Have Financial Markets Become More Informative?

Jennie Bai, Thomas Philippon, and Alexi Savov [*]

September 25, 2015

Abstract

The finance industry has grown, financial markets have become more liquid, information technology has been revolutionized. But have financial market prices become more informative? We derive a welfare-based measure of price informativeness: the predicted variation of future cash flows from current market prices. Since 1960, price informativeness has increased at longer horizons (three to five years). The increase is concentrated among firms with greater institutional ownership and share turnover, firms with options trading, and growth firms. Prices have also become a stronger predictor of investment, and investment a stronger predictor of cash flows. These results suggest increased revelatory price efficiency.

JEL Classification: E2, G1, N2
Keywords: price informativeness, economic growth, investment, revelatory price efficiency, forecasting price efficiency

---

Fama (1970) writes, "The primary role of the capital market is allocation of ownership of the economy's capital stock. In general terms, the ideal is a market in which prices provide accurate signals for resource allocation: that is, a market in which firms can make production-investment decisions ... under the assumption that security prices at any time 'fully reflect' all available information." Since these words were written, financial markets have been transformed: information processing costs have plummeted, and information availability has vastly expanded. Trading costs have fallen, and liquidity has increased by orders of magnitude. Institutional investing has become dominant, and spending on price discovery has increased.[1] The financial sector's share of output has doubled. To assess whether these changes have brought us closer to Fama's ideal, in this paper we ask: Have financial market prices become more informative?

To answer this question, we derive a welfare-based measure of price informativeness and then document its evolution over time. Using U.S. stock market data from 1960 to 2014, we find that among comparable firms price informativeness has increased substantially at medium and long horizons (three to five years) while remaining stable at short horizons (one year). Results from a variety of tests support the interpretation that the rise in price informativeness is due to greater information production in financial markets. Under this interpretation, rising price informativeness has contributed to an increase in the efficiency of capital allocation in the economy.

We use a simple framework to derive the right, welfare-relevant measure of informativeness and generate testable predictions. Standard q-theory (Tobin 1969) implies that investment is proportional to the conditional expectation of future cash flows, making firm value convex in this expectation. Intuitively, investment is an option on information, and firm value embeds the value of this option. It follows that aggregate efficiency is increasing in information (Hayek 1945), which can be quantified by the predicted variance of future cash flows (i.e. the variance of their conditional expectation). We are particularly interested in the information content of prices, which is given by the predicted variance of cash flows using market prices as the conditioning variable. Our price informativeness measure is its square root.

---

[1]Using numbers from French (2008), spending on price discovery has risen from 0.3% to 1% of GDP since 1980.

We construct time series of price informativeness from yearly cross-sectional regressions of future earnings on current stock market valuation ratios (we also include current earnings and sector controls). We focus on the one-, three-, and five-year forecasting horizons and on S&P 500 firms whose stable characteristics allow for a fairly clean comparison over time. We show that price informativeness is increasing with horizon, consistent with prices capturing differences in growth rates between firms. Moreover, current earnings are already a good predictor of next year's earnings, making prices more useful at longer horizon. From a capital allocation perspective, the longer horizons are particularly important since the time-to-build literature suggests that investment plans take over a year to implement, with the cash flows materializing farther down the road.

Our key result is that price informativeness has increased substantially at the three- and five-year horizons. The upward trend is steady throughout the fifty-year sample and its cumulative effect is economically significant: price informativeness is about 60% higher in 2010 than 1960 at the three-year horizon and 80% higher at the five-year horizon. The increase is highly statistically significant. Price informativeness at the one-year horizon, which is smaller to begin with, shows a modest cumulative increase.

The increase in price informativeness is not explained by changes in return predictability. Since valuations are driven by either cash flows or expected returns (Campbell and Shiller 1988), a decrease in cross-sectional return predictability (e.g. a drop in the value premium) could make price informativeness rise even if information production does not. We find that this is not the case by putting returns on the left side of our forecasting regressions, which shows that the predictable component of returns remains stable.[2]

Theory suggests that the information contained in market prices for future earnings should also be reflected in investment decisions. We therefore look at the predicted variance of investment based on market prices. We find that market prices have become stronger predictors

---

[2]For completeness, we also calculate price informativeness for firms beyond the S&P 500. We stress, however, that the composition of this sample has changed dramatically over the years (see Fama and French 2004), making this comparison potentially misleading. This is readily apparent from trends in observable characteristics such as idiosyncratic volatility and earnings dispersion (measures of uncertainty), which have risen drastically. By contrast, these characteristics are remarkably stable for S&P 500 firms. Likely as a result of the compositional shift, price informativeness for firms beyond the S&P 500 appears to decline. Interestingly, the decline is concentrated at the short horizon so again there is relative improvement at the long end. Above all, we view these results as motivating our focus on S&P 500 firms.

of investment as measured by R&D spending (though not CAPX). Thus, when it comes to real decisions like R&D, for which market information is arguably particularly useful, the information content of prices has also increased.

It is important to note that more informative prices do not necessarily imply that financial markets have generated an improvement in welfare. Market prices contain information produced independently by investors, as well as information disclosed by the firm. It is mainly the independent, market-produced component of price informativeness that contributes to the efficiency of capital allocation. Bond, Edmans, and Goldstein (2012) call this component "revelatory price efficiency" (RPE), in contrast to "forecasting price efficiency" (FPE) which also includes information already known to decision makers inside the firm.

Although separating FPE and RPE is challenging, we can use our theoretical framework to guide our analysis. In our framework, managers have access to internal information, some of which they disclose to the market. Investors combine this disclosure with their own independent information to trade, and this causes prices to incorporate both types of information (FPE). Managers then filter out as much of the independent information contained in prices as they can (RPE) and combine it with their own internal information to set investment optimally (aggregate efficiency). The rich two-way feedback between firms and markets in our framework ensures that the predictions we formulate and test are robust to a wide range of models proposed in the literature.

Our framework shows that it is possible to distinguish an increase in market-produced information (RPE) from a pure increase in firm disclosure by looking at aggregate efficiency, the predicted variation of future cash flows based on the manager's full information set. All else equal, an increase in disclosure causes aggregate efficiency to remain the same even as price informativeness (FPE) rises. Although the manager's information set is not observed, it gets reflected in her investment decisions. Specifically, we show that we can bound aggregate efficiency from below by the predicted variation of future cash flows from investment and from above by the cross-sectional dispersion of investment, both of which are increasing in the amount of information the manager has. Measuring investment as either R&D alone or R&D and CAPX together, we find evidence that the predicted variation of earnings from investment has increased. We also find that the cross-sectional dispersion of R&D has increased. This

4

suggests that aggregate efficiency has increased. Combined with the observed rise in price informativeness (FPE), the increase in aggregate efficiency supports the interpretation that market-based information production (RPE), and not just disclosure, has increased.

While we are thus able to rule out a rise in disclosure as the sole explanation for the rise in price informativeness, a more subtle explanation remains: it could be that information production inside firms and disclosure have both increased. The former would explain the rise in aggregate efficiency while the latter would explain the rise in price informativeness. Teasing out this more complicated explanation is challenging and it requires additional predictions we can test. We construct and test four such predictions that exploit cross-sectional differences between firms. While none of our tests is perfect, we find that the overall evidence supports the interpretation that market-based information production (RPE) has increased.

Our first cross-sectional prediction is that market-based information production should be higher for firms with high institutional ownership. Institutional investors have come to dominate financial markets, their stake in the average firm rising from 20% in 1980 to 60% in 2014. Given their professional expertise, we expect them to have a large impact on market-based information production. In our test, we compare firms with institutional ownership above and below the median, going beyond the S&P 500 to obtain greater cross-sectional variation. Interestingly, dispersion has increased so that the gap in institutional ownership between the two groups has widened. We find that price informativeness is both higher and has increased more for the group with high and increasing institutional ownership. This result is consistent with the RPE view that information production in markets has increased.

In our second cross-sectional test, we compare the price informativeness of stocks with and without option listings and stocks with high and low levels of options trading. The CBOE began listing options in 1973 and has been adding new listings in a staggered manner. Our test is based on the idea that options provide traders with leverage, the ability to hedge, and a low-cost way to sell short, all of which increase the incentive and scope for market-based information production. We find that price informativeness has increased more for CBOE-listed firms than for non-listed firms and that price informativeness is higher for firms with higher levels of option turnover. These findings are also consistent with the RPE view.

In our third test, we compare firms with high and low levels of liquidity as proxied by

share turnover. The idea is that greater liquidity facilitates the incorporation of private information into prices. It also increases the incentives of market participants to produce such information. Consistent with this idea, we find that stocks with higher turnover have higher price informativeness. Since liquidity in general and turnover in particular have increased strongly over the past five decades, this finding helps to explain the observed rise in overall price informativeness and supports the view that RPE has increased.

For our final cross-sectional test, we enrich our model with cross-sectional differences between firms. Specifically, we incorporate the natural feature that a firm's cash flows from growth options may not be perfectly correlated with its cash flows from assets in place. The idea is that firm insiders hold an advantage in producing information about assets in place, after all they are the ones who put them there. Valuing growth options, on the other hand, requires making comparisons to other firms and analyzing market trends, and here the market may have the advantage or at least less of a disadvantage. Based on this reasoning, if market-based information has increased we would expect price informativeness to increase more for firms with a lot of growth options (growth firms), whereas if internal information and disclosure have increased we would expect greater improvement among firms with fewer growth options (i.e. value firms). Consistent with the market-based RPE view, we find that price informativeness has risen much more for growth firms than for value firms. This result is interesting from a broader perspective as it indicates that the increase in price informativeness is concentrated among hard-to-value firms where it is most needed.

The rest of this paper proceeds as follows: Section 1 reviews the literature, Section 2 derives our informativeness measure, Section 3 describes the data, Section 4 presents results, and Section 5 concludes.

1   Related literature

Levine (2005) categorizes the economic role of the financial sector into five channels: (1) information production about investment opportunities and allocation of capital; (2) mobilization and pooling of household savings; (3) monitoring of investments and performance; (4) financing of trade and consumption; and (5) provision of liquidity, facilitation of secondary market

trading, diversification, and risk management. Our focus is on documenting (1) empirically.

The information production role of financial markets is part of a classic literature in economics going back at least to Schumpeter (1912) and Hayek (1945). Greenwood and Jovanovic (1990) and King and Levine (1993b) provide endogenous growth models in which information production in financial markets enables efficient investment. We derive a welfare-based measure of price informativeness that is in the spirit of this literature, one that can be easily taken to the data.

The empirical literature on finance and growth largely relies on cross-country comparisons. Examples include King and Levine (1993a), Rajan and Zingales (1998), Morck, Yeung, and Yu (2000), and Bekaert, Harvey, and Lundblad (2001). Our novel methodology exploits firm-level variation, which allows us to examine the information production channel within a single country, in our case the U.S., over time.

The U.S. time series represents a particularly important setting because over the last few decades the U.S. financial sector has grown six times faster than GDP (Philippon 2015). At its peak in 2006, it contributed 8.3% to U.S. GDP compared to 2.8% in 1950 (see Philippon, 2015, and Greenwood and Scharfstein, 2012, for in-depth discussions). Finance has also drawn in a large share of human capital (Philippon and Reshef 2012). The question arises whether these changes have led to an increase in economic efficiency. While it is difficult to discern such a relationship in aggregate U.S. data, we provide a partial answer to this question by using cross-sectional data to examine the informativeness of financial market prices.

The answer is by no means clear a priori. The dot-com bust of 2000 and the financial crisis of 2008 have called the benefits of financial development into question (e.g. Zingales 2015). Prices can be distorted due to behavioral biases (e.g. Hong and Stein 1999; Shiller 2000), or incentives (e.g. Rajan 2005). Gennaioli, Shleifer, and Vishny (2012) argue that financial innovation can increase fragility. Bolton, Santos, and Scheinkman (2011) provide a model in which rents in the financial sector attract an excessive share of the economy's human capital. Philippon and Reshef (2012) document a potentially distorting wage premium in the financial sector and Philippon (2015) finds that the unit cost of financial intermediation has remained relatively high in recent decades. Quantifying information production as we do in this paper contributes to this important effort of measuring value added in the financial sector.

A large theoretical literature with seminal papers by Grossman and Stiglitz (1980), Glosten and Milgrom (1985), Kyle (1985), and Holmström and Tirole (1993) studies the incentives of traders to produce information. As financial technology develops and the cost of producing information shrinks, the information content of prices increases. The information revolution and the growth of financial markets suggest that the premise of this proposition is in place. Our contribution is to assess its implication.

Bond, Edmans, and Goldstein (2012) survey the literature on information production in financial markets, emphasizing the challenge of separating the genuinely new information produced in markets, which they call revelatory price efficiency (RPE), from what is already known and merely reflected in prices which they call forecasting price efficiency (FPE). This distinction can be traced back to Hirshleifer (1971) and Tobin (1984). We follow this conceptual framework and seek to disentangle RPE and FPE by measuring the efficiency of investment and by comparing groups of firms where RPE or FPE is expected to prevail.

Recent theoretical work on asset prices and real efficiency includes Dow and Gorton (1997), Subrahmanyam and Titman (1999), Goldstein and Guembel (2008), Ozdenoren and Yuan (2008), Bond, Goldstein, and Prescott (2010), Goldstein, Ozdenoren, and Yuan (2013), Kurlat and Veldkamp (2015), and Edmans, Goldstein, and Jiang (2015). While these papers share the basic feedback from market prices to investment that is the subject of our paper, each focuses on a particular form of more advanced feedback such as that from investment to market prices. In Section 2, we use our theoretical framework to discuss these papers in some detail, and we derive the predictions we test based on their common features.

On the empirical side, Chen, Goldstein, and Jiang (2007) and Bakke and Whited (2010) find that the relationship between stock prices and investment is stronger for firms with more informative stock prices, whereas Baker, Stein, and Wurgler (2003) find that it is stronger for firms that issue equity more often. Turley (2012) exploits a regulatory change to show that lower transaction costs increase short-term (one to three month) stock price informativeness. Our contribution here is to examine the evolution of price informativeness over a long period of time characterized by unprecedented growth in the financial sector.

The most common measure of informativeness is price non-synchronicity (Roll 1988), which is based on the correlation between a firm's return and a market or industry benchmark (a

high correlation is interpreted as lower informativeness). Papers that adopt this measure include Morck, Yeung, and Yu (2000), Durnev, Morck, Yeung, and Zarowin (2003), and Chen, Goldstein, and Jiang (2007). Durnev, Morck, Yeung, and Zarowin (2003) show that price non-synchronicity is positively related to the correlation between returns and future earnings at the industry level, which helps to validate it as a measure of informativeness. A second popular measure comes from the microstructure literature: the probability of informed trading or PIN (Easley, Kiefer, O'Hara, and Paperman 1996), which is based on order flow. Our contribution here is to derive a welfare-based measure which quantifies the information contained in prices for real outcomes and is easily computed from widely available data.

Our paper is also related to the accounting literature on disclosure (see surveys by Healy and Palepu (2001) and Beyer, Cohen, Lys, and Walther (2010)). Our sample includes some significant changes in disclosure requirements, most prominently Regulation Fair Disclosure in 2000 and Sarbanes-Oxley in 2002. Considerable debate remains regarding the effects of these reforms; even their sign is unsettled.[3] We find no evidence of structural breaks in informativeness around their passage. In addition, our result that aggregate efficiency has increased makes it unlikely that changes in disclosure alone can explain the observed rise in price informativeness.

A second related strand of the accounting literature studies value relevance, the impact of accounting metrics on market values (see e.g. Holthausen and Watts (2001) and Dechow, Zha, and Sloan (2014)). This literature establishes both that earnings information drives returns and that returns do not always fully incorporate earnings information. This is one reason why we include current earnings as a control in our forecasting regressions. There is also evidence that the value relevance of earnings has actually declined over our sample (Collins, Maydew, and Weiss 1997), which would bias our results downward. We show that our main result holds under a variety of accounting metrics, including different measures of earnings and operating cash flows. The broader difference between this literature and our paper is that we measure the extent to which market values predict—as opposed to react to—accounting

---

[3]Heflin, Subramanyam, and Zhang (2003) find no evidence of increased earnings surprises in returns after Reg. FD, suggesting that the information available to market participants was not reduced. On the other hand, Wang (2007) reports that firms cut back on issuing earnings guidance reports after Reg. FD. Yet Bushee, Matsumoto, and Miller (2004) provide evidence that disclosure remained constant or even increased after Reg. FD.

metrics, specifically earnings and investment.

In sum, our paper lies at the intersection of the finance-and-growth literature and the literature on information production in financial markets. Its underlying premise is that measuring price informativeness over time helps to assess the economic value of a growing financial sector.

2 Theoretical framework and discussion

We present a theoretical framework with two goals in mind. The first is to derive a welfare-based measure of price informativeness that we can use in our empirical analysis. The second is to formulate testable predictions that we can use to interpret our results. We also discuss these predictions in the context of the existing literature.

Our framework has two essential components: a q-theory/aggregate efficiency block and an information environment block.

Q-theory and aggregate efficiency: Consider a firm with ex-post fundamental value as in standard q-theory following Hayashi (1982):

$$v\left(z, k\right) \;\; = \;\; \left(1 + z\right)\left(\overline{k} + k\right) - k - \frac{\gamma}{2\overline{k}}k^2, \tag{1}$$

where $\overline{k}$ represents assets in place, k is investment in new capital, z is a productivity shock, and γ is an adjustment cost parameter.

Investment is chosen to maximize firm value under the *manager's* (more generally, the decision maker's) information set $\mathcal{I}_m$: $k^\star = \text{argmax}_k \, \mathbb{E}\left[v\left(z, k\right) | \mathcal{I}_m\right]$. We have normalized the discount rate to zero for simplicity (we address discount rates in Section 4.3). This leads to the well-known q-theory investment equation

$$\gamma \frac{k^\star}{\overline{k}} \;\; = \;\; \mathbb{E}\left[z \mid \mathcal{I}_m\right]. \tag{2}$$

The investment rate $k^\star/\overline{k}$ is proportional to the conditional expectation of net productivity z

given the manager's information set. The maximized ex-post firm value is then

$$\frac{v\left(z,k^\star\right)}{\overline{k}} \quad = \quad 1 + z + \frac{z}{\gamma}\mathbb{E}\left[z|\,\mathcal{I}_m\right] - \frac{1}{2\gamma}\mathbb{E}\left[z|\,\mathcal{I}_m\right]^2. \tag{3}$$

We can also write the expected firm value conditional on investment and the information available to the manager as

$$\mathbb{E}\left[\left.\frac{v\left(z,k^\star\right)}{\overline{k}}\right|\mathcal{I}_m\right] = 1 + \mathbb{E}\left[z|\,\mathcal{I}_m\right] + \frac{1}{2\gamma}\left(\mathbb{E}\left[z\mid\mathcal{I}_m\right]\right)^2. \tag{4}$$

We are interested in the efficiency of capital allocation across firms, so we consider a large number of ex-ante identical firms (same $\overline{k}$) that draw different signals about z. We normalize z to have mean of zero across these firms. Aggregate efficiency is then defined by the ex-ante (or cross-sectional average) firm value

$$\mathbb{E}\left[v\left(z,k^\star\right)\right] \quad = \quad \overline{k} + \frac{\overline{k}}{2\gamma}\mathbb{V}\mathrm{ar}\left(\mathbb{E}\left[z|\,\mathcal{I}_m\right]\right). \tag{5}$$

Aggregate efficiency is a function of the variance of the forecastable component of net productivity z. This is the first key theoretical point that we use in our empirical analysis. The next step is to think about how $\mathcal{I}_m$ is determined in equilibrium.

Information environment: In practice, managers have access to information produced inside the firm, as well as to outside information contained in market prices. We summarize the internal information with the signal

$$\eta \quad = \quad z + \epsilon_\eta, \tag{6}$$

where $\epsilon_\eta \sim N\left(0,\sigma_\eta^2\right)$. The price-based information is contained in the price p of a security linked to the firm's payoff. This information contained in p is itself derived from the private information of informed traders in the market for this security. We summarize the information of these informed traders with the signal

$$s \quad = \quad z + \epsilon_s, \tag{7}$$

11

where $\epsilon_s \sim N(0, \sigma_s^2)$. We assume that ϵ_η and ϵ_s are independent, so we can think of η and s as the two fundamental sources of information that society can use to improve efficiency.

In practice market participants and managers also share common sources of information other than prices, most prominently through disclosure. To take this into account, we assume that traders observe an additional signal coming from the manager:

$$\eta' = \eta + \epsilon_{\eta'}, \tag{8}$$

where $\epsilon_{\eta'} \sim N\left(0, \sigma_{\eta'}^2\right)$ is orthogonal to ϵ_η and ϵ_s. The disclosure signal η' captures the flow of information from the firm to the market, which runs in the opposite direction of the flow of information from the market to the firm in the form of the price p. To summarize, the information set of the manager is $\mathcal{I}_m = \{\eta, \eta', p\}$ and the information set of informed traders is $\mathcal{I}_\tau = \{\eta', s\}$.

Feedback and equilibrium: A full-fledged model needs to specify the objectives of the traders (e.g. CARA or mean variance preferences, constraints, etc.) as well as a trading protocol (e.g. competitive or strategic, with or without market makers, etc.). We present one such model in Appendix A, but for the purpose of this discussion it is more important to focus on the key features shared by nearly all models.

We must first specify exactly which security is traded in financial markets. Recall that v is the total value of the firm. In practice, it can be the case that equity is publicly traded but debt it not, or perhaps that the traded security is an option or a credit derivative. So let us define $\mathcal{F}(z, k)$ as the payoff of the claim that is traded in financial markets. An important particular case is of course $\mathcal{F}(z, k) = v(z, k)$ with $v(\cdot)$ as in equation (3). Since the informed traders' information set consists of η' and s, the equilibrium price typically takes the form

$$p = \alpha\mathbb{E}\left[\mathcal{F}(z, k^\star)|\,\eta', s\right] + \beta u, \tag{9}$$

where u is noise trading demand, and α and β are endogenous coefficients that are part of the rational expectations equilibrium. Exactly how to solve for these coefficients, and whether we actually obtain a linear price function depends on the details of the model. The more

tractable models, including our appendix model, result in pricing functions of the form in (9).

Equilibrium and basic feedback: To summarize, most models in the literature boil down to two equations which we restate for convenience:

$$k^\star = \frac{\overline{k}}{\gamma} \mathbb{E}\left[z|\,\eta, \eta', p\right] \tag{10}$$

$$p = \alpha\mathbb{E}\left[\mathcal{F}\left(z, k^\star\right)|\,\eta', s\right] + \beta u. \tag{11}$$

The basic feedback is that managers learn from prices and so $k^\star$ depends on p. It implies that the informativeness of prices matters for firm value, aggregate efficiency, and welfare. This feature, which is the most important one for our analysis, is common to all models we discuss below, even though they differ in the complexity of the other interactions between value and prices.

Advanced feedback: The more advanced feedback channels depend on the nature of the traded claim and on the trading protocol. For instance, Subrahmanyam and Titman (1999) make the simplifying assumption $\mathcal{F}\left(z, k^\star\right) = z$ to ensure linearity of the conditional expectations. In that case the pricing equation (11) does not depend on the mapping $k^\star$ in (10) and the model remains linear and tractable. Our model in Appendix A adopts this approach and discusses its implications. It can be interpreted as a linear approximation to a more complex model when $k^\star/\overline{k}$ is not too large as is the case in the data.

Other papers (e.g. Goldstein, Ozdenoren, and Yuan 2013) use the more complex but also richer case $\mathcal{F} = v$. In that case, p can be interpreted as the market value of the firm. Firm value is a nonlinear function of z and $k^\star$, so finding p involves solving a complex fixed-point problem. The traders need to form beliefs about the function $k^\star$, i.e. about how the manager uses prices to decide on investment. Traders then use these beliefs to forecast total firm value and this determines the equilibrium price. Dow and Gorton (1997) show that this can lead to multiple equilibria.[4] In one equilibrium managers invest based on prices and this gives traders

---

[4]In their model managers are clueless, $\sigma_\eta^2 = \infty$, and returns on assets in place are independent of z, which is indeed precisely the opposite assumption from Subrahmanyam and Titman (1999). Ozdenoren and Yuan (2008) work with another tractable alternative, $\mathcal{F} = k^\star + z$, similarly assuming $\sigma_\eta^2 = \infty$. In Bond, Goldstein, and Prescott (2010), $\sigma_\eta^2 < \infty$ but $\sigma_s^2 = 0$ so traders have perfect information.

an incentive to gather information. In the other equilibrium prices are not informative and managers do not invest. Goldstein and Guembel (2008) show that the basic feedback can give incentives to a large uninformed speculator to manipulate the stock price by short-selling the stock, inducing inefficient disinvestment, reducing firm value, and thereby making the short-selling strategy profitable. Conversely, Edmans, Goldstein, and Jiang (2015) emphasize the strategic behavior of a large informed trader who knows that whatever information she reveals will be used to increase firm value. This leads to asymmetric revelation of good and bad news. These effects rely on the basic feedback and on the strategic behavior of large traders who understand that they influence prices.

Empirical predictions: The framework outlined above offers a precise overview of the existing literature. Our next task is to formulate specific predictions that we can test empirically.

We begin by quantifying price informativeness, i.e. the forecasting power of prices for future cash flows, which Bond, Edmans, and Goldstein (2012) call forecasting price efficiency (FPE). We scale by $\overline{k}$ to allow for meaningful comparisons across firms, and we define a firm's market to book ratio $q = p/\overline{k}$. FPE is given by the variance of the predictable component of firm value $v/\overline{k}$ given q. From (3), $v/\overline{k}$ has some nonlinear terms in z, but to a first-order approximation $v/\overline{k} \approx 1 + z$, so we will focus on

$$\mathcal{V}_{FPE} \;\equiv\; \mathbb{Var}\left(\mathbb{E}\left[z|\,q\right]\right). \tag{12}$$

FPE measures the total amount of information about future payoffs contained in market prices. At the same time, it is only a forecasting concept. As explained above, aggregate efficiency depends on the information of the manager:

$$\mathcal{V}_M \;\equiv\; \mathbb{Var}\left(\mathbb{E}\left[z|\,\eta,\eta',q\right]\right). \tag{13}$$

We are interested in the part of $\mathcal{V}_M$ that comes from market prices. This is what Bond, Edmans, and Goldstein (2012) call revelatory price efficiency (RPE). It is given by

$$\mathcal{V}_{RPE} \;\equiv\; \mathbb{Var}\left(\mathbb{E}\left[z|\,\eta,\eta',q\right]\right) - \mathbb{Var}\left(\mathbb{E}\left[z|\,\eta,\eta'\right]\right). \tag{14}$$

RPE measures the extent to which prices improve real allocations. When prices are uninformative or when managers already know the information they contain, RPE is low. On the other hand, when prices provide managers with information that is useful for improving the efficiency of investment, RPE is high. This is the core idea of Hayek (1945).

Each of the theoretical models discussed above gives an explicit mapping from the fundamental information structure $(\sigma_s^2,\ \sigma_\eta^2,\ \sigma_{\eta'}^2)$ into the objects of interest, $\mathcal{V}_{FPE}$ and $\mathcal{V}_{RPE}$. We cannot do justice to all the subtle predictions based on advanced feedback, but we can focus on the predictions that are robust across models. In particular, we test the following:

Prediction 1. *All else equal,*

  (i) *a decrease in σ_s^2 (traders produce more information) increases $\mathcal{V}_{FPE}$, $\mathcal{V}_{RPE}$ and $\mathcal{V}_M$.*

  (ii) *a decrease in σ_η^2 (firms produce more information) increases $\mathcal{V}_{FPE}$ and $\mathcal{V}_M$ but not $\mathcal{V}_{RPE}$.*

  (iii) *a decrease in $\sigma_{\eta'}^2$ (firms disclose more information) increases $\mathcal{V}_{FPE}$ but neither $\mathcal{V}_M$ nor $\mathcal{V}_{RPE}$.*

When traders produce more information (their signal s becomes less noisy), prices become more informative and so FPE goes up. RPE also goes up because the additional information in prices is new to managers. As managers use this information, aggregate efficiency increases. Aggregate efficiency also increases when managers produce more information (η becomes less noisy), and this again causes FPE to go up through disclosure. However, in this case prices are merely reflecting information already available managers and so RPE does not rise. Finally, an improvement in disclosure (η' becomes less noisy) leaves aggregate efficiency and RPE unchanged because it does not affect the amount of information available to managers. It, does, however, raise FPE because the additional disclosure gets reflected in prices.

Prediction 1 allows us to interpret an observed trend in FPE as coming from internal information, from market participants, or from disclosure by looking for parallel trends in aggregate efficiency. For instance, an increase in $\mathcal{V}_{FPE}$ and $\mathcal{V}_M$ rules out a pure disclosure explanation (part (iii)). Separating parts (i) and (ii) then requires additional testable predictions. We construct such predictions by enriching the model with cross-sectional differences across firms after we have established the basic trends in FPE.

Our empirical analysis centers on Prediction 1. As we noted, this prediction is common throughout the literature. To motivate it further, we derive Prediction 1 formally in the model we present in Appendix A.

3 Data and summary statistics

We now describe the main aspects of our data and how we construct our sample.

Data sources: Our main sample is annual from 1960 to 2014. We obtain stock prices from CRSP. All accounting variables are from Compustat. Institutional ownership is from 13-F filings provided by Thomson Reuters. The test on option listings uses listing dates from the CBOE (available after 1973 when single-name option trading began) and the test on option turnover uses option volume data from OptionMetrics (available after 1996). The GDP deflator used to adjust for inflation is from the Bureau of Economic Analysis.

We take stock prices as of the end of March and accounting variables as of the end of the previous fiscal year, typically December. This timing convention ensures that market participants have access to the accounting variables that we use as controls.

Sample selection: For most of the paper we limit attention to S&P 500 non-financial firms. These firms represent the bulk of the value of the U.S. corporate sector. As we show, their characteristics have remained remarkably stable, which makes them comparable over time. This is in contrast to the broader universe of all firms, whose characteristics have changed drastically. We report results for these firms in the appendix and summarize them in the text.

Measures: Our main equity valuation measure is the log-ratio of market capitalization M to total assets A, $\log M/A$.[5] Our main cash flow variable is earnings measured as EBIT. In Appendix B we show that our main results are robust to using alternative measures such as EBITDA, net income, and cash flows from operations (CFO). We focus on EBIT because it is most widely available in Compustat and because it is the focus of analyst research. For

---

[5]The correct functional form is whichever one managers use to extract information from prices. With identical firms and normal shocks one could use q, the ratio of the market price to existing assets (see Section 2). In practice, we find that taking logs works slightly better because it mitigates skewness in the data.

investment we use both research and development (R&D) and capital expenditure (CAPX). We scale both current and future cash flows and investment by current total assets. For instance, in a forecasting regression for earnings with horizon h years, the left-side variable is E_{t+h}/A_t. This specification is implied by our framework (see Section 2; we are predicting $v/\overline{k} \approx 1 + z$). In particular, it incorporates growth between t and $t + h$. Unlike prices, we do not take logs because it is the level of cash flows that matters for aggregate efficiency.

Correcting for delisting: We must account for firm delisting to ensure that our forecasting regressions are free of survivorship bias.[6] We do so as follows: When a firm is delisted, we invest the delisting proceeds (calculated using the delisting price and dividend) in a portfolio of firms in the same two-digit SIC industry. We use the earnings accruing to this portfolio to fill in the earnings of the delisted firm. We do the same for investment.

Adjusting for inflation: We adjust for inflation with the GDP deflator. This is necessary because it is real price informativeness that matters for welfare. Since inflation is multiplicative, differences in future nominal cash flows between firms are larger than differences in real cash flows. This biases the forecasting coefficient up during high-inflation periods like the 1970s.[7]

Summary statistics: Table I presents summary statistics for our main sample of S&P 500 firms. The first set of columns covers the full period from 1960 to 2014, whereas the second and third sets cover its first and second half. They show that firms have become larger and their profits have grown with the economy. Yet profitability (earnings over assets) is stable both in terms of levels and cross-sectional dispersion. This is true of current as well as future profitability (measured against current assets), our key left-side variables. Market valuations, our key right-side variable, have risen with the overall market but their cross-sectional dispersion is

---

[6]Survivorship bias would arise if the relationship between market valuations and future earnings is different among firms that are delisted (their future earnings and investment appear as missing in our sample) than among firms that are not delisted. Since our focus is on trends, it is changes in delisting rates that are of concern. In our sample of S&P 500 firms, the delisting rate is slightly higher (3.2% per year) in the second half of the sample than in the first half (2.3%). This is because most delistings occur when a firm is acquired, so delisting tracks the merger waves of the 1980s and 1990s.

[7]In the first circulated draft of the paper (dated December 2013) we incorrectly inferred that price informativeness had remained stable. This was due to the combined effect of three differences in methodology. First, we did not adjust for inflation. This led price informativeness to be overstated in the high-inflation years of the 1970s and early 1980s. Second, we did not correct for delistings, which have increased somewhat in the latter part of our sample. And third, we did not consider the long five-year horizon.

only slightly higher. Investment has shifted a bit from CAPX to R&D and R&D has become more right-skewed, but overall investment rates are stable.

Figure 1 depicts the cross-sectional distribution of several characteristics over time by plotting their median (red line) and their 10th to 90th percentile range (gray shading) in a given year. The top two panels confirm that the distributions of the valuation ratio $\log M/A$ and profitability E/A have remained stable, and the bottom two panels confirm that R&D has become more right-skewed and CAPX has declined in importance.

While the underlying characteristics of these firms have changed little, their trading environment has changed drastically. As Table I shows, share turnover has increased five-fold, institutional ownership has risen by about half, and a large majority of firms now have their options trading on the CBOE in significant volume. These changes reflect the broader transformation in financial markets that serves as the backdrop for our investigation of price informativeness. We return to them in Sections 4.5 to 4.7 below.

The stability among S&P 500 firms stands in sharp contrast to the broader sample of all firms, whose characteristics are presented in Table A.IV and discussed in Appendix C. Among all firms profitability has both fallen and become much more disperse. Consistent with Campbell, Lettau, Malkiel, and Xu (2001), median idiosyncratic volatility has increased from 9.8% to 12.3% per month (for S&P 500 firms the change is negligible from 6.4% to 6.8%). Fama and French (2004) show that these changes are related to the listing of smaller and younger firms and to the emergence of NASDAQ. Besides being more uncertain, these firms are arguably also harder to value since many lack a consistent earnings record. These compositional changes imply that the sample of firms outside the S&P 500 is not comparable over time. We present results for these firms in Appendix C for completeness.

4 Empirical results

Estimation: We construct our measure of price informativeness (FPE) by running cross-sectional regressions of future earnings on current market prices. We include current earnings and industry sector as controls to avoid crediting markets with obvious public information.

Specifically, in each year $t = 1960, \ldots, 2014$ and at every horizon $h = 1, \ldots, 5$, we run

$$\frac{E_{i,t+h}}{A_{i,t}} \quad = \quad a_{t,h} + b_{t,h} \log\left(\frac{M_{i,t}}{A_{i,t}}\right) + c_{t,h}\left(\frac{E_{i,t}}{A_{i,t}}\right) + d_{t,h}^s \mathbf{1}_{i,t}^s + \epsilon_{i,t,h}, \qquad (15)$$

where i is a firm index and $\mathbf{1}^s$ is a sector (one-digit SIC code) indicator. Table A.I discussed in Appendix B provides an example from 2009. These regressions give us a set of coefficients indexed by year t and horizon h.

From Section 2, price informativeness $\mathcal{V}_{FPE}$ is the predicted variance of future cash flows from market prices (equation (12)). We compute it here with the minor change of taking a square root, which gives meaningful units (dollars of future cash flows per dollar of current total assets). From regression (15), price informativeness in year t at horizon h is the forecasting coefficient $b_{t,h}$ multiplied by $\sigma_t(\log(M/A))$, the cross-sectional standard deviation of the forecasting variable $\log M/A$ in year t:

$$\left(\sqrt{\mathcal{V}_{FPE}}\right)_{t,h} \quad = \quad b_{t,h} \times \sigma_t(\log(M/A)). \qquad (16)$$

We are interested in how this measure has evolved over time.

Price informativeness by horizon: Figure 2 gives a first look by plotting average price informativeness by horizon and sub-period. We cap the horizon at five years to ensure that we have enough data to produce reliable estimates. The range between one and five years also covers the time span over which information can plausibly affect investment and investment can produce cash flows. For instance, the time-to-build literature finds that investment plans take about two years to implement with cash flows following in the years after that (Koeva 2000). From a capital allocation perspective, it is therefore the medium and long horizons we look at that are especially important.

The red line in Figure 2 plots price informativeness at each horizon averaged over the full length of the sample (from 1960 to 2014). As expected, informativeness is positive; market prices are positive predictors of future earnings. Informativeness is also increasing with horizon. The reason is that while current earnings are already a good predictor of

earnings one year fro now, prices are useful for predicting earnings farther out.[8] This provides further motivation for focusing on the longer horizons as we do.

The dashed black and dash-dotted blue lines in Figure 2 plot average price informativeness for the first and second half of our sample. Informativeness is higher in the later half at every horizon. The increase is itself increasing with horizon: one-year informativeness is only slightly higher while three- and five-year informativeness show a much larger increase (we look closely at the magnitude and significance of these increases in the next section). From here on, for conciseness we focus on horizons of one, three, and five years ($h = 1, 3, 5$).

4.1 Price informativeness over time

Figure 3 plots the time series of our estimates. Each panel holds horizon fixed and looks across time, ending in 2010 because the last years for which we have three- and five-year estimates are 2009 and 2011, respectively (recall our sample ends in 2014). The two left panels show the forecasting coefficients $b_{t,h}$ from regressions (15), the two middle panels show price informativeness $b_{t,h} \times \sigma_t (\log M/A)$ from (16), and the two right panels show the marginal contribution of market prices to the regression R^2, which measures the fraction of the ex post variation in future earnings that market prices capture. Above the panels are the fitted equations for linear time trends for the three- and five-year horizon estimates. The time trends are normalized so that the intercept measures the value of a given series in 1960 and the slope measures its cumulative change over the full sample period. Adjacent are p-values for the trend coefficients based on Newey-West standard errors with five lags to account for potential autocorrelation.[9]

We begin by noting that the coefficients, informativeness, and marginal R^2 series are always positive, indicating that market prices are consistently positive predictors of future earnings.

---

[8]Formally, Figure A.1 in the appendix shows that while the forecasting coefficient on prices $b_{t,h}$ is increasing with horizon, the forecasting coefficient on current earnings $c_{t,h}$ is decreasing with horizon (see Appendix B for details). Thus, current earnings are relatively more informative at short horizons and prices are relatively more informative at long horizons.

[9]Our choice of lag is based on two considerations. The first is that our estimates come from overlapping regressions, which can induce autocorrelation (for instance our five-year estimate for 1960 uses data from 1960 to 1965, that for 1961 uses data from 1961 to 1966, and so on). The longest overlap is from the five-year horizon, and this is why we use a lag of five (for consistency we apply the same lag at all horizons). The second consideration is that the optimal lag selection procedure of Newey and West (1994) implies an optimal lag of between four and five. Our results are robust to alternative choices.

All series are typically higher at the longer horizons, consistent with what we saw in Figure 2. We note a drop in the three-year series at the end of the NASDAQ boom in 2000 when many high-valuation firms turned out to have low earnings ex post, but this drop is short-lived and does not influence the long-run trend.

Our key result is that the coefficients, marginal R^2, and most importantly, the price informativeness series in Figure 3 all show clear upward trends at both the three- and five-year horizons. By contrast, the one-year series show only a mild increase. In terms of magnitudes, three-year price informativeness is about 60% higher in 2010 than in 1960, and the increase is highly statistically significant. Five-year informativeness is about 80% higher, also highly significant. Although the estimates can be noisy from year to year, the upward trend is steady throughout the five decades of our sample.[10] These results show that the extent to which market prices can be used to distinguish firms that will deliver high earnings in the future from those that will not has increased over the past five decades.

For a more detailed look, we run regressions of price informativeness at each horizon on a set of indicator variables, one for each decade in our sample:

$$\left(\widehat{\sqrt{\mathcal{V}_{FPE}}} \right)_{t,h} = a_h + \sum_d b_{d,h} \times \mathbf{1}_t^d + \epsilon_{t,h}, \quad d = 1970\text{--}79, \dots, 2010\text{--}14 \qquad (17)$$

The baseline, omitted decade is 1960–69 and it is absorbed by the constant a_h. Each coefficient $b_{d,h}$ thus measures the difference in means between decade d and the 1960s. As before, we compute Newey-West standard errors with five lags.

The first three columns of Table II present the results. Overall, they confirm the pattern in Figure 3. The intercepts are positive, significant, and increasing with horizon. At the one-year horizon $(h = 1)$, the coefficients on the decade dummy variables tend to be small, never larger than a quarter of the intercept, and often insignificant. Thus, one-year informativeness has increased only mildly over the course of our sample. Looking at three- and five-year informativeness $(h = 3$ and $5)$, on the other hand, we see coefficients that are much larger, highly significant, and in some cases over half the size of the intercept, especially in the later

---

[10]Indeed, there is no evidence of structural breaks anywhere in our sample, including the years 2000, 2001, and 2002 when Regulation Fair Disclosure, decimalization, and the Sarbanes-Oxley Act were implemented. We report the results of structural break tests in Table A.III and discuss them in Appendix B.

decades of the sample. For instance, five-year price informativeness is about fifty percent higher in the 2000s than in the 1960s. Since our measure is welfare-based, this represents a substantial increase. Table II thus confirms that the increase in medium- and longer-term price informativeness is both statistically and economically significant.

Alternative baseline: The last three columns of Table II run regression (17) but with 1980–89 as the baseline decade. This allows us to gauge whether changes in price informativeness have accelerated or decelerated in the latter half of the sample. Interestingly, most, though not all, of the increase takes place before 1990. From Figure 3, this is likely due to the dip in informativeness around 2000. The trend is otherwise steady and close to linear.

Table A.II in the appendix shows the full set of differences in means between each pair of decades in the sample. Nearly all differences between two subsequent decades are positive and those between decades that are farther apart are typically significant (see Appendix B).

Robustness: Figure A.2 in the appendix shows that the increase in price informativeness is robust to a number of variations. First, we add debt to the valuation ratio to control for possible leverage effects.[11] Second, we use alternative cash flow measures, specifically EBITDA, net income, and cash flows from operations. All measures show an increase in price informativeness ranging between 25% and 75% at the three-year horizon and 50% and 150% at the five-year horizon. Appendix B provides more details.

Beyond the S&P 500: Figure A.3 and Table A.V with discussion in Appendix C replicate the analysis of this section for the universe of all firms. As we saw in Table A.IV, the composition of these firms has changed dramatically. Likely as a result of these changes, price informativeness beyond the S&P 500 appears to decrease. The decline occurs precisely in the years in which observable characteristics change the most, which is consistent with a composition effect. This is best seen around the rise of NASDAQ in the 1980s, and indeed as Fama and French (2004) show, the observable changes are to a significant degree driven by the growing numbers of NASDAQ stocks. Interestingly, short-horizon informativeness drops much more than long-horizon informativeness, so again there is relative improvement at the long end. We return to this sample in Section 4.5 below when we look at institutional ownership. For now, the important point is that these observations motivate our focus on the S&P 500.

---

[11]We do not adopt this as our main specification because debt is measured at book value not market value.

4.2 Market prices and investment

Having established that price informativeness has increased for comparable firms, a natural follow-up question is whether the greater informativeness extends to real firm decisions. Our framework predicts that as prices become more informative, they should also predict investment more strongly. To test this prediction, we calculate the predicted variation of investment from prices. Following the procedure for calculating price informativeness (the predicted variation of earnings from prices), we run our forecasting regressions (15) but with investment on the left instead of earnings. We also add current investment as an additional control. We look at both R&D and CAPX. To be precise, in the case of R&D we run

$$\frac{R\&D_{i,t+h}}{A_{i,t}} = a_{t,h} + b_{t,h} \log\left(\frac{M_{i,t}}{A_{i,t}}\right) + c_{t,h}\left(\frac{E_{i,t}}{A_{i,t}}\right) + d_{t,h}\left(\frac{R\&D_{i,t}}{A_{i,t}}\right) + e^s_{t,h}\mathbf{1}^s_{i,t} + \epsilon_{i,t,h}. (18)$$

Mandatory disclosure of R&D began in 1972 and so we restrict the sample for the R&D regression accordingly (prior to 1972 only about 50 S&P 500 firms report R&D). The predicted variation of investment from prices is then $b_{t,h} \times \sigma_t\left(\log\left(M/A\right)\right)$. The results of this estimation are presented in Figure 4 and Table III.

Figure 4 confirms that prices are positively related to future investment measured as either R&D or CAPX. Looking closely at CAPX first (right two panels), there is no trend in the predicted variation. Table III shows this formally. As we saw in Table I and Figure 1, CAPX has been trending down while R&D has been trending up. Thus, structural forces appear to be leading the importance of CAPX to diminish.

The key result of Figure 4 is that the predicted variation of R&D from prices has increased by a large factor over our sample (left two panels); it is about four times higher in 2010 than in 1960 and the trend is highly significant. Table III confirms this result by computing differences in means relative to the baseline decade 1972–79. The differences are large, significant, and increasing over time. The upward trend here can be seen even at the short one-year horizon. This is predicted by our theory because investment precedes earnings.

Market prices have thus become more informative about real firm decisions such as R&D. This finding is of particular interest because intangible capital is by nature harder to value, making any additional information especially valuable.

4.3 Market prices and returns

Our results so far show that price informativeness has risen. Our next task is to investigate the source of this result. As a first possibility, the increase could be due to a decrease in the cross-sectional predictability of returns. Asset prices are a combination of expected cash flows and expected returns (Campbell and Shiller 1988). A drop in the cross-sectional variation of expected returns could cause the predicted variation of cash flows to rise. In other words, prices could become more informative about cash flows if they become less informative about returns. The cross-sectional variation of expected returns could decline for several reasons: risk prices might fall, the distribution of risk loadings (betas) might become more compressed, or there could be less "noise trading" in the language of models in the literature. The question for us is whether such a decline has occurred at all.

We can test for it by measuring the predicted variation of returns from prices and examining whether it has declined over time. We do so by running our usual forecasting regressions (15) but with returns on the left instead of earnings:

$$\log R_{i,t \to t+h} \quad = \quad a_{t,h} + b_{t,h} \log\left(\frac{M_{i,t}}{A_{i,t}}\right) + c_{t,h}\left(\frac{E_{i,t}}{A_{i,t}}\right) + d_{t,h}^s \mathbf{1}_{i,t}^s + \epsilon_{i,t,h}, \qquad (19)$$

where $\log R_{i,t \to t+h}$ is firm i's log return at horizon h starting in year t. The predicted variation of returns from prices in year t at horizon h is $b_{t,h} \times \sigma_t\left(\log M/A\right)$. The results from this estimation are presented in Figure 5 and Table IV.

As Figure 5 shows, market prices predict returns with a negative sign. This is the well-known value effect: firms with high valuations, i.e. growth firms, tend to have lower average returns (e.g. Fama and French 1992). There are many theories, both rational and behavioral, to explain the value effect. What matters for us is whether the value effect has become weaker over time in a way that could explain the observed increase in price informativeness.

The key result in Figure 5 is that the predicted variation of returns from prices (solid red lines) does not exhibit a trend at any horizon. While the year-to-year estimates are noisy (since returns are volatile), the series are essentially flat at all horizons and the trend estimates are insignificant. For comparison, we have also plotted our price informativeness series (dashed black lines), which climb steadily throughout the sample as we saw in Figure 3.

Table IV looks at the differences in means by decade relative to the 1960s. We see a couple of significant decade-indicator coefficients, but their signs alternate between positive and negative. Thus, we find no evidence of a change in the relationship between prices and expected returns that can account for the observed increase of price informativeness.

4.4 Aggregate efficiency

Our results so far indicate that price informativeness has risen, and that this is driven by greater information about cash flows, not lower return predictability. The next question we ask is where the added information is coming from. As a first step, we want to know whether it is coming from greater information production or simply improved disclosure. For instance, total information may have remained unchanged but the amount of information firms disclose may have increased, perhaps due to more accurate financial reporting. This would make prices more informative (forecasting price efficiency, FPE, would go up) but it would not significantly improve real allocations (revelatory price efficiency, RPE, would remain the same).

We can test the disclosure hypothesis using Prediction 1 of our framework in Section 2. Prediction 1 says that while an increase in disclosure increases price informativeness (FPE), it leaves aggregate efficiency unchanged. This is because aggregate efficiency depends on the information available to the firm's manager, which is unaffected by disclosure. Thus, to test the disclosure hypothesis we need to see if aggregate efficiency has increased with price informativeness. Of course this exercise is of interest more broadly as aggregate efficiency is a key factor in economic growth.

Although aggregate efficiency is not observed, we can use our theoretical framework to bound it between two measurable quantities:

Claim 1. *Aggregate efficiency $\mathcal{V}_M$ is bounded by the predicted variance of cash flows from investment, $\mathbb{V}\mathrm{ar}\left(\mathbb{E}\left[v/\overline{k}\mid k^\star\right]\right)$, and the cross-sectional variance of investment, $\gamma\mathbb{V}\mathrm{ar}\left(k^\star/\overline{k}\right)$:*

$$\mathbb{V}\mathrm{ar}\left(\mathbb{E}\left[\frac{v}{\overline{k}}\middle| k^\star\right]\right) \;\leq\; \mathcal{V}_M \;\leq\; \gamma\mathbb{V}\mathrm{ar}\left(\frac{k^\star}{\overline{k}}\right). \tag{20}$$

The inequality on the right comes from the first-order condition (2). In our framework, since $\gamma k^\star/\overline{k} = \mathbb{E}\left[z \mid \eta, \eta', p\right]$, investment perfectly reveals the information of the manager and

25

we get an equality. In practice, investment is noisy and lumpy and there might be shocks to investment costs that increase the measured variance. In this case we get a strict inequality.

The inequality on the left simply reflects the fact that investment is chosen by the manager, hence it is included in the manager's information set. When the cash flows of assets in place and growth options are perfectly correlated as in (1), investment is an optimal forecast of total cash flows and we get an equality. When this is not the case, investment is an optimal forecast only of cash flows from growth options, and not overall cash flows, and we get a strict inequality (we explore this case in Section 4.8 below).

From Figure 1 and Table I, the cross-sectional dispersion in investment rates has risen in the case of R&D but not CAPX. Yet the average rate of CAPX has fallen (so the dispersion has risen relative to the mean). Thus we are seeing a general decline in importance of CAPX.

By contrast, for R&D we see a dramatic increase in dispersion. The cross-sectional standard deviation of R&D over assets has nearly doubled from 2.8% in the first half of our sample to 5.0% in the second half. From Figure 1, R&D has also become much more skewed: firms in the 90th percentile now spend 10% of assets on R&D each year compared to 5% in the 1960s (the 10th percentile remains close to zero). The increased cross-sectional variation in investment as measured by R&D is consistent with managers having more information and allocating investment accordingly.

From Claim 1, the variation in investment rates represents an upper bound on aggregate efficiency. To calculate the lower bound, we need to measure the predicted variation of earnings from investment. We do this by replacing market prices with investment in our usual forecasting regressions:

$$
\frac{E_{i,t+h}}{A_{i,t}} = a_{t,h} + b_{t,h} \log\left(\frac{R\&D_{i,t}}{A_{i,t}}\right) + c_{t,h} \log\left(\frac{CAPX_{i,t}}{A_{i,t}}\right) + d_{t,h}\left(\frac{E_{i,t}}{A_{i,t}}\right) + e_{t,h}^s \mathbf{1}_{i,t}^s + \epsilon_{i,t,h},
$$

$$(21)$$

We include R&D and CAPX side by side to extract as much information from investment as possible.[12] The predicted variation of earnings from investment is the standard deviation of

---

[12]We did not take logs of investment rates in Section 4.2 because investment there served as a real outcome variable and not an information signal. We take logs here just like we did with market prices because it mitigates skewness and hence it improves forecastability.

the fitted value based on investment:

$$\sigma_t \left(b_{t,h} \log \left(\frac{R\&D_{i,t}}{A_{i,t}} \right) + c_{t,h} \log \left(\frac{CAPX_{i,t}}{A_{i,t}} \right) \right). \tag{22}$$

The results are presented in Figure 6 and Table V. We include a specifications with R&D as the sole predictor (equivalent to imposing $c_{t,h} = 0$ above) and one with both R&D and CAPX.

Figure 6 shows a modest and insignificant increase in the predicted variation of earnings from investment at the three-year horizon. The increase are the five-year horizon is larger and significant at the 10% level. The marginal significance is due to the high level of noisiness in the estimates, perhaps as a result of measurement error and the lumpiness of investment. Yet the magnitudes are comparable to the increase in price informativeness: about 50% at the five-year horizon over a somewhat shorter period (1972–2010 versus 1960–2010). Table V looks at differences in means by decade. The increase in five-year investment informativeness between 1972–79 and 2000–09 is statistically significant at the 10% level with R&D only and at the 5% level with both R&D and CAPX. In the case of R&D and CAPX, there is also significance for the earlier decades.

Our results thus show that the variation in investment and the predicted variation of earnings from investment have both increased, at least when it comes to R&D.[13] Based on the logic of Claim 1, these findings suggest that aggregate efficiency has increased. This evidence favors the view that information production has increased over the view that the increased price informativeness is due to improved firm disclosure.

4.5   Institutional ownership and price informativeness

The key remaining question is whether the increased information production has taken place in markets or inside firms. In the framing of Section 2, we want to distinguish between parts (i) and (ii) of Prediction 1. Under part (i), as market participants produce more information, FPE, aggregate efficiency, and RPE all increase. Under part (ii), as firms produce more information, FPE and aggregate efficiency increase but RPE does not.

---

[13]Looking at both measures is especially useful because it makes it unlikely that the results are driven by changes in measurement error because they tend to push the two measures in opposite directions whereas we see them moving in the same direction.

Pinpointing exactly where information is produced is a challenging task. The ideal experiment would randomize firms' exposure to market-based information production or their capacity to produce information internally and determine which source of variation results in the biggest increase in price informativeness. This ideal experiment is not available to us because our analysis takes place at a high level of aggregation over a long period of time. Our best alternative is to cut the data in ways that proxy for one type of variation or the other. In the remaining sections of the paper we do this in four different ways.

Our first test cuts the data by institutional ownership. Among the most salient trends in financial markets in recent decades is the rise of institutional ownership. The median institutional share has increased from 12% in 1980 to 69% in 2014 among all firms and from 39% to 80% among S&P 500 firms. The difference between the two groups comes from the low end of the distribution: the 10th and 90th percentiles among all firms in 2014 are 12% and 94%, whereas among S&P 500 firms they are 61% and 94%. Hence, while both groups have seen a large increase in average institutional share, the set of all firms offers much more cross-sectional variation. For this reason, in this test we use the sample of all firms.

Our test is predicated on the idea that institutional investors are more likely than retail investors to produce independent information due to their greater scale, expertise, and professional resources. Based on this idea, if higher institutional ownership is associated with higher price informativeness, then that would provide evidence consistent with the hypothesis that the rise in institutional ownership has contributed to the rise in price informativeness. This would then suggest that RPE has increased.

For this test, we split firms into groups with high and low institutional share with the median institutional share in each year as the cutoff. We then run the forecasting regressions (15) separately for each group and calculate price informativeness as in (16).

Figure 7 presents the results. The left panel shows the average institutional share for the high and low groups over time. While both have been trending up, the high group has seen a somewhat larger increase (solid red line) so that the gap between them has actually grown.

The second and third panels of Figure 7 plot price informativeness. Recall from Section 4.1 that price informativeness outside the S&P 500 firms appears to decline, likely due to compositional changes. Figure 7 shows that the decline is entirely contained among firms

with low institutional ownership (dashed black lines). The high group has much higher price informativeness and it shows no sign of a decrease. The differences are very large: three-year price informativeness is three times larger for the high group than the low group. At the five-year horizon it is 50% larger. The two groups are far enough apart that their price informativeness series never cross.

Table VI provides a formal test. Specifically, we regress the difference in price informativeness between the high and low groups on decade dummies. The large and highly significant constants indicate that informativeness is much larger for firms with high institutional ownership at all horizons. Since institutional ownership data is only available after 1980, it is harder to test for trends, yet from the three- and five-year horizons we see that the gap in informativeness has expanded just as the gap in institutional share in Figure 7 has grown.

The results of this section demonstrate a strong relationship between institutional ownership and price informativeness. This is consistent with the view that institutional investors engage in information production and by doing so contribute to a rise in revelatory price efficiency (RPE).

4.6   Option trading and price informativeness

In the second cross-sectional test we examine the relationship between price informativeness and option trading. The CBOE has been listing firms in a staggered manner since 1973. Our test is predicated on the idea that options facilitate the incorporation of market-based information into prices by providing liquidity, opportunities to hedge, embedded leverage, and a low-cost way to short sell. Based on this idea, a positive relationship between price informativeness and option trading would suggest an increase in RPE.

The top two plots of Figure 8 compare price informativeness for S&P 500 firms with and without option listings. While the two groups have similar levels of price informativeness, the upward trend is only visible for the listed firms where it is large and highly significant. The flatness of the series for the unlisted group may be due to its declining membership, from 461 in 1973 to just 78 at the end of our sample (indeed the series becomes quite noisy in later years). We are thus mainly interested in the difference between the two groups, and here the upward trend can be seen more clearly: In Panel A of Table VII we again regress the difference

in price informativeness between the two groups on decade dummies. The negative intercept says that listed firms actually had lower price informativeness in the 1970s when options began trading. In later decades, however, we see positive and significant coefficients, indicating that the rise in price informativeness is concentrated among firms with traded options.

In part to control for the changing composition of the listed and unlisted groups, we look at the intensive margin by comparing price informativeness for firms with high and low levels of option turnover. We calculate option turnover as option volume over a year divided by equity shares outstanding. Intuitively, the impact of option trading on price informativeness should depend on the size of the option market relative to the equity market. Since option volume data (from OptionMetrics) is only available after 1996, we cannot evaluate trends. It is nevertheless useful to look at the level of price informativeness for the two groups and consider it against the overall positive trend in option trading over our sample.

The results are shown in the bottom two plots of Figure 8. We see that price informativeness tends to be higher for firms with high levels of option turnover. Panel B of Table VII confirms that the difference is highly statistically significant. Thus, option trading is positively related to price informativeness.

Based on the idea that options facilitate market-based information production, these results are also consistent with the view that the increased price informativeness we see is associated with greater revelatory price efficiency (RPE).

4.7   Liquidity and price informativeness

In our third cross-sectional test we examine the relationship between liquidity and price informativeness. The past five decades have witnessed an enormous expansion of liquidity in financial markets. As one metric, the typical S&P 500 firm had monthly share turnover of just 1.6% in 1960 versus 20% in 2014 (turnover peaked at 42% in 2009). The increase in liquidity motivates us to ask whether financial market prices have become more informative. After all, it is through trading that private information enters the market. The opportunity to trade in a liquid market also increases the incentive to produce information in the first place.

In this section we split our sample into high and low turnover groups using the median turnover rate in each year as the cutoff. Under the view that liquidity facilitates information

production, price informativeness should be higher for the high turnover group.

Figure 9 shows the results. The first panel plots average log turnover, which has increased strongly for both groups. There is also some convergence as the gap has narrowed over time.

The main result in Figure 9 is that price informativeness is on average higher for the high-turnover group. This is true at both the three- and five-year horizons. Price informativeness also rises for both groups over time, consistent with the rise in their turnover rates.

The last three columns of Table VIII run a formal test. We are mainly interested in the constant, which measures the difference in price informativeness between the high- and low-turnover groups. This constant is positive and highly statistically significant. In terms of magnitudes, five-year informativeness is two points or 50% higher for the high-turnover group than the low-turnover group. Most of the decade dummies are negative though few are statistically significant. The negative coefficients confirm that the price informativeness of the two groups has become more similar just as their turnover rates have been converging.

These results show that higher liquidity is associated with higher price informativeness. As liquidity has risen significantly over time, this finding supports the view that rising liquidity has contributed to the observed rise in price informativeness and an increase in RPE.

4.8   Growth options and price informativeness

In disentangling RPE and FPE we have so far exploited variation in information production in markets. In this section we exploit variation in information production inside firms. To do this we first extend our framework from Section 2 by incorporating firm heterogeneity. A particularly relevant source of heterogeneity empirically are differences in growth options versus assets in place. To capture such differences, we relax the assumption that growth options and assets in place are perfectly correlated by replacing (1) with

$$v\left(z, \tilde{z}, k\right) \;=\; \left(1 + \tilde{z}\right)\overline{k} + zk - \frac{\gamma}{2\overline{k}}k^2, \tag{23}$$

where z and $\tilde{z}$ are not perfectly correlated. We call firms with low assets in place $(\overline{k})$ growth firms and those with high $\overline{k}$ value firms as is customary. To derive a specific testable prediction, we make the following assumption:

Assumption 1. *Managers know relatively more about assets in place while traders know relatively more about about growth options. Formally, $s = z + \epsilon_s$ and $\eta = \tilde{z} + \epsilon_\eta$.*

The assumption that managers (firm insiders) possess an information advantage with respect to assets in place is widely used in the literature. For instance, a large literature on asymmetric information in corporate finance is based on this assumption (e.g Myers and Majluf 1984). In practice, firms have detailed internal reports on costs and sales of existing products that outsiders simply do not have. This type of advantage is likely smaller for future products. For firms that depend on future growth, the relevant information valuation methods rely on comparisons to other firms and analysis of market trends. Here market participants might have an advantage or at least less of a disadvantage. We can now state

Prediction 2. *Under Assumption 1, all else equal*

(i) *a decrease in σ_s^2 (traders produce more information) increases $\mathcal{V}_{FPE}$ more for growth firms (low $\overline{k}$) than value firms (high $\overline{k}$).*

(ii) *a decrease in σ_η^2 (firms produce more information) increases $\mathcal{V}_{FPE}$ more for value firms (high $\overline{k}$) than value firms (low $\overline{k}$).*

Under Assumption 1, traders focus on valuing growth options. As their information increases, the FPE of growth firms rises more than value firms. Managers, on the other hand, focus on assets in place, so an increase in their information has the opposite effect. Hence, Prediction 2 allows us to distinguish RPE and FPE by comparing the trends in FPE of growth and value firms. Of course, this is not a perfect test but we think it contributes to the overall picture that emerges from all of our tests.[14]

To implement it, we split S&P 500 firms into high- and low-valuation groups, using the median value of the valuation ratio $\log M/A$ in each year as the cutoff. The high-valuation group are the growth stocks and the low-valuation group are the value stocks. We then calculate price informativeness separately for each group.

---

[14]For instance, growth firms are more uncertain and may be less transparent. Note, however, that our test is not about the overall difficulty of valuing growth firms versus value firms. Rather, Prediction 2 says that when market-based information production changes, the change in price informativeness should be bigger for growth firms than for value firms.

The results are presented in Figure 10 and Table VIII. Looking at Figure 10, value stocks have relatively low and flat price informativeness over the whole sample. In contrast, for growth firms price informativeness has increased steadily, roughly doubling over the sample. Consistent with Figure 10, Table VIII (first three columns) shows that the difference in informativeness between growth and value firms is generally higher in the latter decades of the sample, especially at the five-year horizon (the drop in the 2000s is due to the year 2000). Thus the increase in price informativeness is concentrated among growth firms.

Under the view that the market has a relative advantage in producing information about growth firms, these results support the interpretation that RPE has increased. They are also of interest more broadly as the prospects of growth firms are inherently harder to assess so any additional information is likely of high value.

5   Conclusion

The past few decades have seen enormous changes in financial markets: Information costs have plummeted, liquidity has deepened, spending on price discovery has increased, and institutional investing has become dominant. Against this backdrop, we ask a simple question: Have financial market prices become more informative? This question is important for economic efficiency and for assessing the value of a growing financial sector.

To answer it, we derive a welfare-based measure of price informativeness, the predicted variation of future cash flows from current market prices. This measure is easily calculated from firm-level stock prices and cash flows. Our measure quantifies the extent to which markets can separate firms that will be profitable in the future from those that will not.

We find that financial market prices *have* become more informative, specifically at the key medium and long horizons of three and five years. Price informativeness at these horizons is 60% to 80% higher in 2014 than in 1960. We present further evidence to suggest that the increase reflects greater revelatory price efficiency; that markets today produce more information that is useful for allocating investment, and in doing so are contributing to the efficiency of capital allocation in the economy.

References

Baker, Malcolm, Jeremy Stein, and Jeffrey Wurgler, 2003, When does the market matter? stock prices and the investment of equity-dependent firms, *Quarterly Journal of Economics* 118, 969–1006.

Bakke, Tor-Erik, and Toni M. Whited, 2010, Which firms follow the market? an analysis of corporate investment decisions, *Review of Financial Studies*.

Bekaert, Geert, Campbell R. Harvey, and Christian Lundblad, 2001, Emerging equity markets and economic development, *Journal of Development Economics* 66, 465 – 504 12th Inter-American Seminar on Economics.

Beyer, Anne, Daniel A. Cohen, Thomas Z. Lys, and Beverly R. Walther, 2010, The financial reporting environment: Evidence from the last decade, *Journal of Accounting and Economics* 50, 296–343.

Bolton, Patrick, Tano Santos, and José Scheinkman, 2011, Cream skimming in financial markets, Working Paper, Columbia University.

Bond, Philip, Alex Edmans, and Itay Goldstein, 2012, The real effects of financial markets, *The Annual Review of Financial Economics* 4, 339–360.

Bond, Philip, Itay Goldstein, and Edward Simpson Prescott, 2010, Market-based corrective actions, *Review of Financial Studies* 23, 781–820.

Bresnahan, Timothy, Paul Milgrom, and J Paul, 1992, *Output Measurement in the Service Sectors* . chap. The real output of the stock exchange, pp. 195–216 (Chicago University Press).

Bushee, B., D. Matsumoto, and G. Miller, 2004, Managerial and investor responses to disclosure regulation: The case of reg fd and conference calls, *The Accounting Review* 79, 617–643.

Campbell, John Y., Martin Lettau, Burton Malkiel, and Yexiao Xu, 2001, Have individual stocks become more volatile? an empirical exploration of idiosyncratic risk, *Journal of Finance* 56, 1–43.

Campbell, John Y, and Robert J Shiller, 1988, The dividend-price ratio and expectations of future dividends and discount factors, *Review of financial studies* 1, 195–228.

Chen, Qi, Itay Goldstein, and Wei Jiang, 2007, Price informativeness and investment sensitivity to stock price, *Review of Financial Studies* 20, 619–650.

Collins, Daniel W., Edward L. Maydew, and Ira S. Weiss, 1997, Changes in the value-relevance of earnings and book values over the past forty years, *Journal of Accounting and Economics* 24, 39 – 67 Properties of Accounting Earnings.

Dechow, Patricia, Jenny Zha, and Richard Sloan, 2014, Stock prices & earnings: A history of research, *Annual Review of Financial Economics* 6.

Dechow, Patricia M, Sagar P Kothari, and Ross L Watts, 1998, The relation between earnings and cash flows, *Journal of accounting and Economics* 25, 133–168.

Dechow, Patricia M, Richard G Sloan, and Amy P Sweeney, 1995, Detecting earnings management, *Accounting review* pp. 193–225.

Dow, James, and Gary Gorton, 1997, Stock market efficiency and economic efficiency: is there a connection?, *The Journal of Finance* 52, 1087–1129.

Durnev, Artyom, Randall Morck, Bernard Yeung, and Paul Zarowin, 2003, Does greater firm-specific return variation mean more or less informed stock pricing?, *Journal of Accounting Research* 41, 797–836.

Easley, David, Nicholas M Kiefer, Maureen O'Hara, and Joseph B Paperman, 1996, Liquidity, information, and infrequently traded stocks, *The Journal of Finance* 51, 1405–1436.

Edmans, Alex, Itay Goldstein, and Wei Jiang, 2015, Feedback effects, asymmetric trading, and the limits to arbitrage and the limits to arbitrage, *American Economic Review*.

Fama, Engene, 1970, Efficient capital markets: A review of theory and empirical work, *Journal of Finance* 25(2), 383–417.

Fama, Eugene F, and Kenneth R French, 1992, The cross-section of expected stock returns, *the Journal of Finance* 47, 427–465.

——— , 2004, New lists: Fundamentals and survival rates, *Journal of Financial Economics* 73, 229 – 269.

French, Kenneth R, 2008, Presidential address: The cost of active investing, *The Journal of Finance* 63, 1537–1573.

Gennaioli, Nicola, Andrei Shleifer, and Robert Vishny, 2012, Neglected risks, financial innovation, and financial fragility, *Journal of Financial Economics* 104, 452 – 468.

Glosten, Lawrence R, and Paul R Milgrom, 1985, Bid, ask, and transaction prices in a specialist market with heterogeneously informed traders, *Journal of Financial Economics* 14, 71–100.

Goldstein, Itay, and Alexander Guembel, 2008, Manipulation and the allocational role of prices, *Review of Economic Studies* 75, 133–164.

Goldstein, Itay, Emre Ozdenoren, and Kathy Yuan, 2013, Trading frenzies and their impact on real investment, *Journal of Financial Economics* 109, 566–582.

Greenwood, Jeremy, and Boyan Jovanovic, 1990, Financial development, growth, and the distribution of income, *Journal of Political Economy* 98, 1076–1107.

Greenwood, Robin, and David Scharfstein, 2012, The growth of modern finance, *Working Paper, Harvard Business School*.

Grossman, Sanford J., and Joseph E. Stiglitz, 1980, On the impossibility of informationally efficient markets, *American Economic Review* 70, 393–408.

Hayashi, Fumio, 1982, Tobin's marginal q and average q: A neoclassical interpretation, *Econometrica* 50, 213–24.

Hayek, Friedrich August, 1945, The use of knowledge in society, *The American economic review* 35, 519–530.

Healy, P. M., and K. G. Palepu, 2001, A review of the empirical disclosure literature, *Journal of Accounting and Economics* 31, 405–440.

Heflin, F., K. Subramanyam, and Y. Zhang, 2003, Regulation fd and the financial information environment: Early evidence, *The Accounting Review* 78, 1–37.

Hirshleifer, Jack, 1971, The private and social value of information and the reward to inventive activity, *The American Economic Review* 61, 561–574.

Holmström, Bengt, and Jean Tirole, 1993, Market liquidity and performance monitoring, *Journal of Political Economy* pp. 678–709.

Holthausen, Robert W., and Ross L. Watts, 2001, The relevance of the value-relevance literature for financial accounting standard setting, *Journal of Accounting and Economics* 31, 3 – 75.

Hong, Harrison, and Jeremy C Stein, 1999, A unified theory of underreaction, momentum trading, and overreaction in asset markets, *The Journal of Finance* 54, 2143–2184.

King, Robert G, and Ross Levine, 1993a, Finance and growth: Schumpeter might be right, *Quarterly Journal of Economics* 108, 717–737.

———— , 1993b, Finance, entrepreneurship and growth, *Journal of monetary Economics* 32, 513–542.

Koeva, Petya, 2000, The facts about time-to-build, IMF Working Paper.

Kurlat, Pablo, and Laura Veldkamp, 2015, Should we regulate financial information?, .

Kyle, Albert S, 1985, Continuous auctions and insider trading, *Econometrica* 53, 1315–1335.

Levine, Ross, 2005, Finance and growth: theory and evidence, *Handbook of economic growth* 1, 865–934.

Morck, Randall, Bernard Yeung, and Wayne Yu, 2000, The information content of stock markets: Why do emerging markets have synchronous stock price movements?, *Journal of Financial Economics* 58, 215–260.

Myers, Stewart C, and Nicholas S. Majluf, 1984, Corporate financing and investment decisions when firms have information that investors do not have, *Journal of Financial Economics* 13, 187–221.

Newey, Witney, and Kenneth West, 1994, Automatic lag selection in covariance matrix estimation, *Review of Economic Studies* 61, 631–653.

Ozdenoren, Emre, and Kathy Yuan, 2008, Feedback effects and asset prices, *Journal of Finance* 63, 1939–1975.

Philippon, Thomas, 2009, The bond market's q, *The Quarterly Journal of Economics* 124, 1011–1056.

———— , 2015, Has the u.s. finance industry become less efficient? on the theory and measurement of financial intermediation, *American Economic Review* pp. 1408–1438.

———— , and Ariell Reshef, 2012, Wages and human capital in the us finance industry: 1909– 2006, *The Quarterly Journal of Economics* 127, 1551–1609.

Rajan, R.G., and L. Zingales, 1998, Financial dependence and growth, *American Economic Review* pp. 559–586.

Rajan, Raghuram G., 2005, Has finance made the world riskier?, *Proceedings of the 2005 Jackson Hole Conference organized by the Kansas City Federal Reserve Bank.*

Roll, Richard, 1988, R^2, *The Journal of Finance* 43, 541–566.

Schumpeter, Joseph A., 1912, *Theorie der wirtschaftlichen Entwicklung* (Dunker & Humblot: Leipzig).

Shiller, Robert J, 2000, *Irrational Exuberance* (Princeton University Press: Princeton).

Subrahmanyam, Avanidhar, and Sheridan Titman, 1999, The going-public decision and the development of financial markets, *Journal of Finance* 54, 1045–1082.

Tobin, James, 1969, A general equilibrium approach to monetary theory, *Journal of Money, Credit and Banking* 1, 15–29.

——— , 1984, On the efficiency of the financial system, *Lloyds Bank Annual Review* pp. 1–15.

Turley, Robert, 2012, Informative prices and the cost of capital markets, working paper.

Wang, I., 2007, Private earnings guidance and its implications for disclosure regulation, *The Accounting Review* pp. 1299–1332.

Zingales, Luigi, 2015, Presidential address: Does finance benefit society?, *forthcoming, The Journal of Finance.*

Appendix

A   Appendix model

In this section we provide a full-fledged model of information production and trading as an example of the framework in Section 2. The model shares the basic setup of equations (1)–(8). Following Subrahmanyam and Titman (1999), we assume the traded claim has payoff z.[15] There are n informed traders who choose their demand x to maximize a standard mean-variance objective:

$$\max_x \ x\mathbb{E}\left[z - p|\, \eta', s\right] - \frac{\rho}{2}x^2\mathbb{V}\text{ar}\left[z|\, \eta', s\right], \tag{A.1}$$

which leads to the usual demand curve

$$x = \frac{\mathbb{E}\left[z|\, \eta', s\right] - p}{\rho\mathbb{V}\text{ar}\left[z|\, \eta', s\right]}. \tag{A.2}$$

From (7) and (8),

$$\mathbb{E}\left[z|\, \eta', s\right] = \frac{h_s s + h_{\eta'}\eta'}{h_z + h_s + h_{\eta'}} \tag{A.3}$$

where $h_z = \frac{1}{\sigma_z^2}$ and $h_s = \frac{1}{\sigma_{\epsilon_s}^2}$ and $h_{\eta'} = \frac{1}{\sigma_{\epsilon_\eta}^2 + \sigma_{\epsilon_{\eta'}}^2}$ are the precisions of s and η'. We also get that

$$\mathbb{V}\text{ar}\left[z|\, \eta', s\right] = \frac{1}{h_z + h_s + h_{\eta'}}. \tag{A.4}$$

Therefore, the demand of each trader is

$$x = \frac{1}{\rho}\left[h_s s + h_{\eta'}\eta' - p\left(h_z + h_s + h_{\eta'}\right)\right] \tag{A.5}$$

We assume a random supply u of shares (equivalently noise traders) so the equilibrium condition is

$$nx = u \tag{A.6}$$

and we get the equilibrium price

$$\left(h_z + h_s + h_{\eta'}\right)p = h_s s + h_{\eta'}\eta' - \frac{\rho}{n}u. \tag{A.7}$$

---

[15]Formally, they assume a perfect correlation between growth options and assets in place, and they assume that the markets trade a claim on the existing assets $\mathcal{F} = z\overline{k}$. This is obviously equivalent to assuming that z is traded directly. Subrahmanyam and Titman (1999) justify their assumption by the fact that there is a deterministic relation in the model between the cash flows of the assets in place and the cash flows of the entire firm. However, because this relation is nonlinear, the cash flow of the total firm is non-normal, which precludes a closed-form solution to the security market equilibrium in a model where a claim on the total firm's cash flow is sold. But since a claim on existing assets provides the same information as would the price of the entire firm, they conclude that this is a sensible assumption.

Next we want to understand what the manager learns. Since she knows η' she can observe

$$s' \;=\; s - \frac{\rho}{nh_s}u \;=\; z + \epsilon_s - \frac{\rho}{nh_s}u \tag{A.8}$$

Therefore her information set is in fact $\{\eta, s'\}$ and she sets

$$\gamma\frac{k^\star}{\overline{k}} \;=\; \mathbb{E}\left[z|\mathcal{I}_m\right] \;=\; \frac{h_\eta\eta + h_{s'}s'}{h_z + h_\eta + h_{s'}}, \tag{A.9}$$

where

$$h_{s'} \;=\; \frac{1}{\sigma_{\epsilon_s}^2 + \left(\frac{\rho}{nh_s}\right)^2\sigma_u^2} \;=\; \frac{h_s}{1 + \left(\frac{\rho}{n}\right)^2\sigma_u^2}. \tag{A.10}$$

To compute the efficiency of the economy as in (13), we substitute (6) and (A.8) into (A.9) and obtain

$$\mathbb{E}\left[z|\mathcal{I}_m\right] \;=\; \frac{(h_\eta + h_{s'})\,z + h_\eta\epsilon_\eta + h_{s'}\left(\epsilon_s - \frac{\rho}{nh_s}u\right)}{h_z + h_\eta + h_{s'}}, \tag{A.11}$$

and so aggregate efficiency is

$$\mathbb{Var}\left(\mathbb{E}\left[z|\mathcal{I}_m\right]\right) \;=\; \frac{(h_\eta + h_{s'})^2\sigma_z^2 + h_\eta + h_{s'}}{(h_z + h_\eta + h_{s'})^2} \;=\; \left(\frac{h_\eta + h_{s'}}{h_z + h_\eta + h_{s'}}\right)h_z^{-1}. \tag{A.12}$$

We can thus state

Proposition A.1. *Aggregate efficiency is increasing in internal information h_η, external information h_s, and uncertainty h_z^{-1}.*

Proof. Recall from (13) that aggregate efficiency is $\mathbb{Var}\left(\mathbb{E}\left[z|\mathcal{I}_m\right]\right)$. The proof follows by substituting (A.10) into (A.12) and taking derivatives. □

The informativeness of prices, on the other hand, depends on all the noises. We have

$$(h_z + h_s + h')\,p \;=\; h_s s + h'\eta' - \frac{\rho}{n}u \tag{A.13}$$

$$\;=\; (h_s + h')\,z + h_s\epsilon_s + h'\left(\epsilon_\eta + \epsilon_{\eta'}\right) - \frac{\rho}{n}u \tag{A.14}$$

so observing the price is equivalent to observing

$$\pi \;=\; \left(1 + \frac{h_z}{h_s + h'}\right)p \;=\; z + \frac{h_s}{h_s + h_{\eta'}}\epsilon_s + \frac{h_{\eta'}}{h_s + h_{\eta'}}\left(\epsilon_\eta + \epsilon_{\eta'}\right) - \frac{\rho}{(h_s + h_{\eta'})\,n}u \tag{A.15}$$

and we have

$$\mathbb{E}\left[z|p\right] \;=\; \frac{h_\pi\pi}{h_\pi + h_z}, \tag{A.16}$$

where

$$h_\pi = \cfrac{1}{\mathbb{V}\text{ar}\left(\frac{h_s}{h_s+h_{\eta'}}\epsilon_s + \frac{h_{\eta'}}{h_s+h_{\eta'}}(\epsilon_\eta + \epsilon_{\eta'}) - \frac{\rho}{(h_s+h_{\eta'})n}u\right)} = \frac{(h_s+h_{\eta'})^2}{h_s + h_{\eta'} + \frac{\rho^2}{n^2}\sigma_u^2}. \quad (A.17)$$

The predicted variance of cash flows (z) from prices (FPE) is

$$\mathbb{V}\text{ar}\left(\mathbb{E}\left[z\,|\,p\right]\right) = \mathbb{V}\text{ar}\left(\cfrac{h_\pi\left(z + \frac{h_s}{h_s+h_{\eta'}}\epsilon_s + \frac{h_{\eta'}}{h_s+h_{\eta'}}(\epsilon_\eta + \epsilon_{\eta'}) - \frac{\rho}{(h_s+h_{\eta'})n}u\right)}{h_\pi + h_z}\right) \quad (A.18)$$

$$= \frac{h_\pi}{h_\pi + h_z}h_z^{-1}. \quad (A.19)$$

So FPE depends on internal information and disclosure via $h_{\eta'}$, on RPE via h_s and on noise trading. As for RPE, we have

$$\mathbb{V}\text{ar}\left(\mathbb{E}\left[z\,|\,\eta,\eta',s'\right]\right) - \mathbb{V}\text{ar}\left(\mathbb{E}\left[z\,|\,\eta,\eta'\right]\right) = \left(\frac{h_\eta + h_{s'}}{h_z + h_\eta + h_{s'}} - \frac{h_\eta}{h_z + h_\eta}\right)h_z^{-1}. \quad (A.20)$$

We have the following comparative statics:

Proposition A.2. *All else equal,*

(i) *an increase in h_s leads to an increase in aggregate efficiency, price informativeness (FPE), and revelatory price efficiency (RPE);*

(ii) *an increase in h_η leads to an increase in aggregate efficiency, an increase in the predicted variance of cash flows from investment, and, if disclosure is positive, to an increase in FPE but not RPE; and*

(iii) *an increase in $h_{\eta'}$, holding h_η constant, only leads to an increase in FPE.*

Proof. The results follow by taking derivatives in the expressions for aggregate efficiency, (A.12), FPE, (A.19), and RPE, (A.20). For the predicted variance of cash flows from investment, in this model it is equal to aggregate efficiency because investment is proportional to the conditional expectation of cash flows based on the manager's information. $\qquad\square$

Proposition A.2 formalizes Prediction 1 in Section 2.

Free entry There are several ways to capture changes in information technology. We can simply assume that signals become more informative, as in the previous proposition. Or we can solve for equilibrium learning and assume the cost of information decreases. We can do this for both managers and traders. In the case of traders, for instance, we can pin down n with a free entry condition. The utility of the informed trader is

$$U = \frac{1}{2\rho}\frac{(\mathbb{E}\left[z - p\,|\,\eta',s\right])^2}{\mathbb{V}\text{ar}\left[z\,|\,\eta',s\right]} = \frac{1}{2\rho}\frac{\left(\frac{h_s s + h_{\eta'}\eta'}{h_z + h_s + h_{\eta'}} - p\right)^2}{\frac{1}{h_z + h_s + h_{\eta'}}}. \quad (A.21)$$

40

Substituting for the price from (A.13), we get

$$U = \frac{\left(\frac{\rho}{n}u\right)^2}{2\rho\left(h_z + h_s + h_{\eta'}\right)}. \tag{A.22}$$

So expected utility of becoming an informed trader is

$$\mathbb{E}\left[U\right] = \frac{\rho\sigma_u^2}{2\left(h_z + h_s + h_{\eta'}\right)}\frac{1}{n^2}. \tag{A.23}$$

Let ψ be the cost of becoming informed. Then in equilibrium $\mathbb{E}\left[U\right] = \psi$ and we have

$$n = \sqrt{\frac{1}{\psi}\frac{\rho\sigma_u^2}{2\left(h_z + h_s + h_{\eta'}\right)}}. \tag{A.24}$$

The number of traders who enter depends on the cost of information, the amount of noise trading, and the signal precisions.[16] This shows how a lower cost of information increases RPE and how we can tease it out from RPE. These predictions map into the framework we presented in Section 2.

B   Price informativeness over time, robustness

Example cross-sectional regression: Table A.I shows the estimates of our cross-sectional regressions (15) for 2009, the last year for which we have data at the five-year horizon. We focus on horizons of one, three, and five years. As Table A.I, the coefficient of market prices is positive and statistically significant. It is also increasing with horizon from 0.039 at the one-year horizon to 0.061 at the five-year horizon. The coefficient on current earnings is also positive and significant coefficient. As Figure A.1 shows, the coefficient on current earnings on typically declines with horizon. The year 2009 is somewhat unusual since it coincides with the trough of the Great Recession. This is why the one-year coefficient on current earnings is lower than in other years.

Forecasting coefficients by horizon: Figure A.1 plots the average coefficients from our cross-sectional forecasting regressions (15) by horizon. The format of the figure follows Figure 2. Like the coefficients on prices, the coefficients on earnings are slightly higher in the second half of the sample, but since the cross-sectional standard deviation of earnings is the same (see Figure 1), the predicted variation of future earnings from current earnings is flat over our sample. Unlike the coefficients on prices, the coefficients on earnings are decreasing in horizon. The long-horizon earnings coefficient is about 0.6, indicating a quasi-permanent effect. These results support the view that current earnings are relatively more informative at short horizons whereas prices are relatively more informative at long horizons. They thus provide further motivation for focusing on price informativeness at longer horizons.

---

[16]We note that in this simple model disclosure increases entry because it is assumed that disclosure is only observed by informed traders and not noise traders. We could make an alternative assumption that disclosure reduces noise trading so this is not a robust prediction.

Controlling for debt: Figure A.2 replicates the analysis in Section 4.1 under a number of variations. In the first variation, we replace the market value of equity M with the sum of the market value of equity and the book value of long-term debt D in calculating the valuation ratio in the forecasting regressions 15. This ensures that our measure is not picking up changes in the cross-sectional relationship between firm leverage and future earnings. As the first column of Figure A.2 shows, price informativeness continues to increase at the three- and five-year horizons even when we adjust for debt. The cumulative growth is 50% at three years and 70% at five years, which is about the same as in our baseline specification and highly significant.

Alternative cash flow measures: The remaining columns of Figure A.2 show robustness to alternative measures of firm cash flows. In the main text we use EBIT because it is most widely available and because it is the focus of market analysts. Here we consider EBITDA, net income, and cash flows from operations (CFO) as alternatives. CFO is calculated following Dechow, Sloan, and Sweeney (1995). This method derives CFO from the balance sheet rather than the cash flow statement. We do this because cash flow statements are not available prior to the promulgation of FASB rule 95 in 1987. The two ways of measuring CFO have 92% correlation where they overlap. As in Dechow, Sloan, and Sweeney (1995) and Dechow, Kothari, and Watts (1998), we take the balance sheet-based measure for the whole sample to ensure our results are comparable over time.

Figure A.2 shows that price informativeness is increasing at three- and five-year horizons using any of these alternative measures. The increase is smallest using net income, 25% at the three-year horizon and 50% at the five-year horizon, and largest with CFO, 75% at the three-year horizon and 150% at the five-year horizon. All are highly significant except net income which has p-values of 0.12 and 0.13. Overall, these results suggest that the observed increase in price informativeness is not driven by a change in the extent to which managers smooth earnings or other issues related to accounting.

Pairwise differences in means: Table A.II presents pairwise differences in means for price informativeness at the three- and five-year horizons (the underlying series are presented in Figure 3 and Table II). In each column, we regress price informativeness on decade-based indicator variables using a different decade as the baseline. The coefficients therefore represent pairwise differences in means between a given decade along a row and the baseline decade along a column. Looking at three years, the sign of most differences is consistent with increasing informativeness throughout the sample. Differences relative to the 1960s are significant. This is because the upward trend takes several decades to accumulate. Looking at five years, the signs are again consistent with increasing informativeness. Differences relative to the 1960s and 1970s are significant.

Structural break tests: We examine the evidence for a structural break in price informativeness. The adoption of Regulation Fair Disclosure in 2000 and the passage of the Sarbanes-Oxley Act in 2002 are likely candidates. These reforms had a large impact on firms' disclosure requirements. Another potentially important reform is decimalization which occurred in 2001. If the observed increase in price informativeness is due to changes in disclosure, then these reforms should lead to detectable changes in our price informativeness series. More broadly, we check whether there is evidence of a structural break at any point in our sample.

To test for structural breaks, we first form the null hypothesis that price informativeness has increased linearly over our sample from 1960 to 2014. Specifically, we run a regression of price informativeness at each horizon (shown in Figure 3) on a constant and a linear time trend. We normalize the linear time trend to zero in 1960 and one in 2014. This allows us to interpret the constant as the value of price informativeness in 1960 and the sum of the constant and slope coefficient as the value of price informativeness in 2014. The results are in Table A.III. The coefficients on the time trend are positive and significant. The point estimate is that the one-year informativeness series is only about 30% higher in 2014 than 1960, while the three- and five-year informativeness series are 62% and 85% higher, respectively.

Next, we run a Supremum Wald test for an unknown break point in the coefficients from the regression on a linear time trend. This test calculates a Wald statistic for the hypothesis that the intercept and slope of this regression are different before and after each year in our sample. It then reports the year with the highest Wald statistic and a p-value that takes into account the search over all years. The results are below the regression estimates in Table A.III. The most likely break point years differ by horizon and none has a p-value below 10% (the lowest p-value is for the five-year series in 1980).

Since the test for an unknown break point has relatively low power, we also perform tests for known break points in 2000 (Reg. FD), 2001 (decimalization), and 2002 (Sarbanes-Oxley). The results are also reported in Table A.III. The p-values are again high, the lowest (0.15) is for the three-year price series in 2002.

Overall, we find no evidence of a structural break point in our price informativeness series. Rather, informativeness has been increasing steadily throughout our fifty-year sample. This makes it less likely that the increase is driven by changes in disclosure requirements which are discrete in nature.

C   Beyond the S&P 500

Table A.IV presents summary statistics for the universe of firms. Compared to the S&P 500, these firms are smaller, less profitable, and have lower market valuation ratios. They also exhibit much greater uncertainty as indicated by their idiosyncratic volatility and cross-sectional dispersion of profitability at all horizons. More importantly, this dispersion has increased between the first and second halves of our sample. For instance, the dispersion of current earnings to assets has nearly doubled. The average level of profitability has also fallen from 9% of total assets to -0.6%. The drop in the median is smaller, from 10.2% to 6.1%, indicating increased left-skewness. Indeed, many of these firms have consistently negative earnings.

Next, we replicate the analysis from Section 4.1 for firms beyond the S&P 500. The results are presented in Figure A.3 and Table A.V. The top two panels of Figure A.3 show that the two groups differ greatly on observable characteristics. From the top left panel, uncertainty has increased drastically among all firms as suggested by the increase in their earnings dispersion. This dispersion has grown from about the same level as for S&P 500 firms in 1960 to about four times as high by 2000. From the top right panel, there has been a parallel rise in the dispersion of market valuations among all firms versus a steady, much less pronounced rise among S&P 500 firms.

The upswings in the dispersion series for all firms correspond to the growth of NASDAQ

in the late 1970s and 80s and the dot-com boom in the 1990s. (Indeed, if we remove NASDAQ firms from the sample the changes are a lot less pronounced.) Both episodes are associated with a large inflow of younger, smaller, and more uncertain firms (see Fama and French 2004). Therefore, the sample of all firms has seen large compositional shifts that imply it is not comparable over time. For S&P 500 firms, there is no evidence of such changes. In particular, their earnings dispersion is virtually constant over the whole fifty-year period.

To see the effects of the compositional changes among all firms, we can look at our informativeness measures, which are shown in the bottom two panels of Figure A.3 (the middle two panels show the forecasting coefficients). In contrast to S&P 500 firms whose price informativeness has risen, for the set of all firms it appears to have declined. The decline occurs in the same years as the rise in the dispersion measures in the top panels. This suggests that it is indeed due to changing firm composition.

Interestingly, the apparent decline is more pronounced at the short horizon. As Table A.V shows, one-year informativeness for all firms falls by a highly significant 73% from the 1960s to the 2000s, whereas five-year informativeness falls by an insignificant 17% (at three years the drop is 60%). Recall from Table II that for S&P 500 firms one-year informativeness is flat, whereas the increase at five years is about 50%. Thus, for both samples there is a comparable relative improvement at the long end. This suggests that the one-year informativeness series helps to tease out the confounding compositional changes.

Table I. Summary statistics

Means, medians, and standard deviations of key variables, S&P 500 firms. Market capitalization is from CRSP in millions of dollars as of the end of March. Total assets, research and development (R&D), capital expenditure (CAPX), and earnings (EBIT) are from Compustat in millions of dollars as of the end of the previous fiscal year. All quantities are adjusted for inflation using the GDP deflator (= 100 in 2010). Next, $\log(M/A)$ is the log-ratio of market cap to assets, $R\&D/A$ is R&D over assets, $CAPX/A$ is CAPX over assets, E/A is EBIT over assets, and $E(t+h)/A$, $h = 1, 3, 5$, is earnings in year $t+h$ over assets in year t. All ratios are winsorized at the 1% level. Idiosyncratic volatility is the standard deviation of returns over the last twelve months after subtracting the market return. Share turnover is volume divided by shares outstanding. Institutional share is the fraction of shares held by institutional investors (from 13-F filings). Option listings is an indicator variable for whether a firm has options trading on the CBOE (available after 1973). Option turnover is $100\times$ option volume over a year divided by equity shares outstanding (from OptionMetrics, 1996 to 2014). The sample consists of S&P 500 non-financial firms, 1960 to 2014.

	Full sample			1960-1985			1986-2014		
	Mean	Median	St. Dev.	Mean	Median	St. Dev.	Mean	Median	St. Dev.
Market Capitalization	10,420	3,213	28,027	3,793	1,481	10,562	17,043	6,796	37,032
Total Assets	11,113	3,931	30,449	5,304	2,194	13,434	16,384	6,426	39,324
R&D	390	90	996	164	54	403	529	133	1,205
CAPX	744	224	1,978	512	145	1,656	943	315	2,198
Earnings	1,101	402	2,750	597	233	1,713	1,544	646	3,348
$\log(M/A)$	-0.166	-0.197	0.879	-0.383	-0.410	0.824	0.032	0.037	0.881
$R\&D/A$	0.038	0.024	0.044	0.029	0.020	0.028	0.044	0.026	0.050
$CAPX/A$	0.071	0.060	0.050	0.080	0.070	0.051	0.063	0.052	0.047
E/A	0.116	0.107	0.075	0.120	0.110	0.073	0.113	0.104	0.077
$E(t+1)/A$	0.124	0.111	0.087	0.127	0.113	0.083	0.122	0.108	0.090
$E(t+3)/A$	0.139	0.117	0.115	0.140	0.119	0.106	0.139	0.114	0.123
$E(t+5)/A$	0.155	0.123	0.145	0.155	0.126	0.131	0.155	0.118	0.159
Idiosyncratic volatility	0.075	0.066	0.040	0.071	0.064	0.033	0.079	0.068	0.045
Share turnover	0.098	0.049	0.146	0.031	0.020	0.038	0.164	0.109	0.180
Institutional share	0.635	0.651	0.207	0.429	0.446	0.172	0.668	0.685	0.193
Option listings	0.635	1.000	0.481	0.259	0.000	0.438	0.895	1.000	0.307
Option turnover	0.351	0.122	1.100				0.351	0.122	1.100
Firm-year obs.	24,701			12,350			12,351		

Table II. Price informativeness over time

Time series regressions of price informativeness by horizon. Price informativeness is calculated as in formula (16) using estimates from the cross-sectional forecasting regressions (15). The resulting price informativeness series are shown in Figure 3. For this table we regress the time series of price informativeness at a given horizon $h = 1, 3, 5$ years on a set of indicator variables corresponding to each decade in our sample. The baseline decade, 1960–69 in the first three columns and 1980–89 in the last three columns, is captured by the constant. Since our sample ends in 2014, there are no five-year price informativeness estimates for the period 2010–2014. We report Newey-West standard errors with 5 lags in parentheses. The sample consists of S&P 500 non-financial firms from 1960 to 2014.

	Price informativeness ($\times 100$)					
	1960–69 baseline			1980–89 baseline		
Horizon h (years):	$h = 1$	$h = 3$	$h = 5$	$h = 1$	$h = 3$	$h = 5$
Constant (1960–69 level)	2.001***	3.111***	4.123***			
	(0.059)	(0.184)	(0.111)			
Constant (1980–89 level)				2.406***	4.186***	5.997***
				(0.188)	(0.276)	(0.075)
1960–69				-0.405**	-1.075***	-1.874***
				(0.197)	(0.332)	(0.134)
1970–79	0.020	0.707*	-0.106	-0.385*	-0.367	-1.980***
	(0.092)	(0.417)	(0.378)	(0.209)	(0.441)	(0.352)
1980–89	0.405**	1.075***	1.874***			
	(0.197)	(0.332)	(0.134)			
1990–99	0.413*	1.406***	1.489***	0.008	0.331	-0.385
	(0.240)	(0.331)	(0.397)	(0.259)	(0.396)	(0.391)
2000–09	0.503***	1.561**	2.143***	0.098	0.487	0.269
	(0.185)	(0.583)	(0.311)	(0.257)	(0.618)	(0.300)
2010–14	0.314	0.840***		-0.091	-0.235	
	(0.288)	(0.253)		(0.339)	(0.327)	
R^2	12.2%	19.5%	53.3%	12.2%	19.5%	53.3%
Obs.	54	52	50	54	52	50

Table III. Market prices and investment

Time series regressions of the predicted variation of investment from prices by horizon. The predicted variation of investment from prices is calculated as $b_{t,h} \times \sigma_t(\log M/A)$, where $b_{t,h}$ is the forecasting coefficient of prices ($\log M/A$) in regression (18) and $\sigma_t(\log M/A)$ is the cross-sectional standard deviation of $\log M/A$ in year t. The resulting predicted variation of investment from prices series are shown in Figure 4. For this table we regress the predicted variation series at a given horizon $h = 1, 3, 5$ years on a set of indicator variables corresponding to each decade in our sample (the baseline decade, 1960–69 for CAPX and 1972–79 for R&D, is captured by the constant). Since our sample ends in 2014, there are no five-year predicted variation estimates for the period 2010–2014. We report Newey-West standard errors with 5 lags in parentheses. The sample consists of S&P 500 non-financial firms from 1960 to 2014. Data on R&D starts in 1972.

	Predicted variation of investment from prices ($\times 100$)					
	R&D			CAPX		
Horizon h (years):	$h=1$	$h=3$	$h=5$	$h=1$	$h=3$	$h=5$
Constant (1960–69 level)				0.942*** (0.212)	1.867*** (0.357)	2.206*** (0.325)
Constant (1972–79 level)	0.134*** (0.027)	0.379*** (0.076)	0.636*** (0.153)			
1970–79				-0.325 (0.232)	-0.238 (0.396)	-0.244 (0.353)
1980–89	0.153*** (0.048)	0.669*** (0.091)	0.908*** (0.160)	0.411 (0.250)	1.209** (0.541)	1.930*** (0.610)
1990–99	0.147 (0.088)	0.779** (0.287)	0.920*** (0.249)	-0.166 (0.216)	0.630 (0.470)	0.813** (0.337)
2000–09	1.028*** (0.097)	1.264*** (0.127)	1.761*** (0.298)	-0.266 (0.302)	-0.911** (0.370)	-0.903** (0.344)
2010–14	0.401*** (0.040)	1.166*** (0.077)		-0.453* (0.226)	-0.455 (0.365)	
R^2	63.7%	50.6%	51.0%	24.9%	46.8%	64.3%
Obs.	42	40	38	54	52	50

Table IV. **Market prices and returns**

Time series regressions of the predicted variation of returns from prices by horizon. The predicted variation of returns from prices is calculated as $b_{t,h} \times \sigma_t (\log M/A)$ where $b_{t,h}$ is the forecasting coefficient of prices ($\log M/A$) in regression (19) and $\sigma_t (\log M/A)$ is the cross-sectional standard deviation of $\log M/A$ in year t. The resulting series are shown in Figure 5. For this table we regress the predicted variation series at a given horizon $h = 1, 3, 5$ years on a set of indicator variables corresponding to each decade in our sample (the baseline decade, 1960–69, is captured by the constant). Since our sample ends in 2014, there are no five-year estimate for the period 2010–2014. We report Newey-West standard errors with 5 lags in parentheses. The sample consists of S&P 500 non-financial firms from 1960 to 2014.

	Predicted variation of returns from prices ($\times 100$)		
Horizon h (years):	$h = 1$	$h = 3$	$h = 5$
Constant (1960–69 level)	-3.214***	-8.712***	-11.101***
	(0.274)	(0.907)	(2.162)
1970–79	-1.197	-0.884	-4.449
	(0.983)	(3.054)	(4.081)
1980–89	0.395	4.686**	5.894*
	(0.607)	(1.787)	(3.416)
1990–99	1.172**	3.416**	4.592
	(0.502)	(1.371)	(2.888)
2000–09	-6.421*	-3.947	-4.987
	(3.196)	(6.322)	(9.293)
2010–14	2.491***	5.189***	
	(0.371)	(0.934)	
R^2	23.2%	13.6%	14.4%
Obs.	54	52	50

Table V. Aggregate efficiency

Time series regressions of the predicted variation of earnings from investment by horizon. The predicted variation of earnings from investment is calculated as $\sigma_t \left(b_{t,h} \log R\&D/A + c_{t,h} \log CAPX/A \right)$, the cross-sectional standard deviation of the fitted linear combination of $R\&D/A$ and $CAPX/A$ in year t from regression (21). We also show results for R&D only, obtained by imposing $c_{t,h} = 0$ in regression (21) and in the calculation of the predicted variation above. The resulting predicted variation series are shown in Figure 6. For this table we regress the predicted variation series at a given horizon $h = 1, 3, 5$ years on a set of indicator variables corresponding to each decade in our sample (the baseline decade, 1972–79, is captured by the constant). Since our sample ends in 2014, there are no five-year estimate for the period 2010–2014. We report Newey-West standard errors with 5 lags in parentheses. The sample consists of S&P 500 non-financial firms from 1972 to 2014 (R&D data starts in 1972).

| | Predicted variation of earnings from investment ($\times 100$) | | | | | |
| | R&D only | | | R&D and CAPX | | |
Horizon h (years):	$h = 1$	$h = 3$	$h = 5$	$h = 1$	$h = 3$	$h = 5$
Constant (1972–79 level)	0.438***	0.911***	1.299***	0.678***	1.243***	1.700***
	(0.111)	(0.260)	(0.207)	(0.057)	(0.205)	(0.225)
1980–89	-0.018	0.192	0.596	0.283**	0.600	1.018***
	(0.189)	(0.473)	(0.361)	(0.124)	(0.409)	(0.299)
1990–99	0.227*	0.533*	0.396	0.287*	0.646**	0.559**
	(0.121)	(0.299)	(0.344)	(0.159)	(0.290)	(0.245)
2000–09	0.146	0.540	0.992*	0.386	0.587**	0.907**
	(0.149)	(0.495)	(0.520)	(0.270)	(0.252)	(0.389)
2010–14	-0.032	-0.431		-0.014	-0.421	
	(0.235)	(0.299)		(0.202)	(0.265)	
R^2	5.2%	10.0%	15.0%	7.3%	13.2%	20.2%
Obs.	42	40	38	42	40	38

49

Table VI. **Institutional ownership and price informativeness**

Time series regressions of the difference in price informativeness between firms with high and low institutional ownership, using the median institutional share in each year as the cutoff. Price informativeness is obtained separately for each group by running the forecasting regressions (15) and calculating the product of the forecasting coefficient and the cross-sectional standard deviation of market prices in year t, $b_{t,h} \times \sigma_t (\log M/A)$. The resulting price informativeness series are shown in Figure 7. For this table we regress the difference in price informativeness between the high and low institutional share groups at a given horizon $h = 1, 3, 5$ years on a set of indicator variables corresponding to each decade in our sample (the baseline decade, 1980–89, is captured by the constant). Since our sample ends in 2014, there are no five-year price informativeness estimates for the period 2010–2014. We report Newey-West standard errors with 5 lags in parentheses. The sample consists of all non-financial firms from 1980 to 2014 when institutional ownership data is available.

| Horizon h (years): | Price informativeness ($\times 100$) high $-$ low institutional ownership | | |
	$h = 1$	$h = 3$	$h = 5$
Constant (1980–89 level)	2.526***	2.842***	2.376***
	(0.304)	(0.123)	(0.255)
1990–99	0.805**	1.996***	2.981***
	(0.387)	(0.309)	(0.452)
2000–09	0.700	1.401***	1.623**
	(0.522)	(0.331)	(0.650)
2010–14	-0.249	2.040***	
	(0.312)	(0.129)	
R^2	22.6%	49.6%	56.3%
Obs.	33	31	29

Table VII. **Option trading and price informativeness**

Time series regressions of the difference in price informativeness between firms with and without option listings (Panel A), and difference in means test of price informativeness of firms with high and low option turnover (Panel B). Option turnover is $100\times$ option volume over a year divided by equity shares outstanding. Price informativeness is obtained separately for each group by running the forecasting regressions (15) and calculating the product of the forecasting coefficient and the cross-sectional standard deviation of market prices in year t, $b_{t,h} \times \sigma_t (\log M/A)$. The resulting price informativeness series are shown in Figure 8. In Panel A we regress the difference in price informativeness between the listed and unlisted groups at a given horizon $h = 1, 3, 5$ years on a set of indicator variables corresponding to each decade in our sample (the baseline decade, 1973–79, is captured by the constant). Since our sample ends in 2014, there are no five-year price informativeness estimates for the period 2010–2014. In Panel B we run a difference in means test for the price informativeness of high and low option turnover firms. Both panels report Newey-West standard errors with 5 lags in parentheses. The sample consists of S&P 500 non-financial firms from 1973 to 2014 for Panel A (the CBOE began listing firms in 1973) and 1997 to 2014 for Panel B (option volume is from OptionMetrics which begins coverage in 1996).

| *Panel A:* | Price informativeness ($\times 100$) | | |
| | listed − unlisted firms | | |
Horizon h (years):	$h = 1$	$h = 3$	$h = 5$
Constant (1973–79 level)	-0.873***	-1.491***	-1.623***
	(0.162)	(0.446)	(0.390)
1980–89	0.682**	1.111**	0.573
	(0.285)	(0.498)	(0.780)
1990–99	1.335***	2.136**	2.188
	(0.294)	(0.906)	(1.601)
2000–09	1.077***	2.455***	2.445**
	(0.376)	(0.759)	(0.961)
2010–14	1.217***	1.810***	
	(0.199)	(0.457)	
R^2	22.0%	21.7%	13.0%
Obs.	41	39	37

| *Panel B:* | Price informativeness ($\times 100$) | | |
| | high − low option turnover firms | | |
Horizon h (years):	$h = 1$	$h = 3$	$h = 5$
Difference in means	1.151***	1.800***	2.949***
	(0.212)	(0.443)	(0.564)
Obs.	17	15	13

Table VIII. Liquidity, growth options, and price informativeness

Time series regressions of the difference in price informativeness between high-turnover and low-turnover firms (first three columns) and between value and growth firms (last three columns). High- (low-) turnover firms are defined as those with a high (low) monthly share turnover using the median share turnover in each year as the cutoff. Growth (value) firms are defined as those with a high (low) valuation ratio ($\log M/A$) using the median valuation ratio in each year as the cutoff. Price informativeness is obtained separately for each group by running the forecasting regressions (15) and calculating the product of the forecasting coefficient and the cross-sectional standard deviation of market prices in year t, $b_{t,h} \times \sigma_t$ ($\log M/A$). The resulting price informativeness series are shown in Figures 9 and 10. For this table we regress the difference in price informativeness between high- and low-turnover firms and between growth and value firms at a given horizon $h = 1, 3, 5$ years on a set of indicator variables corresponding to each decade in our sample (the baseline decade, 1960–69, is captured by the constant). Since our sample ends in 2014, there are no five-year price informativeness estimates for the period 2010–2014. We report Newey-West standard errors with 5 lags in parentheses.

| | Price informativeness (×100) | | | | | |
| | High − low turnover firms | | | Growth − value firms | | |
Horizon h (years):	$h=1$	$h=3$	$h=5$	$h=1$	$h=3$	$h=5$
Constant (1960–69 level)	1.298***	2.012***	2.109**	0.847**	2.591***	3.813***
	(0.464)	(0.634)	(0.802)	(0.403)	(0.393)	(0.315)
1970–79	-0.683	-0.057	-0.186	0.031	-0.521	-1.574***
	(0.475)	(0.648)	(1.068)	(0.395)	(0.535)	(0.437)
1980–89	-0.614	-2.294**	-2.646*	0.862*	0.837	1.599*
	(0.500)	(0.920)	(1.568)	(0.442)	(0.584)	(0.800)
1990–99	0.227	0.560	0.375	1.588***	2.987***	3.029***
	(0.561)	(0.776)	(0.849)	(0.450)	(0.586)	(0.497)
2000–09	-0.199	-0.832	-0.584	0.759*	0.867	1.465**
	(0.506)	(0.960)	(0.942)	(0.449)	(0.730)	(0.676)
2010–14	-0.593	-2.064***		0.136	0.484	
	(0.599)	(0.651)		(0.457)	(0.474)	
R^2	13.1%	23.6%	17.9%	40.5%	36.4%	49.3%
Obs.	54	52	50	54	52	50

52

Table A.I. **Example cross-sectional regression from 2009**

We report a sample cross-sectional forecasting regression (15) for the year 2009, the last year for which we have data at the five-year forecasting horizon:

$$\frac{E_{i,2009+h}}{A_{i,2009}} = a_{2009,h} + b_{2009,h} \log\left(\frac{M_{i,2009}}{A_{i,2009}}\right) + c_{2009,h}\left(\frac{E_{i,2009}}{A_{i,2009}}\right) + d^s_{2009,h}\mathbf{1}^s_{i,2009} + \epsilon_{i,2009,h},$$

where E is earnings (EBIT), A is total assets, M is market cap, and $\mathbf{1}^s$ is an indicator variable for sector s. Standard errors are clustered at the industry level (two-digit SIC code). Note however that these standard errors are not used in subsequent analysis since we use the time series variation in the estimates to form standard errors in our time series regressions (this is equivalent to a Fama-Macbeth regression). The sample consists of S&P 500 non-financial firms for 2009.

Horizon h (years):	E_{2009+h}/A_{2009}		
	$h = 1$	$h = 3$	$h = 5$
Constant	0.044	0.134***	0.094**
	(0.032)	(0.036)	(0.037)
$\log M_{2009}/A_{2009}$	0.039***	0.058***	0.061***
	(0.008)	(0.009)	(0.010)
E_{2009}/A_{2009}	0.454***	0.481***	0.461***
	(0.100)	(0.127)	(0.163)
Sector fixed effects	Yes	Yes	Yes
R^2	62.9%	50.4%	37.9%
Obs.	424	423	420

Table A.II. **Price informativeness, pairwise differences in means**

Differences in means of price informativeness at horizons of three and five years across decades. Price informativeness is calculated as in formula (16) using estimates from the cross-sectional forecasting regressions (15). The resulting price informativeness series are shown in Figure 3. For this table, in each column we regress the time series of price informativeness at a given horizon $h = 3, 5$ years on a set of indicator variables corresponding to each decade in our sample. The baseline decade varies by column. Since our sample ends in 2014, there are no five-year price informativeness estimates for 2010–2014. We report Newey-West standard errors with 5 lags in parentheses. S&P 500 non-financial firms, 1960 to 2014.

Price informativeness (×100), horizon h = 3 years

Baseline decade:	1960–69	1970–79	1980–89	1990–99	2000–09	2010–14
1960–69		-0.707	-1.075**	-1.406***	-1.561*	-0.840**
		(0.417)	(0.332)	(0.331)	(0.583)	(0.253)
1970–79	0.707		-0.367	-0.699	-0.854	-0.133
	(0.417)		(0.441)	(0.475)	(0.675)	(0.424)
1980–89	1.075**	0.367		-0.331	-0.487	0.235
	(0.332)	(0.441)		(0.396)	(0.618)	(0.327)
1990–99	1.406***	0.699	0.331		-0.155	0.566
	(0.331)	(0.475)	(0.396)		(0.716)	(0.326)
2000–09	1.561*	0.854	0.487	0.155		0.721
	(0.583)	(0.675)	(0.618)	(0.716)		(0.548)
2010–14	0.840**	0.133	-0.235	-0.566	-0.721	
	(0.253)	(0.424)	(0.327)	(0.326)	(0.548)	

Price informativeness (×100), horizon h = 5 years

Baseline decade:	1960–69	1970–79	1980–89	1990–99	2000–09
1960–69		0.106	-1.874***	-1.489***	-2.143***
		(0.378)	(0.134)	(0.397)	(0.311)
1970–79	-0.106		-1.980***	-1.595**	-2.249***
	(0.378)		(0.352)	(0.523)	(0.461)
1980–89	1.874***	1.980***		0.385	-0.269
	(0.134)	(0.352)		(0.391)	(0.300)
1990–99	1.489***	1.595**	-0.385		-0.654
	(0.397)	(0.523)	(0.391)		(0.563)
2000–09	2.143***	2.249***	0.269	0.654	
	(0.311)	(0.461)	(0.300)	(0.563)	

Table A.III. **Tests for a structural break in price informativeness**

We test for structural breaks in the evolution of price informativeness over time. Price informativeness is calculated as in formula (16) using estimates from the cross-sectional forecasting regressions (15). The resulting series are shown in Figure 3. For this table we regress each series on a constant and a linear time trend. The linear time trend is normalized to 0 in 1960 and 1 in 2014, hence the constant can be interpreted as the value of price informativeness in 1960 and the sum of the constant and the slope coefficient can be interpreted as the value of price informativeness in 2014. Newey-West standard errors with 5 lags are reported in parentheses. We then run a Supremum Wald test for a break in the estimated coefficients at an unknown break date and a Wald test for a break in the estimated coefficients in 2000, 2001, and 2002 (the adoption years of Regulation Fair Disclosure, decimalization, and the Sarbanes-Oxley Act). For each test we report the Wald statistic and associated p-value. For the test for an unknown break point we also report the year with the highest break point likelihood. The sample consists of S&P 500 non-financial firms from 1960 to 2014.

	Price informativeness ($\times 100$)		
Horizon h (years):	$h = 1$	$h = 3$	$h = 5$
Constant	1.976***	3.140***	3.755***
	(0.097)	(0.254)	(0.224)
Time trend	0.605***	1.940***	3.190***
	(0.224)	(0.451)	(0.343)
R^2	8.74%	18.93%	43.01%
Obs.	54	52	50
Test for an unknown break point:			
Highest likelihood break point	1996	1974	1980
Supremum Wald statistic (χ^2)	4.548	3.767	8.799
p-value	0.633	0.767	0.152
Test for a known break point in 2000:			
Wald statistic (χ^2)	0.830	2.059	0.454
p-value	0.660	0.358	0.797
Test for a known break point in 2001:			
Wald statistic (χ^2)	1.741	0.878	0.021
p-value	0.419	0.645	0.989
Test for a known break point in 2002:			
Wald statistic (χ^2)	0.678	3.762	1.076
p-value	0.712	0.152	0.584

Table A.IV. Summary statistics, all firms

Means, medians, and standard deviations of key variables, all firms. Market capitalization is from CRSP in millions of dollars as of the end of March. Total assets, research and development (R&D), capital expenditure (CAPX), and earnings (EBIT) are from Compustat in millions of dollars as of the end of the previous fiscal year. All quantities are adjusted for inflation using the GDP deflator (= 100 in 2010). Next, $\log(M/A)$ is the log-ratio of market cap to assets, $R\&D/A$ is R&D over assets, $CAPX/A$ is CAPX over assets, E/A is EBIT over assets, and $E(t+h)/A$, $h = 1, 3, 5$, is earnings in year $t + h$ over assets in year t. All ratios are winsorized at the 1% level. Idiosyncratic volatility is the standard deviation of returns over the last twelve months after subtracting the market return. Share turnover is volume divided by shares outstanding. Institutional share is the fraction of shares held by institutional investors (from 13-F filings). Option listings is an indicator variable for whether a firm has options trading on the CBOE (available after 1973). Option turnover is $100\times$ option volume over a year divided by equity shares outstanding (from OptionMetrics, 1996 to 2014). The sample consists of non-financial firms, 1960 to 2014.

	Full sample			1960-1985			1986-2014		
	Mean	Median	St. Dev.	Mean	Median	St. Dev.	Mean	Median	St. Dev.
Market Capitalization	1,611	124	10,283	795	90	4,430	2,106	153	12,545
Total Assets	1,893	165	11,499	1,297	172	6,114	2,200	161	13,452
R&D	59	4	371	33	2	178	69	4	421
CAPX	125	8	748	117	10	718	129	7	762
Earnings	170	10	1,041	134	16	753	188	8	1,159
$\log(M/A)$	-0.198	-0.216	1.066	-0.475	-0.513	0.972	-0.057	-0.052	1.084
$R\&D/A$	0.078	0.031	0.127	0.035	0.018	0.059	0.094	0.042	0.141
$CAPX/A$	0.070	0.048	0.072	0.084	0.062	0.075	0.064	0.042	0.070
E/A	0.027	0.076	0.217	0.092	0.102	0.137	-0.006	0.061	0.242
$E(t+1)/A$	0.052	0.080	0.197	0.106	0.106	0.137	0.025	0.065	0.217
$E(t+3)/A$	0.088	0.084	0.218	0.129	0.110	0.170	0.066	0.068	0.237
$E(t+5)/A$	0.119	0.087	0.252	0.151	0.114	0.210	0.100	0.070	0.271
Idiosyncratic volatility	0.140	0.112	0.111	0.117	0.098	0.077	0.153	0.123	0.124
Share turnover	0.107	0.049	0.238	0.036	0.021	0.052	0.139	0.074	0.279
Institutional share	0.398	0.344	0.307	0.234	0.148	0.250	0.419	0.376	0.308
Option listings	0.529	1.000	0.499	0.131	0.000	0.337	0.664	1.000	0.472
Option turnover	0.245	0.063	0.785				0.245	0.063	0.785
Firm-year obs.	211,984			80,561			131,423		

Table A.V. Price informativeness over time, all firms

Time series regressions of price informativeness by horizon for all firms. Price informativeness is calculated as in (16) using estimates from the cross-sectional forecasting regressions (15). The resulting price informativeness series are shown in Figure A.3. We then regress the time series of price informativeness at a given horizon $h = 1, 3, 5$ years on a set of indicator variables corresponding to each decade in our sample (the baseline decade, 1960–69, is captured by the constant). Since our sample ends in 2014, there are no five-year price informativeness estimates for the period 2010–2014. We report Newey-West standard errors with 5 lags in parentheses. The sample consists of all non-financial firms from 1960 to 2014.

	Price informativeness ($\times 100$)		
Horizon h (years):	$h = 1$	$h = 3$	$h = 5$
Constant (1960–69 level)	2.526***	3.813***	4.982***
	(0.214)	(0.644)	(0.807)
1970–79	0.305	0.711	0.854
	(0.220)	(0.709)	(0.978)
1980–89	-1.276***	-1.188*	-0.317
	(0.274)	(0.654)	(0.868)
1990–99	-1.902***	-1.882***	-0.466
	(0.221)	(0.679)	(0.980)
2000–09	-1.944***	-1.907**	-0.852
	(0.277)	(0.759)	(0.880)
2010–14	-1.854***	-2.266***	
	(0.292)	(0.653)	
R^2	81.8%	61.3%	19.3%
Obs.	54	52	50

Figure 1. **Summary statistics**

The sample consists of non-financial firms in the S&P 500 index from 1960 to 2014. Each panel shows medians (red line) and 10th to 90th percentile range (gray shading). $\log M/A$ is the log ratio of market capitalization to total assets. E/A is EBIT over assets. $R\&D/A$ and $CAPX/A$ are research and development and capital expenditure over assets. All quantities are adjusted for inflation.
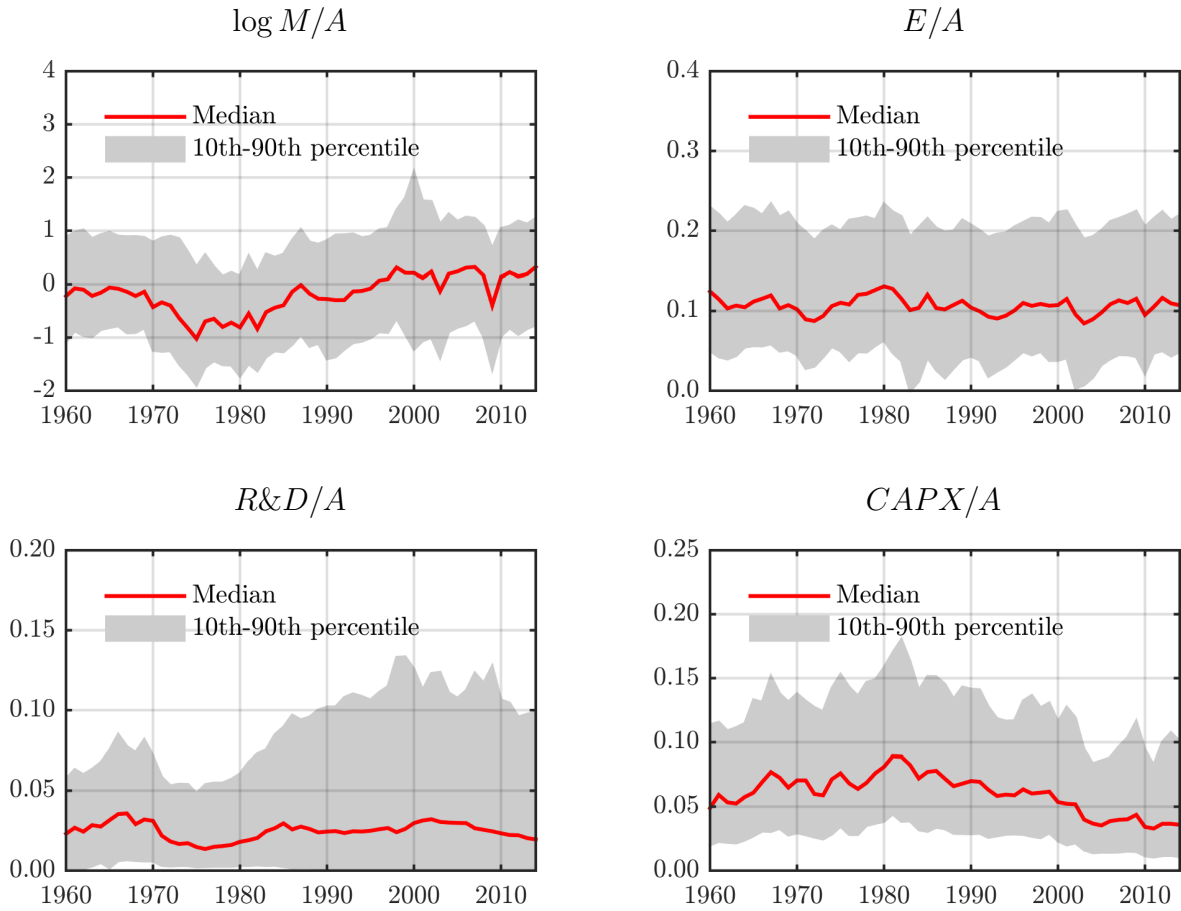
Figure 2. **Average price informativeness by horizon and sub-sample**
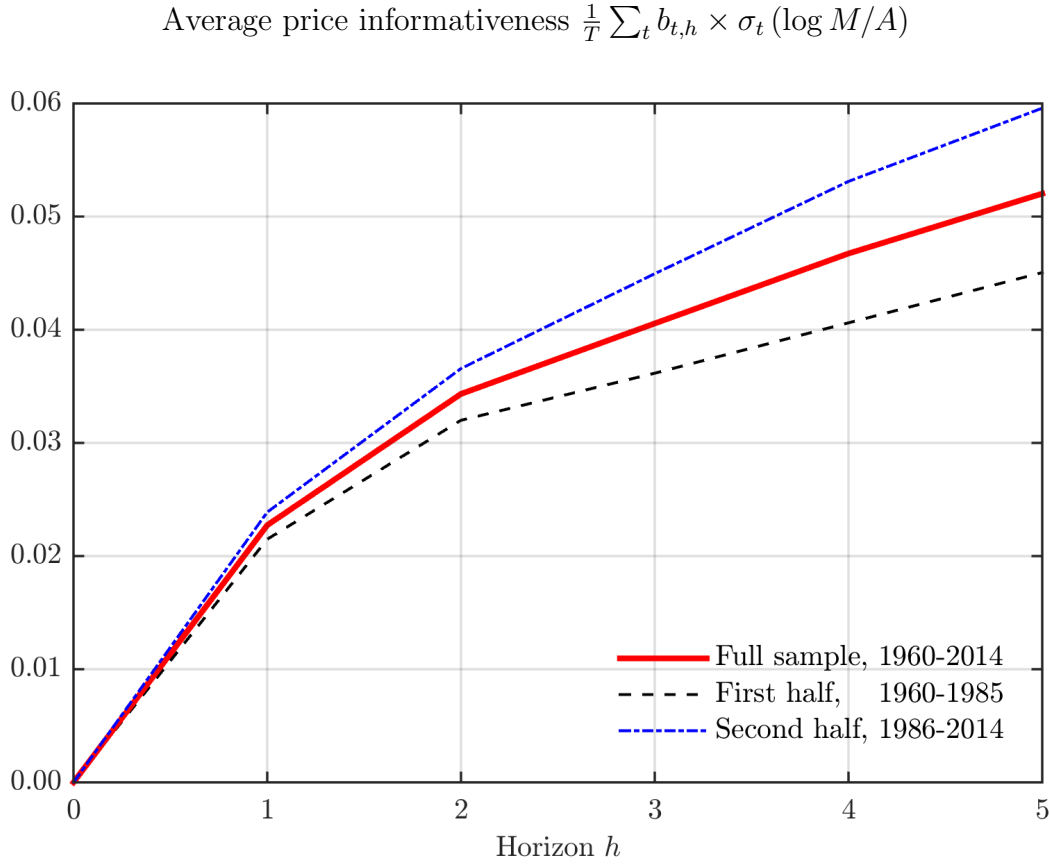
This figure shows average price informativeness calculated from the cross-sectional forecasting regressions (15):

$$E_{i,t+h}/A_{i,t} \quad = \quad a_{t,h} + b_{t,h} \log\left(M_{i,t}/A_{i,t}\right) + c_{t,h}\left(E_{i,t}/A_{i,t}\right) + d_{t,h}^s \mathbf{1}_{i,t}^s + \epsilon_{i,t,h},$$

where M is market cap, A is total assets, E is earnings (EBIT), and $\mathbf{1}^s$ is a sector (one-digit SIC code) indicator variable. We run a separate regression for each year $t = 1960, \ldots, 2014$ and horizon $h = 1, \ldots, 5$. Price informativeness for year t and horizon h is $b_{t,h} \times \sigma_t\left(\log M/A\right)$, where $\sigma_t\left(\log M/A\right)$ is the cross-sectional standard deviation of $\log M/A$ in year t. The horizontal axis represents horizon h. The solid red line shows price informativeness at horizon h averaged over the full sample, i.e. $\frac{1}{55} \sum_{t=1960}^{2014} b_{t,h} \times \sigma_t\left(\log M/A\right)$. The dashed black line is for the first half, 1960 to 1985, and the dash-dotted blue line is for the second half, 1986 to 2014. The sample consists of S&P 500 non-financial firms from 1960 to 2014.

Average price informativeness $\frac{1}{T} \sum_t b_{t,h} \times \sigma_t\left(\log M/A\right)$

Figure 3. Price informativeness over time

Results from the cross-sectional forecasting regressions (15):

$$E_{i,t+h}/A_{i,t} \;=\; a_{t,h} + b_{t,h}\log\left(M_{i,t}/A_{i,t}\right) + c_{t,h}\left(E_{i,t}/A_{i,t}\right) + d_{t,h}^{s}\mathbf{1}_{i,t}^{s} + \epsilon_{i,t,h},$$

where M is market cap, A is total assets, E is earnings (EBIT), and $\mathbf{1}^{s}$ is a sector (one-digit SIC code) indicator. We run a separate regression for each year $t = 1960,\ldots,2014$ and horizon $h = 1,3,5$ (for $h = 5$ the last available estimate is for 2009). The coefficients $b_{t,h}$ are plotted inside a 95% confidence interval. Price informativeness is $b_{t,h}\times\sigma_{t}(\log M/A)$, where $\sigma_{t}(\log M/A)$ is the cross-sectional standard deviation of $\log M/A$ in year t. Above each plot is a linear time trend τ normalized to zero and one at the beginning and end of the sample (plotted in black dots) with p-value based on Newey-West standard errors with five lags. The marginal R^2 is the difference between the full-regression R^2 and the R^2 from a regression that omits $\log M/A$. The sample consists of S&P 500 non-financial firms from 1960 to 2014.

Coefficients $b_{t,h}$ — Price informativeness $b_{t,h}\times\sigma_t(\log M/A)$ — Marginal R^2
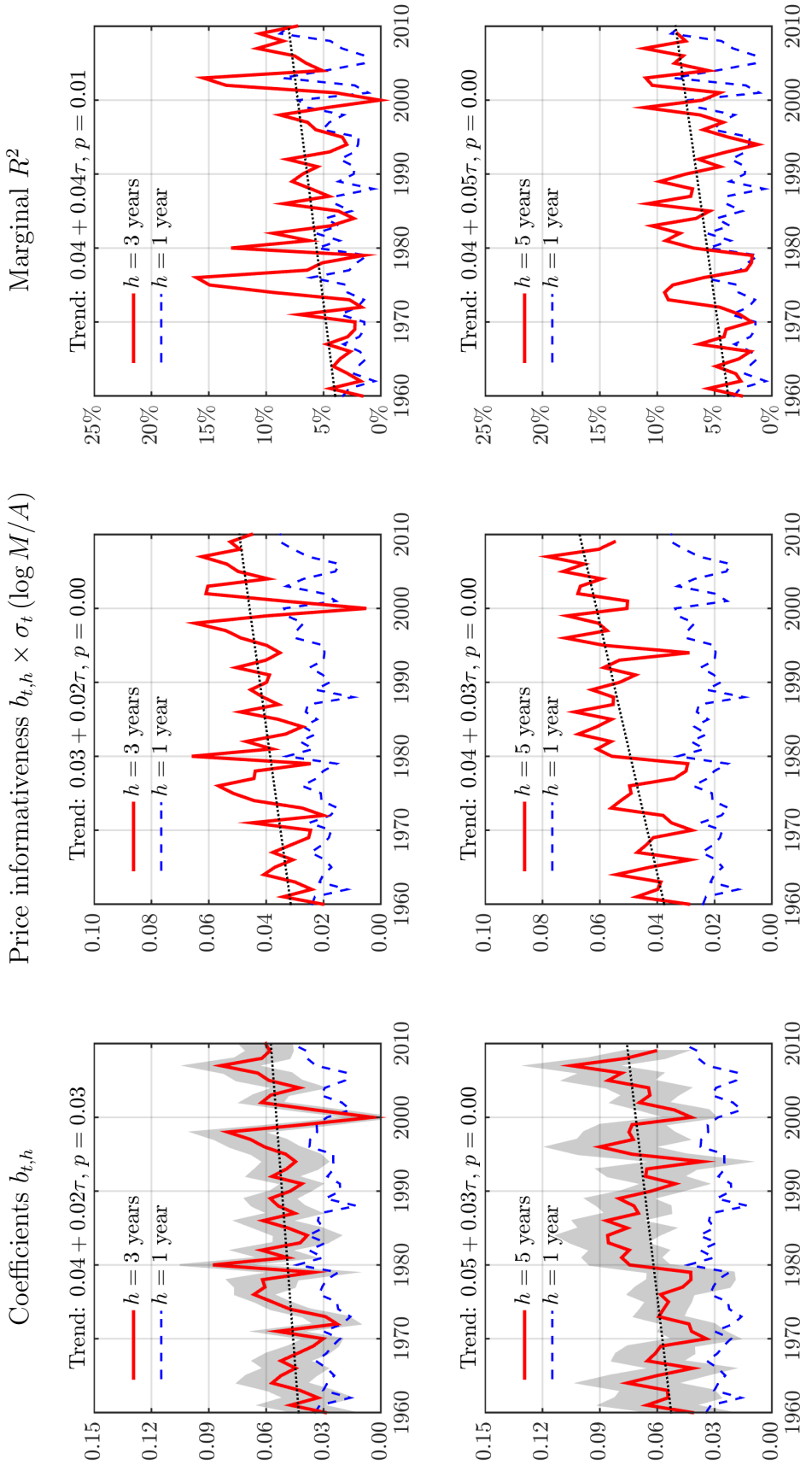
Figure 4. Market prices and investment

The predicted variation of investment from prices calculated from the cross-sectional forecasting regressions (18):

$$\frac{R\&D_{i,t+h}}{A_{i,t}} = a_{t,h} + b_{t,h}\log\left(\frac{M_{i,t}}{A_{i,t}}\right) + c_{t,h}\left(\frac{R\&D_{i,t}}{A_{i,t}}\right) + d_{t,h}\left(\frac{E_{i,t}}{A_{i,t}}\right) + e_{t,h}^s \mathbf{1}_{i,t}^s + \epsilon_{i,t,h},$$

where M is market cap, A is total assets, $R\&D$ is research and development spending, E is earnings (EBIT), and $\mathbf{1}^s$ is a sector (one-digit SIC code) indicator. We run the same regressions for CAPX (capital expenditure). We run a separate regression for each year $t = 1960, \ldots, 2014$ and horizon $h = 1, 3, 5$ (for $h = 5$ the last available estimate is for 2009). Informativeness of prices for investment is $b_{t,h} \times \sigma_t(\log M/A)$, where $\sigma_t(\log M/A)$ is the cross-sectional standard deviation of $\log M/A$ in year t. Above each plot is a linear time trend τ normalized to zero and one at the beginning and end of the sample (plotted in black dots) with p-value based on Newey-West standard errors with five lags. The sample consists of S&P 500 non-financial firms from 1960 to 2014. Data on R&D starts in 1972.

Predicted variation of investment from prices $b_{t,h} \times \sigma_t(\log M/A)$
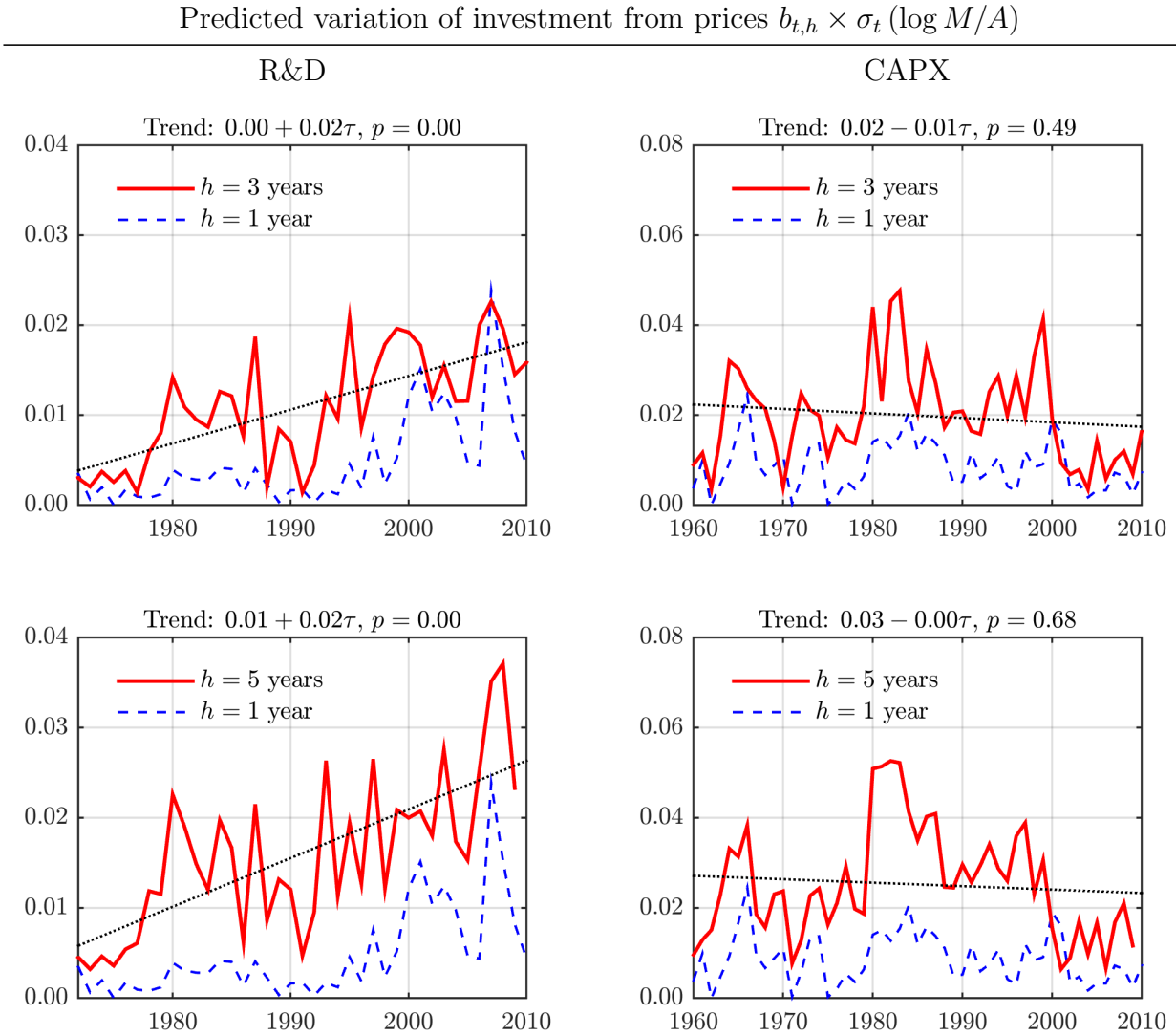
R&D   CAPX

Figure 5. Market prices and returns

The predicted variation of returns from prices calculated from the cross-sectional return predictability regressions (19):

$$\log R_{i,t\to t+h} = a_{t,h} + b_{t,h}\log\left(M_{i,t}/A_{i,t}\right) + c_{t,h}\left(R\&D_{i,t}/A_{i,t}\right) + d_{t,h}\left(E_{i,t}/A_{i,t}\right) + e^s_{t,h}\mathbf{1}^s_{i,t} + \epsilon_{i,t,h},$$

where $\log R_{t\to t+h}$ is the log return from t to $t+h$, M is market cap, A is total assets, E is earnings (EBIT), and $\mathbf{1}^s$ is a sector (one-digit SIC code) indicator variable. We run a separate regression for each year $t = 1960,\ldots,2014$ and horizon $h = 1, 3, 5$ (for $h = 5$ the last available estimate is for 2009). The predicted variation of returns from prices (solid red lines) is $b_{t,h} \times \sigma_t$ ($\log M/A$), where σ_t ($\log M/A$) is the cross-sectional standard deviation of $\log M/A$ in year t. Above each plot is a linear time trend τ normalized to zero and one at the beginning and end of the sample (plotted in black dots) with p-value based on Newey-West standard errors with five lags. We also plot price informativeness (the predicted variation of earnings from prices) for comparison (dashed black lines). The sample consists of S&P 500 non-financial firms from 1960 to 2014.

Predicted variation of returns from prices $b_{t,h} \times \sigma_t$ ($\log M/A$)
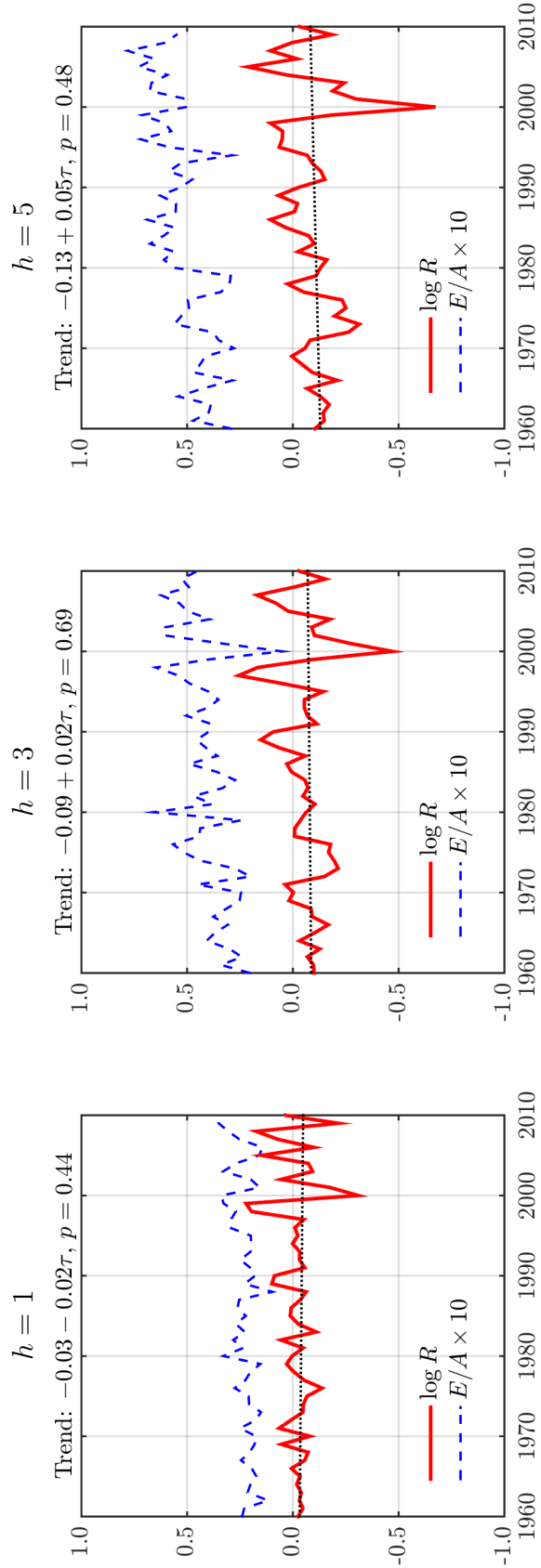
Figure 6. Aggregate efficiency

The predicted variation of earnings from investment calculated from the forecasting regressions (21):

$$\frac{E_{i,t+h}}{A_{i,t}} = a_{t,h} + b_{t,h} \log\left(\frac{R\&D_{i,t}}{A_{i,t}}\right) + c_{t,h} \log\left(\frac{CAPX_{i,t}}{A_{i,t}}\right) + d_{t,h}\left(\frac{E_{i,t}}{A_{i,t}}\right) + e_{t,h}^s \mathbf{1}_{i,t}^s + \epsilon_{i,t,h},$$

where $R\&D$ is research and development, CAPX is capital expenditure, M is market cap, A is total assets, E is earnings (EBIT), and $\mathbf{1}^s$ is a sector (one-digit SIC code) indicator variable. We run a separate regression for each year $t = 1972, \ldots, 2014$ and horizon $h = 1, 3, 5$ (for $h = 5$ the last available estimate is for 2009). The predicted variation of earnings from investment (solid red lines) is $\sigma_t \left(b_{t,h} \log R\&D/A + c_{t,h} \log CAPX/A\right)$, the cross-sectional standard deviation of the fitted linear combination of $R\&D/A$ and $CAPX/A$ in year t. Above each plot is a linear time trend τ normalized to zero and one at the beginning and end of the sample (plotted in black dashes) with p-value based on Newey-West standard errors with five lags. The sample consists of S&P 500 non-financial firms from 1972 to 2014 (R&D data is not available prior to 1972).
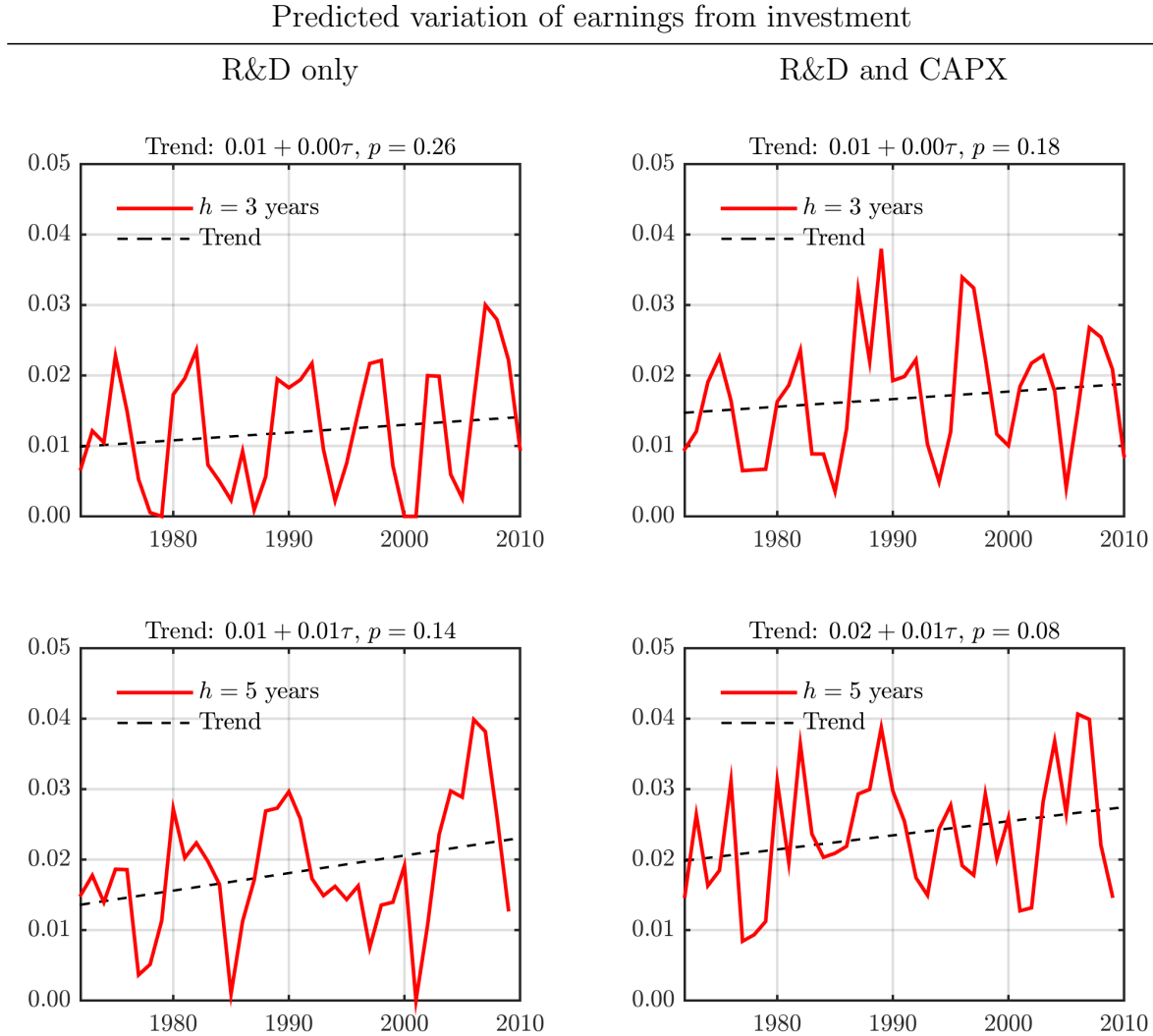
Predicted variation of earnings from investment

R&D only   R&D and CAPX

Figure 7. Institutional ownership and price informativeness

We compare price informativeness for firms with high and low levels of institutional ownership, using the median institutional share in each year as the cutoff. The left panel plots the average institutional share for firms in each group. Price informativeness is obtained separately for each group by running the forecasting regressions (15) and calculating the product of the forecasting coefficient and the cross-sectional standard deviation of market prices in year t, $b_{t,h} \times \sigma_t (\log M/A)$. Above each price informativeness plot is a linear time trend τ normalized to zero and one at the beginning and end of the sample (plotted in black dots) with p-value based on Newey-West standard errors with five lags. The sample consists of all non-financial firms from 1980 to 2014 (institutional ownership data is not available before 1980).
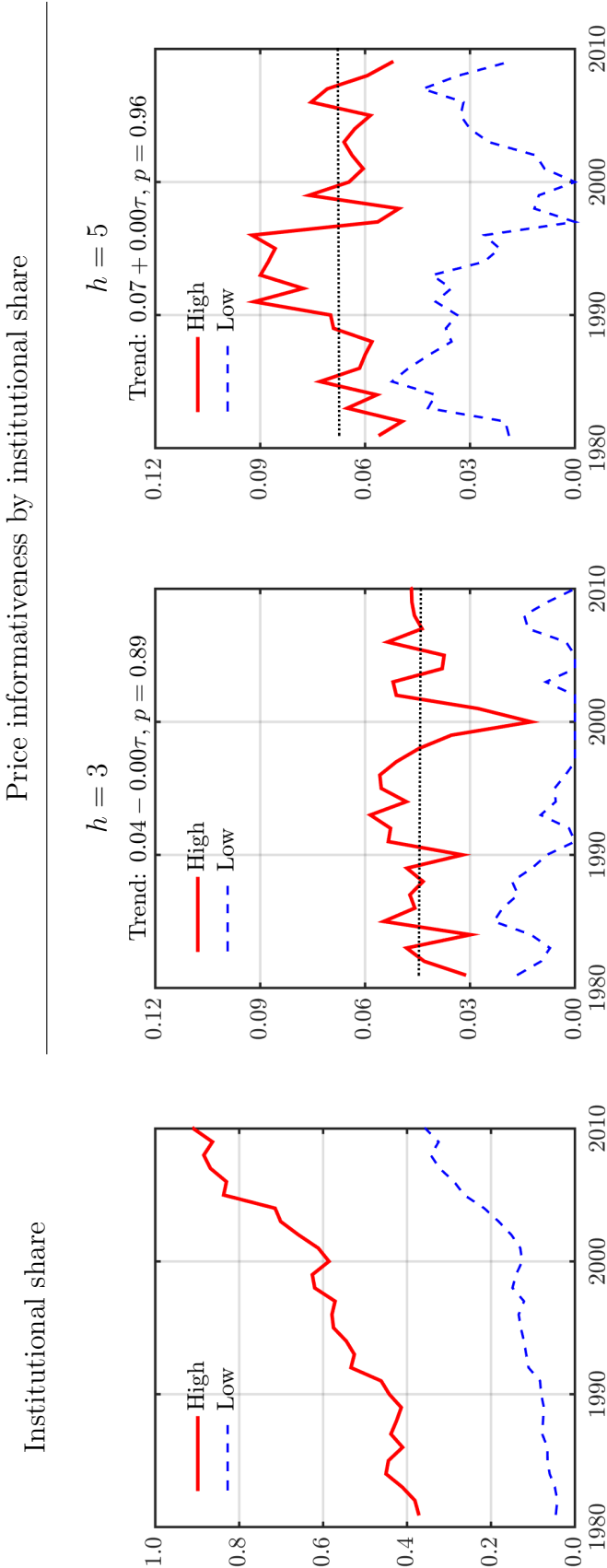
Price informativeness by institutional share

Institutional share

Figure 8. **Option trading and price informativeness**

We compare price informativeness for firms with and without option listings and for firms with high and low option turnover, using median option turnover in each year as the cutoff. Option turnover is $100\times$ option volume over a year divided by equity shares outstanding. Price informativeness is obtained separately for each group by running the forecasting regressions (15) and calculating the product of the forecasting coefficient and the cross-sectional standard deviation of market prices in year t, $b_{t,h} \times \sigma_t (\log M/A)$. Above each plot is a linear time trend τ normalized to zero and one at the beginning and end of the sample (plotted in black dots) with p-value based on Newey-West standard errors with five lags. The sample consists of S&P 500 non-financial firms from 1973 to 2014 for the option listing test (the CBOE began listing firms in 1973) and from 1997 to 2014 for the option turnover test (option volume is from OptionMetrics, which begins coverage in 1996).

Price informativeness by option listings (1973–2010)
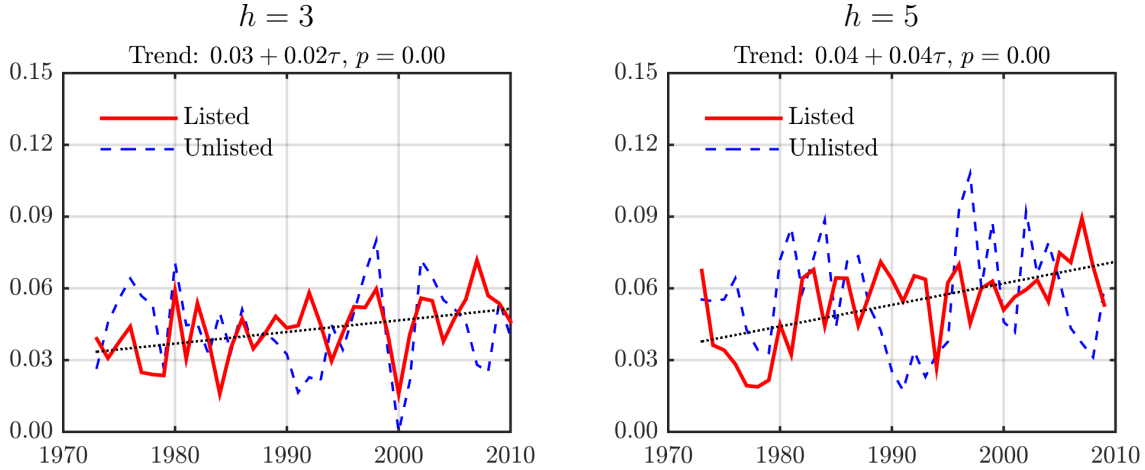
Price informativeness by option turnover (1997–2010)
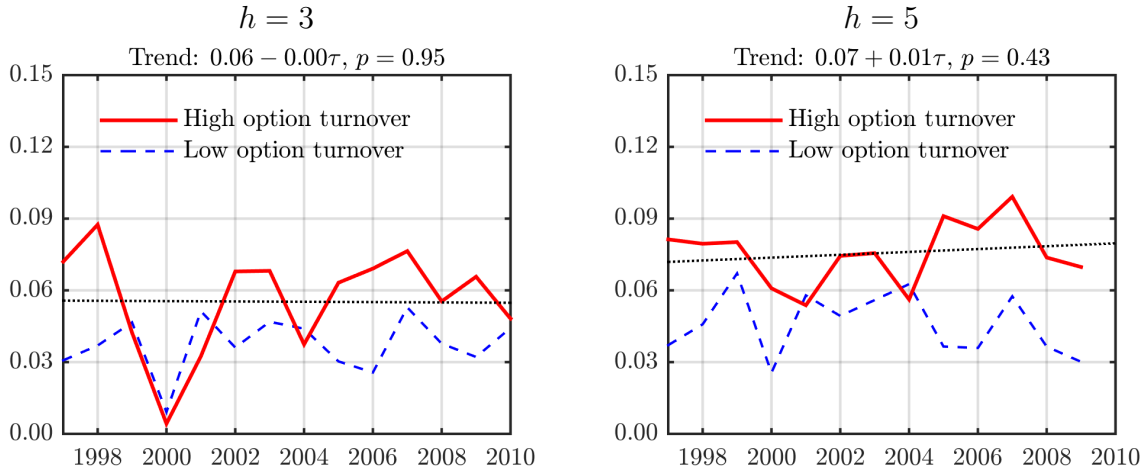

65

Figure 9. Liquidity and price informativeness

We compare price informativeness for firms with high and low levels of share turnover, using the median turnover in each year as the cutoff. The left panel plots the average log turnover for firms in each group. Price informativeness is obtained separately for each group by running the forecasting regressions (16) and calculating the product of the forecasting coefficient and the cross-sectional standard deviation of market prices in year t, $b_{t,h} \times \sigma_t (\log M/A)$. Above each price informativeness plot is a linear time trend τ normalized to zero and one at the beginning and end of the sample (plotted in black dots) with p-value based on Newey-West standard errors with five lags. The sample consists of S&P 500 non-financial firms from 1960 to 2014.

Price informativeness by turnover
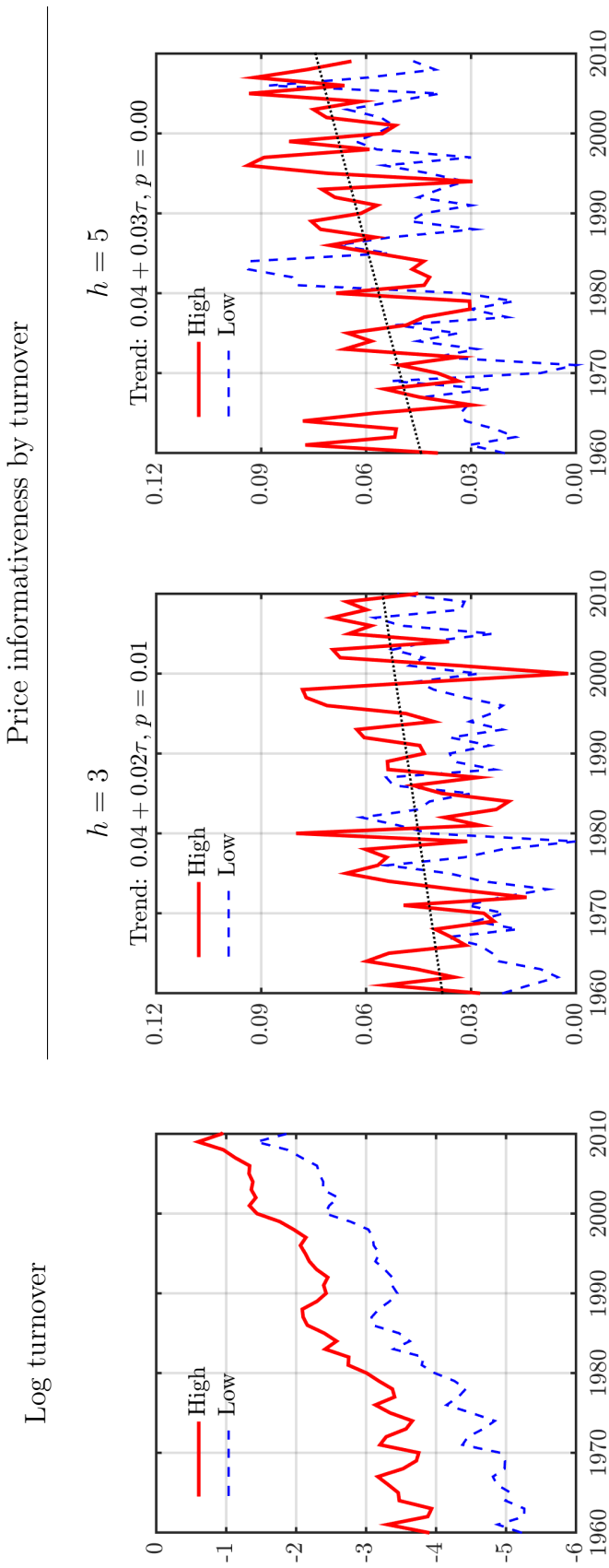
Log turnover

66

Figure 10. Growth options and price informativeness

We compare price informativeness for firms with high and low valuation ratios, using the median value of the valuation ratio $\log M/A$ in each year as the cutoff. We refer to high-valuation firms as growth firms and low-valuation firms as value firms. Price informativeness is obtained separately for each group by running the forecasting regressions (15) and calculating the product of the forecasting coefficient and the cross-sectional standard deviation of market prices in year t, $b_{t,h} \times \sigma_t (\log M/A)$. Above each plot is a linear time trend τ normalized to zero and one at the beginning and end of the sample (plotted in black dots) with p-value based on Newey-West standard errors with five lags. The sample consists of S&P 500 non-financial firms from 1960 to 2014.

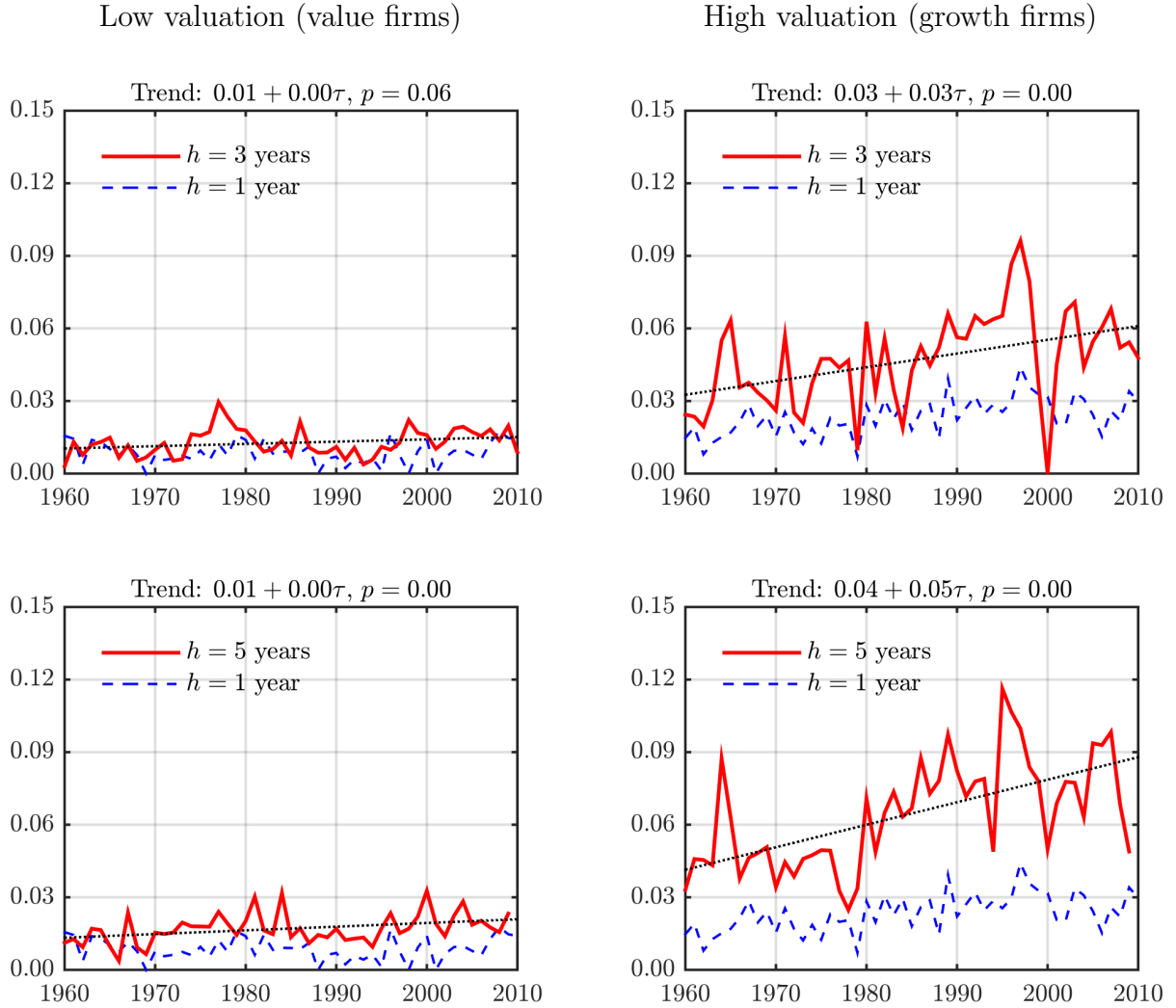Price informativeness by level of valuation

Figure A.1. **Average cross-sectional coefficients by horizon and sub-sample**

This figure shows average coefficients calculated from the cross-sectional forecasting regressions (15):

$$E_{i,t+h}/A_{i,t} \quad = \quad a_{t,h} + b_{t,h} \log \left(M_{i,t}/A_{i,t} \right) + c_{t,h} \left(E_{i,t}/A_{i,t} \right) + d_{t,h}^{s} \mathbf{1}_{i,t}^{s} + \epsilon_{i,t,h},$$

where M is market cap, A is total assets, E is earnings (EBIT), and $\mathbf{1}^{s}$ is a sector (one-digit SIC code) indicator variable. We run a separate regression for each year $t = 1960, \ldots, 2014$ and horizon $h = 1, \ldots, 5$. We report average of the coefficients $b_{t,h}$ for prices and $c_{t,h}$ for earnings. The horizontal axis represents horizon h. The solid red line shows coefficients at horizon h averaged over the full sample, i.e. $\frac{1}{55} \sum_{t=1960}^{2014} b_{t,h}$ and $\frac{1}{55} \sum_{t=1960}^{2014} c_{t,h}$. The dashed black line is for the first half, 1960 to 1985, and the dash-dotted blue line is for the second half, 1986 to 2014. The sample consists of S&P 500 non-financial firms from 1960 to 2014.

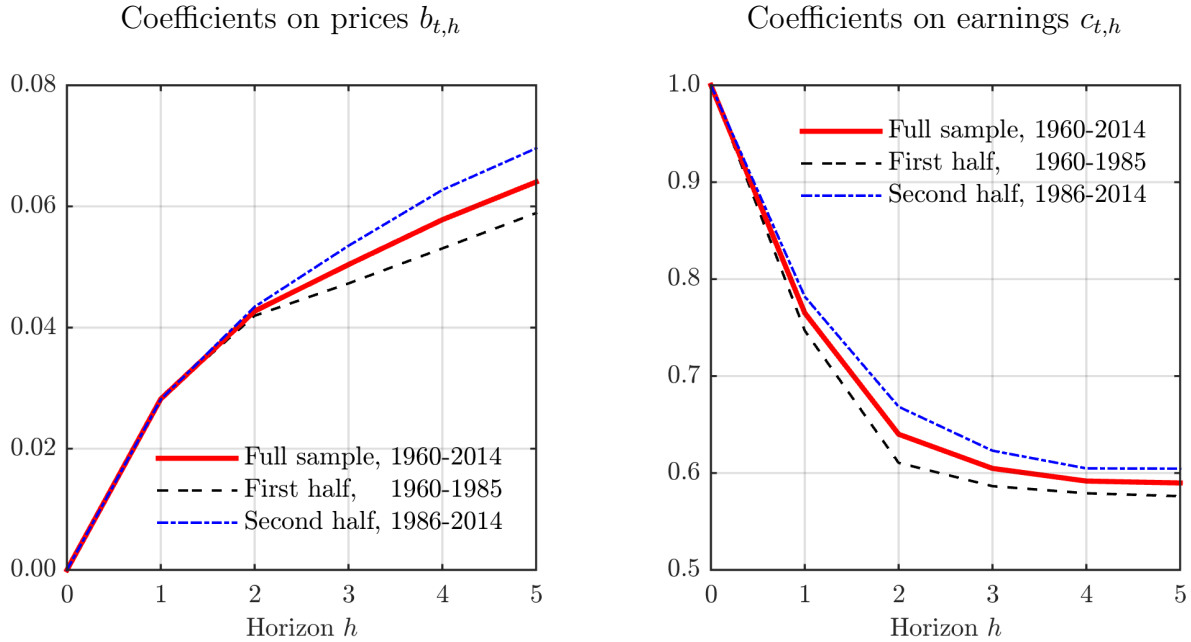Coefficients on prices $b_{t,h}$ — Coefficients on earnings $c_{t,h}$

Figure A.2. Price informativeness, robustness

We report price informativeness under several variations. Price informativeness is calculated by running the forecasting regressions (15) and taking the product of the forecasting coefficient and the cross-sectional standard deviation of market prices in year t, $b_{t,h} \times \sigma_t$ ($\log M/A$). In the first column, we add the book value of debt in calculating the valuation ratio (that is we use $M + D$ instead of M). In the second column, we use EBITDA instead of EBIT to measure earnings. In the third and fourth columns we use net income and cash flow from operations (CFO). Above each plot is a linear time trend τ normalized to zero and one at the beginning and end of the sample (plotted in black dots) with p-value based on Newey-West standard errors with five lags. The sample consists of S&P 500 non-financial firms from 1960 to 2014.
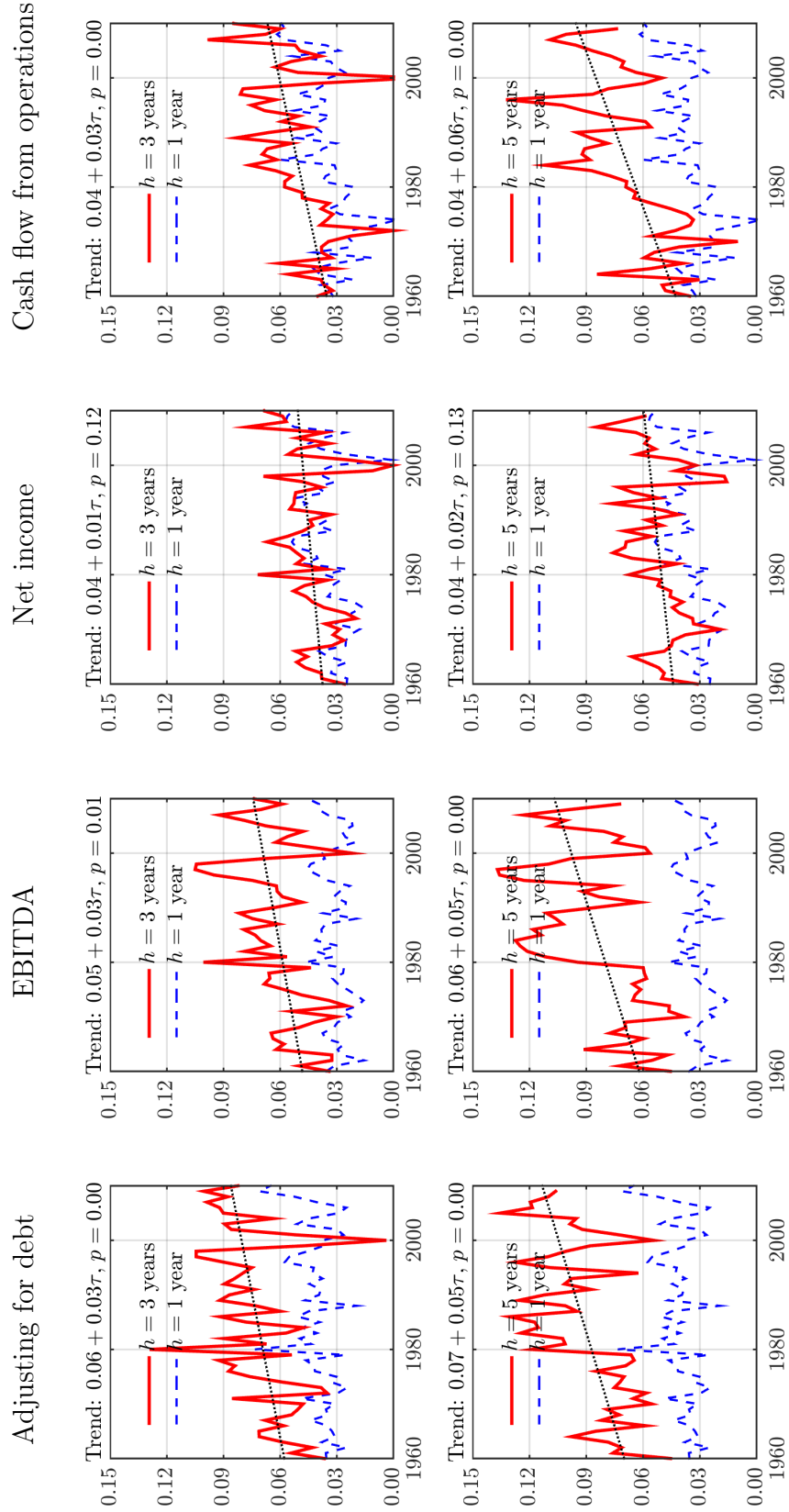
Figure A.3. **Price informativeness, all firms**

Earnings dispersion $\sigma_t(E/A)$, valuation dispersion $\sigma_t(\log M/A)$, coefficients $b_{t,h}$, and price informativeness $b_{t,h} \times \sigma_t(\log M/A)$ from the forecasting regressions (15), run separately for S&P 500 firms and all firms between 1960 and 2014. Above each of the bottom four plots is a linear time trend τ normalized to zero and one at the beginning and end of the sample (plotted in black dots) with p-value based on Newey-West standard errors with five lags. The dispersion series are measured as the cross-sectional standard deviations in each year.

Earnings dispersion $\sigma_t(E/A)$

Valuation dispersion $\sigma_t(\log M/A)$

Coefficients $b_{t,h}$

$h = 3$ Trend: $0.06 - 0.05\tau$, $p = 0.00$

$h = 5$ Trend: $0.07 - 0.04\tau$, $p = 0.00$

Price informativeness $b_{t,h} \times \sigma_t(\log M/A)$

$h = 3$ Trend: $0.04 - 0.03\tau$, $p = 0.00$

$h = 5$ Trend: $0.05 - 0.01\tau$, $p = 0.26$