Do Private Firms (Mis)Learn from the Stock Market? *

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Abstract

This paper examines to what extent the stock market affects private firms through the information channel. Using data for the United Kingdom, I find that private firms' investment responds positively to the valuation of public firms in the same industry. The sensitivity increases with price informativeness. To establish causality, I construct a price noise measure based on public firms' *unrelated* minor segments and show that it positively affects the investment of private firms in the major-segment industry. The results are consistent with models featuring learning from noisy signals and are not driven by alternative channels in the absence of learning.

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1 Introduction

Over the last decade, an extensive literature has examined the extent to which corporate managers learn from the stock market when making decisions. The rationale behind such managerial learning is that because information does not flow freely among investors and firms, diverse pieces of information that are not known to the managers can be aggregated into the stock prices through the trading activities of investors (Grossman and Stiglitz (1980) and Kyle (1985)). In addition, new information about stock market-listed (or “public”) firms is produced and disseminated by information intermediaries, such as financial analysts and business media. In turn, the stock market can have real consequences for corporate policies if managers explore information in the public domain in the hope of making better decisions.[1]

Testing this learning mechanism is challenging because an econometrician cannot perfectly observe the information set used by the manager to make investment decisions, nor observe the manager's belief regarding investment opportunities before learning from the stock market. Even if we were to find a positive relationship between a firm's market valuation and capital investment, it could be driven by the stock price passively reflecting what the manager already knows or unobserved investment opportunities affecting both investment and stock price in the absence of learning. Furthermore, public firms, which are predominantly used in the learning literature, have long been viewed as prone to agency problems (Jensen and Meckling (1976)). Their managers may have incentives to cater to investors' beliefs in order to keep their job by adjusting the investment in response to movements in stock prices (Polk and Sapienza (2009)), which adds another layer of difficulty in uncovering managerial learning.

In this paper, I adopt a novel empirical strategy that can disentangle different sources of information and study whether and to what extent corporate managers learn from the stock prices. First, to overcome the problems of passive reflection and catering associated with public

[1]See Bond, Edmans and Goldstein (2012) for a comprehensive survey of the real effects of the stock markets due to the informational role of market prices.

firms, I focus on private firms and test whether the investment of private firms is sensitive to the stock valuation of public firms in the same industry. To the extent that market prices aggregate diverse pieces of information, the stock prices of public firms in an industry could inform private firms about common industry shocks that an individual manager is unlikely to know completely. In the meantime, since private firms do not have their own stock prices and are mostly owner-managed (Michaely and Roberts (2012)), it is less likely that firm-specific information known by a private firm manager is only passively reflected into their public peers' stock prices or that their investment decisions are affected by agency concerns (Asker, Farre-Mensa and Ljungqvist (2014)) which may have confounded the empirical findings for the learning behavior of public firms.

Still, there is room for endogeneity: If some industry investment opportunities were already known by the private firm manager (but unobserved by the econometrician) and reflected into the stock prices of the public firms, a spurious relationship between private firms' investment and industry stock valuation could still be generated in the absence of learning. To address this concern, I construct a measure of price noise for private firms that is orthogonal to their investment opportunities, and test whether their investment is sensitive to the price noise. The logic is as follows. The stock prices of public firms contain information related to private firms as well as information unrelated ("noise") to private firms. If the manager of a private firm does not learn from the stock price, she will not adjust the investment decision in response to the false signal. If, instead, she learns such information from the stock prices of public firms and cannot completely separate the relevant information from the "noise", then *ex post* the investment of her firm will be sensitive to the stock prices as well as the "noise" in the price signal.[2] Herein lies the second layer of my empirical design.

Finally, I examine whether the evidence is consistent with predictions from the "learning"

[2]This test strategy has been adopted in Morck, Shleifer and Vishny (1990) in search for the impact of investor sentiment on corporate investment through the "Active Informant" channel. Even though various choices of the price "noise" have been used to study the effect of non-fundamental components of stock prices through other channels, they have been overlooked in testing the learning behavior for more than a decade.

framework regarding the role of key parameters, such as stock price informativeness and the extent to which firms are exposed to common shocks. I also show that the findings are not driven by alternative channels such as market competition, internal capital allocation and sentiment.

By utilizing a large panel of private and public firms in the United Kingdom, I find that the investment of private firms reacts positively to the industry stock valuation, proxied by the average market-to-book ratio of assets of all public firms in the same industry. The economic magnitude is considerable: A one standard deviation increase in the industry valuation is associated with a 1.4% increase in capital expenditure (scaled by the beginning-of-year capital) of private firms, which is about 7% of the average investment-to-capital ratio in my sample. This effect is estimated after controlling for a multitude of firm characteristics known to affect investment decisions, characteristics of both public and private peers in the same industry, unobserved time-varying shocks common to all firms (by using year fixed effects), and unobserved heterogeneity at the firm level (by using firm fixed effects).[3]

Next, I find that private firms' investment reacts positively and significantly to the price noise, which is constructed based on the valuation of industry leaders' *unrelated* minor-segment industries. Specifically, for a given private firm that only operates in one industry, the price noise is the average valuation of industries in which the private firm's (public) industry leaders have unrelated minor segments. Compared to existing measures based on mis-valuation,[4] this measure satisfies two conditions that are crucial for testing the "learning" hypothesis.

The first identifying assumption requires that the price noise be unrelated to the investment opportunities.[5] To ensure that industry leaders' minor-segment industries are not related to the industries of private firms, I exclude those minor-segment industries that are within the same

[3]The results are robust and of similar economic magnitude if investment is measured by the annual increase of capital scaled by beginning-of-year capital, which also accounts for fixed assets acquired externally through M&As.

[4]These measures include subsequent stock returns, valuation residuals, price pressure caused by mutual fund fire-sale, and sentiment index.

[5]Otherwise, a spurious relationship between investment and stock price could still be observed in the absence of learning because of comovements in investment opportunities.

one-digit SIC industry as the major-segment industry, and those in which the private firms also have minor segments or are likely to have supplier or customer relationships.[6] Therefore, private firms' investment should not respond to the price noise in the absence of learning, since the price noise is irrelevant for their investment opportunity.

The second identifying assumption requires that the decision maker cannot completely filter out the noise from the price signal.[7] The stock valuation of conglomerate firms reflects information in both their major and minor segments. Due to market imperfections, the latter is not likely to be canceled out in the industry average valuation.[8] Therefore, if the private firms learn from the industry stock valuation, the investment of private firms *ex post* will be sensitive to the valuation of those minor-segment industries.

To address the concern that the price noise may still capture unobserved fundamentals correlated with the major-segment industry, I show from a placebo test that the "mislearning" evidence is not present if the price noise variable is instead constructed from random industries in which the industry leaders do not have minor-segment business. In other words, only when the noise is contained in the price signal does it affect the investment of private firms through learning.

Furthermore, I show that the results are not driven by internal resource allocation and sentiments affecting private firms' cost of capital. I examine segment-level investment and find that industry leaders do not adjust their major-segment investment following valuation changes in minor-segment industries.[9] Therefore, it is unlikely that private firms adjust investments in re-

[6]Excluding such industries helps mitigate the concern of undetected relatedness. But the Chevalier Critique (Chevalier (2004)) may still apply since divisions are not randomly allocated to firms and minor-segment industries may potentially be related to the major-segment industry. I perform a placebo test to further address this.

[7]Otherwise, even if there is learning, the investment will not be sensitive to the "noise".

[8]Ideally, the comparable firms should be pure players that are similar to private firms in size and other characteristics. However, as public firms are more scarce, one has to trade-off the quality of the match and the consistency of the estimate. Even when pure players are available, they are usually much smaller in size than multi-segment firms. Due to market imperfections, new information is usually incorporated into the stock prices of large firms before it spreads to other firms within the industry. As a result, industry leaders' minor segments valuation may still contaminate the pure players' valuation and the industry valuation (Hou (2007) and Cen et al. (2013)).

[9]This is not surprising since the industry leaders are not financially constrained and have less need to finance investment in the major segment by fundings in the minor segments.

sponse to public firms' major-segment investment due to internal allocation. I also adopt a similar strategy as in Baker, Stein and Wurgler (2003) to see if the results are stronger in financially constrained firms. However, the reaction of financially unconstrained firms is as strong as that of constrained firms, which suggests that sentiment cannot explain the findings.

Finally, I show that in industries in which the stock prices are more informative about future fundamentals, private firms' investment responds more to the industry stock valuation.[10] In addition, the sensitivity of private firms' investment to industry valuation increases when firms in the same industry are more likely to face common shocks.[11] Both findings are consistent with predictions from a "learning" framework. The latter also helps rule out the alternative channel that private firms adjust their investment in response to any competition pressure from public peers, since, while generating mixed predictions for what the reaction will be, this strategic view predicts a less pronounced relationship in competitive industries.

My results contribute to a few strands of literature. The idea that stock prices aggregate information from various participants and improve the efficiency of the real economy dates back to Hayek (1945), and has been enriched by theoretical works including Dow and Gorton (1997), Subrahmanyam and Titman (1999) and Goldstein and Guembel (2008), among others. On the empirical side, while Morck, Shleifer and Vishny (1990) cannot reject the hypotheses that the stock market is just a side show, other studies have provided evidence that managers use the information in the stock prices when they decide on investment (Chen, Goldstein and Jiang (2007), Bakke and Whited (2010), and Foucault and Frésard (2014)), mergers and acquisitions (Luo (2005)), and cash savings (Frésard (2012)). The paper that is mostly related to mine in terms of test strategy is a more recent paper by Dessaint et al. (2018). Using price pressure caused by mutual fund

[10] I use (i) the number of public firms in the same three-digit standard industrial classification (SIC) industry, (ii) the fraction of public firms in the same three-digit SIC industry, and (iii) price non-synchronicity as measures for the informativeness of industry average valuation.

[11] I use (i) the number of all firms in the same three-digit standard industrial classification (SIC) industry, (ii) the HHI of the three-digit SIC industry, and (iii) the market share of the top four firms in the three-digit SIC industry as measures for the importance of common shocks.

outflows as the noise measure, the authors document the ripple effects of noise on investment for the public firms in the U.S.. However, my paper is the first to utilize private firms to identify the learning behavior, which provides the advantages in terms of identification and also helps to evaluate the real effects of the stock market more properly. Private firms account for a substantial fraction of the economy of the United Kingdom. For the period from 2000 to 2010, private firms represent 91% of all incorporated entities in the U.K. and 60% of all corporate assets. On average, 61% of the sales, 53% of the pre-tax profits, and 68% of the aggregate capital expenditure were from private firms.[12] Therefore, the findings suggest that the information content of market prices spreads to a larger part of the economy that has not received much attention.

This paper also connects to the empirical literature that compares public and private firms. Using the same data set as in my paper, Brav (2009) finds that private firms mostly rely on debt financing, and Michaely and Roberts (2012) find that private firms smooth dividends less than public firms. Using Sageworks, Asker, Farre-Mensa and Ljungqvist (2014) find that private firms in the U.S. are more responsive to changes in investment opportunities than matched public firms, and Badertscher, Shroff and White (2013) find that the disclosures of financial statements of public firms affect the investment of private firms. While I find that the investment of both public and private firms is sensitive to the industry stock valuation, I do not intend to make a comparison of the two types of firms as the evidence is suggestive that public firms have other incentives to react to the stock prices, potentially due to agency concerns.[13] Evidence on private firms is less subjective to endogeneity and agency problems, and suggests that private firms exploit information from the stock market and are not immune to the noise in the stock market.

[12]The statistics I use are largely comparable to those reported in Brav (2009) for U.K. private firms for an earlier period (1993 to 2003). Furthermore, Asker, Farre-Mensa and Ljungqvist (2014) shows that private firms represent 99.94% of all U.S. firms, 59% of sales and 49% of aggregate pre-tax profits in 2010.

[13]Nonetheless, I present results for the comparison and discuss the interpretation towards to end of the paper.

2 Hypothesis Development

Much effort has been devoted to show theoretically how investors' information is incorporated into the equilibrium stock price.[14] Built on this notion, in this section I discuss the implication for the investment of private and public firms when the stock price contains information that the manager does not yet have, and develop hypotheses to empirically examine whether managers learn from the stock price. A simple model sharing the same spirit can be found in Appendix A.

2.1 The Setting

Consider an environment (say, an industry) in which firms face two types of uncertainty to demand (or productivity), one of which is common to all public and private firms, while the other is specific to one firm only. Prior to the realization of the state, each firm's manager receives a noisy private signal about the shocks to her firm. For a public firm, information on future demand is also reflected in the stock price as investors trade on their private information. Thus, the stock price can be considered as another noisy signal to the manager, and may contain some information that is not yet known to the manager.[15] Moreover, as the stock prices are publicly known, once one takes the average of the stock prices, the component in the signals reflecting firm-specific shocks could be cancelled out when the number of public firms in an industry is sufficiently large. Therefore, the industry average valuation can serve as a noisy signal about the common shock.[16]

[14] One could think of this as in Kyle (1985). That is if, among the investors of a public firm, a fraction of investors receive a perfect signal about future demand of the firm's product and will accordingly buy or sell shares of the firm's stock against the liquidity traders and the dealers. The dealers set the break-even stock price according to the expectations of the firm's value conditioning on the order flow (i.e. the sum of net demand from speculators and liquidity traders) for its stock. Such a mechanism provides a channel through which investors' information is incorporated into the equilibrium stock price, thereby giving the rationale for managers to learn from the market.

[15] Note that this does not suggest that investors have superior knowledge as compared to the corporate manager, but rather to argue that there is new information from the investor side (for example, "serendipitous information" on general demand for a product as considered by Subrahmanyam and Titman (1999)) to complement the manager's information set. Given that signals received by managers are not perfect, this is very likely to be true.

[16] The noise contained in the stock price, which is possibly due to investor sentiment, investor inattention, or any other frictions, could be correlated among stocks as the same friction could affect a group of stocks or the entire market. As a result, it could not be entirely eliminated from the industry average valuation.

Without any agency cost, it is in the manager's interest to incorporate the information contained in the stock prices when making investment decisions. This is because additional (informative) signals allow the manager to form more precise predictions about the future state of the economy and make more efficient real decisions.[17] For a public firm, this means that a manager should use all three sources of information, including her private signals, the stock price of her firm, as well as the industry valuation. Private firms do not have their own stock prices. However, the manager of the private firm could complement her private signal with the information contained in the stock prices of public firms in the same industry, and make more efficient decisions.

2.2 The Response of Private Firms

To empirically detect whether the managers learn from the stock price when deciding on the capital investment, first compare the investment decision of the private firm under the scenario when the manager of the private firm relies on both her private signal and the information embedded in the industry valuation ("Learning") with the counterfactual scenario when she uses the private signal only ("No Learning"). With a quadratic investment adjustment cost, the optimal investment level can be expressed as a linear and increasing function of marginal q, which consists of the manager's expectation of the future productivity and the marginal contribution of new capital goods to future profit.[18] Therefore, it is crucial to compare how managers form the expectations of the future state under the two scenarios.

[17] This intuition is behind the theoretical works that examine the benefits and limitations when decision makers learn from the stock prices, including Dow and Gorton (1997), Subrahmanyam and Titman (1999), Foucault and Gehrig (2008), Goldstein and Guembel (2008), Foucault and Frésard (2014), Edmans, Goldstein and Jiang (2015). See Bond, Edmans and Goldstein (2012) for an excellent survey on this literature.

[18] The assumption of a quadratic investment adjustment cost is standard in the q theory literature. What is distinct from the standard q theory is whether managers' information set automatically incorporates all available information. It is usually assumed that information flows freely between the firm and the market, and managers make use of all the public and private information that is available. However, this is the question to be empirically examined in this paper and other papers in the same vein.

"No Learning" In the absence of learning from stock prices, the manager's expectation of the future state will only be conditional on the private signal, and can be considered as a weighted average of her prior belief and the private signal. Intuitively, the private signal will be given a higher (lower) weight if this signal is more precise (noisy).[19] Suppose that the manager's information set could be controlled for, then the coefficient of regressing investment on the average stock price will be zero as the latter was not used by the manager to form the posterior belief. Moreover, any factors that only affect the stock price but not the manager's prior belief or the private signal will not have any effect on the response of investment to the signals.

"Learning" If the manager of a private firm learns from the stock market, her information set will contain both the private signal and the industry valuation. Then, the conditional expectations of future productivity will be a weighted average of three components: the prior belief, the private signal to the manager, and the signal from the average stock price. Once more, the weight on each signal depends on how precise each signal is relative to the others. It follows that the investment responds positively to the average valuation as long as it is not trivial for the managers to utilize the information in the stock price.[20] Suppose that the manager's information set could be controlled for, then the coefficient of regressing investment on the average stock price will be positive. Moreover, factors that only affect the stock price but not the manager's prior belief or the private signal will play a role for the response of investment to the signals, which provides further predictions for the empirical tests later on.

***Hypothesis* 1:** After controlling for the manager's private signal, investments made by private firms respond positively to the valuation of public firms in the same industry if and only if private firm managers learn from the stock market.

[19]The manager will completely take the signal if the private signal fully informs the future state.

[20]There are two circumstances under which the information in the stock price becomes trivial, one is when there does not exist any uncertainty in the common shock, and the other is when the manager's private signal is perfect. Neither is likely to occur in reality.

However, Hypothesis 1 relies on the assumption that we can perfectly control for the manager's information set. This does not hold when we take the prediction to the data as neither the manager's prior belief nor her private signal is observable to us as econometricians. Omitting those variables that have privately informed the managers about the investment opportunities will bias the estimate when we test whether the stock price has any loading to affect investment. This is because both the private signal and the industry stock valuation contain information about the common shock. Failing to control for the manager's private signal will result in a positive coefficient on the industry valuation even under the "No Learning" scenario.

To solve the problem, a sharper empirical strategy needs to explore the component in the price signal orthogonal to the manager's (relevant) information set. Under the "No Learning" scenario, this component (referred to as "price noise" or "false signal") does not affect the manager's posterior belief about the future state as it does not enter into the manager's private signal. But under the "Learning" scenario, if the manager cannot completely filter out the noise from the industry valuation, then the "price noise" will affect the manager's conditional expectation of the future state and is expected to have a positive coefficient when we regress the investment on the price "noise". Now, even if the manager's private signal cannot be perfectly controlled for, the spurious positive coefficient will no longer show up for exactly the reason that the price "noise" does not affect the manager's private signal.

***Hypothesis* 1b:** The investment of private firms responds positively to the price "noise" of public firms in the same industry, if and only if private firm managers learn from the stock market.

2.3 The Role of Price Informativeness and Common Shocks

Furthermore, factors that affect the stock price but not the manager's prior belief or the private signal will only play a role for the response of investment to the signals under the "Learning" scenario. Two such factors are of particular interest in this framework. First, the variance of the "noise" in the average stock price affects how much weight the manager puts on the average stock price when updating her belief: the more precise (the less noisy) is the signal from the average stock price, the more sensitively does private firms' investment respond to the average stock price. This is consistent with Chen, Goldstein and Jiang (2007) and Foucault and Frésard (2014) for the case of public firms. The industry average stock price is more informative (the noise term in the average stock price is smaller) when the number of public firms in the industry is higher, or when the correlation of stock prices across firms is lower. Therefore,

***Hypothesis* 2:** The sensitivity of private firms' investment to the industry valuation is stronger when the industry has a larger number of public firms, or when there is less co-movement of stock prices within the industry.

The other parameter of interest is the importance of the common shock. The rationale behind learning from the industry valuation is that the average price provides managers with useful information about the common demand shock, since the firm-specific shock vanishes when taking the average of the individual stock prices. Therefore, when uncertainty is more likely to come from the common demand (or productivity) shock, this additional piece of information is more valuable and accounts for a higher weight when managers decide on the optimal investment. Therefore,

***Hypothesis* 3:** The sensitivity of private firms' investment to industry valuation is stronger when the industry common demand shock is more important relative to the firm-specific shock.

2.4 The Response of Public Firms

Finally, the public firms remain to be discussed. Using a full-fledged model, Foucault and Frésard (2014) examine how public firms' managers learn from their own stock prices as well as peer firms' stock prices. They predict and confirm in the data that the investment of public firms reacts positively to the peers' valuation. This sensitivity depends on the informativeness of the signals, and the response to the peer firms' valuation drops significantly after going public. While much of the prediction continues to hold in my framework, some cautions are worth discussing.[21]

First, the optimal reaction of public firms' investment to the industry valuation may not always be positive.[22] If the common shock only accounts for a small proportion of the uncertainty that firms are facing or with almost perfectly correlated price noise terms, the investment of public firms responds *negatively* to the industry stock price. The rationale for the result is as follows: when the industry average stock price has the same noise as the individual stock price, the manager of a public firm could subtract the average stock price from its own stock price to obtain the firm-specific shock. Conditioning on the firm's own stock price, the higher the industry average, the lower the estimate of the firm-specific shock. In such a case, the optimal investment responds *negatively* to the average price. This is in line with recent papers by Brown and Wu (2014) studying the cross-fund learning within mutual fund families, and Ozdenoren and Yuan (2014) studying the risk-taking behavior under common and firm-specific uncertainty when agents have incentives to match the industry average effort. For the response of private firms' investment, the sign is not sensitive to the model specifications, which puts less challenge when drawing inference from the empirical results.

Second, as discussed in the introduction, there are other reasons for public firms to respond to the stock valuation than what has been suggested by the learning hypothesis. For example, the managers of public firms may have incentives to cater to investors' opinion to protect their own livelihood by adjusting the firm's investment in response to movements in stock prices (Polk and Sapienza (2009)). Therefore, it is not guaranteed that the model's prediction under a No-Agency framework can be directly taken to the data to test the learning behavior.

This is especially important when comparing the reactions of private firms with those of public firms or considering the change in the response to industry valuation following a status transition from public (private) to private (public). If we assume that the distribution of the managers'

[21] A more formal analysis can be found in Appendix B.

[22] As shown in Equation ((B.9)) of Appendix B, the weight on the industry average stock price may not always be positive for public firms.

signal does not differ across private and public firms, a private firm always puts a larger weight on the industry valuation than a comparable public firm when both firms make use of all the available information. This is because the public firm has its own stock price and will guide the managers' decision when it is informative about the future state.

***Hypothesis* 4 (No Agency Problem):** When both private firms and public firms learn from the stock market and public firms do not have any agency concerns, private firms respond more to the average stock price than do otherwise equivalent public firms.

However, if the observed or unobserved difference between the two types of firms (or around status changes) cannot be perfectly controlled for, Hypothesis 4 will not be supported by the data.

2.5 Remarks

The conceptual framework in this paper is closely related to the models in preceding papers by Subrahmanyam and Titman (1999) and Foucault and Frésard (2014), among others, which study the implication for corporate policies when managers learn from the stock price. The connection between my paper and the work by Foucault and Frésard (2014) has been discussed. Subrahmanyam and Titman (1999) examine the decision to go public. They do not have a common shock across firms. Therefore, firms' investment will be influenced by the stock price if they go public, and by a private financier's information set if they remain private. In addition, one type of shocks (the "serendipitous information" in their paper) can only be observed by the public investors but not by the private financier. Hence, unless going public, firms cannot get this piece of information, nor can they interpolate it by looking at peer firms' stock prices as there are no fundamental correlations across stocks. This sets the key difference in the way private firms use information in stock prices between Subrahmanyam and Titman (1999) and my framework.

3 Data

3.1 Panel Data for Public and Private Firms

My sample starts with all private and public firms in the United Kingdom for the period 1993 to 2010. The primary data source is the Financial Analysis Made Easy (FAME) database provided by Bureau Van Dijk (BvD) which contains accounting variables in the balance sheet, the profit & loss account, and the statement of cash flow for all private and public companies (approximately 2.9 million) in the United Kingdom. For public firms, the financial data are cross-checked with the Worldscope database provided by Thomson Reuters. Moreover, from Worldscope, I obtain the stock prices to calculate the industry market-to-book valuations, the product segment industry codes and the product segment financials. All pound values are converted to 2005 constant million pounds using the U.K. consumer price index from the World Development Indicators (WDI).

The primary advantage of using the FAME database is that the 1967 Companies Act in the U.K. requires that all limited liability companies, private and public, file their financial statements annually with the U.K. Companies House.[23] Moreover, the 1981 Companies Act requires that all companies submit full statements, except for the "small" and "medium"-sized firms which meet two of the three criteria: (i) sales less than £1.4 million, (ii) book assets less than £1.4 million; (iii) number of employees less than 50.[24] Thus, the mandatory disclosure policy avoids the selection issues associated with some other databases for private firms.

The second advantage is that private and public firms in the U.K. face equivalent accounting standards. All statements of public and private firms must be audited if the annual sales exceed £0.35 million before June 2000 and £1 million after. Moreover, the U.K. tax laws do not discriminate between public and private firms.[25]

[23]Companies House is an executive agency of the U.K Department of Trade and Industry.

[24]Medium firms are allowed to file abbreviated financial statements, while small firms are allowed to only submit an abridged balance sheet without a profit & loss account.

[25]See Brav (2009) and Michaely and Roberts (2012) for more detailed discussions about the FAME database.

FAME does not remove historical information if a firm stops reporting financial data. But it only keeps information for up to 10 years in the web-version or one particular disk in which the sample is dominated by firms incorporated in more recent years and surviving firms. To avoid this "survivorship" bias, I obtain the archived disks from BvD to expand the time-series from 10 years in previous studies to 18 years and collect the financial data backward in time.[26]

Static ("header") information such as listing status, and ownership structures in each disk only reports the last year's value. To obtain this type of information at an annual frequency, I append the archived disks from the earliest possible disk (release 90, December 1996) to the more recent ones (release 270, December 2011).

Following Brav (2009) and Michaely and Roberts (2012), I classify firms as public if they are quoted on the London Stock Exchange, OFEX or AIM, and as private if their company type in FAME is "Private", or "Public Unquoted". I only keep firms that do not change their status from private to public (or public to private) over the sample period to address the concern that the transition firms may not represent the general population of private and public firms.[27]

3.2 Sample Selections

My sample selections follow Michaely and Roberts (2012). First, I exclude the following types: Assurance Company, Guarantee, Limited Liability Partnership, Not Companies Act, Public Investment Trusts, and Other. This is done to restrict the sample to limited liability companies to which the Companies Act applies. Second, I only keep the consolidated financial statements. I also exclude the small firms as defined by the Companies House to prevent there being a large number of missing data, and exclude firm-year observations that do not satisfy the auditing requirements.

Following standard practice, I exclude financial, insurance, and real estate firms (US SIC code

[26]My sample period starts from 1993 since the 1996 disk is the earliest archived disk in BvD and it kept financial data for the past three years.

[27]My results remain the same if I include those firms.

6000-6900), utilities (US SIC code 4900-4999), and public sector firms (US SIC code above 8999). I exclude any firm-year observation that has missing values on book value of asset, sales, or shareholders' equity. I further require that each firm should have five consecutive years of data. My final sample consists of 14,033 private firms and 1,761 public firms.

The variable constructions are presented in Appendix C. Firm characteristics such as sales and cash flows, both scaled by lagged capital, are winsorized separately for public and private firms at 1% level at both tails of the distribution to alleviate the impact of outliers.

Table 1 presents summary statistics for the sample. I report firm-level and industry-level characteristics for private firms as well as public firms. Consistent with previous studies, private firms are much smaller in size than public firms. They depend more on debt (have a higher leverage ratio, and are less involved in the equity market) than public firms. A notable comparison is that while private firms do not have lower capital expenditures than public firms, they have significantly lower investments in fixed assets. This is possibly due to fixed assets acquired through mergers and acquisitions which are much more intensively associated with public firms than with private firms. The distributions of individual market-to-book ratio and the industry average market-to-book ratio are in large consistent with that of previous studies using the U.S sample.[28]

4 Empirical Strategies and Results

4.1 Baseline Test: Private Firms' Investment and Industry Valuation

The hypothesis in this paper can be tested with the traditional linear investment regression. I use the average beginning-of-period Market-to-Book ratio of asset of all public firms in the industry as the measure for the industry valuation. To control for other relevant information on which the manager relies when making investment decisions, I include a set of firm and industry

[28]While a higher mean of the individual public firm's Q and the industry average Q for the U.S. public firms is reported in Foucault and Frésard (2014), the median values are close to my statistics based on the U.K. firms.

characteristics (denoted as $X_{i,t-1}$ and $Industry\_X_{i,t-1}$, respectively) documented in the literature to affect investment decisions. I estimate the following baseline regression

$$I_{i,t} = \alpha + \beta \times Industry\_Q_{i,t} + \lambda \times X_{i,t-1} + \theta \times Industry\_X_{i,t-1} + \kappa_i + \delta_t + \epsilon_{i,t} \tag{1}$$

where the subscript i and t index firms and years, respectively; $I_{i,t}$ is the measure of investment, which is the capital expenditure scaled by beginning-of-period capital; $Industry\_Q_{i,t}$ is the average Market-to-Book ratio of asset at the beginning of period t of all public firms in the three-digit SIC industry to which the private firm i belongs, $X_{i,t-1}$ contains $CashFlow_{i,t-1}$ which is firm i's lagged cash flow scaled by beginning-of-period total assets, and $Ln(Asset)_{i,t-1}$ which is the logarithm of lagged total assets.[29] The vector $Industry\_X_{i,t-1}$ includes the average size of all public firms and private peers and the average cash flow of all public firms and private peers.

The results are reported in Table 2. Consistent with Hypothesis 1, the sensitivity of private firms' investment to the industry valuation is significantly positive in Column (1) without the control variables and in Column (2) when $CashFlow_{i,t-1}$ and $Ln(Asset)_{i,t-1}$ are included to control for firm characteristics that affect investment. The sensitivity remains significantly positive in Column (3) when an extended list of firm characteristics (including sales growth, change of cash holding, tangibility, leverage and zscore) and industry characteristics are controlled for. The economic magnitude is considerable: a one standard deviation increase in the industry valuation is associated with a 1.4% increase in the investment (the capital expenditure scaled by beginning-of-period capital) of private firms ($\beta \times SD(Industry\_Q) = 0.023 \times 0.6 = 1.4\%$), which is about 7% of the average investment-to-capital ratio in my sample. This effect is obtained after controlling for the unobserved time-varying shocks common to all firms (by using year fixed effects), and the unobserved heterogeneity at the firm level (by using firm fixed effects).

[29] Cash flow is widely regarded in the investment literature to capture shocks to productivity and demand. Gala and Gomes (2013) show that cash flow is the primary determinant of investment instead of Tobin's Q, even without capital market imperfections.

My results are robust to how industry valuation is measured. In Columns (4) to (6), I replace the equal-weighted industry valuation with the value-weighted average ($Industry\_Q\_vw_{i,t}$) and the results still hold.[30] The results are also robust to how investment is measured. In unreported tables, I use an alternative investment measure ΔK, which is the annual percentage change in capital, the results remain unchanged. The difference between the two measures is that ΔK does not only account for fixed assets invested internally, but also for fixed assets acquired externally through mergers and acquisitions. But since M&As among private firms are not as active as those in public firms, the sensitivity of the two measures to the industry valuation does not have any material difference.

4.2 Identification: Private Firms' Response to the Price Noise

As we do not perfectly observe the information that the manager has already acquired before learning from the stock market, there is still room for endogeneity problems even with private firms. It is possible that some industry-level investment opportunities have already been known to the private firm manager and are reflected into the stock prices of the public firms, but they are not observed by us as econometricians and are not controlled for in the baseline investment regressions. In this case, we may find $\beta > 0$ even under the "No Learning" scenario when estimating Equation (1). In this subsection, I address this concern by estimating Hypothesis 1b and examine whether the investment of private firms reacts to the noise in the price signal. As demonstrated in Section 2, a positive sensitivity of investment to price noise can only be obtained under the "No Learning" scenario regardless of whether the unobserved investment opportunities are omitted or not.

The stock prices of public firms contain both related information and "noise" to private firms. The price noise is defined as the component in the stock price of public firms that is orthogonal to the investment opportunities of private firms. By definition, if the manager of a private firm does

[30] All the results hold if the industry valuation is constructed with public firms that operate in one industry.

not learn from the stock price, she would not adjust the investment decision in response to the false signal. If, instead, she learns such information from the stock prices of the public firms and cannot completely separate the relevant information from the "noise", then *ex post* the investment of her firm will be sensitive to the "noise" in the price signal.[31]

4.2.1 Price Noise Measure: Industry Leaders' Minor-Segment Industry Valuation

The price noise measure in the "Learning" context must satisfy two conditions. The first condition is that the "noise" should be unrelated to the fundamental investment opportunities, and the second condition is that the decision maker cannot completely filter out the unrelated information from the signal on which she acts. If the first condition is violated and the noise captures fundamentals, then a spurious relationship between investment and stock price could still be observed in the absence of learning, whereas if the second condition is violated, the decision maker will only react to the relevant part of the signal and we should not observe any relationship between investment and the price noise. Existing studies have provided various measures for non-fundamental shocks on stock valuation. These measures include (but are not limited to) subsequent stock returns (Baker, Stein and Wurgler (2003) and Polk and Sapienza (2009)), valuation residuals (Rhodes-Kropf, Robinson and Viswanathan (2005) and Hoberg and Phillips (2010)), and price pressure caused by mutual fund fire-sale (Coval and Stafford (2007) and Edmans, Goldstein and Jiang (2012)). While they are useful for testing whether decision makers have incentives to adjust policies in reaction to non-fundamental movements in stock prices (such as market timing or catering), they may not satisfy those two conditions that are necessary for the test here.

I construct a measure of noise in the price signal (specifically for private firms in the context of

[31] This test strategy has been adopted in Morck, Shleifer and Vishny (1990) in search for the impact of investor sentiment on corporate investment through the "Active Informant" channel for the same reason as argued above. Over a decade, even though various choices of the price "noise" have been used to study the effect of non-fundamental components of stock prices through other channels, they have been overlooked in tests of the learning behavior. A more recent paper by Dessaint et al. (2018) also **uses** this strategy on public firms in the U.S. to test the learning behavior. Using price pressure caused by mutual fund outflows as the noise measure, the authors document that the investment of *public* firms reacts to the price noise of peer public firms.

"Learning") based on the valuation of the industry leaders' *unrelated* minor-segment industries, which, as I show below, satisfies the criteria.

Many public firms have fairly complicated business segments. This is especially common for public firms which are the leaders of their industry. When the minor-segments of public firms are in industries unrelated to the major-segment business, movements of industry valuation that are driven by these minor-segment business satisfy the first condition for price noise, since they are unrelated to the fundamental investment opportunities for private firms which are operating in the public firms' major-segment industry. If private firms do not learn from the industry valuation, the private firms' investment will not respond to the valuation of these unrelated minor-segment industries. As such, the room for a spurious relationship between the investment of private firms and the industry valuation of public firms is squeezed when the unrelated minor-segment industry valuation is used as price noise.

Industry leaders' minor-segment industry valuation also satisfies the second condition. This is simply because the stock valuation of conglomerate firms reflects information in both their major and minor segments. Ideally, for a private firm to examine the signal from stock prices, it is optimal for it to find pure players that are similar in size and other characteristics. However, this is not an easy task. Public firms are more scarce than private firms and one has to trade-off the quality of the match and the consistency of the estimate when picking peer firms. Moreover, pure public players are usually much smaller in size than multi-segment public firms. Due to market imperfections, new information is usually incorporated into the stock prices of large firms, especially industry leaders, before it spreads to other firms within the industry. For this reason, Hou (2007) finds that within the same industry, industry leaders lead followers in stock returns. Cen et al. (2013) further document a strong contemporaneous and lead-lag relation in stock returns between firms from industry leaders' unrelated minor-segment industries and pure players in the industry leaders' major-segment industry, which indicates that less sophisticated investors price industry pure players based on the industry leaders' returns without being able to distinguish between the major and minor segment fundamentals. Therefore, industry leaders' minor segments valuation may still contaminate the industry valuation. If private firms learn from the industry valuation, the investment of private firms *ex post* will be sensitive to the valuation of those minor-segment industries.[32]

I obtain the industry codes and financials for segments of public firms from the Worldscope database, which reports information on product segments for international public firms from 1980 and have sufficient coverage after 1990. Product segments are aggregated within the firm at two-digit segment SIC level in each year.[33] I define the "industry leaders" as firms whose major-segment sales rank in the top five among all firms in that industry, where the "major-segment industry" of a firm is defined as the two-digit SIC industry in which the firm generates more than 50% of its total sales.[34] I also identify "industry pure players" as firms that are not industry leaders and generate all their sales from the major-segment industry. Since industry leaders are usually larger firms, many of them have product segments in two-digit SIC industries other than the "major-segment industry". These are defined as the "minor-segment industry", while the leaders in the minor-segment industry are called "minor-segment industry leaders".[35] For each private firm i, I record all minor-segment industries from its industry leaders, and construct the "minor-segment industry valuation" ($Minor\_Industry\_Q_{i,t}$) as the average of the beginning-of-period Market-to-Book ratio of all public firms in the unrelated minor-segment industries. I also construct the "minor-segment industry leaders' valuation" ($Minor\_Leader\_Q_{i,t}$) as the average of the beginning-of-period Market-to-Book ratio of the industry leaders in the unrelated minor-segment industries. To ensure that the results I obtain are from minor-segment industries that

[32] In the literature, it is difficult to answer why the misvaluation can be established by an econometrician but is not known to the investors. However, this is not the skeleton in the closet here since the managers are reacting to noisy signals before the realization of uncertainty, while the tests in this paper are done *ex post*.

[33] My results are robust if I use three-digit SIC segments, but it raises the concern for comovement of fundamentals among different segments. When the segment SIC code is missing, I replace it by the most recent non-missing SIC code of the segment.

[34] If a firm does not have any such segment, its major-segment industry is regarded as missing.

[35] I require that there be at least five industry leaders and at least five pure players in each two-digit SIC industry. My results are not sensitive to the number of industry leaders and pure players.

are unrelated to the major-segment industry, I exclude industry pairs where the industry leader of one industry has a minor-segment in the other industry, while the industry leader of the other industry also has a minor-segment in the first industry.[36]

4.2.2 The Response of Private Firms' Investment to Price Noise

Using "minor-segment industry leaders' valuation" ($Minor\_Leader\_Q_{i,t}$) and "minor-segment industry valuation" ($Minor\_Industry\_Q_{i,t}$) as two alternative measures for the price noise, I estimate whether the investment of private firms responds positively to the price noise (Hypothesis 1b).

$$I_{i,t} = \alpha + \beta \times Minor\_Q_{i,t} + \lambda \times X_{i,t-1} + \theta \times Industry\_X_{i,t-1} + \kappa_i + \delta_t + \epsilon_{i,t} \quad (2)$$

Hypothesis 1b predicts $\beta = 0$ when private firm managers does not learn from the stock market, and $\beta > 0$ when they learn from the stock market.

For each private firm i, I first measure the price noise with the "minor-segment industry leaders' valuation" ($Minor\_Leader\_Q_{i,t}$), which is the average beginning-of-period Market-to-Book ratio of asset of the industry leaders in the minor-segment industries. The results are reported in Columns (1) to (3) of Table 3. I find that the investment of private firms in the industry leaders' major-segment industry reacts positively and significantly to the valuation of industry leaders' *unrelated* minor-segment industries: a one standard deviation increase in minor-segment industry leaders' valuation is associated with a 0.5% increase in capital expenditure (scaled by the beginning-of-year capital) of private firms in the major segments ($\beta \times SD(Minor\_Leader\_Q) = 0.0083 \times 0.61 = 0.5\%$), about 2.3% of the average investment-to-capital ratio. As in Columns (4) to (6) of Table 3, I found consistent results if the price noise is measured by the "minor-segment industry valuation" ($Minor\_Industry\_Q_{i,t}$), which is the average beginning-of-period Market-to-Book ratio of asset of all public firms in the minor-segment industries. The economic magnitude is also comparable:

[36] In section 4.2.4, I further exclude those minor-segment industries in which the private firms may also have minor segments or with which the private firms are likely to have supplier or customer relationships.

a one standard deviation increase in minor-segment industry valuation is associated with a 0.6% increase in the capital expenditure (scaled by the beginning-of-year capital) of private firms in the major segments ($\beta \times SD(Minor\_Leader\_Q) = 0.016 \times 0.393 = 0.6\%$). The results are obtained after controlling for the unobserved time-varying shocks common to all firms (by using year fixed effects), and the unobserved heterogeneity at the firm level (by using firm fixed effects). They are robust if I also control for an extended list of firm-level and industry-level characteristics that affect investment behavior.[37]

As the noise captures part of the price signal that is orthogonal to private firms' investment opportunities, the findings are consistent with models featuring learning from noisy signals. They suggest that only when private firm mangers learn from the industry valuation and cannot filter out irrelevant information from the industry valuation does the investment of private firms react to the noise of the price signal. Thus, if private firms' investment responds to the noise ("mislearning"), we could infer that they learn from the stock ("learning").

4.2.3 Placebo Tests: Irrelevant Industry Valuation and Private Firms' Investment

One alternative explanation for the results in 4.2.2 is that there are unobserved economic links among certain industries that are unrelated to the major-segment industry and we would pick up a positive relationship between the private firms' investment and the valuation of these industries even if we pick other industries than the minor-segment industries. To address this concern, I conduct a placebo test using the average valuation of public firms in random unrelated industries to see if a positive relationship could still be observed. Specifically, I replace each minor-segment industry by a randomly selected "irrelevant" industry, that is, a two-digit SIC industry that does not belong to the minor-segment (nor the major-segment) industries nor shares any minor-segment industries with the major-segment industry leaders. If the results are driven by the co-movements

[37] The results are robust if I instrument $Industry\_Qi,t$ with $Minor\_Leader\_Q_{i,t}$ or $Minor\_Industry\_Q_{i,t}$, and run a two-stage regression.

among certain industries, I would still observe $\beta > 0$ with the "irrelevant" industries. However, under the "learning" framework, using the "irrelevant" industries will produce $\beta = 0$.

I estimate the following regression for the randomly selected "irrelevant" industries:

$$I_{i,t} = \alpha + \beta \times Random\_Q_{i,t} + \lambda \times X_{i,t-1} + \theta \times Industry\_X_{i,t-1} + \kappa_i + \delta_t + \epsilon_{i,t} \tag{3}$$

where $Random\_Q_{i,t}$ is the average beginning-of-period Market-to-Book ratio of asset of all leaders (or all public firms) in the "random irrelevant" industries that are selected to replace the true minor-segment industries.

I repeat the random draw for 500 times and report the average coefficient across the 500 panel regressions. As shown in Table 4, the results of "mislearning" is not present for the "irrelevant" industries. Once I substitute the average valuation of minor-segment industry leaders (or all public firms) with the corresponding valuation from "irrelevant" industries, the relationship between private firms' investment and price noise completely vanishes. This result suggests that the mechanism is through the noise in the price signal rather than any other noise or comovement: the valuation of "irrelevant" industries does not affect the price signal for private firms, and are thereby not learnt by the private firms' managers.

4.2.4 Robustness Tests: Economically Unlinked Private Firms

To ensure that the results I obtained are, to the largest extent, from unrelated minor-segment industries, I perform several robustness tests on the classification.

First, private firms may also have minor segments in the same set of industries as public firms in the same major-segment industry. If this is the case, then the average valuation of the minor-segment industries may reflect the fundamentals in minor-segment industries within which private firms also have minor segments. To address this concern, I retrieve the secondary SIC code of private firms from FAME.[38] As firms are not only required to report the SIC codes for their business segments, but also for all other industries that they operate, I exclude any common business segments shared by private firms and public industry leaders. I first exclude the firm-year observations for which possible economic links could be found, and then exclude the firms' entire data points if a possible economic link could be found in any year over the sample period. My results are robust as reported in Panel A of Table 5.

Second, it is possible that the industry leaders' minor-segment industries have supplier or customer relationships with private firms in the industry leaders' major-segment industry, thereby having correlated fundamentals with the private firms in the major-segment industry. To address this concern, I exclude minor-segment industries that do potentially have supplier and customer relationships with the major-segment industries. I use the 2012 U.S. Input-Output Tables from the Bureau of Economic Analysis, which provide detailed information on the flows of the goods and services that comprise the product process of industries, and define supplier or customer industries as those industries which account for over 25% of the total flows for a given industry. My results are robust as shown in Columns (1) and (2) of Panel B.

Finally, I exclude the minor-segment industries in which the private firms also have operations. Although not classified by the Input-Output Table, these industries do potentially have supplier or customer relationships with the major-segment industries. My results still stand as reported in Columns (3) and (4) of Panel B. Therefore, my findings are not driven by the co-movements among the major and minor-segment industries due to potential economic links.

4.3 Cross-sectional Tests

In this section, I examine how the informativeness of the industry price signal affects the investment-to-industry valuation sensitivity (Hypothesis 2), and how the industry competition structure af-

[38]Worldscope, from which I obtain the segment SIC code of public firms, does not cover private firms.

fects this sensitivity (Hypothesis 3).

4.3.1 Price Informativeness

I use three measures for the industry price informativeness to examine how the informativeness of the industry price signal affects the investment-to-industry valuation sensitivity. The first measure is based on the number of *public* firms in the same three-digit SIC industry. I use a dummy $H\_\#Public$, which equals 1 if the logarithm of 1 plus the number of public firms of the industry is above the 70th percentile, and equals 0 if it is below the 30th percentile. As in Chemmanur, He and Nandy (2010), the more firms already listed in an industry, the easier it is for outsiders, such as unsophisticated investors, sophisticated investors, financial analysts and market makers, to evaluate firms in that industry. Therefore, if there are more public firms in the industry, the industry price is more precise.

For a similar reason, I use $\%Public$, which is the fraction of the number of public firms to all firms in a three-digit SIC industry, as the second measure for price informativeness. As argued in Badertscher, Shroff and White (2013), the fraction of public to all firms in an industry affects the information environment, and thereby, the price and investment efficiency.

The third measure is price non-synchronicity ($H\_Nonsynchronisity$), which is a dummy equal to 1 if the $Nonsynchronisity$ of a three-digit SIC industry is above the 70th percentile, and equal to 0 if it is below the 30th percentile. As is standard in the literature (see Durnev, Morck and Yeung (2004) and Chen, Goldstein and Jiang (2007) for example), I use the price non-synchronicity (or firm-specific return variation) as the measure for individual price informativeness.[39] Then, I construct the non-synchronicity for the industry valuation following Foucault and Frésard (2014).

As shown in Table 6, I find that in industries where the stock prices are more informative about future fundamentals, private firms' investment responds more to the industry average valuation,

[39] I regress public firm i's weekly stock returns on the market portfolio returns and the industry portfolio returns, obtain the $R^2_{i,t}$ and define firm-specific return variation as $1 - R^2_{i,t}$. Weekly return data are from Worldscope.

consistent with Hypothesis 2. The economic magnitude of the investment-price sensitivity in those industries increases substantially: a one standard deviation increase in industry valuation is associated with an approximately 3.4% increase in private firms' capital expenditure (scaled by the beginning-of-year capital) in industries with a high price informativeness, about 16% of the average investment-to-capital ratio.

4.3.2 Common Shocks

To test whether the sensitivity of private firms' investment to the average stock price is stronger when the common demand (or productivity) shock is more important to firms relative to the firm-specific shock, I use three measures for how likely firms are to face common demand shocks: (i) number of firms in the three-digit SIC industry ($H\_\#Firms$), which is a dummy equal to 1 if the logarithm of 1 plus the number of all firms of the industry is above the 70th percentile, and equal to 0 if it is below the 30th percentile; (ii) the (inverse of) the Herfindahl-Hirschman Index of a three-digit SIC industry (L_HHI), which is a dummy equal to 1 if HHI in a three-digit SIC industry is below the 30th percentile, and equal to 0 if it is above the 70th percentile; and (iii) the market share of the top four firms in a three-digit SIC industry (L_Top4_Shares), which is a dummy equal to 1 if the market share of the top four firms in a three-digit SIC industry is below the 30th percentile, and equal to 0 if it is above the 70th percentile. I adopt these commonly used competition measures in the empirical industrial organization literature because in competitive industries, cost reductions and demand surges are more likely to be common across all firms (Hart (1983), Giroud and Mueller (2011)). As shown in Table 7, I find that in industries where firms are more likely to face common shocks, private firms' investment responds more to the industry average valuation, consistent with Hypothesis 3.

4.4 Alternative Hypothesis

4.4.1 Market Competition and Internal Allocation within Industry Leaders

It may be argued that market competition between public firms and private firms may generate the investment-valuation relationship in the absence of learning. However, this explanation is not supported by the data for several reasons. First, if I include additional variables in the baseline regression in Equation ((1)) to control for the investment of public firms and private firms, all results are robust. Second, the optimal response of private firms to the competition pressure depends on the competition structure. Under Cournot competition, the sensitivity of private firms' investment to industry valuation is expected to be negative, which contradicts the findings up to now. Third, the competition argument predicts that the effect is stronger for concentrated industries in which strategic behaviors are more predominant, which is the opposite to the findings in Section 4.3.2. Finally, market competition cannot explain why private firms' investment reacts to the industry leaders' minor-segment industry. Therefore, the results in this paper are not driven by competitions between public and private firms.

It may still be argued that industry leaders may allocate resources towards or out of the major segment when the unrelated minor-segment industries are experiencing high valuation shocks.[40] If this is the case, the investment of private firms in the industry leaders' major-segment industry may adjust their own investment in expectation of any investment (or disinvestment) of the industry leaders in the major-segment industry. It is unclear whether this alternative mechanism predicts a positive or negative relationship between the private firms' investment and the industry leaders' minor-segment industries as the prediction depends on the competition structure.[41] Nonetheless, I address this concern by directly testing whether there is indeed an internal allocation among the segments of the industry leader.

[40]The direction of the allocation may differ depending on the financial deficit of the minor segments.

[41]For the story to fit the evidence, one has to assume Bertrand (Cournot) competition when private firms anticipate that industry leaders' major-segment receives an inflow (outflow) following an increase in the minor-segment valuation.

I examine whether the investment in the major segment of the industry leaders is affected by the valuation of industry leaders' unrelated minor-segment industry valuation, measured by $Minor\_Leader\_Q_{i,t}$ (in Columns (1) and (2)) and $Minor\_Industry\_Q_{i,t}$ (in Columns (3) and (4)). As shown in Table 8, this is not the case regardless of whether the major-segment industry valuation is included.[42] The investment of the major segment of the industry leaders is not affected by the unrelated minor-segment valuation. Therefore, the internal allocation view does not explain the result. This is not surprising. Theory predicts that headquarters should withdraw resources from existing plants to plants with an increase in investment opportunities, only if the firm is financially constrained (see Giroud and Mueller (2015) for a summary of the theory and the empirical evidence). Industry leaders are at the top of the pyramid to obtain financing and thus rarely rely on the internal allocation to finance the major-segment investment.

4.4.2 Sentiment and Cost of Capital

Another possible channel for the industry valuation to affect the investment of the private firms is that it affects the sentiment of the financier (most likely the bank) and the cost of capital.[43] If bank sentiment is positively affected by the industry valuation, the lower effective cost of capital allows private firms to increase the investment even when the firms are not learning from the stock market. If this is the case, the model in Stein (1996) in the context of sentiment in the equity market implies that the investment made by those firms that are financially constrained will be more sensitive to the sentiment, as they need external financing to fund the marginal project and will be less likely to proceed under unfavorable market conditions.

To address this concern, I test whether the results I obtain are predominant for financially constrained firms following Baker, Stein and Wurgler (2003). I use size, dividend payout, Whited-Wu

[42]The major-segment industry valuation $Major\_Industry\_Q_{i,t}$, which is the beginning-of-period Market-to-Book ratio of all pure players in the major-segment industry, is significantly positive as expected.

[43]Note that the cost of capital may be affected if the firm perceives an investment opportunity by observing an increase in the industry valuation and convinces the bank to obtain debt financing. I do not consider this as an alternative to the learning channel.

Index, and Hadlock-Pierce Index as classification schemes for financial constraints, and consider small firms, firms that do not pay dividends, and firms that have high indices as financially constrained firms. As presented in Table 9, financially constrained firms do not react more to the industry valuation than financially unconstrained firms, which suggests that the results are not fully driven by bank sentiment induced cost of capital in the absence of learning.

4.5 Public Firms' Investment

To study the response of public firms' investment, I estimate the baseline regression for a matched sample of private and public firms as shown in Equation ((4)).

$$I_{i,t} = \alpha + \beta \times Industry\_Q_{i,t} + \beta_2 \times Industry\_Q_{i,t} \times Public_i + \lambda \times X_{i,t-1} + \theta \times X_{i,t-1} \times Public_i + \kappa_i + \delta_t + \epsilon_{i,t} \tag{4}$$

where $Public_i$ is a dummy equal to 0 for a private firm, and 1 for a matched public firm. I use the caliper-based nearest-neighbor matching with replacement adapted to a panel setting following Asker, Farre-Mensa and Ljungqvist (2014).[44] Since one public firm could be matched to different private firms, I end up with more private observations (76,738) than public observations (8,135). The panel structure of the data allows us to estimate the within-firm sensitivity of investment to the industry valuation.

Under the assumption that the distribution of the managers' signal does not differ across private and public firms and that public firms do not have agency costs due to the separation of ownership and control, Hypothesis 4 predicts that a private firm always puts a higher weight on the industry valuation than a comparable public firm, when both firms make use of all available information (i.e. $\beta_2 < 0$). This is because the public firm has its own stock price which will guide managers' decision when it is informative. However, as shown in Column (1) of Table

[44]Starting from 1993, I match private firms with public firms from the same three-digit industry and closest in size. I require that the ratio of their total assets is less than 2. If no match can be found, I drop the observation and look for a match in the following year. Once a match is found, the firm kept in subsequent years.

10, β_2 is statistically insignificantly positive and economically small. This confirms the previous conjecture that public firms have other incentives to respond to the stock valuation than what has been suggested by the learning hypothesis. The most prominent channels documented in the existing literature are the "equity financing channel" and the catering channel. The former suggests that equity issuance and capital investment of public firms be affected by stock prices because the effective cost of external equity of public firms can diverge from the cost of other forms of capital due to movements of the irrational element contained in stock prices (Keynes (1936), Morck, Shleifer and Vishny (1990), Stein (1996) and Baker, Stein and Wurgler (2003), among others). The latter, as in Polk and Sapienza (2009), argues that managers of public firms may try to cater to investors' sentiment to protect their own livelihood by adjusting the investment in response to movements in stock prices. Given these additional differences between public and private firms, one should be extremely careful when drawing inference from evidence of public firms or comparing the change in the response to industry valuation following a status transition from public (private) to private (public).

As public firms are much more active in mergers and acquisitions, I replace the dependent variables in Equation (4) with ΔK, which is the percentage change of capital. A notable finding, as shown in Column (2), is that public firms respond in a much more sensitive way to industry valuation, which is possibly consistent with Rhodes-Kropf, Robinson and Viswanathan (2005) who claim that increasing industry misvaluation increases merger activities.

I further turn to the comparison of financing policies. I replace the dependent variable in Equation (4) with $Equity\ Issue$ and $Debt\ Issue$ constructed using balance sheet items following Dasgupta, Noe and Wang (2011).[45] As shown in columns (3) and (4), public firms' equity financing is much more sensitive to industry valuation, which is consistent with the earlier view that public firms rely much more heavily on equity than do private firms (Brav (2009)). Their debt issuance

[45]Due to data limitation on the actual issuance of private firms, $Equity\ Issue$ is constructed as the annual change of *Book Equity* minus the annual change of *Retained Earnings* (scaled by lagged fixed assets), and $Debt\ Issue$ is the annual change of *Book Debt* (scaled by lagged capital).

is even negatively associated with industry valuation. This substitution of debt with equity is possibly in line with the market timing literature that high returns trigger equity issuance (Baker, Stein and Wurgler (2003), Alti and Sulaeman (2012), among others).

5 Conclusion

Whether the stock market affects the real economy through its role of producing and aggregating information has long been one of the interests of finance studies. While previous studies have documented ample evidence on the relationship of stock prices and public firms' investment, it is challenging to attribute the effect to managerial learning due to the econometricians' inability to observe corporate managers' private information set when making investment decisions.

In this paper, I explore a novel empirical strategy with privately held companies. Using a large panel data set for the United Kingdom, I find that investments of private firms respond positively to the valuation of public firms in the same industry. The sensitivity is stronger in industries where stock prices are more informative or firms are more likely to face common demand shocks. To rule out the possibility that unobserved investment opportunities drive both private firms' investment and the industry valuation and generate a spurious relationship even in the absence of learning, I further show that the investment of private firms reacts positively to the noise in the price signal, measured by the valuation of industry leaders' unrelated minor-segment industries. The evidence is consistent with models featuring learning from noisy signals, and is not driven by alternative channels in the absence of learning.

"The price system is just one of those formations which man has learned to use (though he is still very far from having learned to make the best use of it) after he had stumbled upon it without understanding it" (Hayek (1945)). In this paper, I show that private firms behave in such a way that the managers exploit information contained in the stock prices, but cannot completely filter out information related to multisegment public leaders but unrelated to themselves.

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Appendices

A Framework for the Hypothesis

This appendix illustrates the mechanism for the stock market to affect the investment of private firms through a learning channel.

A.1 Production Technology

Consider a market (say, an industry) with N public firms and M private firms.[A.1] They sell products for which demand (or productivity) is uncertain, and generate cash flow at date 1. At date 0, each firm i is endowed with constant capital k_0, and needs to decide whether to adjust **its** capacity or not. Through investing the amount of I_i, the firm can adjust the level of capital to k_i, i.e.,

$$k_i = k_0 + I_i \,. \tag{A.1}$$

I assume a quadratic investment adjustment cost so that the optimal investment can be expressed as a linear function of marginal q.[A.2] Then, the project value V_i is given by the reduced-form function

$$V_i = \mathrm{E}\left[v_i \pi\left(k_i\right) - I_i - \left(a_1 I_i + \frac{a_2}{2} I_i^2\right) \mid \Omega_i\right] \,, \tag{A.2}$$

where E is the expectations operator, Ω_i is the information set of firm i's manager at date 0, $\pi\left(k_i\right)$ is the continuous production function, $\pi(0) = 0$, $\pi_k\left(k_i\right) > 0$, $\pi_{kk}\left(k_i\right) < 0$, and $\lim_{k\to 0} \pi_k\left(k_i\right) = \infty$.

The demand (or productivity) shock v_i is a linear combination of two shocks:

$$v_i = \Phi + \eta_i \,, \tag{A.3}$$

where Φ is common to all firms in the market and is normally distributed with mean $\mu_\Phi > 0$ and variance σ_Φ^2, while η_i is specific to firm i and is an i.i.d. normal variable with mean 0 and variance σ_η^2. Moreover, the firm-specific shock η_i is independent of the common shock Φ.

The first-order condition for maximizing the firm value in Equation (A.2) subject to (A.1) is

$$\mathrm{E}\left(v_i \mid \Omega_i\right) \pi_k\left(k_i^*\right) = 1 + a_1 + a_2\left(k_i^* - k_0\right) \,. \tag{A.4}$$

Thus, the optimal investment can be expressed as a linear function of marginal q, which consists of the manager's expectation of the future productivity and the marginal contribution of new capital goods to future profit:

$$I_i^* = \left(k_i^* - k_0\right) = \frac{1}{a_2}\mathrm{E}\left(v_i \mid \Omega_i\right) \pi_k - \frac{a_1 + 1}{a_2} \,. \tag{A.5}$$

[A.1] The analysis applies to a continuum of firms in the market. The finite number N will only be useful when studying the effect of the informativeness of the market signal, as discussed later.

[A.2] This is standard in the q theory literature. What is distinct from the standard q theory is whether the information set Ω_i automatically incorporates all the available information.

A.2 Information Structure

At date 0, firm i's manager receives a signal m_i about i's future demand (or productivity):

$$m_i = \Phi + \eta_i + \varepsilon_i \, , \tag{A.6}$$

where the signal noise term ε_i is normally distributed with mean 0 and variance σ^2_ε. It is assumed to be independent of Φ and η_i, and is independent of ε_j for any $j \in (1, \ldots, N + M)$ and $j \neq i$.

Moreover, for public firm i where $i \in (1, \ldots, N)$, with some noise ω_i, information on future demand (or productivity) is also reflected in the stock price p_i[A.3]

$$p_i = \Phi + \eta_i + \omega_i \, , \tag{A.7}$$

where ω_i is normally distributed with mean 0 and variance σ^2_ω. ω_i is independent of Φ, η_i and ε_i, but could be correlated with ω_j with some correlation $0 \leq \rho \leq 1$ for any $j \in (1, \ldots, N)$ and $j \neq i$. In other words, the stock price contains some "false" signal possibly due to investor sentiment, investor inattention, or any other frictions that affect a group of stocks or the entire market.

Therefore, the average of stock prices $\bar{p}$ reveals the common shock with some noise:

$$\bar{p} = \Phi + \bar{\omega} \, , \tag{A.8}$$

where $\bar{\omega}$ is the price noise term for $\bar{p}$. Since ω_i follows an N-dimensional joint-normal distribution, $\bar{\omega}$ follows a normal distribution with a mean of 0 and a variance of $\sigma^2_{\bar{\omega}}$.[A.4] When N goes to infinity, $\sigma^2_{\bar{\omega}}$ converges to $\rho\sigma^2_\omega$, whereas with finite N, $\sigma^2_{\bar{\omega}}$ is given by

$$\sigma^2_{\bar{\omega}} = \frac{1}{N}\sigma^2_\omega + \frac{N-1}{N}\rho\sigma^2_\omega, \tag{A.9}$$

which equals σ^2_ω if $\rho = 1$ or $N = 1$, and have the following properties otherwise:

$$\frac{\partial \sigma^2_{\bar{\omega}}}{\partial N} = -\frac{(1-\rho)\,\sigma^2_\omega}{N} < 0; \tag{A.10}$$

$$\text{and} \quad \frac{\partial \sigma^2_{\bar{\omega}}}{\partial \rho} = \frac{N-1}{N}\sigma^2_\omega > 0. \tag{A.11}$$

which suggests that when there is more than one public firm in the market and there exists some but not perfect correlation across the price noise terms, the average stock price is more informative (less volatile) if (i) the number of public firms in the market is higher; or (ii) the price noise terms are less correlated. These results motivate the use of the number of public firms in the industry and price-nonsynchronicity as proxies for informativeness of the industry average price.

[A.3]Note that I do not attempt to model the price generating process in detail and explicitly show how the shocks are linked to the stock price, but rather rely on the predictions from existing models such as Kyle (1985).

[A.4]If ω_i is i.i.d. instead, then $\bar{\omega}$ vanishes so that $\bar{p}$ is a perfect signal of the common shock Φ.

A.3 Stock Prices and Private Firms' Investment

In this subsection, I derive the investment decision of the private firm under two scenarios: "No Learning" and "Learning". Since the optimal investment I_i^* is linear and increasing in managers' expectations as in Equation (A.5), the problem here can be translated into a comparison of managers' expectations of future conditions under the two scenarios.

No Learning. If private firm i's manager ($i = 1, \ldots, M$) does not learn from the stock market, her expectation of future shocks will only be conditional on the private signal (i.e., $\Omega_i = m_i$) and can be expressed as a weighted average of the unconditional belief of the shock (which is a constant known to all agents by assumption) and the managerial private signal:

$$\mathrm{E}\left(v_i \mid m_i\right) = \left(1 - \lambda_{Pri}^{No}\right) \mu_\Phi + \lambda_{Pri}^{No} m_i \tag{A.12}$$

where

$$\lambda_{Pri}^{No} = \frac{\sigma_\Phi^2 + \sigma_\eta^2}{\sigma_\Phi^2 + \sigma_\eta^2 + \sigma_\varepsilon^2} \tag{A.13}$$

λ_{Pri}^{No} is higher if the private signal is more precise (i.e. $\frac{\partial \lambda_{Pri}^{No}}{\partial \sigma_\varepsilon^2} < 0$).

Suppose that the manager's information set (m_i) could be controlled for, then regressing the investment on both signals will give us a coefficient of λ_{Pri}^{No} on m_i, and a coefficient of zero on $\bar{p}$ (i.e, $\beta_{Pri}^{No} = 0$) as the stock price was not used by the manager.

Learning from the Stock Market. If private firm i's manager learns from the stock market, her information set will contain both signals (i.e., $\Omega_i = [\bar{p}, m_i]$), and the conditional expectations of the shocks will be a weighted average of three components: the unconditional belief of the shock, the signal from the average stock price, and the private signal to the manager, i.e.

$$\mathrm{E}\left(v_i \mid \bar{p}, m_i\right) = \left(1 - \beta_{Pri}^{Learn} - \lambda_{Pri}^{Learn}\right) \mu_\Phi + \beta_{Pri}^{Learn} \bar{p} + \lambda_{Pri}^{Learn} m_i \tag{A.14}$$

where

$$\beta_{Pri}^{Learn} = \frac{\sigma_\Phi^2 \sigma_\varepsilon^2}{\sigma_\Phi^2\left(\sigma_\eta^2 + \sigma_\varepsilon^2\right) + \sigma_{\bar{\omega}}^2\left(\sigma_\Phi^2 + \sigma_\eta^2 + \sigma_\varepsilon^2\right)} \tag{A.15}$$

$$\text{and} \qquad \lambda_{Pri}^{Learn} = \frac{\sigma_\Phi^2 \sigma_\eta^2 + \sigma_{\bar{\omega}}^2\left(\sigma_\Phi^2 + \sigma_\eta^2\right)}{\sigma_\Phi^2\left(\sigma_\eta^2 + \sigma_\varepsilon^2\right) + \sigma_{\bar{\omega}}^2\left(\sigma_\Phi^2 + \sigma_\eta^2 + \sigma_\varepsilon^2\right)} \tag{A.16}$$

Here, investment responds positively to average valuation ($\beta_{Pri}^{Learn} > 0$) as long as (i) there exists uncertainty in the common shock (i.e. $\sigma_\Phi^2 > 0$), and (ii) the manager's private signal is not perfect (i.e. $\sigma_\varepsilon^2 > 0$). Both conditions are satisfied for the model to be non-trivial. Therefore,

***Hypothesis* 1:** After controlling for the manager's private signal, the investment of private firms responds positively to the valuation of public firms in the same industry if and only if private firm managers learn from the stock market.

When Hypothesis 1 is taken to the data, however, we cannot perfectly control for the manager's information set (m_i) as it is not observable to us as econometricians. To solve this problem, rearranging terms in Equation (A.14) yields

$$\mathrm{E}\left(v_i \mid \bar{p}, m_i\right) = \left(1 - \beta_{Pri}^{Learn} - \lambda_{Pri}^{Learn}\right)\mu_\Phi + \beta_{Pri}^{Learn}\bar{\omega} + \lambda_{Pri}^{Learn}\left(\eta_i + \varepsilon_i\right) + \left(\beta_{Pri}^{Learn} + \lambda_{Pri}^{Learn}\right)\Phi \quad \text{(A.17)}$$

where β_{Pri}^{Learn} and λ_{Pri}^{Learn} are derived in Equations (A.15) and (A.16). Thus, a testable version of Hypothesis 1 can be developed, which explores $\bar{\omega}$, the component in the price signal that is orthogonal to the manager's (relevant) information set.

Hypothesis **1b:** The investment of private firms responds positively to the price "noise" of public firms in the same industry, if and only if private firm managers learn from the stock market.

A.4 Comparative Statics under the "Learning" Scenario

Under the"No Learning" scenario, the variance of the noise term in the average stock price ($\sigma_{\bar{\omega}}^2$) plays no role in the optimal investment decision. This is not the case under the "Learning" scenario: the more precise (the less noisy) is the signal from the average stock price, the more sensitively does private firms' investment respond to the average stock price. This can be seen from the following partial derivative:

$$\frac{\partial \beta_{Pri}^{Learn}}{\partial \sigma_{\bar{\omega}}^2} = -\frac{\sigma_\Phi^2\sigma_\varepsilon^2\left(\sigma_\Phi^2 + \sigma_\eta^2 + \sigma_\varepsilon^2\right)}{\left[\sigma_\Phi^2\left(\sigma_\eta^2 + \sigma_\varepsilon^2\right) + \sigma_{\bar{\omega}}^2\left(\sigma_\Phi^2 + \sigma_\eta^2 + \sigma_\varepsilon^2\right)\right]^2} < 0 \quad \text{(A.18)}$$

As shown in Equations (A.10) and (A.11), the industry average stock price is more informative ($\sigma_{\bar{\omega}}^2$ is smaller) when the number of public firms (N) is higher, or when the correlation of the stock price across firms (ρ) is lower. Using N as a proxy and ρ as an inverse proxy for the informativeness of the average industry stock price, the model predicts that

Hypothesis **2:** The sensitivity of private firms' investment to the industry valuation is stronger when the industry has a larger number of public firms, or when there is less co-movement of stock prices within the industry.

Finally, when firms are more likely to face common shocks, the information from the average valuation is more valuable. To see this, define f as the fraction of the variance of common shocks to the variance of total shocks (i.e., $f = \frac{\sigma_\Phi^2}{\sigma_\Phi^2 + \sigma_\eta^2}$ and $0 < f < 1$). Taking the partial derivative of β_{Pri}^{Learn} with respect to f yields

$$\frac{\partial \beta_{Pri}^{Learn}}{\partial f} = \frac{\sigma_\eta^2\sigma_\varepsilon^2\sigma_{\bar{\omega}}^2\left(\sigma_\eta^2 + \sigma_\varepsilon^2\right)}{(1-f)\left[\sigma_\Phi^2\left(\sigma_\eta^2 + \sigma_\varepsilon^2\right) + \sigma_{\bar{\omega}}^2\left(\sigma_\Phi^2 + \sigma_\eta^2 + \sigma_\varepsilon^2\right)\right]^2} > 0 \quad \text{(A.19)}$$

Therefore,

Hypothesis **3:** The sensitivity of private firms' investment to industry valuation is stronger when the industry common shock is more important relative to the firm-specific shock.

B The Response of Public Firms without Agency Costs

In this Appendix, I derive the optimal investment responses of public firms. I only consider the benchmark case without any agency cost. Therefore, the public firms discussed here differ from private firms only in one dimension: the presence of the firm's own stock price.

B.1 Stock Prices and Private Firms' Investment

No Learning. When managers do not learn from the stock market, public firms will follow the same decision rule as private firms under the "No Learning" scenario as in Equation (A.12).

Learning from Own Stock Price. If the public firm i ($i = 1, \ldots, N$) makes use of i's own stock price, but ignores the average stock price (i.e., $\Omega_i = [p_i, m_i]$), [B.1] the conditional expectation of the future state can be derived as

$$\mathrm{E}\left(v_i \mid p_i, m_i\right) = \left(1 - \gamma_{Pub}^{Narrow} - \lambda_{Pub}^{Narrow}\right)\mu_\Phi + \gamma_{Pub}^{Narrow} p_i + \lambda_{Pub}^{Narrow} m_i \tag{B.1}$$

where

$$\gamma_{Pub}^{Narrow} = \frac{\sigma_\varepsilon^2\left(\sigma_\Phi^2 + \sigma_\eta^2\right)}{\sigma_\varepsilon^2\left(\sigma_\Phi^2 + \sigma_\eta^2\right) + \sigma_\omega^2\left(\sigma_\Phi^2 + \sigma_\eta^2 + \sigma_\varepsilon^2\right)} \tag{B.2}$$

$$\text{and} \qquad \lambda_{Pub}^{Narrow} = \frac{\sigma_\omega^2\left(\sigma_\Phi^2 + \sigma_\eta^2\right)}{\sigma_\varepsilon^2\left(\sigma_\Phi^2 + \sigma_\eta^2\right) + \sigma_\omega^2\left(\sigma_\Phi^2 + \sigma_\eta^2 + \sigma_\varepsilon^2\right)} \tag{B.3}$$

Learning from Own and Average Stock Price. When firm i learns from both i's own stock price and the industry average stock price (i.e., $\Omega_i = [\bar{p}, p_i, m_i]$), [B.2] the conditional expectation of the future state can be derived as

$$\mathrm{E}\left(v_i \mid \bar{p}, p_i, m_i\right) = \left(1 - \beta_{Pub}^{Learn} - \gamma_{Pub}^{Learn} - \lambda_{m_i}^{Learn}\right)\mu_\Phi + \beta_{Pub}^{Learn}\bar{p} + \gamma_{Pub}^{Learn} p_i + \lambda_{Pub}^{Learn} m_i \tag{B.4}$$

where

$$\beta_{Pub}^{Learn} = \frac{1}{\Lambda}\sigma_\varepsilon^2\left[\sigma_\Phi^2\sigma_\omega^2 - \sigma_{\bar{\omega}}^2\left(\sigma_\Phi^2 + \sigma_\eta^2\right)\right] \tag{B.5}$$

$$\gamma_{Pub}^{Learn} = \frac{1}{\Lambda}\sigma_\eta^2\sigma_\varepsilon^2\left(\sigma_\Phi^2 + \sigma_{\bar{\omega}}^2\right) \tag{B.6}$$

$$\lambda_{Pub}^{Learn} = \frac{1}{\Lambda}\left[\sigma_\Phi^2\sigma_\eta^2\sigma_\omega^2 + \sigma_{\bar{\omega}}^2\left(\sigma_\omega^2 - \sigma_{\bar{\omega}}^2\right)\left(\sigma_\Phi^2 + \sigma_\eta^2\right)\right] \tag{B.7}$$

$$\text{and} \qquad \Lambda = \sigma_\Phi^2\sigma_\eta^2\sigma_\varepsilon^2 + \sigma_\eta^2\left(\sigma_\Phi^2\sigma_\omega^2 + \sigma_\varepsilon^2\sigma_{\bar{\omega}}^2\right) + \left(\sigma_\omega^2 - \sigma_{\bar{\omega}}^2\right)\left[\sigma_\Phi^2\sigma_\varepsilon^2 + \sigma_{\bar{\omega}}^2\left(\sigma_\Phi^2 + \sigma_\eta^2 + \sigma_\varepsilon^2\right)\right] \tag{B.8}$$

[B.1] Such a scenario is similar to the "narrow learning" results examined in Foucault and Frésard (2014).

[B.2] This is similar to the "learning from peers" case in Foucault and Frésard (2014).

As N goes to infinity, we have $\sigma_{\bar{\omega}}^2 = \rho\sigma_{\omega}^2$. Then, the weights on each signal become

$$\beta_{Pub}^{Learn} = \frac{\sigma_{\varepsilon}^2\sigma_{\omega}^2}{\Lambda}\left[(1-\rho)\,\sigma_{\Phi}^2 - \rho\sigma_{\eta}^2\right] \tag{B.9}$$

$$\gamma_{Pub}^{Learn} = \frac{\sigma_{\eta}^2\sigma_{\varepsilon}^2}{\Lambda}\left(\sigma_{\Phi}^2 + \rho\sigma_{\omega}^2\right) \tag{B.10}$$

$$\lambda_{Pub}^{Learn} = \frac{\sigma_{\omega}^2}{\Lambda}\left[\sigma_{\Phi}^2\sigma_{\eta}^2 + \rho\,(1-\rho)\,\sigma_{\omega}^2\left(\sigma_{\Phi}^2 + \sigma_{\eta}^2\right)\right] \tag{B.11}$$

and
$$\Lambda = \sigma_{\Phi}^2\sigma_{\eta}^2\sigma_{\varepsilon}^2 + \sigma_{\eta}^2\sigma_{\omega}^2\left(\sigma_{\Phi}^2 + \rho\sigma_{\varepsilon}^2\right) + (1-\rho)\,\sigma_{\omega}^2\left[\sigma_{\Phi}^2\sigma_{\varepsilon}^2 + \rho\sigma_{\omega}^2\left(\sigma_{\Phi}^2 + \sigma_{\eta}^2 + \sigma_{\varepsilon}^2\right)\right] \tag{B.12}$$

For all possible values of ρ, we have

$$\Lambda > 0, \quad \gamma_{Pub}^{Learn} > 0, \text{ and } \quad \lambda_{Pub}^{Learn} > 0$$

The sign of β_{Pub}^{Learn}, however, depends on the value of ρ and $f = \frac{\sigma_{\Phi}^2}{\sigma_{\Phi}^2+\sigma_{\eta}^2}$:

(1) when $\rho = 0$, meaning that $\bar{p}$ is a perfect signal of the common shock, $\beta_{Pub}^{Learn} > 0$;

(2) when $0 < \rho < 1$, $\beta_{Pub}^{Learn} > 0$ if $f > \rho$, and $\beta_{Pub}^{Learn} <= 0$ if $f <= \rho$;

(3) when $\rho = 1$, meaning that the average price noise is as volatile as the individual one, $\beta_{Pub}^{Learn} < 0$.

B.2 Comparison of Public and Private Firms

Given any value of ρ, if the only difference between the public and the private firm is the presence of own stock price, the difference in their investment-to-industry stock price sensitivity is given by

$$\beta_{Pri}^{Learn} - \beta_{Pub}^{Learn} = \frac{\left(\sigma_{\Phi}^2 + \rho\sigma_{\omega}^2\right)\left[\sigma_{\Phi}^2\sigma_{\varepsilon}^2 + \rho\sigma_{\omega}\left(\sigma_{\Phi}^2 + \sigma_{\eta}^2 + \sigma_{\varepsilon}^2\right)\right]}{\Lambda\left[\sigma_{\Phi}^2\left(\sigma_{\eta}^2 + \sigma_{\varepsilon}^2\right) + \rho\sigma_{\omega}^2\left(\sigma_{\Phi}^2 + \sigma_{\eta}^2 + \sigma_{\varepsilon}^2\right)\right]} \tag{B.13}$$

where β_{Pri}^{Learn} is the private firm's weight on the industry average stock price under the "Learning" scenario, β_{Pub}^{Learn} is the public firms' weight on the industry average stock price when the manager learns from its own stock price and the industry average price, and Λ is given in Equation (B.12).

It can be show that $\beta_{Pri}^{Learn} - \beta_{Pub}^{Learn} > 0$ if (i) there is uncertainty about the common demand or productivity (i.e. $\sigma_{\Phi}^2 > 0$), and (ii) managers do not receive a perfect signal about future shocks (i.e. $\sigma_{\varepsilon}^2 > 0$). Therefore,

***Hypothesis* 4 (No Agency Problem):** When both private firms and public firms learn from the stock market and public firms do not have any agency concerns, private firms respond more to the average stock price than do public firms.

C Variable Definitions

In this appendix, we discuss the definitions of the main variables used in this paper. All definitions coincide with line items in corporate balance sheets, profit and loss (P&L) accounts, and the cash flow statement in the FAME database or other studies utilizing the FAME database.

C.1 Firm-level variables

Total Assets is the balance sheet item Total Asset reported in 2005 constant million pounds;

K (capital) is the balance sheet item Fixed Asset reported in 2005 constant million pounds, which is the sum of the tangible asset and the intangible asset;

Capx/K is the cash flow statement item Capital Expenditures scaled by the beginning-of-period capital;

Major_Capx/K is Capital Expenditures from the firm's major segment scaled by the beginning-of-period capital of the major segment, where major (minor) segments are the two-digit SIC industry in which the firm generates more (less) than 50% of its total sales;

ΔK is the annual change of capital scaled by the beginning-of-period capital;

Ln(Asset) is the logarithm of Total Assets;

CashFlow is the cash flow of the period scaled by the beginning-of-period Total Assets, where cash flow is the sum of the profit & loss account items Profit (Loss) for the Period and Depreciation;

ΔSales is the annual change of sales scaled by the beginning-of-period Total Assets, where sales **correspond** to the profit & loss account item Turnover;

ΔCash is the annual change of cash holdings scaled by the beginning-of-period Total Assets, where cash holdings are the sum of the balance sheet items Bank & Deposits and Investment;

Tangibility is the sum of the balance sheet items Land & Buildings, Fixtures & Fittings, and Plant & Vehicles, scaled by the beginning-of-period Total Assets;

Leverage is defined as Book Debt plus Trade Creditors, scaled by the beginning-of-period Total Assets;

Equity Issue is the annual change of Book Equity minus the annual change of Retained Earnings, scaled by the beginning-of-period capital, where Book Equity is constructed using the balance sheet items and is the sum of Shareholders Fund and Deferred Tax, and Retained Earnings is defined as the balance sheet item profit & loss account;

Debt Issue is the annual change of Book Debt scaled by the beginning-of-period capital, where Book Debt is constructed using the balance sheet items and is defined as Long Term Debt plus Short Term Loans & Overdrafts minus Group Loans;

Market-to-book for public firms is the market-to-book ratio of assets, where the market value of assets is defined as Total Assets − Book Equity + stock price at the end of the fiscal year × number of shares outstanding;

Own_Q for public firms is the beginning-of-period *Market-to-book*;

FC_Size is a dummy that equals 1 (0) if the firm's total asset ranks below (above) the bottom (top) 30th percentile among all firms of the same public/private status in the three-digit SIC industry in a given year;

FC_Dividend is a dummy that equals 1 if the firm does not pay any dividend in the year and 0 if the firm's dividend payout is positive;

FC_WW is a dummy that equals 1 (0) if the Whited-Wu Index is above (below) the top (bottom) 30th percentile among all firms of the same public/private status in the three-digit SIC industry in a given year;

FC_HP is a dummy that equals 1 (0) if the Hadlock-Pierce Index is above (below) the top (bottom) 30th percentile among all firms of the same public/private status in the three-digit SIC industry in a given year;

C.2 Industry-level variables

Industry_Q is the equal-weighted average of the beginning-of-period *Market-to-book* of public firms in a three-digit SIC industry;

Industry_Q_vw is the value-weighted average of the beginning-of-period *Market-to-book* of public firms in a three-digit SIC industry, where the weight is the Total Assets;

Private_CashFlow is the average *CashFlow* of private peers in the three-digit SIC industry;
Private_Ln(Asset) is the average *Ln(Asset)* of private peers in the three-digit SIC industry;
Public_CashFlow is the average *CashFlow* of public firms in a three-digit SIC industry;
Public_Ln(Asset) is the average *Ln(Asset)* of public firms in a three-digit SIC industry;
Minor_Leader_Q is the average beginning-of-period *Market-to-book* of all unrelated minor-segment industry leaders for a two-digit SIC industry;

Minor_Industry_Q is the average beginning-of-period *Market-to-book* of all unrelated minor-segment industries for a two-digit SIC industry;

Random_Leader_Q is the average beginning-of-period *Market-to-book* of all leaders in the "random irrelevant" industries that are selected for the private firm;

Random_Industry_Q is the average beginning-of-period market-to-book of the "random irrelevant" industries that are selected for the private firm;

Major_Industry_$\mathbf{Q_{i,t}}$ is the average beginning-of-period market-to-book of all pure-players for the two-digit SIC industry in the industry leaders' major-segment industry;
#Public is the logarithm of 1 plus the number of public firms in a industry;

H_#Public is a dummy which equals 1 if *#Public* of the industry is above the 70th percentile, and **equals** 0 if it is below the 30th percentile;

%Public is the fraction of number of public firms to all firms in a three-digit SIC industry;

Nonsynchronisity is estimated by the $1 - R^2$ from running weekly firm return on the market return and three-digit SIC industry return;

H_Nonsynchronisity is a dummy which equals 1 if the $Nonsynchronisity$ of a three-digit SIC industry is above the 70th percentile, and equals 0 if it is below the 30th percentile;

#**Firms** is the logarithm of 1 plus the number of all firms in a three-digit SIC industry;

H_#Firms is a dummy which equals 1 if the $\#Firms$ of a three-digit SIC industry is above the 70th percentile, and equals 0 if it is below the 30th percentile;

HHI is the Herfindahl-Hirschman Index of a three-digit SIC industry calculated as the sum of squared market shares;

L_HHI is a dummy which equals 1 if HHI in a three-digit SIC industry is below the 30th percentile, and equals 0 if it is above the 70th percentile;

Top4_Share is the market share of the top four firms in a three-digit SIC industry;

L_Top4_Share is a dummy which equals 1 if the $Top4\_Share$ in a three-digit SIC industry is below the 30th percentile, and equals 0 if it is above the 70th percentile.

Table 1: **Summary Statistics**

This table reports the descriptive statistics of the main variables used in the analysis. The sample period is from 1993 to 2010. All variables are defined in Appendix C. The accounting variables for public and private firms are from the FAME database. The stock prices used to calculate the industry market-to-book valuations are from the Worldscope database. The product segment industry codes and product segment financials are also from Worldscope. I restrict the sample to limited liability companies to which the Companies Act applies, and only keep the consolidated financial statements to mitigate the impact of inter-company dividends on my results. I also exclude the small firms as defined by the Companies House to prevent a large number of missing data, and exclude firm-year observations that do not satisfy the auditing requirements. I also exclude financial, insurance, and real estate firms (US SIC code 6000-6900), utilities (US SIC code 4900-4999), and public sector firms (US SIC code above 8999), and any firm-year observation that has a missing book value of asset, sales, or shareholders' equity. I further require that each firm should have 5 consecutive years of data. All pound values are converted to 2005 constant million pounds using the U.K consumer price index from the WDI. Firm characteristics are winterized separately for public and private firms at 1% level at both tails. Firm-level variables are presented in Panel A. Industry characteristics (firm-year average) are presented in Panel B. Reported statistics include the number of observations (Obs.), mean, median and standard deviation (SD).

Panel A. Firm Characteristics

	Private Firms				Public Firms			
	Obs.	Mean	Median	SD	Obs.	Mean	Median	SD
$Capx/K$	69,962	0.216	0.095	0.453	12,177	0.174	0.100	0.242
ΔK	109,154	0.119	-0.018	0.676	12,177	0.267	0.025	0.978
$Ln(Asset)$	110,292	2.720	2.506	1.487	12,178	4.563	4.313	2.053
$CashFlow$	110,114	0.055	0.051	0.134	12,177	0.074	0.081	0.149
$\Delta Sales$	110,294	0.114	0.045	0.570	12,178	0.132	0.059	0.425
$\Delta Cash$	99,573	0.013	0.000	0.110	12,146	0.019	0.001	0.139
$Tangibility$	108,722	0.276	0.215	0.237	12,178	0.277	0.228	0.232
$Leverage$	106,295	0.392	0.371	0.266	12,158	0.322	0.305	0.198
$Equity\ Issue$	109,454	0.046	-0.003	0.513	12,177	0.280	-0.001	1.558
$Debt\ Issue$	109,512	0.058	0.000	1.500	12,177	0.084	0.000	0.587
Own_Q					11,480	1.809	1.425	1.245

Panel B. Industry Characteristics

	Private Firms				Public Firms			
	Obs.	Mean	Median	SD	Obs.	Mean	Median	SD
Industrt_Q	110,294	1.674	1.566	0.596	12,178	1.804	1.655	0.668
Industry_Q_vw	110,294	1.619	1.511	0.602	12,178	1.767	1.584	0.743
Minor_Leader_Q	77,565	1.816	1.652	0.609	8,356	1.840	1.706	0.603
Minor_Industry_Q	79,853	1.758	1.698	0.393	8,498	1.725	1.685	0.383
#Public	110,294	2.225	1.946	0.917	12,178	2.427	2.197	0.997
%Public	110,294	0.101	0.063	0.094	12,178	0.310	0.212	0.291
Nonsynchronicity	110,294	0.705	0.724	0.145	12,178	0.727	0.766	0.154
#Firms	110,294	4.797	4.700	1.057	12,178	3.918	3.932	1.374
HHI	110,294	0.131	0.072	0.144	12,178	0.241	0.165	0.217
Top4_Share	110,294	0.483	0.449	0.225	12,178	0.648	0.657	0.248

Table 2: **Industry Valuation and Private Firms' Investment**

This table presents the results from estimating Equation ((1)) for private firms as shown below:

$$I_{i,t} = \alpha + \beta \times Industry\_Q_{i,t} + \lambda \times X_{i,t-1} + \theta \times Industry\_X_{i,t-1} + \kappa_i + \delta_t + \epsilon_{i,t}$$

The dependent variable investment $I_{i,t}$ is measured by $Capx/K$, which is Capital Expenditures scaled by the beginning-of-period capital. The main independent variable in columns (1) to (3) is $Industry\_Q_{i,t}$, the equal-weighted average of the beginning-of-period market-to-book ratio of public firms in the three-digit SIC industry to which the private firm belongs, and in columns (4) to (6) it is $Industry\_Q\_vw_{i,t}$, which is the value-weighted average. Columns (2), (3), (5), and (6) control for private firms' own lagged $CashFlow$ and $Ln(Asset)$. In addition, columns (3) and (6) control for $Private\_CashFlow$, $Private\_Ln(Asset)$, $Public\_CashFlow$, $Public\_Ln(Asset)$, which are the average cash flow and size for all private peers and public firms at the beginning-of-period, respectively. All variable constructions are described in Appendix C. All regression models are estimated with firm-fixed effects and year-fixed effects. Since the main right-hand-side variable is at the three-digit SIC industry level, t-statistics in parentheses are adjusted using the Huber-White estimator allowing within industry clusters to be conservative. Coefficients significant at the 10%, 5%, and 1% levels are marked with *, **, and ***, respectively.

	(1) $Capx/K$	(2) $Capx/K$	(3) $Capx/K$	(4) $Capx/K$	(5) $Capx/K$	(6) $Capx/K$
$Industry\_Q_{i,t}$	0.028***	0.024***	0.022***			
	(3.33)	(3.22)	(3.11)			
$Industry\_Q\_vw_{i,t}$				0.023***	0.018**	0.016*
				(2.95)	(2.11)	(1.94)
$CashFlow_{i,t-1}$		0.629***	0.625***		0.630***	0.625***
		(18.20)	(18.03)		(18.22)	(18.08)
$Ln(Asset)_{i,t-1}$		-0.156***	-0.159***		-0.156***	-0.158***
		(-13.01)	(-13.87)		(-12.94)	(-13.85)
Year FE & Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Other Controls	No	No	Yes	No	No	Yes
Obs.	69,962	64,748	64,747	69,962	64,748	64,747
$Adj.R^2$	0.193	0.220	0.220	0.193	0.219	0.220

Table 3: **Minor-Segment Industry Valuation and Private Firms' Investment**

This table presents the results from estimating Equation ((2)0 for private firms as shown below:

$$I_{i,t} = \alpha + \beta \times Minor\_Q_{i,t} + \lambda \times X_{i,t-1} + \theta \times Industry\_X_{i,t-1} + \kappa_i + \delta_t + \epsilon_{i,t}$$

Industry codes and financials for segments of public firms are obtained from the Worldscope database. I exclude industry pairs where the industry leader of one industry has a minor-segment in the other industry, while the industry leader of the other industry also has a minor-segment in the first industry. The dependent variable investment $I_{i,t}$ is $Capx/K$, which is Capital Expenditures scaled by the lagged capital. The primary independent variable $Minor\_Q_{i,t}$ in models (1) to (3) is $Minor\_Leader\_Q_{i,t}$, which is the average beginning-of-period market-to-book of all unrelated minor-segment industry leaders for the two-digit SIC industry to which the private firm belongs; in models (4) to (6) it is the $Minor\_Industry\_Q_{i,t}$, which is the average beginning-of-period market-to-book of all unrelated minor-segment industries for a two-digit SIC industry to which the private firm belongs Columns (2), (3), (5) and (6) control for private firms' own lagged $Ln(Asset)$ and $CashFlow$, and the average value of all private peers, and that of public firms. In addition, columns (3) and (6) control for $Private\_CashFlow$, $Private\_Ln(Asset)$, $Public\_CashFlow$, $Public\_Ln(Asset)$, which are the average cash flow and size for all private peers and public firms at the beginning-of-period, respectively. All variable constructions are described in Appendix C. All regression models are estimated with firm-fixed effects and year-fixed effects. t-statistics in parentheses are adjusted using the Huber-White estimator allowing within industry clusters. Coefficients significant at the 10%, 5%, and 1% levels are marked with *, **, and ***, respectively.

	(1) $Capx/K$	(2) $Capx/K$	(3) $Capx/K$	(4) $Capx/K$	(5) $Capx/K$	(6) $Capx/K$
$Minor\_Leader\_Q_{i,t}$	0.008**	0.008**	0.007**			
	(2.32)	(2.56)	(2.31)			
$Minor\_Industry\_Q_{i,t}$				0.021**	0.016**	0.014*
				(2.45)	(2.01)	(1.84)
$CashFlow_{i,t-1}$		0.637***	0.627***		0.630***	0.620***
		(16.43)	(16.83)		(16.58)	(16.70)
$Ln(Asset)_{i,t-1}$		-0.146***	-0.149***		-0.150***	-0.153***
		(-10.39)	(-11.48)		(-10.23)	(-11.21)
Year FE & Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Other Controls	No	No	Yes	No	No	Yes
Obs.	48,756	45,279	45,279	50,713	46,773	46,773
$Adj.R^2$	0.193	0.221	0.222	0.195	0.219	0.220

Table 4: **Random Irrelevant Industry Valuation and Private Firms' Investment**

This table presents the results from estimating Equation ((3)) for private firms as shown below:

$$I_{i,t} = \alpha + \beta \times Random\_Q_{i,t} + \lambda \times X_{i,t-1} + \theta \times Industry\_X_{i,t-1} + \kappa_i + \delta_t + \epsilon_{i,t}$$

Each minor-segment industry used to estimate Equation ((2)) is replaced by a randomly selected irrelevant industry, that is, a two-digit SIC industry that does not belong to the minor-segment industries nor shares any minor-segment industries with the major-segment industry leaders. The dependent variable investment $I_{i,t}$ is $Capx/K$, which is Capital Expenditures scaled by the lagged capital. The primary independent variable $Random\_Leader\_Q_{i,t}$ in models (1) and (2) is the average beginning-of-period market-to-book of all leaders in the "random irrelevant" industries that are selected for the private firm; in models (3) and (4) it is the $Random\_Industry\_Q_{i,t}$, which is the average beginning-of-period market-to-book of the "random irrelevant" industries that are selected for the private firm. I control for private firms' own lagged $Ln(Asset)$ and $CashFlow$, and the average value of all private peers, and that of public firms. All variables are described in Appendix C. All regression models are estimated with firm-fixed effects and year-fixed effects. The reported estimates are the cross-simulation average of the coefficients from 500 simulations. 95% confidence intervals are included in brackets and coefficients are marked with *** if 95% confidence intervals do not span zero.

	(1) $Capx/K$	(2) $Capx/K$	(3) $Capx/K$	(4) $Capx/K$
$Random\_Leader\_Q_{i,t}$	-0.0001	-0.0001		
	[-0.0007, 0.0004]	[-0.0006, 0.0004]		
$Random\_Industry\_Q_{i,t}$			-0.0015***	-0.0016***
			[-0.002, -0.001]	[-0.002, -0.001]
$CashFlow_{i,t-1}$	0.644***	0.636***	0.645***	0.637***
	[0.644, 0.645]	[0.636, 0.036]	[0.644, 0.646]	[0.637, 0.638]
$Ln(Asset)_{i,t-1}$	-0.147***	-0.149***	-0.147***	-0.149***
	[-0.147, -0.147]	[-0.149, -0.149]	[-0.147, -0.147]	[-0.149, -0.149]
Year FE & Firm FE	Yes	Yes	Yes	Yes
Other Controls	No	Yes	No	Yes
Obs.	56,296	56,296	55,303	55,302
$Adj.R^2$	0.225	0.225	0.225	0.226

Table 5: **Robustness Tests**

This table presents the results from estimating Equation ((2)) for private firms that are economically unlinked to the industry leaders. In panel A, I first exclude the firm-year observations if a private firm shares one or more minor-segment industries with the industry leaders in that year (the results are presented in columns (1) and (2)), and then exclude the private firms if they share one or more minor-segment industries with the industry leaders at any time over the sample period (the results are presented in columns (3) and (4)). In panel B, I first exclude the minor-segment industries that potentially have supplier or customer relationships with the major-segment industries (the results are presented in columns (5) and (6)), and then exclude the minor-segment industries shared by industry leaders and the private firms in the industry leaders' major-segment industries (the results are presented in columns (7) and (8)). I define private firms' segments as secondary SIC industries reported in the private firms' accounts. Supplier and customer industries are defined using the 2012 U.S. Input-Output Tables provided by the Bureau of Economic Analysis. The dependent variable investment $I_{i,t}$ is $Capx/K$, which is Capital Expenditures scaled by lagged capital. The primary independent variable $Minor\_Leader\_Q_{i,t}$ in columns (1), (3), (5) and (7) it is the average beginning-of-period market-to-book of all minor-segment industry leaders for the two-digit SIC industry to which the private firm belongs. In columns (2), (4), (6) and (8) it is the $Minor\_Industry\_Q_{i,t}$, which is the average beginning-of-period market-to-book of all minor-segment industries for a two-digit SIC industry to which the private firm belongs. I control for private firms' own lagged $Ln(Asset)$ and $CashFlow$, and the average value of all private peers, and that of public firms. All variable constructions are described in Appendix C. All regression models are estimated with firm-fixed effects and year-fixed effects. t-statistics in parentheses are adjusted using the Huber-White estimator, allowing within industry clusters. Coefficients significant at the 10%, 5%, and 1% levels are marked with *, **, and ***, respectively.

Panel A. Excluding potential economic linked observations

	Excluding private firm-years sharing the same minor segments with industry leaders		Excluding private firms sharing the same minor segments with industry leaders	
	(1)	(2)	(3)	(4)
	$Capx/K$	$Capx/K$	$Capx/K$	$Capx/K$
$Minor\_Leader\_Q_{i,t}$	0.009***		0.007*	
	(2.63)		(1.78)	
$Minor\_Industry\_Q_{i,t}$		0.015*		0.022***
		(1.92)		(2.66)
$CashFlow_{i,t-1}$	0.634***	0.625***	0.625***	0.612***
	(15.58)	(15.51)	(14.27)	(14.36)
$Ln(Asset)_{i,t-1}$	-0.151***	-0.155***	-0.144***	-0.149***
	(-10.87)	(-10.65)	(-10.75)	(-10.12)
Year FE & Firm FE	Yes	Yes	Yes	Yes
Other Controls	Yes	Yes	Yes	Yes
Obs.	42,275	43,802	37,183	38,491
$Adj.R^2$	0.222	0.220	0.216	0.216

Panel B. Excluding potential economic linked minor-segment industries

	Excluding minor-segment industries in supplier or customer industries		Excluding minor-segment industries shared by private firms and leaders	
	(1)	(2)	(3)	(4)
	$Capx/K$	$Capx/K$	$Capx/K$	$Capx/K$
$Minor\_Leader\_Q_{i,t}$	0.007**		0.009**	
	(2.22)		(2.47)	
$Minor\_Industry\_Q_{i,t}$		0.016**		0.019**
		(2.02)		(2.23)
$CashFlow_{i,t-1}$	0.625***	0.620***	0.632***	0.664***
	(16.47)	(16.70)	(13.46)	(15.90)
$Ln(Asset)_{i,t-1}$	-0.147***	-0.153***	-0.157***	-0.169***
	(-11.46)	(-11.21)	(-15.51)	(-12.65)
Year FE & Firm FE	Yes	Yes	Yes	Yes
Other Controls	Yes	Yes	Yes	Yes
Obs.	45,055	46,773	42,198	36,253
$Adj.R^2$	0.221	0.220	0.228	0.228

Table 6: **Private Firms' Investment and the Informativeness of Industry Stock Price**

This table presents the results from estimating Equation ((1)), adding an interaction term of $Industry\_Q_{i,t}$ (or $Industry\_Q\_vw_{i,t}$) with the measures for $informativeness$ of firm i's industry stock price at the beginning-of-period. The dependent variable is $Capx/K$, which is Capital Expenditures scaled by the beginning-of-period capital. $Industry\_Q_{i,t}$ is the average of the beginning-of-period market-to-book ratio of public firms in the three-digit SIC industry to which the private firm belongs and $Industry\_Q\_vw_{i,t}$ is the value-weighted average. I also control for private firms' own lagged $Ln(Asset)$ and $CashFlow$, and the average value of all private peers, as well as the average value of public firms. Measures for $Informativeness$ include: (i) $H\_\#Public$, a dummy equals 1 if the logarithm of 1 plus the number of public firms of the industry is above the 70th percentile, and it equals 0 if it is below the 30th percentile; (ii) $\%Public$, the fraction of number of public firms to all firms in a three-digit SIC industry; and (iii) H_Nonsynchronisity, a dummy equals 1 if the $Nonsynchronisity$ of a three-digit SIC industry is above the 70th percentile, and equals 0 if it is below the 30th percentile. All variable constructions are described in Appendix C. All regression models are estimated with firm-fixed effects and year-fixed effects. t-statistics in parentheses are adjusted using the Huber-White estimator allowing within industry clusters. Coefficients significant at the 10%, 5%, and 1% levels are marked with *, **, and ***, respectively.

Informativeness Measures:	$H\_\#Public$		% Public		H_Nonsynchronisity	
	(1)	(2)	(3)	(4)	(5)	(6)
	$Capx/K$	$Capx/K$	$Capx/K$	$Capx/K$	$Capx/K$	$Capx/K$
$Industry\_Q_{i,t}$	0.011		0.010		0.021*	
	(1.04)		(1.25)		(1.93)	
$Industry\_Q_{i,t} \times Informativeness_{i,t-1}$	0.047***		0.111**		0.029**	
	(3.32)		(2.29)		(2.12)	
$Industry\_Q\_vw_{i,t}$		0.011		-0.001		0.010
		(1.02)		(-0.11)		(0.93)
$Industry\_Q\_vw_{i,t} \times Informativeness_{i,t-1}$		0.026*		0.136***		0.023*
		(1.78)		(2.93)		(1.65)
Year FE & Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Other Controls	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	35,194	35,194	64,696	64,696	35,810	35,819
$Adj.R^2$	0.230	0.230	0.220	0.220	0.228	0.225

Table 7: **Private Firms' Investment and Industry Common Shocks**

This table presents the results from estimating Equation ((1)), adding an interaction term of $Industry\_Q_{i,t}$ (or $Industry\_Q\_vw_{i,t}$) with the measures for the *competitiveness* of firm i's industry at the beginning-of-period. The dependent variable is $Capx/K$, which is Capital Expenditures scaled by the beginning-of-period capital. $Industry\_Q_{i,t}$ is the average of the beginning-of-period market-to-book ratio of public firms in the three-digit SIC industry to which the private firm belongs, and $Industry\_Q\_vw_{i,t}$ is the value-weighted average. I also control for private firms' own lagged $Ln(Asset)$ and $CashFlow$, and the average value of all private peers, as well as the average value of public firms. Measures for *competitiveness* of the industry include: (i) $H\_\#Firms$, a dummy equal to 1 if the logarithm of 1 plus the number of all firms of the industry is above the 70th percentile, and equal to 0 if it is below the 30th percentile; (ii) L_HHI, a dummy equal to 1 if HHI in a three-digit SIC industry is below the 30th percentile, and equal to 0 if it is above the 70th percentile; and (iii) L_Top4_Shares, a dummy which equals 1 if the market share of the top four firms in a three-digit SIC industry is below the 30th percentile, and equals 0 if it is above the 70th percentile. All variable constructions are described in Appendix C. All regression models are estimated with firm-fixed effects and year-fixed effects. t-statistics in parentheses are adjusted using the Huber-White estimator allowing within industry clusters. Coefficients significant at the 10%, 5%, and 1% levels are marked with *, **, and ***, respectively.

Competitive Industry Measures:	$H\_\#Firms$		L_HHI		L_Top4_Shares	
	(1)	(2)	(3)	(4)	(5)	(6)
	$Capx/K$	$Capx/K$	$Capx/K$	$Capx/K$	$Capx/K$	$Capx/K$
$Industry\_Q_{i,t}$	0.002		0.017*		0.011	
	(0.18)		(1.81)		(1.30)	
$Industry\_Q_{i,t} \times Competitive_{i,t-1}$	0.038***		0.022*		0.027**	
	(2.90)		(1.77)		(2.16)	
$Industry\_Q\_vw_{i,t}$		-0.003		0.010		0.013
		(-0.36)		(1.09)		(1.43)
$Industry\_Q\_vw_{i,t} \times Competitive_{i,t-1}$		0.022*		0.015		0.020*
		(1.74)		(1.26)		(1.67)
Year FE & Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Other Controls	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	35,986	35,986	40,087	40,087	39,144	39,144
$Adj.R^2$	0.045	0.233	0.228	0.228	0.225	0.225

Table 8: **Alternative Hypothesis: Internal Allocation within Industry Leaders**

This table presents the results to examine whether the major-segment investment of industry leaders reacts to the valuation of industry leaders' minor-segment industries. The sample consists of public firms that are the industry leaders of a two-digit SIC industry. Major (minor) segments are the two-digit SIC industry in which the firm generates more (less) than 50% of its total sales. Industry leaders are firms whose major-segment industry sales rank in the top five among all firms in that industry. Segment-level data are from Worldscope. The dependent variable is $Major\_Capx/K$, which is Capital Expenditures scaled by the lagged capital for the major-segment. The primary independent variable $Minor\_Leader\_Q_{i,t}$ in columns (1) and (2) is the average beginning-of-period market-to-book of all minor-segment industry leaders for the two-digit SIC industry; in columns (3) and (4) is the $Minor\_Industry\_Q_{i,t}$, which is the average beginning-of-period market-to-book of all minor-segment industries for a two-digit SIC industry. Columns (2) and (4) control for $Major\_Industry\_Q_{i,t}$, which is the average beginning-of-period market-to-book of all pure-players for the two-digit SIC industry in the industry leaders' major-segment industry. I control for the firm's own lagged $Ln(Asset)$ and $CashFlow$. All variable constructions are described in Appendix C. All regression models are estimated with firm-fixed effects and year-fixed effects. t-statistics in parentheses are adjusted using the Huber-White estimator allowing within industry clusters. Coefficients significant at the 10%, 5%, and 1% levels are marked with *, **, and ***, respectively.

	(1) $Major\_Capx/K$	(2) $Major\_Capx/K$	(3) $Major\_Capx/K$	(4) $Major\_Capx/K$
$Minor\_Leader\_Q_{i,t}$	-0.0005	-0.001		
	(-0.14)	(-0.37)		
$Minor\_Industry\_Q_{i,t}$			0.008	0.006
			(1.25)	(0.94)
$Major\_Industry\_Q_{i,t}$		0.013**		0.014**
		(2.09)		(2.60)
$CashFlow_{i,t-1}$	0.116*	0.107*	0.098*	0.090*
	(1.90)	(1.80)	(1.81)	(1.71)
$Ln(Asset)_{i,t-1}$	-0.028***	-0.028***	-0.028***	-0.027***
	(-4.36)	(-4.46)	(-4.55)	(-4.63)
Year FE & Firm FE	Yes	Yes	Yes	Yes
Other Controls	Yes	Yes	Yes	Yes
Obs.	1,313	1,313	1,310	1,310
$Adj.R^2$	0.410	0.413	0.423	0.427

Table 9: **Alternative Hypothesis: Sentiment and Cost of Capital**

This table presents the results to examine whether the investment of financially constrained (private) firms is more sensitive to the movement of the industry valuation. The dependent variable is $Capx/K$, which is Capital Expenditures scaled by the beginning-of-period capital. $Industry\_Q_{i,t}$ is the average of the beginning-of-period market-to-book ratio of public firms in the three-digit SIC industry to which the private firm belongs. $Industry\_Q_{i,t} \times FC_{i,t-1}$ is the interaction of $Industry\_Q_{i,t}$ and the financial constraint dummy, where the financial constraint dummy is defined by size, dividend payout, Whited-Wu Index, and the Hadlock-Pierce Index, respectively. I also control for the corresponding financial constraint dummy, the private firm's own lagged $Ln(Asset)$ and $CashFlow$, and the average value of all private peers, as well as the average value of public firms. All variable constructions are described in Appendix C. All regression models are estimated with firm-fixed effects and year-fixed effects. t-statistics in parentheses are adjusted using the Huber-White estimator allowing within industry clusters. Coefficients significant at the 10%, 5%, and 1% levels are marked with *, **, and ***, respectively.

	(1) $Capx/K$	(2) $Capx/K$	(3) $Capx/K$	(4) $Capx/K$
$Industry\_Q_{i,t}$	0.0200*** (2.65)	0.0251*** (3.03)	0.0204* (1.74)	0.0147* (1.84)
$Industry\_Q_{i,t} \times FC\_Size_{i,t-1}$	0.00123 (0.11)			
$Industry\_Q_{i,t} \times FC\_Dividend_{i,t-1}$		-0.00595 (-0.82)		
$Industry\_Q_{i,t} \times FC\_WW_{i,t-1}$			0.00488 (0.45)	
$Industry\_Q_{i,t} \times FC\_HP_{i,t-1}$				0.00695 (0.60)
$FC_{i,t-1}$	-0.0518 (-0.99)	0.0360*** (2.92)	-0.0739*** (-3.58)	0.0151 (0.32)
$CashFlow_{i,t-1}$	0.588*** (15.77)	0.611*** (17.34)	0.487*** (10.96)	0.600*** (15.13)
$Ln(Asset)_{i,t-1}$	-0.146*** (-12.58)	-0.160*** (-14.02)	-0.183*** (-14.50)	-0.144*** (-11.32)
Year FE & Firm FE	Yes	Yes	Yes	Yes
Other Controls	Yes	Yes	Yes	Yes
Obs.	36,536	64,747	36,964	36,401
$Adj.R^2$	0.249	0.220	0.231	0.259

Table 10: **Comparison of Public and Private Firms on A Matched Sample**

This table presents the results from estimating Equation ((4)) for **a** matched sample of private and public firms:

$$Y_{i,t} = \alpha + \beta \times Industry\_Q_{i,t} + \beta_2 \times Industry\_Q_{i,t} \times Public_i + \lambda \times X_{i,t-1} + \theta \times X_{i,t-1} \times Public_i + \kappa_i + \delta_t + \epsilon_{i,t}$$

The dependent variable in model (1) is $Capx/K$, which is Capital Expenditures scaled by lagged capital, in model (2) it is ΔK, which is the annual change of capital scaled by lagged capital, in model (3) it is $Equity\ Issue$, which is the annual change of Book Equity minus the annual change of Retained Earnings, scaled by lagged capital, and in model (4) is $Debt\ Issue$, which is the annual change of Book Debt, scaled by lagged capital. Thus, the financing variables are defined with balance sheet items. The main independent variable $Industry\_Q_{i,t}$ is the average of the beginning-of-period market-to-book ratio of public firms in the three-digit SIC industry, and its interaction with the dummy *Public* which equals 1 if it is a public firm and 0 if private. I also control for the public firm's own beginning market-to-book, the private firm's own lagged $Ln(Asset)$ and $CashFlow$ and their interactions with *Public*. All variable constructions are described in Appendix C. I use the caliper-based nearest-neighbor matching adapted to a panel setting following Asker, Farre-Mensa and Ljungqvist (2014). Starting from 1993, I match private firms with public firms from the same three-digit industry and closest in size. I require that the ratio of their total assets is less than 2. If no match can be formed, I drop the observation and look for a match in the following year. Once a match is found, it is kept in subsequent years to ensure the panel structure of the data. All regression models are estimated with firm-fixed effects and year-fixed effects. t-statistics in parentheses are adjusted using the Huber-White estimator allowing within firm clusters. Coefficients significant at the 10%, 5%, and 1% levels are marked with *, **, and ***, respectively.

	Investment		Financing	
	(1)	(2)	(3)	(4)
	$Capx/K$	ΔK	$Equity\ Issue$	$Debt\ Issue$
$Industry\_Q_{i,t}$	0.024***	0.019**	0.029***	0.028*
	(3.87)	(2.30)	(4.33)	(1.66)
$Industry\_Q_{i,t}\times$ Public	0.001	0.094***	0.083*	-0.045**
	(0.08)	(3.32)	(1.87)	(-2.19)
$Own\_Q_{i,t}$	0.036***	0.191***	0.250***	0.070***
	(9.22)	(8.13)	(6.71)	(5.82)
$CashFlow_{i,t-1}$	0.626***	0.688***	-0.195***	0.477***
	(20.12)	(18.90)	(-6.22)	(5.88)
$Ln(Asset)_{i,t-1}$	-0.158***	-0.305***	-0.085***	-0.389***
	(-17.61)	(-27.61)	(-9.89)	(-16.91)
$CashFlow_{i,t-1}\times$ Public	-0.396***	0.150	-0.257	-0.082
	(-9.17)	(0.87)	(-0.93)	(-0.70)
$Ln(Asset)_{i,t-1}\times$ Public	0.089***	0.018	-0.253***	0.262***
	(8.83)	(0.62)	(-6.03)	(9.92)
$Constant$	0.524***	0.777***	0.286***	0.887***
	(19.88)	(16.89)	(4.01)	(10.28)
Obs.	52,111	77,092	77,333	77,361
$Adj.R^2$	0.244	0.076	0.116	0.001