How much do managers learn from the financial market? The decomposition of the investment-price sensitivity

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Abstract

Managers can learn information from the financial market, which can guide their investment decisions. However, how much do managers learn from stock prices? Even though previous literature provides some evidence on the relationship between managers' investment decisions and learning from stock prices, this indirect evidence cannot identify the proportion of elasticity of investment on stock prices coming from learning in the stock market. This paper develops a model of managers' learning in the context of investment decisions to decompose the investment-price sensitivity. The model is built with a noisy expectation framework, and managers and informed traders make optimal decisions based on the information signals they observe. Leveraging our model, we can decompose the investment-price sensitivity into two sources of covariance: internal information (already known to managers) and manager's learning (new to managers). We calibrate the model by matching the moments to the empirical counterparts of S&P 500 firms. The finding is that about 54% of the investment-price sensitivity contributes to the manager's internal information and 46% of that comes from the stock market learning. The increase in investment-price sensitivity does not necessarily indicate more market learning. Furthermore, the analysis of the full disclosure case has some implications for corporate disclosure policies that the increase in the disclosure may harm managers' learning from the financial market.

Keywords: Investment, financial markets, Financial efficiency, Disclosure

JEL Codes: E22, G31, G14

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Introduction

The primary function of financial market is the production and aggregation of information through trading. Theoretical literature and empirical evidence have supported the learning hypothesis that managers can learn some information from the stock markets. And this information can guide their investment decisions. The rationale behind this is that even though manager has a precise signal about their own firm's prospect, she is less informed about macroeconomic factors, industry competition and growth opportunities. A series of literature has provided evidence for this hypotheis. For example, Chen et al. (2007) finds that investment is more sensitive to Tobin's q with more private information in stock prices. Foucault and Fresard (2014) shows that firms learn from peer's stock prices, and the learning effect is stronger when a firm's stock price informativeness is lower or when its manager is uninformed. Even though previous literature provides some evidence on the relation between manager's investment decision and learning from stock prices, these indirect evidence cannot identify the proportion of elasticity of investment on stock prices coming from learning in the stock market. Furthermore, we cannot analyze the dynamics of manager's learning from stock prices when there are shocks to different information signals. A difficult task here is the decomposition of market-produced information from the firm-released information disclosed to the market in stock prices. This paper helps to understand the decomposition of investment-price sensitivity and how it responses to different shocks.

In this project, we ask following questions related to the effect of managers' learning from stock prices on their investment decisions: (i) How much do managers learn from the information in stock prices that incorporated through speculative trading and new to the managers (market learning)? How much information contained in the stock prices is already known to the manager (internal learning)? (ii) How does internal learning and market learning change with respect to changes in information signals? (iii) What's the effect of the change in fundamental shocks on internal learning and market learning? To answer these questions, following Bai et al. (2016), this paper develops a parsimonious model to decompose the investment-price sensitivity and identify different elasticity in response to different resources of the information. Our focus is not to identify the optimal investment level but how the elasticity of investment to to stock prices changes when there are shocks to different information signals. Further, we can estimate the welfare change generated by the financial market.

In the theoretical model, we have three major players: manager, informed traders and uninformed traders. Manager has superior (but not perfect) information about the productivity of the firms. Informed traders can incorporate their private information through speculative trading into stock prices. Uninformed traders provide liquidity in the market due to their liquidity needs. Public information is shared between traders through regular earnings announcements. Thus, stock price is a mix of public information, private information and noises. Manager is better informed about her own firm's profitability, earning and such accounting information. But she is less informed about market demand, industry competition, macroeconomic condition and other prospects. Making investment decision involves an integration of both internal and external information, it is inevitable for managers to resort to the information in stock market. After manager observes the stock prices and extracts some information from prices, she chooses the optimal investment level to maximize the firms' value. Thus, the investment level is correlated with the amount of the information that managers can learn from in the stock prices. In our model, informed traders maximize their mean-variance utility function to choose their demand. Market clears by equating the informed traders' demand and external liquidity supply, then equilibrium market price is determined and represented by a mix of signals and noise. Regressing the investment on Tobin's Q (a normalized price measure), we can get the investment-price sensitivity, which a standard measure to gauge how the investment reacts to the stock prices. Leveraging on our model, we can decompose the investment-price sensitivity into two sources of covariance: internal information (already known to managers) and manager's leaning (new to manager). The first covariance arises from internal information, if manager receives a high precision signal of her firm's productivity, she relys more on her internal information. The investment-price sensitivity arises even if she does not learn much from stock market. The second covariance arises from manager's learned information from stock prices, if manager extract more precise information about the fundamental of the firm, in other words, the price is more informative, her investment decision is more sensitive to the stock price. In this way, we answer the questions that how much managers can learn new information from stock prices by decomposing the investment-price sensitivity into two parts.

Based on the model, this paper finds that about 54% of the investment-price sensitivity comes from manager's internal information and 46% comes from market's learning. I conduct the analysis of how investment-price sensitivity, internal learning, market learning and forecasting price efficiency changes in response to the shocks of information signals, noise trading, realtive risk aversion and the uncertainty of fundamentals. The result shows that investment-price sensitivity will increase with an improvement in precison of internal signals, a reduction in noises, lower relative risk aversion and higher uncertainty in fundamentals. Market (internal) learning will increase as there is a lower precision of internal signal, higher precison of private signal, less noises in trading, low relative risk aversion and lower uncertainty in fundamentals. Forecasting price efficiency will increase as manager has a more precise internal information and private information of informed traders,much less noises in trading, low relative risk aversion and higher uncertainty in fundamentals. Comparing the baseline model (partial disclosure) with the full disclosure model, I find that market learning declines even though investment-price sensitivity and forecasting price efficiency both increase under the full disclosure. My finding echoes the result in (Jayaraman and Wu, 2018) that disclosure could reduce manager's ability to extract decision-relevant information from prices. These results have implications for policy-makers when they consider a reform about firm's mandatory disclosure policy. Also this paper sheds a light on the changes of market learning, internal learning and forecasting price efficiency when the firm faces a higher uncertainty in the fundamentals, espicially when the economy is experiencing a downturn.

Related Literature This paper contributes to the strand of literature that study the effect of market prices on corporate decisions (Luo (2005),Chen et al. (2007),Bennett et al. (2020), see Bond et al. (2012) and Goldstein (2022) for a survey). Chen et al. (2007) first examines relationship between the sensitivity of investment to stock prices and price informativeness. The hypothesis is that when prices are more informative, corporate investments are more sensitive to stock prices because managers will levy more on the information in stock prices to optimize their investment decisions. They find that the sensitity of investment to stock prices is positively related to the price informativeness, which consistent with the story that manager learns new information from the stock prices when making the investment decisions. Foucault and Frésard (2012) utilize the cross-listing to study the manager's learning from stock prices. The idea is that the precision of information conveyed by their stock price to managers is higher for the cross-listed firms than non-cross-listed firms, thus enhancing managers' reliance on stock prices. This paper provides the empirical evidence that the investment-to-price sensitivity of firms cross-listed on U.S. exchanges is significantly higher than that of non-cross-listed firms, which supports the manager's learning story. Edmans et al. (2017) uses the variation of the price informativeness created by a staggered enforcement of insider trading laws across 27 countries. The regulatory change in enforcement of insider trading laws discoverage manager's trading on their information but encourages more outsiders to acacquite and trade on the outsider information, and so bringing more of the information that is not known to managers into the price. This cause managers to base their investment levels on their respective stock prices in a greater extent because there is more relevant information in stock prices for their investment decisions. Furthermore, recent literature extend this strand of literature by studying the effect of peer's valuation on firm's investment. Foucault and Fresard (2014) find that manager learn additonal information about growth opportunity by looking at peer's stock price. Thus, the firm's investment decision is influenced not only by their own stock price but also by the stock price of their peers.

To study the effect of price informativeness on corporate investment decisions, the challenge is that there is no accepted way to separate the private information in stock prices that is new to managers from that already known to managers. The concern about previus finding is that if the information in stock prices is already known to managers without looking at stock prices, it automatically lead to the positive relation between the sensitivity of investment to stock price and price informativeness. Previous literature adopts several different strategies to circumvent this problem. For example, Chen et al. (2007) includes insider trading activities and earnings surprise to control for managerial information. They provide stronger support for their main finding that managers learn from the private information in stock price about their own firms' fundamentals and incorporate this information in the corporate investment decisions. However, the measures of managerial information are endogeous, and the vadility of this result depends on the extent that insider trading activities and earnings surprises are reasonable proxies for managarial information. Foucault and Frésard (2012) use a novel stragety that cross-listing enhances the price informativeness for those cross-listed stock, which natually create an environment to study the effect of the amount of private information impounded into the price on corporate investment decisions. Edmans et al. (2017) utilized the regulatory shock to the amount of insider's information impounded in the stock prices to isolate the effect of private information in stock prices on corporate investment decisions.

This paper also relates to the disclosure and real effect of stock prices on real decisions (e.g. the investments). (Goldstein and Yang, 2019) build a theoretical model and study the effect of disclosure on real-efficiency. They find that if the positive effect of providing more information deminates the negative effect of reducing new information learned by manager, then disclosure has a positive effect on the forecast quality of managers. (Jayaraman and Wu, 2018) use mandatory segment reporting in the United States as an exogenous shock to the disclosure to study the overall impact of disclosure. Their empirical evidence supports that the benefit of lower information asymmetry overweighs the cost of lower learning from stock prices, suggesting that a net negative consequence of promoting the disclosure. (Bird et al., 2020) utilized the staggered introduction of EDGAR(Electronic Data Gathering, Analysis, and Retrieval) platform to further test the hypothesis that prices be less informative to managers due to the crowding out of external information gathering. The idea is that publicizing more internal information disincentivizes the outsider to acquire information and impound these fundamental-relevant into stock prices.

The first contribution of this paper is to disentangle the new information from those information managers already known in the stock prices. Based on reduced model, prior literature finds the positive relation between investment-price sensitivity and the amount of private information on stock prices. Due to the difficulty of observing the information set of manager, researchers have not investigate how much information managers can learn from stock prices. We contribute to fill this gap by decomposing the investment-price sensitivity from different information sources based on a simple structural model. Second, we could perform counterfactual analysis to examine the effect of regulations on firms or other shocks on the investment decisions through impacting manager's learning channel. Thus our paper could provide some insights to regulators when they plan to make reforms on firms.

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Outline The paper is organized as follows. Section 1 describes the information environment, sets up the equilibrium and demonstrates hwo to decompose the investment-price sensiticity. Section 2 provides a quantitative analysis and the main quantitative results of the decomposition of two channels - internal learning and market learning. Section 3 conducts a comparative analysis, and Section 4 concludes.

1 Model

We present a static model of manager's learning in the context of investment. In the model, we have three major players: manager, informed traders and uninformed traders. Manager's objective is to maximize firm's value and she chooses the optimal investment level based on her forecast about productivity shock. Informed traders actively participate in the stock trading market, and they choose the traded quantitiy to maximize their utility. Uninformed traders provide exogenous liquidity in the stock market and clear the market.

There are three dates, t= 0,1,2. At date 0, firms release a subset of internal information to the public through public disclosure. Informed traders trade in the stock market based on their information about the fundamentals of the firm and the stock price is determined simultaneously. At date 1, after observing the stock prices, managers can extract some new information and choose the optimal capital level to maximize firm's value based on her forecast of the fundamental of the firm. At date 2, the productivity shock is realized and z is realized and all payoffs are received.

1.1 Environment

Production Technology The real side of the firm is characterized by a production technology that uses only capital, k. Per period output is given by $(1+z)(\bar{k}+k)$, $\bar{k}$ is the assets in place, k is the investment in new capital, z is the true productivity shock which cannot observed perfectly by managers or market participants in the stock market. The shock z follows a normal distribution

$$z \sim N(0, \sigma_z^2) \tag{1}$$

Information Environment Following (Bai et al., 2016), we model the information environment faced by agents in the market. In our model, there is a productivity shock z. Managers could observe an imperfect signal about the true productivity based on her internal information. Besides, she also could extract some information from the stock prices in the financial market.

The internal information produced by the firm is summerized by:

$$\eta = z + \epsilon_\eta \tag{2}$$

where $\epsilon_\eta \sim N(0, \sigma_\eta^2)$. The precision of this signal η is denoted as $h_\eta = 1/\sigma_\eta^2$.

Informed traders can produce and incorporate private information about firm's productivity into security prices. The private information observed by the informed traders is summerized by:

$$s = z + \epsilon_s \tag{3}$$

where $\epsilon_s \sim N(0, \sigma_s^2)$. The precision of this signal s is denoted as $h_s = 1/\sigma_s^2$. We assume that ϵ_η and ϵ_s are independent.

Informed traders and managers also share common sources of information, most prominently through disclosure. For example, public firms release quarterly earnings statement, in this way, managers disclose part of their internal information to the public. This additional information observed by informed traders is summerized by:

$$\eta^{'} = \eta + \epsilon_{\eta'} \tag{4}$$

where $\epsilon_{\eta'} \sim N(0, \sigma^2_{\eta'})$ is orthogonal to ϵ_η and ϵ_s. The precision of this signal $\eta^{'}$ is denoted as $h_{\eta'} = 1/(\sigma^2_\eta + \sigma^2_{\eta'})$.

Traders and stock market There is a number of n ex-ante identical informed traders in the stock markets. Informed traders acquire the information about firm's fundamentals and trade on their information to maximize their utility. Each informed trader is endowed wtih two signals about the fundamentals of the firms at date 0. The first signal is the private information s observed by the informed traders. The second signal is the public information $\eta^{'}$ observed by all participants in the market. Each informed trader can buy or sell x shares of stocks in the market. They have a standard mean-variance expected utility with coefficent of risk aversion ρ:

$$\max_x x\mathbb{E}[z - p|\eta^{'}, s] - \frac{\rho}{2} x^2 \mathbb{V}ar[z|\eta^{'}, s] \tag{5}$$

The stock price is denoted by p. Following Goldstein et al. (2013), we assume that informed traders do not observe the price when they trade in the market and hence they submit the market order, as in Kyle (1985). The simple setup is to caputure the idea that managers have the stock price information that informed traders do not have when managers are making the investment decisions.

Market clearing At date 0, conditional on his information set, each informed trader submits a market order to sell or buy a specific number of shares of stocks. Also there is a noisy supply of uninformed traders who are subject to random shocks that force them to buy or sell the stock at any current price. The traditional interpretation of noisy supply is that there is a group of agents who trade for exogenous reasons, such as liquidity or hedging needs. They don't trade on their information and they will accept any current price of stocks. This noise ensures that the information extracted from stock prices is not a percise signal about information that others traders may know. The exogenous noisy supply of the stocks is as follows:

$$u \sim N(0, \sigma_u^2) \tag{6}$$

Firm's investment We consider a firm with ex-post fundamental value as follows:

$$v(z, k) = (1 + z)(\bar{k} + k) - k - \frac{\gamma}{2\bar{k}} k^2 \tag{7}$$

where $\bar{k}$ is the assets in place, k is the investment in new capital, z is the productivity shock and γ is the adjustment cost parameter. Without loss of generality, here I assume that the firm purchases and sells capital at a price of one. And firm must incur a capital stock adjustment costs of $C = \gamma\bar{k}\left(\frac{k}{\bar{k}}\right)^2$. This cost can be considered as the extra cost of raising the capital, which is increasing in the rate of adjustment, which is also increasing in the size of the new investment. [1] The total value of the firm is the value he captures from the ouput generated by the production technology minus her cost of raising capital. At date 1, the manager is endowed with two signals. The first signal is her internal information about the fundamental η. The second signal is the information extracted from the stock price $s^{'} = s - \frac{\rho}{nh_s}u = z + \epsilon_s - \frac{\rho}{nh_s}u$. The precision of this signal is denoted as $h_{s^{'}} = 1/(\sigma_s^2 + (\frac{\rho}{nh_s})^2\sigma_u^2)$. It is important to emphasis that even manager has a superior information about firm's fundamental, she still has an incentive to look at the stock prices and learn from the market, as traders in the market have other signals that she does not know. The manager chooses the

[1] Charles C. Holt (1960) found a quadratic specification of adjustment costs to be a good approximation of hiring and layoff costs, overtime costs, inventory costs and machine setup costs in the selected manufacturing industries. The costs of investment may also be related to the rate of adjustment with higher costs for more rapid changes, specified as $C = \gamma\bar{k}\left(\frac{k}{\bar{k}}\right)^2$

investment level k^* to maximize the firm value conditional her information set $\mathcal{I}_m = \{\eta, s'\}$:

$$k^* = argmax_k \mathbb{E}[v(z,k)|\mathcal{I}_m] \tag{8}$$

1.2 Equilibrium

Given the above equations, we now turn to the definition of the equilibrium.

Definition 1 *A equilibrium consists of a price level p, an investment policy k^* for the manager, strategies for informed traders x, such that*

- *Given p,informed traders choose their demand of shares x to solve a mean-variance utility maximizing problem*
- *Given the price level p, managers choose the optimal investment k^* to solve firm value maximizing problem under her information set*
- *The market clearing condition is satisfied : $nx = u$*

1.3 The decomposition of investment-price sensitivity

In this section, we will solve for the equilibrium and especailly demonstrate how we decompose the investment-price sensitivity. Generally, investment-price sensitivity arised from two sources of covariance between investment and the stock price p: internal learning (information already known to managers) and manager's leaning (information new to manager). The first covariance arises from internal information, if manager receives a high precision signal of her firm's productivity, she rely more on her internal information. Through the internal learning channel, the investment-price sensitivity arises even if the manager does not learn much from stock market. The second covariance arises from manager's learned information from stock market, if manager extract more precise information about the fundamental of the firm, in other words, the price is more informative, her investment decision is more sensitive to the stock price.

Lemma 1 *In the equilibrium, we have the following[2]:*

1. *Firm optimal investment is given by*

$$k^* = \frac{\bar{k}}{\gamma} \cdot \frac{h_\eta \eta + h_{s'} s'}{h_z + h_\eta + h_{s'}} \tag{9}$$

2. *The equilibrium price in the stock market is given by*

$$p = \frac{h_s s + h_{\eta'} \eta' - \frac{\rho}{n} u}{h_z + h_s + h_{\eta'}} \tag{10}$$

3. *Forecasting price efficiency (FPE) is*

$$\mathbb{V}ar(\mathbb{E}[z|p]) = \frac{h_\pi}{h_\pi + h_z} h_z^{-1} \tag{11}$$

4. *We decompose the investment-price sensitivity as follows:*

$$\beta_{k^* p} = \frac{cov(k^*, p)}{Var(p)} = \Delta\{ \underbrace{cov(\eta, p)}_{internal\ information} + \underbrace{cov(s', p)}_{manager's\ learning} \} \tag{12}$$

where $\Delta = \frac{\bar{k}}{\gamma Var(p)(h_z + h_\eta + h_{s'})(h_z + h_{\eta'} + h_s)}$

$$cov(\eta, p) = h_\eta * \left(h_s h_z^{-1} + h'_\eta h_z^{-1} + h_{\eta'} h_\eta^{-1} \right)$$

$$cov(s', p) = h_{s'} * \left(h_s h_z^{-1} + h_{\eta'} h_z^{-1} + 1 + \frac{\rho^2}{n^2 h_s} \sigma_u^2 \right)$$

2 Quantitative Analysis

In this section, I quantify the decomposition of investment-price sensitivity using calibrated parameters that match U.S. firms data. Based on this quantitative analysis, I can assess the

[2] See AppendixA.1 for details.

importance of the two channels (i.e. internal learning and market learning) on manager's investment decisions.

2.1 Estimation of the investment-price sensitivity

To decompose the investment-price sensitivity, the first step I need is to estimate the magnitude of investment-price sensitivity. I obtain S&P 500 firms' data from the Compustat. The sample period is from 1985 to 2015. I exclude firms in the financial industries (SIC code 6000–6999) and utility industries (SIC code 4900-4990). I also drop firm-year observations with less than \$10 million book value of equity. The final sample consists of 7,745 firm-year observations with 363 firms.

To get the estimation of investment-price sensitivity, I run cross-sectional regressions of future capital expenditures on current market prices:

$$\underbrace{\frac{CAPX_{i,t+1}}{Asset_{i,t}}}_{\text{Investment}} = \alpha + \beta \underbrace{\left(\frac{M_{i,t}}{Asset_{i,t}}\right)}_{\text{Price}} + \underbrace{\delta \left(\frac{CF_{i,t+1}}{Asset_{i,t}}\right) + \lambda \left(\frac{1}{Asset_{i,t}}\right)}_{\text{Controls}} + \underbrace{(e^s \mathbf{1}^s)}_{\text{Industry Effect}} + \underbrace{(e^t \mathbf{1}^t)}_{\text{Year Effect}} + \epsilon_{i,t} \tag{13}$$

As in Equation 13, the dependent variable is the investment of the firms. I use the capital expenditures scaled by beginning-of-year book assets to approximate the investments. I use the firm's Tobin's Q in our analysis as a normalized price measure. And Tobin's Q is calculated as the market value of equity (price times shares outstanding from CRSP) plus book value of assets minus the book value of equity (Item 6–Item 60), scaled by book assets, all measured at the end of year t. The main coefficient of interest is β, which measures the sensitivity of investment to stock prices. I also include several control variables to accommodate their effects on investments. The control variables ($Controls$) are as follows: $1/Asset_{i,t}$, $CF_{i,t}/Asset_{i,t}$. I include $1/Asset_{i,t}$ because both the dependent variable (I_{it}) and the price measure Q_{it} are scaled by the book assets in the previous year ($Asset_{i,t}$), which may induce the spurious correlation. Previous studies have documented the effect of cash flows ($CF_{i,t}$) on investments (e.g. Fazzari et al. (1988)), thus we include both cash flows $CF_{i,t}/Asset_{i,t}$. We measure cash flows as the sum of net income before extraordinary items (Item 18), depreciation and amortization expenses (Item 14), and R&D expenses (Item 46), scaled by beginning-of-year book assets. I also control for the industry effect and time effect. Table 1 shows the estimation result. In my sample period, the investemtn-price sensitivity is about 0.005.

2.2 Parameterization

To reduce the burden of estimation, I set a subset of parameters exogenously using data moments, then I estimate the rest of parameters within the model. Table 2 summarizes these externally calibrated parameters.

My theory builds on the optimization of agents' behavior conditional on their information set. So a group of important parameters are the precision of agents' information. Even though I cannot observe the managers or the informed traders information set directly, I could exploit literature advanced approach to estimate some of these information precision externally. Following Brogaard et al. (2022), I can identify and obtain the precision of public information and the noises from stock price movements based on a return variance decomposition model [3]. So, the precision of public information $h_{\eta'}$ is set to be 0.2096. The variance of noise trading σ_s^2 is chosen with a value of 3.88.

The model requires five parameters to be calibrated internally: the precision of productivity shock h_z, the precision of manager's information h_η, the precision of manager's learning from stock prices $h_{s'}$, the relative risk aversion $\frac{\rho}{n}$, the replacement costs γ. We jointly calibrate them to match five data moments. The moments for the data are : (1) the precision of information of informed traders, (2) the forecasting price efficiency, (3) the investment-price sensitivity, (4) the variance of price measure and (5) the variance of investment. [4]

Table 3 summarizes the moment descriptions and values for the calibration.

[3]See Appendix A.3 for the details.
[4]See Appendix A.2 for the details.

2.3 Decompostion of the investment-price sensitivity

Table 4 presents the calibrated values and the propotion of internal learning and manager learning from decomposing the investment-price sensitivity.

The precision of productivity shock is about 3.5. The estimated precision of the unobserved manager's information is about 0.4668, consistent with my assumption, which is greater than the precision of public information 0.2096. The precision of manager's learned signal from stock prices is about 0.0021, which is much lower than the precision of private information 0.2725. The relative risk aversion is about 2.76, and this number is comparable with the estimate in Kurlat and Veldkamp (2015) [5]. The replacement cost parameter is about 2.85. Compared to the results in Cooper and Haltiwanger (2006), this estimate is in a reasonable range.

Based on all the parameters mentioned above, the model generates two covariances: (i) the covariance between price and internal information signal, (ii) the covariance between price and manager's learned signal. The internal information covariance is about 0.2731 and the second manager's learning covariance is slightly lower, which is about 0.2301.

Furthermore, the result of the decomposition for two channels is that: about 54% of the investment-price sensitivity comes from internal learning and about 46% of the investment-price sensitivity comes from the manager learning. In this way, I can assess the importance of these two channels on the sensitivity of investment to stock prices.

3 Comparative Analysis

In this section, I study the dynamics of investment-price sensitivity, internal learning, market learning and forecasting price efficiency in response to the shocks of signals. Especially, I compare the baseline model (partical disclosure) with the full disclosure model to study the effect of disclosure policy on manager's market learning.

[5] Kurlat and Veldkamp (2015) gets the estimate for the relative risk aversion in bond market, so my estimate in stock market is greater thatn their estimate.

3.1 Shocks to information signals

Figure 1 demonstrates how investment-price sensitivity, internal learning, market learning and forecasting price efficiency changes when the precision of internal information changes. When the internal information is more precise, investment-price sensitivity is increasing. The improvement in internal informaion precision leads the manager to rely more on her internal information and less on the stock-market learned information. As what we can see from the second and third panel graph, internal learning is increasing and market learning is decreasing at the same time. This implies that even though investment-price sensitiviy increases, it doe not nessarily mean that manager's investment decision response more to the impounded new information in stock prices. This result also provides a good explanation for the importance of isolating the internal learning channel from the market learning channel. Price reflects more about the fundamental information, so the forecasting price efficiency is increasing.

Under the full disclosure, investment-price sensitivity is higher than the baseline model. Internal learning is higher than that in the baseline model, and market learning is lower than that in the baseline market. This results echoes the finding in Jayaraman and Wu (2018) that disclosure could reduce managers' ability to glean decision-relevant information from prices. Besides, I find that full disclosure increases forecasting price efficiency because more disclosure will enhance the price informativeness.

Figure 2 shows the dynamics of investment-price sensitivity, internal learning, market learning and forecasting price efficiency when the precision of informed traders' signal changes. When the private information signal observed by informed traders is less precise (variance becomes larger), the investment-price sensitivity increases in the beginning and then drops as the variance becomes higher. There is a relative higher proportion of market learning and a relative lower proportion of internal learning when the private signal gets more precise. That is because when informed traders have a more accurate signal about the fundamentals, manager will glean more relevant information from stock prices. Also, the forecasting price efficiecy will increase as informed traders bring more useful information into stock prices.

For the comparison between baseline model and full disclosure model, there is higher investment-price sensitivity, forecasting price efficiency and internal learning but lower market learning under full disclosure. This result is the same as what I find when the precision of internal information changes.

3.2 Noise trading

Figure 3 illustrates the how investment-price sensitivity, internal learning, market learning and forecasting price efficiency in response to the change in the variance of noise in stock prices. Due to the existence of noise traders, manager cannot have a perfect information about what others know about the fundamentals. As the noises becomes larger, the investment-price sensitivity decreases, market learning decreases but internal learning increases. The explanation behind this is the larger noises reduce manager's ability to extract relevant information from stock prices, so she will rely more on her internal information. And the noises reduces forecasting price efficiency.

This result echoes the empirical finding in Dessaint et al. (2018) that a firm's investment reponse to the noise in its product market peers' stock prices by controlling for the effect of firms' own stock price. This result also suggests that nonfundamental shocks to stock prices can generate a a harmful real effect on investment efficiencies because they influence managers' beliefs about their growth opportunities.

The result of comparison between baseline model and full disclosure model still holds.

3.3 Relative risk aversion

Figure 4 shows the dynamics of investment-price sensitivity, internal learning, market learning and forecasting price efficiency when the relative risk aversion of informed traders changes. As the relative risk aversion becomes higher, the investment-price sensitivity becomes lower, and manager relys more on internal learning and less on market learning. Moreover, forecasting price efficiency decreases as the increase in relative risk aversion. A possible reason behind this is that as informed traders are more risk averse on the average, they will be less active in acquiring and trading on the private information. As a result, the forecasting price efficiency decreases, and manager's market learning also declines.

3.4 Uncertainy in the fundamentals

Figure 5 shows the analysis of the change in the investment-price sensitivity, internal learning, market learning and forecasting price efficiency as the uncertainty of the fundamentals changes. The change in the uncertainty of firm's fundamental will have a non-negligible impact on manager's investment decisions. As there is higher uncertainty about the fundamental, investment-price sensitivity increases, internal learning increases but market learning decreases, forecasting price efficiency also increases. The intuition behind this is that manager will put more confidence on her internal information when there is higher uncertainty about future payoffs. It is more profitable to acquire and trader on the private information when people have a more diverse prediction about future fundamentals, so informed traders incorporates more information in the stock price and forecasting price efficiency increases.

For the comparison between baseline model and full disclosure model, there is higher investment-price sensitivity, forecasting price efficiency and internal learning but lower market learning under full disclosure. This result is the same as what I find in previous analysis.

4 Conclusion

This paper develops a manager's learning model in the context of investment decisions to decompose the investment-price sensitivity in order to measure how much managers can learn from the stock prices. In this context, manager optimizes her investment decision by making a forecast of firm's future fundamentals based on her internal information and new information learned from stock prices. The stock price is a mix of various sources of information, so the investmenrt-price sensitivity cannot tell us how much the importance of new information impounded in stock price is. In this sense, this paper contributes to isolate market learning channel (information new to the manager) from the internal learning channel (information already known to manager) in the investment-price sensitivity. This main finding is that about 46% of the investment-price sensitivity comes from manager's market learning and about 54% comes from the manager's internal learning. Manager relys less on market learning if the firms disclose full information even though the investment-price sensitivity and forecasting price efficiency is higher. Moreover, manager's market learning declines when the firm faces a higher uncertainty in the fundamentals. These results have implications for policy-makers for designing disclosure policy and when the ecocomy is experiencing a downturn.

References

Bai, J., T. Philippon, and A. Savov (2016). Have financial markets become more informative? *Journal of Financial Economics 122*(3), 625–654.

Bennett, B., R. Stulz, and Z. Wang (2020). Does the stock market make firms more productive? *Journal of Financial Economics 136*(2), 281–306.

Bird, A., S. A. Karolyi, T. G. Ruchti, and P. Truong (2020, 10). More is Less: Publicizing Information and Market Feedback*. *Review of Finance 25*(3), 745–775.

Bond, P., A. Edmans, and I. Goldstein (2012). The real effects of financial markets. *Annual Review of Financial Economics 4*(1), 339–360.

Brogaard, J., T. H. Nguyen, T. J. Putnins, and E. Wu (2022, 01). What Moves Stock Prices? The Roles of News, Noise, and Information. *The Review of Financial Studies.*

Charles C. Holt, Franco Modigliani, J. F. M. H. A. S. (1960). Planning production, inventories, and work force. *Englewood Cliffs.*

Chen, Q., I. Goldstein, and W. Jiang (2007, 05). Price Informativeness and Investment Sensitivity to Stock Price. *The Review of Financial Studies 20*(3), 619–650.

Cooper, R. W. and J. C. Haltiwanger (2006). On the nature of capital adjustment costs. *The Review of Economic Studies 73*(3), 611–633.

Dessaint, O., T. Foucault, L. Frésard, and A. Matray (2018, 11). Noisy Stock Prices and Corporate Investment. *The Review of Financial Studies 32*(7), 2625–2672.

Edmans, A., S. Jayaraman, and J. Schneemeier (2017). The source of information in prices and investment-price sensitivity. *Journal of Financial Economics 126*(1), 74–96.

Fazzari, S., R. G. Hubbard, and B. Petersen (1988). Financing constraints and corporate investment. *Brookings Papers on Economic Activity 19*(1), 141–206.

Foucault, T. and L. Fresard (2014). Learning from peers' stock prices and corporate investment. *Journal of Financial Economics 111*(3), 554–577.

Foucault, T. and L. Frésard (2012, 09). Cross-Listing, Investment Sensitivity to Stock Price, and the Learning Hypothesis. *The Review of Financial Studies 25*(11), 3305–3350.

Goldstein, I. (2022, 08). Information in Financial Markets and Its Real Effects*. *Review of Finance 27*(1), 1–32.

Goldstein, I., E. Ozdenoren, and K. Yuan (2013). Trading frenzies and their impact on real investment. *Journal of Financial Economics 109*(2), 566–582.

Goldstein, I. and L. Yang (2019). Good disclosure, bad disclosure. *Journal of Financial Economics 131*(1), 118–138.

Jayaraman, S. and J. S. Wu (2018, 08). Is Silence Golden? Real Effects of Mandatory Disclosure. *The Review of Financial Studies 32*(6), 2225–2259.

Kurlat, P. and L. Veldkamp (2015). Should we regulate financial information? *Journal of Economic Theory 158*, 697–720. Symposium on Information, Coordination, and Market Frictions.

Kyle, A. S. (1985). Continuous auctions and insider trading. *Econometrica 53*(6), 1315–1335.

Luo, Y. (2005). Do insiders learn from outsiders? evidence from mergers and acquisitions. *The Journal of Finance 60*(4), 1951–1982.

Tables

VARIABLES	Investment
Price	0.0052***
	[3.5965]
1/Asset	1.0596**
	[2.1336]
Cash Flows	0.1360***
	[7.1406]
Constant	0.0324***
	[11.9450]
Industry Effect	YES
Year Effect	YES
Observations	7,745
R-squared	0.5399
Adj_R-squared	0.529

Standard errors are clustered by firm and t-statistics are reported below each estimate.*** **and * denote statistical significance at the 0.01, 0.05 and 0.10 levels.

Table 1: Estimation of the investment-price sensitivity

Parameters	Description	Sources	Value
$h_{\eta'}$	the precision of public information	Brogaard et al. (2022)	0.2096
h_s	precision of private information	Brogaard et al. (2022)	0.2725
σ_u^2	the variance of noise trading	Brogaard et al. (2022)	3.88

Table 2: Externally Calibrated Parameters

Moment	Description	Sources	Value
$\mathbb{V}ar(\mathbb{E}[z\|p])$	Forecasting Price Efficiency	Following Bai et al. (2016)	5.76e-04
$h_s = \phi(h_{s'}, \rho, n, \sigma_u^2)$	the relationship between manager's learning	get σ_s^2 from VAR decomposition following Brogaard et al. (2022)	0.2725
$\beta_{\bar{k},q}$	the investment-price sensitivity	regressing $R\&D/at$ on Tobin's Q across firms	0.005
$\mathbb{V}ar(p)$	the variance of price	S&P 500 firms data	2.3738
$\mathbb{V}ar(K/\bar{K})$	the variance of investment divided by asset in place	S&P 500 firms data	0.0039

Table 3: Targeted Moments

Parameters	Description	Estimated Value
h_z	the precision of productivity shock	3.5493
h_η	the precision of manager's information	0.4668
$h_{s'}$	the precision of manager's learning from stock prices	0.0021
$\frac{\rho}{n}$	relative risk aversion	2.7594
γ	the replacement cost of capital	2.8549
cov_internal learning	the covariance between price and internal information	0.2731
cov_manager learning	the covariance between price and manager learning	0.2301
Internal learning%	the fraction of investment-price sensitivity from internal information	54.27%
Manager learning%	the fraction of investment-price sensitivity from manager learning in stock markets	45.73%

Table 4: Calibrated parameter values

Figures

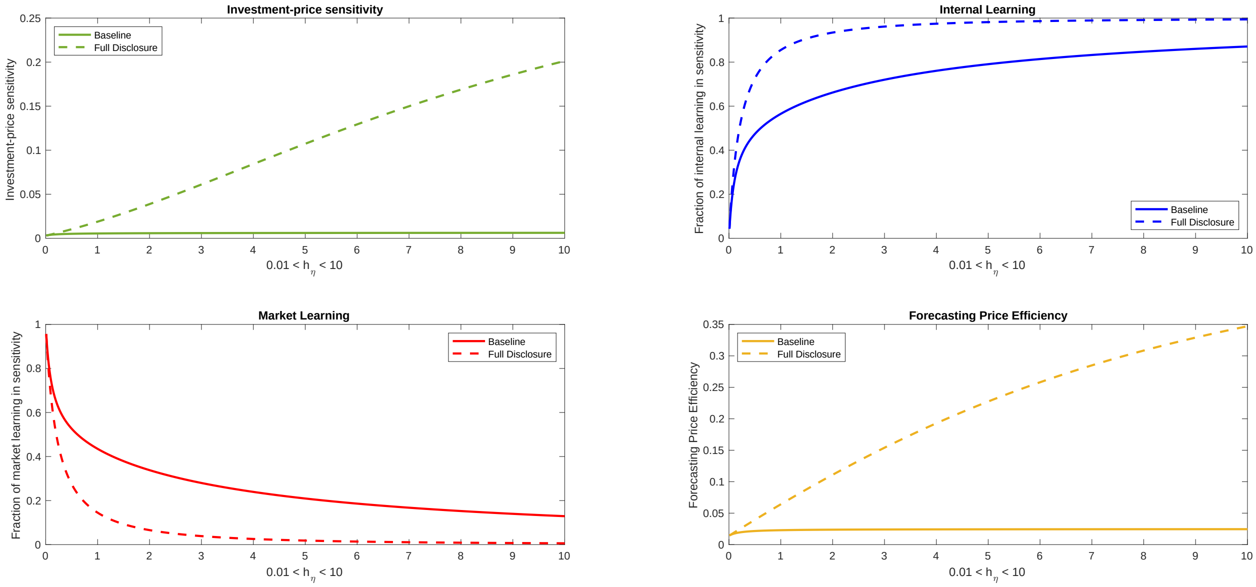

Figure 1: Dynamics when precision of internal information changes

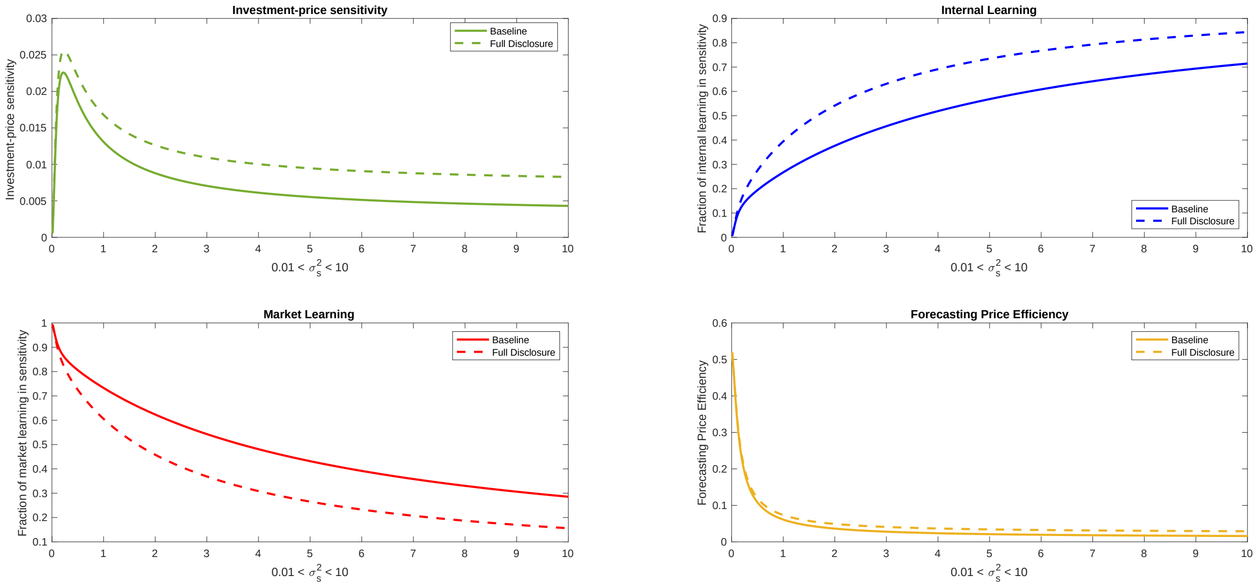

Figure 2: Dynamics when precision of informed trading changes

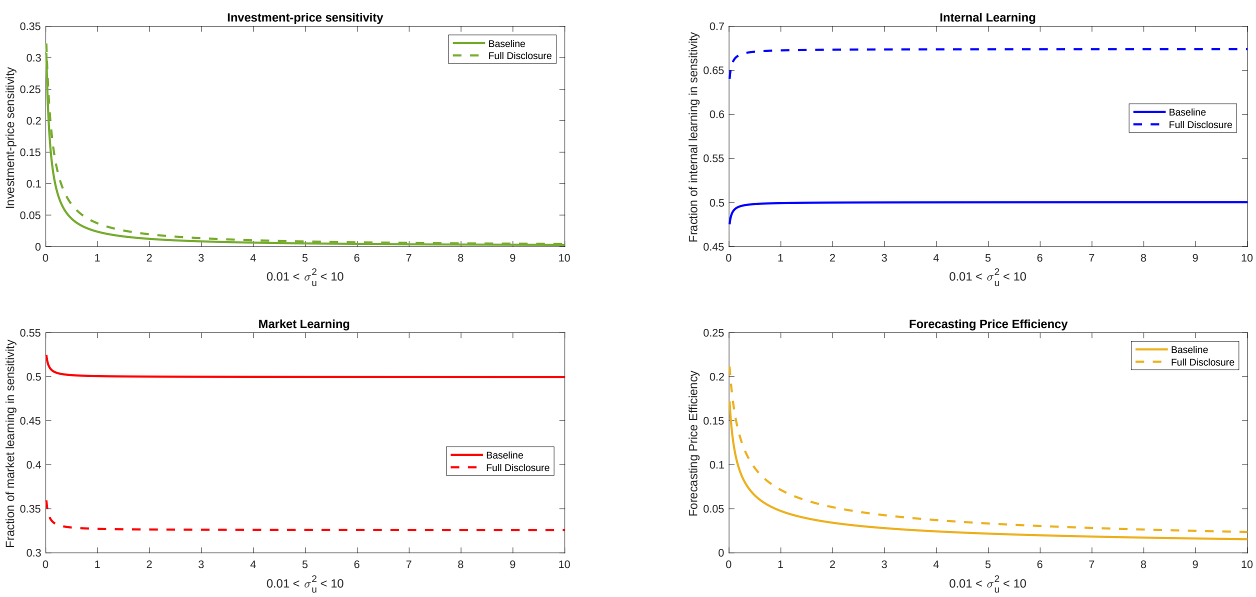

Figure 3: Dynamics when precision of noise trading changes

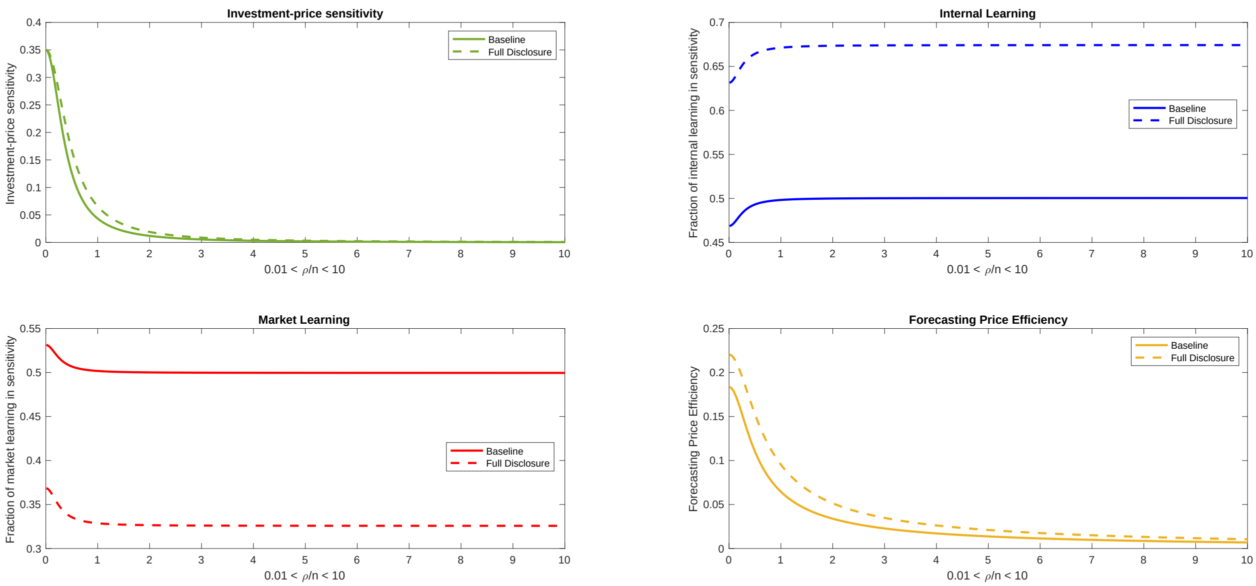

Figure 4: Dynamics relative risk aversion of informed traders changes

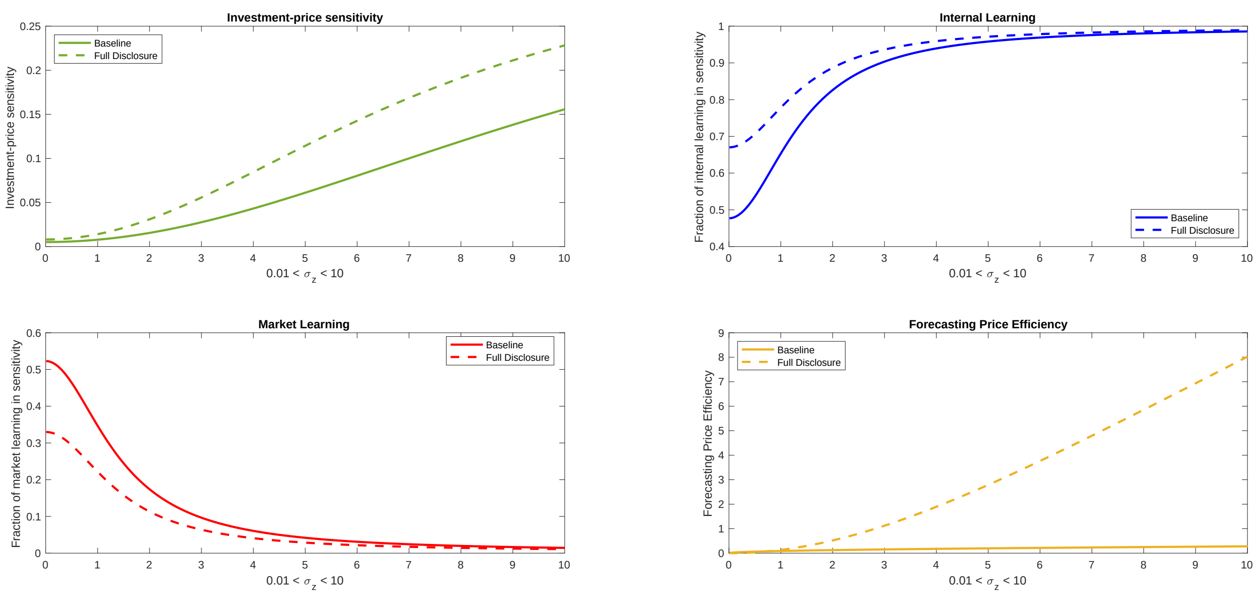

Figure 5: Dynamics when uncertainty of the fundamentals changes

A Appendix

A.1 Characterization of the Equilibrium

There are n informed traders who choose their demand x to maximize a standard mean-variance objective:

Therefore, the demand of each trader is

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

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

$$nx = u \tag{A.2}$$

and we get the equilibrium price

$$p = \frac{h_s s + h_{\eta'}\eta' - \frac{\rho}{n}u}{h_z + h_s + h_{\eta'}} \tag{A.3}$$

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

$$s' = s - \frac{\rho}{nh_s}u = z + \epsilon_s - \frac{\rho}{nh_s}u \tag{A.5}$$

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

$$\gamma\frac{k^*}{\bar{k}} = \mathbb{E}[z|\mathcal{I}_m] = \frac{h_\eta \eta + h_{s'}s'}{h_z + h_\eta + h_{s'}} \tag{A.4}$$

where

$$h_{s'} = \frac{h_s}{1 + (\frac{\rho}{n})^2 h_s^{-1}\sigma_u^2} \tag{A.5}$$

To compute the efficiency of the economy,we obtain

$$\mathbb{E}[z|\mathcal{I}_m] = \frac{(h_\eta + h_{s'})z + h_\eta \epsilon_\eta + h_{s'}(\epsilon_s - \frac{\rho}{nh_s}u)}{h_z + h_\eta + h_{s'}} \tag{A.6}$$

and so aggregate efficiency is

$$\mathbb{V}ar(\mathbb{E}[z|\mathcal{I}_m]) = (\frac{h_\eta + h_{s'}}{h_z + h_\eta + h_{s'}})h_z^{-1} \tag{A.7}$$

Forecasting price efficiency (FPE) is

$$\mathbb{V}ar(\mathbb{E}[z|p]) = \frac{h_\pi}{h_\pi + h_z} h_z^{-1} \tag{A.8}$$

where

$$h_\pi = \frac{(h_s + h_{\eta'})^2}{h_s + h_{\eta'} + \frac{\rho^2}{n^2}\sigma_u^2}$$

As for Revelatory Price Efficiency, we have

$$\mathbb{V}ar(\mathbb{E}[z|\eta, \eta^{'}, s^{'}]) - \mathbb{V}ar(\mathbb{E}[z|\eta, \eta^{'}]) = \left(\frac{h_\eta + h_{s'}}{h_z + h_\eta + h_{s'}} - \frac{h_\eta}{h_z + h_\eta}\right) h_z^{-1} \tag{A.9}$$

From A.4, the optimal investment is as follows:

$$\gamma \frac{k^*}{\bar{k}} = \mathbb{E}[z|\mathcal{I}_m] = \frac{h_\eta \eta + h_{s'} s^{'}}{h_z + h_\eta + h_{s'}} \tag{A.10}$$

$$k^* = \frac{\bar{k}}{\gamma} \cdot \frac{h_\eta \eta + h_{s'} s^{'}}{h_z + h_\eta + h_{s'}}$$

We decompose the investment-price sensitivity as follows:

$$\beta_{k^*p} = \frac{cov(k^*, p)}{Var(p)} = \Delta\{ \underbrace{cov(\eta, p)}_{\text{internal information}} + \underbrace{cov(s^{'}, p)}_{\text{manager's learning}} \} \tag{A.11}$$

where $\Delta = \frac{\bar{k}}{\gamma Var(p)(h_z + h_\eta + h_{s^{'}})(h_z + h_{\eta^{'}} + h_s)}$

$$cov(\eta, p) = h_\eta * \left(h_s h_z^{-1} + h_\eta^{'} h_z^{-1} + h_{\eta'} h_\eta^{-1}\right)$$

$$cov(s^{'}, p) = h_{s'} * \left(h_s h_z^{-1} + h_{\eta'} h_z^{-1} + 1 + \frac{\rho^2}{n^2 h_s}\sigma_u^2\right)$$

A.2 Moment Conditions

$$h_s = h_{s'} * \left(1 + (\frac{\rho}{n})^2 h_s^{-1} \sigma_u^2\right) \tag{A.12}$$

$$\mathbb{V}ar(\mathbb{E}[z|p]) = \frac{h_\pi}{h_\pi + h_z} h_z^{-1} \tag{A.13}$$

where

$$h_\pi = \frac{(h_s + h_{\eta'})^2}{h_s + h_{\eta'} + \frac{\rho^2}{n^2}\sigma_u^2}$$

Define $\tilde{k} = k^*/\bar{k}$, where k^* is the optimal level of investment, $\bar{k}$ is the asset in place

$$\beta_{\tilde{k},q} = \frac{cov(\frac{k^*}{\bar{k}}, \frac{p}{\bar{k}})}{var(q)} = \frac{cov(k^*, q)}{var(q)} = \Delta\{cov(\eta, p) + cov(s', p)\} \tag{A.14}$$

where $\Delta = \frac{1}{\gamma(h_z + h_{s'} + h_\eta)(h_z + h_s + h_{\eta'})var(q)}$

$$cov(\eta, p) = h_\eta * \left(h_s h_z^{-1} + h_\eta' h_z^{-1} + h_{\eta'} h_\eta^{-1}\right)$$

$$cov(s', p) = h_{s'} * \left(h_s h_z^{-1} + h_{\eta'} h_z^{-1} + 1 + \frac{\rho^2}{n^2 h_s}\sigma_u^2\right)$$

$$\mathbb{V}ar(p) = \frac{\left((h_s + h_{\eta'})^2 h_z^{-1} + h_s + h_{\eta'} + \frac{\rho^2}{n^2}\sigma_u^2\right)}{(h_z + h_s + h_{\eta'})^2} \tag{A.15}$$

$$\mathbb{V}ar(\frac{K^*}{\bar{K}}) = \frac{(h_\eta + h_{s'})^2 h_z^{-1} + h_\eta + h_s'}{\gamma^2(h_z + h_\eta + h_{s'})^2} \tag{A.16}$$

A.3 Return Variance Decomposition

Consider the log of the observed price at time t, p_t, as the sum of two components:

$$p_t = m_t + s_t \tag{A.17}$$

where m_t is the efficient price and s_t is the pricing error.

m_t follows a random walk with drift μ and innovations w_t :

$$m_t = m_{t-1} + \mu + w_t \tag{A.18}$$

The stock return is

$$r_t = p_t - p_{t-1} = \mu + w_t + \Delta_{s_t} \tag{A.19}$$

The random-walk innovations,w_t , can then be decomposed into three parts:

$$w_t = \theta_{rm}\varepsilon_{rm,t} + \theta_x\varepsilon_{x,t} + \theta_r\varepsilon_{r,t} \tag{A.20}$$

Thus,

$$r_t = \underbrace{\mu}_{\text{discount rate}} + \underbrace{\theta_{rm}\varepsilon_{rm,t}}_{\text{market-wide info}} + \underbrace{\theta_x\varepsilon_{x,t}}_{\text{private info}} + \underbrace{\theta_r\varepsilon_{r,t}}_{\text{public info}} + \underbrace{\Delta_{s_t}}_{\text{noise}} \tag{A.21}$$

We estimate the components of Equation A.21 using a structural VAR with five lags to allow a full week of serial correlation and lagged effects:

$$\begin{aligned}
r_{m,t} &= \sum_{l=1}^{5} a_{1,l} r_{m,t-l} + \sum_{l=1}^{5} a_{2,l} x_{t-l} + \sum_{l=1}^{5} a_{3,l} r_{t-l} + \varepsilon_{rm,t} \\
x_t &= \sum_{l=0}^{5} b_{1,l} r_{m,t-l} + \sum_{l=1}^{5} b_{2,l} x_{t-l} + \sum_{l=1}^{5} b_{3,l} r_{t-l} + \varepsilon_{x,t} \\
r_t &= \sum_{l=0}^{5} c_{1,l} r_{m,t-l} + \sum_{l=1}^{5} c_{2,l} x_{t-l} + \sum_{l=1}^{5} c_{3,l} r_{t-l} + \varepsilon_{r,t}
\end{aligned}$$

where $r_{m,t}$ is the market return, x_t is the signed dollar volume of trading in the given stock (positive values for net buying and negative values for net selling), and r_t is the stock return.