Option Implied Dividends

Jac. Kragt*

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Abstract

This is the first paper to calculate and analyze option-implied dividends for individual US companies, while accounting for the early exercise premium. These firm-level implied dividends show substantial variation relative to actual dividends over time as well as in the cross-section. Implied dividends predict actual dividends, particularly upward dividend changes. Stock prices correlate strongly with changes in implied dividends, so much so that price changes are partly reversed subsequently. An announcement to cut dividends causes a stock's price to drop by 2.6% on average, but if it is correctly predicted by implied dividends the response is negligible.

*j.c.kragt@uvt.nl, Tilburg University. I thank Joost Driessen, Frank de Jong, Peter Schotman, Ralph Koijen, Rik Frehen and participants at the OptionMetrics 2016, the ESSEC/Eurofidai 2017 and the Lancaster University Frontiers of Factor Investing 2018 conferences for their helpful comments.

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1 Introduction

The value that market participants put on future dividends is the subject of this paper. I propose a methodology to imply future dividend valuations from option prices for individual US firms and construct a database of such implied dividends. The approach includes a solution for dealing with the early exercise premium embodied in US stock options. This paper is the first to present a firm-level data set of implied dividends and use them in cross-sectional asset pricing. I show that the implied dividend data are informative and useful, as they compare well to actual dividends and show economically sensible patterns in term structures over various horizons. Implied dividends anticipate changes in actual dividends, as is demonstrated when a firm introduces to pay dividends for the first time. More generally, implied dividends have predictive power for actual dividend changes as well as for stock returns. Stock prices respond less strongly to changes in dividends if they are correctly predicted by implied dividends.

The rationale to investigate option prices to find dividends is that they are a function of the assumptions made by market participants about the volatility of the underlying stock and about the dividends it will throw off. Options are the only instrument in financial markets which contain such forward-looking information about dividends for individual companies in meaningful numbers[1]. They also exist for several expiry dates, which gives insight into a term structure of future dividends.

The case to imply dividend valuations paid by all constituent companies of the S&P 500 index from option prices has been made by van Binsbergen, Brandt and Koijen (2012). These authors apply the put-call parity (PCP) to index options for finding the implied dividends. For such European-style index options, the direct application of PCP is an appropriate methodology. Options of individual US stocks, however, are American style and exercisable before their expiry date. The embedded early exercise premium introduces a deviation in the PCP which, without proper adjustment, would disqualify it for the purpose of finding implied dividends directly from the prices of American options. I present a methodology to

[1] Addressing cross sectional asset pricing puzzles by means of dividend valuations requires access to priced dividends for individual companies. Unfortunately, such products are few and far between. Dividend futures for individual European stocks exist in small numbers since 2010, but they are scarcely traded and their liquidity is limited. In the US market, publicly traded dividend futures were introduced for the S&P 500 in 2016, but do not exist for individual companies.

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circumvent this issue by modeling option prices and solving for implied volatility and implied dividends at the same time, using a binomial tree model. The core of this procedure is the minimization of the squared difference between the model prices and the market prices of put-call option pairs in a single step.

The procedure provides a database of implied dividends for each firm out to three quarters ahead of the observation date. The data set is as large as the set of companies on which stocks options are traded. A subset of companies have stock options expiring in excess of two years (LEAPS), with an according horizon for implied dividends.

The data set bears out that implied dividends vary substantially over time and in the cross-section. Nevertheless they track actual dividends well, despite that these observable data do not play a part in calculating implied dividends. Over time, they are on average valued lower than actual dividends, except in periods immediately following bear markets. In the period of 1996 to 2015, the average actual dividend yield is 56 basis points per quarter. Expressed as an implied quarterly dividend yield, the average term structure shows a decline of a little over 1 basis points per quarter. Implied dividends in the highest cross-sectional quartile are often substantially above actual dividends and in the lowest they are mostly below. For longer horizons this dispersion is smaller than for shorter horizons.

Implied dividends show that market participants anticipate changes in dividends. In fact, 57% of dividend increases are correctly predicted at horizon of six months by implied dividends whereas dividend cuts are not predicted by implied dividends (close to 50 %). For five to twenty days ahead Fodor, Stowe and Stowe (2017) find stronger predictive strength in implied dividends. More generic tests also reveal that upward changes in dividends in particular are predicted by implied dividends. Future dividend raises are better predicted with higher sensitivity to implied dividends for longer horizons than dividend cuts.

These predictions are, however, obfuscated by the nature of dividend changes. Actual dividends are often left unchanged for an extended period of time by company management pursuing a dividend smoothing policy and the prevalence of such no-changes in dividends is vast. An estimation methodology that takes account of this feature of the data orders them into a separate category. Actual dividend changes are categorized into upward small and large changes, negative changes and zero changes. An ordered Probit estimation then reveals the probabilities of a raise, a cut or a no-change occurring for a given implied dividend being higher or lower than the dividend that was last paid. Although significant, the material

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effect of implied dividends on a change in such probabilities is not large. The Probit results show that the marginal effect to the probability of predicting an actual increase by implied dividends moving from below to above actual dividends amounts to about 2%.

Portfolios of stocks with fast dividend growth, defined as a high valuation of future dividends relative to current dividends, show high returns. In the 12 months *prior* to sorting, the fastest quartile portfolio returns are about 0.90% per month above those of the slowest quartile portfolio. If a stock moves up or down in portfolio quartile rankings, that explains a return of 0.72% in the same quarter.

Future returns, however, paint the opposite picture. In fact, in the year following sorting, portfolios of fast dividend growth stocks underperform those with slow dividend growth by 0.30% per month. Low returns following an expected increase in dividend may seem counter-intuitive, but if the earlier coincidence of high implied dividends and high returns is a stock price overreaction, then low returns afterwards is merely a reversal in the stock price.

The dividend yield premium (documented by among others Fama and French (1993) and Conover et al., (2016)) may be a consequence of the reversal phenomenon. Fast dividend growth causes a stock to rise, which in turn reduces the dividend yield if this rise is larger than the actual dividend increase. An anticipated increase in dividends, when dividend growth is positive, will not necessarily materialize in an actual dividend increase. Low returns following fast dividend growth and a low dividend yield may thus be one and the same: a consequence of a high stock price rather than of a low dividend.

The effect of a change in dividend growth on returns appears to depend on the level of dividend growth. When it is fast or slow, a change in dividend growth down or up matters significantly more to returns than when dividend growth falls into one of two middle quartiles. This is also true for the reversal pattern after portfolios are sorted. For example, when dividend growth is fast, stock prices respond stronger to a decrease in dividend growth because there is a larger potential for a reduction in dividend growth.

Just as implied dividends predict changes in actual dividends, the effect of an announcement of a dividend change on stock prices is also affected if implied dividends correctly predict the change. Larkin, Leary and Michaely (2016) note that stock prices typically fall around an announcement to cut dividends by about twice as much as they rise in case of a dividend increase. They argue that market participants are less surprised by a dividend change if a company has cut dividends before and they show that this reduces the stock price

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response. This mitigated element of surprise plays a part once implied dividends are included in testing the announcement effect as well. Although dividend cuts are not well-predicted by implied dividends, the three-day stock price response to a dividend cut is reduced from –2.6% to about zero if it is correctly predicted by implied dividends. Any response reduction in case of dividend raises, however, is invisible.

This paper is organized as follows. The next section sets out the procedure to imply dividend valuations from US stock options. This involves a discussion of the minimization procedure and the criteria to calculate the data and is followed by a description of the dividends as implied. The section concludes with an example of the implied dividend data. In section three implied dividends are deployed in several tests for their predictive power of actual dividends. Section four tests implied dividends for explaining contemporaneous returns and predicting future returns, and for the stock price response to announcements to change dividends. The final section contains the conclusions and suggestions for further work.

2 Implying dividends from option prices

The market valuation of dividends is found from the relationship between stock prices and futures. Pricing a future contract $F_{t,n}$ that matures at time n needs to take account of the time value of money r and for the fact that the buyer of a future does not receive the cash distributed by the stock, which is represented by the present value of its dividend $PV_t(D_{t+n})$ paid up to n in the case of a stock S_t

$$PV_t(D_{t+n}) = S_t - e^{-r_{t,n}} F_{t,n}. \tag{1}$$

The economic interpretation of dividend present value is discussed below.

As futures of individual stocks are not sufficiently available for obtaining an empirically meaningful data set, I use options instead. Put-call parity (PCP) is a model free relationship which enables to find dividends as implied by option prices. The intuition is that the combination of opposite positions in otherwise equal call and put options[2] creates the payoff of a future. This pricing relationship is given by the equality of the difference between the

[2]In the case of options with the same underlying stock, strike and expiry date.

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price of a European call option $c_{t,n}$ and put option $p_{t,n}$ to the discounted difference between option strike K and future price $F_{t,n}$

$$c_{t,n} - p_{t,n} = (F_{t,n} - K)e^{-r_{t,n}}. \tag{2}$$

Combining (1) and (2) describes the PCP, where the price of the future is replaced by option prices

$$PV_t(D_{t+n}) = S_t + p_{t,n} - c_{t,n} - Ke^{-r_{t,n}}. \tag{3}$$

This depiction is clear cut for European options as the value of dividends can be traced back directly to the variables on the right hand side, which are all observable. But American style options on US stocks with prices $C_{t,n}$ and $P_{t,n}$ allow for exercise before the expiry date resulting in a strictly positive early exercise premium (EEP) in addition to the prices of their European-style equivalents

$$PV_t(D_{t,n}) = S_t + (P_{t,n} - EEP_{put,t,n}) - (C_{t,n} - EEP_{call,t,n}) - Ke^{-r_{t,n}}. \tag{4}$$

The inclusion of these premiums in the PCP shows that there is no need to deviate from the principle of the PCP approach, but that a correction for the premiums that the early exercise present is required to apply it.

2.1 The model

The standard for pricing American options uses a binomial tree, introduced by Cox, Ross and Rubinstein (1979). The binomial CRR model builds up stock prices and option prices by up and down scenarios in constant time steps as the horizon extends into the future until the expiry date of the option. The American put and call option prices in the CRR model are a function of

$$P_{t,n} = f(\sigma_{t,n}, PV_t(D_{t+n}), S_t, n, K, r_{t,n}), \tag{5}$$

$$C_{t,n} = f(\sigma_{t,n}, PV_t(D_{t+n}), S_t, n, K, r_{t,n}), \tag{6}$$

in which $PV_t(D_{t,n})$ is the present value at time t of all dividends to be paid between t and expiry n periods later, $r_{t,n}$ is the risk-free rate until n and $\sigma_{t,n}$ is the volatility of the stock with price S_t implied from an option with a strike K.

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The build-up of the binomial tree requires to specify whether dividends are paid at discrete points in time, or continuous through time. Discretely timed dividends, as I apply the model, allow for the possibility of a payment shortly before expiry, which would trigger exercise at such a date in the life of the option. The CRR model thus takes into account the pricing consequences for options on the stock of such precipitous exercise.

If no assumptions are made about either implied volatility or implied dividends, then unique solutions cannot be found for each equation (5) and (6) independently from each other. At the same time, each of the two implied unknowns should be equal for calls and puts. The implied volatility refers to the volatility of the stock price, which is the same stock for the call and the put option. The implied dividend refers to the dividend implied to be paid by the company issuing the stock, which is also the same for both options. It follows that, with two equations and two unknowns, unique values can be found for implied dividend and implied volatility under this presumption for pairs of call and put options which have the same strike, expiry date and underlying stock characteristics.

There are concerns that the implied volatility in particular is not the same for calls and puts. The literature on the pricing of options and potential causes for mispricing in the Black-Scholes-Merton (1973) framework looks for trading demand and supply pressure as a potential cause. Bollen and Whaley (2004) argue that changes in implied volatility of index and stock options are related to net buying pressure measured by trades occurring away from the bid/ask midpoint. This causes the implied volatility function across moneyness of the options not to be flat as expected in the classic framework. Cremers and Weinbaum (2010) state that differences between call and put implied volatilities do not reflect pure arbitrage opportunities, rather these represent deviations from PCP, which can be viewed as proxies for price pressures. The authors conclude that such deviations in option prices can lead stock prices by days. Gârleanu, Pedersen and Poteshman (2009) identify the relative demand for index and stock options by end-users. Option prices are priced away from the Black-Scholes-Merton framework as they cannot be hedged perfectly by intermediaries. The authors measure the expensiveness of options as their implied volatility relative to the expected volatility for the life of the option and establish a positive relation between option expensiveness and end-user demand[3].

[3]The effects of noise in the data and of short-lived price pressure are mitigated by aggregation, which is discussed in the next subsection.

There are other concerns with the exact application of the PCP. Kalay, Karakaş and Pant (2014) use deviations to establish the value of the voting premium. The difference of voting share prices from their non-voting synthetic cash flow equivalent using options measures the value of the right to vote as shareholders. They find the voting premium to be positive and increasing with the expiry of the options.

The two pricing equations for put and call options (5) and (6) each have the same two unknown implied dividend and implied volatility and the same observables. Cremers and Weinbaum (2010), Gârleanu, Pedersen and Poteshman (2009) and Kalay, Karakaş and Pant (2014) employ in their analysis the implied volatilities delivered in the Ivy DB data set from OptionMetrics. As in Bollen and Whaley (2004), these are calculated under the constant dividend yield assumption (OptionMetrics, 2011). Harvey and Whaley (1992) state: "Since firms tend to pay stable quarterly dividends at regular periodic intervals during the calendar year, little uncertainty exists about the dividend parameters for short term index options.". This means that future dividends are proxied by the most recent dividend that actually has been paid. With that unobservable input to the model pinned down, it is possible to imply a value for the volatility of the underlying stock from the price of a single option.

From the market for dividend derivatives, however, it is established empirically that risk neutral dividend expectations are neither flat for any horizon nor constant over time (Binsbergen et al., 2013, and Kragt, de Jong and Driessen, 2015). The actual expectation about future dividends prevailing in the market will be different from its last known value for two key reasons. The first is that the present value of a dividend expected to be paid at time n depends on several ingredients:

$$PV_t(D_{t+n}) = D_t exp(g_{t,n} - \theta_{t,n} - r_{t,n}). \tag{7}$$

Expected dividends $E_t(D_{t+n})$ grow at rate $g_{t,n}$ from currently paid dividends D_t and are discounted at the risk premium $\theta_{t,n}$ and the risk free rate $r_{t,n}$ for finding its present value $PV_t(D_{t+n})$. The assumption that the last known dividend will be continued at the same level beyond the observation date thus implicitly equates the objective expected growth rate $g_{t,n}$ to $\theta_{t,n} + r_{t,n}$ for all n.

Furthermore, instead of projecting dividends at a constant rate into the future, market participants are likely to change their expectations of future dividends over time based on

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their assessment of a company's willingness and ability to pay dividends. Such expectations may change whether the company makes a public statement about its dividends or not. It is the variation in the market valuation of dividends, as denoted in equation (7), that the following procedure is intended to capture.

I identify a call and put option pair that is the same for all characteristics, among which future dividends and volatility are unobservable. These two unknowns can be found, in principle, exactly given the option pricing equations (5) and (6). However, model implied prices $\hat{C}_{t,n}$ and $\hat{P}_{t,n}$ depend on building up the CRR binomial trees. They cannot be determined analytically by reverse engineering as this would involve starting from the back-end of the tree. This problem is resolved by equating model and observed prices respectively, while the option pricing equations for call and put are inverted at the same time.

In practice, the procedure starts by guessing values for the two unknown implied variables, calculating model prices and reiterating new guesses until convergence of model and observed prices. As both pricing equations require the same guessed value for the inputs, this is pursued by minimizing the quadratic difference between model prices and the observed end-of-day mid-prices of both a pair of call and put options in a single equation:

$$F = (P_{t,n} - \hat{P}_{t,n})^2 + (C_{t,n} - \hat{C}_{t,n})^2, \tag{8}$$

where F is a function of the implied dividend and implied volatility of the modeled option prices. The minimization of F given the observed option prices results in a unique value for both implied dividends between t and n and for implied volatility for horizon n for each option pair in the data set[4].

The minimization method is based on two main assumptions: Markets are transparent and efficient, and end-of-day close option prices contain all economically relevant information relevant to market participants. Considering implied volatility and implied dividend to be the same for call and put options is not an assumption but a fact as they both refer to the same single stock[5].

[4]The Matlab function `fminsearch` is used for performing the minimization.

[5]As a check on the robustness of minimization procedure, I include stock loan fees as part of the return to shareholders. Such fees can be regarded as a source of income to be derived from owning a stock in addition to its dividend. By expanding the methodology to find implied dividends, stock loan fees are implied simultaneously but separately from implied dividends. Implied fees correspond to actual fees, while showing a negative slope in their term structure (see the Appendix).

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2.2 Data and aggregation

The Ivy DB database provided by OptionMetrics contains all options traded on US stocks starting in 1996 and are included in the data set until August 2015. The minimization is performed under the condition that prices relate to companies with CRSP share codes 10 or 11, which restricts the set to regular companies only[6]. Overall, the data set contains option prices for 5,700 individual companies, which constitues most of the stocks traded on the NYSE, AMEX and NASDAQ. The prices used are daily and are taken as the average of the bid and ask closing prices[7]. The data set includes a total of 337 million option prices. The daily stock prices S_t and current dividends D_t are also taken from the Ivy DB database. The risk free rate $r_{t,n}$ is proxied by the Eurodollar Libor spot rate, downloaded from Datastream.[8]

To construct a data set that is a large as possible, but from which irrelevant options are eliminated, I apply the following filters:

1. Options for which OptionMetrics does not provide a value for implied volatility are excluded. As OptionMetrics applies the constant dividend assumption, implied volatilities cannot be calculated for options which are far in-the-money or far out-of-the-money. Such options are less frequently traded, which is the main reason to exclude them.

2. Options expiring within 90 days of the observation date are excluded. Once a dividend is announced, there is little uncertainty about the magnitude of the payment being made. As some firms announce dividend payments farther in advance than others, the degree of risk embodied in implied dividends payable in the near future will vary among them. Only a small fraction of firms announce dividends beyond a horizon of 90 days, so restricting the data set to longer option maturities allows for a like-for-like comparison of implied dividends among firms.

Many stocks exist in the data set for just a part of the data period, they sometimes have options traded on them and not all companies pay dividends consistently. Consequently, it

[6]This excludes REITS, ETFs and several other underlying types.

[7]Market closing time of options on individual stocks is at 4:00 pm, which matches the closing time of the stocks. Timing differences between the two markets should not be a major concern.

[8]Gârleanu, Pedersen and Poteshman (2009), Cremers and Weinbaum (2010) also deploy Libor for this purpose.

is insightful to regard the prevalence of the data per period[9]. Over the 79 quarters in the data period, there are 153,589 quartercompanies with options, or some 64% of all available stocks (Panel A in Table 1). More often than not, a single stock will have options of the same expiry date with several strikes traded on it. Options with different strikes do not have the same implied volatilities, as the volatility surface is not flat but skewed. But as long as the expiry dates of option pairs are the same, the implied value for dividends remain equal to the market's value put on the dividends paid before expiry regardless of the option strike. Option pairs with the same expiry will thus produce the same implied dividends, but varying implied volatilities for varying strikes.

On average, for every observation date and expiry date combination, there are three option pairs with different strikes in the data set. To reduce measurement error, it is useful to find the implied dividends from all option pairs available. I calculate implied dividends from available options pairs for a given expiry date and underlying stock and take their median to determine the relevant value for each observation date. Alternative methods to find averages deliver materially the same results.[10]

The minimization is performed for dividends to be paid discretely, as this accounts for the early exercise premium in the CRR model. This requires identifying dates beyond the observation date at which dividends are assumed to be attributed to the stock. The relevant date to include in the pricing model is the ex-dividend date, which is the first business day following the date on which the dividend is attributed to the stock. The settlement date

[9] I work with quarterly periods for reasons that are clarified later.

[10] An alternative weighting scheme takes account of the impact of the bid-ask spread on the precision of the estimates for the implied dividends. Bid-ask spreads tend to be large for options that are traded infrequently, such as when their strikes are far in or out of the money. Large bid-ask spreads involve a wide range of consistent mid-prices, which increases the potential for measurement error. The larger the bid-ask spread, the smaller the weight in the averaging of the dividend implied from the option pairs

$$PV(D) = \sum_{i=1}^{n} \frac{w_j PV(D)_{K_j}}{w_j}$$

in which the weight w_j for the option pair with strike K_j is set by

$$w_j = (0.05 + |BO_c| + |BO_p|)^{-1}$$

with $|BO_c|$ and $|BO_p|$ representing the bid-ask spread of the call and put options respectively. A constant 0.05 is added to avoid inversion of zero. Although this approach appears more robust to measurement error, it delivers materially the same results and is not pursued.

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at which the dividend is actually paid into the account of the owner is not relevant. If the owner decides to sell the stock as of the ex-dividend date, but before the payment date, then the dividend will not be paid into the owner's account.

The latest date at which a dividend has actually been paid is known at any observation date and is used as a starting point. Most US companies pay dividends at a quarterly frequency (Panel B in Table 1). The subsequent date at which the next dividend is assumed to be paid is set to the last ex-dividend date plus 91 calendar days, the following quarterly payment goes ex-dividend after 182 calendar days and so on[11]. Such assumptions about the exact dates cannot be avoided even if company statements about ex-dividend dates were analyzed piecemeal. Many stocks have LEAPS[12] traded on them, which are options with expiry dates extending out to over two and a half years (Panel A in Table 1). In general, companies provide guidance about dividend dates of at most one year in the future. For these long dated options, an assumption about the date of going ex-dividend always has to be made.

Options with an expiry date of more than three months beyond the observation date can span more than a single implied dividend payment. The dollar value of each of them is assumed to be the same. Relaxing this assumption would increase the number of free variables in the minimization which prevents finding unique solutions in the minimization of an individual option pair with more than one dividend payments in (8). At the same time, at any observation date the present value of the first to be paid dividend is implied from the first to expire option during which life a dividend is expected to be paid. From the options with the next quarterly expiry date, both the first and the second future dividends present values are implied simultaneously. By deducting the first quarter implied value, the second dividend's implied value can be isolated, and by iteration the same applies to dividends further into the future.

Companies do not necessarily have to be current dividend payers to have dividends implied from their stock options. Often firms do not pay dividends for a protracted period of time, or never pay dividends at all. Sometimes they are current payers, but interrupt payment for a few years before they return as payers. Several hundred companies in the

[11]Implied dividends are calculated for firms that do not currently pay dividends as well, simply because they might start to do so at any point in time. The date at which the potential dividend is assumed to be paid by a non-current dividend payer is 91 calendar days following the observation date.

[12]Long-term Equity Anticipation Securities.

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data set have paid dividends at an interval different than quarterly. And many among them switch payment frequency.

The choice made for aggregation deals with these issues by dividing the data into subsets of observation quarters of companies which pay dividends at a quarterly rate and of observation quarters of companies which do not pay dividends. The quarterly frequency is chosen since this allows to establish a data set of implied dividends of which the horizon is constant. In practice, the expiry dates of regular stock options with expiries shorter than nine months are dispersed over a calendar year in a manner that is not the same for all companies. They tend to follow a pattern of expiries in January/April/July/October, February/May/August/November or March/June/September /December. Exceptions exist, particularly in the latter half of the data period. Also, LEAPS always expire in January of up to two years and eight months ahead. If a monthly frequency were pursued, then the horizon would reduce by a month twice for each month that passes and then jump ahead for two months. Aggregation of daily implied dividends to a monthly frequency thus produces a term structure of which the horizon is not the same across companies. Aggregating to buckets of quarterly averages resolves this issue. Appendix I sets out the procedure for this aggregation.

2.3 Summary description of the minimization results

The results of the minimizations are pictured in dividend yields, that is, in present values of implied dividends relative to the share price at quarter t. All companies in the data set have regular options traded on their stock, while some companies also have LEAPS traded on their stock. The expiry of regular options extends out to no more than nine months, but the expiry of LEAPS can be as long as two years and eight months. As a result, growth rates beyond the third quarter are based on LEAPS and thus consists of a smaller sample of companies (Panel B in Table 1). All data discussed are value weighted.

The term structure of dividend yields averaged over the data period for stocks without LEAPS (Figure 1) starts at 0.60% for currently paid dividends and drops to 0.53% for the average of the first, second and third quarter forward. Average implied dividends of stocks with LEAPS are at about the same level and show a noticeable decrease for quarters beyond the third. The implied dividend yield over the eight quarters following the current quarter

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is valued at no more than 0.45% to 0.48%, which is a fifth to a quarter less than the current dividend yield. These figures broadly match the levels and slope pattern for dividends based on option prices reported elsewhere (Binsbergen, Brandt and Koijen, 2012).[13]

Figures 3 and 4 illustrate implied dividend yields over time next to the current dividend yield for value weighted averages across all companies who pay dividends at a quarterly rate. Figure 3 shows the implied dividend yield of one quarter ahead and the sum of one and two quarters ahead, Figure 4 contains the implied dividend yield of one to three and one to eight quarters ahead. Several observations stand out. First of all, option prices capture anticipated dividends sensibly over time. The implied dividend yields follow the actual dividend yield well, despite that they are calculated in the minimization process without reference to actual dividends. Second, implied dividends are below current dividends for longer dated horizons. This means that growth rate $g_{t,n}$ is smaller on average than the risk-adjusted discount rate $\theta_{t,n} + r_{t,n}$ (see Equation (7)). Lastly, the level difference between current dividend yields and implied dividend yields decreases during the time span of the data set. In the latter half, the implied dividends are higher relative to current dividends for both short and long dated options. Lower interest rates can partly explain this structural shift.

The term structure emerges clearly in Figures 5 and 6, which portray sample average growth rates of implied dividends relative to actual dividends. Over time, there is substantial variation in dividend growth, with an upward trend as time passes. Implied dividend growth is negative throughout for longer horizons, but hovers around zero for horizons of one and two quarters. In 2008 a change has occurred taking dividend growth substantially higher. From their peak in 2008, current dividends measured as dividends per share fell by 10%. In part, the sudden increase in dividend growth is a denominator effect as share prices fell.

Returning to the combined set of companies with and without LEAPS, current dividend yields show substantial variation. Breaking them down into deciles indicates a dividend yield of less than 0.2% per quarter for the lowest decile, the highest decile companies pay in excess of 1.1% dividend per quarter (Figure 2).

[13] These authors calculate dividend prices of the S&P 500 index based on PCP over the period 1996 to 2009. The levels they find are close despite differences in data period, smaller set of firms and S&P-weighting versus value-weighting. The slope of the term structure they report at an average of -5.15% for horizon 6 to 12 months ahead and -2.95% for 12 to 18 months ahead. The average slopes found here are a little less than twice as steep. The authors report a positive slope of 0.50% for 18 to 24 months ahead, whereas I find a decrease of -3.2% (figure 1). A slope from actual dividends to 6 months ahead implied dividends can not be calculated from the data they present.

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Growth rates of implied dividends vary substantially among individual companies as well. The shortest horizons give the biggest dispersion in growth rates (Figures 7 and 8). The breakpoint of the highest decile in first quarter growth is nearly 100%, while the breakpoint of the lowest decile is minus 50%. Options of companies in these deciles thus price a near doubling and halving respectively of dividends in the following quarter. Growth rates in consecutive quarters remain widely dispersed. The average growth rate after the third quarter ranges from nearly minus 40% for the lowest decile breakpoint, to over 60% and 30% growth for the highest decile breakpoints of three quarters and two years average dividend yields.

2.4 An example of a change in dividend policy and anticipatory pricing in options

The present value relationship assumes that the value of a stock is derived from expected dividends, but such valuation does not necessarily require that any dividend is currently paid. In fact, the expectation that dividends will be paid may lie far ahead in the future. Implied dividends give some insight into the length of that expectation horizon.

Often companies attain substantial market capitalization even though they do not pay dividends. A case in point is Apple Inc. (AAPL US) which attained a market capitalization in 2011 of US$ 354 billion following seventeen years of not paying dividends. Its operating profitability reached US$ 35 billion in fiscal year 2011.

The procedure to imply dividends from option prices works equally well for stocks whether dividends are being paid or not. The implied values found for such stocks are usually close to zero. Only when market participants anticipate dividend payments in the future will implied dividends be significantly above zero.

There are 683 instances in the data set in which a company started to pay dividends after at least one year of no dividend payments. In these instances, there is some anticipation discernible from implied dividends ahead of time. Of these companies, the dividend valuation implied one quarter ahead amounted to a little over 30% of the newly installed dividend paid one quarter later. A quarter earlier, this had already reached 28% and three quarters before the payment the valuation reached 17%. For companies with LEAPS traded on their stock, dividend valuation going back even further could be obtained. However, there are only 19 instances of newly started dividend payments in the data set among such companies. In

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view of this small number, it is instructive to single out an example.

On 19 March 2012 Apple Inc. announced its intent to start paying dividends later in the year[14]. Figure 9 shows implied dividends for Apple priced into LEAPS expiring in January 2013. In the six months preceding the announcement, the implied dividend had already risen from zero to about $ 0.50 per share. Market participants adjusted their expectations, anticipating at least some dividend payment until the start of the year 2013, which is clearly reflected in option prices before the announcement was made.

Next to the uncertainty over dividend initiation itself, there is uncertainty over its timing. Figure 10 shows the Apple dividends implied from an option series which expires in July 2012, which is before the first payment went ex-dividend in August 2012. It is clear from the implied dividends in this series too that, during the first quarter of 2012, the market anticipated payment of dividends to start before the July expiry date of the option. But when Apple announced that the ex-dividend date would be in August, the implied dividend vanished from this expiry series. Market participants appear to have realized that payment was to occur after the option expired.

Following the announcement, the option implied dividend per share per quarter until January 2013 rose from about $0.50 first to about $1.25 and then to $2.00. The implied dividend remains lower than the announced level of $2.65 because the exact number of discrete dividend payments deviates from the model assumptions at the time of the press release on the 19^{th} of March.[15]

3 The predictive power of implied dividends

An obvious question is whether implied dividends have predictive power for actual dividends. The opinion that investors express about the value of future dividends as implied in option prices can be tested as an explanatory variable for the same dividends being paid later.

[14] Apple stated: "... the Company plans to initiate a quarterly dividend of $2.65 per share sometime in the fourth quarter of its fiscal 2012, which begins on July 1, 2012."

[15] Apple paid two dividends of $2.65 before the expiry of the January 2013 LEAPS. Since Apple didn't pay dividends up to that point, payments are modeled to occur 91 days, 182 and 273 days following the observation date. There are thus three payment dates over which to divide the present value of two anticipated dividend payments between the announcement on 19 March and 20 April, which is 273 days before the expiry of this LEAPS in January 2013. It is noteworthy, however, that after 20 April the implied dividend still doesn't reach the announced amount of $ 2.65.

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In the period 1996 to 2015, nearly 74,000 quarterly dividend payments were made by companies with stocks on which options were traded (Table 3). Most of the time companies leave dividend payments unchanged relative to the previous quarter, which confirms that a commonly accepted policy of dividend smoothing is widespread. Nonetheless, there are many instances of a change in dividend policy. Four types of policy changes are identified. In over 11,000 cases firms increase dividend, where in more than 2,000 cases they decreased it. At only 66 occurrences, firms terminating dividends are rare, and the majority of them go out of business not long after. In total 683 times a company started paying dividends, which is defined as a dividend payment following at least four quarters of non-payment.

At a quarterly rate of 0.79%, the dividend yield is on average highest in the last quarter for companies that make a payment before they cease to do so. Presumably a high yield reflects a low share price in which discontinuation of the firm is anticipated. The group of companies decreasing dividends, reduce it from a dividend yield of 0.66% to 0.48% (the median \$ cut is -46%). When they increase payment, the change is more modest from 0.55% to 0.62% (the median \$ increase is 11%). Companies initiating dividend payments are the most frugal relative to their stock price and introduce payment at a yield of 0.44%. The biggest group of companies leaves their dividends unchanged at a dividend yield of 0.57%. This pattern confirms that companies are careful to increase their dividends, but once it happens they act more determined.

The example of implied dividends anticipating Apple's dividend initiation in 2012 suggests that dividends implied by option prices are forward looking not only in theory, but also in practice. An interesting question is whether this relationship holds up across companies and through time. In particular, I investigate whether implied dividends provide information about future dividends over and above lagged dividends. Since dividend changes are often zero and do not show a continuous distribution, an ordered Probit estimation is pursued in addition to a standard OLS.

3.1 Predictive OLS regressions

If market participants were to predict dividend changes correctly, then the relationship between actual and implied dividend changes would be linear, with a coefficient equal to one and zero intercept. The following regression equation is a first attempt to test the hypothesis

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$$d_{j,t+n} = \alpha_t + \beta_t DG_{j,t,n} + \epsilon_{j,t} \tag{9}$$

The actual dividend change $d_{j,t+n}$ is defined as the relative change in the dividend paid n quarters following the observation quarter t for a given (portfolio of) stocks j

$$d_{j,t+n} = \frac{D_{j,t+n}}{D_{j,t}} - 1, \tag{10}$$

and the implied dividend change $DG_{j,t,n}$ is the dividend change for n quarters ahead relative to the observation quarter as implied by the data $PV_t(D_{j,t+n})$:

$$DG_{j,t,n} = \frac{PV_t(D_{j,t+n})}{D_{j,t}} - 1. \tag{11}$$

Implied dividends, at the same time, are valuations of future dividends and not objective expectations of future dividends (see equation (7)). The difference between the two is the dividend risk premium, which is not the subject of investigation here. Under the hypothesis that this risk premium is constant over time, it should surface as a non-zero intercept. However, if the dividend risk premium is time-varying, it may also show up in the coefficient of implied dividends. The appropriate hypothesis for testing the predictive content of implied dividends is that their relationship to actual dividends is close to linear with a coefficient close to one.

The implied dividend data are quite noisy. Figure 11 contains a scatter plot of actual and implied dividend changes two quarters ahead of the observation quarter. The plot shows that they are heavily scattered away from a hypothesized regression line of model (9), which is at least in part caused by measurement error at the stage of the calculations laid out in the previous section.

The plot also bears out that downward and upward dividend changes do not mirror each other. Under the model, downward changes should be concentrated in the southwest quadrant and upward changes in the northeast quadrant. For upward changes this appears reasonably clearly, but it is only barely visible for downward changes. As far as visible, downward changes align vertically close to zero implied dividend growth, while positive changes align horizontally slightly above zero actual dividend growth. Neither pattern fit well to model (9).

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To assess these patterns statistically in addition to the base model, upward and downward changes are separated and introduced as two different independent variables to an alternative model, as follows:

$$d_{j,t+n} = \alpha_t + \beta_{up,t} I_{DG>0} \times DG_{j,t,n} + \beta_{down,t} I_{DG<0} \times DG_{j,t,n} + \epsilon_{j,t}, \tag{12}$$

in which dummies $I_{DG>0}$ and $I_{DG<0}$ attain the value of 1 for a positive implied dividend change and a negative one respectively and 0 otherwise.

OLS regressions are run cross-sectionally for each quarter t of the data period of 1996 to 2015. This quarter-by-quarter approach allows for calculating standard errors of quarterly beta's, in a manner similar to Fama and MacBeth (1973). The predictive power of implied dividends is tested for n one to three quarters ahead, resulting in 77 to 79 regressions per n.

The estimated coefficients from the regressions of models (9) and (12) are displayed in Table 2. The averages of the coefficients of model (9) bear out that implied dividends do not forecast actual dividends very strongly. Only 7 to 10% of a change in implied dividends translates into actual dividend changes. The noisiness of the data may prevent a stronger relationship to appear, but even though these coefficients are small, they are significant, particularly for predictions two and three quarters ahead.

The alpha's in these regressions are close to but significantly larger than zero. There may be at least two explanations that implied dividend changes are smaller than actual dividend changes. Dividends increase throughout the data period, by on average 2.4% per quarter. Considering that only a fraction of such average change is picked up by implied dividends, the intercept reflects a substantial part of the average increase. A second explanation is that implied dividends are risk-neutral. If model (9) is true, while expected values of dividends coincide with their realization later, then the alpha would reflect the risk premium and the time value of money as a result of which a positive value is expected.

The test results of the alternative model (12) confirms the visual inspection of the data in Figure 11. Applying up and down dummies to implied dividend changes shows that negative predicted changes attract an unexpected negative sign and are small and not significant. Only positive changes demonstrate statistically relevant predictive power for actual dividends[16].

[16]The weakness of negative predictions is also reflected in an average R^2 of 0.35% for a model that only includes negative predictions (1.10% to 1.60% for model (12)).

Their coefficients come out slightly stronger than in the base model, which is to be expected given the filtering of the weak power present in downward changes. Market participants only reflect upward dividend changes in option implied dividends as dividend cuts remain largely unpredicted by implied dividends.

3.2 Predictive ordered Probit

The scatter plot in Figure 11 depicts another particularity of the relationship between actual and implied dividends. Dividends are set by company management and are thus discretionary in nature. The plot shows that firms often choose a "round percentage" for a dividend change, for example, minus 50%[17] or plus 50%. One in five dividend payments constitutes a change in the size of the payment, with increases occurring about five times as often as decreases (Table 3). At four out of five times, the most prevalent dividend change is therefore no change as also noted by Guttman, Kadan and Kandel (2010) and Baker, Mendel and Wurgler (2016). The last paid actual dividend is therefore highly relevant to the next payment due to the wide-spread policy of dividend smoothing.

While implied dividends may signal a change in future dividends, only when a change in actual dividends occurs will implied dividends be identified as relevant to future dividends. Moreover, any change in dividends tends to be large. The median increase amounts to about 11 percent while the median decrease is –46 percent (Table 3). If implied dividends predict a small change in actual dividends, it may often be too small to be effected by company management. Baker, Mendel and Wurgler (2016) note that this obscures a highly non-linear relationship where changes around zero occur much more frequently than larger movements. The high persistence in actual dividends thus presents a challenge to the linearity assumed in models (9) and (12).

Isolating the many zero-change occurrences in actual dividends in the data set requires a simple comparison of the number of instances in which a dividend change is correctly predicted by implied dividends. The north-east quadrant in Figure 11 contains correctly predicted increases, the south-west quadrant contains correctly predicted decreases and the other quadrants show incorrect predictions. A positive implied dividend, defined as an implied dividend value above its median, correctly predicts a future increase in dividends in

[17] Nearly one in four decreases is exactly minus 50%. Baker, Mendel and Wurgler (2016) discuss salience and round numbers in dividends and dividend changes in more detail.

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54 to 57% of the observed instances, depending on the horizon of the dividend implied. A decrease is predicted correctly by implied dividends below their median just about as often as it is predicted incorrectly (Table 4). This poor result for dividend cuts is matched by the weak explanatory power of implied decreases in the OLS estimates (Table 2).

The only other study of this relationship in the literature is by Fodor, Stowe and Stowe (2017). These authors investigate 389 dividend payments made by US companies in 2008 and 2009 and find that a bigger discount of an implied dividend relative to the previous dividend increases the likelihood that the dividend will be cut next time one is scheduled. Their findings are more conclusive and a possible reason is that the horizon at which they appraise the predictive power of implied dividends is five days and twenty days, whereas the data in this paper use implied dividends to predict at a horizon of two to three quarters. The example of Apple Inc. in Figure 9 demonstrates that six months ahead of their dividend initiation announcement, implied dividends did not signal a change in dividends but they clearly did in the month prior to the announcement[18].

The characteristics of the data set induces to order the actual dividends data set into categories. This is followed by Probit estimation which produces the probabilities of the dividends being changed as predicted by positive or negative implied dividends.

Actual dividend changes d are ordered into four categories: a middle no-change category that is identified as actual dividend growth close to zero, a decrease category and two increase categories for small and large increases. These categories are represented formally as follows:

$$y = \begin{cases} 1 & if \quad d \leq -0.01 \\ 2 & if \quad -0.01 < d \leq 0.01 \\ 3 & if \quad 0.01 < d \leq b \\ 4 & if \quad d > b \end{cases}$$

Actual dividend changes d are ordered into a category $y = 1$ for cuts, of which the upper boundary is set to -0.01. Zero changes are categorized separately in $y = 2$.[19] Small

[18]It is clear that the data set used by Fodor, Stowe and Stowe (2017) includes only a fraction of US firms that pay dividends and have options traded on their stock. In the data set used in this paper, the number of quartercompanies for 2008 and 2009 is more than 5.000.

[19]The purpose of the boundaries that define $y = 2$ is solely to isolate the zero-change instances into a separate category. Setting these boundaries to small fractions other than but close to -0.01 and 0.01 is not material to the results.

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increases are allocated to the third category $y = 3$ and large increases are allocated to the fourth category $y = 4$. Carving up increases serves to account for the wide-spread policy of dividend smoothing. Due to such policies, companies prefer to adjust dividends in small upward steps so that small dividend increases appear plentiful in the data set. They are captured when the increase is smaller than b, while increases larger than b populate a category of their own. Boundary b will be varied in order to exhibit the sensitivity of the parameter coefficients to it. Carving up the first category into one for small and large cuts is not material to the results due to the small number of small dividend cuts and because cuts are large more often than not.

Ordinal values y represent latent variable y^* which is a linear function of the model:

$$y^*_{j,t} = \beta_{up,t} I_{DG>0} + \epsilon_{j,t}. \tag{13}$$

The up-dummy $I_{DG>0}$ attains a value of 1 when implied dividends are larger than actual dividends and 0 otherwise. The probabilities of selecting one of the categories are equal to the probabilities of the latent variable falling into an estimated intercept (α_i) category. These probabilities then are equal to the standard cumulative distribution function Φ value of the estimated parameters

$$P(y = 1) = P(y^* \leq \alpha_1 | DG, \beta_{up}) = \Phi(\alpha_1 - \beta_{up} I_{DG>0})$$

$$P(y = 2) = P(\alpha_1 < y^* \leq \alpha_2 | DG, \beta_{up}) = \Phi(\alpha_2 - \beta_{up} I_{DG>0}) - \Phi(\alpha_1 - \beta_{up} I_{DG>0})$$

$$P(y = 3) = P(\alpha_2 < y^* \leq \alpha_3 | DG, \beta_{up}) = \Phi(\alpha_3 - \beta_{up} I_{DG>0}) - \Phi(\alpha_2 - \beta_{up} I_{DG>0})$$

$$P(y = 4) = P(\alpha_3 < y^* | DG, \beta_{up}) = 1 - \Phi(\alpha_3 - \beta_{up} I_{DG>0})$$

Coefficient β_{up} indicates the impact of a unit change in implied dividends on the probability of one of the categories occurring. The model is estimated using maximum likelihood for each quarter in the data set. The coefficients are then averaged over all quarters and their t-statistics are calculated following the method of Fama & MacBeth (1973), similar to the t-statistics in the OLS regression in the previous section. Regressions are performed for dividends one, two and three quarters ahead of the observation quarter.

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Results of the Probit estimation are shown in Table 5 for boundary value $b = 0.10$.[20] For one quarter ahead the intercepts are further removed from the distribution mid-point than for two quarters ahead and, in turn, they are further removed than for three quarters ahead (Panel A). A change in implied dividends thus signals a larger likelihood of predicting a change in actual dividends the further ahead such change is implied. A potential reason is that nearby dividend changes may be known as they are announced sometimes several months before the ex-dividend date.

The implied dividend coefficient β_{up} has the expected positive sign. The inference is that a change in implied dividends from negative to positive reduces the likelihood of actual dividends falling in *cut* category 1, and increases the likelihood of falling in category 4, in which dividends rise by more than b. The coefficient of positive changes varies between 0.056 to 0.090 over the three quarters horizon, differing statistically from zero based on Fama & MacBeth t-statistics.

Are these coefficients material to the probabilities of actual dividends moving from one category to another? The marginal effects of the coefficients in this Probit estimation are defined as the change in the likelihood of falling into a particular category in response to implied dividends pointing to an increase instead of a cut. Translating this marginal effect to the discrete character of the dummy-variable is performed by differencing the probability of a certain category of a dividend increase from a dividend cut

$$\delta P(\alpha_{i-1} < y^* \leq \alpha_i | \beta_{up} I_{DG>0}) = [\Phi(\alpha_i - \beta_{up} I_{DG>0}) - \Phi(\alpha_{i-1} - \beta_{up} I_{DG>0})] - [\Phi(\alpha_i) - \Phi(\alpha_{i-1})]$$

Panel B in Table 5 shows the probabilities of a category occurring in case of a negative implied dividend. For example, among observations of negative implied dividends, the probability of dividends actually being cut two quarters later is 0.047. Marginal effects on the likelihood of falling into the $y = 1$ (decreasing) or $y = 2$ (zero change) actual dividend category are negatively affected by implied dividend changes (Panel C in Table 5), as is determined by coefficient β_{up}. In the example given, if implied dividends move from negative to positive, the probability of dividends being cut two quarters later drops by 0.008 to 0.039 (Panel C). An implied dividend larger than actual dividend thus reduces the chance of falling into these categories and increases the chance of falling into the one of the two

[20]Figures 12 and 13 show marginal effects for other values of b.

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dividend increase categories $y = 3$ and $y = 4$.

The marginal effect of a positive implied dividend for an actual dividend change to fall in one of the positive categories is 2.1% to 2.7%. For dividend increases cut-off at 10%, the chances of falling into the increase $y = 4$ category above 10% is larger than to fall into the $y = 3$ small increase category. On average, a positive implied dividend hints at a larger increase in dividends rather than a small one.

Dividend smoothing is a policy practiced by company management to change dividends only slowly in response to earnings changes. Based on survey evidence, Lintner (1956) observes that many managements believe that most stockholders prefer a reasonably stable dividend rate and that they put a premium on stability or gradual growth in the rate. Survey evidence in Brav et al. (2005) shows that managers feel strongly that the penalty for reducing dividends is substantially greater than the reward for increasing them. Evidenced by survey data, companies often pursue a policy to smooth dividend payments as long as conditions regarding stable earnings, among others, are fulfilled (Brav et al., 2005). Together with a desire to avoid dividend cuts, such a policy leads to increases in dividends being more frequent but also smaller than dividend cuts.

It is worthwhile to find out whether smaller dividend increases, induced by regular policies, are indeed better predicted by implied dividends than larger ones that are more likely to reflect a one-off adjustment to the firm's structurally improved financial position. Cutting off the data set of dividend increases into two separate increase categories $y = 3$ and $y = 4$ serves this purpose.

The sensitivity of the marginal effect of a positive implied dividend to the value of the upper category boundary b is instructive (the results discussed thus far refer to $b = 0.10$. The marginal effect relative to the probability of a dividend falling into the $y = i$ category for decreasing implied dividends provides insight into the importance of moving from negative to positive implied dividends:

$$\frac{\delta P(\alpha_{i-1} < y^* \leq \alpha_i | \beta_{up} I_{DG>0})}{P(\alpha_{i-1} < y^* \leq \alpha_i | \beta_{up} I_{DG>0})} = \frac{[\Phi(\alpha_i - \beta_{up} I_{DG>0}) - \Phi(\alpha_{i-1} - \beta_{up} I_{DG>0})] - [\Phi(\alpha_i) - \Phi(\alpha_i - 1)]}{\Phi(\alpha_i) - \Phi(\alpha_{i-1})}.$$

Figures 12 and 13 shows this marginal effect conditional on boundary b for the two raise categories $y = 3$ and $y = 4$. A boundary b slightly above 1% constructs a narrow category $y = 3$, which involves that a positive implied dividend has a limited effect on improving the

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probability of predicting an increase correctly to that small raise category. Larger boundaries increase the size of the category and thus the probability of a raise falling into it, but the probability of predicting the small raise category increases more than proportionally up to a boundary of approximately 25%[21]. Predicting the large raise category deteriorates already at a small boundary. Consequently, a move from negative to positive implied dividends improves the chances of predicting a raise smaller than 25%. Raises larger than that are predicted better by implied dividends only marginally. The policy of firms to raise dividends at a steady moderate pace rather than in large jumps thus appears in market pricing.

4 Stock returns conditional on implied dividends

The central item of investigation is the relationship between the valuation of future dividends and expected returns in a cross-section of stocks. This section discusses the average portfolio returns in relation to dividend growth as well as to the combination of dividend growth and dividend yield. It closes with an investigation of stock price responses to announcements of changes in dividend policies.

The relevance of future dividends to stock prices is evident in the standard dividend discount model (DDM)

$$S_t = \sum_{n=1}^{\infty} PV_t(D_{t+n}), \tag{14}$$

which simply equates the value of a stock S_t to the sum of the present value PV_t of all dividends D_{t+n} that it is expected to pay at $t+n$.

In the framework of the DDM, cash returns on a stock R_{t+1} follow from the dividend yield and from price changes, and the latter is linked to actual dividends and the growth rate of future dividends as defined in equation (11).

$$R_{t+1} = D_{t+1} \sum_{n=1}^{\infty}(1 + DG_{t+1,n}) - D_t \sum_{n=1}^{\infty}(1 + DG_{t,n}) + D_{t+1}. \tag{15}$$

Consequently, whether dividends are valued to grow fast or slowly does not necessarily influence returns. If growth rates and dividends remain unchanged from one period to the

[21] The level difference between the proportional marginal effects of differing horizons shown in these figures is due to the differences found in the intercepts (Table 5).

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next, cash returns equal the dividend paid and the stock's price remains unchanged. Only if the dividend growth rate or the actual dividend changes can a stock's price change.

4.1 Portfolio returns before and after monthly single-sorting

A first step to investigate the claim that dividend growth affects returns is to visualize stock returns as a function of the valuation of future dividends. From July 1997 to June 2015, portfolios of stocks are sorted each month by implied dividend growth into quartiles. The horizon for implied growth is 5 to 7 months following the sorting month[22]. Returns are then calculated for the months surrounding the sorting month, from 12 months prior to sorting to 12 months following sorting. Portfolio returns are value-weighted. The data set contains only stocks for which dividend growth rates can be found. This means that stocks on which no options are traded and stocks of companies that pay no dividends are excluded. In the early years of the data period the returns of about 500 companies are available, by the end of the data period this has increased to over 1,000 companies.

In the first DG quartile, future dividends are valued consistently well below actual dividends at -26% and in the fourth quartile they are consistently valued above actual dividends at $+41\%$[23]. Such growth rates are large enough that objective growth $g_{t,n}$ in equation (7) should play a part. Very slow DG cannot reasonably be expected to be caused by high discounting values $r_{t,n} + \theta_{t,n}$ alone in the case of first quartile DG and very fast DG cannot reasonably be expected to be caused by low discounting values for the high DG quartile. Broadly speaking, dividends are expected to be cut in the first quartile and to be raised in the fourth quartile at an objective measure.

The main message emerging from this exercise is the return reversal at the point of sorting. Returns before sorting are low for slow DG stocks and high for fast DG stocks, which fits in with the DDM as anticipated in equation (15). Following sorting, however, the pattern is reversed (Figure 14, (a) and (d) respectively).

In the sorting month itself, stocks of which dividends are expected to be cut show average returns, but in the run-up to that point returns are poor. The average monthly return in the 12 preceding months is 0.66%, against 1.10% in the 12 months following sorting. A mirrored pattern is clear in the returns of the fast DG portfolio, showing an average of 1.57% before

[22]Other horizons do not materially change the estimation outcomes.

[23]Both on a average in the data set and at a horizon of 6 months.

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sorting and 0.80% after sorting. Second and third quartile DG portfolios return closer to average both before and after sorting.

The data shown in Figure 14 suggests that the relationship (15) between returns and dividends occurs throughout the preceding year, and in particular in the second to fourth month before sorting[24]. In the year-long run-up to sorting, high/low DG stocks outperform/underperform the market average by a cumulative 6.33%/−4.53%. This excellent/dismal performance of high/low DG stocks before sorting suggests that such stocks may have become expensive/cheap by some measure by the time of sorting. This raises the question whether the reversal pattern is a correction of irrational overshooting in the price of the stock, of which a discussion follows below.

4.2 Portfolio returns before and after monthly double-sorting

The dividend yield DY can be regarded as a measure of the expensiveness of a stock. Portfolios double-sorted on dividend growth and dividend yield shed some light on their interaction as relevant to returns and thus on reversal patterns. Figure 15 shows value weighted monthly returns of the first and fourth quartiles of DG/DY sorted portfolios. The low DY and fast DG portfolio returns in the months preceding sorting are substantial (1.81%) and they fall to below average following sorting (Panel (b)). Such return reversal does not appear for a high DY/fast DG portfolio (Panel (d)). If anything, this portfolio has somewhat higher returns following sorting.

The high DY/slow DG portfolio in Panel (c) shows a similar but opposite reversal pattern. Before sorting it performs poorly at only 0.20% per month and it reverses to a slightly above average return in the period following sorting. Again this contrasts starkly to slow DG portfolios that start from a low dividend yield (Panel (a)). Their returns are above 1.50% in months 12 to 6 preceding sorting, then drop to less than 0.50% in the remaining months up to sorting to bounce back to slightly above average in the period following sorting.

The return patterns found in the first and fourth quartile portfolios sorted by DG only in the previous subsection are sharpened when they are sorted by DY as well. If dividends

[24] The size of a dividend payment is often announced in the month preceding it. If an announcement is made to change dividends, then the stock has normally undergone the returns associated with the change in dividends in the month immediately before sorting. During the second to fourth month before sorting, first quartile DG stocks return as little as 0.35% per month, whereas fourth quartile DG stocks return 1.69%.

are expected to fall/rise, this negatively/positively influences returns contemporaneously, but much more so if dividend yield is high/low. The level of the dividend yield thus clearly matters to returns associated with fast or slow dividend growth.

A possible interpretation is that the potential for gains or losses in dividends influences returns. For example, a portfolio of high DY has more return from dividend to lose than a low DY portfolio. When market expectation is for dividends to fall, then returns are lower in the run-up to sorting of stocks with high dividend yields that have more to lose than of stocks with low dividend yields.

But this mechanism may be blurred: high DG stocks that are expensive, as measured by a low dividend yield, show strong returns in the run-up to sorting which cause them to stay expensive and remain or end up in the low DY quartile[25]. In such instances, actual dividends may have risen less, if at all, than stock prices gained. If that happens, their subsequent returns are low. The opposite is true for high DG stocks that are cheap as measured by a high dividend yield, and mutatis mutandis for low DG portfolios. Changes in dividend growth may cause stock prices to overshoot due to such prior returns. The tendency towards fair pricing following such a move is the reversal found.

Portfolios sorted by dividend yield alone produce future excess returns. (Fama and French 1993, Conover et al., 2016). Along the line of reasoning above, it may be not the dividend itself that affects subsequent returns, but irrational prior returns associated with dividend growth being at least partly reversed. If a stock rises in conjunction with fast dividend growth, the dividend yield falls if this rise is larger than the actual dividend increase. A low return following a low dividend yield might thus be nothing other than a reflection of a stock's expensiveness. This is not to rule out a rational explanation for the phenomenon, although that requires large moves in risk premiums.

4.3 Cross-sectional regressions

When investors change the valuation of expected dividends, the stock price as a present value of future dividends should change too if markets are efficient (15). I investigate empirically the connection between dividend growth and returns as well as its predictive power for future returns in a cross-sectional setting.

[25]In the months preceding sorting these stocks did not necessarily fall in the low DY quartile.

Stocks are sorted each quarter into 4 portfolios by the growth rate from actual dividends to implied dividends at a horizon of 6 months, as before. I refrain from using dividend growth rates per stock as regressors because the implied dividend data are noisy. The indicator for dividend growth change $I_{\Delta DG_{j,t}}$ is defined as a change in dividend growth quartile of stock j. Its value equals 1 if $DG_{j,t}$ increases in its quartile ranking from quarter $t-1$ to quarter t, it is -1 if the ranking decreases and is zero otherwise. The equation to test is as follows:

$$R_{j,t+i} = \alpha_t + \beta_t I_{\Delta DG_{j,t}} + \epsilon_{j,t}, \tag{16}$$

where $R_{j,t+i}$ are quarterly returns of stock j in quarter $t+i$ in excess of the data set average. This regression is run for each quarter in the data set from 1996 to 2015. The β_t and its t-statistic are calculated following the Fama-Macbeth method.

The contemporaneous return ($i = 0$) of an individual stock explained by a change in $DG_{j,t}$ quartile amounts to 0.72% during a quarter (Table 6, model 16) and this coefficient is highly significant. This result confirms that stock prices respond to implied dividends in line with the DDM[26]. The same can not be said for the power of a stock return prediction by the same variable. Dividend growth has a small impact on stock returns two quarters ahead ($i = 2$) with a coefficient not significantly different from zero.

I continue by differentiating the sensitivities of returns to up and down dividend growth. Work with this data set in the previous section suggests that downward and upward changes in actual dividends are not equally well predicted, and this asymmetry may occur for stock returns as well. To distinguish between up and down moves, I introduce dummies which capture upward, downward and zero changes in the DG quartile: $I_{\Delta DG_{j,t}>0} = 1$ if the DG quartile indicator increases from quarters $t-1$ to t, $I_{\Delta DG_{j,t}<0} = 1$ if it decreases and $I_{\Delta DG_{j,t}=0} = 0$ if remains unchanged[27]. The following model reflects this distinction:

$$R_{j,t+i} = \beta_{1,t} I_{\Delta DG_{j,t}>0} + \beta_{2,t} I_{\Delta DG_{j,t}<0} + \beta_{3,t} I_{\Delta DG_{j,t}=0} + \epsilon_{j,t}. \tag{17}$$

The regression results of this model indicate a similar relationship to stock returns re-

[26]At 1.3% the R^2 seems low, but this is quite reasonable given the large dispersion in individual stock returns and the measurement error in the regressor.

[27]Increases and decreases in dividend growth each account for 20% of a total of 46,564 dividend growth quarters in the data set.

gardless of whether dividends are implied to increase or to decrease. Both sensitivities are 0.72%, highly significant and very close to the coefficient in model (16) that does not make the distinction (Table 6, model 17). The quarters in which the dividends growth quartile does not change constitute about 60% of the data set. The dummy for these instances attracts a coefficient that is close to zero, which is as expected.

Lastly, I combine levels and changes in implied dividends as explanatory variables of stock returns to test whether the impact of a change in dividend growth depends on the level of dividend growth. The following model serves this purpose:

$$\begin{aligned} R_{j,t+i} = \alpha_t + \beta_{1,t} I_{\Delta DG_{j,t}} \times I_{DG=1} + \beta_{2,t} I_{\Delta DG_{j,t}} \times I_{DG=2} + \\ \beta_{3,t} I_{\Delta DG_{j,t}} \times I_{DG=3} + \beta_{4,t} I_{\Delta DG_{j,t}} \times I_{DG=4} + \epsilon_{j,t}. \end{aligned} \tag{18}$$

$I_{\Delta DG_{j,t}}$ is the quarterly change in the DG of stock j from $t-1$ to t, as before. $I_{DG=q}$ takes on the value 1 if DG falls in quartile q.

The results in Table 6 (model 18) show the differentiation in the sensitivities to the different levels of dividend growth as measured by quartiles for contemporaneous stock returns ($i = 0$). If it is either low or high (quartiles 1 or 4), the price response to a change in dividend growth is just under 1.00. If dividend growth is more muted (quartiles 2 and 3), the response is on average 0.40 smaller.

The interpretation of these results is as follows. Dividend growth in quartile 1 tends to be negative and in quartile 4 it tends to be positive. If dividend growth moves up ($\Delta DG_{j,t} > 0$) from a decreasing path ($DG_{j,t} = 1$), at least its decrease lessens, and if it moves down ($\Delta DG_{j,t} < 0$) from an increasing path ($DG_{j,t} = 4$), at least its increase lessens[28]. If either happens, stock prices react more strongly than when dividend growth is closer to unchanged in quartiles 2 and 3. Consequently, stock prices respond more sharply to a change in dividend growth when there is high dividend growth to be lost or low dividend growth to be increased[29].

To connect with the earlier findings about reversal, the same model is tested for its predictive power ($i = 2$). This regression shows the opposite relationship suggested by reversal, but it is weaker. The sensitivity of stock returns in quartiles 1 and 4 have the

[28]Note that $\Delta DG_{j,t}$ cannot be positive in quartile 4 and cannot be negative in quartile 1.

[29]A similar response is found when dividend yield replaces dividend growth as an interaction term in each of the regressors.

expected negative sign and returns are reversed by about 0.15% per quartile indicator over two quarters. Compared to the contemporaneous regression (model 18, $i = 0$), this sensitivity is a relevant proportion of the difference between their coefficients (0.94 and 0.97) and those of quartiles 2 and 3 (0.48 and 0.62). A meaningful degree of reversal thus appears to exist, although the coefficients of the first and fourth quartile regressors are not significant[30].

An et al. (2014) report that portfolios sorted by implied volatilities produce excess returns. They find that stocks with call/put options that have experienced increases in implied volatilities tend to have high/low future returns, which is attributed to informed traders. I suggest a different explanation for the phenomenon. These authors apply implied volatility data provided by OptionMetrics, which are calculated under the assumption that future dividends as inputs to the option pricing model are fixed and equal to actual dividends. As shown by other authors (for example Binsbergen et al., 2013, and Kragt, de Jong and Driessen, 2015), implied dividends often differ drastically from actual dividends. All other things equal, a price increase in a call option may be caused by an increase in implied volatility when implied dividends are fixed, or by a decrease in implied dividends when implied volatility is fixed. The results in this section are that future returns are high when implied dividends are low, which is therefore close to the results of An et al. (2014), albeit labeled differently[31]. But since they fix implied dividends, I argue with their interpretation that the return relationship to option prices is a consequence of a preference among informed investors to trade in option markets first, which then leads stock returns[32]. I contend that no inefficiency between markets is required for a predictive capacity of options: my results show that the relationship may run past implied dividends. Stock options contain information about dividends which drive returns, and are not necessarily a channel for returns themselves.

4.4 Stock price response to actual dividend changes

The degree of predictability of future dividends may be picked up in the response of the stock price to a change in dividend policy. If an announcement to change dividends is expected, then it should be reflected in the stock price before the fact. Larkin, Leary and Michaely

[30] Regressions including lagged returns as explanatory variables do not find cross-sectional relevance (not shown here).

[31] The authors strictly apply changes in implied volatility as a return predictor, not levels.

[32] Cremers and Weinbaum (2010) make a similar claim.

(2016) document that market reaction, measured as three-day stock return in absolute terms, to dividend reductions is more than double that of increases. They also find that institutional investors, mutual funds in particular, are more likely to hold dividend-smoothing stocks, but retail investors are less likely to do so. Dividend smoothing thus affects the composition of a firm's shareholders but, according to the authors, has little impact on its stock price.

The previous section documents that negative implied dividend growth has very little to say about actual dividends, while positive implied dividend growth does, and with the expected sign. Implied dividends thus indicate that investors do not see dividend cuts coming and may consequently be more surprised by them than in the case of increases. I investigate whether the difference in stock price responses between cuts and increases as well as the size of the response is connected with the expectations of future dividends that is part of the option implied valuation. I also test the impact on stock prices of dividend changes for being correctly or incorrectly predicted by implied dividends.

To establish the data sample, I identify all dividend changes of companies paying dividends at a quarterly rate in the period of 1996 to 2015 with stocks that have options traded on them as before. Following the approach of Grullon et al. (2002)[33], small changes due to rounding and recording of stock splits, as well as extreme observations, are eliminated by limiting the dividend announcements to those with absolute value of changes in quarterly common dividend per share between 12.5% and 500%. The sample is restricted to distribution events in which the declaration date is a non-missing trading date and there is no more than one dividend announcement made per event. For every dividend change, the three-day Cumulative Abnormal Return ($CAR_{j,t}$) is the sum of daily returns of the stock of the announcing firm j around the announcement ([-1,+1] trading days) minus the CRSP value-weighted market return. The implied dividends are calculated as the median of the ten trading days preceding the dividend announcement date.

The stock price response is regressed on the actual dividend changes d and implied dividend changes DG in the following model:

$$
\begin{aligned}
CAR_{j,t} = {} & \alpha_t + \beta_{1,t} I_{d<0} + \beta_{2,t} I_{d>0} \times d_{j,t} + \beta_{3,t} I_{d<0} \times d_{j,t} + \beta_{4,t} I_{DG<0} + \\
& \beta_{5,t} I_{d>0} \times I_{DG>0} + \beta_{6,t} I_{d>0} \times I_{DG<0} + \beta_{7,t} I_{d<0} \times I_{DG>0} + \beta_{8,t} I_{DG<0} \times I_{DG<0} + \epsilon_{j,t}, \quad (19)
\end{aligned}
$$

[33]Their approach is followed by Larkin, Leary and Michaely (2016) as well.

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from which parameters are included in the regression in several compositions. Results are presented in Table 7, showing only the two-quarter ahead implied dividends for ease of presentation. One and three quarter ahead implied dividends deliver broadly the same results, as usually different implied horizons jointly point to an increase or a cut.

Starting without implied dividends, the pattern found by Larkin, Leary and Michaely (2016) that dividends cuts weigh more on stock returns than dividends raises is repeated. The intercept shows a 0.7% three-day price return in response to dividend increases and a return of -1.6% for dividend cuts ($\alpha + \beta_1$, model (1)). Once the interaction of the size of the change is included, taking into account that the average cut μ_d is -0.42, the average response to a cut is about the same ($\alpha + \beta_1 + \beta_3 \times \mu_d$, model (2)). This data sample also shows that the impact of the size of dividend cuts on stock prices β_3 is ten times as large as that of dividend increases β_2[34].

Next I test whether implied dividends decrease the surprise impact of a dividend change on stock prices. If the implied dividend points to a dividend cut by means of a down-dummy $I_{DG<0}$ then the positive surprise impact is indeed reduced to -0.4% ($\alpha + \beta_1 + \beta_4$, model (3) versus -0.6%, model (2)). Statistically these results are not strong, the coefficient of the down-dummy is not significant and the R^2 does not improve once the dummy is included.

Will stock prices respond differently to a dividend change that is correctly predicted by implied dividends from one that is not? A direct test of this question is pursued in model (4) in Table 7, which deploys four interaction terms. The regressors capture the four possible scenarios when a dividend change occurs: a correctly predicted increase or cut and an incorrectly predicted increase or cut. The results point to a very clear distinction between the response to the kind of change. A dividend raise is followed by a positive three-day stock return of $0.6-0.7\%$ whether correctly predicted by implied dividends or not. A cut, however, causes a substantial drop in stock prices (-2.6%) if it is not anticipated by implied dividends. If the cut is predicted, the response is only -0.2%. The coefficient for unpredicted cuts is strongly significant and subsumes most of the impact of a dividend cut on stock returns (β_1).

In summary, as a predictor of stock returns around dividend announcement, implied dividends do not necessarily affect the impact from an announcement. But once implied dividends are used to predict dividend changes, it is the incorrectly predicted cuts that move stock prices. Taking this conclusion together with the earlier results leads to the following

[34] Larkin, Leary and Michaely (2016) report a ratio of four between dividend cuts and increases.

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interpretation on the element of surprise from changing dividends. Testing equation (12) shows that increased dividend payments are significantly predicted by implied dividends, whereas dividend cuts are not. It is reasonable to presume that the expectations contained in implied dividends also prevail in the valuation of stocks; if market participants have reason to anticipate that a firm will raise dividends, then they will reflect this in the equilibrium price of its stock as well as in its dividends. Once the firm delivers on a higher dividend, the stock price may be unmoved by this fact alone. Since dividend cuts are not well predicted by implied dividends, a dividend cut usually is a surprise causing a stock's price to drop.

Larkin, Leary and Michaely (2016) find an explanation for the large negative response to dividend cuts in controlling for whether firms have cut at least once before. If they have, then the absolute impact on the stock price is about equal for an increase or a cut. A previous cut raises the awareness to the possibility of another cut in the future, reducing the element of surprise if a subsequent cut occurs. Their argument is thus similar to implied dividends predicting a dividend change: the announcement effect on stock prices reduces if there is reason to be less surprised about it.

5 Conclusion

There is a lot of information about the valuation of future dividends of individual firms to be gained from option prices. This study is the first to present a methodology to extract dividend valuations from option prices and and to apply the data found to their predictive power for dividends and stock returns.

A novel element in this methodology is that it clears the hurdle of dealing with the early exercise premium that is not present in index options but is an element of value in American style options of US stocks. The Cox, Ross and Rubinstein (1979) binomial tree takes account of this premium and the tree is constructed simultaneously for a pair of put and call options with otherwise equal characteristics by guessing the same values for implied dividends and implied volatilities for the put and call pricing models. Analyzing dividends from stock options thus implied reveals their predictive power and adds to the understanding of cross-sectional stock returns.

In view of these results, there is good reason to pursue further research on implied dividends. The first is to improve on the methodology itself and find additional means to

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validate the data. Investigation of the relationship with actual dividends and stock prices can be done at a more detailed level, notably at a daily frequency to check for price pressures. Other tracts of research can involve firm characteristics and their relationship to implied dividends. Idiosyncratic risk isolated from systemic risk may be referenced in the context of a CAPM. An obvious pursuit for this is to construct a factor based on implied dividends and establish whether portfolios of high implied dividends produce high or low stock returns.

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6 Appendix

6.1 Aggregation of daily implied dividends into quarterly buckets

The daily dollar value of the implied dividend as found in the minimization of equation (8) is divided by the stock price of the day. This daily implied dividend yield is then averaged over the period from the first day following the third Friday in a given month until and including the third Friday of the next month. Constructing months this way guarantees that averages refer to the same option expiry date. Only if an implied dividend falls before an expiry date is it included in the option price. If it is paid after the expiry date it is not, even though it may still occur in the same calendar month. Hence the redefinition of months. The average is calculated after dropping the two most extreme values in each month.

The next step in the reduction of the data frequency is to bucket the values for each three months into a quarterly dividend yield. This involves taking an average again, but the horizon of the three implied dividends is not constant and it is therefore appropriate to interpret these as buckets instead of averages. Quarterly buckets are only taken if daily solutions for implied values exist for at least 75% of the days of the quarter. Equipped with quarterly dividend yields, a growth rate with a quasi-constant horizon is calculated, starting from a dividend actually paid in a given quarter to implied dividends in the ensuing quarters. A quarterly data set has the added benefit that it brings the frequency of the dividends implied in line with the dividend payment frequency that is the most prevalent among US companies. Lastly, I assume that any distortion in implied dividends due to inventory imbalances among market makers, asymmetric information or fixed cost is of constant mean over the daily implied values averaged to quarterly buckets.

6.2 Stock loan fees and robustness

The PCP relationship contains all instruments relevant to an investor wishing to run a portfolio of options. However, market makers in particular use long and short positions in stocks as well to hedge their exposure to stock prices as a result of their option book. In cases where such market participants take short positions in the stock, they need to take into account the cost of doing so. D'Avolio (2002) documents that these stock loan fees amount to 25 basis points per annum on average. In his sample 91% of all stocks are not hard-to-borrow, and these can be borrowed at a running cost of 17 basis points.[35]

If cash income from stocks not only appears as dividends, this should be incorporated in the PCP. It is straightforward to add loan fees f_t to the dividend $PV_t(D_{t+n})$ paid by the company on its shares. The left-hand side of the PCP as depicted in equation (3) is thus expanded with fees as follows

$$PV_t(D_{t+n}) + S_t(e^{f_{t,n}} - 1) = S_t + p_{t,n} - c_{t,n} - Ke^{-r_{t,n}}, \tag{20}$$

which, for small $f_{t,n}$, approximately equals

$$PV_t(D_{t+n}) = S_t e^{-f_{t,n}} + p_{t,n} - c_{t,n} - Ke^{-r_{t,n}}. \tag{21}$$

Market data for stock loan fees are available and they can in principle be included in the minimization in (8). However, stock loan fees may be adjusted throughout the period that the stocks are on loan. Stock lenders and borrowers may terminate lending at any point in time (Avellaneda and Lipkin, 2009). As a consequence, the actual cost of borrowing a stock is not precisely captured by loan fee data. Moreover, fees in the PCP in equation (21) presume a cost for borrowing stocks throughout the life of the option, whereas the typical period for borrowing stocks is measured in days. In the data sample, option expiries extend out to over two years. As a consequence, market data about fees that represent the actual cost anticipated for borrowing stocks until the expiry date of particular options do not exist and including fees in the PCP would require unverifiable assumptions about their future value.

An alternative route to take account of stock loan fees is to imply them in a manner similar to implied dividends. The minimization in (8) is performed on two equations, allowing for two unknowns: implied volatility and implied dividend. To find another implied variable is feasible by expanding the number of option pairs in the minimization from one to two. The two pairs are the same except for the strike, which increases the number of unknowns by a third variable: the implied volatility of the second option pair. The number of equations,

[35] These stocks are *General Collateral*, which are all loaned at the same fee since they are readily available and the fee only needs to compensate for the service of stock lending. Stocks that are hard-to-borrow are loaned at a sometimes much higher fee, which makes up for the difference between the average fee of all stocks and the General Collateral fees documented by Avellaneda and Lipkin (2009).

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however, is increased from two to four, thus allowing for a fourth variable to be estimated as well: implied stock loan fees. Similar to dividends, the stock loan fee refers to the share and not the options. Therefore, the stock loan fee is the same for the modeled prices of both option pairs and can be implied as a fourth variable. The fact that they can be identified separately from dividends is due to the fact that stock loan fees are deemed continuous, whereas dividends are paid discretely.

In order to find implied stock loan fees, two pairs of call and put options are identified that have the same characteristics except for the strike instead of one pair of options. The modeled prices of all four options share the same implied dividend and implied stock loan fee. For each option pair with the same strike volatilities are implied separately from each other. This leads to four unknown variables to be implied: dividend, stock loan fees and the volatility of the first pair and the volatility of the second pair. F is a function of all four:

$$F = (p_{t,n,k} - \hat{p}_{t,n,k})^2 + (c_{t,n,k} - \hat{c}_{t,n,k})^2 + (p_{t,n,k+1} - \hat{p}_{t,n,k+1})^2 + (c_{t,n,k+1} - \hat{c}_{t,n,k+1})^2, \quad (22)$$

and is minimized as follows. Each model price is calculated starting by guessing values for the four unknown variables which serve as input to the CRR binomial tree. The four model prices are compared to their market prices in equation (22) after which new values are guessed until convergence of model and observed prices.

The procedure is performed for option pairs with strikes that are next to each other. For example, if there are 6 adjacent strikes available of options with the same expiry date, the minimization is performed on option pairs with strikes 1 and 2, 2 and 3, and so on, until strikes 5 and 6. The implied values for dividends and stock loan fees represented as the output of the minimization procedure are the medians of the five values implied. They are aggregated to quarterly averages in the same way as implied dividends, explained in the main text.

The implied stock loan fees produced by the minimization are shown in Figures 16 and 17. Throughout the data period, the fees move between 15 and 20 bppa up to two quarters ahead and slightly lower in the quarters beyond. Implied fees for different expiries move in conjunction with each other.

The levels of the implied fees come close to the market data for General Collateral fees of 17 bppa documented by D'Avolio (2002). The fact that implied fees move in a tight range reflects that investor opinions about future fees change little compared to current fees as time passes. This is confirmed by the term structure of implied stock loan fees in Figure 18. Its slope is negative but shallow. If average stock loan fees do not change much over time, investors may be motivated to make an assumption to this effect in the pricing of options.

Cross-sectional dispersion is shown in Figure 19. The breakpoint for the decile with smallest implied stock lending fees stands at 12 bppa against 22 bppa for the decile with the largest fees. Such a difference is not substantial. Stocks that are hard-to-borrow can require fees for several percentage points per annum (Avellaneda and Lipkin, 2009) and the largest decile would be expected to have a higher breakpoint. However, such fees occur more often for small stocks (Avellaneda and Lipkin, 2009) and these are less likely to be present in this database consisting only of stocks that have options traded on them. Moreover, in the minds of investors high fees do not necessarily remain high for a prolonged period. Implied fees represent their expectations of stock lending until expiry of the options, which may be led more by the average of fees than by the fee of a particular stock that happens to be in demand.

As implied stock loan fees do not show large dispersion, their effect on the dispersion of implied dividends should be small. Implied dividends which are calculated while taking account of stock loan fees according to (21) indeed show very similar patterns and levels as those calculated without regarding fees. Although the minimization method to find implied dividends appears robust to the inclusion of fees, I chose to omit them in this paper. The interpretation of implied dividends is thus to include stock loan fees throughout this paper.

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Table 1: **Option and LEAPS Distribution and Dividend Payment Frequencies**

Prevalence of options and dividend payment frequencies for US stocks traded from 1996 to August 2015. A quartercompany is a quarter of daily data in which at least 45 trading days of options are available for a given stock.

Panel A: Excluded from the data set are options of which OptionMetrics does not provide implied volatilities and with maturities shorter than three months. LEAPS are options with a maturity at start of at least two years.

Panel B: Payment frequency of dividends per quartercompany. The data set includes options of stocks with quarterly dividend frequencies only.

	Number of Quartercompanies
Panel A: Prevalence of options	
Stocks total	238,964
Stocks without options	85,375
Stocks with options	153,589
Stocks with LEAPS	39,389
Stocks without LEAPS	114,200
Panel B: Dividend frequency of stocks with options	
Any	153,589
Annual	813
Semi-annual	2,284
Quarterly	78,623
Monthly	531
None paid	71,338

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Table 2: **Predictive regressions of actual dividend changes on implied dividend changes.**

Actual n-quarter dividend change is defined as the growth rate of a dividend paid n quarters ahead of the observation quarter t for a given company j: $d_{j,t+n} = \frac{D_{j,t+n}}{D_{j,t}} - 1$. Implied dividend change is defined as the value in quarter t of the dividend implied by option prices for quarter $t+n$ relative to the actual dividend paid in quarter t: $DG_{j,t,n} = \frac{PV_t(D_{j,t+n})}{D_{j,t}} - 1$. For each quarter in the data set the regression equation is estimated for one, two and three quarters ahead. The coefficient estimates are averaged over t and their t-stats are calculated by dividing the average coefficient values by their standard deviation, multiplied by the square root of the number of quarters. The t-statistics are reported in parentheses. The estimated equations are:

$$d_{j,t+n} = \alpha_t + \beta_t DG_{j,t,n} + \epsilon_{j,t+n}$$

$$d_{j,t+n} = \alpha_t + \beta_{up,t} I_{d>0} \times DG_{j,t,n} + \beta_{down,t} I_{d<0} \times DG_{j,t,n} + \epsilon_{j,t+n}$$

	Number of quarters ahead of implied dividends					
	1		2		3	
Intercept	0.004	0.002	0.018	0.016	0.037	0.029
	(0.97)	(0.33)	(4.95)	(4.27)	(6.26)	(5.04)
β_t	0.097		0.102		0.168	
	(2.38)		(6.68)		(5.88)	
$\beta_{up,t}$		0.100		0.105		0.184
		(2.37)		(6.55)		(6.04)
$\beta_{down,t}$		-0.015		-0.002		-0.062
		(-0.77)		(-0.08)		(-1.87)
R^2	0.009	0.011	0.011	0.014	0.012	0.016

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Table 3: **Prevalence of dividend changes.**

Panel A describes the number of quarterly dividend changes and their median and average size for five different types of dividend changes from 1996 to 2015 in US listed stocks that have options traded on them. Panel B shows the average dividend yield during the quarter before the quarter in which the dividend payment was made or terminated. Panel C shows the same for the quarter in which the dividend payment was made or terminated. The definitions for dividend changes made by Baker and Wurgler (2004, p 1134) partly coincide. Initiations as defined here equal new and list dividend payers, while Terminations equal new non-payers in Baker and Wurgler (2004).

Panel A	Increases	Decreases	Initiations	Terminations	Unchanged	Total
Number	11,564	2,357	683	66	59,211	73,881
Median change (%)	10.81	-45.71		-100	0	0
Average change (%)	24.16	-42.32		-100	0	2.46
Panel B	*Quarter before dividend change*					
Average Dividend Yield	0.55	0.66		0.79	0.57	0.57
StDev	0.37	0.54		0.60	0.40	0.40
Panel C	*Quarter of dividend change*					
Average Dividend Yield	0.62	0.48	0.44		0.57	0.57
StDev	0.38	0.43	0.39		0.41	0.41

Table 4: **Correctly and incorrectly predicted dividend changes.**

The table shows the number of instances in the data set of correctly and incorrectly predicted dividend changes (zero-changes are excluded) and the fraction of correct and incorrect predictions. Correct implied dividend predictions of non-zero changes in actual dividends are defined as follows: if an n-quarter ahead implied dividend at time t is higher than its median and the n-quarter ahead actual dividend of the corresponding firm is increased relative to the actual dividend at time t, then the implied dividend correctly predicts the increase. Correctly predicted dividend cuts are determined similarly but in the downward direction. Incorrectly predicted dividend changes occur when the implied dividend points to an increase while a decrease materializes and vice versa. Definitions of implied and actual dividend changes are as before.

	1 quarter ahead		2 quarters ahead		3 quarters ahead	
	Number	Fraction	Number	Fraction	Number	Fraction
Correct increases	4,807	0.577	8,790	0.573	11,118	0.545
Correct decreases	795	0.497	1,404	0.507	1,850	0.510
Incorrect increases	3,531	0.423	6,546	0.427	9,295	0.455
Incorrect decreases	805	0.503	1,365	0.493	1,779	0.490
Total	9,938		18,105		24,042	

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Table 5: **Ordered Probit estimations of actual dividend changes on implied dividend changes.**

Ordinal values y represent latent variable y^* which is a linear function of the model: $y^*_{j,t} = \beta_{up,t} I_{DG>0} + \epsilon_{j,t}$. The up-dummy $I_{DG>0}$ attains a value of 1 for values of $DG_{j,t,n}$ larger than 0, which means that the implied dividend is higher than the actual dividend paid in quarter t, and 0 otherwise. Actual dividend changes d are ordered into categories as follows:

$$y = \begin{cases} 1 & if \quad d \leq -0.01 \\ 2 & if \quad -0.01 < d \leq 0.01 \\ 3 & if \quad 0.01 < d \leq b \\ 4 & if \quad d > b \end{cases}$$

Probabilities of falling into category $y = i$ are given by:

$$P(y = i) = P(\alpha_{i-1} < y^* \leq \alpha_i | \beta_{up} I_{DG>0}) = \Phi(\alpha_i - \beta_{up} I_{DG>0}) - \Phi(\alpha_{i-1} - \beta_{up} I_{DG>0})$$

for $y = [1, 4]$, and where Φ is the cumulative normal distribution function. The coefficients indicate the impact of a unit change in implied dividends on the probability of one of the categories occurring.
The increase in the likelihood of falling into category i due to a positive implied dividend is calculated by deducting the likelihood of a cut falling into a category i from the likelihood of an increase falling into that category:
$\delta P(\alpha_{i-1} < y^* \leq \alpha_i | \beta_{up} I_{DG>0}) = [\Phi(\alpha_i - \beta_{up} I_{DG>0}) - \Phi(\alpha_{i-1} - \beta_{up} I_{DG>0})] - [\Phi(\alpha_i) - \Phi(\alpha_{i-1})]$
Panel A describes the coefficients of the Probit estimation, t-statistics are reported in parentheses. Panel B shows the probabilities of a category occurring when implied dividends are negative. Panel C contains the marginal effects of a move in implied dividends from negative to positive on the probability of falling into category $y = i$. Boundary b is set to 0.10.

		Number of quarters ahead of implied dividends		
		1	2	3
Panel A	$\hat{\alpha}_{1,t}$	-1.855	-1.596	-1.442
		(-73.40)	(-55.09)	(-45.91)
	$\hat{\alpha}_{2,t}$	1.077	0.630	0.297
		(48.06)	(24.95)	(10.84)
	$\hat{\alpha}_{3,t}$	1.465	1.095	0.843
		(54.18)	(33.20)	(21.09)
	β_{up}	0.090	0.080	0.056
		(6.48)	(4.98)	(3.29)
Panel B	Probability of category y being chosen for negative implied dividends ($\beta_{up} = 0$)			
$d \leq -0.01$	$y = 1$	0.026	0.047	0.067
$-0.01 < d \leq 0.01$	$y = 2$	0.812	0.662	0.528
$0.01 < d \leq 0.10$	$y = 3$	0.077	0.136	0.189
$d > 0.10$	$y = 4$	0.085	0.155	0.216
Panel C	Marginal effect from a move in implied dividends from negative to positive			
$d \leq -0.01$	$y = 1$	-0.006	-0.008	-0.008
$-0.01 < d \leq 0.01$	$y = 2$	-0.015	-0.018	-0.014
$0.01 < d \leq 0.10$	$y = 3$	0.008	0.009	0.006
$d > 0.10$	$y = 4$	0.013	0.018	0.016

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Table 6: **Cross-sectional regressions of excess returns on dividend growth.**

Each quarter in the period 1996-2015 portfolios are formed by sorting stocks on dividend growth (DG). Excess returns $R_{j,t+i}$ are defined as their returns above the quarter average, i quarters ahead of the observation quarter. These excess returns are regressed on DG in three equations, in which $I_{\Delta DG_{j,t}}$ is a change in the DG quartile ranking equal to 1 if the change from quarter $t-1$ to t is upward and -1 if it is downward, $I_{\Delta DG_{j,t}>0}$ equals 1 if $\Delta DG_{j,t}$ is positive, $I_{\Delta DG_{j,t}<0}$ equals 1 if $\Delta DG_{j,t}$ is negative and $I_{\Delta DG_{j,t}=0}$ equals 1 if ΔDG is unchanged. Regressions are performed each quarter. The coefficients reported are calculated as the average of the quarterly coefficients, the t-statistics are averaged multiplied by the square root of the number of regressions performed (78 for $n = 0$) (Fama and MacBeth, 1973). The R^2 reported are the average of the quarterly R^2.

$$R_{j,t+i} = \alpha_t + \beta_t I_{\Delta DG_{j,t}} + \epsilon_{j,t} \tag{16}$$

$$R_{j,t+i} = \beta_{1,t} I_{\Delta DG_{j,t}>0} + \beta_{2,t} I_{\Delta DG_{j,t}<0} + \beta_{3,t} I_{\Delta DG_{j,t}=0} + \epsilon_{j,t} \tag{17}$$

$$\begin{aligned} R_{j,t+i} = \alpha_t + \beta_{1,t} I_{\Delta DG_{j,t}} \times I_{DG=1} + \beta_{2,t} I_{\Delta DG_{j,t}} \times I_{DG=2} + \\ \beta_{3,t} I_{\Delta DG_{j,t}} \times I_{DG=3} + \beta_{4,t} I_{\Delta DG_{j,t}} \times I_{DG=4} + \epsilon_{j,t} \end{aligned} \tag{18}$$

	(16)		(17)		(18)	
	$i = 0$	$i = 2$	$i = 0$	$i = 2$	$i = 0$	$i = 2$
Intercept	-0.001	-0.001			0.001	-0.013
	(-0.33)	(-0.32)			(0.01)	(-0.10)
$I_{\Delta DG_{j,t}}$	0.718	-0.067				
	(13.08)	(-1.39)				
$I_{\Delta DG_{j,t}>0}$			0.716	-0.052		
			(11.45)	(-0.97)		
$I_{\Delta DG_{j,t}<0}$			-0.724	0.083		
			(-12.13)	(1.43)		
$I_{\Delta DG_{j,t}=0}$			0.004	-0.018		
			(0.19)	(-0.68)		
$\Delta DG_{j,t} \times (DG_{j,t} = 1)$					0.935	-0.148
					(9.07)	(-1.59)
$\Delta DG_{j,t} \times (DG_{j,t} = 2)$					0.483	-0.068
					(6.90)	(-0.86)
$\Delta DG_{j,t} \times (DG_{j,t} = 3)$					0.618	0.061
					(7.80)	(0.84)
$\Delta DG_{j,t} \times (DG_{j,t} = 4)$					0.975	-0.162
					(8.25)	(-1.43)
R^2	0.013	0.003	0.015	0.005	0.020	0.009

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Table 7: **Stock price response to dividend announcements.**

The dependent variable $CAR_{j,t}$ is the stock price response to dividend change announcements, defined as the return of a stock on which a dividend change is announced during the three days around the announcement [-1,1] minus the CRSP value-weighted market return. Actual n-quarter dividend change is defined as the growth rate of a dividend paid n quarters ahead of the observation quarter t for a given company j: $d_{j,t+n} = \frac{D_{j,t+n}}{D_{j,t}} - 1$. Implied dividend change is defined as the value in quarter t of the dividend implied by option prices for quarter $t+n$ relative to the actual dividend paid in quarter t: $DG_{j,t,n} = \frac{PV_t(D_{j,t+n})}{D_{j,t}} - 1$. Dummies $I_{d>0}/I_{d<0}/I_{DG>0}/I_{DG<0}$ take on the value 1 when actual (D_t) or implied ($PV_t(D_{j,t+n})$) dividends are increased/cut and are 0 otherwise. The regressions are performed by including either dummies or the interaction of the parameters with dummies. The t-statistics are reported in parentheses.
The estimated equations are:

$$CAR_{j,t} = \alpha + \beta_1 I_{d<0} + \beta_2 I_{d>0} \times d_{j,t} + \beta_3 I_{d<0} \times d_{j,t} + \beta_4 I_{DG<0} + \beta_5 I_{d>0} \times I_{DG>0} + \beta_6 I_{d>0} \times I_{DG<0} + \beta_7 I_{d<0} \times I_{DG>0} + \beta_8 I_{DG<0} \times I_{DG<0} + \epsilon_{j,t}$$

	(1)	(2)	(3)	(4)
Intercept	0.007	0.006	0.005	
	(6.82)	(4.62)	(3.52)	
$I_{d<0}$	-0.023	-0.007	-0.006	
	(-11.38)	(-1.35)	(-1.25)	
$I_{d>0} \times d$		0.003	0.003	
		(1.74)	(1.71)	
$I_{d<0} \times d$		0.030	0.030	
		(3.49)	(3.49)	
$I_{DG<0}$			0.002	
			(0.90)	
$I_{d>0} \times I_{DG>0}$				0.006
				(2.03)
$I_{d>0} \times I_{DG<0}$				0.007
				(4.08)
$I_{d<0} \times I_{DG>0}$				-0.026
				(-8.81)
$I_{d<0} \times I_{DG<0}$				-0.002
				(-0.52)
R^2	0.021	0.024	0.024	0.016

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Figure 1: **Average actual and implied dividend yields.** Data are shown over the 1996-2015 data set for a given number of quarters ahead of the observation quarter for all firms (value-weighted) with and without LEAPS traded on their stocks.

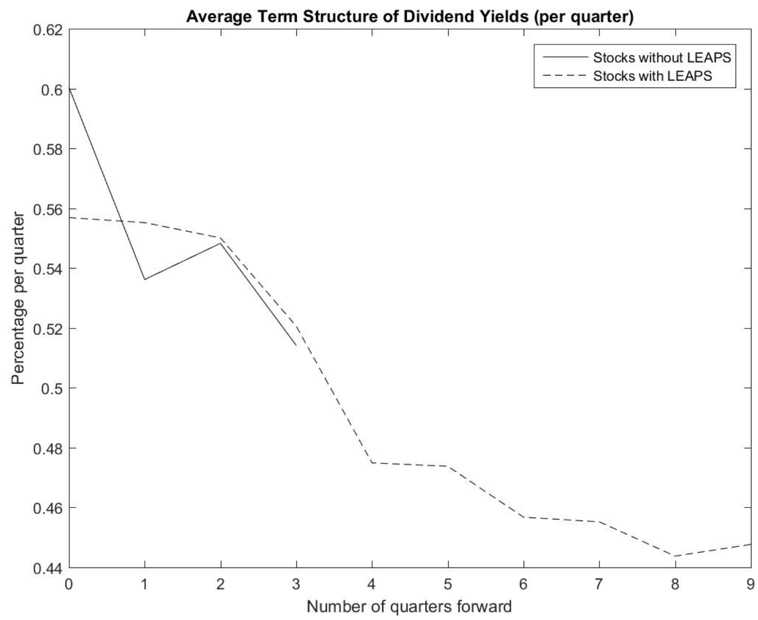

Figure 2: **Decile breakpoints of current quarterly dividend yields for all quartercompanies.**

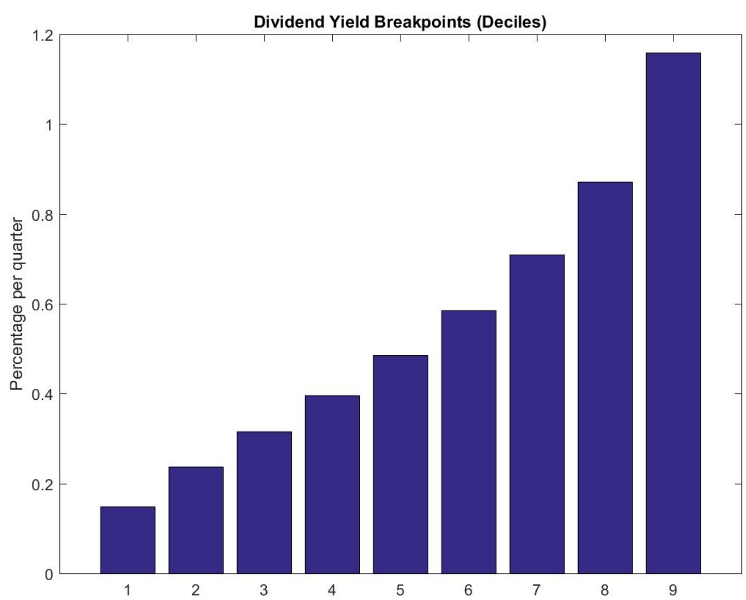

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Figure 3: **Dividend yields per quarter, current, 1 quarter ahead and 1 to 2 quarters ahead.** Yields are value-weighted over all firms who pay dividends at a quarterly rate.

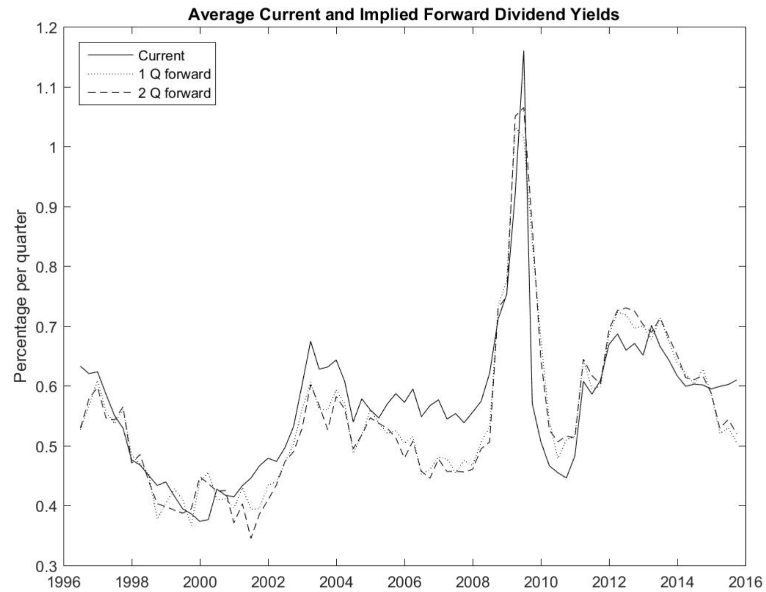

Figure 4: **Dividend yields per quarter, current, 1 to 3 quarters ahead and 1 to 8 quarters ahead.** Yields are value-weighted over all firms who pay dividends quarterly.

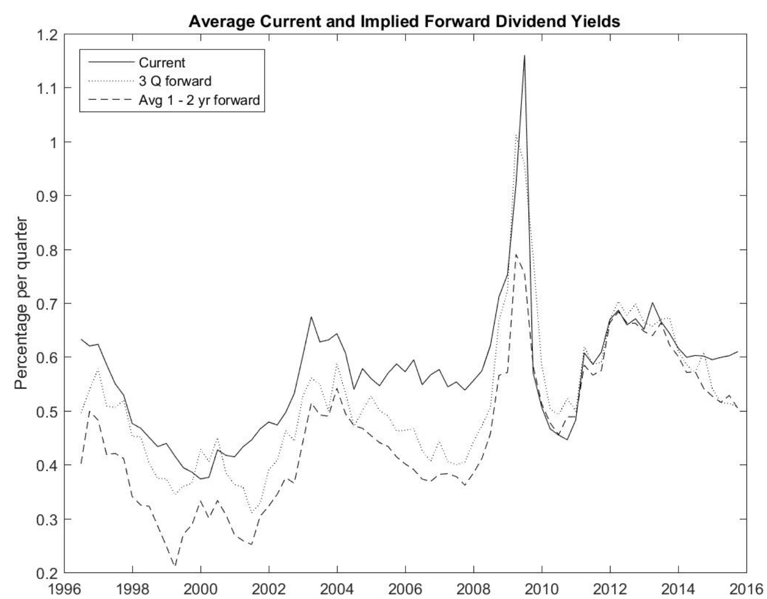

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Figure 5: **Implied dividend growth rates 1 quarter ahead and 1 to 2 quarters ahead relative to current dividends.** Growth rates are value-weighted over all firms who pay dividends at a quarterly rate.

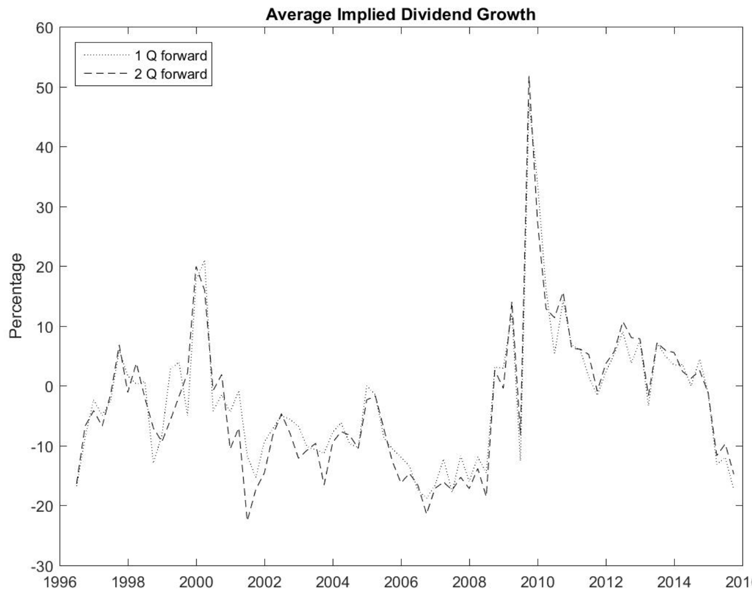

Figure 6: **Implied dividend growth rates 1 to 3 quarters ahead and 1 to 8 quarters ahead relative to current dividends.** Growth rates are value-weighted over all firms who pay dividends quarterly.

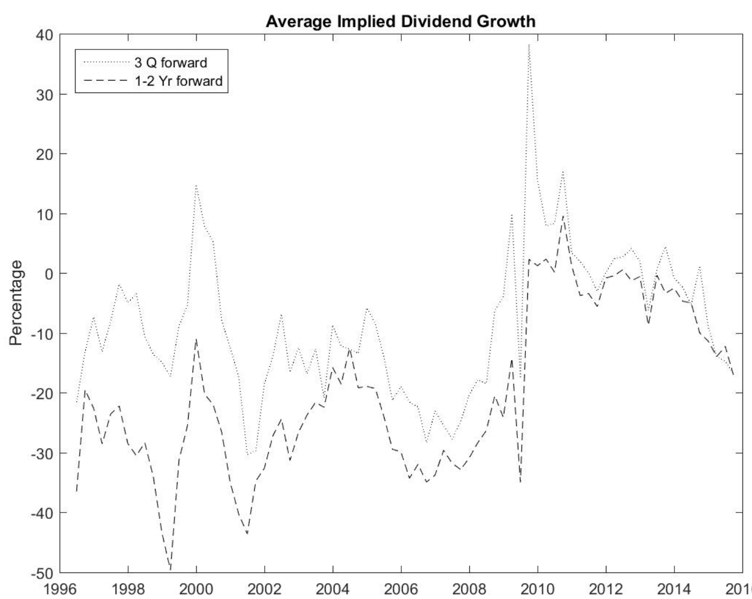

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Figure 7: **Decile breakpoints of implied dividend growth rates for 1 quarter ahead and 1 to 2 quarters ahead for all quartercompanies.**

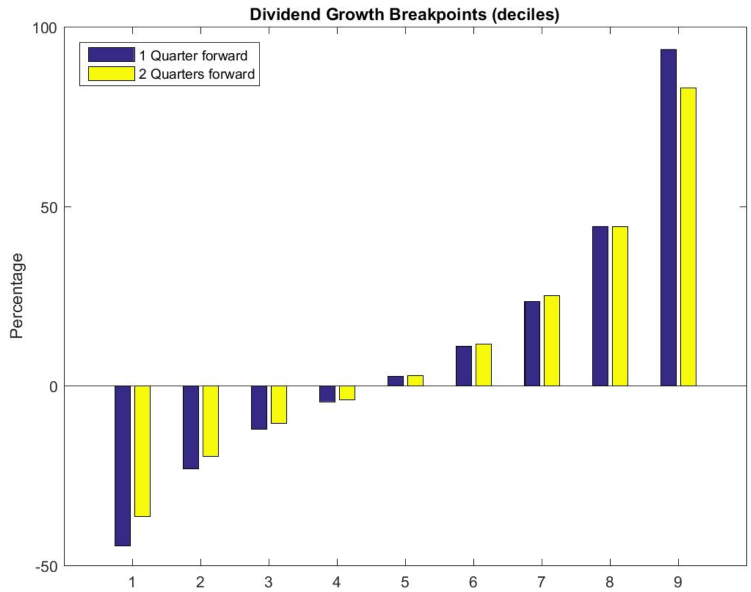

Figure 8: **Decile breakpoints of implied dividend growth rates for 1 to 3 quarters ahead and 1 to 8 quarters ahead for all quartercompanies.**

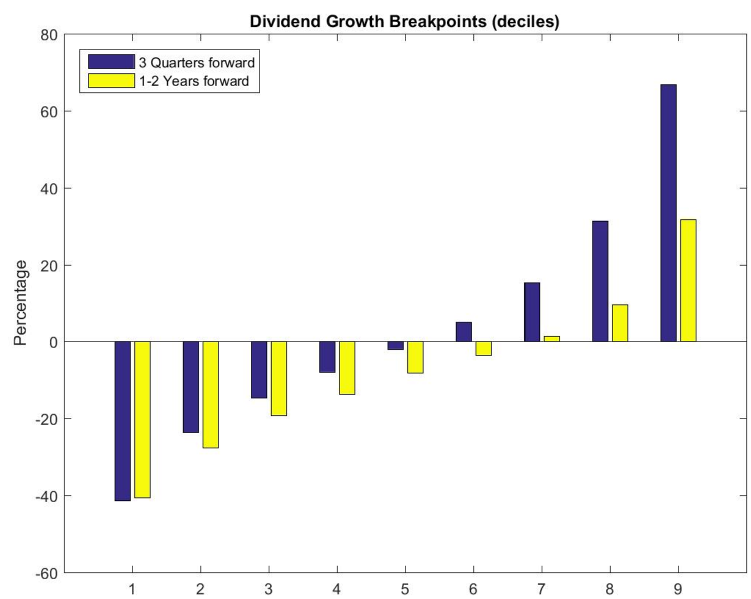

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Figure 9: **Apple Inc. dividends as implied by the LEAPS expiring in January 2013.** Normalized to a quarterly rate.

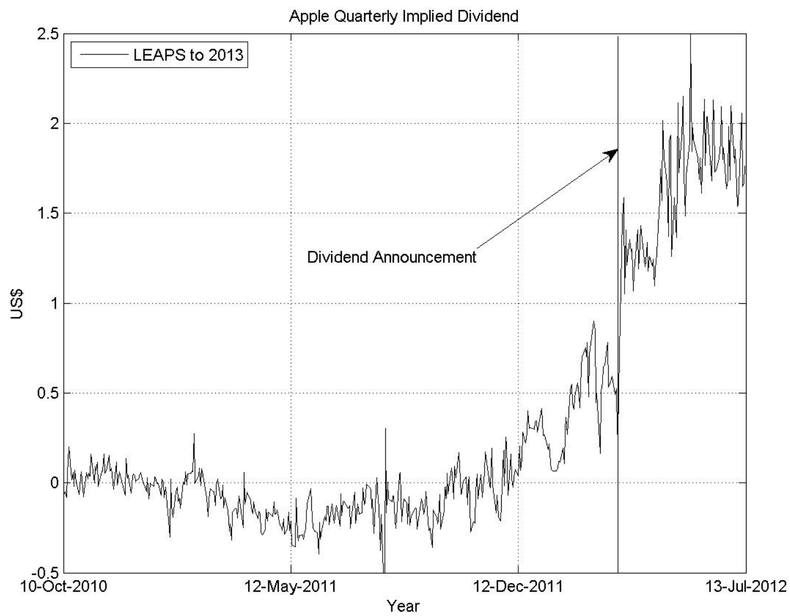

Figure 10: **Apple Inc. dividends as implied by the stock option expiring in July 2012.** Normalized to a quarterly rate.

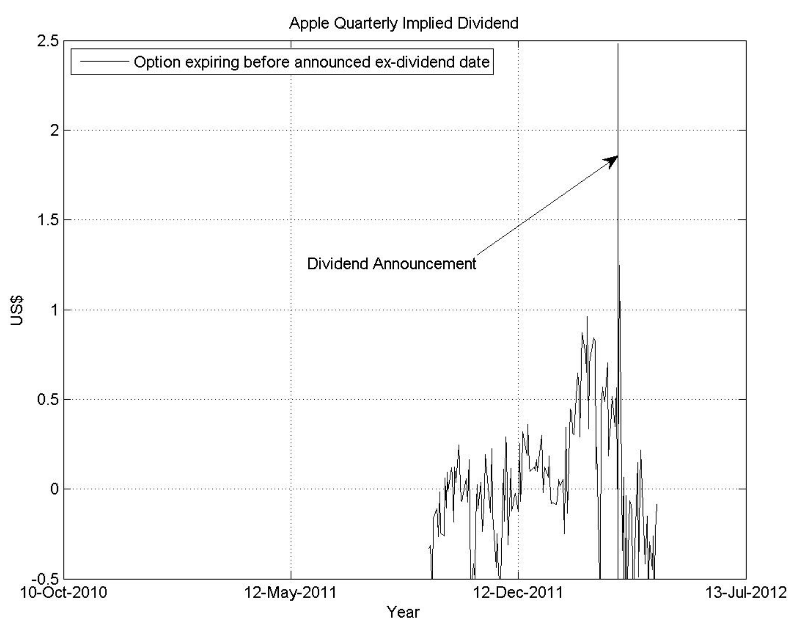

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Figure 11: **Contingency chart of actual dividends and implied dividends.** Implied dividends refer to 2 quarters ahead. A dot indicates an actual change in dividends $d_{j,t}$ against a change as implied by the data $DG_{j,t+2}$.

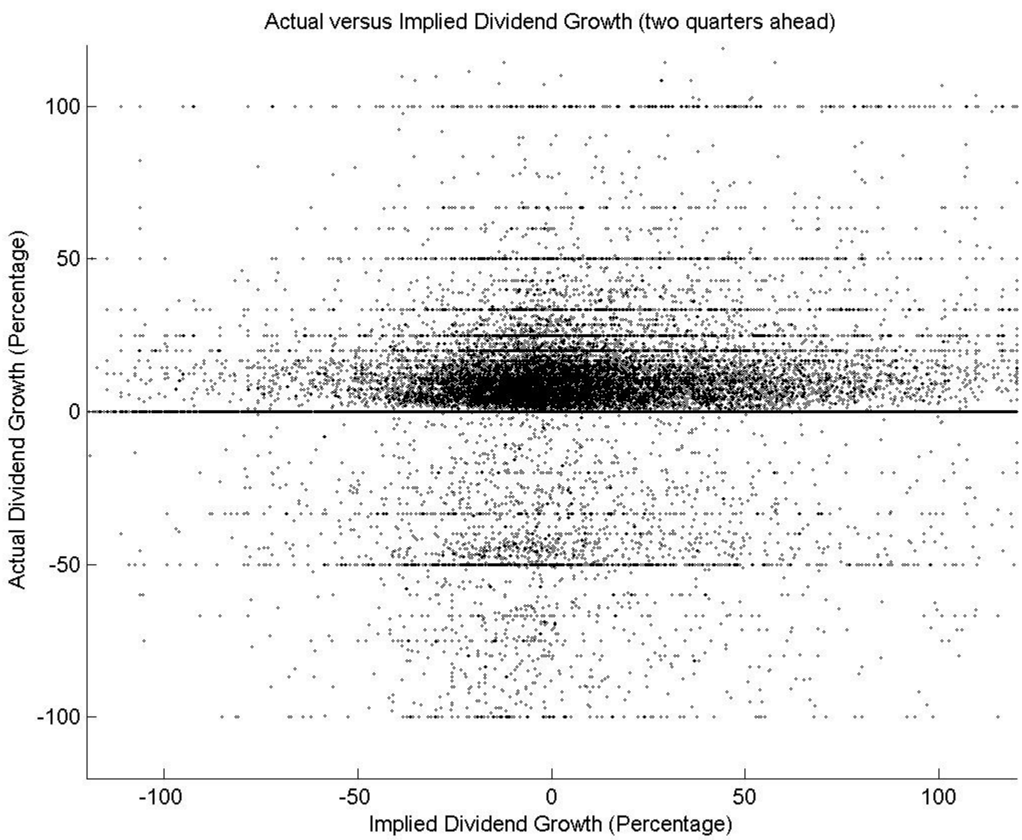

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Figure 12: **Marginal effects from a change in implied dividends.** Increases in the likelihood of the small dividend raise category $y = 3$, which is defined as $0.01 < d \leq b$, occurring due to a change in implied dividends moving from negative to positive, relative to the probability of a dividend falling into the small dividend increase category. Marginal effects for 1, 2 and 3 quarters ahead.

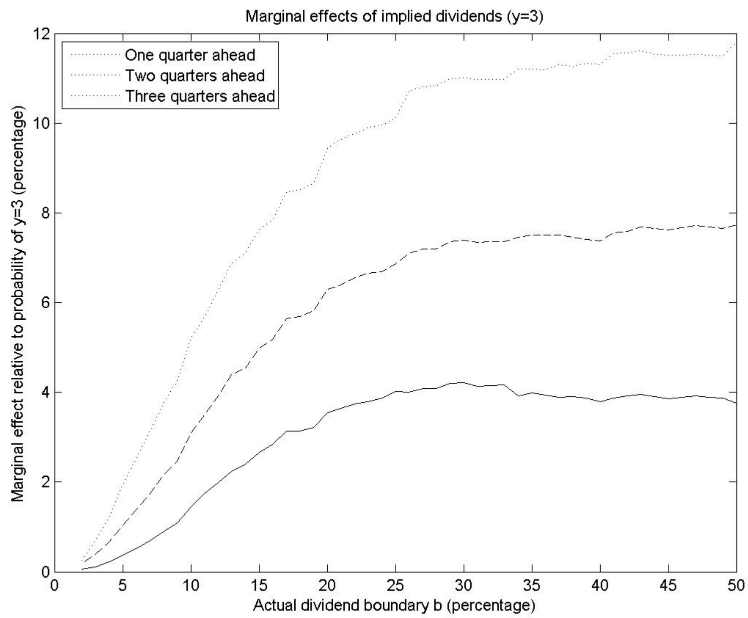


Figure 13: **Marginal effects from a change in implied dividends.** Increases in the likelihood of the large dividend raise category $y = 4$, which is defined as $d > b$, occurring due to a change in implied dividends moving from negative to positive, relative to the probability of a dividend falling into the large dividend increase category. Marginal effects for 1, 2 and 3 quarters ahead.

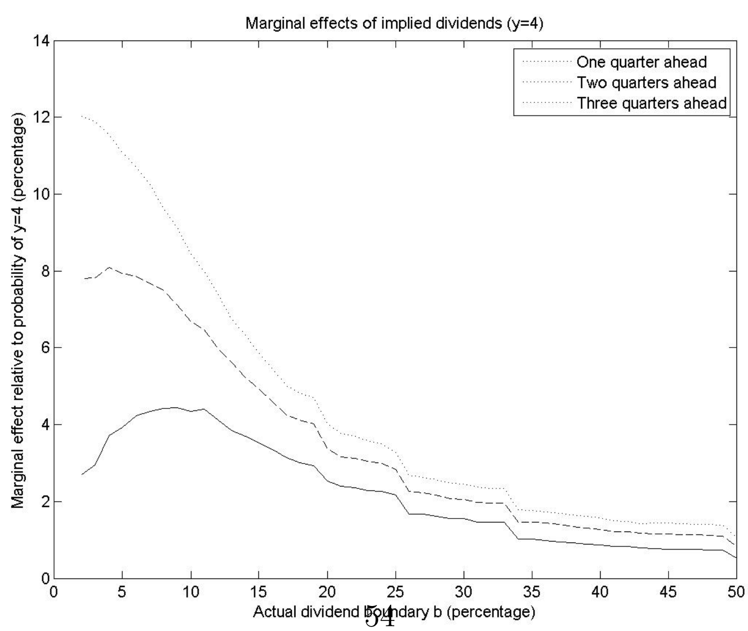
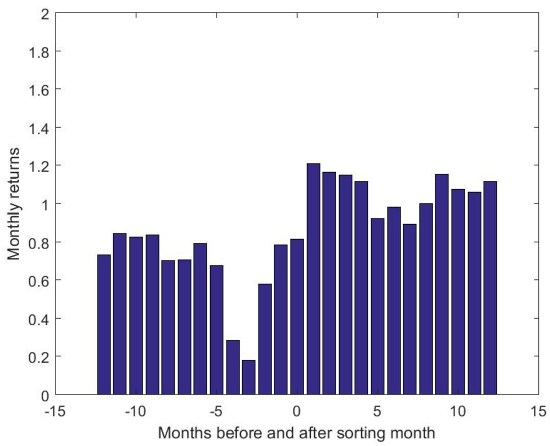
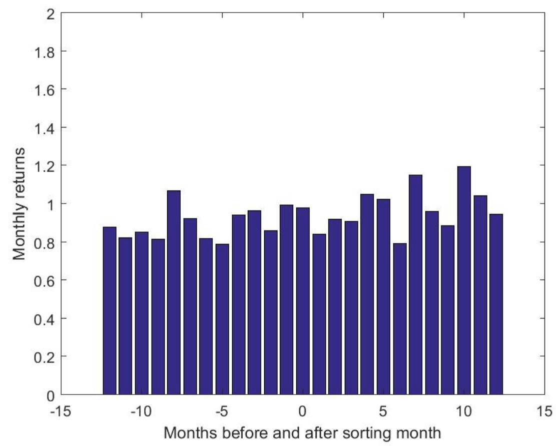


Figure 14: **Monthly value-weighted returns of portfolios of stock sorted at month = 0 by dividend growth implied 6 months ahead of the sorting month.**

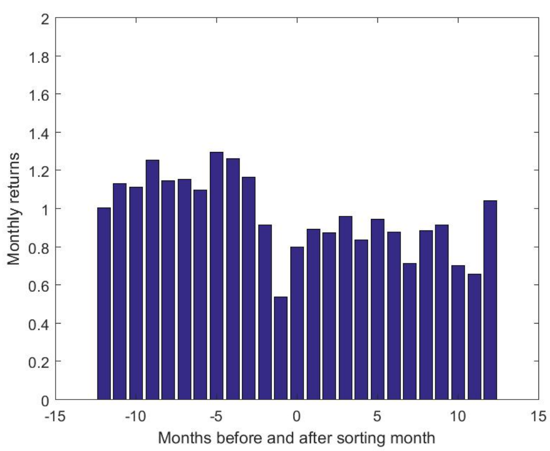
Returns refer to the 12 months before and after the sorting month. Stocks are sorted each month. Period: July 1997 – June 2015.



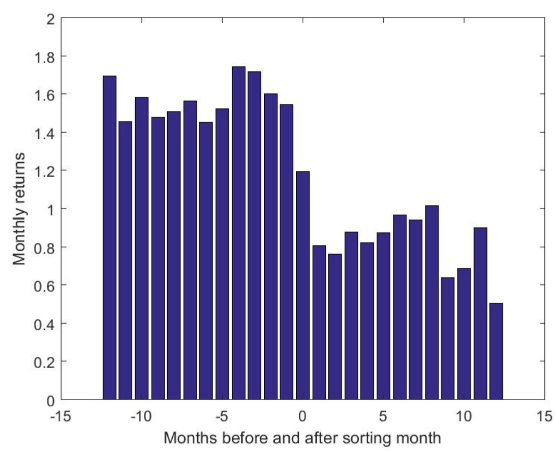
(a) 1^{st} quartile dividend growth



(b) 2^{nd} quartile dividend growth



(c) 3^{rd} quartile dividend growth



(d) 4^{th} quartile dividend growth

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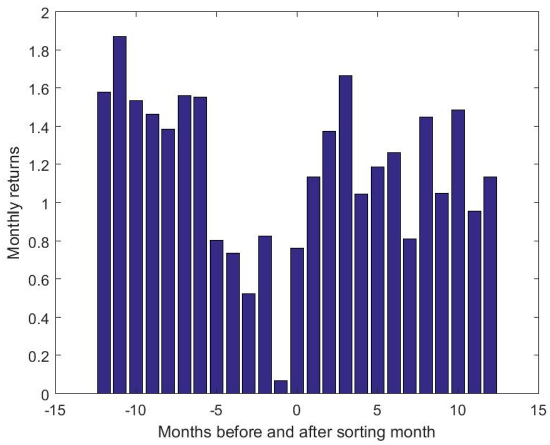
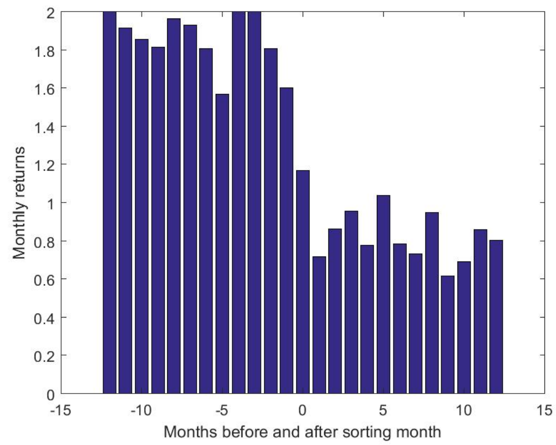
Figure 15: **Monthly value-weighted returns of portfolios of stock double-sorted at month = 0 by dividend yield and by dividend growth implied 6 months ahead of the sorting month.**

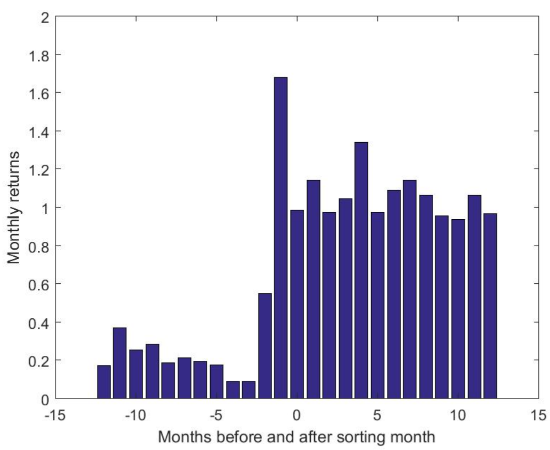
Low dividend yield and slow dividend growth refer to the first quartile and high dividend yield and fast dividend growth to the fourth quartile. Returns refer to the 12 months before and after the sorting month. Stocks are sorted each month. Period: July 1997 – June 2015.



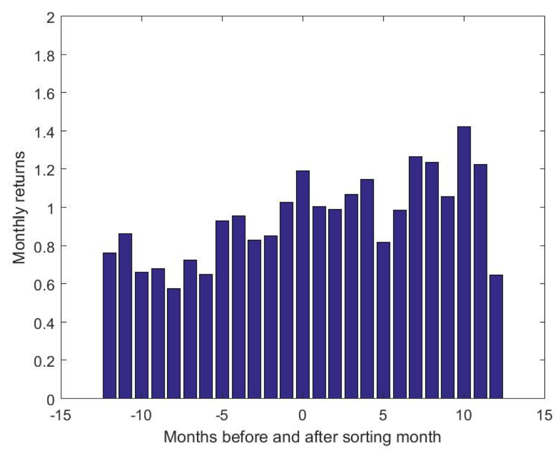
(a) Low dividend yield and slow dividend growth



(b) Low dividend yield and fast dividend growth



(c) High dividend yield and slow dividend growth



(d) High dividend yield and fast dividend growth

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Figure 16: **Implied stock loan fees 1 quarter ahead and 1 to 2 quarters ahead.** Normalized to bppa. Fees are value-weighted over all firms who pay dividends at a quarterly rate.

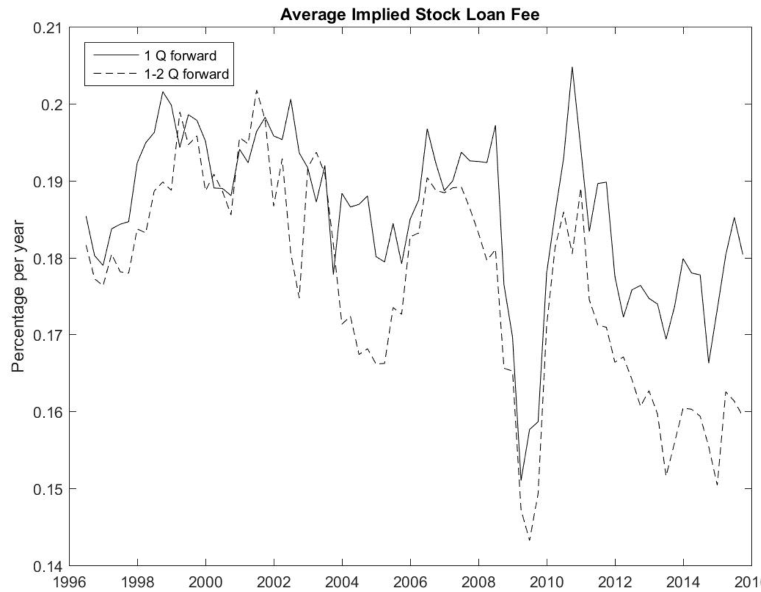

Figure 17: **Implied stock loan fees 1 to 3 quarters ahead and 1 to 8 quarters ahea.** Normalized to bppa. Fees are value-weighted over all firms who pay dividends at a quarterly rate.

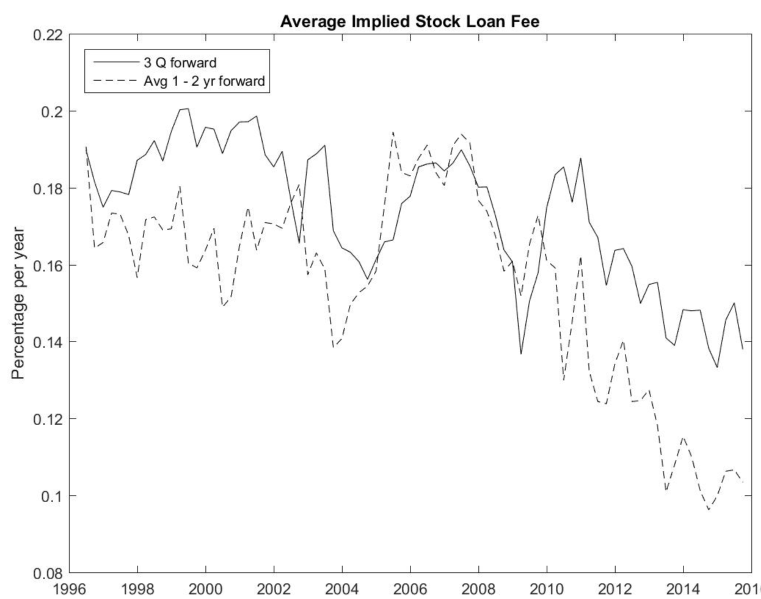

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Figure 18: **Average implied stock loan fees.** Data are averaged over the 1996-2015 data set for a given number of quarters ahead of the observation quarter for all firms (value-weighted) with and without LEAPS traded on their stocks.

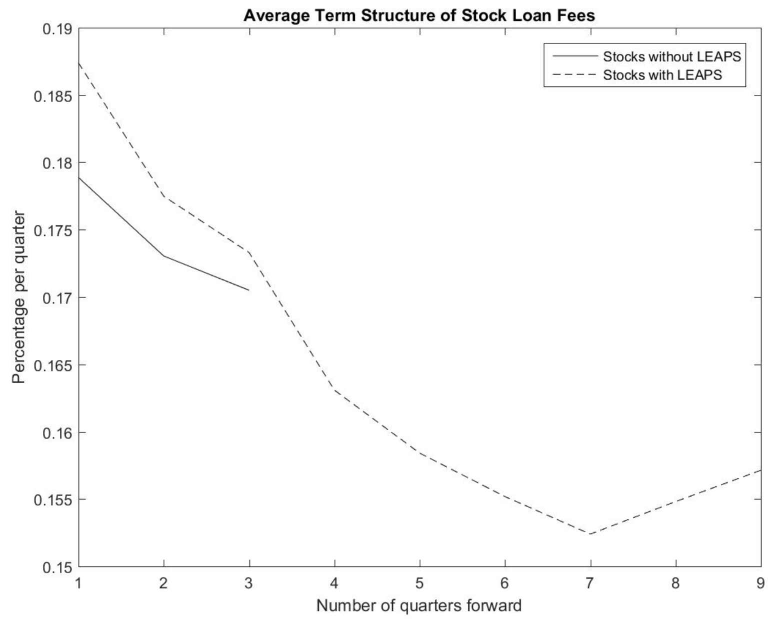
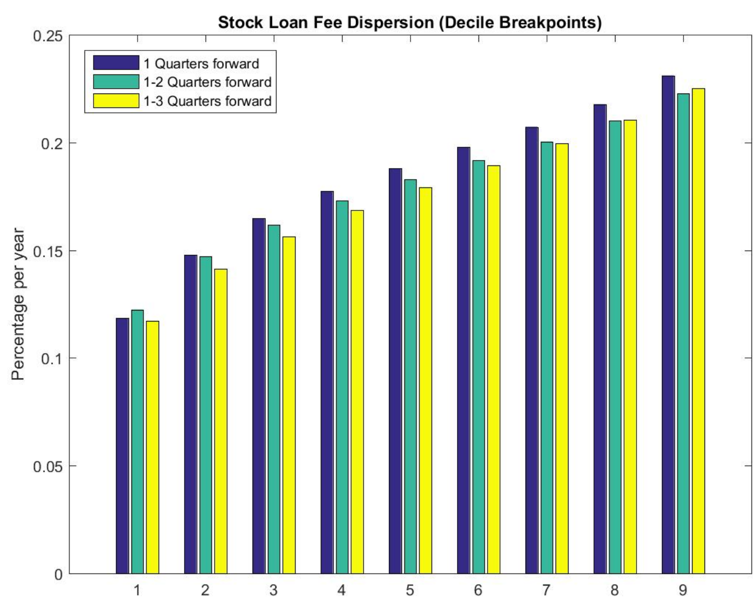


Figure 19: **Decile breakpoints of implied stock loan fees.** Data are shown for 1 quarter ahead, 1 to 2 quarters ahead and for 1 to 3 quarters ahead for all quartercompanies.



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