue successfully that closely-held, yet publicly traded, firms, such as those that have just had IPOs are most likely to fall into this class.

4.1 What Explains the Price Drop?

If the price drop is due to the simultaneous interaction of the downward sloping demand curve for shares and the shift in supply, then it maybe interesting to empirically explain the magnitude and variation of the price drop around the lock-up period.

4.1.1 Supply Shifts

Assuming that the shift in supply arises from existing shareholders desire to float the stock, the main motivation would seem to be diversification needs. In particular, existing shareholders would like to sell some, if not most, of their existing shares under two likely scenarios: (i) a large run-up in the stock price prior to the end of the lock-up period, and (ii) large volatility of the underlying price. Under both scenarios, the investor faces greater asset risk because his holdings reflect significant portfolio risk.[13] Another measure is the number of actual new shares that can be traded, that is, the percentage of shares that are actually unlocked. While the data is available for only a subsample of firms with respect to the number of unlocked shares, it seems worthwhile investigating the predictive content of this variable.

Table 4 provides regressions of the price change for each stock around the lock-up period on these variables, as well as important descriptive variables for stocks (such as volume, stock price level, and firm size). These descriptive variables are chosen to address some of the issues raised (and already commented on) in Section 3.1 and to provide for popular controls in the empirical analysis. In addition, two samples are estimated, i.e., the full sample and a subsample which includes the unlocked shares variable.

In general, the most important determinants, economically as well as statistically, are the variables associated with diversification. As expected, high volatility stocks tend to

[13] One could argue that a large run-up actually works in the opposite direction. With significant wealth, the marginal value of gaining or losing a dollar is reduced if the agent is risk averse. Of course, this is an empirical question.

have much larger price drops. In fact, for a one standard deviation increase in volatility, one should expect an additional impact of -1.02% and 1.86% respectively on the 0/-1 and -4 CARs. Stock prices are not only the most sensitive economically to this variable, but also statistically (as measured by the t-statistics). The other diversification variable, the prior stock price run-up, is also important but actually goes in the opposite direction. For a one standard deviation increase in the run-up, the price actually increases 0.67% or 1.24% at the lock-up end, depending on the CAR measure. There are two possible interpretations of this result. First, the wealth effect described in footnote 13 subsumes the diversification effect. In other words, once the volatility effect of diversification is accounted for, the wealth effect dominates. Second, if there is a tendency for investors to sell losers, then there might be more selling pressure at the end of a lock-up for stocks that have performed poorly.[14]

The final variable, the amount of shares unlocked, is both economically and statistically weak. For example, a one standard deviation increase in the number of shares unlocked leads to a 0.28% increase in the CAR (albeit with little confidence). Ex ante, one would expect a decrease in the CAR with long-run downward sloping demand curves. This is in contrast to other theories, especially liquidity-driven ones. However, the lack of statistical significance, coupled with this variable not being a perfect proxy for the stock's float, make these results difficult to interpret.[15]

4.1.2 Demand Curve Indicators

The discussion in Section 4 above suggests that some firms may be more likely to face downward sloping demand curves for their shares. It, therefore, might be interesting

[14] Of course, while this is consistent with tax-loss selling around the turn of the year, O'Dean (1998) generally finds the opposite result, namely investors have a tendency to hold onto losers.

[15] The fact that one firm has more shares unlocked does not necessarily mean its volume will be greater. The key feature is the characteristics of the existing shareholders, i.e., are they likely to sell? Table 4 shows that the volatility of the stock return seems to be an especially important component.

to explore this idea empirically. In particular, we measure the following two "demand curve variables": (I) the standard deviation of analysts earnings forecasts as a measure of divergent opinions and thus downward sloping demand curves, and (II) the ratio of stock volatilities after a market closure versus no closure as a similar measure (e.g., Harris and Raviv (1993))[16].

Table 5 reports regressions of our two CAR measures against these demand variables, controlled for the supply effects and firm characteristics employed in the previous regression. The results generally support the hypothesis of downward sloping demand curves. For example, consider the relation between the standard deviation of earnings forecasts and the CAR at the lock-up end (day 0/-1). The result is economically and statistically significant. As an illustration, a one standard deviation increase in this measure leads to a 0.54% drop in stock prices. In other words, a steeper demand curve is consistent with a larger price drop, all the supply shifts held constant. The other variable based on volume around market closures provides weaker evidence, albeit in the right direction. In particular, for a corresponding increase in standard deviation, there is an additional drop of 0.39%.

5 Conclusion

This paper has provided powerful evidence that stock prices fall around the end of their IPO lock-up period. This result is especially puzzling given that almost all IPOs are subject to lock-up agreements which are clearly spelled out in public documents, i.e., completely anticipated. Since the price drop does not appear to be the result of a spurious effect, this paper provides clear evidence against markets rationally incorporating all

[16]Harris and Raviv (1993) argue that this is a reasonable measure of divergent beliefs among investors. That is, the volatility on mondays and after holidays compared to the volatility on other days of the week should be greater the greater investor's beliefs vary, which results in downward sloping demand curves for shares.

public information. While the fact that the price gets bid up too much in the first place is clearly anomalous, we provide arguments and evidence that the lock-up effect is not arbitrageable. In fact, trading costs, the difficulty of shorting newly-public stocks, and short-term capital gains faced by the original shareholders, all help explain this fact.

From an economic viewpoint, the stock price fall is somewhat consistent with a downward sloping demand curve for shares. Moreover, certain variables, such as the stock price volatility, have clear predictive power for the magnitude of this fall. It might be interesting to analyze the price and volume effects of other permanent shifts in the supply of shares. These include for example stock repurchases (e.g., Comment and Jarrell (1991) and Hodrick (1992)), seasoned equity offerings (e.g., Asquith and Mullins (1986), Kalay and Shimrat (1987), and Barclay and Litzenberger (1988)), the execution of stock options or forced conversion of bonds (e.g., Mikkelson (1981) and Carpenter and Remmers (1999)) , and the introduction of traded options or the amount of short interest (e.g., Asquith and Meulbrouk (1999)). The results in this paper suggest it may be worth reinvestigating cases with permanent shocks to supply. Alternatively, is there something unique about IPOs that cause these price changes? We hope this idea is explored in future research.

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Table 1
Sample description

The sample includes 1053 IPOs issued between 1996-1998 with a lockup period of less than one year that ended before 12/31/1998. We exclude stocks with a price lower than $4 five days before the lockup end.

	Mean	Median	Std Dev	Q1	Q3
Sample description					
Market value of equity day -5, thousands	296,160	134,966	901,983	74,367	289,308
Total return from offering price	0.2932	0.1125	1.1237	-0.1875	0.4919
Shares unlocked/Shares outstanding	0.5932	0.6302	0.1768	0.5296	0.7095
Standard deviation of stock return	0.0410	0.0401	0.0149	0.0510	0.0304
Bid Ask spread/Price	0.0332	0.0260	0.0256	0.0150	0.0440
Short intrerest/Shares outstanding	0.0074	0.0015	0.0191	0.0002	0.0063
Short intrerest/Shares issued in IPO	0.0309	0.0047	0.0746	0.0008	0.0216
Volume in days -60 to -20					
Shares traded daily	73,729	41,725	123,646	22,549	77,381
Dollar traded daily	1,555,323	554,618	4,946,814	246,770	1,261,817
Daily shares volume/Shares outstanding	0.0057	0.0038	0.0073	0.0023	0.0066

Table 2
Excess return and excess volume around lockup end date.

The sample includes 1053 IPOs issued between 1996-1998 with a lockup period of less than one year that ended before 12/31/1998. We exclude stocks with a price lower than $4 five days before the lockup end. Daily excess return is measured at stock return minus an IPO index return. Excess volume is the ratio shares traded to the average number of shares traded on days -60 to -20 relative to lockup end.

Panel A
Excess return around lockup end date.

	Mean	Median	% positive
Full Sample, 1053 obs			
Cumulative excess return days -1 to 0	-0.0115[a]	-0.0080[a]	0.42[a]
Cumulative excess return days -4 to 0	-0.0203[a]	-0.0176[a]	0.38[a]
Cumulative excess return days 1 to 3	0.0023	-0.0024	0.48
Sample with daily STD>0.04, 528 obs			
Cumulative excess return days -1 to 0	-0.0183[a]	-0.0197[a]	0.36[a]
Cumulative excess return days -4 to 0	-0.0329[a]	-0.0365[a]	0.34[a]
Cumulative excess return days 1 to 3	0.0017	-0.0075	0.45[b]
CAR from -1 to 0 by year			
Lockup end 1996, 273 obs	-0.0131[a]	-0.0084[a]	0.44[b]
Lockup end 1997, 404 obs	-0.0103[a]	-0.0077[a]	0.42[a]
Lockup end 1998, 376 obs	-0.0116[a]	-0.0083[a]	0.40[a]
CAR from -4 to 0 by year			
Lockup end 1996, 273 obs	-0.0171[a]	-0.0130[a]	0.38[a]
Lockup end 1997, 404 obs	-0.0234[a]	-0.0184[a]	0.34[a]
Lockup end 1998, 376 obs	-0.0193[a]	-0.0189[a]	0.43[a]
Out of sample period 1990-1995 (1785 obs)			
Cumulative excess return days -1 to 0	-0.0063[a]	-0.0082[a]	0.44[a]
Cumulative excess return days -4 to 0	-0.0128[a]	-0.0147[a]	0.41[a]
Cumulative excess return days 1 to 3	-0.0042	-0.0006	0.46[a]

Panel B

Excess volume around lockup end date.

	Mean	Std Dev
Full sample		
Average excess volume days -20 to -2	1.151	1.170
Average excess volume days -1 and 0	1.614	2.737
Average excess volume days 1 to 20	1.382	1.331
Excess volume days -1 and 0, by year		
Lockup end 1996	1.705	3.090
Lockup end 1997	1.659	2.840
Lockup end 1998	1.499	2.322

Panel C

Correlation of Excess volume and excess return

Dependent variable	Average excess volume	
	Days -1 to 0	Days 1 to 20
Cumulative excess return days -1 to 0	-0.165^a	-0.032
	(0.000)	(0.290)
Average excess volume days -1 and 0		0.368^a
		(0.000)

a,b,c denotes significantly different from zero at the 1, 5, and 10 percent levels.

Table 3
Excess return and the ability to exploit the strategy

Linear regressions relating cumulative abnormal return during the end of the lockup period with and firm characteristics measures 5 days before the lockup ends. The sample includes 1053 IPOs issued between 1996-1998 with a lockup period of less than one year that ended before 12/31/1998. We exclude stocks with a price lower than $4 five days before the lockup end. Short interest is the number of shares held in short position prior to then end of the lockup period.

Dependent variable	Cumulative excess return	
	days -1 to 0	days -4 to 0
Intercept	0.408[a]	0.774
	(3.11)	3.86
Short intrerest/Shares issued in IPO	0.169[a]	-0.270[a]
	(3.76)	(3.93)
Bid ask spread	-0.401[a]	-0.765[a]
	(3.16)	(3.96)
Observations	461	461
Adj -R squared	0.036	0.047

a,b,c denotes significantly different from zero at the 1, 5, and 10 percent levels.

Table 4
Excess return and firm characteristics

Linear regressions relating cumulative abnormal return during the end of the lockup period with and firm characteristics measures 5 days before the lockup ends. The sample includes 1053 IPOs issued between 1996-1998 with a lockup period of less than one year that ended before 12/31/1998. We exclude stocks with a price lower than $4 five days before the lockup end.

Dependent variable	Cumulative excess return			
	days -1 to 0		days -4 to 0	
Intercept	0.023	-0.011	-0.006	-0.058
	(0.70)	(0.18)	(0.13)	(0.65)
Number of lockup days	0.000	0.000	0.000	0.000
	(0.33)	(0.91)	(0.93)	(0.88)
Total return from offering price	0.006[a]	0.038[a]	0.011[a]	0.068[a]
	(2.95)	(4.15)	(3.55)	(5.13)
Standard deviation of stock return	-0.682[a]	-0.660[a]	-1.251[a]	-1.694[a]
	(4.71)	(2.61)	(5.61)	(4.68)
Log of daily dollar trade	0.006[b]	0.011[b]	0.010[b]	0.019[a]
	(2.15)	(2.19)	(2.40)	(2.71)
Stock price day -5	0.000	-0.002[b]	-0.001[a]	-0.005[a]
	(1.14)	(2.50)	(2.75)	(4.43)
Log of equity value	-0.006[c]	-0.007	-0.005	-0.006
	(1.92)	(1.11)	(1.05)	(0.57)
Shares unlocked/Shares outstanding		0.016		0.008
		(0.81)		(0.28)
Observations	1051	421	1051	421
Adj -R squared	0.025	0.050	0.038	0.094

a,b,c denotes significantly different from zero at the 1, 5, and 10 percent levels.

Table 5
Excess return and downward sloping demand curve

Linear regressions relating cumulative abnormal return during the end of the lockup period with and firm characteristics measures 5 days before the lockup ends. The sample includes 1053 IPOs issued between 1996-1998 with a lockup period of less than one year that ended before 12/31/1998. We exclude stocks with a price lower than $4 five days before the lockup end. STD of analyst earnings forecast is the average standard deviation of analyst forecast for FY1 (annual earning) over the first year after the IPO. After closure STD/No closure STD is the natural log of the ratio of standard deviation of returns on day after market closure to standard deviation of returns on other days.

Dependent variable	Cumulative excess return			
	days -1 to 0		days -4 to 0	
Intercept	0.043	0.023	0.010	-0.006
	(1.07)	(0.72)	(0.16)	(0.12)
Number of lockup days	0.000	0.000	0.000^b	0.000
	(0.68)	(0.27)	(2.04)	(0.91)
Total return from offering price	0.005^a	0.006^a	0.009^a	0.011^a
	(2.62)	(2.99)	(2.85)	(3.56)
Standard deviation of stock return	-0.743^a	-0.693^a	-1.477^a	-1.259^a
	(4.39)	(4.79)	(5.63)	(5.63)
Log of daily dollar trade	0.008^a	0.006^b	0.015^a	0.010^b
	(2.58)	(2.14)	(3.23)	(2.39)
Stock price day -5	0.000	0.000	-0.002^a	-0.001^a
	(1.37)	(1.00)	(2.88)	(2.68)
Log of equity value	-0.009^b	-0.006^c	-0.009	-0.005
	(2.39)	(1.95)	(1.56)	(1.07)
STD of analyst earnings forecast	-0.341^b		-0.366^c	
	(2.44)		(1.69)	
After closure STD/No closure STD		-0.014^c		-0.009
		(1.93)		(0.86)
Observations	913	1051	913	1051
Adj -R squared	0.034	0.027	0.050	0.038

a,b,c denotes significantly different from zero at the 1, 5, and 10 percent levels.

Figure 1: Average volume relative to lockup

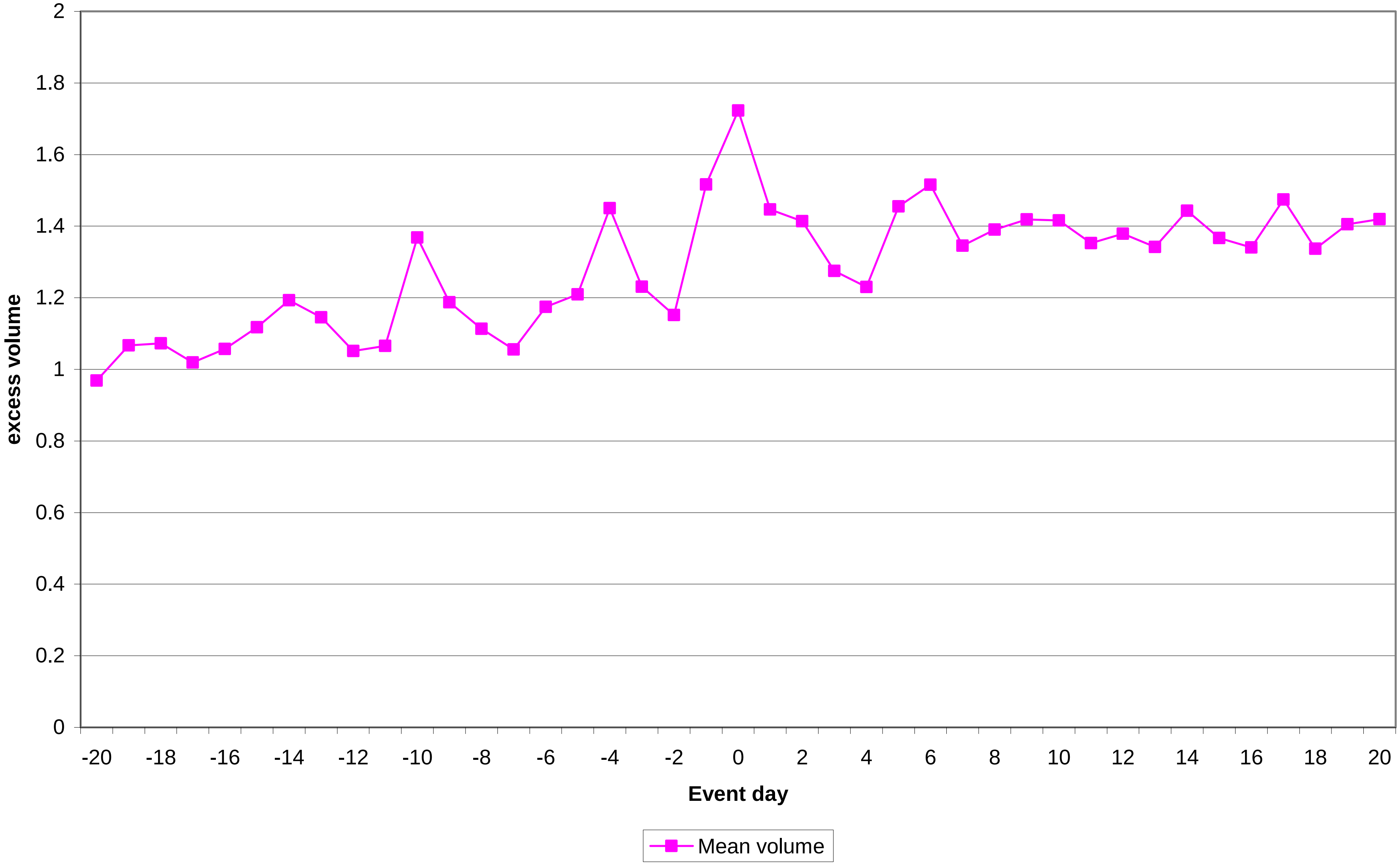

Figure 2A: Daily excess return relative to lockup

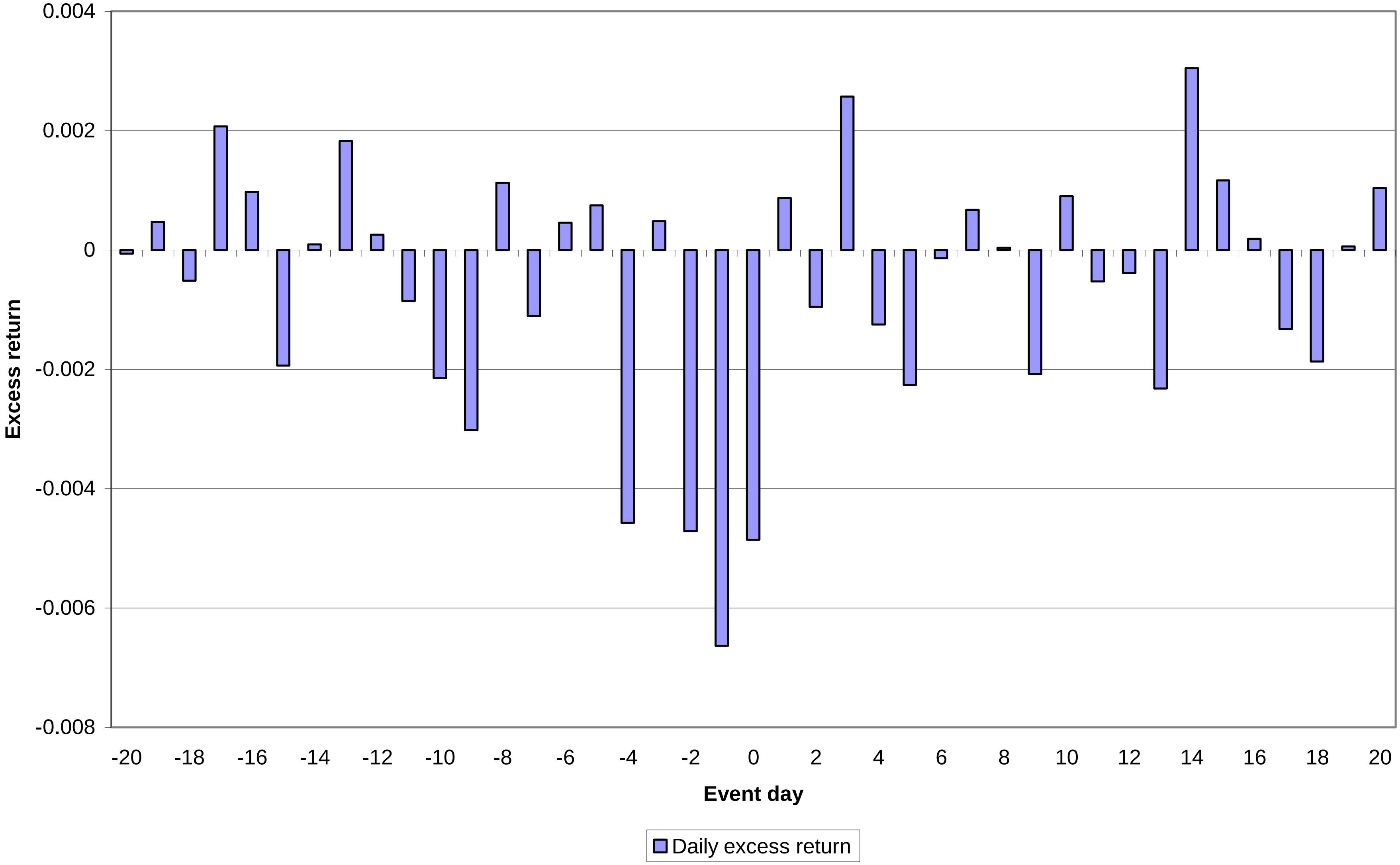

Figure 2B: Cumulative return relative to lockup

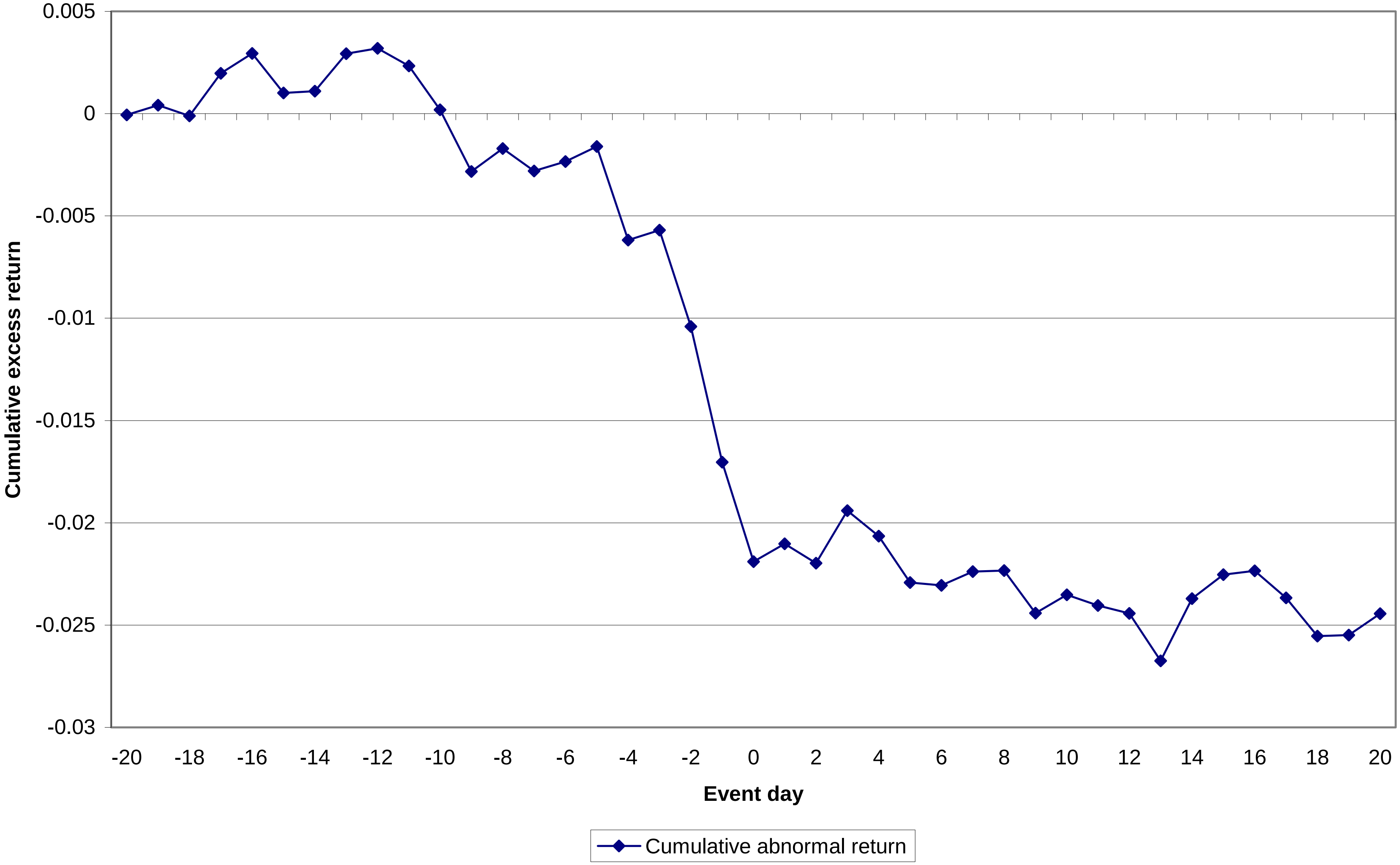

Figure 3: Close price relative to bid ask spread