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# Signaling Safety

Finance Working Paper N° 653/2020
February 2020

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## Abstract

Contrary to signaling models' central predictions, changes in the level of cash flows do not empirically follow changes in dividends. We use the Campbell (1991) decomposition to construct cash-flow and discount-rate news from returns and find the following: (1) Both dividend changes and repurchase announcements signal changes in cash-flow volatility (in opposite direction); (2) larger cash-flow volatility changes come with larger announcement returns; and (3) neither discount-rate news, nor the level of cash-flow news, nor total stock return volatility change following dividend changes. We conclude cash-flow news—and not discount-rate news—drive payout policy, and payout policy conveys information about future cash-flow volatility.

Keywords: Dividends, Payout Policy, Cash-Flow Volatility, Signaling Model

JEL Classifications: G35

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# Signaling Safety*

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# I. Introduction

The idea that dividend changes convey information about firms' future prospects has a long tradition in finance and economics dating back at least to Miller and Modigliani (1961). Miller and Rock (1985), Bhattacharya (1979), and others later formalize this idea, which can explain why dividend changes come with large announcement returns, but also predicts that changes in dividends should be followed by changes in earnings or cash flows in the same direction. However, numerous empirical studies have failed to find evidence supporting this mechanism. In their review paper, DeAngelo et al. (2009) discuss the evidence and write, "We conclude that managerial signaling motives [...] have at best minor influence on payout policy" (p. 95).

In this paper, we show dividends do convey information, but it is information about the second moment of earnings, and not about the first moment. We show both theoretically and empirically that dividend changes signal changes in cash-flow volatility in the opposite direction. We borrow a method from asset pricing, namely the Campbell and Shiller (1988a,b) return decomposition, to split movements in stock returns into parts coming from news about future cash flows and parts coming from news about future discount rates.

Changes in cash-flow volatility follow changes in dividend policy in the opposite direction both at the extensive margin, initiations and omissions, and at the intensive margin, dividend increases and decreases. Cash-flow volatility decreases, on average, by 15% in the five years after dividend increases relative to the prior five-year average, whereas it increases by 7% after dividend cuts. Furthermore, volatility decreases by 20% after dividend initiations and it increases by 6% after dividend omissions. In addition, announcements of larger changes in dividends come with larger cumulative abnormal returns and are followed by larger changes in cash-flow volatility.

To construct measures of cash-flow and discount-rate news, we follow Vuolteenaho (2002) and apply the Campbell-Shiller method at the individual firm level. We then examine whether cash-flow and discount-rate news vary around dividend events. For each event, we estimate two firm-level vector auto-regressions (VARs) using 60 months of data



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before and after the event, construct cash-flow and discount-rate news, and test whether cash-flow and discount-rate news following the dividend event differ from those before the event.

An advantage of this method is that it directly uses information in returns to infer cash-flow news rather than relying on balance-sheet variables such as earnings or cash flows that are only available at a lower frequency, are prone to manipulation in the short run, and are non-stationary in levels. Moreover, unlike total stock return volatility, our return decomposition establishes directly whether any variation around dividend events occurs because of news about future cash flows or discount rates, both for levels and second moments. Finally, an important benefit of the return decomposition is that we can provide novel evidence on changes in discount rates and the relation to corporate decisions (Cochrane (2011)). We find no significant change in discount-rate news around dividend events. This latter finding indicates discount-rate news does not drive corporate dividend policies, consistent with the finding that it does not vary across firms in the long run (see Keloharju, Linnainmaa, and Nyberg (2019)).

Our results are robust to changing the estimation window of the VAR (36 or 48 months), to increasing the number of lags in the VAR (2, 3, or 4 lags), to considering pre-trends in cash-flow volatility, to matching our dividend-event firms to non-dividend firms with similar characteristics, and across subsamples.

What about the first moment of cash flows? In line with the earlier literature, we find no change in cash flows around dividend events, which is inconsistent with the idea that dividends convey information about the first moment. Because we show that neither discount-rate news nor total stock-return volatility changes following dividend changes, we establish that any change in firm-level riskiness following dividend events relates exclusively to cash-flow volatility.

This result reinforces the advantages of our approach relative to traditional measures of risk including total stock return volatility and beta (e.g., Grullon et al. (2002), Hoberg and Prabhala (2009)). Our results indicate changes in the volatility of cash-flow news drive the evidence in Grullon et al. (2002) of a decrease in systematic risk, that is, beta, following dividend increases and changes in discount-rate news.



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What explains the negative relation between changes in dividends and subsequent changes in cash-flow volatility? We develop a signaling model in which managers have superior information about future cash-flow volatility, generating predictions in line with our empirical findings. In our framework, signaling considerations predict cash-flow volatility should decrease following a dividend increase, and should increase following a dividend decrease. Furthermore, larger dividend payments should carry more information. Thus, within a signaling framework, our model can explain the larger decreases in cash-flow volatility and larger cumulative abnormal returns following the announcement of larger dividend increases.

The model predicts cross-sectional heterogeneity in the reaction of cash-flow volatility around dividend events, which helps pin down the economic mechanism. In our signaling model, as in Miller and Rock (1985), the cost of the signal is foregone investment opportunities. Consequently, following a dividend change, the model predicts a larger change in future cash-flow volatility for firms with smaller current earnings, because the foregone future investment opportunities at a given dividend level increase. As a result, the same dollar of dividend should carry a larger information content for firms with a lower earnings level. In the data, we find the same dollar of dividend paid is followed by a 25% larger reduction in cash-flow volatility for firms with smaller current earnings, consistent with the prediction of the model. We also find the results are stronger in the subset of firms that are financially constrained, using the definition of financial constraints of Hadlock and Pierce (2010), consistent with the model.

The predictions of our signaling model differ from those of the traditional signaling models of dividends, in which dividend changes signal changes in the first moment of future earnings.[1] These signaling models predict that, first, following dividend changes, profits should change in the same direction; and second, firms with growth opportunities and young and risky firms should be more prone to use dividends as signal. By contrast, our model implies safer firms, that is, those with more stable profits, signal more frequently. This prediction is consistent with our empirical findings, as well as with the findings of Kahle and Stulz (2017)) and others that mature and less risky firms pay the bulk of

[1]See, among others, Bhattacharya (1979, 1980), John and Williams (1985), Miller and Rock (1985), Kumar (1988), Bernheim (1991), and Guttman et al. (2010).



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dividends. We also discuss to what extent the predictions of our signaling model differ from those of alternative theories, including precautionary savings and agency, and we argue that other theories are unlikely to explain our results in full.

Our paper also contains caveats. The main contributions of the paper are empirical in nature, and the role of the model is to provide some theoretical guidance for organizing the host of new empirical regularities we uncover. To keep tractability, we make several simplifying assumptions, but our model is too stylized to speak to all findings in the large dividend-signaling literature. First, in the tradition of Miller and Rock (1985), we model the decision of firm managers in a world of risk-neutral investors. Risk neutrality appears to be a good approximation for many diversified institutions that are large shareholders in many dividend-paying firms. On the other hand, our model does not have a stochastic discount factor, which may provide additional insights. Second, we find that cash-flow volatility is priced in the stock market. At the same time, our model is silent on whether the stock market should value idiosyncratic or systematic cash-flow volatility. Empirically, we find firm cash flow volatility around dividend events at least in part reflects a systematic component.[2] Moreover, empirical and theoretical asset-pricing work documents that idiosyncratic risk is priced (Fu (2009), Constantinides and Duffie (1996)). Third, in our model, cash-flow volatility matters because of the concavity of the production function as a result of Jensen's inequality. Hence, in addition to the direct signaling effect on firm value, our model also predicts an indirect effect through higher future earnings. At first glance, our model's implication of such an indirect effect might appear at odds with our earlier empirical findings of no change in the first moment of cash-flow news around dividend events. We reconcile these seemingly inconsistent findings by estimating this indirect effect to be orders-of-magnitude smaller than the direct signaling effect on cash-flow volatility. The small magnitude of this indirect effect, together with the fact that we would expect this indirect effect at future (possibly long) horizons might help explain why the empirical literature has failed to find significant changes in the first moment of cash-flows around dividend events. By contrast, our empirical results concerning the

[2]Hence, we can provide additional insights into which aspects of the distribution of future earnings are priced in the stock market. By contrast, much of the literature has focused on measurement issues of accounting earnings (e.g., see Ham et al. (2019).



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second moment of cash flows remain robust.

Given our results so far, the question of whether similar dynamics regarding future cash flows occur around share repurchases is a natural one. This question is particularly relevant given the path of payout policies in the past four decades, whereby share repurchases have become the dominant form of cash payouts (Farre-Mensa et al. (2014)). We find a 15% decline in cash-flow volatility following share-repurchase announcements and no changes in either the first moment of cash-flow news or discount-rate news. Also consistent with our results on dividends and with the signaling hypothesis, we find larger share-repurchase programs are associated with both larger reductions in cash-flow volatility and larger announcement returns. We conclude that announcements of changes to firms' payout policies, whether through dividends or share repurchases, convey information about future changes in firms' cash-flow volatility.

Our results yield several important insights and we highlight four of them here. First, dividends do convey information, but the information or the signal is about expected earnings volatility. As we argue below, this finding is consistent with Lintner (1956) and survey evidence in Brav et al. (2005) of how managers set corporate dividend policy. Using alternative methods, we also confirm that the information conveyed in dividends is not about the first moment of earnings: The level of earnings does not increase economically and statistically after a dividend increase.

Second, our framework and results are able to explain why stable and mature firms tend to signal more, as opposed to growth firms, because they have stable cash flows, a finding that was otherwise puzzling under the idea that firms signal the first moment of cash flows. Third, whereas prior literature rightly suggests dividends and share repurchases have many different features, we document a key and novel shared attribute: Both dividend changes and share repurchases signal future changes in expected cash-flow volatility in the opposite directions. Finally, our method and our evidence speak to the debate on whether cash flow, or discount rates drive corporate finance decisions (e.g., Fama and French (1988), Cochrane (2011)). Our finding that dividend changes and repurchases do not convey information about discount-rate news reinforces the notion that cash flows–and not discount rates–drive corporate financial decisions, at least with



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respect to payout policies.

We are not the first to suggest dividend changes are related in some form to future changes in cash-flow volatility. The empirical literature on dividends and cash flows goes back at least to Lintner (1956). Whereas most of the literature interprets Lintner (1956) as evidence about the relationship between the level of dividends and cash flows, his findings that managers increase dividends only when they believe earnings have increased "permanently" can also be interpreted as reflecting risk. Accordingly, Benartzi et al. (1997) show earnings do not increase after dividends increase, but earnings are less likely to decrease in the years following a dividend increase, consistent with dividends reflecting a permanent increase in earnings (see also Jagannathan et al. (2000) and Guay and Harford (2000)). Grullon et al. (2002) and DeAngelo et al. (2006) present some evidence that systematic risk is lower after dividend increases, and interpret it as suggesting dividends convey information about firm "maturity." Our paper extends these earlier efforts in at least three ways. First, using a novel method, we are able to establish that not only do dividend changes convey information about future volatility, but also that the decrease in volatility is attributed to changes in cash-flow volatility. Second, using a simple theoretical model, we are able to offer a consistent explanation to these findings, suggesting managers signal future reductions in volatility through dividends. Third, consistent with our theoretical framework, we find the relationship extends beyond dividends and applies to stock repurchases as well.

# II. Method

To test our hypotheses on changes in cash flows and discount rates following dividend changes, we require measures of the first and second moment of expected cash flows and discount rates. We borrow a method from asset pricing to estimate the first and second moment of future cash flows and discount rates, and use it to test our hypotheses.

To see the intuition underlying the method, consider a simple discounted cash-flow model, with current and expected future cash flows in the numerator and expected future discount rates in the denominator. In this framework, returns today can be



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unexpectedly high due to either positive news about current or future cash flows—the numerator—or due to negative discount-rate news—the denominator. This method allows us to (i) test our hypotheses on changes in expected cash-flow volatility (measured by the second moment of cash-flow news) following dividend changes, (ii) revisit the prior literature on earnings changes (measured by the first moment of cash-flow news) following dividend changes, and (iii) examine discount-rate changes (measured by discount-rate news) following dividend changes.

A large literature in economics and finance employs this method, initially developed by Campbell (1991), to decompose returns into news originating from cash flows and discount rates. Bernanke and Kuttner (2005), Gorodnichenko and Weber (2016), and Weber (2015) find cash-flow news is as important as discount-rates news for stock returns to monetary policy shocks following Federal Open Market Committee monetary policy announcements. Vuolteenaho (2002) extends the VAR methodology to the individual firm level and finds cash-flow news is the main driver of stock returns at the firm level.

The method provides a direct empirical counterpart to our hypotheses about *cash-flow* volatility. By contrast, other measures of volatility (e.g., total stock return volatility, implied volatility from option prices) do not allow a decomposition into components originating from cash flows or discount rates. As we show below, total stock return volatility does not change following dividend changes, implying total stock return volatility is a poor proxy for cash-flow volatility. Furthermore, the method is not subject to the bias arising from non-stationarity when estimating cash flows from accounting information. In fact, because corporate earnings are not stationary, measuring cash-flow volatility using the realized variance of earnings might pick up such non-stationarity rather than any information content of dividends. A large literature in accounting has implicitly recognized the non-stationarity and has adopted a variety of adjustments for linear or non-linear trends in corporate earnings (see, e.g., DeAngelo, DeAngelo, and Skinner (1996) and Grullon, Michaely, and Swaminathan (2002)). However, no consensus exists on which adjustment is more appropriate (see, e.g., DeAngelo et al. (2009)). The observation that earnings are non-stationary is akin to the observation by Fama (1965) and others that stock prices are non-stationary, which prompted the field of asset pricing to focus on stock



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returns, that is, stock-price changes, rather than levels of stock prices.

## *A.* Stock-Return Decomposition

We decompose stock returns into estimates of cash-flow and discount-rate news before and after dividend announcements. Because this method has so far not been applied in a corporate finance context, we briefly review the basic ingredients and closely follow the original notation.

Vuolteenaho (2002) takes the dividend-discount model of Campbell and Shiller (1988a) for the aggregate market return as a starting point and applies it to the individual firm. He adapts the present-value formula to accounting data, because many individual firms pay dividends at irregular intervals. Three main assumptions are necessary to achieve this goal. First, the clean surplus identity holds; that is, earnings ($X$) equal the change in the book-value of equity ($\Delta B_t$) minus dividends ($D$). Second, the book value of equity, dividends, and the market value of equity ($M$) are strictly positive. Third, log book and market equity and log dividends and log book equity are cointegrated. We use small letters to denote the log of a variable unless specified otherwise.

These assumptions allow us to write the log book-to-market ratio, $\theta$, as

$$\theta_{t-1} = k_{t-1} + \sum_{s=0}^{\infty} \rho^s r_{t+s} - \sum_{s=0}^{\infty} \rho^s (roe_{t+s} - f_{t+s}). \tag{1}$$

$roe$ is log return on equity, which we define as $roe_t = \log(1 + X_t/B_{t-1})$, $r_t$ denotes the excess log stock return, $r_t = \log(1 + R_t + F_t) - f_t$, $R_t$ is the simple excess return, $F_t$ is the interest rate, $f_t$ is log of 1 plus the interest rate, $k$ summarizes linearization constants, which are not essential for the analysis, and $\rho$ is a discount factor. The book-to-market ratio can be low, because market participants expect low future discount rates; that is, they discount a given stream of cash flows at a low rate (first component on the right-hand side of equation (1)), or because they expect high future cash flows (second component on the right-hand side of equation (1)).

We can follow Campbell (1991) to get return news from changes in expectations from



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$t-1$ to $t$ and reorganizing equation (1):

$$r_t - \mathbb{E}_{t-1}\, r_t = \Delta\, \mathbb{E}_t \sum_{s=0}^{\infty} \rho^s (roe_{t+s} - f_{t+s}) - \Delta\, \mathbb{E}_t \sum_{s=1}^{\infty} \rho^s r_{t+s}. \tag{2}$$

$\Delta\, \mathbb{E}_t$ denotes the change in the expectations operator from $t-1$ to $t$, that is, $\mathbb{E}_t(\cdot) - \mathbb{E}_{t-1}(\cdot)$. Therefore, returns can be high, if we have news about higher current and future cash flows or lower future excess returns.

We then introduce notation and write unexpected returns as the difference in cash-flow news, $\eta_{cf,t}$, and discount-rate news, $\eta_{r,t}$:

$$r_t - \mathbb{E}_{t-1}\, r_t = \eta_{cf,t} - \eta_{r,t}. \tag{3}$$

## *B.* Vector Autoregression

A VAR provides a simple time-series model to infer long-horizon properties of returns from a short-run model and to implement the return decomposition. Let $z_{i,t}$ be a vector at time $t$ containing firm-specific state variables. We begin by assuming a first-order VAR describes the evolution of the state variables well. Later, we relax this assumption and examine robustness to increasing the number of lags, and find similar results using two, three, and four lags. We can then write the system as

$$z_{i,t} = \Gamma z_{i,t-1} + u_{i,t}. \tag{4}$$

$\Sigma$ denotes the variance-covariance matrix of $u_{t+1}$, and we assume it is independent of the information set at time $t-1$.

We assume the state vector $z$ contains firm returns as the first component, and we define the vector $\boldsymbol{e1'} = [1\ 0\ \ldots\ 0]$. We can now write unexpected stock returns as

$$r_{i,t} - \mathbb{E}_{t-1}\, r_{i,t} = \boldsymbol{e1'} u_{i,t}. \tag{5}$$



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Discount-rate news is

$$\eta_{r,t} = \Delta\, \mathbb{E}_t \sum_{s=1}^{\infty} \rho^s r_{t+s}, \tag{6}$$

which we can now simply write as

$$\eta_{r,t} = \boldsymbol{e1'} \sum_{s=1}^{\infty} \rho^s \Gamma^s u_{i,t+s} \tag{7}$$

$$= \boldsymbol{e1'} \rho\Gamma(\mathbb{1} - \rho\Gamma)^{-1} u_{i,t} \tag{8}$$

$$= \lambda' u_{i,t}, \tag{9}$$

where $\mathbb{1}$ is an identity matrix of suitable dimension and the last line defines notation.

We can then write cash-flow news as

$$\eta_{cf,t} = (\boldsymbol{e1'} + \lambda') u_{i,t}, \tag{10}$$

and the variance of cash-flows as

$$\delta(\eta_{cf,t}) = (\boldsymbol{e1'} + \lambda')\Sigma(\boldsymbol{e1} + \lambda). \tag{11}$$

# III. Data

We use balance-sheet data from the quarterly Compustat file and stock-return data from the monthly CRSP file. We follow Grullon, Michaely, and Swaminathan (2002) and Michaely, Thaler, and Womack (1995) in defining quarterly dividend changes and dividend omissions and initiations and Vuolteenaho (2002) in the sample and variable construction of the state variables of the VAR we defined in section II. We detail both below. The sample period for dividend events is 1964-2013, because we require sufficient post-event data to estimate the VAR.



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## *A.* Cash-Flow and Return News: Sample Screens

We follow Vuolteenaho (2002) and impose the following data screens. A firm must have quarter $t-1$, $t-2$, and $t-3$ book equity and $t-1$ and $t-2$ net income and long-term debt data. Market equity must be available for quarters $t-1$, $t-2$, and $t-3$. A valid trade exists during the month immediately preceding quarter $t$ returns. A firm has at least one monthly return observation during each of the preceding five years. We exclude firms with quarter $t-1$ market equity less than USD 10 million and book-to-market ratio of more than 100 or less than 1/100.

## *B.* Cash-Flow and Return News: Variable Definitions

The simple stock return is the three-month cumulative monthly return, recorded from $m$ to $m+2$ for $m \in \{Feb, May, Aug, Nov\}$. We follow Shumway (1997) and assume a delisting return of $-30\%$ if a firm is delisted for cause and has a missing delisting return. $r_t$ is then the market-adjusted log return following Vuolteenaho (2002). Market equity is the total market equity at the firm level from CRSP at the end of each quarter. If quarter $t$ market equity is missing, we compound the lagged market equity with returns without dividends.

Book equity is defined as in Weber (2018) and Chinco et al. (2019) and equals shareholders' equity plus balance-sheet deferred taxes and investment tax credit (item TXDITCQ) if available, minus the book value of preferred stock. Depending on availability, we use stockholders' equity (item SEQQ), or common equity (item CEQQ) plus the carrying value of preferred stock (item PSTKQ), or total assets (item ATQ) minus total liabilities (item LTQ) in that order as shareholders' equity. We use redemption value (item PSTKRQ) if available, or carrying value for the book value of preferred stock. If book equity is unavailable, we proxy it by the last period's book equity plus earnings, less dividends. If neither earnings nor book equity are available, we assume the book-to-market ratio has not changed, and compute the book-equity proxy from the last period's book-to-market ratio and this period's market equity. We set negative or zero book-equity values to missing.



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GAAP (US Generally Accepted Accounting Principles) ROE follows D'Acunto et al. (2018) and is the earnings over the last period's book equity. We use earnings available for common equity, in the ROE formula. When earnings are missing, we use the clean-surplus formula to compute a proxy for earnings. In either case, we do not allow the firm to lose more than its book equity. Hence, the minimum GAAP ROE is truncated to $-100\%$. We calculate leverage as book debt over the sum of book equity and book debt. Book debt is the sum of debt in current liabilities, total long-term debt, and preferred stock.

Each quarter, we log transform market equity, stock returns, and return on equity and cross-sectionally demean it. A log transformation may cause problems if returns are close to $-1$ or if book-to-market ratios are close to zero or infinity. We mitigate these concerns by redefining a firm as a portfolio of 90% common stock and 10% Treasury bills, using market values. Every period, the portfolio is rebalanced to these weights.

## *C.* Dividend Changes

We use the CRSP daily file to identify dividend changes, and follow Grullon, Michaely, and Swaminathan (2002) in the sample screens and to construct quarterly dividend changes. We use all dividend changes for common stocks of U.S. firms listed on NYSE, Amex, and Nasdaq that satisfy the following criteria. The distribution is a quarterly taxable cash dividend, and the previous cash-dividend payment was within a window of 20–90 trading days prior to the current dividend announcement. We focus on dividend changes between 12.5% and 500%. The lower bound ensures we include only economically meaningful dividend changes, and the upper bound eliminates outliers. We also ensure no other non-dividend distribution events, such as stock splits, stock dividends, mergers, and so on, occur within 15 trading days surrounding the dividend announcement. We end up with 2,441 dividend increases and 2,461 dividend decreases over 1964–2013.

## *D.* Initiations and Omissions

We follow Michaely, Thaler, and Womack (1995) to construct our dividend initiation and omission sample. We require the following criteria for initiations to be in our sample. We



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focus on common stocks of U.S. companies that have been traded on the NYSE or AMEX for two years prior to the initiation of the first cash dividend. This screen eliminates new listings of firms that had previously traded on NASDAQ or on another exchange and switched the exchange with the pre-announced intention of paying dividends in the near future. We end up with 1,069 dividend initiations over 1964–2013.

For omissions, the sample must meet one of the following three criteria: (i) The company declared at least six consecutive quarterly cash payments and then paid no cash payment in a calendar quarter; (ii) the company declared at least three consecutive semi-annual cash payments and then paid no cash payments in the next six months; or (iii) the company declared at least two consecutive annual cash payments and then paid no cash payments in the next year. We first identify potential omission quarters using the three conditions. We then use the Wall Street Journal (WSJ) Index to extract all information about dividend omissions. We enrich the WSJ Index data with searches on Factiva and ProQuest for any additional information regarding dividend omissions. We end up with 1,233 dividend omissions over 1964–2013.

## *E.* Share Repurchases

We use Thomson ONE to construct our share-repurchase sample. We use all repurchases of common stock announced between 1980 and 2013 for which we can determine the amount announced. Our procedure follows Jagannathan, Stephens, and Weisbach (2000), but they also study repurchases of preferred stock, which is not relevant for our purpose of studying payout policy to common stockholders, and Grullon and Michaely (2002), who use the Compustat definition of share repurchases and report a correlation of 0.97 between the Compustat and the SDC measures of share repurchases.

We end up with 2,662 share-repurchases announcements. Table 1 reports descriptive statistics for our sample. Despite imposing both the dividend sample screens above and the VAR restrictions of section II., our sample sizes are comparable to those in prior studies on dividend changes (e.g., see Grullon et al. (2002)), dividend initiations and omissions (e.g., Michaely et al. (1995)), and share repurchases (e.g., Grullon and Michaely (2004)). Relaxing these restrictions does not affect our results on dividend changes,



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dividend initiations and omissions, and share repurchases. Furthermore, we find few delistings following dividend events, suggesting that sample selection is not an issue in our data.

We ensure across specifications that we have non-overlapping data for the two VARs before and after dividend events and share repurchases; that is, two events at the firm level are at least 10 years apart.

# IV. Results

In this section, we report our main empirical results. In section IV.*A.*, we report the estimates of the VAR and the VAR-implied importance of cash-flow news and discount-rate news for our sample of firms. In section IV.*B.*, we report our univariate tests on the first and second moment of cash-flow and discount-rate news, and in section IV.*C.* we explore the robustness of our main findings along several dimensions. In section IV.*D.*, we examine cumulative abnormal returns to the announcements of dividend events.

## *A. Estimates of the VAR System*

Following our discussion in section II., a central ingredient for our analysis is an estimate of the transition matrix $\Gamma$ of the VAR system and the discount factor $\rho$. We estimate $\rho$ as the regression coefficient of the excess log ROE minus the excess log stock return, plus the lagged book-to-market ratio on the book-to-market ratio. We find an estimate of 0.986, which is almost identical to the estimate of Vuolteenaho (2002).

Table 2 reports point estimates of a constant VAR across firms and time with t-stats in parentheses. Consistent with findings in the literature, we find returns are positively autocorrelated, load positively on the log book-to-market ratio, and log profitability. The quarterly book-to-market ratio is highly autocorrelated and loads positively on lagged returns, and negatively on lagged profitability. Profitability is autocorrelated at the quarterly frequency, and loads positively on lagged returns and negatively on the lagged book-to-market ratio. The dynamics of our state variables are broadly consistent with findings in the literature, particularly Vuolteenaho (2002).



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To study the small sample properties of the VAR, we implement a Monte Carlo simulation and re-estimate the VAR 1,000 times. Specifically, we first randomly draw a 10-year period with replacement from our full sample. Using these 10 years of data, we estimate a new gamma matrix and store the coefficient estimates. We repeat this step 1,000 times and plot the distribution of point estimates of the VAR in Figure 1. We find across simulations that the point estimates are tighly distributed around the full-sample estimates.

## *B. Dividend Events and Cash-Flow Volatility*

We estimate a VAR before and after each dividend-event-quarter using all available firm observations with non-missing balance-sheet data over a five year horizon but requiring at least three years of data. We then use equation (11) to calculate the first and second moment of cash-flow news and discount-rate news and compare these statistics after dividend events relative to before. If dividends convey information about cash flows or discount rates, their first or second moment or both will be different after the dividend events relative to before. To ensure overlapping dividend events do not drive our results, we randomly drop one of the two events. Results are robust to which event we drop and to not dropping any event.

Table 3 reports changes in cash-flow news and discount-rate news after dividend events relative to before separately for dividend increases, decreases, initiations, and omissions. We estimate for each dividend event two VARs before and after the quarter of the event using all firm observations with non-missing data. We then create cash-flow and discount-rate news at the firm level using 60 months of data before and after the dividend event, winsorize the data at the 1% and 99% levels, and report the average changes for a given firm across events in the table.

Using our novel method, we first revisit results reported in earlier literature and examine changes in the first moment following dividend changes. In Panel A, we find positive dividend changes, dividend initiations, negative dividend changes, or dividend omissions or pooling across events do not result in a statistically significant change in cash-flow news after the event relative to before the event. These findings are consistent



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with most of the earlier literature, which does not detect any predictive power of dividend events for the first moment of future realized earnings.

In Panel B, we also find dividend events are not followed by changes in discount-rates news. These results indicate market expectations of lower future discount rates are unlikely to drive the positive announcement returns to increases in dividends or dividend initiations.

We then turn to cash-flow volatility. We find in Panel C that dividend increases are followed by a decrease in the variance of cash-flow news in the five years after the event relative to the variance of cash-flow news in the five years before. Similarly, for dividend decreases, we see an increase in the variability of cash-flow news after the event relative to before. Changes in dividends are followed by changes in cash-flow volatility in the opposite direction, consistent with our hypothesis that dividends convey information about cash-flow volatility.

The numbers in Panel C are difficult to interpret. We therefore scale the changes in the variance of cash-flow-news around the dividend events by the average variance in cash-flow-news before the event in Panel D. We see the variance of cash-flow news drops by, on average, 15% of the average variance before the event after announcements of dividend increases (see column (1)) but increases by more than 7% after dividend cuts (see column (4)). Dividend initiations result in a variance of cash-flow news, which is, on average, 20% lower than the average variance before the dividend event. Dividend omissions lead to an increase in the cash-flow variance of 6%, which is highly statistically significant (see columns (2) and (5)).

## *C. Robustness and Extensions*

Vuolteenaho (2002) argues large amounts of data are necessary to get precise estimates of the transition matrix $\Gamma$ of the VAR. So far, we have used separate estimates for the transition matrix to get residuals for the five years before and after each dividend event. In Table 4, we impose less stringent restrictions on $\Gamma$, thus trading off efficiency with precision. At the same time, we have used a limited sample, because we jointly impose the same restrictions as Vuolteenaho (2002), Grullon et al. (2002), and Michaely et al.



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(1995). To increase our sample sizes, we now also report results for a specification in which we do not impose some of the restrictions of the initial papers we follow.

Table 4 directly reports the change in the variance of cash-flow news after the dividend event relative to before as a fraction of the average variance before the event. In Panel A, we estimate one VAR for the whole sample period and then use the estimate for $\Gamma$ to calculate both residuals in the five years before and after the dividend event and the cash-flow news. In Panel B, we combine the previous two approaches and estimate one VAR across all firms and events to get an estimate of $\Gamma$, but then estimate separate VARs before and after each dividend events to get the VAR residuals. Panel C requires only 12 non-missing quarters within five years before and after the dividend event. We do not restrict our sample to non-overlapping event windows within firms, and if no return or dividend data are available, we substitute zeros for both returns and dividends. All three panels confirm our baseline results. Announcements of dividend increases or initiations result in lower cash-flow volatility after the announcement relative to before, whereas announcements of dividend cuts or omissions result in an increased cash-flow volatility.

We explore the robustness of our results to including more lags in the estimation of the VAR in Table 5. Panel A presents results for a VAR with two lags, Panel B considers three lags, and Panel C considers four lags. Our results are in general stronger than in the baseline setting with one lag. Next, we consider robustness to shortening the estimation window of the VAR, which in our baseline setting was five years. Panel A of Table 6 presents results for estimating the VARs with three years of data before and after dividend events; Panel B present results using four years of data before and after. Again, the results are stronger than in the baseline setting.

One concern with our results is that the changes in cash-flow volatility that we document around dividend events reflect pre-existing trends and thus are unrelated to dividends. To gauge the extent of pre-trends, we estimate VARs in the years before the actual dividend events, and study the changes in the variance of cash-flow news in these pre-event windows. Table 7 reports the results. We find these differences are either statistically indistinguishable from zero, or have the "wrong" sign, indicating pre-trends do not explain our findings.



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The possibility of structural breaks during our sample period may raise the concern that our results are concentrated in the earlier part of the sample. For example, return predictability decreased in the 1990s (see Lettau and Van Nieuwerburgh (2007)). Clean surplus accounting might also be more likely to break in the same period, and many firms stopped paying dividends (Fama and French (2001)) or started more intensively substituting dividends for repurchases (Grullon and Michaely (2002)). Panels A and B of Table 8 split our sample in half (1964–1988 and 1989–2013) and repeat our baseline analysis for both subsamples separately. We estimate a constant $\Gamma$ matrix within each sample to ensure we have enough data points for reliable estimates.

We see in Panel A that results for the early part of our sample are similar to our baseline results: Dividend increases and initiations result in lower future cash-flow volatility, whereas dividend cuts and omissions are associated with increases in cash-flow volatility. More importantly, we also find very similar results in Panel B despite the various potential structural changes, including a significant change in dividend taxation in the middle of the second period (in 2003). To directly test whether the change in taxation can partially explain our findings, we also report in Panel C results for a sub-sample beginning in 2003. We find similar results to our baseline findings. The sub-sample test we perform here also allows us to draw some insight on the role of differential taxation in dividend signaling. We discuss this issue in more detail below.

One concern with our findings so far is that dividend events might coincide with market-wide breakpoints in cash-flow volatility, so that we might merely capture an overall market-wide phenomenon for mature firms with similar observable characteristics, and unrelated to dividend changes. Table 9 considers this alternative explanation. We report the scaled change in the volatility of cash-flow news for our event firms relative to the scaled change in the volatility of cash-flow news of observationally similar firms that do not have dividend events. Specifically, we use a nearest-neighbor algorithm to match firms based on propensity scores. We estimate propensity scores with a logit regression of the treatment indicator on the book-to-market ratio, leverage, age, and size (the same variables we use in our regression analysis of Table 12 below). We lose few observations relative to our baseline analysis, due to missing matches. Table A.1



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reports the characteristics we use for the matching exercise both for event firms and observationally similar firms. Characteristics are similar for both sets of firms for the averages as well as for the standard deviations.

We see in Table 9 that this alternative story cannot explain our findings. Firms that increase their dividends see a large drop of 15% in the variance of their cash-flow news after the announcement relative to before and relative to the change for observationally similar firms that do not have a dividend event. The drop in variance is similar in magnitude to our baseline specification. For decreases in dividends, instead, we see an increase in the variance of cash-flow news following the cut relative to before and to matched firms. Results for dividend initiations and omissions are also consistent with our baseline analysis.

Changes in the future riskiness of cash flows might occur over time, and we can reasonably assume changes in the variance of cash-flow news build up with horizon.[3] To examine this intuition, we study the change in the variance of cash-flow news over time using larger windows in Table A.2 of the Online Appendix. We see on impact a reduction in the variance of cash-flow news in the year around the dividend event for positive dividend changes. The reduction builds up over the following two years and levels off after four years. We observe a similar build up for dividend cuts and omissions.

Finally, we examine a premise of the signaling model we develop below, namely, that external financing and hedging are not costless. Extending this line of reasoning, one would expect our results to be stronger for firms that are more financially constrained. To examine this premise empirically, we use the financial-constraints index of Hadlock and Pierce (2010). Consistent with our premise, we find that following dividend changes, the change in cash-flow volatility (in the opposite direction) and the abnormal returns are larger for firms that are more financially constrained. We report these results in the Online Appendix, Table A.3.

The changes in cash-flow volatility around dividend changes raise the question of whether these changes are entirely idiosyncratic or whether they share some systematic component. To address this question, we regress our firm-level changes in cash-flow

[3]We thank our AFA discussant Yufeng Wu for this suggestion.



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volatility on a value-weighted market-wide measure of cash-flow volatility that aggregates across all firms with dividend events. Table 10 reports a positive and statistically significant loading on the market-wide measure of cash-flow volatility across dividend events, suggesting at least in part that the changes in cash-flow volatility that we document reflect a systematic component.

Our results indicate dividend changes are followed by changes in cash-flow volatility in the opposite direction. This result is novel. Furthermore, our results indicate that following dividend changes, the cash-flow levels are unchanged. These results are inconsistent with prior dividend-signaling models, but consistent with earlier empirical literature that used accounting-based measures of cash-flow or earnings levels. In Table A.4 in the Online Appendix, we show the variance of cash-flow news and total return volatility are only mildly positively correlated with each other, which decreases the likelihood that changes in generic return volatility can explain our findings. In Table A.5 in the Online Appendix, we directly show that annualized stock return volatility does not change around the dividend events, or the change has the "wrong" sign. We use five years of daily return data before and after the dividend events to calculate stock return volatility consistent with the windows we use in the VAR.[4] Finally, our results indicate that following dividend changes, the firm's discount-rate news is unchanged. This result is also novel and clarifies the earlier evidence of Grullon et al. (2002) and Hoberg and Prabhala (2009) that beta and other measures of firm risk are lower following dividend payments. Our results clarify that only cash-flow volatility changes, and discount rates do not. Therefore, our evidence is consistent with the hypothesis that dividends convey information about cash-flow volatility, that is, the second moment of future earnings. The evidence indicates discount-rate news does not drive corporate dividend policies. Next, we examine cumulative abnormal returns to dividend events, and how such dividend announcement returns relate to subsequent changes in cash-flow volatility.

[4]Our results might differ from previous literature (Venkatesh (1989), Jones et al. (2014), Jayaraman and Shastri (1993), Chay and Suh (2009)) because we use a different window to calculate total return volatility and we have a substantially larger sample period.



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## *D. Returns around Dividend Events*

So far, we have shown dividend changes are associated with a reduction in future cash-flow volatility. We now turn to examining dividend announcement returns. If dividend changes convey information about subsequent changes in cash-flow volatility, announcements of larger dividends should come with both larger cumulative announcement returns and larger subsequent changes in cash-flow volatility in the opposite direction.

Therefore, we study how the immediate market reaction to dividend changes is related to the subsequent change in cash-flow volatility and to the size of the dividend change itself. We first confirm in Table A.6 in the Online Appendix that in our sample, dividends do represent good news for investors, consistent with previous findings. Table A.6 reports the univariate market response to dividend changes in a three-day window bracketing the dividend event. Columns (1) to (3) show positive announcement returns for dividend increases, dividend initiations, and the pooled sample ranging between 0.7% and 2.37%. For cuts in dividends, columns (4) to (6) show a negative announcement return of 0.7% and a negative return of 8.7% for omissions. All results are nearly identical when we look at market-adjusted returns.

We then turn to a test of our hypothesis. We split the data into two sub-samples by the size of the dividend changes, using the median dividend change as the break point. Table 11 reports the results. In Panel A of Table 11, we see in column (1) that for large increases in dividends, the variance of cash-flow news drops by more than 21%, on average, after the announcement. The drop in variance is 14 percentage points smaller in column (2) when we instead study increases in dividends that are below the median increase. Column (3) shows the difference is highly statistically significant. We bootstrap the difference to calculate standard errors. Columns (4) and (5) instead show that announcements of large dividend cuts drive the increase in cash-flow-news variance. The difference is again highly statistically significant (see column (6)).

In Panel B of Table 11, we find in columns (1) to (3) that announcement returns for above-median dividend increases are significantly larger than announcement returns for below-median dividend increases; and we find in columns (4) to (6) that announcement returns for above-median dividend decreases are significantly larger in absolute terms (i.e.,



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they are more negative) than announcement returns for below-median dividend decreases. Together with our earlier results in Panel A, these results indicate larger changes in dividends carry more information because they are associated with larger announcement returns and larger subsequent changes in cash-flow volatility in the opposite direction, consistent with the hypothesis that dividend changes convey information about future cash-flow volatility.

# V. Theoretical Framework

In this section, we develop a framework to account for our empirical results of section IV. In Online Appendix I.*I.*, we show that a simple framework with symmetric information and a precautionary savings motive is sufficient to generate the prediction that dividend payments should correlate negatively with subsequent changes in cash-flow volatility. This baseline framework, however, cannot account for the announcement return evidence we present. We consider two alternative ways to augment the precautionary-savings model. First, in section V.*A.*, we consider a setting with asymmetric information about future cash-flow volatility. Next, in section V.*B.*, we consider a setting with agency costs. In both settings, we derive cross-sectional predictions that allow us to empirically distinguish across models.

## *A. A Signaling Model of Dividends and Cash-Flow Volatility*

Consider a manager running a firm on behalf of risk-neutral investors, which operates for three dates ($t = 0, 1, 2$) and two periods. At $t = 0$, the manager starts with cash reserves, $\omega_0$, and invests $I_0 \leq \omega_0$. At $t = 1$, the manager receives an endowment, $\omega_1$, and decides whether to pay dividends, $D_1$. Next, cash flows are realized, $Y_1 = R \cdot f(I_o) + \nu$, where $f$ is a production function with $f' > 0$, $f'' < 0$, and $f''' > 0$; the shock $\nu$ is distributed according to function $G$, with expected value $\mathbb{E}(\nu)$ that we normalize to 0, and a known variance $\sigma^2$, with $\mid \nu \mid << Y$. Parameter $R$ indicates investment opportunities, using a formulation introduced in Johnson et al. (2000) and Choe et al. (1993). We denote $\mathbb{E}[Y_1] = Y$. We only rule out extreme negative realizations to avoid the firm going bankrupt at $t = 2$.



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After dividends are paid and cash flows are realized, the manager invests any remaining cash, $I_1 = \omega_1 + Y_1 - D_1 + (\omega_0 - I_0)$. At $t = 2$, the manager pays out the final cash flows, $Y_2 = R \cdot f(I_1) + \nu$. The interest rate equals zero.

Notice that in this setting $\mathbb{E}[Y_2] = \mathbb{E}[R \cdot f(I_1) + \nu] = R \cdot f\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right)$ where $a$ is the certainty equivalent coefficient in the sense of Arrow-Pratt. For clarity of illustration in the main text we assume that the Arrow-Pratt coefficient is scale-invariant, i.e., $a(I_1^*) \equiv a$, which is the case for exponential production functions. In Online Appendix I.*I.* we analyze the general case.

To understand this formulation, note that in our framework, randomness in $Y$ reduces the expected profits if the function $f(.)$ is concave, in which case the firm is essentially risk averse with respect to fluctuations in $Y$, in the precise sense that $\mathbb{E}[f(Y)] < f(\mathbb{E}[Y])$, that is, Jensen's inequality.[5]

We introduce asymmetric information by assuming the manager learns $\sigma^2$ at $t = 1$ before paying dividends, whereas investors only observe $D_1$. As a result, at $t = 1$, asymmetric information exists concerning the variance of the firm's cash flows, $\sigma^2$, which is distributed according to function $\Xi$ over $[\sigma^2_{\min}, \sigma^2_{\max}]$. Prior to $t = 1$, the investors and the manager have symmetric information on $\sigma^2$ with $\mathbb{E}[\sigma^2] = \sigma_p^2$, that is, the prior. Both the investors and the manager also know $\mathbb{E}[\nu] = 0$. Therefore, whereas the manager knows the true $\sigma^2$, investors attempt to infer $\sigma^2$ from the dividend policy. Thus, the timeline is as follows:

**Time 0**: The firm gets endowment $\omega_0$; wlog invests $I_0 = \omega_0$;

**Time 1**: The firm gets endowment $\omega_1$; the firm manager learns the true $\sigma^2$ and decides how much dividend $D_1$ to pay; after $D_1$ is paid, investors trade; then, $Y_1 = R \cdot f(I_0) + \nu$ is realized; next, the firm invests $I_1 = \omega_1 + Y_1 - D_1$;

**Time 2**: $Y_2 = R \cdot f(I_1) + \nu$ is realized; the remaining cash is paid out; the world ends.

This setting captures a seasoned firm that has been in operation since well before the dividend decision and expects to continue to operate in the future. Accordingly, we can think of Time 0 as "the distant past," Time 1 as "now," and Time 2 as "the distant future." Similarly, we can interpret the endowments as the cash flows resulting from

[5]This insight exactly parallels the one in Froot, Scharfstein, and Stein (1993) about conditions under which risk management increases firm value. See also Rampini and Viswanathan (2013).



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past investment decisions. Throughout the analysis, we assume the existence of financial constraints. To illustrate our results in the starkest manner, we completely shut down the firm's access to financial markets, although our results only require that external financing is not perfectly costless. Similarly, we maintain that managers cannot perfectly hedge the risk of the firm's future cash flows.[6]

For signaling to have scope, at least some investors need to have shorter horizons than others. Consistent with the signaling literature (e.g., Miller and Rock (1985)), we assume some investors are hit by an idiosyncratic liquidity shock at $t = 1$ and as a result must sell their shares. To be precise, we assume a fraction $k$ of these investors sell after dividends $D_1$ are paid and before cash flows $Y_1$ are realized, whereas the remaining fraction $(1-k)$ will hold their shares until $t = 2$, at which time they will learn the realization of $\sigma^2$. Investors may trade shares continuously between $t = 0$ and $t = 2$. We can summarize the information set of the two groups of investors with respect to endowment, investment, random shock, and net dividends at the time of the announcement of $D_1$ as

$$\begin{aligned} \left\{\omega_0, \omega_1, I_0, D_1, \mathbb{E}(\nu) = 0, Var(\nu) = \sigma^2\right\} &= \phi^h \\ \{\omega_0, \omega_1, I_0, D_1, \mathbb{E}(\nu) = 0\} &= \phi^s, \end{aligned}$$

where $\phi^h$ is the information set of the investors who continue holding their shares, and $\phi^s$ is the information set of those who decide to sell. The perceived value of the firm at time 1 by those who decide to sell is thus

$$V_1^s = D_1 + \mathbb{E}\left[Y_2 \mid \phi^s\right] = D_1 + \mathbb{E}\left[R \cdot f(\omega_1 + Y_1 - D_1) \mid \phi^s\right].$$

Similarly, the perceived value of the firm at time 1 by those who decide to hold is

$$V_1^h = D_1 + \mathbb{E}\left[Y_2 \mid \phi^h\right] = D_1 + \mathbb{E}\left[R \cdot f(\omega_1 + Y_1 - D_1) \mid \phi^h\right].$$

[6] With perfect financial risk management and hedging, a firm's earnings become fully informative about the firm's future prospects, thereby limiting any information content of dividend policy (see, e.g., DeMarzo and Duffie (1995)).



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The manager acts in the interest of investors who own the firm at $t = 1$, and maximizes

$$\begin{aligned} \max_{\{D_1\}} \quad & W_1 = kV_1^s + (1-k)V_1^h \\ & \text{subject to} \\ & Y_2 = R \cdot f(I_1) + \nu \\ & D_1 \leq \omega_1, \end{aligned}$$

where we assume $\omega_1$ is sufficiently large and investors know the investment at time 1 will be $I_1 = \omega_1 + Y_1 - D_1$ after the realization of $Y_1$.

We solve the model in Online Appendix I.*A*. Figure 2 illustrates the equilibrium. The worst firm type with the highest variance, $\sigma^2_{max}$, sets dividends $D_1^\star$ as in the first-best, full-information case. As variance decreases, firms pay more dividends and forego more investment opportunities. Therefore, relative to the first-best case with full information, the signaling equilibrium features excessive dividend payment and under-investment.

In Online Appendix I.*D.*, we show the concavity of the production function guarantees the single-crossing property of signaling games is satisfied. More broadly, we show this problem satisfies the Riley (1979) conditions for games of incomplete information, and we derive the ordinary differential equation (ODE) together with a boundary condition that uniquely determines the schedule. Furthermore, we prove in Online Appendix I.*E.* that this solution is the Riley equilibrium outcome and it is the unique separating equilibrium of our game, by applying the results of Mailath (1987), and we show in Online Appendix I.*F.* that it is the unique equilibrium that survives standard refinement concepts for this class of games (Esö and Schummer (2009); see also Ramey (1996) and Cho and Sobel (1990)).

In this model, dividends are a signal to the market about the cash-flow volatility. Because managers care about short-term investors, they would like to signal that their cash flows have low volatility and therefore higher value. For this signal to be credible, it must be costly. To prevent imitation and thus generate a separating equilibrium, the signal must be costlier for low types than for high types. This conclusion follows from the concavity of the production function, because riskier firms have more to lose in terms of



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foregone investment if they pay larger dividends in an attempt to imitate safer firms.

We can now derive the main comparative statics, which guide our interpretation of the data. The proofs are in Online Appendix I.*B.* The first comparative static indicates dividend changes should be followed by changes in future cash-flow volatility in the opposite direction.

**Prediction 1 (signaling - time series)**. Changes in dividends should be followed by changes in future cash-flow volatility in the opposite direction; that is, $\dfrac{\partial \sigma^2(D_1)}{\partial D_1} < 0$.

Paying higher dividends will increase the probability of needing to forego future investment opportunities, as the (expected) volatility of future cash flows increases. Asymmetric information amplifies this channel, because riskier firms will not be able to afford paying out higher dividends to imitate safer firms.

The second comparative static provides the more nuanced cross-sectional prediction of our signaling model.

**Prediction 2 (signaling - cross-section)**. Following a dividend increase (decrease), a larger decrease (increase) occurs in cash-flow volatility for firms with smaller (larger) current earnings:

$$\frac{\partial^2 \sigma^2\left(D_1\right)}{\partial D_1 \partial Y} = -\frac{2f''(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2(D_1)}{k \cdot a \cdot R \cdot \left[f'(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2(D_1)\right]^2} > 0.$$

Prediction 2 states the cross derivative of cash-flow volatility with respect to dividends and (current) earnings is positive. The intuition is that the smaller the earnings, the larger the foregone investment opportunities for a given level of dividend payment. Therefore, the same dividend should carry a larger information content for future changes in cash-flow volatility for firms with smaller earnings. This prediction depends crucially on asymmetric information about future cash-flow volatility and does not obtain in the basic setting with



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symmetric information.[7]

Our next predictions relate to the effect of dividend announcements on firm value. In a fully separating equilibrium, investors perfectly learn the firm's type, $\sigma^2$, from the dividend announcement. Then, recalling that $\sigma_p^2$ indicates the prior belief about cash-flow volatility, we obtain by Taylor-series approximation the change in firm value upon the dividend announcement, $\Delta V$, as follows:

$$\Delta V \approx D_1 - \mathbb{E}\left[D_1\right] - \frac{a}{2}(\sigma^2 - \sigma_p^2) R f'(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2),$$

where $\mathbb{E}\left[D_1\right]$ indicates the prior expectation of dividends. As in the dividend-signaling literature, $\frac{\Delta V}{\Delta D_1} > 0$, thus reflecting the fact that larger dividend announcements represent news about better future prospects. In our framework and contrary to the extant literature, better future firm prospects refer not to the first but to the second moment of future cash flows. This line of reasoning leads us to an additional testable prediction.

**Prediction 3 (signaling - firm value)**. Denote with $\Delta\sigma^2 = \left(\sigma^2 - \sigma_p^2\right)$ the change in (expected) future cash-flow volatility. Also, denote with $\Delta D = D_1 - \mathbb{E}\left[D_1\right]$ the (unexpected) change in dividends. We then obtain

$$\frac{\Delta V}{\Delta \sigma^2} = -\frac{a}{2} R f'(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2) < 0, \ \frac{\Delta V}{\Delta D} = 1 > 0;$$

that is, larger dividend announcement returns should be associated with larger dividend changes and larger subsequent reductions in cash-flow volatility, which is consistent with our empirical findings in Table 11.

Prediction 3 implies announcements of dividend changes should carry a larger information content (i.e., have a larger announcement return), because the expected reduction in future cash-flow volatility increases. Note also that Prediction 3 does not

[7]This prediction is also unique within the class of signaling models and crucially depends on the cost of the signal being foregone investment opportunities. In a model in which the cost of the signal is an exogenously assumed "flotation cost" of having to issue equity in the future following a negative shock, Kale and Noe (1990) obtain that idiosyncratic volatility should decrease following dividend increases, but systematic volatility should change non-monotonically with dividend payments. Because the cost of the signal is exogenous, Kale and Noe (1990) find no cross-sectional variation in the expected change in volatility following dividend changes.



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obtain in the basic setting with symmetric information that we discuss in Online Appendix I.*I.*

Finally, in our framework, dividends and share repurchases are two equivalent ways to return cash to shareholders. As a result, Predictions 1 and 3 should also apply to share repurchases.

## *B. Agency and Cash-Flow Volatility*

An alternative explanation of dividend policy is that dividends can help address managerial agency problems. The fact that cash is paid out to investors as dividends, rather than being wasted in managerial private benefits, represents good news for investors. In addition, paying dividends may expose companies to the possible need to raise external funds in the future, which may further shift control to outside investors and reduce agency problems (e.g., Easterbrook (1984); see also Fluck (1999), Myers (2000), Lambrecht and Myers (2012), and Wu (2018) for additional examinations of these ideas).

To nest some of these ideas into our framework, two main alternative formulations exist, which differ according to whether managerial private benefits are a function of the dollar amount of dividends paid (*additive formulation*) or of the percent of earnings paid out as dividends (*multiplicative formulation*).

### *B.1 Agency: Additive Formulation*

We assume the manager bears some private agency costs $c(D_1)$ from paying a dividend $D_1$, where the function $c$ is convex, that is, $c' > 0$ and $c'' > 0$. (This formulation is standard and is akin to assuming the existence of (concave) private benefits of control, which increase in a concave manner with the cash flows that are not distributed to the shareholders, $Y - D$.) As we show in Online Appendix I.*J.*, under this additive formulation, we derive the following sharp predictions:

**Prediction** $i$ **(additive agency - time series)**.

$$\frac{\partial \sigma^2}{\partial D_1} < 0.$$



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**Prediction** $ii$ **(additive agency - cross-section)**.

$$\frac{\partial^2 \sigma^2}{\partial D_1 \partial Y} < 0.$$

Prediction (i) states that, as in the signaling model, higher dividends should correlate with lower future cash-flow volatility. Two effects are at play. First, lower future cash-flow volatility implies a higher income available for paying dividends, holding investment opportunities fixed. Second, lower future cash-flow volatility enables managers to extract fewer private benefits (incur higher agency costs), again holding investment fixed.

Prediction (ii) states that, unlike the signaling model, the *larger* the current earnings, the larger the reduction in cash-flow volatility should be following the same dollar of dividend paid. Unlike Prediction 2 from the signaling model, in this case, larger current earnings make extracting more private benefits (incur lower agency costs) easier, for a given dollar of dividends. The reason is larger earnings allow the manager not only to pay dividends, but also to extract private benefits, holding fixed future investment.

Finally, in agency settings, low investment opportunities should magnify agency problems. To capture these ideas, we can use a similar formulation to Johnson et al. (2000) and Choe et al. (1993) and assume the production function, $f$, is pre-multiplied by a positive parameter $R$ representing investment opportunities. As we show in Online Appendix I.$L$., we obtain

**Prediction A.1 (additive agency - investment opportunities)**.

$$\frac{\partial^2 \sigma^2}{\partial D_1 \partial R} < 0.$$

The decline in cash-flow volatility following dividend increases should be more pronounced for firms with *smaller* investment opportunities, reflecting the fact that smaller investment opportunities magnify the extent of agency costs. Lower cash-flow volatility facilitates the extraction of private benefits, high investment opportunities mute this effect because they increase the cost of extracting private benefits relative to engaging in efficient investment.

Interestingly, we also show in Online Appendix I.$L$. with this same formulation



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of investment opportunities, in the signaling model, we obtain the opposite prediction, $\frac{\partial^2\sigma^2}{\partial D_1 \partial R} > 0$. Intuitively, the scope of using dividends to signal future declines in cash-flow volatility is magnified when investment opportunities are larger.

### *B.2 Agency: Multiplicative Formulation*

In this section, we discuss a multiplicative formulation of agency theory. According to this formulation, the manager pays off as dividends a fraction of cash flows $d_1$ and enjoys private benefits $b(1-d_1)$ from paying a dividend $d_1$, where the function $b$ is concave, that is, $b' > 0$ and $b'' < 0$.

Under this formulation, we show in Online Appendix I.*K.* it is no longer possible to obtain sharp predictions, because the signs of the comparative statics exercises become ambiguous. A new effect arises because lower future cash-flow volatility implies higher future income, enabling managers to extract higher private benefits (incur lower agency costs). This effect pushes toward a positive correlation between changes in dividends and subsequent changes in cash-flow volatility. As a result, in general, we obtain that $\frac{\partial\sigma^2}{\partial D_1} \gtreqless 0$. This finding has two implications. First, on the face of it, this new effect cannot be of first-order importance in the data, because empirically we find $\frac{\partial\sigma^2}{\partial D_1} < 0$, consistent with the signaling model and with the additive agency model. The second implication is more nuanced because it implies the second-order cross derivatives also have ambiguous sign, $\frac{\partial^2\sigma^2}{\partial D_1 \partial Y} \gtreqless 0$, $\frac{\partial^2\sigma^2}{\partial D_1 \partial R} \gtreqless 0$. Under a multiplicative formulation, new effects arise because lower future cash-flow volatility implies higher future income, enabling managers to extract higher private benefits (incur lower agency costs). Similarly, higher current earnings and higher future investment opportunities also allow managers to divert larger cash flows. In sum, the multiplicative agency model does not yield sharp, clear-cut empirical predictions. As a result, this multiplicative version of the agency model cannot be falsified in the data.

The takeaway of this section is that by examining how changes in volatility following dividend changes vary in the cross section as a function of the level of earnings and as a function of investment opportunities, that is, by estimating equation (13) below, we can shed light on the economic mechanism driving our results and gain additional insights relative to the specific predictions of signaling theory and of agency theory, at least in its



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additive formulation.[8]

# VI. Inspecting the Mechanism

In this section, we report additional empirical tests designed to establish the economic mechanism driving our main results. In section VI.*A.*, we present cross-sectional tests of our theoretical Prediction 2, which are a direct implication of the signaling framework. In section VI.*B.*, we study the indirect effect of dividend changes on the level of cash flows that arises due to the concavity of the production function and Jensen's inequality. In section VI.*C.*, we examine share repurchases. In section VI.*D.* we examine additional implications of an agency channel. In section VI.*E.*, we examine the extent to which tax arguments can explain our results.

## *A. Cross-Sectional Variation*

To examine the theoretical mechanism underlying our findings, we turn to a regression framework to examine cross-sectional variation in the response of cash-flow volatility to dividend changes. Specifically, for each dividend change in our sample, we now estimate a regression of percent changes in cash-flow volatility, $\Delta\,\mathbb{V}\mathrm{ar}(\eta_cf_{it})$, for firm $i$ and dividend event $t$, which we measure from stock returns using the methodology in section II., on the percent changes in dollar dividends, $\Delta D_{it}$:

$$\Delta\,\mathbb{V}\mathrm{ar}(\eta_cf_{it}) = \alpha + \gamma \cdot \Delta D_{it} + \delta \cdot X_{it} + \varepsilon_{it}. \tag{12}$$

We control for a host of additional potential determinants of cash-flow volatility and dividend payments, $X_i$, such as firm age, size, book-to-market, and financial leverage, as well as year and industry fixed effects at the Fama and French 17-industry level, and cluster standard errors at the dividend-quarter level. We impose non-overlapping events so we can consider equation (12) as a purely cross-sectional test. We expect $\gamma < 0$

[8]Bernheim and Wantz (1995) propose a test to distinguish between signaling and agency theories of dividends, although the conclusions of such tests are sensitive to the econometric techniques employed (see Bernhardt et al. (2005)).



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following Prediction 1.

To test the cross-sectional predictions of signaling and agency models, we then estimate the following specification:

$$\Delta\, \mathbb{V}\mathrm{ar}(\eta_cf_{it}) = \alpha + \beta_1 \cdot \Delta D_{it} + \beta_2 \cdot eps_{it} + \beta_3 \cdot \Delta D_{it} \cdot eps_{it} + \delta \cdot X_{it} + \varepsilon_{it}, \tag{13}$$

where *eps* is earnings per share. Our main coefficient of interest is $\beta_3$. From our signaling model of section V.*A*., we should expect $\beta_3 > 0$. According to the precautionary-savings setting with a constant Arrow-Pratt coefficient and symmetric information, we should expect $\beta_3 = 0$. The additive formulation of the agency model instead predicts $\beta_3 < 0$. We should also expect $\beta_1 < 0$ as per our baseline Prediction 1, and also $\beta_2 < 0$, reflecting a scale effect. Therefore, by estimating equation (13), we can tease out the nuanced cross-sectional predictions that allow us to distinguish between alternative mechanisms that might drive our baseline univariate results.

Table 12 reports the estimates. Column (1) confirms our baseline finding in a regression framework: Dividend changes correlate with subsequent changes in the variance of cash-flow news in the opposite direction. The interpretation is that firms change their dividend payout in anticipation of future changes in cash-flow volatility. In column (2), we add earnings per share (*eps*) as an additional covariate. Adding *eps* slightly increases the drop in variance following dividend increases. Firms with higher *eps* have a smaller variance in cash-flow news. Column (3) confirms our novel Prediction 2, consistent with the signaling model and inconsistent with the precautionary-savings and additive agency models: Dividend increases result in a drop in the variance of cash-flow news, but this drop is muted for firms with higher *eps*. Column (4) adds a host of potential determinants of cash-flow volatility and dividend payments such as firm age, size, book-to-market, and financial leverage. None of these additional covariates have a large impact on our main estimates of interest. Positive dividend changes are followed by a decline in cash-flow volatility, which is muted for firms with higher earnings per share. Columns (5) to (8) add year and industry fixed effects at the Fama and French 17-industry-level definition and confirm our basic findings.



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We show in the Online Appendix that results are robust when we add the initial variance of cash-flow news (see Table A.7), when we add the level of cash and equivalents as control variable (see Table A.8), and when we use cash flows rather than earnings (see Table A.9). Hence, the data support Prediction 2 of the signaling model in that the cross-sectional change in cash-flow volatility following dividend changes is muted for firms with larger earnings.

## *B. Indirect Effect of Cash-Flow Volatility*

Our signaling model suggests that in addition to the direct impact of the change in earnings volatility on value today through the signaling channel, increased earnings volatility also has an indirect impact on the first moment of the earnings distribution. Expected profits tomorrow, $\mathbb{E}[Y_2]$, change in the opposite direction relative to a change in cash-flow volatility, $\sigma$, according to

$$\frac{\partial}{\partial \sigma}\mathbb{E}[Y_2] = -\frac{a}{2} \cdot f'. \tag{14}$$

The key question is thus whether the magnitude of this indirect effect of cash-flow volatility on future earnings through Jensen's inequality is large or small relative to the direct signaling effect of cash-flow volatility on firm value. To get an idea of the magnitude of this indirect effect, we first note that in our model, earnings are positively autocorrelated, because a shock to today's earnings translates into an increase in future expected earnings

$$\frac{\partial}{\partial Y}\mathbb{E}[Y_2] = f'. \tag{15}$$

These comparative statics provide an insight into the relative magnitudes: The derivative of future expected earnings with respect to cash-flow volatility (equation (14)) equals the derivative of future expected earnings with respect to current earnings *times a multiplicative constant*, $-\frac{a}{2}$.



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Furthermore, combining the two comparative statics above,

$$\frac{dY}{d\sigma} = -\frac{a}{2}, \tag{16}$$

implies we can estimate the parameter a in our data by the cross-sectional regression of earnings ($eps$) on cash-flow volatility,

$$eps_i = \alpha + \beta \cdot \sigma_i + \varepsilon_i. \tag{17}$$

We present the results of this estimation strategy in Table 13. Our estimates imply the indirect effect of cash-flow volatility on future earnings is small, as $\hat{\beta} = -0.04$ (see column 2 of Table 13).[9] Furthermore, this effect is an order of magnitude smaller than the autoregressive coefficient of earnings, which is 0.6.

These findings have three implications. First, the main effect of cash-flow volatility on firm value is the direct signaling effect that we document in our paper. It works through changes in cash-flow volatility following dividend changes, as documented by our results that firms with larger dividend changes exhibit both larger CARs, and larger changes in cash-flow volatility in the opposite direction.

Second, changes in cash-flow volatility should also have an indirect effect on firm value through changes in future earnings. The reason is Jensen's inequality: With a concave production technology, less volatile inputs translate into higher expected earnings, which, in turn, will influence the firm's market value. Empirically, this indirect effect is statistically significant and has the theoretically expected sign, but the magnitude of this effect is small.

Third, our findings help explain why the extant empirical literature has found no changes in earnings following dividend changes. In light of our results, the magnitude of such changes in future earnings may be small and apply to earnings in the not-so-

[9]The estimate implies a CARA coefficient $\hat{a} = 0.08$, which in our setting also represents the curvature parameter of the firm's production function. We show in Online Appendix I.*M.* this value implies a similar curvature of the production function to the one in Li et al. (2016) in a structural estimation of the model by Rampini and Viswanathan (2013)((see also Rampini and Viswanathan (2010)).



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near future, so that typical empirical methods will have little power to detect statistical significance at longer horizons even if economic theory predicts non-zero effects.

## *C. Repurchases*

We now examine announcements of share repurchases. Together with dividends, share-repurchase decisions constitute the firm's overall payout policy. Unlike dividends, which are sticky and regular, share repurchases tend to be lumpy and infrequent. However, because share repurchases are yet another way to return cash to shareholders, our framework in section V. predicts patterns of cash-flow volatility following announcements of share repurchases similar to the results following announcements of dividend increases and initiation.

Table 14 reports the results for scaled changes in the variance of cash-flow news after the repurchase announcements relative to before. We find the variance of cash-flow news is, on average, 15% lower after the repurchase announcements relative to before. We then split the data into two sub-samples by the size of the share-repurchase announcements, using the median amount as cutoff. Consistent with our results for changes in dividends and with the predictions of the signaling model, we see in columns (2) and (3) of Panel A that large repurchase announcements are followed by a drop in cash-flow volatility that is more than 6% larger than the drop in variance for repurchase announcements below the median.

We then examine announcement returns to share repurchases in Panel B of Table 14. Consistent with prior literature, we find an announcement return of about 2% for all repurchase announcements. We see in columns (2) to (4) that announcement returns are almost 1.5% larger for large repurchase announcements relative to small ones.

These findings imply share-repurchase announcements convey information similar to announcements of dividend increases and initiations. Prior research (e.g., Jagannathan et al. (2000), Grullon and Michaely (2002)) emphasizes differences in the timing and scope of dividends and share repurchases. Our novel result is that share repurchases and dividend announcements convey very similar information to the market regarding changes in future cash-flow volatility.



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## *D. Investment Opportunities*

The signaling model with investment opportunities in section V. predicts the decline in cash-flow volatility following dividend increases should be more pronounced for firms with *larger* investment opportunities, because larger investment opportunities magnify the scope of signaling with dividends. Conversely, the additive formulation of our agency model predicts the opposite, because when investment opportunities are smaller, agency costs are larger.

To test these predictions, we employ two proxies for investment opportunities, namely, the book-to-market ratio and idiosyncratic volatility. The book-to-market ratio is a standard proxy for investment opportunities, and has a strong industry component (e.g., see Cohen and Polk (1995), Daniel et al. (1997), and Freyberger et al. (2019)). Idiosyncratic volatility also picks up within-industry variation. Firms with higher idiosyncratic volatility are harder to forecast. According to our signaling model, we would expect that the smaller the book-to-market ratio and the larger the idiosyncratic volatility, the larger the reduction in cash-flow volatility following dividend changes.

In Table 15, we split firms by their ex-ante idiosyncratic volatility. Specifically, we first calculate a firm's ex-ante idiosyncratic volatility on a four-quarter rolling basis relative to a Fama and French three-factor model using daily data. We then assign a firm into the large idiosyncratic volatility sample if it had a volatility in the top third of the distribution in the respective Fama and French 17 industries in the quarter before the dividend event and in the small volatility sample if it was in the bottom third. Large heterogeneity exists in firms' idiosyncratic volatility, and our procedure ensures we do not simply split our sample based on industry.

We find in columns (1) and (2) of Panel A of Table 15 that dividend increases for firms with large idiosyncratic volatility result in a decrease in the average cash-flow volatility of 19%, which is almost 9 percentage points larger than the drop for firms with low idiosyncratic volatility. The bootstrapped difference between the changes in cash-flow volatility within high- and low-volatility firms is highly statistically significant. We also find that firms with large ex-ante volatility largely drive the increase in cash-flow volatility after announced cuts in dividends, with the difference being statistically significant



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(see columns (4) to (6)). In addition, we repeat the sample splits for announcement returns. Panel B of Table 15 reports announcement returns, separately for firms with high and low idiosyncratic volatility. We find larger announcement returns in absolute value for firms with higher idiosyncratic volatility, and the difference is again statistically significant. These results are consistent with the predictions of the signaling model. They are inconsistent with the additive formulation of agency theory, although they can be rationalized under the multiplicative formulation of agency.

In Panel A of Table 16, we split firms by their ex-ante book-to-market ratio excluding the middle tercile. We find that firms with smaller book-to-market ratios experience a larger reduction in cash-flow volatility following dividend increases compared to firms with high book-to-market ratios. Following dividend decreases, firms with high book-to-market ratios experience a somewhat smaller increase in cash-flow volatility. Panel B of Table 16 reports announcement returns, separately for firms with high and low book-to-market ratio. We find slightly smaller announcement returns for low book-to-market firms after positive dividend news but more negative returns after negative dividend news relative to high book-to-market firms. The sample split by book-to-market ratio produces results that are, in general, consistent with the signaling model with investment opportunities with the exception of the announcement returns after positive dividend news for high-investment-opportunity firms.

## *E. Taxes*

Many theoretical and empirical papers on dividend policy rely, directly or indirectly, on tax arguments. In some signaling models, the cost of the signal is the deadweight cost of the taxes paid on dividends relative to the (lower) tax that would be paid on capital gains (see, e.g., John and Williams (1985), and Bernheim (1991)). In other models (e.g., Shleifer and Vishny (1986) Section V and Allen et al. (2000)), differential taxation across different shareholders (institutions vs. retail investors) explains dividend policy as a way for corporations to attract institutions as large shareholders.

These tax-based explanations have been helpful in thinking about dividend policy. However, since the Jobs and Growth Tax Relief Reconciliation Act of 2003 in the U.S.,



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dividends are taxed at the same rate as capital gains even for individual investors (and for many classes of institutional investors, taxation has been the same since even before the Jobs Act). In this more recent tax regime, 2003–2013, we find in Panel C of Table 8 results similar to those we obtained in the full sample, as well as in the early 1964–1988 sub-sample characterized by differential taxation.

As a result, constructing a dividend equilibrium, signaling or otherwise, in which differential taxation plays any role, whether differential corporate taxation of dividends versus capital gains, or differential personal taxation across different investors, has become challenging. For these reasons, we abstract from taxation in our analysis of dividend policy.

# VII. Conclusion

The notion that changes in dividend policy convey information to the market is intuitive, and managers support it in surveys. The strong market reaction to announcements of dividend changes further suggests dividend policy *does* contain value-relevant information. But empirical research so far has found little support for dividend-signaling models in the data: No meaningful relation exists between changes in dividends and changes in future earnings, and "the wrong firms are paying dividends, and the right firms are not" (DeAngelo et al. (2009), p.185). Consistent with existing theories, the empirical literature has focused on the relationship between dividend changes and changes in earnings—the first moment—rather than between dividend changes and changes in earnings volatility—the second moment.

In this paper, we study whether the cash-flow volatility changes around dividend events. We use the Campbell (1991) return decomposition to estimate cash-flow volatility from data on stock returns. We find cash-flow volatility decreases following dividend increases (and initiations), and cash-flow volatility increases following dividend decreases (and omissions). Furthermore, larger dividend changes are followed by larger changes in cash-flow volatility in the expected direction.

To understand the theoretical forces driving these findings, we develop a model that



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allows for both signaling and agency motives in an additive formulation. Both motives have identical implications for the change in the variance of cash flows around dividend events, but they make predictions of opposite signs regarding the interaction with the level of earnings. In the signaling model, the smaller the current earnings, the more information a given dollar of dividends contains, because the cost of the signal is foregone investment opportunities. In the agency model, the higher the current earnings, the more strongly the market should react, because low earnings already constrain the private benefits of managers. In the cross section, we find empirically the same dollar of dividend paid is followed by a larger reduction in cash-flow volatility for firms with smaller current earnings consistent with the signaling model. We also study a multiplicative version of the agency model in which managers can divert a fraction of earnings and show that this formulation does not deliver sharp predictions.

Payout policies have attracted voluminous research, both theoretical and empirical, over the past decades. Our contributions are threefold. First, we provide an innovative method in a corporate finance context to measure the first and second moment of future cash flows; second, we provide a host of new facts about cash-flow volatility and payout policy; and third, we offer a simple model to rationalize our empirical results. Our static model simultaneously rationalizes our novel empirical results on payout policy and expected cash-flow volatility, as well as many results from the prior literature. The main takeaway of our analysis is that the riskiness of future cash flows is a central determinant of firms' payout policies.

Signaling models in corporate finance have fallen out of favor since empirical research failed to find support for their central predictions that cash flows should change after dividend changes in the same direction, and that younger and riskier firms should pay more dividends than mature ones. Our paper shows the importance of considering precisely which moment of the distribution of future cash flows dividend changes might signal. Far beyond our specific application, our evidence suggests a need to reconsider more broadly the predictions of signaling models in corporate finance and other fields.

The method we employ to measure the moments of the distribution of expected cash flows and discount rates, combined with our findings regarding firms' conveying



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information about the second moment of future cash flows, suggests opportunities for future research exploring the motives of other corporate financial decisions. For example, Kogan et al. (2019) examine whether "unusually large" investment expenditures (i.e., "spikes") are followed by lower cash-flow volatility, as implied by the exercise of real options, or by larger cash-flow volatility, as implied by agency theory. Our method may also be able to shed light on questions beyond finance. For example, a recent strand of research in economics has stressed ways in which aggregate uncertainty can affect firm investment dynamics (e.g., Bloom (2009), Bloom et al. (2007)). Researchers may now expand this line of reasoning to investigate the precise relevant source of uncertainty driving firms' investment policies.



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# References


Allen, F., A. E. Bernardo, and I. Welch (2000). A theory of dividends based on tax clienteles. *Journal of Finance 55*(6), 2499–2536.

Benartzi, S., R. Michaely, and R. Thaler (1997). Do changes in dividends signal the future or the past? *Journal of Finance 52*(3), 1007–1034.

Bernanke, B. S. and K. N. Kuttner (2005). What explains the stock market's reaction to federal reserve policy? *Journal of Finance 60*(3), 1221–1257.

Bernhardt, D., A. Douglas, and F. Robertson (2005). Testing dividend signaling models. *Journal of Empirical Finance 12*(1), 77–98.

Bernheim, B. D. (1991). Tax policy and the dividend puzzle. *RAND Journal of Economics 22*(4), 455–476.

Bernheim, B. D. and A. Wantz (1995). A tax-based test of the dividend signaling hypothesis. *American Economic Review 85*(3), 532–551.

Bhattacharya, S. (1979). Imperfect information, dividend policy, and "the bird in the hand" fallacy. *Bell Journal of Economics 10*(1), 259–270.

Bhattacharya, S. (1980). Nondissipative signaling structures and dividend policy. *Quarterly Journal of Economics 95*(1), 1–24.

Bloom, N. (2009). The impact of uncertainty shocks. *Econometrica 77*(3), 623–685.

Bloom, N., S. Bond, and J. Van Reenen (2007). The impact of uncertainty shocks. *Review of Economic Studies 74*(3), 391–415.

Brav, A., J. R. Graham, C. R. Harvey, and R. Michaely (2005). Payout policy in the 21st century. *Journal of Financial Economics 77*(3), 483–527.

Campbell, J. and R. Shiller (1988a). The dividend-price ratio and expectations of future dividends and discount factors. *Review of Financial Studies 43*(3), 661–676.

Campbell, J. and R. Shiller (1988b). Stock prices, earnings, and expected dividends. *Journal of Finance 43*(3), 661–676.

Campbell, J. Y. (1991). A variance decomposition for stock returns. *Economic Journal 101*(405), 157–179.

Chay, J.-B. and J. Suh (2009). Payout policy and cash flow uncertainty. *Journal of Financial Economics 1*(93), 88–107.

Chinco, A., A. Neuhierl, and M. Weber (2019). Estimating the anomaly baserate. *Chicago Booth Research Paper* (19-10).

Cho, I.-K. and J. Sobel (1990). Strategic stability and uniqueness in signaling games. *Journal of Economic Theory 50*(2), 381–413.

Choe, H., R. W. Masulis, and V. Nanda (1993). Common stock offerings across the business cycle: Theory and evidence. *Journal of Empirical Finance 1*(1), 3–31.

Cochrane, J. H. (2011). Presidential address: Discount rates. *Journal of Finance 66*, 1047–1108.

Cohen, R. B. and C. K. Polk (1995). An investigation of the impact of industry factors in asset pricing tests. *Unpublished manuscript, University of Chicago*.

Constantinides, G. M. and D. Duffie (1996). Asset pricing with heterogeneous consumers. *Journal of Political economy 104*(2), 219–240.




Electronic copy available at: https://ssrn.com/abstract=3064029

D'Acunto, F., R. Liu, C. Pflueger, and M. Weber (2018). Flexible prices and leverage. *Journal of Financial Economics 129*(1), 46–68.

Daniel, K., M. Grinblatt, S. Titman, and R. Wermers (1997). Measuring mutual fund performance with characteristic-based benchmarks. *Journal of Finance 52*(3), 1035–1058.

DeAngelo, H., L. DeAngelo, and D. J. Skinner (1996). Reversal of fortune dividend signaling and the disappearance of sustained earnings growth. *Journal of Financial Economics 40*(3), 341–371.

DeAngelo, H., L. DeAngelo, and D. J. Skinner (2009). Corporate payout policy. *Foundations and Trends® in Finance 3*(2–3), 95–287.

DeAngelo, H., L. DeAngelo, and R. M. Stulz (2006). Reversal of fortune dividend signaling and the disappearance of sustained earnings growth. *Journal of Financial Economics 81*(2), 227–254.

DeMarzo, P. M. and D. Duffie (1995). Corporate incentives for hedging and hedge accounting. *Review of Financial Studies 8*(3), 743–771.

Easterbrook, F. H. (1984). Two agency-cost explanations of dividends. *American Economic Review 74*(4), 650–659.

Esö, P. and J. Schummer (2009). Credible deviations from signaling equilibria. *International Journal of Game Theory 38*(3), 411–430.

Fama, E. F. (1965). The behavior of stock-market prices. *Journal of Business 38*(1), 34–105.

Fama, E. F. and K. R. French (1988). Dividend yields and expected stock returns. *Journal of Financial Economics 22*, 3–25.

Fama, E. F. and K. R. French (2001). Disappearing dividends: changing firm characteristics or lower propensity to pay? *Journal of Financial Economics 60*(1), 3–43.

Farre-Mensa, J., R. Michaely, and M. C. Schmalz (2014). Payout policy. *Annual Review of Financial Economics 6*, 75–134.

Fluck, Z. (1999). The dynamics of the manager-shareholder conflict. *Review of Financial Studies 12*(2), 379–404.

Freyberger, J., A. Neuhierl, and M. Weber (2019). Dissecting characteristics nonparametrically. *Review of Financial Studies (forthcoming).*

Froot, K. A., D. S. Scharfstein, and J. C. Stein (1993). Risk management: Coordinating corporate investment and financing policies. *Journal of Finance 48*(5), 1629–1658.

Fu, F. (2009). Idiosyncratic risk and the cross-section of expected stock returns. *Journal of financial Economics 91*(1), 24–37.

Gorodnichenko, Y. and M. Weber (2016). Are sticky prices costly? evidence from the stock market. *American Economic Review 106*(1), 165–99.

Grullon, G. and R. Michaely (2002). Dividends, share repurchases, and the substitution hypothesis. *Journal of Finance 57*(4), 1649–1684.

Grullon, G. and R. Michaely (2004). The information content of share repurchase programs. *Journal of Finance 59*(2), 651–680.

Grullon, G., R. Michaely, and B. Swaminathan (2002). Are dividend changes a sign of



Electronic copy available at: https://ssrn.com/abstract=3064029

firm maturity? *Journal of Business 75*(3), 387–424.

Guay, W. and J. Harford (2000). The cash-flow permanence and information content of dividend increases versus repurchases. *Journal of Financial Economics 55*(3), 385–415.

Guttman, I., O. Kadan, and E. Kandel (2010). Dividend stickiness and strategic pooling. *Review of Financial Studies 12*(23), 4455–4495.

Hadlock, C. J. and J. R. Pierce (2010). New evidence on measuring financial constraints: Moving beyond the KZ index. *Review of Financial Studies 5*(23), 1909–1940.

Ham, C., Z. Kaplan, and M. T. Leary (2019). Do dividends convey information about future earnings? *Journal of Financial Economics, forthcoming*.

Hoberg, G. and N. R. Prabhala (2009). Disappearing dividends, catering, and risk. *Review of Financial Studies 1*(22), 79–116.

Jagannathan, M., C. P. Stephens, and M. S. Weisbach (2000). Financial flexibility and the choice between dividends and stock repurchases. *Journal of Financial Economics 57*(3), 355–384.

Jayaraman, N. and K. Shastri (1993). The effects of the announcements of dividend increases on stock return volatility: The evidence from the options market. *Journal of Business Finance and Accounting 20*(5), 673–685.

John, K. and J. Williams (1985). Dividends, dilution, and taxes: A signalling equilibrium. *Journal of Finance 40*(4), 1053–1070.

Johnson, S., P. Boone, A. Breach, and E. Friedman (2000). Corporate governance in the asian financial crisis. *Journal of Financial Economics 58*(1-2), 141–186.

Jones, J. S., J. Gu, and P. Liu (2014). Do dividend initiations signal a reduction in risk? evidence from the option market. *Review of Quantitative Finance and Accounting 42*(1), 143–158.

Kahle, K. M. and R. M. Stulz (2017). Is the US public corporation in trouble? *Journal of Economic Perspectives 31*(3), 67–88.

Kale, J. R. and T. H. Noe (1990). Dividends, uncertainty, and underwriting costs under asymmetric information. *Journal of Financial Research 13*(4), 265–277.

Keloharju, M., J. T. Linnainmaa, and P. Nyberg (2019). Long-term discount rates do not vary across firms. Technical report, National Bureau of Economic Research.

Kogan, S., R. Michaely, S. Rossi, and M. Weber (2019). Corporate investment and subsequent changes in stock returns. *Unpublished manuscript*.

Kumar, P. (1988). Shareholder-manager conflict and the information content of dividends. *Review of Financial Studies 2*(1), 111–136.

Lambrecht, B. M. and S. C. Myers (2012). A Lintner model of payout and managerial rents. *Journal of Finance 67*(5), 1761–1810.

Lettau, M. and S. Van Nieuwerburgh (2007). Reconciling the return predictability evidence. *Review of Financial Studies*.

Li, S., T. M. Whited, and Y. Wu (2016). Collateral, taxes, and leverage. *Review of Financial Studies 29*(6), 1453–1500.

Lintner, J. (1956). Distribution of incomes of corporations among dividends, retained earnings, and taxes. *American Economic Review 46*(2), 97–113.

Mailath, G. J. (1987). Incentive compatibility in signaling games with a continuum of



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types. *Econometrica 55*(6), 1349–1365.

Michaely, R., R. H. Thaler, and K. L. Womack (1995). Price reactions to dividend initiations and omissions: Overreaction or drift? *Journal of Finance 50*(2), 573–608.

Miller, M. H. and F. Modigliani (1961). Dividend policy, growth, and the valuation of shares. *Journal of Business 34*(4), 411–433.

Miller, M. H. and K. Rock (1985). Dividend policy under asymmetric information. *Journal of Finance 40*(4), 1031–1051.

Myers, S. C. (2000). Outside equity. *Journal of Finance 55*(3), 1005–1038.

Ramey, G. (1996). D1 signaling equilibria with multiple signals. *Journal of Economic Theory 69*(2), 508–531.

Rampini, A. A. and S. Viswanathan (2010). Collateral, risk management, and the distribution of debt capacity. *Journal of Finance 65*(6), 2293–2322.

Rampini, A. A. and S. Viswanathan (2013). Collateral and capital structure. *Journal of Financial Economics 109*(2), 466–492.

Riley, J. G. (1979). Informational equilibrium. *Econometrica 47*(2), 331–359.

Shleifer, A. and R. W. Vishny (1986). Large shareholders and corporate control. *Journal of Political Economy 94*(3), 461–488.

Shumway, T. (1997). The delisting bias in CRSP data. *Journal of Finance 52*(1), 327–340.

Venkatesh, P. (1989). The impact of dividend initiation on the information content of earnings announcements and return volatility. *Journal of Business 62*(2), 175–197.

Vuolteenaho, T. (2002). What drives firm-level stock returns? *Journal of Finance 57*(1), 233–264.

Weber, M. (2015). Nominal rigidities and asset pricing. *Unpublished manuscript, University of Chicago*.

Weber, M. (2018). Cash flow duration and the term structure of equity returns. *Journal of Financial Economics 128*(3), 486–503.

Wu, Y. (2018). What's behind the smooth dividends? Evidence from structural estimation. *Review of Financial Studies 31*(10), 3979–4016.



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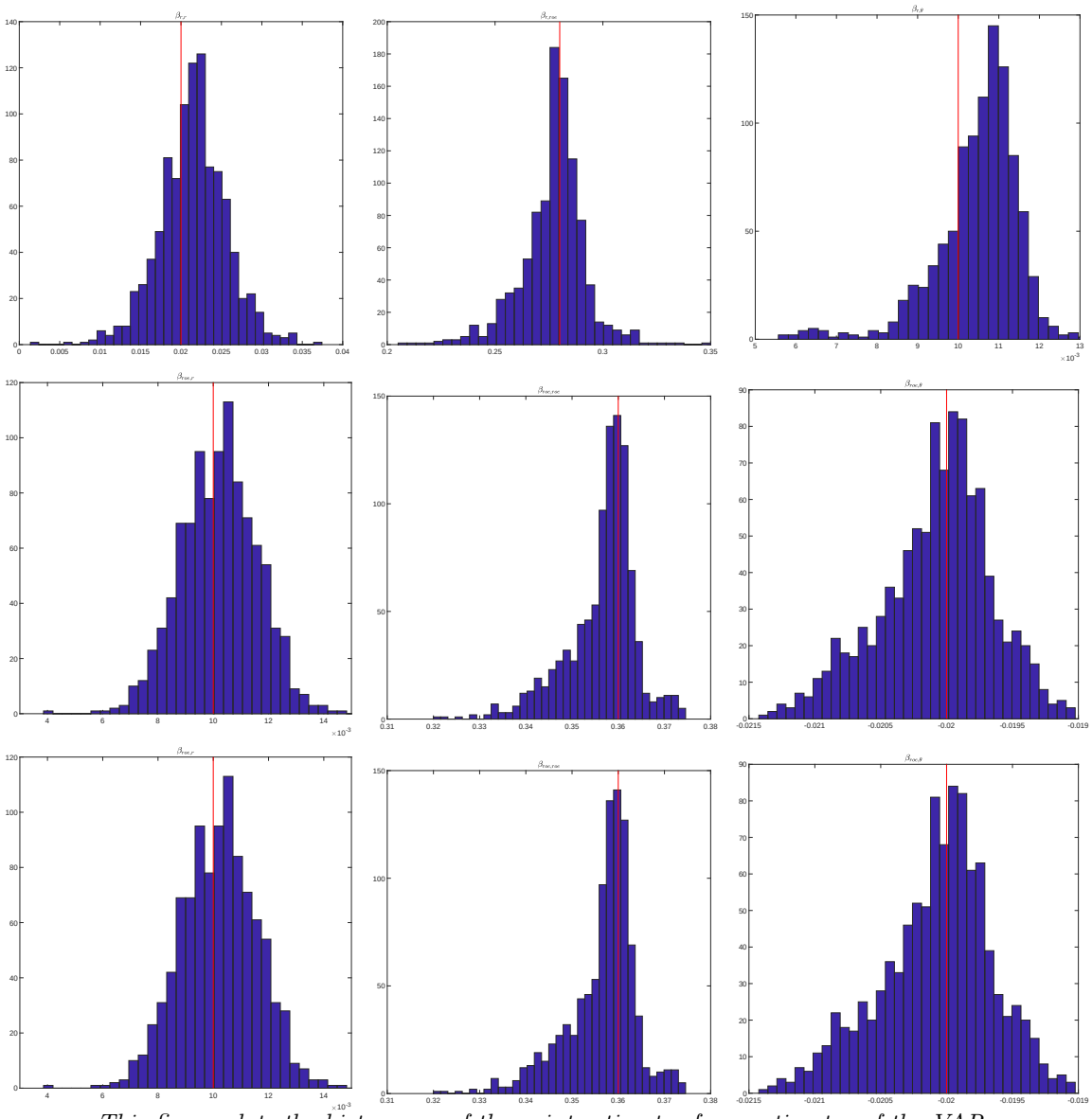
Figure 1: **Histogram of VAR Point Estimates from Simulation**



*This figure plots the histograms of the point estimates from estimates of the VAR. Each simulation consists of 1,000 draws. In each draw, we randomly choose a ten-years period with replacement and estimate the VAR we use in our empirical analysis. The red lines indicate the full sample estimates we report in Table 2.*



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Figure 2: **Model Solution**

*This figure plots the solution of the signaling model of Section V.A. The red line depicts the equilibrium downward sloping relationship between dividends, $D_1$, and cash flow volatility, $\sigma^2$. The worst firm type with the highest variance, $\sigma^2_{max}$, sets dividends $D_1^\star$ as in the first-best, full-information case.*

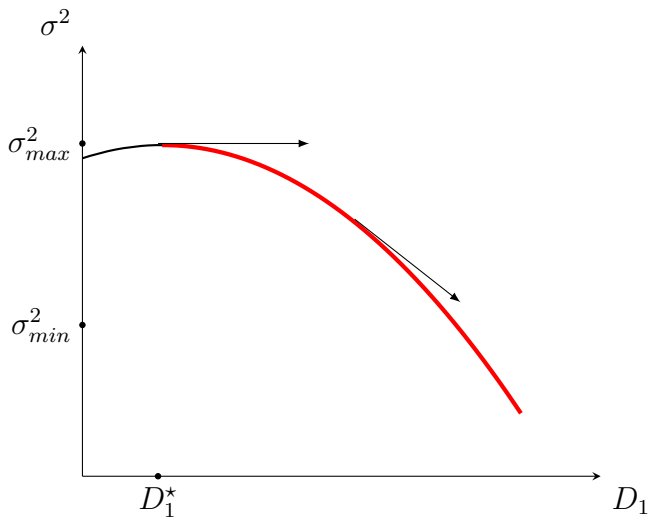




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Table 1: **Descriptive Statistics**

*This table reports descriptive statistics. $\Delta\,\mathbb{V}\mathrm{ar}(\eta_cf)/mean(\eta_cf)$ is the scaled change in the variance of cash-flow news around dividend events, $\Delta\eta_cf$ is the change in cash-flow news, $\Delta\eta_dr$ is the change in discount-rate news, BM Ratio is the book-to-market-ratio, and Market Cap is the log market capitalization in millions. We calculate cash-flow and discount-rate news following Vuolteenaho (2002). Our sample period is 1964 till 2013.*

| | $\Delta Div > 0$ | | | | $\Delta Div < 0$ | | | |
|---|---|---|---|---|---|---|---|---|
| | Nobs | Median | Mean | Std | Nobs | Median | Mean | Std |
| $\Delta\,\mathbb{V}\mathrm{ar}(\eta_cf)/mean(\eta_cf)$ | 2,441 | -0.13 | -0.15 | 0.76 | 2,461 | 0.06 | 0.07 | 0.83 |
| $\Delta\eta_cf$ | 2,441 | 0.00 | 0.00 | 0.02 | 2,461 | 0.00 | 0.00 | 0.02 |
| $\Delta\eta_dr$ | 2,441 | 0.00 | 0.00 | 0.00 | 2,461 | 0.00 | 0.00 | 0.00 |
| BM Ratio | 2,441 | 1.05 | 1.36 | 3.17 | 2,461 | 1.10 | 1.48 | 2.97 |
| Market Cap | 2,441 | 0.45 | 4.34 | 19.23 | 2,461 | 0.44 | 3.53 | 13.70 |
| Delistings 5 years post Event | 21 | | | | 12 | | | |

| | **Initiations** | | | | **Omissions** | | | |
|---|---|---|---|---|---|---|---|---|
| | Nobs | Median | Mean | Std | Nobs | Median | Mean | Std |
| $\Delta\,\mathbb{V}\mathrm{ar}(\eta_cf)/mean(\eta_cf)$ | 1,069 | -0.21 | -0.20 | 1.30 | 1,233 | 0.05 | 0.06 | 0.88 |
| $\Delta\eta_cf$ | 1,069 | 0.00 | 0.00 | 0.02 | 1,233 | 0.00 | 0.00 | 0.01 |
| $\Delta\eta_dr$ | 1,069 | 0.00 | 0.00 | 0.00 | 1,233 | 0.00 | 0.00 | 0.00 |
| BM Ratio | 1,069 | 1.01 | 1.29 | 0.86 | 1,233 | 1.39 | 1.93 | 2.76 |
| Market Cap | 1,069 | 0.20 | 1.67 | 5.34 | 1,233 | 0.15 | 1.88 | 11.24 |
| Delistings 5 years post Event | 34 | | | | 10 | | | |



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Table 2: **Estimate of Transition Matrix of VAR System**

*This table reports point estimates of a constant VAR for all firms following the method we outline in Section II.. $r_t$ denotes the excess log stock return, $\theta$ is the log book-to-market ratio, and roe is the log return-on-equity. The sample period from 1964 till 2013.*

| | $r$ | $\theta$ | $roe$ |
|---|---|---|---|
| | (1) | (2) | (3) |
| $r$ | 0.02 | 0.01 | 0.28 |
| | (2.12) | (9.87) | (13.61) |
| $\theta$ | 0.10 | 0.94 | −0.65 |
| | (4.07) | (223.29) | (−9.67) |
| $roe$ | 0.01 | −0.02 | 0.36 |
| | (2.02) | (−29.49) | (28.85) |



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Table 3: **Change in Cash-Flow and Discount-Rate News Around Dividend Events**

*This table reports changes in cash-flow and discount-rate news around dividend events using the methodology of Vuolteenaho (2002) which we describe in Section II.. Panel A reports the average change in mean cash-flow news across firm events ($\Delta\eta_cf$), Panel B reports the average change in mean discount-rate news ($\Delta\eta_dr$), Panel C reports the average change in the variance of cash-flow news ($\Delta\,\mathbb{Var}(\eta_cf)$), and Panel D reports the average change in the variance of cash-flow news scaled by the average variance of cash-flow news before the event ($\Delta\,\mathbb{Var}(\eta_cf)/mean(\mathbb{Var}(\eta_cf))$). Our sample period is 1964 till 2013.*

| | $\Delta Div > 0$ | Initiation | Pooled | $\Delta Div < 0$ | Omission | Pooled |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | | | **Panel A. $\Delta$ Cash-flow News: $\Delta\eta_cf$** | | | |
| | -0.0001 | 0.0000 | 0.0000 | -0.0003 | 0.0001 | -0.0002 |
| | (-0.22) | (0.47) | (-0.37) | (-1.08) | (0.85) | (-0.82) |
| | | | **Panel B. $\Delta$ Discount-rate News: $\Delta\eta_dr$** | | | |
| | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | (-0.70) | (1.22) | (-1.17) | (-0.81) | (0.93) | (-0.15) |
| | | | **Panel C. $\Delta$ Variance Cash-flow News: $\Delta\,\mathbb{Var}(\eta_cf)$** | | | |
| | -0.0015 | -0.0027 | -0.0019 | 0.0006 | 0.0005 | 0.0006 |
| | (-9.65) | (-4.94) | (-8.63) | (4.38) | (2.42) | (4.95) |
| | | | **Panel D. $\Delta$ Scaled Variance Cash-flow News: $\Delta\,\mathbb{Var}(\eta_cf)/mean(\mathbb{Var}(\eta_cf))$** | | | |
| | -14.86% | -20.01% | -16.43% | 7.29% | 6.09% | 6.89% |
| | (-9.65) | (-4.94) | (-9.33) | (4.38) | (2.42) | (4.95) |
| Nobs | 2,441 | 1,069 | 3,510 | 2,461 | 1,233 | 3,694 |



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Table 4: **Scaled Change in Variance of Cash-Flow News Around Dividend Events: Robustness**

*This table reports robustness results for changes in cash-flow news around dividend events using the methodology of Vuolteenaho (2002) which we describe in Section II.. Panel A estimates one VAR for the whole sample period and then uses the estimate for $\Gamma$ to calculate both residuals in the five years before and after the dividend event and the cash-flow news. Panel B estimates one VAR across all firms and events to get an estimate of $\Gamma$, but then estimates separate VARs before and after each dividend events to get the news terms. Panel C requires only 12 non-missing quarters within five years before and after the dividend event and we do not restrict our sample to non-overlapping event windows within firms. Our sample period is 1964 till 2013.*

| | $\Delta Div > 0$ | Initiation | Pooled | $\Delta Div < 0$ | Omission | Pooled |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | | | **Panel A. Constant Gamma** | | | |
| | −14.06% | −25.45% | −17.53% | 17.70% | 10.50% | 15.27% |
| | (−9.39) | (−7.33) | (−11.08) | (8.13) | (3.94) | (9.01) |
| | | | **Panel B. Mezzanine Gamma** | | | |
| | −15.96% | −23.25% | −18.18% | 10.72% | 14.10% | 11.84% |
| | (−11.47) | (−6.03) | (−11.05) | (6.57) | (5.79) | (8.70) |
| Nobs | 2,441 | 1,069 | 3,510 | 2,461 | 1,233 | 3,694 |
| | | | **Panel C. Extended Sample** | | | |
| | −12.76% | −16.73% | −13.80% | 9.06% | 6.26% | 8.71% |
| | (−6.93) | (−4.87) | (−8.26) | (4.51) | (2.57) | (5.32) |
| Nobs | 4,869 | 1,732 | 6,601 | 4,709 | 1,233 | 5,942 |



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Table 5: **Scaled Change in Variance of Cash-Flow News Around Dividend Events: VAR Robustness**

*This table reports robustness results for changes in cash-flow news around dividend events using the methodology of Vuolteenaho (2002) which we describe in Section II.. Panel A estimates the VAR with two lags, Panel B estimates the VAR with three lags, and Panel C estimates the VAR with four lags. Our sample period is 1964 till 2013.*

| | $\Delta Div > 0$ | Initiation | Pooled | $\Delta Div < 0$ | Omission | Pooled |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | | | **Panel A. Two-Lags VAR** | | | |
| | −17.29% | −27.86% | −20.40% | 17.12% | 20.23% | 18.16% |
| | (−8.45) | (−8.48) | (−11.73) | (6.52) | (5.74) | (8.62) |
| | | | **Panel B. Three-Lags VAR** | | | |
| | −17.52% | −24.02% | −19.43% | 16.53% | 21.45% | 18.18% |
| | (−8.61) | (−7.31) | (−11.22) | (6.35) | (5.93) | (8.60) |
| | | | **Panel C. Four-Lags VAR** | | | |
| | −18.11% | −23.77% | −19.77% | 15.82% | 20.88% | 17.51% |
| | (−9.11) | (−7.30) | (−11.63) | (6.21) | (5.72) | (8.38) |
| Nobs | 2,441 | 1,069 | 3,510 | 2,461 | 1,233 | 3,694 |



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Table 6: **Scaled Change in Variance of Cash-Flow News Around Dividend Events: Years Robustness**

*This table reports robustness results for changes in cash-flow news around dividend events using the methodology of Vuolteenaho (2002) which we describe in Section II.. Panel A estimates the VAR with three years before and after the dividends events and Panel B estimates the VAR with four years before and after the dividends events. Our sample period is 1964 till 2013.*

| | $\Delta Div > 0$ | Initiation | Pooled | $\Delta Div < 0$ | Omission | Pooled |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | | | **Panel A. Three-Years VAR** | | | |
| | −19.98% | −24.64% | −21.35% | 21.30% | 29.26% | 23.96% |
| | (−8.19) | (−6.27) | (−10.29) | (6.47) | (6.56) | (9.03) |
| | | | **Panel B. Four-Years VAR** | | | |
| | −20.64% | −27.45% | −22.64% | 19.26% | 24.55% | 21.03% |
| | (−9.56) | (−7.57) | (−12.17) | (6.55) | (5.98) | (8.79) |
| Nobs | 2,441 | 1,069 | 3,510 | 2,461 | 1,233 | 3,694 |



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Table 7: **Scaled Change in Variance of Cash-Flow News Around Dividend Events: Pre-Trends**

*This table reports robustness results for changes in cash-flow news around dividend events using the methodology of Vuolteenaho (2002) which we describe in Section II.. Panel A estimates the VAR three years before the actual dividends events, Panel B estimates the VAR five years before the actual dividends events, and Panel C estimates the VAR ten years before the actual dividends events. Our sample period is 1964 till 2013.*

| | $\Delta Div > 0$ | Initiation | Pooled | $\Delta Div < 0$ | Omission | Pooled |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | | | **Panel A. Three-Years Pre-Events** | | | |
| | 2.50% | −6.72% | 0.03% | −5.65% | −8.38% | −6.51% |
| | (0.78) | (−1.40) | (0.01) | (−1.85) | (−1.80) | (−2.55) |
| Nobs | 2,097 | 780 | 2,877 | 2,130 | 1,034 | 3,163 |
| | | | **Panel B. Five-Years Pre-Events** | | | |
| | 9.10% | −8.15% | 3.07% | −8.25% | 3.18% | −4.65% |
| | (3.82) | (−1.42) | (1.38) | (−3.76) | (0.83) | (−2.40) |
| Nobs | 1,747 | 558 | 2,305 | 1,816 | 841 | 2,656 |
| | | | **Panel C. Ten-Years Pre-Events** | | | |
| | −0.03% | −5.59% | −1.36% | −1.25% | −5.90% | −3.34% |
| | (−0.01) | (−1.49) | (−0.78) | (−0.71) | (−1.25) | (−1.22) |
| Nobs | 1,223 | 242 | 1,465 | 1,288 | 483 | 1,770 |



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Table 8: **Scaled Change in Variance of Cash-Flow News Around Dividend Events: Sample Split**

*This table reports changes in cash-flow news around dividend events using the methodology of Vuolteenaho (2002) which we describe in Section II.. Panel A reports results for the first half of the sample, Panel B reports results for the second half of the sample, and Panel C reports results for a sample from 2003 until 2013.*

| | $\Delta Div > 0$ | Initiation | Pooled | $\Delta Div < 0$ | Omission | Pooled |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | | | **Panel A. 1964 – 1988** | | | |
| | −12.53% | −5.72% | −11.10% | 8.23% | 11.19% | 9.36% |
| | (−6.34) | (−0.80) | (−5.35) | (3.90) | (3.79) | (5.46) |
| Nobs | 1,155 | 307 | 1,462 | 1,175 | 533 | 1,708 |
| | | | **Panel B. 1989 – 2013** | | | |
| | −15.47% | −25.83% | −19.32% | 16.61% | 8.43% | 13.16% |
| | (−6.69) | (−5.27) | (−8.54) | (6.02) | (2.54) | (6.23) |
| Nobs | 1,286 | 762 | 2,048 | 1,286 | 700 | 1,986 |
| | | | **Panel C. 2003 – 2013** | | | |
| | −11.31% | −31.85% | −18.84% | 20.31% | 18.59% | 19.58% |
| | (−2.99) | (−5.27) | (−5.80) | (3.91) | (3.05) | (4.95) |
| Nobs | 848 | 491 | 1,339 | 609 | 491 | 1,100 |



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Table 9: **Scaled Change in Variance of Cash-Flow News Around Dividend Events: Matched Sample**

*This table reports scaled changes in cash-flow news around dividend events using the methodology of Vuolteenaho (2002) which we describe in Section II.. The table reports scaled changes in the variance of cash-flow news for firms with dividend events relative to scaled changes in the variance of cash flow news for similar firms without dividend events. We match firms based on the propensity score using the book-to-market ratio, leverage, age, and size. Our sample period is 1964 till 2013.*

| | $\Delta Div > 0$ | Initiation | Pooled | $\Delta Div < 0$ | Omission | Pooled |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | -14.81% | -25.72% | -17.80% | 7.25% | 5.36% | 6.68% |
| | (-9.57) | (-5.90) | (-9.89) | (4.32) | (2.27) | (4.87) |
| Nobs | 2,401 | 906 | 3,307 | 2,419 | 1,051 | 3,470 |



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Table 10: **Average Loadings of Firm-Level Cash-Flow News on Market-Wide News Around Dividend Events**

*This table reports the average loadings of firm-level cash-flow news on market-wide cash flow news using the methodology of Vuolteenaho (2002) which we describe in Section II.. We use all firms with a dividend event in a given quarter and value-weight individual firm level cash-flow news to define market cash-flow news. Our sample period is 1964 till 2013.*

| | $\Delta Div > 0$ | Initiation | $\Delta Div < 0$ | Omission |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Market Cash-Flow News | 0.78 | 1.10 | 0.79 | 0.81 |
| | (6.86) | (3.66) | (3.56) | (4.40) |



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Table 11: **Scaled Change in Variance of Cash-Flow News and Announcement Returns Around Dividend Events: Heterogeneity**

*This table reports the average change in the variance of cash-flow news scaled by the average variance of cash-flow news before the event ($\Delta\,\mathbb{Var}(\eta_cf)/mean(\mathbb{Var}(\eta_cf))$) using the methodology of Vuolteenaho (2002) which we describe in Section II. in Panel A and announcement returns in Panel B. The Table splits dividend events by the size of the dividend change using the dividend change terciles as cutoff excluding the middle tercile. Announcement returns are cumulative returns in a three-day window bracketing the dividend event. We bootstrap the difference between large and small changes. Our sample period is 1964 till 2013.*

| | $\Delta Div > 0$ | | | $\Delta Div < 0$ | | |
|---|---|---|---|---|---|---|
| | Large Increase | Small Increase | $\Delta$ | Large Cut | Small Cut | $\Delta$ |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | **Panel A. $\Delta$ Scaled Variance Cash-flow News: $\Delta\,\mathbb{Var}(\eta_cf)/mean(\mathbb{Var}(\eta_cf))$** | | | | | |
| | −21.37% | −7.32% | −14.55% | 7.50% | 0.38% | 8.01% |
| | (−7.65) | (−2.96) | (−12.30) | (2.65) | (0.13) | (7.44) |
| Nobs | 814 | 814 | | 820 | 820 | |
| | **Panel B. Cumulative Returns** | | | | | |
| | 0.80% | 0.57% | 0.33% | −0.75% | −0.52% | −0.25% |
| | (8.09) | (8.31) | (5.39) | (−3.66) | (−2.86) | (−2.96) |
| Nobs | 814 | 814 | | 820 | 820 | |



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Table 12: **Regression of Changes in Variance of Cash-Flow News Around Dividend Events**

*This table reports estimates from the following specification:*

$$\Delta\, \mathbb{Var}(\eta_cf_{it}) = \alpha + \beta_1 \cdot \Delta D_{it} + \beta_2 \cdot eps_{it} + \beta_3 \cdot \Delta D_{it} \cdot eps_{it} + \delta \cdot X_{it} + \varepsilon_{it}.$$

*We regress changes in the scaled variance of cash-flow news around dividend events using the methodology of Vuolteenaho (2002) which we describe in Section II. of firm $i$ at event $t$, $\Delta\, \mathbb{Var}(\eta_cf_{it})$, on the dividend change, $\Delta D_{it}$, earnings per share, $eps_{it}$, the interaction between the two, as well as additional covariates, $X_{it}$, with t-statistics in parentheses. Additional covariates include firm age, size, book-to-market, and financial leverage. We add year and industry fixed effects at the Fama & French 17 industry level whenever indicated. We cluster standard errors at the dividend-quarter level. Our sample period is 1964 till 2013.*

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| $\Delta Div$ | −0.26 | −0.24 | −0.37 | −0.35 | −0.15 | −0.14 | −0.25 | −0.23 |
| | (−5.55) | (−5.31) | (−5.94) | (−6.06) | (−4.92) | (−4.66) | (−5.01) | (−5.00) |
| $eps$ | | −0.17 | −0.12 | −0.17 | | −0.14 | −0.10 | −0.11 |
| | | (−1.56) | (−1.87) | (−2.71) | | (−1.41) | (−1.75) | (−1.76) |
| $\Delta Div \times eps$ | | | 0.24 | 0.21 | | | 0.19 | 0.18 |
| | | | (3.12) | (3.19) | | | (2.64) | (2.51) |
| Age | | | | 0.00 | | | | 0.00 |
| | | | | (1.37) | | | | (1.20) |
| Book-to-market | | | | 28.21 | | | | 132.62 |
| | | | | (0.33) | | | | (2.41) |
| Leverage | | | | −0.35 | | | | −0.14 |
| | | | | (−2.54) | | | | (−1.13) |
| Size | | | | 0.05 | | | | 0.01 |
| | | | | (3.06) | | | | (1.10) |
| Constant | 0.03 | 0.12 | 0.08 | −0.86 | | | | |
| | (0.45) | (1.22) | (1.01) | (−2.75) | | | | |
| Year FE | | | | | X | X | X | X |
| Industry FE | | | | | X | X | X | X |
| R2 | 2.06% | 2.89% | 3.89% | 5.11% | 30.60% | 31.15% | 31.80% | 32.24% |
| Nobs | 3,127 | 3,127 | 3,127 | 3,127 | 3,127 | 3,127 | 3,127 | 3,127 |



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Table 13: **Regression of Changes in Variance of Cash-Flow News Around Dividend Events**

*This table reports estimates from the following specification:*

$$eps_{it} = \alpha + \beta_1 \cdot eps_{it-1} + \beta_2 \cdot \mathbb{Var}(\eta_cf_{it-1}) + +\delta \cdot X_{it} + \varepsilon_{it}.$$

*We regress earnings per share ($eps_{it}$) after dividend events of firm $i$ at event $t$ on earnings per share before dividend events, the volatility of cash-flow news ($\mathbb{Var}(\eta_cf_{it-1})$) using the methodology of Vuolteenaho (2002) which we describe in Section II., $eps_{it}$, as well as additional covariates, $X_{it}$, with t-statistics in parentheses. Additional covariates include firm age, size, book-to-market, and financial leverage. We add year and industry fixed effects at the Fama & French 17 industry level whenever indicated. We cluster standard errors at the dividend-quarter level and standardize all covariates. Our sample period is 1964 till 2013.*

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| eps | 0.60 | | 0.56 | | 0.59 | | 0.54 | |
| | (5.09) | | (4.64) | | (5.00) | | (4.53) | |
| $\mathbb{Var}(\eta_cf)$ | | −0.04 | | −0.02 | | −0.06 | | −0.04 |
| | | (−2.23) | | (−1.18) | | (−2.74) | | (−1.92) |
| Age | | | 0.01 | 0.03 | | | 0.02 | 0.05 |
| | | | (0.66) | (1.13) | | | (1.15) | (2.05) |
| BM | | | −0.02 | −0.03 | | | 0.00 | −0.01 |
| | | | (−0.64) | (−1.02) | | | (−0.03) | (−0.31) |
| Leverage | | | −0.01 | 0.01 | | | −0.01 | −0.02 |
| | | | (−0.68) | (0.38) | | | (−0.68) | (−1.04) |
| Size | | | 0.14 | 0.28 | | | 0.14 | 0.28 |
| | | | (2.85) | (10.35) | | | (2.98) | (10.24) |
| Year FE | | | | | X | X | X | X |
| Industry FE | | | | | X | X | X | X |
| R2 | 0.36 | 0.00 | 0.39 | 0.10 | 0.38 | 0.05 | 0.40 | 0.14 |
| Nobs | 3,127 | 3,127 | 3,127 | 3,127 | 3,127 | 3,127 | 3,127 | 3,127 |



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Table 14: **Share Repurchases: Heterogeneity**

*This table reports the average change in the variance of cash-flow news scaled by the average variance of cash-flow news before the event ($\Delta\,\mathbb{V}\mathrm{ar}(\eta_cf)/mean(\mathbb{V}\mathrm{ar}(\eta_cf))$) using the methodology of Vuolteenaho (2002) which we describe in Section II. in Panel A and announcement returns in Panel B. The Table splits repurchase announcements by the size of the repurchase using the median repurchase as cutoff. Announcement returns are cumulative returns in a three-day window bracketing the dividend event. We bootstrap the difference between large and small changes. Our sample period is 1964 till 2013.*

| | Baseline | Large Repurchase | Small Repurchase | $\Delta$ |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | **Panel A. $\Delta$ Scaled Variance Cash-flow News: $\Delta\,\mathbb{V}\mathrm{ar}(\eta_cf)/mean(\mathbb{V}\mathrm{ar}(\eta_cf))$** | | | |
| | −14.79% | −18.05% | −11.54% | −5.39% |
| | (−6.51) | (−5.65) | (−3.56) | (−13.19) |
| Nobs | 2,662 | 1,331 | 1,331 | |
| | **Panel B. Cumulative Returns** | | | |
| | 1.91% | 2.62% | 1.19% | 1.41% |
| | (12.11) | (10.15) | (6.68) | (36.01) |
| Nobs | 2,662 | 1,331 | 1,331 | |



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Table 15: **Sample split by Idiosyncratic Volatility: Scaled Change in Variance of Cash-Flow News and Announcement Returns Around Dividend Events**

*This table reports the average change in the variance of cash-flow news scaled by the average variance of cash-flow news before the event ($\Delta\,\mathbb{V}\mathrm{ar}(\eta_cf)/mean(\mathbb{V}\mathrm{ar}(\eta_cf))$) using the methodology of Vuolteenaho (2002) which we describe in Section II. in Panel A and announcement returns in Panel B. The table splits firms by their ex ante idiosyncratic volatility using terciles as cutoff excluding the middle tercile. Specifically, we first calculate a firms' ex ante idiosyncratic volatility on a four-quarter rolling basis relative to a Fama & French three-factor model using daily data. Announcement returns are cumulative returns in a three-day window bracketing the dividend event. We bootstrap the difference between large and small changes. Our sample period is 1964 till 2013.*

| | $\Delta Div > 0$ | | | $\Delta Div < 0$ | | |
|---|---|---|---|---|---|---|
| | Large Vol | Small Vol | $\Delta$ | Large Vol | Small Vol | $\Delta$ |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | **Panel A. $\Delta$ Scaled Variance Cash-flow News: $\Delta\,\mathbb{V}\mathrm{ar}(\eta_cf)/mean(\mathbb{V}\mathrm{ar}(\eta_cf))$** | | | | | |
| | −19.23% | −10.96% | −8.22% | 11.90% | 4.52% | 6.36% |
| | (−6.50) | (−4.72) | (−6.92) | (2.31) | (3.51) | (4.67) |
| Nobs | 752 | 872 | | 824 | 814 | |
| | $\Delta Div > 0$ | | | $\Delta Div < 0$ | | |
| | Large Vol | Small Vol | $\Delta$ | Large Vol | Small Vol | $\Delta$ |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | **Panel B. Announcement Returns** | | | | | |
| | 0.83% | 0.66% | 0.19% | −0.88% | −0.78% | −0.15% |
| | (4.12) | (5.07) | (2.65) | (−4.47) | (−3.21) | (−2.25) |
| Nobs | 752 | 872 | | 824 | 814 | |



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Table 16: **Sample Split by Book-to-Market: Scaled Change in Variance of Cash-Flow News and Announcement Returns Around Dividend Events**

*This table reports the average change in the variance of cash-flow news scaled by the average variance of cash-flow news before the event ($\Delta\,\mathbb{V}\mathrm{ar}(\eta_cf)/mean(\mathbb{V}\mathrm{ar}(\eta_cf))$) using the methodology of Vuolteenaho (2002) which we describe in Section II. in Panel A and announcement returns in Panel B. The table splits firms by their book-to-market ratio using using terciles as cutoff excluding the middle tercile. Announcement returns are cumulative returns in a three-day window bracketing the dividend event. We bootstrap the difference between large and small changes. Our sample period is 1964 till 2013.*

| | $\Delta Div > 0$ | | | $\Delta Div < 0$ | | |
|---|---|---|---|---|---|---|
| | Low BM | High BM | $\Delta$ | Low BM | High BM | $\Delta$ |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | **Panel A. $\Delta$ Scaled Variance Cash-flow News: $\Delta\,\mathbb{V}\mathrm{ar}(\eta_cf)/mean(\mathbb{V}\mathrm{ar}(\eta_cf))$** | | | | | |
| | −16.61% | −11.85% | 5.45% | 9.89% | 6.86% | −2.84% |
| | (−6.30) | (−4.46) | (6.80) | (3.51) | (2.31) | (−3.91) |
| Nobs | 812 | 813 | | 819 | 819 | |
| | $\Delta Div > 0$ | | | $\Delta Div < 0$ | | |
| | Low BM | High BM | $\Delta$ | Low BM | High BM | $\Delta$ |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | **Panel B. Announcement Returns** | | | | | |
| | 0.62% | 0.96% | 0.33% | −1.01% | −0.55% | 0.47% |
| | (4.08) | (5.46) | (6.47) | (−4.44) | (−3.05) | (7.75) |
| Nobs | 812 | 813 | | 819 | 819 | |



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# Online Appendix: Signaling Safety

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*Not for Publication*



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# I. Theoretical Appendices

In this Section we present our theoretical proofs. Appendix *A.* solves the signaling model of Section VA. Appendix *B.* states and proves the main comparative statics results of the signaling model. Appendix *C.* presents an example with the log production function. Appendix *D.* verifies that the six assumptions given by Riley (1979) for signaling games hold in our framework. Henceforth we refer to the best separating equilibrium outcome discussed in the text as the "Riley outcome". Appendix *E.* verifies that the assumptions of Theorem 1, Theorem 2 and Corollary of Mailath (1987) hold for our signaling model, which implies that the Riley outcome is the unique separating equilibrium of our model. Appendix *F.* verifies that the assumptions of Theorem 1 of Esö and Schummer (2009) hold for our signaling model, which implies that the Riley outome is the unique equilibrium that survives the "credible deviations" refinement (Esö and Schummer (2009); see also Cho and Sobel (1990) and Ramey (1996)). Appendix *G.* states Theorem 1, Theorem 2 and Corollary of Mailath (1987). Appendix *H.* states Theorem 1 of Esö and Schummer (2009). Appendix *I.* considers the baseline setting, both with a general Arrow-Pratt certainty equivalent formulation and in the CARA special case. Appendix *J.* considers the additive formulation of the agency model. Appendix *K.* studies the multiplicative formulation of the agency model. Appendix *L.* proves the comparative statics of signaling and agency models relative to investment opportunities. Appendix *M.* considers estimates of our production function and compares them with the literature.

## *A.* Solving the Signaling Model

Assume we can associate to each level of variance $\sigma^2$ a level of dividends $D_1$ that solves the optimization problem of the manager. We write this correspondence as $\sigma^2(D_1)$. If $\sigma^2(D_1)$ is single-valued and if the market is rational, we get the following condition,

$$V^s(D_1) = V^h(\sigma^2(D_1), D_1) = V^h(\sigma^2, D_1).$$



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We then obtain

$$\begin{aligned} V^s(-\sigma^2(D_1), D_1) &= D_1 + R \cdot f(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2(D_1)), \\ V^h(-\sigma^2, D_1) &= D_1 + R \cdot f(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2). \end{aligned}$$

Valuation schedules that satisfy the conditions above and solve the maximization problem of the manager are termed "informationally consistent price functions" (Riley (1979)). To find the Pareto-dominant schedule, we start from the boundary condition that the worst firm that has the highest variance, that is, $\sigma^2_{max}$, will choose the same optimal dividend $D_1$ as it would in the full-information case, so that

$$\begin{aligned} 1 - R \cdot f'(\omega_1 + Y - D_1^\star - \frac{a}{2}\sigma^2) &= 0 \\ \sigma^2({D_1}^\star) &= \sigma^2_{max}. \end{aligned}$$

Because $V^s(D_1) = V^h(\sigma^2(D_1), D_1) = V^h(\sigma^2, D_1)$, the first-order condition is

$$kV^h_{-\sigma^2}(-\sigma^2(D_1), D_1)\frac{\partial(-\sigma^2)}{\partial D_1} + kV^h_d(-\sigma^2(D_1), D_1) + (1-k)V^h_d(-\sigma^2, D_1) = 0.$$

Given $\sigma^2(D_1) = \sigma^2$, the first-order condition is equivalent to the condition

$$kV^h_{-\sigma^2}(-\sigma^2(D_1), D_1)\frac{\partial(-\sigma^2)}{\partial D_1} + V^h_d(-\sigma^2, D_1) = 0;$$

that is,

$$1 - R \cdot f'(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2) - \frac{ka}{2} \cdot R \cdot f'(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2(D_1)) \cdot \frac{\partial \sigma^2(D_1)}{\partial D_1} = 0.$$

Then the ordinary differential equation (ODE) together with the boundary condition above uniquely determine the schedule. The worst firm type with the highest variance, $\sigma^2_{max}$, sets dividends $D_1^\star$ as in the first-best, full-information case. As variance decreases, firms pay more dividends and forego more investment opportunities. Therefore, relative to the first-best case with full information, the signaling equilibrium features excessive



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dividend payment and under-investment. Figure 2 illustrates the equilibrium.

We can establish the relevant solution informally by checking the second-order conditions for a maximum of the optimization problem of the manager

$$\frac{\partial}{\partial D_1}\left[kV^h_{-\sigma^2}(-\sigma^2(D_1),D_1)\frac{\partial(-\sigma^2)}{\partial D_1}+kV^h_d(-\sigma^2(D_1),D_1)+(1-k)V^h_d(-\sigma^2,D_1)\right]<0.$$

Substituting the first-order condition leads to a simple condition guaranteeing a maximum,

$$-V^h_{d\sigma^2}(\sigma^2,D_1)\frac{\partial\sigma^2}{\partial D_1}<0.$$

Because $V^h_{d\sigma^2}(\sigma^2,D_1)=\frac{a}{2}\cdot R\cdot f''(\omega_1+Y-D_1-\frac{a}{2}\sigma^2)<0$, a maximum occurs if and only if $\frac{\partial\sigma^2}{\partial D_1}<0$. The relevant solution must lie on the right-hand side of the red line in Figure 2 where higher dividends are associated with a lower variance of cash flow. Thus, only dividends that exceed $D_1^\star$ are optimal. This solution is the Riley equilibrium outcome. In the Appendix, we show this equilibrium is the unique separating equilibrium of our game, by applying the results of Mailath (1987), and we show it is the unique equilibrium that survives standard refinement concepts for this class of games (Esö and Schummer (2009); see also Ramey (1996) and Cho and Sobel (1990)).

In this model, dividends are a signal to the market about the cash-flow volatility. Because managers care about short-term investors, they would like to signal that their cash flows have low volatility and therefore higher value. For this signal to be credible, it must be costly. To prevent imitation and thus generate a separating equilibrium, the signal must be costlier for low types than for high types. This conclusion follows from the concavity of the production function, because riskier firms have more to lose in terms of foregone investment if they pay a larger dividend in an attempt to imitate safer firms.

## *B.* Proof of Comparative Statics

Here we state and prove the main comparative statics.

**Prediction 1 (signaling - time series)**. The dividend changes should be followed by changes in future cash flow volatility in the opposite direction, i.e. $\frac{\partial\sigma^2(D_1)}{\partial D_1}<0$



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**Proof.** The proof is immediately given in the analysis of the schedules in the main text.

Combining the FOC and SOC of the manager's optimization problem we get a simple condition guaranteeing a maximum

$$-V^h_{d\sigma^2}(\sigma^2, D_1)\frac{\partial \sigma^2}{\partial D_1} < 0 \tag{A.1}$$

With $V^h_{d\sigma^2}(\sigma^2, D_1) = \frac{a}{2}Rf''(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2) < 0$, a maximum occurs if and only if $\frac{\partial \sigma^2}{\partial D_1} < 0$.

■

**Prediction 2 (signaling - cross-section).** Following a dividend increase (re. decrease), there's a larger decrease (re. increase) in cash flow volatility for firms with smaller (re. larger) current earnings, i.e. $\frac{\partial^2 \sigma(D_1)}{\partial D_1 \partial Y} > 0$

**Proof.** Recall the FOC,

$$1 - R \cdot f'(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2) - \frac{ka}{2} \cdot R \cdot f'(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2(D_1)) \cdot \frac{\partial \sigma^2(D_1)}{\partial D_1} = 0, \tag{A.2}$$

we get

$$\frac{\partial \sigma^2(D_1)}{\partial D_1} = \frac{1 - R \cdot f'(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2)}{\frac{ka}{2} \cdot R \cdot f'(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2(D_1))} \tag{A.3}$$

Then

$$\begin{aligned}
\frac{\partial^2 \sigma^2(D_1)}{\partial D_1 \partial Y} &= \frac{\partial\Big(\frac{1 - R \cdot f'(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2)}{\frac{ka}{2} \cdot R \cdot f'(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2(D_1))}\Big)}{\partial Y} \\
&= -\frac{2f''(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2(D_1))}{k \cdot a \cdot R \cdot \Big[f'(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2(D_1)\Big]^2} > 0
\end{aligned}$$

because $f'' < 0$. ■



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## *C.* An Example

For this example, define $f(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2) = \ln\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right)$ and assume $R = 1$.

The ODE (i.e. FOC)

$$1 - f'(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2(D_1)) - \frac{ka}{2} \cdot f'(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2(D_1)) \cdot \frac{\partial \sigma^2(D_1)}{\partial D_1} = 0 \quad \text{(A.4)}$$

becomes

$$\frac{\partial \sigma^2(D_1)}{\partial D_1} = \frac{2(\omega_1 + Y - D_1 - 1 - \frac{a}{2}\sigma^2)}{k \cdot a}. \quad \text{(A.5)}$$

Together with the boundary condition which says the worst type chooses the dividend such that $\sigma^2(D_1^\star) = \sigma^2_{max}$, we get the solution to this problem,

$$\sigma^2(D_1) = \frac{2(\omega_1 + Y - 1 - \frac{a}{2}\sigma^2)D_1 - D_1^2 + a \cdot k \cdot \sigma^2_{max} + D_1^{\star 2} - 2(\omega_1 + Y - 1 - \frac{a}{2}\sigma^2)D_1^\star}{k \cdot a} \quad \text{(A.6)}$$

where $D_1 \geq D_1^\star$. It is then immediate to check that $\frac{\partial \sigma^2(D_1)}{\partial D_1} < 0$ and $\frac{\partial^2 \sigma^2(D_1)}{\partial D_1 \partial Y} > 0$.

## *D.* Proof of Riley (1979) conditions

This Section shows that our signaling model of Sections IIB-IID satisfies the Riley (1979) conditions for signaling games. **Proof.** Let

$$\begin{aligned} W &= k \cdot V^s + (1-k) \cdot V^h \\ V^s &= D_1 + R \cdot f\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2(D_1)\right) \\ V^h &= D_1 + R \cdot f\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right) \end{aligned}$$

so that

$$W = D_1 + k \cdot R \cdot f\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2(D_1)\right) + (1-k) \cdot R \cdot f\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right).$$

Riley (1979) assumptions:



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**A1.** The unobservable attribute, $\sigma^2$, is distributed on $[\sigma^2_{min}, \sigma^2_{max}]$ according to a strictly increasing distribution function

**A2.** The functions $W(\cdot)$, $V^h(\cdot)$ are infinitely differentiable in all variables

**A3.** $\frac{\partial W}{\partial V^s} > 0$

**A4.** $V^h(-\sigma^2, D_1) > 0$; $\frac{\partial V^h(-\sigma^2, D_1)}{\partial(-\sigma^2)} > 0$

**A5.** $\frac{\partial}{\partial(-\sigma^2)}\left(\frac{-\frac{\partial W}{\partial D_1}}{\frac{\partial W}{\partial V^s}}\right) < 0$

**A6.** $W\left(-\sigma^2; D_1, V^h(-\sigma^2, D_1)\right)$ has a unique maximum over $D_1$.

Assumptions **A1-A4** are immediate.

Condition **A5** is also known as the "single crossing condition" of signaling games and is that $\frac{\partial}{\partial(-\sigma^2)}\left(\frac{-\frac{\partial W}{\partial D_1}}{\frac{\partial W}{\partial V^s}}\right) < 0$.

$\frac{\partial W}{\partial D_1} = 1 - R \cdot f'\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right)$

$\frac{\partial W}{\partial V^s} = k$.

Hence:

$$\begin{aligned}\frac{\partial}{\partial(-\sigma^2)}\left(\frac{-\frac{\partial W}{\partial D_1}}{\frac{\partial W}{\partial V^s}}\right) &= \frac{\partial}{\partial(-\sigma^2)}\left(\frac{-1 + R \cdot f'\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right)}{k}\right) \\ &= \frac{a \cdot R \cdot f''\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right)}{2k} < 0\end{aligned}$$

because $f''(\cdot) < 0$.

Condition **A6** requires that $V^h(-\sigma^2, D_1)$ has a unique maximum over $D_1$, which it does at the point $D_1^\star$ such that

$$R \cdot f'\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right) = 1 \tag{A.7}$$

with the S.O.C. $R \cdot f''\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right) < 0$ satisfied. ■

Because the Riley conditions are satisfied, we refer to the separating equilibrium of Section IIC in the main text as the "Riley equilibrium" and to the separating equilibrium outcome of Section IIC in the main text as the "Riley outcome".



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## *E.* Uniqueness of the Separating Equilibrium

This section shows that the Riley equilibrium is the unique separating equilibrium of our model.

According to Theorem 1, Theorem 2 and Corollary in Mailath (1987) (see Appendix D), if the payoff function satisfies Mailath (1987)'s conditions (1)-(5) and the single crossing condition (7), together with the initial value condition (6), then the Riley equilibrium is the unique separating equilibrium solution.

To begin with, in the dividend framework, the set of possible types is the interval $[\sigma^2_{min}, \sigma^2_{max}] \subset \mathbb{R}$ and the set of possible actions is $\mathbb{R}$. Let $\tau^{-1}(D_1) = \sigma^2(D_1)$ where $\tau : [\sigma^2_{min}, \sigma^2_{max}] \to \mathbb{R}$ is the proposed equilibrium one-to-one strategy.

Recall that

$$\begin{aligned} W &= k \cdot V^s + (1-k) \cdot V^h \\ V^s &= D_1 + R \cdot f\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2(D_1)\right) \\ V^h &= D_1 + R \cdot f\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right) \end{aligned}$$

so the expected payoff function is

$$\begin{aligned} W\left(-\sigma^2, -\sigma^2(D_1), D_1\right) &= D_1 + k \cdot R \cdot f\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2(D_1)\right) \\ &\quad + (1-k) \cdot R \cdot f\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right) \end{aligned}$$

As we already shown $\sigma^2(D_1)$ $(i.e., \tau^{-1}(D_1))$ solves the optimization problem, it satisfies *incentive compatibility*:

$$(IC) \quad \tau(\sigma^2) \in \underset{D_1 \in \tau\left(\left[\sigma^2_{min}, \sigma^2_{max}\right]\right)}{\operatorname{argmax}} W\left(-\sigma^2, -\tau^{-1}(D_1), D_1\right), \ \forall \sigma^2 \in [\sigma^2_{min}, \sigma^2_{max}]$$

Mailath (1987)'s regularity conditions on the payoff function $W$,

(1) $W\left(-\sigma^2, -\sigma^2(D_1), D_1\right)$ is $C^2$ on $[\sigma^2_{min}, \sigma^2_{max}]^2 \times \mathbb{R}$ (smoothness)

(2) $W_2$ never equals zero, and so is either positive or negative (belief monotonicity)

(3) $W_{13}$ never equals zero, and so is either positive or negative (type monotonicity)



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(4) $W_3\left(-\sigma^2,-\sigma^2,D_1\right) = 0$ has a unique solution in $D_1$, denoted $\phi\left(\sigma^2\right)$, which maximizes $W\left(-\sigma^2,-\sigma^2,D_1\right)$, and $W_{33}\left(-\sigma^2,-\sigma^2,\phi\left(\sigma^2\right)\right) < 0$ ("strict" quasi-concavity)

(5) there exists $k > 0$ such that for all $\left(-\sigma^2,D_1\right) \in \left[\sigma^2_{min},\sigma^2_{max}\right] \times \mathbb{R}$, $W_{33}\left(-\sigma^2,-\sigma^2,D_1\right) \geq 0 \Rightarrow \mid W_3\left(-\sigma^2,-\sigma^2,D_1\right) \mid > k$ (boundedness)

The other two conditions which play a role in what follows are

(6) $\tau\left(\sigma^2_w\right) = \phi\left(\sigma^2_w\right)$, where $\sigma^2_w = \sigma^2_{max}$ if $W_2 > 0$ and $\sigma^2_{min}$ if $W_2 < 0$ (initial value)

(7) $\frac{W_3\left(-\sigma^2,-\sigma^2(D_1),D_1\right)}{W_2\left(-\sigma^2,-\sigma^2(D_1),D_1\right)}$ is a strictly monotonic function of $-\sigma^2$ (single crossing).

Condition (1) is satisfied because it is obvious that $W\left(-\sigma^2,-\sigma^2(D_1),D_1\right)$ is $C^2$ on $\left[\sigma^2_{min},\sigma^2_{max}\right]^2 \times \mathbb{R}$.

Condition (2) is satisfied because $W_2$ is always negative and will never be zero.

$$W_2 = \frac{\partial W}{\partial(-\sigma^2(D_1))} = \frac{k\cdot a\cdot R}{2} f'\left(\omega_1 + Y - D_1 - \frac{a}{2}\cdot\sigma^2(D_1)\right) > 0 \tag{A.8}$$

since $f'(\cdot) > 0$.

Condition (3) is satisfied because $W_{13} < 0$ is always negative and will never equal zero.

$$\begin{aligned} W_{13} &= \frac{\dfrac{\partial W}{\partial(-\sigma^2)}}{\partial D_1} \\ &= \frac{\dfrac{(1-k)\cdot a\cdot R}{2} f'\left(\omega_1 + Y - D_1 - \frac{a}{2}\cdot\sigma^2\right)}{\partial D_1} \\ &= \frac{-(1-k)\cdot a\cdot R}{2} f''\left(\omega_1 + Y - D_1 - \frac{a}{2}\cdot\sigma^2\right) > 0 \end{aligned}$$

since $f''(\cdot) < 0$.

Condition (4) is satisfied because $f'(\cdot)$ is monotonic with $f''(\cdot) < 0$.

$$\begin{aligned} W_3\left(-\sigma^2,-\sigma^2,D_1\right) &= 0 \\ &\Longleftrightarrow \\ 1 - R\cdot f'\left(\omega_1 + Y - D_1 - \frac{a}{2}\cdot\sigma^2\right) &= 0 \end{aligned}$$



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Since $f'(\cdot) > 0$ is monotonic, $W_3\left(-\sigma^2, -\sigma^2, D_1\right) = 0$ has a unique solution in $D_1$, denoted $\phi(\sigma^2)$. It is easy to show that $\phi(\sigma^2)$ also maximizes $W\left(-\sigma^2, -\sigma^2, D_1\right)$.

$W\left(-\sigma^2, -\sigma^2, D_1\right) = D_1 + R \cdot f\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right)$

To find the optimal $D_1$ that maximizes $W\left(-\sigma^2, -\sigma^2, D_1\right)$, the F.O.C. is $W_3\left(-\sigma^2, -\sigma^2, D_1\right) = 0$ which is already shown above and the S.O.C. is $W_{33}\left(-\sigma^2, -\sigma^2, D_1\right) < 0$ which is shown below,

$$\begin{aligned} W_{33}\left(-\sigma^2, -\sigma^2, D_1\right) &= \frac{\partial W_3}{\partial D_1} \\ &= \frac{1 - R \cdot f'\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right)}{\partial D_1} \\ &= R \cdot f''\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right) < 0 \end{aligned}$$

since $f''(\cdot) < 0$.

Condition (5) is satisfied because if for all $(-\sigma^2, D_1) \in [\sigma^2_{min}, \sigma^2_{max}] \times \mathbb{R}$, $W_{33}\left(-\sigma^2, -\sigma^2, D_1\right) \geq 0$ then there exist some $k > 0$ such that $\mid W_3\left(-\sigma^2, -\sigma^2, D_1\right) \mid > k$.

$$\begin{aligned} W_{33}\left(-\sigma^2, -\sigma^2, D_1\right) &\geq 0 \\ &\Longleftrightarrow \\ R \cdot f''\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right) &\geq 0 \end{aligned}$$

Thus, to maximize the expected payoff function, the manager will never choose $D_1^\star$ where $D_1^\star$ is the solution of $1 - f'\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right) = 0$. The reason is that $D_1^\star(\sigma^2)$ will minimize the expected utility payoff function instead of maximizing it.

$$W_3 = 1 - R \cdot f'\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right) \neq 1 - R \cdot f'\left(\omega_1 + Y - D_1^\star - \frac{a}{2} \cdot \sigma^2\right) = 0 \quad \text{(A.9)}$$

Thus, $\mid W_3\left(-\sigma^2, -\sigma^2, D_1\right) \mid > 0$. It means we can always find some $k > 0$ such that $\mid W_3\left(-\sigma^2, -\sigma^2, D_1\right) \mid > k$.

The next step is to show that both the initial value condition and the single crossing



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condition hold.

Condition (6) holds because $W_2 < 0$, in the solution proposed the worst-type firm behaves as if it is in the full information case in equilibrium, i.e. $\tau(\sigma^2_{max}) = \phi(\sigma^2_{max})$.

Condition (7) holds because

$$\begin{aligned}
W_3\left(-\sigma^2, -\sigma^2(D_1), D_1\right) &= 1 - k \cdot R \cdot f'\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2(D_1)\right) \\
&\quad + \frac{k \cdot a \cdot R}{2} f'\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2(D_1)\right) \frac{\partial(-\sigma^2(D_1))}{\partial D_1} \\
&\quad -(1-k) \cdot R \cdot f'\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right) \\
W_2\left(-\sigma^2, -\sigma^2(D_1), D_1\right) &= \frac{\partial W}{\partial(-\sigma^2(D_1))} \\
&= \frac{k \cdot a}{2} f'\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2(D_1)\right) \\
\text{Then, } \frac{\partial \frac{W_3\left(-\sigma^2, -\sigma^2(D_1), D_1\right)}{W_2\left(-\sigma^2, -\sigma^2(D_1), D_1\right)}}{\partial(-\sigma^2)} &= -\frac{a}{2} \cdot \frac{2(1-k)}{k \cdot a} \frac{f''\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2(D_1)\right)}{f'\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2(D_1)\right)} \\
&= -\frac{1-k}{k} \cdot \frac{f''\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2(D_1)\right)}{f'\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2(D_1)\right)} > 0
\end{aligned}$$

Thus $\dfrac{W_3\left(-\sigma^2, -\sigma^2(D_1), D_1\right)}{W_2\left(-\sigma^2, -\sigma^2(D_1), D_1\right)}$ is a strictly increasing function of $(-\sigma^2)$.

Since Mailath (1987)'s conditions (1)-(7) are satisfied, the Riley equilibrium is the unique separating equilibrium of our model.

## *F.* Equilibrium Refinement and Uniqueness

In this Section we want to show that our game belongs to the class of monotonic signaling games discussed in Section 3 of Esö and Schummer (2009), (see also Cho and Sobel (1990) and Ramey (1996)) and thus we can apply theorem 1 of Esö and Schummer (2009) to show that in this game the Riley equilibrium (i.e., the unique separating equilibrium as per above) is also the unique equilibrium that is immune to Credible Deviations.

First, let's check the 5 assumptions of Esö and Schummer (2009), A1 to A5, one by one. The firm (Sender) with variance $\sigma^2$ (type) decides to pay $D_1$ (signal). The investors



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(receivers) in the market buy the share of the firm at price $V^s(D_1)$ in the belief that the dividend $D_1$ reflect the value of the firm as a function of the unobserved variance, which can be denoted as $\sigma^2(D_1)$.

**A1.** $W(-\sigma^2, D_1, V^s(D_1))$ is strictly increasing in $V^s(D_1)$ for all $(-\sigma^2, D_1)$. In order to avoid solutions involving arbitrarily large messages and actions we assume that $\lim_{D_1 \to \infty} W(-\sigma^2, D_1, V^s(D_1)) = -\infty$.

**Proof.**

$$\frac{\partial W(-\sigma^2, D_1, V^s(D_1))}{\partial V^s(D_1)} = k > 0$$

■

**A2.** Assume that $V^s(D_1)$ is such that, for any type $\sigma^2$ and message $D_1$, the Receiver has a unique best response, i.e. that $BR(-\sigma^2, D_1)$ is a singleton.

**Proof.** Since the investors (Receivers) act as price takers, they purchase the shares of the firm at the price $V^s(D_1)$. Their best response $BR(-\sigma^2, D_1)$ is a singleton $\{V^s(D_1) : V^s(D_1) = V^h(D_1)\}$. ■

**A3.** Assume that $V^s(D_1)$ is strictly increasing in $(-\sigma^2(D_1)$ for all $(D_1, V^s)$.

**Proof.**

$$\frac{\partial V^s}{\partial(-\sigma^2(D_1))} = \frac{a}{2} R f'(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2(D_1)) > 0.$$

In particular,

$$\frac{\partial V^h}{\partial(-\sigma^2)} = \frac{a}{2} R f'(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2) > 0.$$

■

Together with monotonicity, A3 captures the idea that the manager (Sender) wants to induce the investors (Receivers) to buy the firm at a larger price by trying to convince them that the firm type is better (its variance is lower).

**A4.** Assume the game satisfies the central assumption in Spencian signaling games, the single crossing condition, that $-(\partial W/\partial D_1)/(\partial W/\partial(V^s(D_1)))$ is strictly decreasing in $-\sigma^2$.



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**Proof.** According to the proof of Riley (1979)'s assumption A5 (see Appendix A), this assumption obviously holds. ■

**A5.** Assume that $W(-\sigma^2, D_1, V^h(D_1))$ is strictly quasi-concave in $D_1$.

**Proof.** Similar with the proof of Mailath (1987)'s condition (4) (see Appendix B), this assumption obviously holds. In detail,

$$\begin{aligned} W(-\sigma^2, D_1, V^h(D_1)) &= V^h(D_1) \\ &= D_1 + R \cdot f\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right). \end{aligned}$$

We have

$$\frac{\partial W(-\sigma^2, D_1, V^h(D_1))}{\partial D_1} = 1 - R \cdot f'\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right) = 0$$

has a unique solution and

$$\frac{\partial^2 W(-\sigma^2, D_1, V^h(D_1))}{\partial D_1^2} = R \cdot f''\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right) < 0.$$

Thus, $W(-\sigma^2, D_1, V^h(D_1))$ is strictly quasi-concave in $D_1$. ■

Thus, our game satisfies the assumptions of monotonic signaling games discussed in Esö and Schummer (2009). As a result, the Riley outcome is the unique equilibrium outcome that is immune to Credible Deviations.

## *G.* Mailath (1987)

This Section states results in Mailath (1987) that are used above.

Suppose the set of possible types is the interval $[m, M] \subset \mathbb{R}$ and the set of possible actions is $\mathbb{R}$. If $\tau : [m, M] \to \mathbb{R}$ is an equilibrium one-to-one strategy for the informed agent, then when he chooses $y \in \tau([m, M])$ the uninformed agents infer his type is $\tau^{-1}(y)$. Thus, his expected payoff is $U(\alpha, \tau^{-1}(y), y)$. Furthermore, $\tau$ is an optimal strategy for the informed agent, so that $\tau(\alpha)$ maximizes the expected payoff. So, for $\tau$ to be a separating equilibrium strategy it must be one-to-one and satisfy *incentive compatibility* (IC):



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$$(IC) \quad \tau(\alpha) \in \underset{y \in \tau([m,M])}{\operatorname{argmax}} U(\alpha, \tau^{-1}(y), y), \ \forall \alpha \in [m, M]$$

If $U(\alpha, \tau^{-1}(y), y)$ has no other maximizer for $y \in \tau([m, M])$ for all $\alpha \in [m, M]$, then $\tau$ satisfies strict incentive compatibility (SIC), i.e.,

$$(SIC) \quad \tau(\alpha) = \underset{y \in \tau([m,M])}{\operatorname{argmax}} U(\alpha, \tau^{-1}(y), y) \ \forall \alpha \in [m, M].$$

The regularity conditions on $U$ are (where subscripts denote partial derivatives):

(1) $U(\alpha, \hat{\alpha}, y)$ is $C^2$ on $[m, M]^2 \times \mathbb{R}$ (smoothness)

(2) $U_2$ never equals zero, and so is either positive or negative (belief monotonicity)

(3) $U_{13}$ never equals zero, and so is either positive or negative (type monotonicity)

(4) $U_3(\alpha, \alpha, y) = 0$ has a unique solution in $y$, denoted $\phi(\alpha)$, which maximizes $U(\alpha, \alpha, y)$, and $U_{33}(\alpha, \alpha, \phi(\alpha)) < 0$ ("strict" quasi-concavity)

(5) there exists $k > 0$ such that for all $(\alpha, y) \in [m, M] \times \mathbb{R}$ $U_{33}(\alpha, \alpha, y) \geq 0 \Rightarrow | U_3(\alpha, \alpha, y) | > k$ (boundedness)

The other two conditions which play a role in what follows are

(6) $\tau(\alpha^w) = \phi(\alpha^w)$, where $\alpha^w = M$ if $U_2 < 0$ and $m$ if $U_2 > 0$ (initial value)

(7) $\frac{U_3(\alpha,\hat{\alpha},y)}{U_2(\alpha,\hat{\alpha},y)}$ is a strictly monotonic function of $\alpha$ (single crossing)

**Theorem 1** *Suppose (1) - (5) are satisfied and $\tau : [m, M] \to \mathbb{R}$ is one-to-one and satisfies incentive compatibility. Then $\tau$ has at most one discontinuity on $[m, M]$, and where it is continuous on (m,M), it is differentiable and satisfies* $(DE) \quad \dfrac{d\tau}{d\alpha} = \dfrac{-U_2(\alpha, \alpha, \tau)}{U_3(\alpha, \alpha, \tau)}$. *Furthermore, if $\tau$ is discontinuous at a point, $\alpha'$ say, then $\tau$ is strictly increasing on one of $[m, \alpha')$ or $(\alpha', M]$ and strictly decreasing on the other, and the jump at $\alpha'$ is of the same sign as $U_{13}$.*

**Theorem 2** *Suppose, in addition, that either the initial value condition or the single crossing condition for $(\hat{\alpha}, y)$ in the graph of $\tau$ is satisfied. Then $\tau$ is strictly monotonic on $(m, M)$ and hence continuous and satisfies the differential equation (DE) there. If the initial value condition is satisfied, then in fact $\tau$ is continuous on $[m, M]$ and $\dfrac{d\tau}{d\alpha}$ has the same sign as $U_{13}$.*



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The following corollary shows that incentive compatibility and the initial value condition together imply uniqueness. Let $\tilde{\tau}$ denote the unique solution to the following restricted initial value problem: (DE), $\tau(\alpha^w) = \phi(\alpha^w)$ and $(d\tau/d\alpha)U_{13} > 0$.

**Corollary**: suppose (1)-(5) are satisfied and the initial value condition holds. If $\tau$ satisfies incentive compatibility, then $\tau = \tilde{\tau}$.

## *H.* Esö and Schummer (2009)

This Section states results in Esö and Schummer (2009) that are used above.

Define the Sender-Receiver game which is denoted by the tuple $(\Theta, \pi, u_S, u_R)$. The Sender has private information that is summarized by his type $\theta \in \Theta = \{\theta_1,\ \theta_2, \cdots,\ \theta_n\} \subset \mathbb{R}$, where $\theta_1 < \theta_2 < \cdots < \theta_n$. The commonly known prior probability that the Sender's type is $\theta$ is $\pi(\theta)$. Upon realizing his type, the Sender chooses a message $m \in \mathbb{R}_+$. A strategy for the Sender is a function $M : \Theta \to \mathbb{R}_+$. The Sender and Receiver receive respective payoffs of $u_S(\theta, m, a)$ and $u_R(\theta, m, a)$, which are both continuously differentiable in $(m, a)$.

The Receiver's (posterior) beliefs upon receiving the Sender's message is a function $\mu : \mathbb{R}_+ \to \Delta(\Theta)$, where $\Delta(\Theta)$ refers to the set of probability distributions on $\Theta$. For any message $m \in \mathbb{R}_+$ and any fixed (posterior belief) distribution $\tilde{\pi} \in \Delta(\Theta)$, denote the Receiver's best responses to $m$ (given $\tilde{\pi}$) by $BR(\tilde{\pi}, m) \equiv \text{argmax}_{a \in \mathbb{R}} \mathbb{E}\left[u_R(\theta, m, a) \mid \tilde{\pi}\right]$.

### Formalizing Credible Deviations

**Definition 1** *(Vulnerability to a Credible Deviation) Given an equilibrium $(M, A, \mu)$, we say that an out-of-equilibrium message $m \in \mathbb{R}_+ \backslash M(\Theta)$ is a Credible Deviation if the following condition holds for exact one (non-empty) set of types $C \subseteq \Theta$.*

$$C = \{\theta \in \Theta : u_S^\star(\theta) < \min_{a \in BR(C,m)} u_S(\theta, m, a)\} \tag{A.10}$$

*We call $C$ the (unique) Credible Deviators' Club for message $m$. If such a message exits, the equilibrium is Vulnerable to a Credible Deviation.*



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**Monotonic Signaling Games and the Uniqueness of the Equilibrium**

Following Cho and Sobel (1990) and Ramey (1996), monotonic signaling games are defined as follows,

**A1.** $u_S(\theta, m, a)$ is strictly increasing in $a$ for all $(\theta, m)$. One can think of $a$ as some sort of compensation for the Sender. In order to avoid solutions involving arbitrarily large messages and actions we assume that $\lim_{m\to\infty} u_S(\theta, m, a) = -\infty$.

**A2.** Assume that $u_R$ is such that, for any type $\theta$ and message $m$, the Receiver has a unique best response, i.e. that $BR(\theta, m)$ is a singleton. We denote this action as $\{\beta(\theta, m)\} \equiv BR(\theta, m)$ and $\beta(\theta, m)$ is uniformly bounded from above.

**A3.** Assume that $BR(\tilde{\pi}, m)$ is greater for beliefs that are greater in the first-order stochastic sense, and in particular, $\beta(\theta, m)$ is strictly increasing in $\theta$ for all $(m, a)$ (Cho and Sobel 1990, p. 392).

**A4.** Assume the game satisfies the central assumption in Spencian signaling games, the single crossing condition, that $-(\partial u_S/\partial m)/(\partial u_S/\partial a)$ is strictly decreasing in $\theta$.

**A5.** Assume that $u_S(\theta, m, \beta(\theta, m))$ is strictly quasi-concave in $m$.

An additional piece of notation simplifies the exposition. For any $\theta$ and $m$, let $\hat{a}(\theta, m)$ be the action to satisfy,

$$u_S(\theta, m, \hat{a}(\theta, m)) = u_S^\star(\theta) \tag{A.11}$$

if such an action exists, and denote $\hat{a}(\theta, m) = \infty$ otherwise. This action by the Receiver would give Sender-type $\theta$ his equilibrium payoff after sending $m$. If such an action exists, it is unique by monotonicity.

**Lemma 3** *If an equilibrium $(M, A, \mu)$ is not Vulnerable to Credible Deviations, it is a separating equilibrium - no two types send the same message.*

**Lemma 4** *Any equilibrium whose outcome is different from the Riley outcome is Vulnerable to Credible Deviations.*

**Theorem** *The Riley outcome is the unique equilibrium outcome that is not Vulnerable to Credible Deviations.*



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## *I.* Baseline Setting: General Case and CARA Special Case

In the baseline setting, the manager chooses the dividend payment to maximize

$$\begin{aligned}
&\max_{D_1} \quad D_1 + \mathbb{E}\left[Y_2\right] \\
&\text{subject to} \\
&Y_2 = R \cdot f\left(I_1\right) + \nu \\
&D_1 \leq \omega_1,
\end{aligned}$$

which implies, assuming for illustration that the second constraint is slack, $D_1 < \omega_1$,

$$\max_{D_1} \quad D_1 + R \cdot f\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right),$$

where $\mathbb{E}\left[Y_2\right] = \mathbb{E}\left[R \cdot f(I_1) + \nu\right] = R \cdot f\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right)$ and $a$ is the certainty equivalent coefficient in the sense of Arrow-Pratt. We begin by assuming that the Arrow-Pratt coefficient is scale-invariant, i.e., $a\left(I_1^*\right) \equiv a$, for clarity of illustration, which is the case for exponential production functions. Later in this section we analyze the general case.

To understand this formulation, note that in our framework, randomness in $Y$ reduces the expected profits if the function $f\left(.\right)$ is concave, in which case the firm is essentially risk averse with respect to fluctuations in $Y$, in the precise sense that $\mathbb{E}\left[f\left(Y\right)\right] < f\left(\mathbb{E}\left[Y\right]\right)$, that is, Jensen's inequality.[1] The first-order condition is $1 - R \cdot f'\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right) \geq 0$.

**Prediction 1 (baseline)**. The following result is straightforward:

$$\frac{\partial \sigma^2}{\partial D_1} = -\frac{2}{a} < 0.$$

Larger dividends should be associated with subsequent lower cash-flow volatility. Because managers pay dividends before the cash flows are realized, managers take into account, in a certainty-equivalence sense, that paying higher dividends will increase the probability of foregoing future investment opportunities, as the (expected) volatility of

[1] This insight exactly parallels the one in Froot, Scharfstein, and Stein (1993) about conditions under which risk management increases firm value. See also Rampini and Viswanathan (2013).



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cash flows increases. This prediction follows from the precautionary savings motive, because in our setting lower dividends directly translate in higher cash balances available for future investment.[2]

This stylized model already delivers the main hypothesis of our paper; that is, dividend changes should be followed by changes in cash-flow volatility in the opposite direction. We now consider the more general case, $a = a\left(I_1^*\right)$, and for illustration we maintain $R = 1$. Recall the manager's maximization problem is,

$$\begin{aligned} \max_{D_1} \quad & D_1 + \mathbb{E}\left[Y_2\right] \\ & s.t. \\ & Y_2 = f(I_1) + \nu \\ & D_1 \leq \omega_1 \end{aligned}$$

We can rewrite $D_1 + \mathbb{E}(Y_2)$ as

$$\begin{aligned} D_1 + \mathbb{E}(Y_2) &= D_1 + \mathbb{E}(f(I_1) + \nu) \\ &= D_1 + \mathbb{E}(f(\omega_1 + Y_1 - D_1)) \qquad \text{(since } \mathbb{E}(\nu) = 0) \\ &= D_1 + \mathbb{E}(f(\omega_1 + Y + \nu - D_1)) \qquad \text{(since } \mathbb{E}(Y_1) = f(I_0) = Y) \end{aligned}$$

Let $f(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2) = \mathbb{E}\left[f(\omega_1 + Y + \nu - D_1)\right]$. By first order Taylor expansion of the left-hand side (LHS),

$$f(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2) \approx f(\omega_1 + Y - D_1) + f'(\omega_1 + Y - D_1)(-\frac{a}{2}\sigma^2)$$

By second order Taylor expansion of the right-hand side (RHS),

$$\begin{aligned} f(\omega_1 + Y + \nu - D_1) &= f(\omega_1 + Y - D_1 + \nu) \\ &\approx f(\omega_1 + Y - D_1) + f'(\omega_1 + Y - D_1)\nu + \frac{f''(\omega_1 + Y - D_1)}{2}\nu^2 \end{aligned}$$

[2]Together with Jensen's inequality, this equivalence between cash balances and the negative of cash payouts implies that lower cash-flow volatility will eventually result in higher investment and cash flows at Time 2. In a richer model with a wedge between cash holdings and cash payouts, this prediction would no longer necessarily hold.



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Taking expectation in both sides, obtain

$$\begin{aligned}
\mathbb{E}\left[f(\omega_1+Y+\nu-D_1)\right] &\approx f(\omega_1+Y-D_1)+f'(\omega_1+Y-D_1)\mathbb{E}(\nu)+\frac{f''(\omega_1+Y-D_1)}{2}\mathbb{E}(\nu^2) \\
&= f(\omega_1+Y-D_1)+\frac{f''(\omega_1+Y-D_1)}{2}\mathbb{E}(\nu^2) \quad (\text{since } \mathbb{E}(\nu)=0) \\
&= f(\omega_1+Y-D_1)+\frac{f''(\omega_1+Y-D_1)}{2}\sigma^2
\end{aligned}$$

Comparing Taylor expansions of LHS and RHS, we obtain $a(Y,D_1)=-\dfrac{f''(\omega_1+Y-D_1)}{f'(\omega_1+Y-D_1)}$. It is not only a function of $Y$, but also a function of $D_1$. Therefore, $D_1+\mathbb{E}(Y_2)$ can be expressed as $D_1+f(\omega_1+Y-D_1-\dfrac{a(Y,D_1)}{2}\sigma^2)$. The F.O.C. of the problem is

$$1-f'(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)-\frac{\sigma^2}{2}f'(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)\frac{\partial a(Y,D_1)}{\partial D_1}=0$$

We can then show that:
$\dfrac{\partial\sigma^2}{\partial D_1}<0$ if

$$\frac{a(Y,D_1)f''(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)}{2f'(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)}-\frac{1}{\sigma^2}\left[1-f'(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)\right]<0.$$

**Proof.** Let $G(D_1,\sigma^2)=1-f'(\omega_1+Y-D_1-\dfrac{a(Y,D_1)}{2}\sigma^2)-\dfrac{\sigma^2}{2}f'(\omega_1+Y-D_1-\dfrac{a(Y,D_1)}{2}\sigma^2)\dfrac{\partial a(Y,D_1)}{\partial D_1}=0$,

$$\begin{aligned}
\frac{\partial\sigma^2}{\partial D_1} &= -\frac{\frac{\partial G}{\partial D_1}}{\frac{\partial G}{\partial\sigma^2}} \\
&= -\frac{f''(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)\left[1+\frac{\sigma^2}{2}\frac{\partial a(Y,D_1)}{\partial D_1}\right]^2-\frac{\sigma^2}{2}f'(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)\frac{\partial^2 a(Y,D_1)}{\partial D_1^2}}{f''(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)\left[1+\frac{\sigma^2}{2}\frac{\partial a(Y,D_1)}{\partial D_1}\right]\frac{a(Y,D_1)}{2}-\frac{1}{2}f'(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)\frac{\partial a(Y,D_1)}{\partial D_1}}
\end{aligned}$$

Recalling the F.O.C.,

$$1-f'(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)-\frac{\sigma^2}{2}f'(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)\frac{\partial a(Y,D_1)}{\partial D_1}=0, \quad \text{(A.12)}$$



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we have $\dfrac{\partial a(Y,D_1)}{\partial D_1} = \dfrac{2}{\sigma^2}\left[\dfrac{1}{f'(\omega_1+Y-D_1^\star-\dfrac{a(Y,D_1)}{2}\sigma^2)}-1\right]$. The S.O.C. is

$$f''(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)\left[1+\frac{\sigma^2}{2}\frac{\partial a(Y,D_1)}{\partial D_1}\right]^2-\frac{1}{2}f'(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)\frac{\partial^2 a(Y,D_1)}{\partial D_1^2}<0$$

Thus,

$$\begin{aligned}
\frac{\partial^2 a(Y,D_1)}{\partial D_1^2} &> \frac{\partial\big(\frac{2}{\sigma^2}\left[\dfrac{1}{f'(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)}-1\right]\big)}{\partial D_1} \\
&= \frac{2}{\sigma^2}\frac{f''(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)\left[1+\frac{\sigma^2}{2}\frac{\partial a(Y,D_1)}{\partial D_1}\right]}{f'(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)^2} \\
&= \frac{2}{\sigma^2}\frac{f''(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)}{f'(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)^3}
\end{aligned}$$

Thus, if $f''\dfrac{a(Y,D_1)}{2f'}-\dfrac{f'}{2}\dfrac{\partial a(Y,D_1)}{\partial D_1}<0$ (i.e., $f''\dfrac{a(Y,D_1)}{2f'}-\dfrac{1}{\sigma^2}[1-f']<0$),

$$\frac{\partial\sigma^2}{\partial D_1} < -\frac{\dfrac{f''}{f'^2}-\dfrac{\sigma^2}{2}f'\dfrac{2f''}{\sigma^2 f'^3}}{f''\dfrac{a(Y,D_1)}{2f'}-\dfrac{f'}{2}\dfrac{\partial a(Y,D_1)}{\partial D_1}} \Rightarrow \frac{\partial\sigma^2}{\partial D_1}<0$$

where $f'=f'(\omega_1+Y-D_1-\dfrac{a(Y,D_1)}{2}\sigma^2)$, $f''=f''(\omega_1+Y-D_1-\dfrac{a(Y,D_1)}{2}\sigma^2)$ and $f'''=f'''(\omega_1+Y-D_1-\dfrac{a(Y,D_1)}{2}\sigma^2)$. ■

We can now examine the cross derivative, $\dfrac{\partial^2\sigma^2}{\partial D_1\partial Y}$, and see that in general its sign is ambiguous.

$$\frac{\partial^2\sigma^2}{\partial D_1\partial Y} = \frac{\partial(\frac{\partial\sigma^2}{\partial D_1})}{\partial Y}$$



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According to the proof above,

$$\frac{\partial\sigma^2}{\partial D_1} = \frac{-f''\left[1+\frac{\sigma^2}{2}\frac{\partial a(Y,D_1)}{\partial D_1}\right]^2+\frac{\sigma^2}{2}f'\frac{\partial^2 a(Y,D_1)}{\partial D_1^2}}{f''\left[1+\frac{\sigma^2}{2}\frac{\partial a(Y,D_1)}{\partial D_1}\right]\frac{a(Y,D_1)}{2}-\frac{1}{2}f'\frac{\partial a(Y,D_1)}{\partial D_1}}$$

where $f' = f'(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)$, $f'' = f''(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)$ and $f''' = f'''(\omega_1+Y-D_1-\frac{a(Y,D_1)}{2}\sigma^2)$. Let A denote the numerator of $\frac{\partial\sigma^2}{\partial D_1}$ and B denote the denominator of $\frac{\partial\sigma^2}{\partial D_1}$, then

$$\frac{\partial^2\sigma^2}{\partial D_1\partial Y} = \frac{A'B-AB'}{B^2}$$

where

$$\begin{aligned} A'B &= \{\left[\frac{\sigma^2 f''}{2}\frac{\partial^2 a}{\partial D_1^2}-f'''(1+\frac{\sigma^2}{2}\frac{\partial a}{\partial D_1})^2\right]\left[1+\frac{\sigma^2}{2}\frac{\partial a}{\partial D_1}\right]+\frac{\sigma^2}{2}f'\frac{\partial(\frac{\partial^2 a}{\partial D_1^2})}{\partial Y}-2f''\left[1+\frac{\sigma^2}{2}\frac{\partial a}{\partial D_1}\right]\frac{\sigma^2}{2}\frac{\partial^2 a}{\partial D_1\partial Y}\} \\ &\quad\times\{f''\left[1+\frac{\sigma^2}{2}\frac{\partial a}{\partial D_1}\right]\frac{a}{2}-\frac{1}{2}f'\frac{\partial a}{\partial D_1}\} \end{aligned}$$

and

$$\begin{aligned} AB' &= \{-f''\left[1+\frac{\sigma^2}{2}\frac{\partial a(Y,D_1)}{\partial D_1}\right]^2+\frac{\sigma^2}{2}f'\frac{\partial^2 a(Y,D_1)}{\partial D_1^2}\} \\ &\quad\times\{f'''(1+\frac{\sigma^2}{2}\frac{\partial a}{\partial D_1})^2\frac{a}{2}-\frac{1}{2}f''\frac{\partial a}{\partial D_1}(1+\frac{\sigma^2}{2}\frac{\partial a}{\partial D_1})+\frac{a}{2}f''\frac{\sigma^2}{2}\frac{\partial^2 a}{\partial D_1\partial Y}-\frac{f'}{2}\frac{\partial^2 a}{\partial D_1\partial Y}\} \end{aligned}$$



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**Special Case**

Assume $f(x) = A - e^{-kx}$ with constants $A > 0$ and $k > 0$. To begin with,

$$\begin{aligned} f'(x) &= -(-ke^{-kx}) = ke^{-kx} \\ f''(x) &= -k^2 e^{-kx} \end{aligned}$$

In this case, $a = \dfrac{-f''(\omega_1 + Y - D_1)}{f'(\omega_1 + Y - D_1)} = k$ is constant.
The F.O.C. will be

$$1 - f'(\omega_1 + Y - D_1 - \frac{a}{2}\sigma^2) = 0$$

Prediction 1 (Special Case).
$\dfrac{\partial \sigma^2}{\partial D_1} < 0$

**Proof.** Let $J = 1 - f'(\omega_1 + Y - D_1 - \dfrac{a}{2}\sigma^2) = 0$,

$$\frac{\partial \sigma^2}{\partial D_1} = -\frac{\dfrac{\partial J}{\partial D_1}}{\dfrac{\partial J}{\partial \sigma^2}} = -\frac{f''(\omega_1 + Y - D_1 - \dfrac{a}{2}\sigma^2)}{f''(\omega_1 + Y - D_1 - \dfrac{a}{2}\sigma^2)\frac{a}{2}} = -\frac{2}{a} < 0$$

Because $a = k > 0$. ■

Prediction 2 (Special Case).
$\frac{\partial^2 \sigma^2}{\partial D_1 \partial Y} = 0$
Proof: by inspection.



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## *J.* Agency: Additive Formulation

We report here the proofs of the statements in Section VB in the main text. Under an additive agency formulation, the maximization program is:

$$\max_{D_1} D_1 + \mathbb{E}\left[Y_2\right] - c\left(D_1\right),$$
$$\text{subject to}$$
$$Y_2 = R \cdot f\left(I_1\right) + \nu$$
$$0 \leq d_1 \leq 1.$$

The first-order condition is $1 - R \cdot f'\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right) - c'\left(D_1\right) \geq 0$. Therefore, we obtain:

**Prediction** $i$ **(additive agency - time series)**.

$$\frac{\partial \sigma^2}{\partial D_1} = -\frac{2}{a} + \frac{2 \cdot c''\left(D_1\right)}{a \cdot R \cdot \left[f''\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right)\right]} < 0.$$

As in the baseline setting and in the signaling model, higher dividends should correlate with lower future cash-flow volatility. Two effects are at play. First, as in the baseline setting, lower future cash-flow volatility implies a higher income available for paying dividends, holding investment opportunities fixed. Second, lower future cash-flow volatility enables managers to more easily extract private benefits (re. incur lower agency costs) and pay more dividends, again holding investment fixed.

Now, however, the *larger* the current earnings, the larger the reduction in cash-flow volatility should be following the same dollar of dividend paid:

**Prediction** $ii$ **(additive agency - cross-section)**.

$$\frac{\partial^2 \sigma^2}{\partial D_1 \partial Y} = -\frac{2 \cdot c''\left(D_1\right) \cdot f'''\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right)}{a \cdot R \cdot \left[f''\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right)\right]^2} < 0.$$

## *K.* Agency: Multiplicative Formulation

We assume the manager faces a private (agency) cost $c(d_1)$ from paying as dividends a fraction $d_1$ of cash flows in the first period and the remaining cash in the second period,



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where the function $c$ is convex, that is, $c' > 0$ and $c'' > 0$. In this setting, the manager chooses the dividend payment to maximize

$$\max_{d_1} \omega_1 \left[d_1 - c\left(d_1\right)\right] + \mathbb{E}\left[Y_2\right]\left[1 - c\left(d_1\right)\right]$$
$$\text{subject to}$$
$$Y_2 = R \cdot f\left(I_1\right) + \nu$$
$$0 \leq d_1 \leq 1.$$

The first-order condition is: $\omega_1 \left[1 - c'\left(d_1\right)\right] - \omega_1 \cdot R \cdot f'\left(\left(1 - d_1\right)\omega_1 + Y - \frac{a}{2} \cdot \sigma^2\right)\left[1 - c\left(d_1\right)\right] - c'\left(d_1\right) \cdot R \cdot f\left(\left(1 - d_1\right)\omega_1 + Y - \frac{a}{2} \cdot \sigma^2\right) \geq 0$ or for brevity $\omega_1\left(1 - c'\right) - \omega_1 \cdot R \cdot f'\left(1 - c\right) - c' \cdot R \cdot f \geq 0$. Therefore, we obtain:

**Prediction $i$ (multiplicative agency - time series)**.

$$\frac{\partial \sigma^2}{\partial d_1} = -\frac{2\omega_1}{a} + \frac{2 \cdot c'' \cdot \left(\omega_1 + f\right)}{a \cdot R \cdot \left[\omega_1 \cdot f''\left(1 - c\right) + f'c'\right]} - \frac{2 \cdot \omega_1 \cdot f' \cdot c'}{a \cdot \left[\omega_1 \cdot f''\left(1 - c\right) + f'c'\right]} \gtrless 0$$

To illustrate, assume that $\omega_1 \cdot f''\left(1 - c\right) + f'c' < 0$ (the discussion for the reverse case in which $\omega_1 \cdot f''\left(1 - c\right) + f'c' > 0$ is largely symmetric).

Three effects are at play. First, as in the baseline setting, lower future cash flow volatility implies a higher income available for paying dividends, holding investment opportunities fixed. Second, lower future cash-flow volatility enables managers to more easily extract private benefits (re. incur lower agency costs) and pay more dividends, again holding investment fixed. These effects are as in the additive agency model, and predict a negative correlation between $\sigma^2$ and $d_1$. Now, however, a third effect also arises, as lower future cash flow volatility, implying a higher future income, also allows managers to divert a larger share of the cash flows. This third effect is captured by the term $f'c'$. As a result, the sign of the comparative static exercise cannot be uniquely determined and the prediction is therefore ambiguous.

We can now compute the cross-derivative:



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**Prediction** $ii$ **(multiplicative agency - cross-section)**.

$$\frac{\partial^2\sigma^2}{\partial d_1 \partial Y} = \frac{-\omega_1^2 \cdot f''' + c'' \cdot f' + 2\omega_1 \cdot f'' c'}{R \cdot \left\{\frac{a}{2} \cdot \left[\omega_1 \cdot f''(1-c) + f'c'\right]\right\}^2} \lesseqgtr 0$$

As in the additive agency model, larger current earnings make extracting more private benefits (re. incur lower agency costs) easier. Now, a further effect also arises, namely, higher current earnings also allow managers to divert larger cash flows. This latter effect is captured by the terms $f'c'$. As a result, this cross-sectional prediction is also ambiguous.

## *L.* Investment Opportunities

To model investment opportunities we follow Johnson et al. (2000) and Choe et al. (1993) and assume that the production function, $f$, is pre-multiplied by a positive parameter $R$ representing investment opportunities. The maximization program of the additive agency model then becomes:

$$\begin{aligned}
&\max_{D_1} D_1 + \mathbb{E}\left[Y_2\right] - c\left(D_1\right), \\
&\text{subject to} \\
&Y_2 = R \cdot f\left(I_1\right) + \nu \\
&D_1 \leq \omega_1.
\end{aligned}$$

We establish:

**Prediction A.1 (additive agency - investment opportunities )**.

$$\frac{\partial^2\sigma^2}{\partial D_1 \partial R} = \frac{-2 \cdot c''\left(D_1\right) \cdot f''\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right)}{a \cdot \left[R \cdot f''\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right)\right]^2} > 0$$

In the additive agency model, the decline in cash flow volatility following dividend increases should be more pronounced for firms with *smaller* investment opportunities. The reason is that, if lower cash flow volatility facilitates extraction of private benefits, then high investment opportunities mute this effect because they increase the cost of



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extracting private benefits relative to engaging in efficient investment.

Conversely, the maximization program of the multiplicative agency model becomes

$$\max_{d_1} \omega_1 \left[d_1 - c\left(d_1\right)\right] + \mathbb{E}\left[Y_2\right]\left[1 - c\left(d_1\right)\right]$$
$$\text{subject to}$$
$$Y_2 = R \cdot f\left(I_1\right) + \nu$$
$$0 \leq d_1 \leq 1.$$

We obtain:

**Prediction A.2 (multiplicative agency - investment opportunities)**.

$$\frac{\partial^2 \sigma^2}{\partial d_1 \partial R} = \frac{-c'' \cdot \omega_1 \cdot \frac{a}{2} \cdot \left[\omega_1 \cdot f''\left(1-c\right) + f'c'\right]}{\left\{\frac{a}{2} \cdot R \cdot \left[\omega_1 \cdot f''\left(1-c\right) + f'c'\right]\right\}^2} \gtrless 0$$

Relative to the additive agency model, a new effect arises, as higher investment opportunities also allow managers to divert larger cash flows, an effect captured by the terms $f'c'$. As a result, the sign of this comparative statics depends on the term in parentheses. If $\left[\omega_1 \cdot f''\left(1-c\right) + f'c'\right] < 0$ then the multiplicative agency model generates the same prediction as the additive agency model (see above). If instead $\left[\omega_1 \cdot f''\left(1-c\right) + f'c'\right] > 0$ then the multiplicative agency model generates the same prediction as the signaling model (see below).

Finally, the maximization program of the signaling model becomes

$$\max_{\{D_1\}} \quad W_1 = kV_1^s + (1-k)V_1^h$$
$$\text{subject to}$$
$$Y_2 = R \cdot f\left(I_1\right) + \nu$$
$$D_1 \leq \omega_1,$$

We establish:



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**Prediction S.1 (signaling - investment opportunities).**

$$\frac{\partial^2 \sigma^2}{\partial D_1 \partial R} = \frac{-f'\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right)}{\left[R \cdot f''\left(\omega_1 + Y - D_1 - \frac{a}{2} \cdot \sigma^2\right)\right]^2} < 0$$

In the signaling model, the decline in cash flow volatility following dividend increases should be more pronounced for firms with higher investment opportunities. The intuition is that the scope of using dividends to signal future declines in cash flow volatility is magnified when investment opportunities are larger.

## *M.* Curvature of the Production Function

Under the assumption of a (negative) exponential production function, our firm is akin to a risk averse agent with CARA utility and its curvature is fully described by the Arrow-Pratt coefficient of absolute risk aversion (or certainty equivalence), $a$. As a result, our estimates of equation (17), particularly of $\hat{\beta} = -0.04$ in column 2 of Table 13, implies a coefficient of $\hat{a} = 0.08$. In this section, we discuss how this estimate compares with estimates in the literature. First, we note that much of the quantitative corporate finance literature does not study a setting in which firms are "essentially risk averse" as in ours, and assumes a Cobb-Douglas production function, $y_t = k^{\gamma} \cdot l^{(1-\gamma)}$. The literature then typically calibrates $\hat{\gamma} = 0.33$ based on macroeconomic estimates of the capital share in production functions.

Closer to our focus, Froot, Scharfstein, and Stein (1993) present a static model of a firm with a concave production function and stress that such firm can be understood as being effectively risk averse with respect to fluctuations in cash flows, thereby providing a microfoundation for corporate risk management and the use of derivative contracts. Recently, Rampini and Viswanathan (2010) and Rampini and Viswanathan (2013) develop this basic intuition in dynamic models of risk management, capital structure and corporate financing. Li, Whited, and Wu (2016) conduct a full-fledged structural estimation of the Rampini and Viswanathan (2013) model, and estimate the curvature of the production function. In their setting, the concavity of the production function together with financial constraints (and particularly collateral constraints) induce curvature in the value function,



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which is what they estimate in the data. In this sense, therefore, the firm's risk aversion in the Li, Whited, and Wu (2016) and Rampini and Viswanathan (2013) papers is an induced property of the value function stemming from the whole theoretical framework rather than a single parameter as in our CARA setting.

Specifically, Li, Whited, and Wu (2016) consider a production function, $y_t = z_t k_t^{\gamma}$, and in their baseline setting (i.e., their Table 1) they estimate the curvature parameter $\hat{\gamma}$ to be in the range $[0.52, 0.88]$, where the estimate $\hat{\gamma} = 0.52$ indicates a "high curvature / steep production function / high risk aversion" (in the sense discussed above) and results from realistic tax rates between 0.1 and 0.2, while $\hat{\gamma} = 0.88$ indicates a "flat production function" with "low curvature / low risk aversion" and results from a benchmark setting with zero tax rates. Furthermore, in a series of experiments they report values of their curvature parameter between 0.52 and 0.61 in their model with non-state contingent debt (Table 4).

How do our estimates compare with the Li, Whited, and Wu (2016) estimates? Once more, a direct comparison is not possible, because in our setting risk aversion is captured by a single CARA parameter, while in their setting risk aversion is a feature of the concavity of the production function together with collateral constraints. Notwithstanding the above caveats and qualifications, one can nevertheless gauge a visual comparison of our estimate with those of Li, Whited, and Wu (2016), and we report them in the Figure A.1. From this exercise, it appears that our estimate of $\hat{a} = 0.08$ has a curvature that is locally "close" to that of Li, Whited, and Wu (2016)s upper bound of $\hat{\gamma} = 0.52$.



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Figure A.1: **Estimates of the Curvature of the Production Function**

*This figure plots the implied curvature of the production function in our model (solid line) with the implied curvature of the production function in Li, Whited, and Wu (2016) (dotted lines). Li, Whited, and Wu (2016) consider a production function,* $Y = z \cdot K^{\gamma}$*, and estimate* $\hat{\gamma}$ *to be in the range* $[0.52, 0.88]$*. We consider a negative exponential function* $Y = w \cdot exp(-aK) + v$ *and estimate* $\hat{a} = 0.08$*. For illustration, in the plot below we use* $z = 1$*,* $w = -4.88$*, and* $v = 5.61$*.*

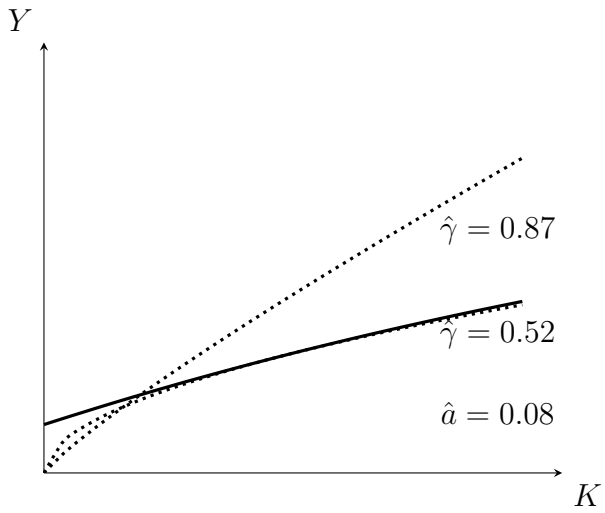




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Table A.1: **Descriptive Statistics Matching**

*This table reports descriptive statistics for the event firms and the observationally-similar firms matched on propensity scores. BM is the book-to-market-ratio, Size is the log market cap, Lev is financial leverage and age is the time since the firm has been on CRSP. Our sample period is 1964 till 2013.*

| | **Event Firms** | | | | **Matched Firms** | | | |
|---|---|---|---|---|---|---|---|---|
| | Nobs | Median | Mean | Std | Nobs | Median | Mean | Std |
| BM | 6,777 | 0.70 | 0.92 | 0.79 | 6,777 | 0.80 | 0.98 | 0.73 |
| Size | 6,777 | 19.66 | 19.74 | 1.93 | 6,777 | 18.98 | 19.20 | 1.94 |
| Leverage | 6,777 | 0.41 | 0.43 | 0.27 | 6,777 | 0.39 | 0.41 | 0.22 |
| Age | 6,777 | 12.75 | 15.96 | 9.93 | 6,777 | 12.50 | 14.44 | 9.03 |



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Table A.2: **Scaled Change in Variance of Cash-Flow News Around Dividend Events: Build-Up**

*This table reports changes in cash-flow news around dividend events using the methodology of Vuolteenaho (2002) which we describe in Section II.. We study the build-up of the change in the variance of cash-flow news after the dividend event over time when we expand the event window. Our sample period is 1964 till 2013.*

| | $\Delta Div > 0$ | Initiation | Pooled | $\Delta Div < 0$ | Omission | Pooled |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $(\mathbb{Var}(\eta_cf_{t:t+1} - \mathbb{Var}(\eta_cf_{t-1:t})/mean(\mathbb{Var}(\eta_cf_{t-5:t}))$ | −9.00% | −17.04% | −11.75% | 5.34% | 11.58% | 7.50% |
| | (−3.61) | (−5.21) | (−5.91) | (1.97) | (2.87) | (3.33) |
| $(\mathbb{Var}(\eta_cf_{t:t+2} - \mathbb{Var}(\eta_cf_{t-2:t})/mean(\mathbb{Var}(\eta_cf_{t-5:t}))$ | −14.29% | −21.97% | −16.91% | 9.36% | 11.91% | 10.40% |
| | (−7.96) | (−8.33) | (−11.37) | (4.64) | (4.24) | (6.36) |
| $(\mathbb{Var}(\eta_cf_{t:t+3} - \mathbb{Var}(\eta_cf_{t-3:t})/mean(\mathbb{Var}(\eta_cf_{t-5:t}))$ | −15.98% | −21.63% | −17.71% | 8.43% | 11.93% | 9.63% |
| | (−10.42) | (−9.21) | (−13.79) | (4.93) | (4.79) | (6.82) |
| $(\mathbb{Var}(\eta_cf_{t:t+4} - \mathbb{Var}(\eta_cf_{t-4:t})/mean(\mathbb{Var}(\eta_cf_{t-5:t}))$ | −16.12% | −23.58% | −18.48% | 9.10% | 8.14% | 8.64% |
| | (−11.44) | (−10.96) | (−15.65) | (5.71) | (3.47) | (6.54) |
| $(\mathbb{Var}(\eta_cf_{t:t+5} - \mathbb{Var}(\eta_cf_{t-5:t})/mean(\mathbb{Var}(\eta_cf_{t-5:t}))$ | −14.86% | −20.01% | −16.43% | 7.29% | 6.09% | 6.89% |
| | (−9.65) | (−4.94) | (−16.07) | (4.38) | (2.42) | (6.19) |
| Nobs | 2,441 | 1,069 | 3,510 | 2,461 | 1,233 | 3,694 |



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Table A.3: **Sample Split by Financial Constraints: Scaled Change in Variance of Cash-Flow News and Announcement Returns Around Dividend Events**

*This table reports the average change in the variance of cash-flow news scaled by the average variance of cash-flow news before the event ($\Delta\,\mathbb{V}\mathrm{ar}(\eta_cf)/mean(\mathbb{V}\mathrm{ar}(\eta_cf))$) using the methodology of Vuolteenaho (2002) which we describe in Section II. in Panel A and announcement returns in Panel B. The Table splits dividend events by the Hadlock-Pierce Index using the terciles as cutoff excluding the middle tercile. Announcement returns are cumulative returns in a three-day window bracketing the dividend event. We bootstrap the difference between large and small financial constraints. Our sample period is 1964 till 2013.*

| | $\Delta Div > 0$ | | | $\Delta Div < 0$ | | |
|---|---|---|---|---|---|---|
| | High Constraints | Low Constraints | $\Delta$ | High Constraints | Low Constraints | $\Delta$ |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | **Panel A. $\Delta$ Scaled Variance Cash-flow News: $\Delta\,\mathbb{V}\mathrm{ar}(\eta_cf)/mean(\mathbb{V}\mathrm{ar}(\eta_cf))$** | | | | | |
| | −16.98% | −11.58% | 5.20% | 9.10% | 6.98% | −3.11% |
| | (−5.98) | (−4.56) | (6.78) | (3.07) | (2.56) | (−3.21) |
| Nobs | 813 | 814 | | 820 | 820 | |
| | **Panel B. Cumulative Returns** | | | | | |
| | 1.02% | 0.60% | −0.37% | −0.84% | −0.63% | 0.23% |
| | (5.34) | (4.42) | (−7.13) | (−4.50) | (−3.25) | (4.48) |
| Nobs | 813 | 814 | | 820 | 820 | |



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Table A.4: **Correlation between Variance of Cash Flow News and Stock Return Volatility**

*This table reports correlations of the variance of cash-flow news using the methodology of Vuolteenaho (2002) which we describe in Section II. and stock-return volatility which we calculate using five years of daily data around dividend events. The sample period from 1964 till 2013.*

| | Before (1) | After (3) |
|---|---|---|
| Initiations | 17.82% | 21.54% |
| Dividend Increases | 22.38% | 21.31% |
| Omissions | 20.62% | 21.29% |
| Dividend Decreases | 21.56% | 21.34% |



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Table A.5: **Scaled Change in Stock Return Volatility Around Dividend Events**

*This table reports changes in annualized stock return volatility around dividend events using using five years of daily data before and after the dividend event. Panel A reports the average change in annualized stock return volatility and Panel B reports the average change in annualized stock return volatility scaled by the average stock return volatility before the event. Our sample period is 1964 till 2013.*

| | $\Delta Div > 0$ | Initiation | Pooled | $\Delta Div < 0$ | Omission | Pooled |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | | | **Panel A. Δ Annualized Return Variance** | | | |
| | 18.42% | 18.16% | 18.31% | -6.42% | 5.43% | -4.24% |
| | (8.39) | (5.24) | (9.82) | (-2.77) | (0.93) | (-1.95) |
| | | | **Panel B. Δ Scaled Annualized Return Variance** | | | |
| | 3.76% | 3.70% | 3.73% | -1.31% | 1.11% | -0.86% |
| | (8.39) | (5.24) | (9.82) | (-2.77) | (0.93) | (-1.95) |
| Nobs | 2,441 | 1,069 | 3,510 | 2,461 | 1,233 | 3,694 |



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Table A.6: **Announcement Returns**

*This table reports three-day cumulative returns on dividend event days for a sample period from 1964 till 2013.*

| | $\Delta Div > 0$ | Initiation | Pooled | $\Delta Div < 0$ | Omission | Pooled |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | 0.72% | 2.37% | 1.22% | -0.70% | -8.68% | -3.38% |
| | (7.69) | (11.00) | (13.11) | (-6.11) | (-29.77) | (-24.37) |
| Nobs | 2,441 | 1,069 | 3,510 | 2,461 | 1,233 | 3,694 |



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Table A.7: **Regression of Changes in Variance of Cash-Flow News Around Dividend Events: Initial Variance**

*This table reports estimates from the following specification:*

$$\Delta\, \mathbb{Var}(\eta_cf_{it}) = \alpha + \beta_1 \cdot \Delta D_{it} + \beta_2 \cdot eps_{it} + \beta_3 \cdot \Delta D_{it} \cdot eps_{it} + \delta \cdot X_{it} + \varepsilon_{it}.$$

*We regress changes in the scaled variance of cash-flow news around dividend events using the methodology of Vuolteenaho (2002) which we describe in Section II. of firm i at event t, $\Delta\, \mathbb{Var}(\eta_cf_{it})$, on the dividend change, $\Delta D_{it}$, earnings per share, $eps_{it}$, the interaction between the two, as well as additional covariates, $X_{it}$, with t-statistics in parentheses. Additional covariates include firm age, size, book-to-market, and financial leverage. We add year and industry fixed effects at the Fama & French 17 industry level whenever indicated. We cluster standard errors at the dividend-quarter level. Our sample period is 1964 till 2013.*

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| $\Delta Div$ | −0.26 | −0.24 | −0.37 | −0.13 | −0.15 | −0.14 | −0.25 | −0.11 |
| | (−5.55) | (−5.29) | (−5.94) | (−2.76) | (−4.92) | (−4.64) | (−5.04) | (−2.90) |
| $eps$ | | −0.17 | −0.12 | −0.22 | | (−0.14) | (−0.10) | (−0.16) |
| | | (−1.59) | (−1.91) | (−4.41) | | (−1.43) | (−1.77) | (−3.21) |
| $\Delta Div \times eps$ | | | 0.24 | 0.17 | | | 0.20 | 0.16 |
| | | | 3.13 | 3.18 | | | 2.67 | 2.87 |
| $\mathbb{Var}_{t-1}(\eta_cf)$ | | | | −93.65 | | | | −80.83 |
| | | | | (−29.17) | | | | (−32.08) |
| Age | | | | 0.00 | | | | 0.00 |
| | | | | (1.23) | | | | (0.24) |
| Book-to-market | | | | 81.87 | | | | 112.71 |
| | | | | (0.93) | | | | (1.81) |
| Leverage | | | | 0.16 | | | | 0.14 |
| | | | | (1.36) | | | | (1.33) |
| Size | | | | 0.04 | | | | 0.01 |
| | | | | (2.57) | | | | (0.87) |
| Constant | 0.03 | 0.12 | 0.08 | 0.09 | | | | |
| | (0.45) | (1.24) | (1.04) | (0.29) | | | | |
| Year FE | | | | | X | X | X | X |
| Industry FE | | | | | X | X | X | X |
| R2 | 2.06% | 2.89% | 3.89% | 39.16% | 30.60% | 31.15% | 31.80% | 52.24% |
| Nobs | 3,127 | 3,127 | 3,127 | 3,127 | 3,127 | 3,127 | 3,127 | 3,127 |



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Table A.8: **Regression of Changes in Variance of Cash-Flow News Around Dividend Events**

*This table reports estimates from the following specification:*

$$\Delta\, \mathbb{Var}(\eta_cf_{it}) = \alpha + \beta_1 \cdot \Delta D_{it} + \beta_2 \cdot eps_{it} + \beta_3 \cdot \Delta D_{it} \cdot eps_{it} + \delta \cdot X_{it} + \varepsilon_{it}.$$

*We regress changes in the scaled variance of cash-flow news around dividend events using the methodology of Vuolteenaho (2002) which we describe in Section II. of firm i at event t, $\Delta\, \mathbb{Var}(\eta_cf_{it})$, on the dividend change, $\Delta D_{it}$, earnings per share, $eps_{it}$, the interaction between the two, as well as additional covariates, $X_{it}$, with t-statistics in parentheses. Additional covariates include firm age, size, book-to-market, financial leverage, and cash. We add year and industry fixed effects at the Fama & French 17 industry level whenever indicated. We cluster standard errors at the dividend-quarter level. Our sample period is 1964 till 2013.*

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| $\Delta Div$ | −0.26 | −0.24 | −0.37 | −0.35 | −0.15 | −0.14 | −0.25 | −0.23 |
| | (−5.55) | (−5.31) | (−5.94) | (−6.05) | (−4.92) | (−4.66) | (−5.01) | (−5.03) |
| $eps$ | | −0.17 | −0.12 | −0.18 | | −0.14 | −0.10 | −0.23 |
| | | (−1.56) | (−1.87) | (−2.76) | | (−1.41) | (−1.75) | (−1.78) |
| $\Delta Div \times eps$ | | | 0.24 | 0.21 | | | 0.19 | 0.18 |
| | | | (3.12) | (3.20) | | | (2.64) | (2.54) |
| Age | | | | 0.00 | | | | 0.00 |
| | | | | (1.44) | | | | (1.21) |
| Book-to-Market | | | | 34.02 | | | | 134.39 |
| | | | | (0.40) | | | | (2.44) |
| Leverage | | | | −0.35 | | | | −0.14 |
| | | | | (−2.58) | | | | (−1.12) |
| Size | | | | 0.05 | | | | 0.02 |
| | | | | (3.35) | | | | (1.23) |
| Cash | | | | −0.00 | | | | −0.00 |
| | | | | (−2.35) | | | | (−1.40) |
| Constant | 0.03 | 0.12 | 0.08 | −0.86 | | | | |
| | (0.45) | (1.22) | (1.01) | (−2.75) | | | | |
| Year FE | | | | | X | X | X | X |
| Industry FE | | | | | X | X | X | X |
| R2 | 2.06% | 2.89% | 3.89% | 5.24% | 30.60% | 31.15% | 31.80% | 32.27% |
| Nobs | 3,127 | 3,127 | 3,127 | 3,127 | 3,127 | 3,127 | 3,127 | 3,127 |



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Table A.9: **Regression of Changes in Variance of Cash-Flow News Around Dividend Events**

*This table reports estimates from the following specification:*

$$\Delta\, \mathbb{Var}(\eta_cf_{it}) = \alpha + \beta_1 \cdot \Delta D_{it} + \beta_2 \cdot CF_{it} + \beta_3 \cdot \Delta D_{it} \cdot CF_{it} + \delta \cdot X_{it} + \varepsilon_{it}.$$

*We regress changes in the scaled variance of cash-flow news around dividend events using the methodology of Vuolteenaho (2002) which we describe in Section II. of firm $i$ at event $t$, $\Delta\, \mathbb{Var}(\eta_cf_{it})$, on the dividend change, $\Delta D_{it}$, cash flow, $CF_{it}$, the interaction between the two, as well as additional covariates, $X_{it}$, with t-statistics in parentheses. Additional covariates include firm age, size, book-to-market, financial leverage, and cash. We add year and industry fixed effects at the Fama & French 17 industry level whenever indicated. We cluster standard errors at the dividend-quarter level. Our sample period is 1964 till 2013.*

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| $\Delta Div$ | −0.26 | −0.27 | −0.26 | −0.25 | −0.15 | −0.16 | −0.15 | −0.14 |
| | (−5.55) | (−5.62) | (−5.47) | (−5.71) | (−4.92) | (−5.11) | (−4.82) | (−4.90) |
| $CF$ | | −0.09 | −0.11 | −0.09 | | −0.06 | −0.08 | −0.08 |
| | | (−2.54) | (−3.53) | (−2.87) | | (−2.47) | (−3.17) | (−3.20) |
| $\Delta Div \times CF$ | | | 0.02 | 0.02 | | | 0.02 | 0.02 |
| | | | (3.05) | (2.91) | | | (2.40) | (2.62) |
| Age | | | | 0.00 | | | | 0.00 |
| | | | | (1.38) | | | | (1.23) |
| Book-to-market | | | | 57.49 | | | | 150.01 |
| | | | | (0.62) | | | | (2.55) |
| Leverage | | | | −0.33 | | | | −0.11 |
| | | | | (−2.43) | | | | (−0.95) |
| Size | | | | 0.03 | | | | 0.00 |
| | | | | (1.92) | | | | (−0.16) |
| Constant | 0.03 | 0.03 | 0.02 | −0.53 | | | | |
| | (0.45) | (0.34) | (0.32) | (−1.76) | | | | |
| Year FE | | | | | X | X | X | X |
| Industry FE | | | | | X | X | X | X |
| R2 | 2.06% | 2.61% | 2.75% | 3.52% | 30.60% | 30.80% | 30.94% | 31.45% |
| Nobs | 3,127 | 3,127 | 3,127 | 3,127 | 3,127 | 3,127 | 3,127 | 3,127 |



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Table A.10: **Scaled Change in Variance of Cash-Flow News and Announcement Returns Around Dividend Events: Total Vol**

*This table reports the average change in the variance of cash-flow news scaled by the average variance of cash-flow news before the event ($\Delta\,\mathbb{V}\mathrm{ar}(\eta_cf)/mean(\mathbb{V}\mathrm{ar}(\eta_cf))$) using the methodology of Vuolteenaho (2002) which we describe in Section II. in Panel A and announcement returns in Panel B. The table splits firms by their ex ante total stock return volatility. Specifically, we first calculate a firms' ex ante total volatility on a four-quarter rolling basis using daily data. We then assign a firm into the large total volatility sample if it had a volatility above the 30% percentile of firm volatility in the respective Fama & French 17 industry in the quarter before the dividend event. Announcement returns are cumulative returns in a three-day window bracketing the dividend event. We bootstrap the difference between large and small changes. Our sample period is 1964 till 2013.*

| | $\Delta Div > 0$ | | | $\Delta Div < 0$ | | |
|---|---|---|---|---|---|---|
| | Large Vol | Small Vol | $\Delta$ | Large Vol | Small Vol | $\Delta$ |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | **Panel A. $\Delta$ Scaled Variance Cash-flow News: $\Delta\,\mathbb{V}\mathrm{ar}(\eta_cf)/mean(\mathbb{V}\mathrm{ar}(\eta_cf))$** | | | | | |
| | −16.49% | −13.13% | −3.74% | 9.61% | 3.79% | 3.45% |
| | (−7.23) | (−6.39) | (−6.27) | (4.28) | (1.55) | (4.64) |
| Nobs | 1,262 | 1,179 | | 1,482 | 979 | |
| | $\Delta Div > 0$ | | | $\Delta Div < 0$ | | |
| | Large Vol | Small Vol | $\Delta$ | Large Vol | Small Vol | $\Delta$ |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | **Panel B. Announcement Returns** | | | | | |
| | 0.93% | 0.48% | 0.44% | −0.93% | −0.31% | −0.73% |
| | (5.97) | (5.10) | (11.15) | (−5.44) | (−2.85) | (16.34) |
| Nobs | 1,262 | 1,179 | | 1,482 | 979 | |



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