Intraday Analysis of the Limit Order Bias at the Ex-Dividend Day of U.S. Common Stocks

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ABSTRACT

This study places Dubofsky's (1992) "limit order adjustment hypothesis" under the microscope of an intraday analysis, which employs a minute-by-minute trade and quote data recorded during the ex-dividend days of common stocks listed on NYSE, AMEX and NASDAQ. Dufosky's (1992) model concluded that the asymmetric adjustment of open limit orders for cash dividend payments under the NYSE and AMEX rules is sufficient to create abnormal returns on the ex-dividend day. Empirical evidence shows that the limit order bias incurred due to the asymmetric adjustment of open limit orders seems to dominate the overnight ex-day returns but at the same time, it is significantly corrected via active trading up until the close of the ex- dividend day. As a result, the significant association of the ex-day price drop discrepancy with the opening limit order bias eventually disappears before the ex-dividend day close. Finally, it is found that the reversal of the limit order bias is in fact quicker in stocks which are more liquid or listed on NASDAQ where strong competition among dealers is envisaged to drive stale quotes closer to the fair adjustment of the dividend.

JEL classification: *G14, G39*
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1. Introduction

Dubofsky (1992) argued that a special microstructure feature, that is, the effect of exchange rules dictating the dividend adjustment on limit orders that are still open at the ex-dividend day of US common stocks, is the main cause for the ex-day abnormal returns that have been widely evidenced in the ex-day literature. Dubofsky's (1992) hypothesis challenges the so called "tax hypothesis" that was initially introduced by Elton and Gruber (1970) and subsequently supported by several authors. Furthermore, recent evidence by Jakob and Ma (2004, 2005) qualify Dubofsky's (1992) model as a valid explanation for the ex-dividend price drop anomaly.

Dubofsky (1992, 1997) stated that previously placed limit orders that are still standing on the opening of the ex-dividend day are capable of inducing a positive return bias on the basis of the non-adjustment of limit orders to sell for the omission of the dividend, as dictated in the exchange rules. Naturally, the positive abnormal returns are envisaged to last until the ex-day close insofar as non-adjusted open limit orders continue to impact transaction prices up until the closure of the trading session. This study employs high frequency data for stocks listed on NYSE, AMEX and NASDAQ which pay cash dividends during the period from the 21st of October 2010 until the 31st of December 2011, to examine in particular whether the impact of the order flow bias is in fact prevailing throughout the entire duration of the ex-dividend day. Our main finding is that although the limit order bias dominates the stock price adjustment for the dividend at the open, its impact is transitory, and thus, losing its relevance in explaining abnormal returns at the close of the ex-dividend day. In addition, we show that, as reasonably predicted by Dubofsky (1992), active trading volume and the institutional framework that characterizes the intensity with which professional market makers supply liquidity to the market do indeed accelerate the correction of the limit order bias intraday.

Furthermore, this study is one of the very few that test microstructure effects using time stamped price and quote data over the entire course of ex-dividend day trading for U.S. common stocks.[1] It is also the first study that investigates the impact of the open order adjustment at the ex-dividend day of NASDAQ listed stocks (NASDAQ Rule 3220), in parallel with NYSE and AMEX stocks, for which the exchange rules (NYSE Rule 118 and AMEX Rule 132) regarding the dividend adjustment are essentially the same.

Several studies deployed the cum-day close to ex-day open rather than the cum-day close to ex-day close price drops in their pursuit of confirming the validity of alternative hypotheses in explaining the ex-day anomaly, on the grounds that overnight price drops are less noisy, thereby, producing more robust results (Lakonishok and Vermaelen (1986), Graham, Michaely and Roberts (2003), and Jakob and Ma (2004)). In relation to this, our empirical results imply that this is not advisable, as the price drops at the ex-day opening are due to be afflicted with the open limit order bias. Nevertheless, price drops calculated at the ex-day close are not equally affected and thus, provide safer methodological ground for future research in what drives the ex-day price drop discrepancy.

The remainder of this paper is organized as follows. Section 2 summarizes related literature on microstructure effects present on the ex-dividend day and states the

[1] To the best of our knowledge, the only other study that employs high frequency ex-day data is made by Balasubramaniam et al. (2010) who perform an intraday analysis of ex-dividend days collected from the NYSE, AMEX and NASDAQ under different tax and price quotation regimes over the period from 1994 to 2003.

hypotheses that will be empirically investigated. Section 3 lays out the institutional framework applicable to this study, the methodology employed to compute relevant variables, the sample selection and filters applied to the data. Section 4 presents the empirical results in the context of testing the stated hypotheses and Section 5 concludes the study.

2. Review of the Literature and Development of the Hypotheses

2.1 Review of the Literature

Within the microstructure framework, the "tick size hypothesis" introduced by Bali and Hite (1998) and the "limit order adjustment hypothesis" introduced by Dubofsky (1992) directly challenged the tax hypothesis proposed by the widely cited study of Elton and Gruber (1970) in the context of identifying the main driver of the positive abnormal returns apparent on the ex-dividend day of U.S. common stocks.[2]

Bali and Hite (1998) examined a sample of taxable distributions made by stocks listed at NYSE and AMEX for the period from July 2, 1962 until December 31, 1994 during which the tick size was equal to 12.5 cents. They argued that whenever the dividend is an inexact multiple of the regulatory tick size, the stock price drop will be systematically rounded downwards, on the grounds that no investor would be willing to pay more than the dividend amount (in terms of ex-day capital losses) to "buy" the dividend. Nonetheless, Graham, Michaely, and Roberts (2003), and Jakob and Ma (2004) who

[2] Another microstructure hypothesis that competes with these two in explaining the ex-dividend day anomaly is the "bid-ask bounce" tested by Frank and Jagannathan (1998) on a sample of stocks listed in the Hong Kong Stock Exchange (HKSE) where neither dividends nor capital gains are taxable.

tested the "tick size hypothesis" with extensive ex-day samples of NYSE stocks spanning through periods of three distinct tick size regimes, provided no support for Bali and Hite's (1998) predictions.

On the other hand, Dubofsky (1992) proposed the "limit order adjustment hypothesis" as an explanation for the ex-dividend day anomaly prevalent in U.S. common stocks, which is based on how NYSE Rule 118 and AMEX Rule 132 dictate how previously placed ("good-till-canceled") limit orders to buy and sell stock are handled on ex-days. On both exchanges, open limit orders to buy a stock (at the bid) must be reduced by the cash dividend amount at the opening of the ex-dividend day. Moreover, in case the adjusted limit buy order price is not a multiple of the tick size, (equal to \$1/8 over Dubofsky's (1992) period examined), it is further reduced to the next lower tick. On the other hand, limit orders to sell (at the ask) are not consistently reduced by the ex-cash dividend amount.[3] The author argued that, the asymmetric adjustment of open limit orders on ex-days under the NYSE and AMEX rules is sufficient to create ex-day abnormal returns under three assumptions: (i) the cum-dividend day closing price is the mean of the best bid and ask quotes specified by open good-till-canceled buy and sell limit orders,

[3] As pointed out by Jakob and Ma (2005), even if there were no adjustment at either limit orders to buy or limit orders to sell at the ex-dividend day opening, investors who place limit buy orders at the bid have greater incentives to adjust their orders for the dividend than investors who place limit sell orders at the ask. This is because on the bid side, limit order traders would prefer to buy at the lower adjusted price whereas on the ask side limit order traders would not voluntarily pursue to sell their stocks at a price reduced by the dividend amount, although such an initiative would result in the fair valuation of the stock price on the ex-dividend day. In this context, one would reasonably wonder why the NYSE and AMEX exchanges mechanically adjust the open ex-day prices in a direction in which limit order investors should be inherently inclined to do in the first place. One plausible explanation for this is that the stock exchange regulators assume that investors placing market orders are more likely to be aware of the deprivation of the right to the dividend at the ex-day than investors who have placed "good-till-canceled" limit orders to sell or buy before the ex-day. In this respect, limit order investors would be protected from buying the stock at the ex-dividend day at a price higher than one that is fairly reduced by the dividend amount, whereas market order investors would only buy the stock at the adjusted fair price, thereby forcing stale limit sell orders remained at the order book overnight to be canceled or adjusted downward for as to be executed.

respectively (ii) on the ex-dividend day close, the best bid and ask quotes are those of the outstanding limit orders previously placed by investors during the cum-dividend period and adjusted as specified by the aforementioned NYSE and AMEX rules and (iii) the opening or closing trade on the ex-day is executed at one of these two quotes, with equal probabilities.

As correctly pinpointed by Jakob and Ma (2004), Dubofsky's (1992) model explicitly specifies that the ex-day price drop must be equal to one half of the dividend amount rounded though upwards whenever this falls in between ticks. At the same time, the bid-ask spread is due to widen at the ex-day open since the ask quotes of open limit order to sell will not follow the adjustment of the bid quotes of open limit order to buy. Jakob and Ma's (2004) results provided support for Dubofsky's (1992) model since they found ex-day dollar price drops measured with bid quotes to be consistently higher than price drops measured with ask quotes, and also bid-ask spread to significantly increase, in particular at the ex-day open, across three different tick size regimes. Moreover, Jakob and Ma (2005), who investigated the ex-day anomaly for stocks in the Toronto Stock Exchange (TSX) where there is no adjustment mechanism for open limit orders, nominate the "limit order adjustment hypothesis" as the only, among the tax hypothesis (Elton and Gruber (1970), Elton, Gruber and Blake (2005)), the transaction cost hypothesis (Kalay 1982) and the other abovementioned microstructure hypotheses, that could explain the Canadian ex-day puzzle.

According to the empirical results presented by Dubofsky (1992), support for his model was only provided by samples of stocks paying small dividends given that abnormal returns at the ex-day close for high dividend yield stocks were found to be statistically insignificant on average. The author attributed this result to the active trading and specialist intervention taking place for high dividend yield stocks, by which intraday quotes from unadjusted orders to sell are revised towards the fully adjusted price, thereby correcting for the abnormal returns evident at the ex-day open.[4]

2.2 Hypotheses

The most straightforward inference made by Dubofsky's (1992) model is that the bid-ask spread will substantially increase from cum-day close to ex-day open, which is confirmed by the empirical results of Jakob and Ma (2004, 2005). A starting point for this study would be to attempt to endorse such an argument by identifying the positive return bias expected due to the increase of the bid-ask spread at the opening of the ex-dividend day:

Hypothesis 1: Due to the significant bid-ask spread increase at the opening of NYSE, AMEX and NASDAQ caused by the asymmetric dividend adjustment of open limit buy/sell orders, a positive return bias will be present at the ex-day opening.

In addition, Dubofsky (1992) hypothesized that active ex-day trading supported by greater specialist intervention will minimize the likelihood that the bias incurred by the asymmetrical limit order adjustment at the ex-day open will have any impact on closing prices. In this context, the high frequency nature of our data provides us with a unique opportunity to examine whether the open order bias diminishes in the course of intraday trading:

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[4] Furthermore, Dubofsky (1992) argued that the specialists' intervention during the ex-dividend day is expected to be substantial compared to a normal trading day as short-term traders and low-taxed, long-term investors engaging in dividend capturing are envisaged to sell their stock holdings in order to cash the accrued profit from their trading strategies.

Hypothesis 2: As active trading takes place during the ex-day, new limit orders entered and market orders executed at prices that effectively reflect the dividend adjustment, the open order bias evident at the ex-day opening is expected to be corrected before the closing of the ex-dividend day.

Naturally, the open order bias should be the main factor contributing to the ex-dividend anomaly, as measured by the price drop ratio (PDR) or the abnormal returns (AR^{ex}) calculated at the ex-dividend day open. At the same time, to the extent that the positive return bias at the open is reversed before the close of the ex-day, it should also cease to affect the valuation of the dividend at the ex-day close. These predictions are briefly summarized as follows:

Hypothesis 3: The ex-day price drop discrepancy, as measured by the overnight PDR and AR^{ex} *(estimated with opening ex-day prices), should be significantly associated to the open order bias. Nevertheless, the intraday correction of the ex-day open order bias will render PDR and* AR^{ex} *at the ex-day close unaffected by the transitory impact of the asymmetric dividend adjustment of open limit buy/sell orders.*

Dubofsky (1992) commented that, most likely, the abnormal returns created by the limit order exchange rules at the ex-day open will persist until the ex-day close, primarily in samples of low-yielding, thinly traded stocks. In relation to this, Jakob and Ma (2005) formally tested whether higher trading volumes, dividend dollar amounts or dividend yields have any power in reducing the abnormal returns generated by the asymmetrical limit order adjustment. They found that it is only trading volume created by active trading during the ex-dividend day that significantly reduces the ex-day abnormal returns. Thereby, Hypothesis 4 associates the speed of the correction of the open order bias at the ex-day open with the volumes of trades executed during the ex-day trading session, as follows:

Hypothesis 4: Intraday trading volume, which represents the intensity with which investors update their quoted prices to adjust trades for the omission of the dividend on the ex-day, will contribute to a faster reversal of the bid-ask spread widening incurred at the ex-day opening.

Finally, Dubofsky (1992) makes special mention to the designated exchange's specialists who will satisfy market orders with the view to reducing the bid-ask spread in the context of their duty in maintaining an orderly and liquid market. The effectiveness of professional market makers in accelerating the narrowing of the bid-ask spread, which is expanded at the ex-day open, will most likely be determined by the distinct institutional characteristics of each exchange, as hypothesized below:

Hypothesis 5: The speed of the narrowing of the bid-ask spread is expected to be higher in the exchange where professional market makers intensely compete to provide liquidity to the market.

Next, we move to a brief description of the institutional framework, which provides the main ground for the empirical analysis that will follow.

3. Institutional Framework, Data and Methodology

3.1 NYSE, AMEX and NASDAQ Institutional Framework

NYSE is an order driven market where each stock is assigned a designated specialist who oversees the consolidated order book for all the stock's orders routed to the exchange's floor. At the opening and closing of the trading day, the specialist monitors a call auction by which any orders standing in the order book are matched on the basis of the exchange's order precedence rules and executed at a single market clearing price. Between the open and close, placed orders are executed, if marketable, or remain in the order book, if not, on a continuous basis. The exchange rules also require the specialist to promote a "fair and orderly market" by posting bid and ask quotes with the view to mitigating potential order flow imbalances.[5]

On the other hand, NASDAQ constitutes a computerized quote driven market where the order flow for a specific stock is allocated to many dealers who maintain their own separate order book but compete with each other via the continuous notification of their bid and ask quotes to other traders. The dealers are obliged to include limit orders placed by other investors in their books against which marketable orders can trade in priority. At the opening (closing) of the trading day, NASDAQ operates consolidated order crossing facilities by which all on-open (on-close) orders and standing orders from the continuous order book are brought together, matched and executed at a single price. Furthermore, interdealer markets exist to enable dealers arrange trades among themselves, in particular, in the course of minimizing their stock inventory accumulation. Overall, NASDAQ dealers are assumed to have a greater discretion in choosing their trading counterparts whereas NYSE specialists are envisaged to own a unique informational advantage over other traders provided by the knowledge of the entire order flow for a particular stock at any time.

[5] Since the acquisition of AMEX by NYSE Euronext in October 2008, which represents a family of exchanges including, inter alia, the NYSE and Euronext equity markets, the existing AMEX market systems were transitioned to the NYSE Euronext technology under which the NYSE also operates.

Regarding the adjustment of dividends on the ex-dividend day, the treatment is quite uniform for all three exchanges. According to NYSE Rule 118 and AMEX Rule 132, when a security is quoted ex-dividend, any limit orders to buy that are still active at the opening of the ex-dividend day shall be automatically reduced by the amount of the cash dividend whereas any open limit orders to sell shall not do so. Alike, according to NASDAQ Rule 3220, any dealer holding an open limit order to buy from a customer or another broker/dealer shall, prior to executing the order, reduce the order price by the amount of the cash dividend.[6] On the other hand, open limit orders to sell are not symmetrically adjusted for the dividend at the ex-day open in NASDAQ.

Finally, over the examined period, the minimum price variation (tick size) is $0.01 for securities with prices greater or equal than $1.00 and $0.0001 for securities with prices less than $1.00, in both NYSE and NASDAQ. In AMEX, the tick size is equal to $0.01 for all price ranges of securities.[7] As a result, given that all examined markets are fully decimalized, we presume that no tick size effects will be posing any material disturbance to the pricing of the ex-dividend day.[8]

3.2 Data Sample Construction and Filtering

The examined sample contains all cash dividends distributed by U.S. common stocks that are primarily listed on NYSE, AMEX and NASDAQ during the period from the 21st of

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[6] For relevant excerpts from the exchange rulebooks regarding the open order price adjustment on the ex-dividend day of NYSE, AMEX and NASDAQ stocks, see Appendix A-3.1.

[7] For relevant exchange rules regarding minimum price variations in NYSE, AMEX and NASDAQ, see Appendix A-3.2.

[8] In particular, the tick size effects described in the studies made by Dubofsky (1992), Bali and Hite (1998), and Jakob and Ma (2005), which mainly examined periods when markets were not fully decimalized, are assumed not to have a significant impact on our tested samples.

October 2010 until the 31^{st} of December 2011. The final dataset is assembled through a stepwise match of data retrieved from Bloomberg, whereby each cash dividend is merged with daily price, quote and volume data on the ex-dividend day, which is subsequently merged with time stamped intra-ex-day price, quote and volume data extracted on a minute-by-minute frequency.[9] Likewise, daily prices for the composite indices corresponding to NYSE, AMEX and NASDAQ (with Bloomberg codes: NYA, XAX and CCMP respectively) are merged with their minute-by-minute prices on the ex-dividend day, which are successively matched with the intra-ex-day prices of the common stock sample on the basis of the time stamp.

The initial cash dividend sample comprises 7,318 cash dividends out of which 98.0% corresponds to regular dividends with the rest being mostly special dividends (1.8%) and return of capital (0.2%) cash distributions. Several screening filters are applied to the initial sample in order to mitigate the effect of non-complete data history, thin trading and outliers. First, we exclude dividends for which no closing trade price on the cum/ex-dividend day or intra-day data was reported, the last time-stamped trade price is greater than \$200 or less than \$1 at the ex-dividend day close, or deviates by more than \$0.3 from the daily closing price. Next, dividends with less than or equal to only five traded minutes during the ex-day and those distributed by NYSE and AMEX stocks on the 27^{th} of May 2011 for which date Bloomberg did not report index intra-day data for the corresponding indices were also deleted from the sample. In total, 1,269 (17.3% of the initial sample) are filtered out resulting in a “clean” sample of 6,049 observations, as

[9] More specifically, the minute-by-minute prices, bid quotes and ask quotes refer to last trade that took place within each consecutive minute during the ex-dividend day whereas the minute-by-minute volume figures refer to the total volume of all trades carried out within each consecutive minute.

illustrated in Table 1. Finally, after calculating the PDR and AR^{ex} (both being described in the following section), at both the opening and closing of the ex-dividend day, we perform and upper and lower 2.5% quantile trim on the basis of the closing PDR and AR^{ex} distributions to control for extreme values.[10]

Insert **Table 1** here

3.3 Methodology

At the ex-dividend day open, the bid-ask spread is envisaged to increase relative to the one existing at the cum-dividend close due to the asymmetrical adjustment of the limit orders still open at the ex-day opening. In order to test Hypotheses 1 and 2, we need to quantify the impact of the limit order adjustment rules of the exchanges on the pricing of stocks at the opening of the ex-dividend day. For this reason, we employ the order flow bias as computed by Conrad and Conroy (1994), which is due to measure the expected change of the bid-ask spread in combination with the tendency of a stock to close at the ask price due to the execution of a buy trade. We opt for the order flow bias measure rather than just the change of the bid-ask spread because the effect of the non-adjustment of open limit order to sell will be evidently recorded at the opening price of the ex-dividend day insofar as it is combined with a high probability of the opening trades to take place at the ask side.

Following Conrad and Conroy's (1994) methodology, the ex-dividend day trade returns are decomposed into bid returns and order flow effects occurring at the ex-dividend day.

[10] The 2.5% upper and lower quantile trim follows Graham, Michaely and Roberts (2003), with the difference that this study's PDR and AR^{ex} samples are separately trimmed on the grounds that their distributions do not share the same outliers.

More specifically, the intraday trade return (TR_{im}) at each minute m of an i ex-dividend day for a particular stock can be approximated by the sum of the bid return (BR_{im}) and the order flow bias ($OFbias_{im}$), which captures the change of the proportional bid-ask spread (BAS_{im}) and the change of the within spread location of the trade (Loc_{im}) from one minute to the other.[11] In particular,

$$TR_{im} = \frac{(P_{im} - P_{im-1})}{P_{im-1}} * 100\% \approx BR_{im} + OFbias_{im} \quad (1)$$

where:

$$BR_{im} = \frac{(B_{im} - B_{im-1})}{B_{im-1}} * 100\% \quad (2)$$

$$OFbias_{im} = (Loc_{im} * BAS_{im}) - (Loc_{im-1} * BAS_{im-1}) \quad (3)$$

$$Loc_{im} = \frac{(P_{im} - B_{im})}{(A_{im} - B_{im})} \quad (4) \qquad BAS_{im} = \frac{(A_{im} - B_{im})}{B_{im}} * 100\% \quad (5)$$

where P_{im}, B_{im} and A_{im} are the price of the closing trade, best bid quote and best ask quote, respectively, at each minute m of an i ex-dividend day for a particular stock. *Loc* ranges from zero to one and reflects the probability that the trade will be executed at the ask price. In specific, a mean *Loc* value above 0.5 indicates the tendency of the trade to take place at the ask whereas a mean *Loc* value below 0.5 indicates the tendency of the trade to take place at the bid.

Hypothesis 3 explicitly associates the asymmetric adjustment of open limit buy/sell orders at the opening of the ex-dividend day with the price drop anomaly widely

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[11] According to Conrad and Conroy (1994), the approximation of the trade return holds for small values of ($Loc_{im}*BAS_{im}$). For a simplified proof of the approximation, see Appendix A-4.

documented in the ex-day literature. To measure the ex-day discrepancy, we calculate the standard metrics employed in the ex-dividend day bibliography, namely, the Price Drop Ratio (PDR_i) and the ex-day Abnormal Return (AR_i^{ex}) both adjusted for the market return as follows:

$$PDR_i = \frac{P_i^{cum} - \left(\dfrac{P_i^{ex}}{1 + R^{index}}\right)}{D_i} \quad (6), \qquad AR_i^{ex} = \frac{P_i^{ex} - P_i^{cum} + D_i}{P_i^{cum}} - R^{index} \quad (7)$$

where P_i^{cum} is the closing daily price on the *i* cum-dividend day for a particular stock, P_i^{ex} is the price of the last trade at the closing/opening minute of an *i* ex-dividend day for a particular stock, D_i is the amount of the dividend corresponding to the *i* ex-dividend day for a particular stock, and R_i^{index} is the contemporaneous ex-day return of the respective index of each exchange, namely NYSE, AMEX and NASDAQ. The PDR and AR^{ex} are calculated both at the opening, where the limit order adjustment will mostly have an effect on the stock price, and the closing of the ex-dividend day. In theory, if the ex-dividend day opening trade takes place at the fully adjusted bid price, Loc will be zero and the ex-day price drop will be equal to the dividend. Correspondingly, if the ex-dividend day opening trade takes place at the non-adjusted ask price, Loc will be one and the ex-day price will not drop. In alignment with Dubofsky's (1992) theoretical framework, if the opening trade, takes place at the ask or bid price with an equal probability on average across the sample, the mean Loc will be 0.5 and the average ex-day price drop will be equal to one half of the dividend amount.

4. Empirical Results

4.1 Descriptive Statistics and Graphs

This section presents descriptive statistics for the general characteristics of the sampled stocks listed on NYSE, AMEX and NASDAQ, the intraday pattern of their trading volume throughout the ex-dividend day and finally, the PDR and AR^{ex} distributions derived from the 95% trimmed samples.

First, Table 2 presents summary statistics for the dividends and trading activity of common stocks together for NYSE and AMEX, and separately for NASDAQ, on the basis of the 95% trimmed PDR sample. The mean dividend amount and dividend yield paid by NYSE & AMEX stocks is $0.236 and 0.698% respectively. On the other hand, although NASDAQ stocks distribute a smaller average dividend amount of $0.181 than NYSE and AMEX stocks, they offer a higher mean dividend yield equal to 0.956% because they are relatively low priced compared to their NYSE and AMEX counterparts (mean stock price at the cum-dividend day close approximately equal to $24 for NASDAQ while close to $38 for NYSE and AMEX). Furthermore, the average stock listed on NYSE and AMEX is more liquid than the average NASDAQ stock as it reports a total daily volume of 566,383 shares and a volume of 1,668 shares traded every minute on average during its ex-day (compared to 353,696 shares and 1,236 shares of total and minute average ex-day volume, respectively, for NASDAQ stocks). The same conclusions are drawn from the respective median values, reported in Panel B of Table 2.

Insert **Table 2** here

Prior microstructure literature (Jain and Joh (1988), Foster and Viswanathan (1993), Gerety and Mulherin (1992), McInish and Wood (1990) and Chan, Christie and Schultz (1995)) has documented a U-shaped pattern for intraday trade volume for all major financial markets. We investigate whether such a pattern is also observed in particular at the ex-dividend day of U.S. common stocks. In this respect, trade volume per minute is expressed as a % of total ex-day volume which is subsequently averaged across ex-dividend days for each minute. As depicted in Figure 1, trade volume peaks at the open and close whereas remains at stable low levels in the interim of the ex-dividend day, thereby confirming its U-shaped evolution for both the NYSE and AMEX stocks, and the NASDAQ stocks. The same intra-day pattern is recorded when trade volume per minute is alternatively expressed as a multiple of the ex-dividend day minute average trade volume, as illustrated in Figure A-5.1 of the Appendix.

Insert **Figure 1** here

Finally, descriptive statistics are presented in Table 3 for the PDR and the AR^{ex} as computed either at the opening or the closing of the ex-day, separately for NYSE and AMEX stocks, and NASDAQ stocks, as well as for the group of all stocks listed on all exchanges. In addition, tests are performed on median and mean values to examine whether the sample PDR (AR^{ex}) is equal to its theoretical value, namely, whether PDR is equal to one (AR^{ex} equal to zero).[12]

[12] All statistics have been calculated after trimming the top and bottom 2.5 percentiles separately for the closing PDR and closing AR^{ex} samples.

For NYSE and AMEX stocks, the mean PDR at the open is 0.798 significantly lower than one at the 1% level (t-stat= −4.16) whereas the mean PDR at the close, equal to 0.959, is higher than the one calculated at the open and not significantly different to one at the 10% level (t-stat= −0.67). The median PDR at the close, equal to 0.925 (z-stat= −2.62) is also found higher than the median PDR at the open (0.866, z-stat= −8.38). Similarly, the mean and median AR^{ex} at the close, equal to 0.053% (t-stat= 2.48) and 0.045% (z-stat= 2.50) respectively, are almost half of the mean and median AR^{ex} at the open equal to 0.101% (t-stat= 7.72) and 0.088% (z-stat= 9.31) respectively.

For NASDAQ stocks, the mean PDR at the open, equal to 1.023 (t-stat= 0.37), is not significantly different to one at the 10% level but the median PDR at the open, equal to 0.905 (z-stat= −3.15) is significantly different to one at the 1% level. On the other hand, the mean and median AR^{ex} at the open, equal to 0.049% (t-stat= 2.48) and 0.058% (z-stat= 3.65) respectively, and the mean and median AR^{ex} at the close, equal to 0.092% (t-stat= 2.74) and 0.076% (z-stat= 2.37) respectively, are all significantly different to zero at the 1% level.[13]

<u>Insert **Table 3** here</u>

The fact that, for NYSE and AMEX stocks, the PDR at the close is higher than the PDR at the open and, likewise, the AR^{ex} at the close is lower than the AR^{ex} at the open provides preliminary evidence that the order flow bias assumed to create the ex-day

[13] The mean PDR and AR^{ex} calculated using the daily open and close trade prices differ immaterially from the ones presented here, which are computed with the trading prices of the opening or closing minute of the ex-dividend day.

anomaly at the open is somehow corrected, thereby leading to higher (lower) PDR (AR^{ex}) values at the close.[14] The same evidence of higher PDR and lower AR^{ex} values at the close versus the open of the ex-day is also obtained in the aggregate sample that contains the stocks from all three exchanges.

4.2 Limit Order Adjustment and Order Flow Bias

Jakob and Ma (2005) find evidence of a substantial widening of the bid-ask spread from cum-day close to ex-day open at the ex-dividend day of stocks listed on the Toronto Stock Exchange despite the fact that both the ask quote and bid quote are not mechanically adjusted by the dividend amount on the basis of the exchange's rule. In relation to Hypothesis 1, we investigate the possibility of a widening and subsequent narrowing of the bid-ask spread during the ex-dividend day of NYSE, AMEX and NASDAQ stocks by graphing the evolution of their relative trade price, ask quote and bid quote averaged over 15 minute intervals during the ex-dividend day. The relative trade price is the ratio of ($P^{ex,m}/P^{cum}$) where $P^{ex,m}$ is the intra-day trade price at each *m* minute during the ex-dividend day and P^{cum} is the closing trade price at the cum-dividend day. The relative ask quote is the ratio of ($A^{ex,m}/A^{cum}$) where $A^{ex,m}$ is the intra-day best ask quote at each *m* minute during the ex-dividend day and A^{cum} is the best ask quote at the cum-dividend day close. The relative bid quote is the ratio of ($B^{ex,m}/B^{cum}$) where $B^{ex,m}$ is the intra-day best bid quote at each *m* minute during the ex-dividend day and B^{cum} is the best bid quote at the cum-dividend day close. The minute-by-minute relative trade price,

[14] A similar conclusion cannot be drawn for the PDR and AR^{ex} values of the NASDAQ sample. Nevertheless, due to its relatively small size, we consider its means and medians as less robust than the ones of the NYSE and AMEX.

ask quote and bid quote are first averaged over 15 minute intervals during each ex-dividend day, and the 15 minute averages of the relative trade price, ask quote and bid quote are subsequently averaged across the sample of ex-dividend days.[15]

According to Figure 2, for the NYSE and AMEX stocks, the magnitude of the drop of the ask quote does not follow that of the drop of the bid quote at the opening of the ex-dividend day resulting in a substantial widening of the bid-ask spread. Nevertheless, the extended opening bid-ask spread seems to narrow quickly in the first 30 minutes of the ex-day trading session and eventually falls to its lowest intra-day level at the closure of the market.

For the NASDAQ stocks, a similar pattern is evident with two distinct features in comparison to the NYSE and AMEX stocks; the narrowing of the bid-ask spread is more rapid as it takes place within a few minutes from the ex-day opening while at the ex-day close it is again abruptly widened to a higher than its prior intra-day level.[16] The same conclusions are drawn when, instead of the means, the cross sectional medians of the relative trade price, ask quote and bid quote are computed for each 15 minute interval as depicted in the Appendix, Figure A-5.2.

Insert **Figure 2** here

[15] More precisely, given the particular focus of this study on the opening of the ex-day, the first relative trade and quote values are calculated at the opening minute, that is, 9:30 a.m,, the second ones refer to the interval from 9:31 a.m. to 9:35 a.m., the third ones refer to the interval from 9:36 a.m. to 9:45 a.m., while the fourth (i.e. 9:46 a.m. - 10:00 a.m.) and all subsequent intervals are 15 minute intervals. In total, means are calculated for 28 intervals until the close of the ex-dividend day.

[16] Brock and Kleidon (1992), McInish and Wood (1992), and Lee, Mucklow and Ready (1993) found evidence of a U-shaped intraday pattern for the bid-ask spread for NYSE stocks, where spreads are widest immediately after the open and immediately preceding the close. Chan, Christie and Schultz (1995) on the other hand, found that spreads are relatively stable during the trading session but narrow quickly near the close for NASDAQ stocks.

On the basis of the definition of the order flow bias (Equation 3), it is reasonable to assume that its evolution will be driven by the change of the bid-ask spread during the ex-dividend day. In this respect, the evidence provided by the graphs illustrated in Figure 2 is expected to also be confirmed by formal statistical tests on the order flow bias. In specific, the order flow bias is hypothesized to be significantly positive at the ex-day open (Hypotheses 1) and significantly negative during the ex-day trading session (Hypotheses 2) for both NYSE and AMEX, and NASDAQ samples. Furthermore, as indicated by Figure 2, the order flow bias in particular for the NASDAQ sample is anticipated to be significantly positive again at the ex-dividend day close.

Table 4 presents the breakdown of the mean total return (*TR*) into the mean bid return (*BR*) and the mean order flow bias (*OFbias*), at the opening, at the closing and in the interim minutes of the ex-dividend day, separately for NYSE and AMEX stocks and NASDAQ stocks, as well as for all stocks listed on all exchanges. Consistent with Hypothesis 1, the mean order flow bias at the ex-day open of the NYSE and AMEX sample is equal to 0.19%, which is significantly positive at the 1% significance level (t-statistic= 27.48). Similarly, the mean order flow bias at the ex-day open of the NASDAQ sample is equal to 0.62%, which is also significantly positive at the 1% significance level (t-statistic= 21.43).

Insert **Table 4** here

In addition, in agreement with Hypothesis 2, the positive order flow bias existing at the ex-day open is almost fully reversed before the ex-day close, as active intra-day trading will pertain to new limit and market orders executed at prices that fully reflect the dividend adjustment. For the NYSE and AMEX sample, the interim cumulative order flow bias and the order flow bias at the ex-day close are -0.18% and -0.01%, the aggregate of which entirely offsets the high positive order flow bias incurred at the ex-day open. As a result, the cum-day close to ex-day close cumulative order flow bias is not significantly different to zero (t-statistic= 0.87), thereby confirming the full correction of the opening order flow bias.

For the NASDAQ sample, although the interim cumulative order flow bias is -0.59%, hence, indicating a significant reversal of the positive order flow bias at the open, the minute order flow bias at the close rises to 0.56% due to the sudden increase of the bid-ask spread at the last minute of the trading session illustrated in Figure 2. Overall, we find evidence that the positive order bias evident at the ex-day open is in fact reversed before the closing of the trading day in all examined exchanges, which is in alignment with Hypothesis 2. As a robustness test, we replicated Table 4 using medians rather than means. Median values for TR, BR and OFbias presented in Table A-5.2 of the Appendix provide similar conclusions in support of Hypotheses 1 and 2.

4.3 Impact of the Limit Order Adjustment on the Ex-Dividend Day Price Drop

Hypothesis 3 states that although the positive order flow bias evident at the ex-dividend day opening is expected to have a significant explanatory power on the PDR/AR^{ex} computed with opening trading prices, this will not be the case when PDR/AR^{ex} is calculated at the ex-day close. To perform a direct test on Hypothesis 3, the PDR/AR^{ex} of the 95% trimmed samples are regressed against the OFbias, a group of control variables that capture other microstructure effects on the ex-day, and the dividend yield which constitutes the explanatory variable most widely used in the ex-dividend bibliography. Accordingly, the regression equation that is estimated with the method of OLS[17] takes the following form:

$$PDR_{it} \;/\; AR_{it}^{ex} = \alpha + \beta_1 OFbias_i^{open} + \beta_2 BAS_{it} + \beta_3 Loc_{it} + \beta_4 TVol_{it} + \beta_5 DY_i + \varepsilon_{it} \quad (8)$$

where, $OFbias^{open}$ is the order flow bias at the opening of the *i* ex-dividend day for a particular stock, *BAS* is the proportional bid-ask spread, *Loc* is the within spread location of the trade, *TVol* is the natural logarithm of the trading volume over the relevant minute, and *DY* is the stock dividend yield equal to the dividend amount over the closing price on the cum-day. The subscript *t* refers to the time when the regression model is estimated, namely to either the opening or the closing of the ex-dividend day. Finally, all microstructure explanatory variables, namely, $\text{OFbias}^{\text{open}}$, BAS, Loc and TVol, are orthogonalized before Equation 8 is estimated to account for implicit collinearity incurred due to the contemporaneous nature of these regressors.

According to Hypothesis 3, when regressing PDR (AR^{ex}), β_1 is predicted to be significantly negative (positive) at the ex-day opening when the asymmetrical limit order adjustment is due to hinder the full price drop. In contrast, it is expected to be found insignificantly different to zero at the ex-day closing by which time the opening order flow bias is envisaged to be already corrected. Table 5 presents the empirical results for the set of estimations of Equation 8 at the open and close of the ex-dividend day performed separately for NYSE and AMEX stocks, and for NASDAQ stocks. As reported in Panel A, the OFbias is negatively associated with the open PDR at the 1%

[17] The t-statistics of the estimated OLS coefficients are computed with heteroscedasticity consistent standard errors, according to the White (1980) correction.

significance level, whereas it becomes insignificant when the PDR is calculated at the close. Similarly, Panel B shows that the OFbias is positively related to the AR^{ex} at the open at the 1% significance level but again, it is insignificant in relation to the AR^{ex} at the close. Estimation results are consistent when the NYSE and AMEX sample and the NASDAQ sample are either tested separately or together, thereby providing support for Hypothesis 3, which predicts that OFbias will lose its explanatory power over the ex-day price drop anomaly towards the close of the ex-dividend day.

Insert **Table 5** here

Furthermore, Loc constitutes the only regressor which seems to significantly influence the ex-day close dividend valuation at the 5% (1%) level for the NYSE and AMEX (NASDAQ) sample. More specifically, the higher the probability that the stock price will close at the ask, the lower (higher) the ex-day close PDR (AR^{ex}) will be, thus implying that microstructure effects, other than the open limit order adjustment, remain important for the explanation of the ex-day price drop discrepancy.[18]

4.4 Factors Contributing to the Speed of the Limit Order Bias Correction

In the discussion of his results, Dubofsky (1992) named the active trading volume and professional market makers' intervention as two of the factors which would most likely contribute to the fast correction of the open limit order bias, without though performing

[18] As a robustness test, we repeated all estimations illustrated in Table 5 after omitting the orthogonalization of regressors. Estimated coefficient signs and significance levels presented in Table A-5.3 of the Appendix do not materially differ from the ones reported here.

any direct test on the basis of these predictions. In an attempt to fill this gap, we examine whether the speed of the correction of the limit order bias can be indeed associated with the ex-day trading volume or the distinct exchange characteristics that determine the intensity with which professional market makers assist in the fair reflection of the dividend adjustment into stock prices.

Hypothesis 4 associates the speed of the intraday correction of the BAS widening incurred at the ex-day opening with the volume of trades executed during the ex-day trading session. In order to test this hypothesis, we first define the first minute in which the cumulative percentage change of the BAS from the cum-day close becomes equal to or less than zero as the assumed point in time when the full reversal of the BAS widening has been achieved. Next, we group ex-days on the basis of the minute within which the BAS widening is fully reversed, over the interval from the ex-day open until 10:00 a.m., during which period the majority of the sample reports a reversal of the BAS widening. Finally, for each group of ex-days, we calculate the cross-sectional median of the average trading volume recorded over their entire ex-dividend day and thus, graph the computed median values against each minute within which the reversals of the BAS widening have materialized, separately for the NYSE and AMEX sample, and the NASDAQ sample.[19]

As demonstrated in Figure 3, ex-days for which the open BAS widening is reversed immediately after the ex-day open are the ones with the highest reported average intraday volume during the ex-dividend day. On the basis of the downward sloping curve of the graph, we deduce that the smaller the ex-day trading activity for a particular stock the longer it will take for the reversal of the BAS widening incurred at the ex-day open. This

[19] Due to the small size of the minute-by-minute ex-day samples constructed for the purpose of plotting figure 3, means are particularly affected by trade volume outliers and therefore, they are not reported.

conclusion is derived for both the NYSE and AMEX, and NASDAQ samples, thereby providing support for Hypothesis 4.

Insert **Figure 3** here

Stoll and Whaley's (1990) and Brock and Kleidon's (1992) models associated the widening of BAS for NYSE stocks with the exchange's specialists market power and control of the aggregate order book. The main implication of these models is that the dissimilar institutional characteristics of different markets are expected to have a material impact on the evolution of bid-ask spreads during the trading day. In this context, Chan, Christie and Schultz (1995) found that NASDAQ stocks are characterized by a narrower BAS than NYSE stocks towards their trading close and attributed their result, again, to the lack of market power over order flow among the various dealers operating in NASDAQ. On the basis of such contention, we would expect differences with regards to the speed of reversal of the bid-ask spread increase evident at the ex-day opening between NYSE and AMEX stocks, and NASDAQ stocks.

Hypothesis 5 implies that the widened BAS at the ex-day open is anticipated to narrow more quickly in NASDAQ, where professional dealers intensely compete for order flow in the market, than in NYSE and AMEX stocks, where the single specialist assigned to each stock has greater control on the spread determination. Figure 4 depicts the evolution of cross-sectional means and medians of the BAS which is first averaged over 15 minute intervals for each stock. Is it evident that the decline of the BAS after the ex-day open is more abrupt for the NASDAQ sample but relatively slower for the NYSE and AMEX sample. In unreported analysis, we found that, from the ex-day open until 9:35 a.m., the mean BAS for the NASDAQ sample has decreased by -52% (from 1.67% to 0.80%) whereas for the NYSE and AMEX sample, its reduction over the same interval, is only -27% (from 0.47% to 0.34%). Moreover, from the ex-day open until 9:44 a.m., the mean BAS percentage reduction is equal to -60% for the NASDAQ sample versus -42% for the NYSE and AMEX sample, thereby, providing evidence in favor of the Hypothesis 5.

Insert **Figure 4** here

5. Conclusion

This study is motivated by Dufosky's (1992) model which concludes that the asymmetric adjustment of open limit orders for cash dividend payments under the NYSE and AMEX rules is sufficient to create abnormal returns on the ex-dividend day. In this study, we investigate the power of such prediction by using minute-by-minute trade and quote data recorded during the ex-dividend days of common stocks listed on NYSE, AMEX and NASDAQ over the period from the 21st of October 2010 until the 31st of December 2011. In this context, we deploy Conrad and Conroy's (1994) order flow bias metric to proxy for the impact of the asymmetric limit order adjustment at the opening of the ex-dividend day.

The order flow bias, which encompasses the anticipated widening of the bid-ask spread at the opening of the ex-dividend day, is found to dominate the overnight returns but at the same time, is significantly corrected before the close of the ex-dividend day. As a result, the significant association of the ex-day price drop discrepancy with the opening order flow bias disappears at the ex-dividend day close. Finally, empirical evidence shows that the reversal of the bid-ask spread widening, which constitutes the main component of the order flow bias, at the ex-day open, is in fact quicker in stocks which are more liquid or listed on NASDAQ where strong competition among dealers is envisaged to drive stale quotes closer to the fair adjustment of the dividend.

In a nutshell, this study concludes that Dufosky's (1992) limit order adjustment hypothesis has indeed evidenced explanatory power for the price drop discrepancy evident at the ex-day open, which nonetheless fades out, via active trading, before the ex-day close.

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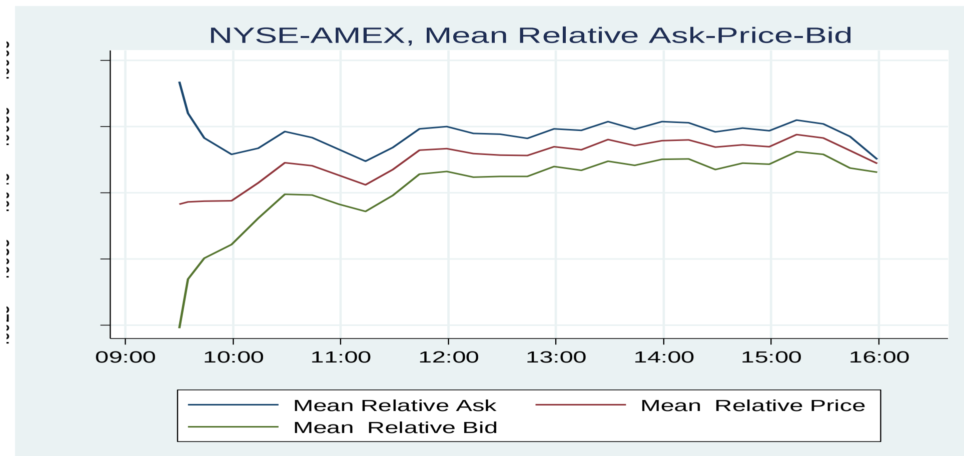
Figure 1
Intra Ex-Dividend Day Evolution of Trade Volume:
As a % of Ex-day Total Trade Volume

This figure illustrates the evolution of trade volume over minute intervals during the ex-dividend day separately for stocks listed on the NYSE and AMEX and stocks listed on the NASDAQ. Trade volume per minute is expressed as a % of total trade ex-day volume which is subsequently averaged across the sample of ex-dividend days for each minute.

Figure 2

Intra Ex-Dividend Day Evolution of the Relative Trade Price, Ask & Bid Quotes

This figure illustrates the evolution of the relative trade price, ask quote and bid quote averaged over 15 minute intervals during the ex-dividend day separately for stocks listed on the NYSE and AMEX and stocks listed on the NASDAQ. The relative trade price is the ratio of $(P^{ex,m}/P^{cum})$ where $P^{ex,m}$ is the intra-day trade price at each *m* minute during the ex-dividend day and P^{cum} is the closing trade price at the cum-dividend day. The relative ask quote is the ratio of $(A^{ex,m}/A^{cum})$ where $A^{ex,m}$ is the intra-day best ask quote at each *m* minute during the ex-dividend day and A^{cum} is the closing best ask quote at the cum-dividend day. The relative bid quote is the ratio of $(B^{ex,m}/B^{cum})$ where $B^{ex,m}$ is the intra-day best bid quote at each *m* minute during the ex-dividend day and B^{cum} is the closing best bid quote at the cum-dividend day. The minute-by-minute relative trade price, ask quote and bid quote are first averaged over 15 minute intervals during each ex-dividend day, and the 15 minute averages of the relative trade price, ask quote and bid quote are subsequently averaged across the sample of ex-dividend days.



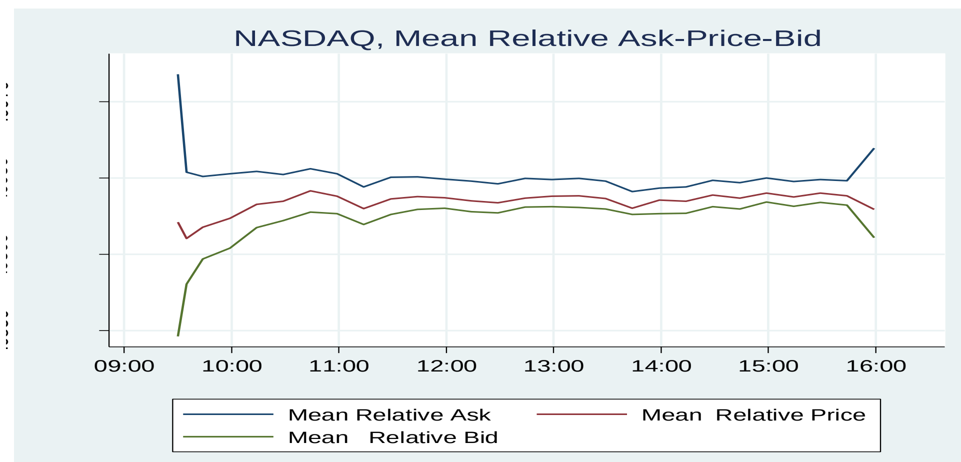
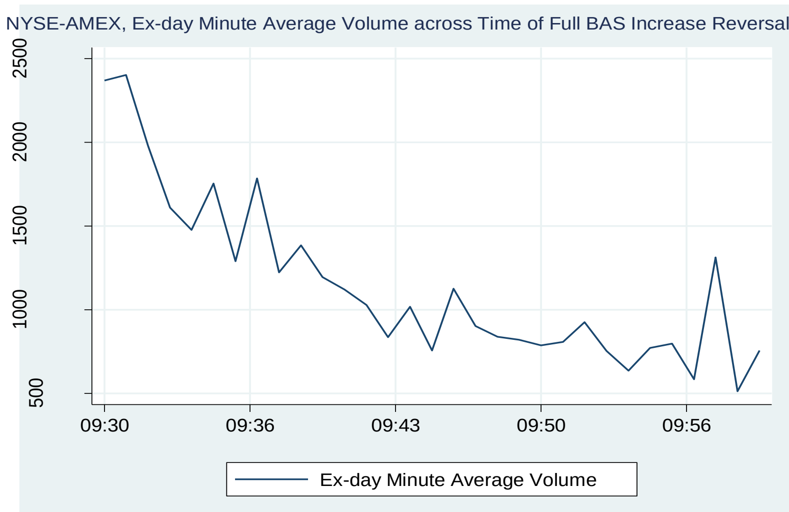


Figure 3
Ex-day Minute Average Volume across Time of Full Bid-Ask Spread Increase Reversal

This figure illustrates the median of the ex-day minute average volume across stocks that share the same point in time when the open bid-ask spread (BAS) widening is fully reversed over the interval from the ex-dividend day open until 10:00 a.m. The reversal of the open BAS widening is assumed to take place within the minute in which the cumulative percentage change of the BAS from the cum-day close becomes equal to or less than zero for the first time during the ex-day. The ex-day minute average volume is defined as the average number of shares traded over one minute within the ex-dividend day for each stock. The medians of the ex-day minute average volume are plotted against each minute within which the reversals of the BAS widening have materialized, separately for the NYSE and AMEX sample, and the NASDAQ sample.



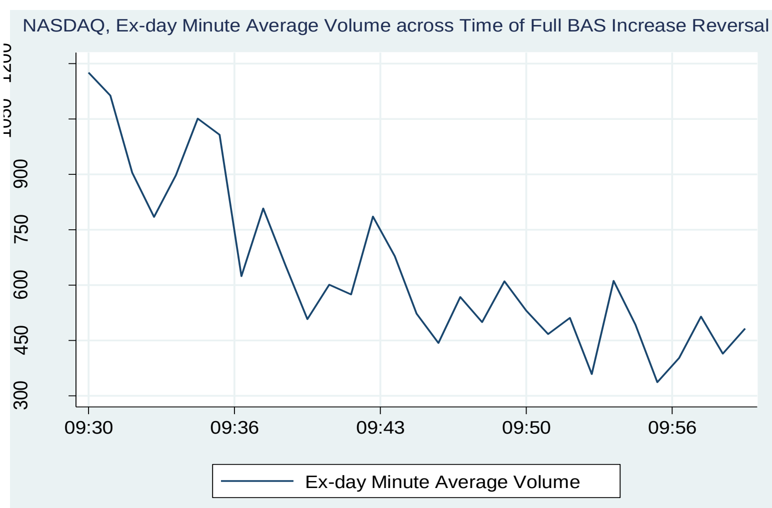
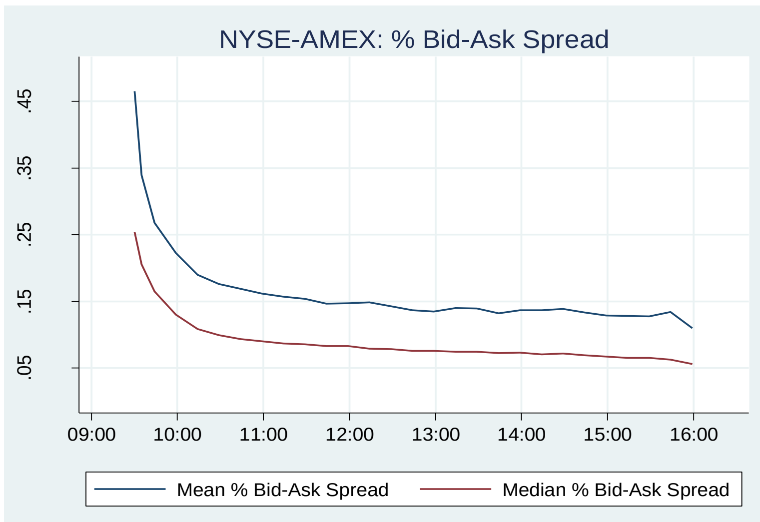


Figure 4
Intra Ex-Dividend Day Evolution of the Bid-Ask Spread:
NYSE and AMEX versus NASDAQ

This figure illustrates the evolution of the percentage bid-ask spreads (BAS) averaged over 15 minute intervals during the ex-dividend day, separately for stocks listed on the NYSE and AMEX, and stocks listed on the NASDAQ. The BAS is equal to [(A – B) / B] where B is the best bid quote and A is the best ask quote at the close of each minute over the ex-dividend day. The minute-by-minute BAS figures are first averaged over 15 minute intervals during each ex-dividend day, and subsequently the mean and median values of the 15 minute averages of the BAS are calculated across the sample of ex-dividend days.



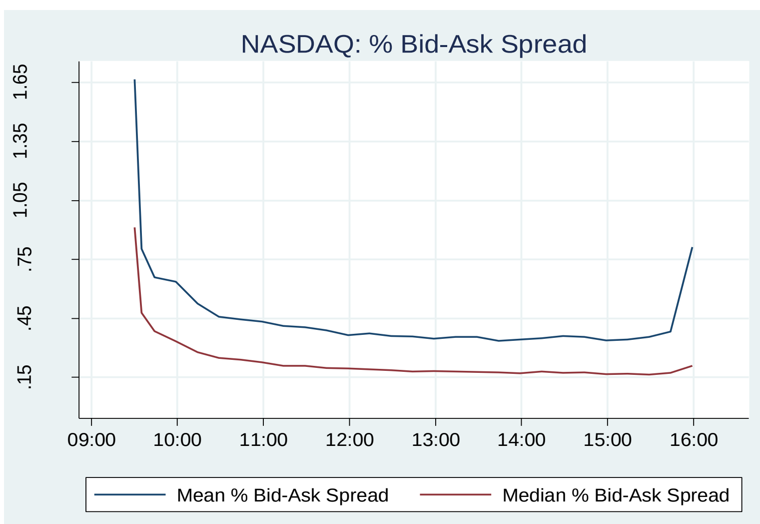


Table 1
Filters of Sample Screening Cash Dividends
Distributed by NYSE, AMEX and NASDAQ Common Stocks

The initial sample consists of the Bloomberg history of cash dividends paid by common stocks primarily listed on NYSE, AMEX and NASDAQ from October 21st, 2010 until December 31st, 2011. The initial sample size is reduced by the removal of dividends, for which a closing trade price on the cum/ex-dividend day or intra-day data during the ex-day were unavailable, whose last time-stamped trade price is greater than $200 or less than $1 at the ex-dividend day close, or deviates by more than $0.3 from the daily closing price, which report less than or equal to only five traded minutes during the ex-day, and which are distributed by NYSE and AMEX stocks on the 27th of May 2011, on which date index intra-day data for the corresponding indices was unavailable. The second and third column of the table report the quantity of observations removed as a number and as a percentage of the initial sample size, respectively. In addition, in order to mitigate the outlier impact the PDR and the AR^{ex} total distributions are separately trimmed at the 2.5% upper and 2.5% lower tail.

Filters and Trimming applied to the ex-day sample; 21st October 2010 - 31st December 2011	Removed Obs	Removed %	Residual Obs
Ex-days for all cash dividends.			7,318
Exclude dividends for which no daily cum-day or ex-day trade price was available.	488	6.7%	6,830
Exclude ex-days for which no intra-day time-stamped data was retrieved.	291	4.0%	6,539
Exclude dividends for which the last time-stamped trade price on the ex-day is greater than $200 or less than $1.	5	0.1%	6,534
Exclude ex-days for which the last time-stamped trade price on the ex-day is higher or lower than the daily closing price by more than $0.3.	32	0.4%	6,502
Exclude ex-days of thinly traded stocks (with less than or equal to five traded minutes within the ex-day).	399	5.5%	6,103
Exclude dividends going ex on the 27th of May 2011, for which no intra-day time-stamped data was retrieved for the NYSE & AMEX exchanges.	54	0.7%	6,049
Trim the 2.5% upper tail and 2.5% lower tail of the ex-day PDR/AR^{ex} distribution of the total sample.	326		5,723

Table 2
Descriptive Statistics for NYSE, AMEX and NASDAQ Common Stocks

This table presents descriptive statistics for the dividend yield (DY%), dividend amount (Div$), trade price at the close of the cum-dividend day (Price), daily trade volume (Vol(day)) and minute average trade volume (Vol(min)) on the ex-dividend day separately for stocks listed on the NYSE and AMEX and stocks listed on the NASDAQ. Panel A reports means and Panel B reports medians on the basis of the 95% trimmed closing PDR sample.

Panel A: Means	Obs	DY(%)	Div($)	Price	Vol(day)	Vol(min)
NYSE & AMEX	3,738	0.698%	0.236	37.857	566,383	1,668
NASDAQ	1,985	0.956%	0.181	24.090	353,696	1,236
All Exchanges	5,723	0.787%	0.217	33.082	492,613	1,518

Panel B: Medians	Obs	DY(%)	Div($)	Price	Vol(day)	Vol(min)
NYSE & AMEX	3,738	0.548%	0.175	32.945	218,057	749
NASDAQ	1,985	0.635%	0.120	18.690	38,530	429
All Exchanges	5,723	0.578%	0.150	27.540	131,071	590

Table 3
Descriptive Statistics for the PDR and AR^{ex}
At the Open and at the Close of the Ex-Dividend Day

This table presents summary statistics for the price drop ratio (PDR) and the abnormal return (AR^{ex}) as computed either at the opening or the closing of the ex-day, separately for NYSE and AMEX stocks and NASDAQ stocks, as well as for all stocks listed on all exchanges. In addition, t-statistics and z-statistics are reported for testing whether the sample mean and median values are equal to their theoretical values (PDR =1 and AR^{ex} =0). Means and medians have been calculated after trimming the top and bottom 2.5 percentiles separately for the closing PDR and closing AR^{ex} samples. Panel A refers to PDR statistics while panel B refers to AR^{ex} statistics. The PDR is defined as $[(P^{cum} - (P^{ex}/(1 + R^{index}))) / Div]$ and the AR^{ex} is defined as $[((P^{ex} - P^{cum} + Div) / P^{cum}) - R^{index}]$. P^{cum} is the daily trade price at the closing of the cum-dividend day, P^{ex} is the price of either the closing or opening trade of the ex-dividend day, and Div is the dividend amount. Both PDR and AR^{ex} are adjusted for the contemporaneous ex-day return of the respective composite index (R^{index}) for each exchange, namely, NYSE, AMEX and NASDAQ. The Wilcoxon signed-rank test is used for testing median values. The Wilcoxon signed-rank test was used for testing median values. *** and ** denote statistical significance at the 1% and 5% level, respectively, using a two-tailed test.

Panel A	NYSE & AMEX		NASDAQ		All Exchanges	
PDR	Open	Close	Open	Close	Open	Close
Obs	3,738	3,738	1,985	1,985	5,723	5,723
Mean	0.798***	0.959	1.023	1.046	0.876***	0.989
t-stat (PDR=1)	-4.16	-0.67	0.37	0.53	-3.22	-0.22
Median	0.866***	0.925***	0.905***	0.901	0.876***	0.920***
z-stat (PDR=1)	-8.38	-2.62	-3.15	-1.51	-8.64	-3.01
Min	-32.685	-13.930	-38.495	-12.174	-38.495	-13.930
Max	68.645	18.537	28.051	19.310	68.645	19.310
Variance	8.792	14.078	7.791	15.068	3.136	14.421
Skewness	2.463	0.436	0.312	0.616	1.795	0.504
Kurtosis	93.087	6.348	44.077	6.355	78.551	6.362

Panel B	NYSE & AMEX		NASDAQ		All Exchanges	
AR^{ex}	Open	Close	Open	Close	Open	Close
Obs	3,764	3,764	1,959	1,959	5,723	5,723
Mean	0.101%***	0.053%**	0.049%**	0.092%***	0.083%***	0.066%***
t-stat (AR^{ex}=0)	7.72	2.48	2.48	2.74	7.58	3.65
Median	0.088%***	0.045%**	0.058%***	0.076%**	0.080%***	0.052%***
z-stat (AR^{ex}=0)	9.31	2.50	3.65	2.37	9.64	3.40
Min	5.110%	-3.965%	-4.622%	-5.981%	-5.110%	-5.981%
Max	5.021%	4.282%	7.680%	4.293%	7.680%	4.293%
Variance	0.006%	0.017%	0.008%	0.022%	0.007%	0.019%
Skewness	0.204	0.023	0.668	0.046	0.387	0.038
Kurtosis	9.318	3.323	13.765	3.187	11.308	3.310

Table 4
Mean Trade Return, Bid Return and Order Flow Bias; At the Open, Close and during the Ex-Dividend Day

This table presents the breakdown of the mean total return (TR) into the mean bid return (BR) and the mean order flow bias (OFbias), at the opening, at the closing and in the interim minutes of the ex-dividend day, separately for NYSE and AMEX stocks and NASDAQ stocks, as well as for all stocks listed on all exchanges. TR is the minute-by-minute percentage change of the trade price and BR is the minute-by-minute percentage change of the bid quote. The OFbias is equal to $[(Loc_m*BAS_m) - (Loc_{m-1}*BAS_{m-1})]$ where Loc_m is the within spread location of the trade and BAS_m is the proportional bid-ask spread at each minute *m* of the ex-dividend day. Loc is equal to [(P – B) / (A – B)] and BAS is equal to [(A – B) / B] where P is the trade price, B is the best bid quote and A is the best ask quote at the close of each minute over the ex-dividend day. For the intra-day period between the opening and the closing of the ex-dividend day, minute-by-minute TR, BR and OFbias are first summed over the interim minutes for each ex-dividend day, and then averaged across the sample of ex-dividend days. The number below the mean values is the t-statistic. [a] denotes statistical significance at the 1% level, using a two-tailed test.

	NYSE & AMEX			NASDAQ			All Exchanges		
Minute	TR	BR	OFbias	TR	BR	OFbias	TR	BR	OFbias
Open	-0.59%[a]	-0.78%[a]	0.19%[a]	-0.84%[a]	-1.43%[a]	0.62%[a]	-0.67%[a]	-1.00%[a]	0.34%[a]
	-22.24	-28.55	27.48	-17.82	-27.63	21.43	-28.35	-39.24	30.09
Interim	0.04%	0.22%[a]	-0.18%[a]	0.10%	0.70%[a]	-0.59%[a]	0.06%[a]	0.39%[a]	-0.32%[a]
	1.34	8.01	-26.97	2.06	13.28	-20.54	2.39	14.99	-29.03
Close	0.01%[a]	0.02%[a]	-0.01%[a]	-0.01%	-0.51%[a]	0.56%[a]	0.00%	-0.17%[a]	0.19%[a]
	3.41	5.65	-2.94	-0.67	-10.73	9.51	0.97	-9.90	9.16
All	-0.54%[a]	-0.54%[a]	0.00%	-0.74%[a]	-1.24%[a]	0.59%[a]	-0.61%[a]	-0.78%[a]	0.21%
	-14.84	-14.89	0.87	-11.88	-15.64	9.86	-18.96	-21.43	9.75
Obs	3,738	3,738	3,738	1,984	1,984	1,984	5,722	5,722	5,722

Table 5
Relationship between PDR/AR^{ex} and OFbias at the Open and at the Close of the Ex-Dividend Day: Orthogonal Regressors

This table reports the estimated coefficients and their t-statistics of the regressions of PDR/AR^{ex} of the 95% trimmed samples against OFbias and a group of control variables separately for NYSE and AMEX stocks and NASDAQ stocks, as well as for all stocks listed on all exchanges. The estimated equation is:

$$PDR_{it} / AR_{it}^{ex} = \alpha + \beta_1 OFbias_i^{open} + \beta_2 BAS_{it} + \beta_3 Loc_{it} + \beta_4 TVol_{it} + \beta_5 DY_i + \varepsilon_{it}$$

where, $OFbias^{open}$ is the order flow bias at the opening of the i ex-dividend day for a particular stock, BAS is the proportional bid-ask spread, Loc is the within spread location of the trade, TVol is the natural logarithm of the trading volume over the relevant minute, and DY is the stock dividend yield equal to the dividend amount over the closing price on the cum-day. The subscript t refers to the time when the regression model is estimated, namely to either the opening or the closing of the ex-dividend day. The microstructure explanatory variables, namely, $OFbias^{open}$, BAS, Loc and TVol, are orthogonalized before OLS coefficients are computed with heteroscedasticity consistent standard errors, according to the White (1980) correction. The number in parentheses below the coefficient is the t-statistic. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively, using a two-tailed test.

Panel A	NYSE & AMEX		NASDAQ		All Exchanges	
PDR	Open	Close	Open	Close	Open	Close
Intercept	0.7620***	0.9940***	1.0365***	1.0538***	0.8825***	1.0010***
	9.69	11.10	15.74	11.50	20.38	18.25
OFbias	-0.1213***	0.0418	-0.2743***	-0.0818	-0.1563***	-0.0209
	-3.07	0.72	-4.09	-0.96	-3.94	-0.41
BAS	0.2015***	-0.0745	0.2290***	0.0400	0.2202***	0.0249
	4.80	-1.38	3.52	0.53	5.10	0.55
Loc	0.0050	-0.2015**	-0.2553***	-0.2218***	-0.1145***	-0.1961***
	0.13	-2.33	-2.94	-2.61	-3.18	-2.77
TVol	-0.0605	0.0140	-0.0602	0.0803	-0.0898**	0.0418
	-1.14	0.23	-0.93	0.95	-2.14	0.83
DY	5.2185	-5.0594	-1.7991***	-1.5243*	-0.9473	-1.8246
	1.10	-1.05	-2.95	-1.67	-0.93	-1.65
Adj. R^2	0.007	0.004	0.025	0.004	0.011	0.003
F-stat	5.78	1.80	6.93	2.51	11.55	2.41
Obs	3,738	3,738	1,984	1,984	5,722	5,722

Panel B	NYSE & AMEX		NASDAQ		All Exchanges	
AR^{ex}	Open	Close	Open	Close	Open	Close
Intercept	0.0012***	0.0006*	0.0003	0.0004	0.0008***	0.0004*
	5.75	1.94	0.91	1.03	4.49	1.74
OFbias	0.0006***	0.0001	0.0011***	0.0002	0.0007***	0.0002
	3.67	0.31	3.51	0.46	3.75	0.66
BAS	-0.0011***	0.0003	-0.0011***	-0.0006	-0.0010***	-0.0003
	-4.99	1.05	-4.19	-1.34	-5.70	-1.22
Loc	0.0001	0.0007**	0.0011***	0.0009***	0.0006***	0.0007**
	0.39	2.03	5.52	2.90	4.64	2.43
TVol	0.0002	-0.0002	0.0001	-0.0007*	0.0003**	-0.0004**
	1.35	-0.85	0.33	-1.95	2.07	-2.20
DY	-0.0227	-0.0092	0.0263	0.0616**	0.0040	0.0372*
	-0.99	-0.27	0.85	2.37	0.19	1.83
Adj. R^2	0.027	0.004	0.048	0.011	0.029	0.005
F-stat	10.42	1.27	15.36	4.26	19.22	3.48
Obs	3,764	3,764	1,959	1,959	5,723	5,723

Appendix

A-3 Microstructure Rules for NYSE, AMEX and NASDAQ

A-3.1 Rules of (Open) Limit Order Adjustment on the Ex-Dividend Day: NYSE, AMEX and NASDAQ

NYSE: Rule 118. Orders to Be Reduced and Increased on Ex-Date

When a security is quoted ex-dividend, ex-distribution, ex-rights or ex-interest, the following kinds of orders shall be reduced by the value of the payment or rights, and increased in shares in the case of stock dividends and stock distributions which result in round-lots, on the day the security sells ex:

(1) Open buying orders;

(2) Open stop orders to sell.

The following shall not be reduced:

(1) Open stop orders to buy;

(2) Open selling orders.

Reduction of orders—Odd amounts.—When the amount of a cash dividend is not equivalent to or is not a multiple of the fraction of a dollar in which bids and offers are made in the particular stock, orders shall be reduced by the next higher variation.

AMEX: Rule 132. Price Adjustment of Open Orders on "Ex-Date"

(a) When a security is quoted ex-dividend, ex-distribution, ex-rights or ex-interest, the following kinds of orders shall be reduced by the cash value of the payment or rights, except where the security is quoted "ex" a stock dividend or stock distribution in which case the provisions of paragraph (b) below shall apply, on the day the security sells ex:

(1) Open buying orders;

(2) Open stop orders to sell. (With open stop limit orders to sell, the limit, as well as the stop price, shall be reduced.)

The following shall not be reduced:

(1) Open stop orders to buy;

(2) Open selling orders.

<u>NASDAQ: 3220. Adjustment of Open Orders</u>

(a) A member holding an open order from a customer or another broker/dealer shall, prior to executing or permitting the order to be executed, reduce, increase or adjust the price and/or number of shares of such order by an amount equal to the dividend, payment or distribution, on the day that the security is quoted ex-dividend, ex-rights, ex-distribution or ex-interest, except where a cash dividend or distribution is less than one cent ($.01), as follows:

(1) In the case of a cash dividend or distribution, the price of the order shall be reduced by subtracting the dollar amount of the dividend or distribution from the price of the order and rounding the result to the next lower minimum quotation variation used in the primary market.

………

(d) The term "open order" means an order to buy or an open stop order to sell, including but not limited to "good `till cancelled," "limit" or "stop limit" orders which remain in effect for a definite or indefinite period until executed, cancelled or expired.

(e) The provisions of this Rule shall not apply to:

……….

(4) Open stop orders to buy;

(5) Open sell orders;

A-3.2 Rules for Minimum Price/Quote Variations: NYSE, AMEX and NASDAQ

NYSE: Rule 62. Variations

……

The minimum price variation (MPV) for quoting and entry of orders in equity securities admitted to dealings on the Exchange shall be as follows:

Price of Order or Interest	Minimum Price Variation
Less Than $1.00	$.0001
$1.00 or greater	$.01

AMEX: Rule 127. Minimum Price Variations

The minimum price variation for dealings in equity securities shall be one cent ($.01)

NASDAQ: 4613. Market Maker Obligations

……

The minimum quotation increment for quotations of $1.00 or above in all System Securities shall be $0.01. The minimum quotation increment in the System for quotations below $1.00 in System Securities shall be $0.0001.

A-4 Proof of the Approximation of the Trade Return to the Sum of the Bid Return and the Order Flow Bias:

$$TR_{im} = \frac{\left(T_{im} - T_{im-1}\right)}{T_{im-1}}$$

$$\textit{which for } T_{im-1} \approx B_{im-1},$$

$$= \frac{\left(T_{im} - T_{im-1}\right)}{B_{im-1}} = \frac{\left(T_{im} - T_{im-1}\right) + \left(B_{im} - B_{im-1}\right) - \left(B_{im} - B_{im-1}\right)}{B_{im-1}}$$

$$= \frac{\left(B_{im} - B_{im-1}\right)}{B_{im-1}} + \frac{\left(T_{im} - B_{im}\right) - \left(T_{im-1} - B_{im-1}\right)}{B_{im-1}}$$

$$= \frac{\left(B_{im} - B_{im-1}\right)}{B_{im-1}} + \left\{ \frac{\left(T_{im} - B_{im}\right)}{B_{im-1}} * \frac{\left(A_{im} - B_{im}\right)}{\left(A_{im} - B_{im}\right)} - \frac{\left(T_{im-1} - B_{im-1}\right)}{B_{im-1}} * \frac{\left(A_{im-1} - B_{im-1}\right)}{\left(A_{im-1} - B_{im-1}\right)} \right\}$$

$$\textit{which for } B_{im} \approx B_{im-1},$$

$$= \frac{\left(B_{im} - B_{im-1}\right)}{B_{im-1}} + \left\{ \frac{\left(T_{im} - B_{im}\right)}{\left(A_{im} - B_{im}\right)} * \frac{\left(A_{im} - B_{im}\right)}{B_{im}} - \frac{\left(T_{im-1} - B_{im-1}\right)}{\left(A_{im-1} - B_{im-1}\right)} * \frac{\left(A_{im-1} - B_{im-1}\right)}{B_{im-1}} \right\}$$

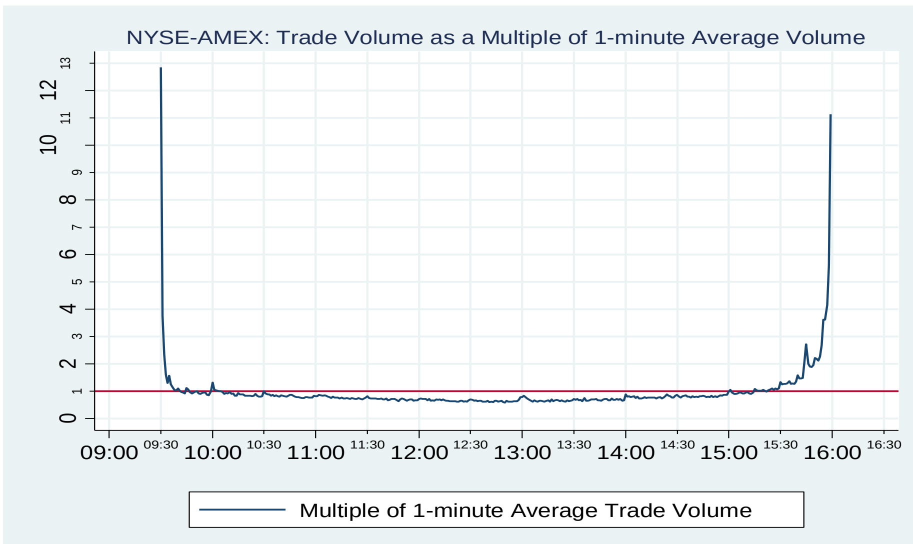
$$= BR_{im} + \left(Loc_{im} * BAS_{im}\right) - \left(Loc_{im-1} * BAS_{im-1}\right)$$

$$= BR_{im} + OFbias_{im}$$

A-5 Robustness Tests: Intraday Analysis of the Ex-Dividend Day of U.S. Common Stocks

Figure A-5.1
Intra Ex-Dividend Day Evolution of Trading Volume; As a multiple of Ex-day Minute Average Trade Volume

This figure illustrates the evolution of trade volume in minute intervals during the ex-dividend day separately for stocks listed on the NYSE and AMEX and stocks listed on the NASDAQ. Trade volume per minute is expressed as a multiple of the ex-dividend day minute average trade volume which is subsequently averaged across the sample of ex-dividend days for each minute.



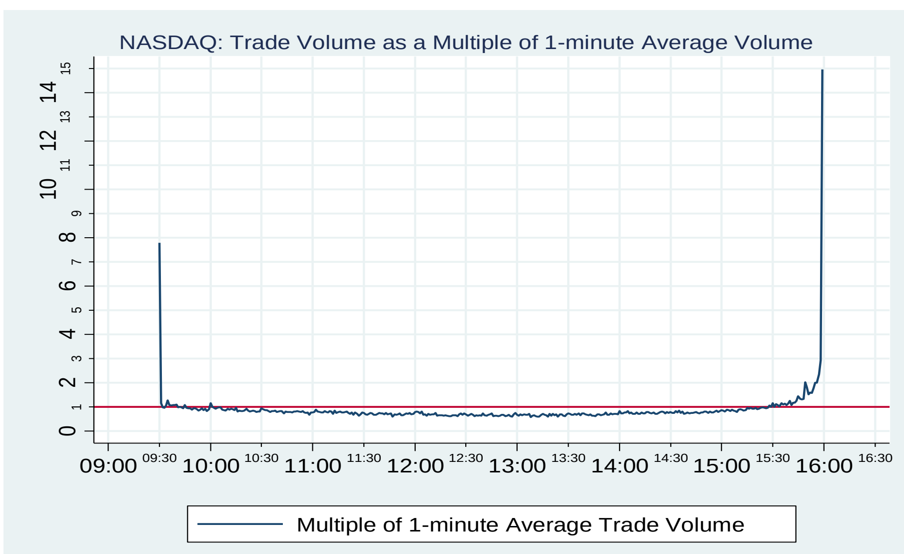


Figure A-5.2
Intra Ex-Dividend Day Evolution of the Relative Trade Price, Ask & Bid Quotes – Medians

This figure illustrates the evolution of the relative trade price, ask quote and bid quote averaged over 15 minute intervals during the ex-dividend day separately for stocks listed on the NYSE and AMEX and stocks listed on the NASDAQ. The relative trade price is the ratio of ($P^{ex,m}/P^{cum}$) where $P^{ex,m}$ is the intra-day trade price at each *m* minute during the ex-dividend day and P^{cum} is the closing trade price at the cum-dividend day. The relative ask quote is the ratio of ($A^{ex,m}/A^{cum}$) where $A^{ex,m}$ is the intra-day best ask quote at each *m* minute during the ex-dividend day and A^{cum} is the closing best ask quote at the cum-dividend day. The relative bid quote is the ratio of ($B^{ex,m}/B^{cum}$) where $B^{ex,m}$ is the intra-day best bid quote at each *m* minute during the ex-dividend day and B^{cum} is the closing best bid quote at the cum-dividend day. The minute-by-minute relative trade price, ask quote and bid quote are first averaged over 15 minute intervals during each ex-dividend day, and the 15 minute interval medians of the relative trade price, ask quote and bid quote are subsequently computed across the sample of ex-dividend days.

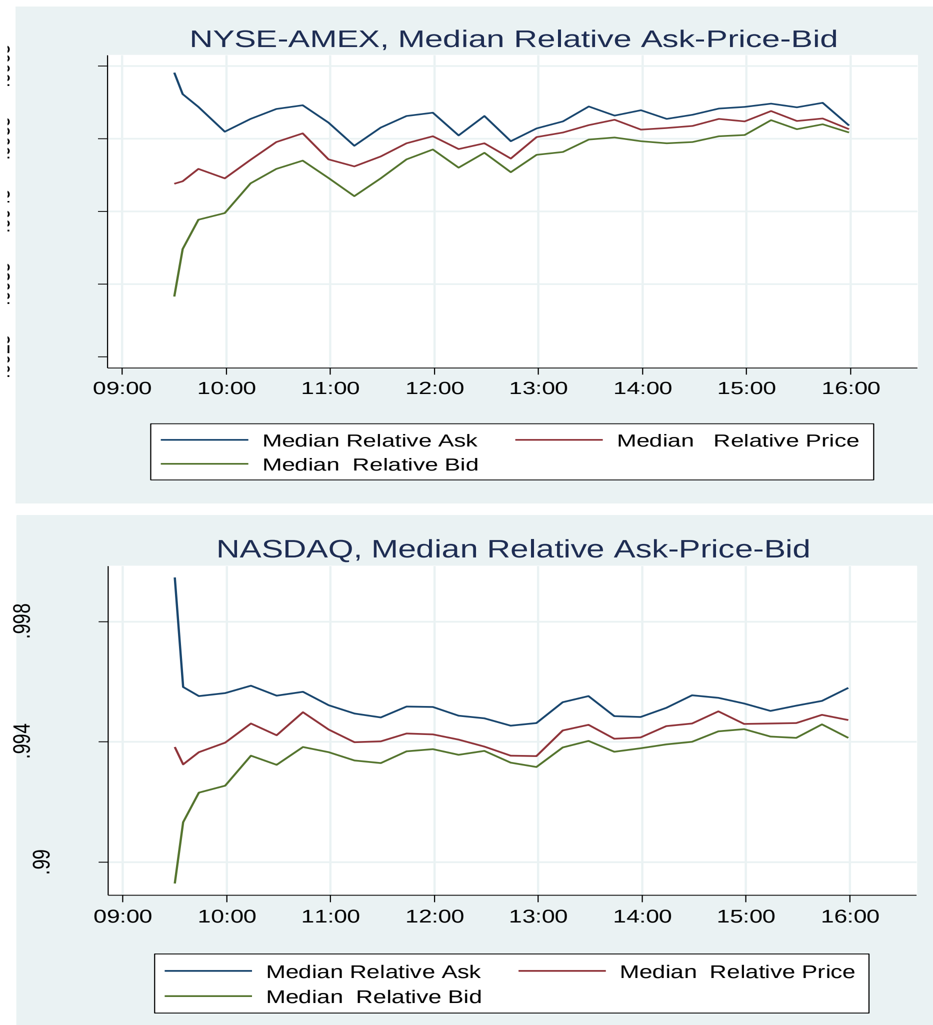


Table A-5.3
Median Trade Return, Bid Return and Order Flow Bias: At the Open, Close and during the Ex-Dividend Day

This table presents the breakdown of the median total return (TR) into the median bid return (BR) and the median order flow bias (OFbias), at the opening, at the closing and in the interim minutes of the ex-dividend day, separately for NYSE and AMEX stocks and NASDAQ stocks, as well as for all stocks listed on all exchanges. TR is the minute-by-minute percentage change of the trade price and BR is the minute-by-minute percentage change of the bid quote. The OFbias is equal to $[(Loc_m*BAS_m) - (Loc_{m-1}*BAS_{m-1})]$ where Loc_m is the within spread location of the trade and BAS_m is the proportional bid-ask spread at each minute *m* of the ex-dividend day. Loc is equal to [(P – B) / (A – B)] and BAS is equal to [(A – B) / B] where P is the trade price, B is the best bid quote and A is the best ask quote at each minute of the ex-dividend day. For the intra-day period between the opening and the closing of the ex-dividend day, minute-by-minute TR, BR and OFbias are first summed over the interim minutes for each ex-dividend day, and then their median is calculated across the sample of ex-dividend days. The number below the median values is the z-statistic computed on the basis of the Wilcoxon signed-rank test for medians. [a] denotes statistical significance at the 1% level, using a two-tailed test.

	NYSE & AMEX			NASDAQ			All Exchanges		
Period/Var.	TR	BR	OFbias	TR	BR	OFbias	TR	BR	OFbias
Open	-0.49% [a]	-0.64% [a]	0.09% [a]	-0.59% [a]	-1.02% [a]	0.27% [a]	-0.52% [a]	-0.76% [a]	0.12% [a]
	-32.21	-37.92	35.16	-28.84	-34.56	27.07	-43.05	-51.42	43.84
Interim	0.02%	0.17% [a]	-0.08% [a]	0.13% [a]	0.50% [a]	-0.26% [a]	0.06% [a]	0.26% [a]	-0.11% [a]
	1.17	8.22	-36.29	3.41	14.83	-25.89	3.08	15.78	-43.85
Close	0.01% [a]	0.01% [a]	0.00%	0.00%	-0.06% [a]	0.06% [a]	0.00% [a]	-0.01% [a]	0.00% [a]
	6.88	8.78	-0.99	-0.74	-20.14	19.93	4.50	-8.13	13.63
All	-0.45% [a]	-0.47% [a]	0.00%	-0.51% [a]	-0.70% [a]	0.06% [a]	-0.47% [a]	-0.54% [a]	0.00% [a]
	-18.35	-18.40	-0.42	-13.46	-18.32	20.13	-22.71	-25.77	13.63
Obs	3,738	3,738	3,738	1,985	1,985	1,985	5,723	5,723	5,723

Table A-5.4
Relationship between PDR/AR^{ex} and OFbias at the Open and at the Close of the Ex-Dividend Day: Non-Orthogonal Regressors

This table reports the estimated coefficients and their t-statistics of the regressions of PDR/AR^{ex} of the 95% trimmed samples against OFbias and a group of control variables separately for NYSE and AMEX stocks and NASDAQ stocks, as well as for all stocks listed on all exchanges. The estimated equation is:

$$PDR_{it} \,/\, AR_{it}^{ex} = \alpha + \beta_1 OFbias_i^{open} + \beta_2 BAS_{it} + \beta_3 Loc_{it} + \beta_4 TVol_{it} + \beta_5 DY_i + \varepsilon_{it}$$

where, OFbias^{open} is the order flow bias at the opening of the *i* ex-dividend day for a particular stock, BAS is the proportional bid-ask spread, Loc is the within spread location of the trade, TVol is the natural logarithm of the trading volume over the relevant minute, and DY is the stock dividend yield equal to the dividend amount over the closing price on the cum-day. The subscript *t* refers to the time when the regression model is estimated, namely to either the opening or the closing of the ex-dividend day. The OLS coefficients are computed with heteroscedasticity consistent standard errors, according to the White (1980) correction. The number in parentheses below the coefficient is the t-statistic. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively, using a two-tailed test.

Panel A	NYSE & AMEX		NASDAQ		All Exchanges	
PDR	Open	Close	Open	Close	Open	Close
Intercept	1.1226***	1.0126***	1.5429***	0.9614**	1.4538***	0.9006***
	3.34	2.59	4.39	2.24	6.23	3.28
OFbias	-79.8212***	12.8165	-22.4495***	-5.3179	-33.1814***	-2.0272
	-4.40	0.89	-2.64	-0.79	-4.20	-0.33
BAS	38.0782***	-31.2208	7.1366	0.5356	13.4806***	0.5873
	3.54	-1.21	1.56	0.54	3.12	0.60
Loc	0.0041	-0.1882**	-0.4284***	-0.4914***	-0.1981***	-0.2168***
	0.06	-2.34	-2.95	-2.61	-3.25	-2.77
TVol	-0.0432	0.0095	-0.0366	0.0439	-0.0562**	0.0249
	-1.14	0.23	-0.93	0.95	-2.14	0.83
DY	5.2185	-5.0594	-1.7991***	-1.5243*	-0.9473	-1.8246
	1.10	-1.05	-2.95	-1.67	-0.93	-1.65
Adj. R^2	0.007	0.004	0.025	0.004	0.011	0.003
F-stat	5.78	1.80	6.93	2.51	11.55	2.41
Obs	3,738	3,738	1,984	1,984	5,722	5,722

Panel B	NYSE & AMEX		NASDAQ		All Exchanges	
AR^{ex}	Open	Close	Open	Close	Open	Close
Intercept	0.0000	0.0013	-0.0008	0.0024	-0.0010	0.0022**
	-0.04	0.88	-0.78	1.38	-1.41	2.01
OFbias	0.4304***	-0.0016	0.1097***	0.0119	0.1609***	0.0148
	4.39	-0.02	2.92	0.31	4.10	0.45
BAS	-0.2225***	0.1269	-0.0450**	-0.0079	-0.0704***	-0.0073
	-3.59	0.77	-2.40	-1.46	-3.61	-1.36
Loc	0.0001	0.0007**	0.0018***	0.0020***	0.0010***	0.0008**
	0.45	2.03	5.52	2.89	4.69	2.44
TVol	0.0002	-0.0001	0.0000	-0.0004*	0.0002**	-0.0003**
	1.35	-0.85	0.33	-1.95	2.07	-2.20
DY	-0.0227	-0.0092	0.0263	0.0616**	0.0040	0.0372*
	-0.99	-0.27	0.85	2.37	0.19	1.83
Adj. R^2	0.027	0.004	0.048	0.011	0.029	0.005
F-stat	10.42	1.27	15.36	4.26	19.22	3.48
Obs	3,764	3,764	1,959	1,959	5,723	5,723