Buying Manipulation around Seasoned Equity Offerings*

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Abstract

We show that seasoned equity offerings (SEOs), in which secondary share-offering size greatly exceeds market share turnover, provide a unique opportunity for stock price manipulation by speculators holding restricted shares. The proposed new theory is consistent with several puzzling empirical findings, for example, the positive abnormal stock return between announcement and issuance and the long-term poorer returns of issuing firms after SEOs. The manipulation is characterized by a strong buying in the secondary market prior to the issuance, which drives up the market price and thereby the offering price of restricted shares, and a large amount of liquidation of restricted shares in the SEO. Our model predicts that favorable market reactions with speculator's manipulative intent after SEO announcement could occur, which naturally leads to a successful issuance and over-investment based long-term underperformance after SEO.

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1. Introduction

Seasoned equity offering (SEO) is a common approach for firms to raise fresh capital and several related distinct phenomena have been empirically documented in the literature. Among many of them, high returns preceding the SEOs and the long-term underperformance after the SEOs are the two most salient anomalies (e.g., Asquith and Mullins Jr (1986), Bayless and Chaplinsky (1991), Loughran and Ritter (1995), Spiess and Affleck-Graves (1995), Loughran and Ritter (1997), and Baker and Wurgler (2000)).

The stock price pre-runup actually refers to two separate price reactions, before and after the issuance announcement respectively. First, firms announce equity issuance generally following a period of high stock return. Market timing (e.g., Bayless and Chaplinsky (1996), Schultz (2003), and Jenter (2005)) and earnings management (e.g., Teoh, Welch, and Wong (1998), Rangan (1998), Jo and Kim (2007), and Cohen and Zarowin (2010)) are the two most plausible explanations attempting to resolve this puzzle. Second, Mikkelson and Partch (1986) find that the average return for completed offerings is positive between the announcement and the issuance while the the average return between the announcement and cancellation is negative. Clarke, Dunbar, and Kahle (2001) also document the cancellation of equity issuance when the market reaction to the announcement is unfavorable.

Long-term underperformance of issuing firms also remains a puzzle. Although earnings management and market timing theory could predict the poorer returns of the issuing firms relative to non-issuing matched firms. Many empirical studies appear to challenge their theoretical implications. For example, an empirical study conducted by DeAngelo, DeAngelo, and Stulz (2010) finds that the near-term cash need is the primary SEO motive, while market-timing and lifecycle stage only exert ancillary influences since 62.6% of issuers will run out of cash within a year after the SEO if without the offer proceeds. Loughran and Ritter (1997) argue that if a firm plans to boost current earnings by borrowing against future earnings, the firm will expose itself to the risk that the stock price may decline due to general market movements before the firm has had an opportunity to issue overvalued equity.

Several recent studies document a significant over-investment pattern among equity issuing firms compared to the non-issuing matched firms. Walker and Yost (2008) find that equity issuing firms increase capital expenditures and R&D investment following an SEO regardless of the stated use of funds, and the stock return will be more favorably if a firm provides specific plan for the investment increase after SEO. Lyandres, Sun, and Zhang (2005) also find that the underperformance of issuing firms results from the negative investment-expected return relation. In their studies, there is no significant underperformance of issuing firms after controlling for investment expenditures. Both rational and irrational theories have been developed to explain this puzzling stylized fact. Carlson, Fisher, and Giammarino (2006) present a rational theory of SEOs in a real options framework, where expected returns decrease endogenously since new assets are less risky than growth options. Irrational explanation is developed by Daniel, Hirshleifer, and Subrahmanyam (1998), and they argue that since investors are generally too optimistic about their private information signals which may lead to irrational over-investment.

In this paper, we propose a model to explain both the stock price increase between announcement and successful issuance and the long-term investment-based poorer performance of issuing firms. In our model, a firm plans to fund its novel project by SEO proceeds. Though we do not explicitly model the motive of firm managers on using equity issuance, many theoretical and empirical findings support the popularity of SEO as a capital raising vehicle. For example, pecking order theory of Myers and Majluf (1984) predicts that equity issuance is a better choice when firms face high level of leverage. We model the interaction between secondary market trading prior to the issuance and the setting of the equity offering price to investigate the nature and effects of stock price manipulation around a SEO. A strategic trader possibly possessing private information about the security value and holding restricted shares can influence the offer price by trading in the secondary market prior to a SEO.[1] We show that even if the strategic trader actually has no fundamental information,

[1]Restricted securities are securities acquired in unregistered, private sales from the issuer or an affiliate of the issuer. Investors typically receive restricted securities through private placement offerings, Regulation D

the trader may buy to signal false positive news about the firm's investment prospects by open market trades to inflate the SEO price and thus, the proceeds, this strategic investor receives from the secondary issue. The cost of such manipulation to the strategic trader, reduced firm value from distorted investment decisions, is mitigated by the liquidation of his position in the SEO.[2]

In our setup, a firm has an investment opportunity with uncertain net present value (NPV). One of the firm's restricted shareholder is a speculator (henceforth, informed speculator or speculator for simplicity) who owns restricted shares. The informed speculator is currently not an insider in the company and thus, can liquidate his holdings in secondary offers. At the same time, because he is not an insider, the informed speculator does not directly control the firm's investment policy.[3]

The informed speculator is likely to have superior information about this investment opportunity that is relevant for the optimal investment decision, and, is not yet known to the firm. Such information could be about the project's cost of capital, future demand of the product, or the product's position relative to its competitors' products. Whether the speculator actually has the relevant information is itself a source of private information. When the informed speculator is actually informed, he optimally chooses to trade in the firm's stock based on his information. Specifically, he sells the stock when he has negative information and buys it when he has positive information.

offerings, employee stock benefit plans, as compensation for professional services, or in exchange for providing "seed money" or start-up capital to the company. See, for example, `http://www.sec.gov/investor/pubs/rule144.htm`.

[2]SEC Rule 144 provides a safe harbor for restricted share sales in secondary offerings: If an investor is not (and have not been for at least three months) an affiliate of the company issuing the restricted securities and has held the restricted securities for at least one year, he can sell the securities without any restrictions. See, for example, `https://www.sec.gov/reportspubs/investor-publications/investorpubsrule144htm.html`.

[3]The question arises: Why these investors need an SEO to liquidate their restricted shares? This is because the restricted shares cannot be sold in public, even if the investor has met the conditions of Rule 144, unless the 'restriction legend' is removed from the certificate. Only a transfer agent can remove a restrictive legend, but the transfer agent won't remove the legend unless the consent of the issuer is obtained–usually in the form of a legal document from the issuer's general counsel–that the restricted legend can be removed. This is a tedious process for the company as well as the investor. In practice, typically the company buys back the shares from the investor and issues unrestricted shares to the public to fund the buyback in a SEO.

The trading process is modeled in a market microstructure setting based on modified Glosten and Milgrom (1985). As in Glosten and Milgrom (1985), the information of the speculator gets partially reflected in the stock price. Extending Golsten and Milgrom, in our model, the information in the price is then optimally taken into account by the firm in its investment decision. The endogenously determined stock price and real value of the firm can complicate the equilibrium analysis considerably. Typically in microstructure models with sequential trading,[4] manipulative strategies require more than one round of trade, where early trades distort prices and later trades capture the profits from trading on the distortion. The institutional features of a SEO permit us to develop a model of manipulation with a single round of trading. We exploit the difference between the price-setting and the market-clearing mechanisms in the open market and the SEO and show that the informed speculator can use multiple markets rather than multiple rounds to profitably manipulate.

Our main result is that the information from the financial market to the real investment decision generates equilibria where the speculator buys the stock even when he happens to be uninformed while the market believes he is informed.[5] This manipulation reduces the informativeness of the price and the efficiency of the resulting investment decision. From the perspective of market regulation, it is important to note that this distortion is not caused by short selling or even by covered share selling but rather by share acquisition by "savvy" investors. To our knowledge, such acquisitions have never been questioned by the financial economics literature, which focuses on selling manipulation nor by the popular financial press, or legal scholarship which focuses on short-sellers "attacking" firms to drive down share prices.[6] Thus, our analysis has novel implications for market regulation.

Because, manipulation is costly for the informed speculators in terms of the intrinsic value of the residual holdings and because it can only benefit the informed speculator through offer

[4]See, for example Kyle (1985) and Glosten and Milgrom (1985).

[5]United States v. Mulheren, 938 F.2d 364, 366-68 (2d Cir. 1991) court agreed that a manipulative intent is enough, but the the government has to prove beyond a reasonable doubt that the defendant's sole intent was to artificially inflate the stock price.

[6]See, for example, Goldstein and Guembel (2008) for more details.

price inflation, it is not surprising that the sort of manipulation we discuss is only viable under certain parametric restrictions. The conditions are that (*i*) the ex-ante NPV of the investment is not too negative; (*ii*) the value of the investment is very sensitive to the informed speculator's information, and (*iii*) market prices are fairly informative. Thus, in such cases, our model predicts a large buying pressure followed by acceptance of the new project which is unconditionally a negative NPV project.

Manager's learning from markets in general and in particular, market prices has received empirical support in the recent work of Durnev, Morck, and Yeung (2004), Luo (2005), Bond, Edmans, and Goldstein (2012), and Chen, Goldstein, and Jiang (2006). It is important to note, however, this learning by managers is key to our main results. If stock price dictates the terms of firms access to capital (e.g., Baker, Stein, and Wurgler (2003)); that is, prices play a resource-allocation role, it is also sufficient to generate our main result on a buying initiated manipulation. For example, in a recent study Edmans, Goldstein, and Jiang (2015) show that the feedback effect increases (reduces) the profitability of buying (selling) on good (bad) information. Their result suggests that while positive net present value (NPV) projects will be encouraged, some negative NPV projects will not be rejected, leading to overinvestment.

The ability of the speculator to obtain accurate private information regarding the prospects of the firm's investment opportunity around SEOs is critical to our result. Also, if the informed speculator does not trade in line with their private information, e.g., following a manipulative equilibrium derived by Gerard and Nanda (1993), the trading result and the stock price prior to a SEO will be not informative and the firm manager will not rely on the stock price to make the investment decision. Chemmanur, He, and Hu (2009) and Gibson, Safieddine, and Sonti (2004) show that institutions are able to identify and obtain more allocations in SEOs with better long-run stock returns. The smart money trades in the same direction as their private information indicates. Further, SEO issuers with more pre-offer institutional net buying are associated with a smaller SEO discount. However, any possible manipulation equilibrium will increase the probability that a firm might forgo in the investment opportunity and hence the SEO.

Our model is consistent with the argument made by Loughran and Ritter (1997) on the long-term underperformance of the issuing firms:

> *One interpretation of this is that the firms are investing in what the market views as positive net present value (NPV) projects, but in fact the projects all too often have negative NPVs. We find that issuers continue to invest heavily even while their performance deteriorates. This suggests that the managers are just as overoptimistic about the issuing firms' future profitability as are investors. It is also consistent with Jensen's (1993) hypothesis that corporate culture is excessively focused on growth.*

Our theory implies that only SEOs which combine both primary and secondary offerings provide opportunities for speculators to follow a buying manipulation strategy. Some evidence can be found in Healy and Palepu (1990). They report no postissue operating performance decline for the median issuer using a sample of 93 SEOs in which all of the shares offered were newly-issued by the firm (pure primary offerings).

The model also predicts that smaller and less liquid firms are more subject to buying manipulations since the trading cost of the speculator to generate large enough price impact is low when the firm's stock is less liquid in secondary market. This is consistent with the findings of Loughran and Ritter (1997), where they find while both large and small issuers display deteriorating postissue operating performance relative to nonissuing firms, the subsequent stock returns are lowest for the smallest issuers. Denis and Sarin (2001) also find consistent empirical evidence.

The most similar work to ours is that of Dittmar and Thakor (2007). In their model, managers choose equity to fund their projects when the investors' beliefs about project payoffs are likely to be consistent with theirs, thus maximizing the likelihood of agreement with investors. Both our and their models assume that the manager cares both about the short-term stock price and about the firm's long-term equity value after they invest in the project. The market reaction to the firm's investment relies on the investors' evaluation of the project. However, we assume that if the marker reaction is unfavorable to the SEO announcement the firm will forego both the SEO and the project, rather than switching to debt issuance to finance the project in their model. Many literature related to market feedback effect provides supporting evidence for our assumptions. Moreover, our model focus on the price increase between the SEO announcement and the issuance date, instead of the price runups prior to the announcement.

Our work contributes to several fields. First, the work is related to stock price manipulation. For example, Attari, Banerjee, and Noe (2006) and Goldstein and Guembel (2008) model situations where manipulation is facilitated by private information about information quality. However, distinct from their models, we model a buy-side manipulation requiring only a single round of trading. Because the paper connects microstructure manipulation with institutional features of the public offering, it is also more closely tied to the empirical corporate finance literature on public offerings. Our model also add to the a discussion on the role of restricted shares, for example, Kahn and Winton (1998). In addition, the analysis has clear regulatory implications for rules regulating stock trading by restricted shareholders before the SEO offerings which are quite specific to the SEO context required for the sort of manipulations we model to succeed.

Of Course, none of our qualitative results is meant to argue that other strategies, e.g., disseminating fake news, earnings management, do not have any impact on the stock prices around SEOs. In that sense, our model is very conservative since managers are more likely to do the SEO even following a very small or no price raise-up if they have interests to cash out from SEOs. In addition, they will have strong incentives to push up the stock prices prior to the issuance if they plan to personally profit from the secondary offering of SEOs. This is exactly what has been observed in many countries, especially in Chinese stock market[7]. Without strong supervision and regulations, some firm managers open stock trading accounts

[7]http://www.airitilibrary.com/Publication/alDetailedMesh?docid=1007368X-200912-200912290036-200912290036-114-116

and capital management firms without revealing their identities to pull up stock price prior to the SEOs. From this perspective, our theory claims that even if the managers of issuing firms only have incentives to maximize the firms' wealth, rather than personal wealth, they are still possibly be misled by the speculator to do the SEOs and invest in negative NPV projects.

The remainder of the paper is organized as follows: Section 2 presents the basic setups of the model with no SEO. In section 3, we derive some results about the strategic trading with no SEO as a benchmark. Section 4 then introduces SEO and derives the existence conditions for the all three equilibria, i.e., buying-initiated manipulative equilibrium, separating equilibrium and selling equilibrium. Section 5 analyses empirical implications. In section 6, we consider the robustness of the model by limiting the trading actions. Section 7 concludes. Most proofs and modeling details are relegated to the Appendix.

2. The model setup

In this section, We introduce the game structure regarding the strategic trading behaviors with no SEO. We assume the firm has sufficient internal cash flows to fund the investment opportunity and hence it does not need equity offering or debt issuing to raise fresh capital. Section 4 then introduces SEO and manifests how the potential SEO changes the speculator's trading direction.

There are four players in the game. A firm with a potential project is going to make the investment decision. A strategic speculator with restricted shares of the firm may have private information regarding the project's prospects and will trade based on her private information. Liquidity traders will trade due to liquidity shocks. The marketmaker clears the market by pricing the firm's stock conditional on the observed aggregate order flow.

The game has four dates $t = \{t_0, t_1, t_2, t_3\}$. At t_0, the firm announces the potential project. The firm manager may decide to accept it or reject it based on its conditional net present value (NPV) on the secondary market reaction. At t_1, the speculator actively acquires information and observes the private signal. After that, the market opens, and agents can trade on the firm's stock on the secondary market. The trading session ends at the beginning of t_2. The trading outcomes become publicly observable, and the firm managers make the investment decision based on that. Since the firm has enough internal cash flow, it will not conduct either SEO or debt issuing to fund the project if it decides to accept. All uncertainties are resolved at t_3, at which point the firm pays a liquidating dividend. We assume that all agents are risk neutral, markets are competitive, and the risk-free rate is zero.

2.1. *The new project*

The only source of uncertainty regarding the firm's fundamental value is a potential new project. The cash flows from firm's all earlier projects have known value. The cash flow from the new project can equal either y_g or y_b, where $y_g > y_b$. The probability that the cash flow equals y_g, under the the firm's initial assessment, is given by q. Undertaking the new project requires an investment of $c > 0$. We express the upside and downside payoffs from the new project as follows:

$$y_b = c - \gamma, \tag{1}$$

$$y_g = y + c - \gamma. \tag{2}$$

Here $-\gamma < 0$ represents the loss from undertaking the new project in state b, and y is the difference between y_g and y_b, the payoffs in states g and b. We assume that $y - \gamma > 0$ which implies that the project has a positive NPV in state g. Because the project has a positive NPV in state g and a nonpositive NPV in state b, there exists a cutoff level of q, say $\bar{q}$, such that the NPV of the project equals 0. $\bar{q}$ is defined by

$$\bar{q} = \frac{\gamma}{y}. \tag{3}$$

For all $q \in [0, \bar{q}]$, the NPV of the new project is expected to be nonpositive and for all $q \in (\bar{q}, 1]$, the NPV of the new project is expected to be positive. In this paper, we assume $q \leq \bar{q}$ and hence if the firm receives no information after the initial assessment, the project will be rejected.

2.2. Capital structure of the firm

The firm has m existing outstanding claims. Some of these shares are 'floating' shares, freely tradable, while others are restricted, and thus cannot be sold on secondary markets. The total market value of all shares restricted and unrestricted is V_0. Thus, the initial price per share given no investment is $P_0 = V_0/m$. Of these m outstanding claims, αm are held by outside investors (float), both retail and institutional. The remaining $(1 - \alpha)m$ shares are held as restricted shares by the firm insiders, like the top management, as well as one particular outside investor, whom we call the "informed speculator."

Informed investors own restricted shares, may have some private information about the firm's prospects, but do not control the firm's operating or investment policies. Examples of such investors are venture capitalists who received restricted shares as part of distribution associated with an IPO, or former senior executives who received restricted shares as part of their compensation package. The remainder of the restricted shares are held by 'insiders,' these agents are uninformed, determine firm operating policies and act to maximize total share value which includes the value of the newly issued shares.

To simplify the presentation, we assume that half of the restricted shares are held by insiders. Hence, the initial value of the informed speculators portfolio is $W_0 = P_0 \frac{(1-\alpha)m}{2}$. Although an equal division of the restricted shareholdings between insiders and outsiders is only a simplifying assumption, it is worthy of note that, on average insider and outsider restricted shareholdings, right after the IPO, are comparable in magnitude.[8]

[8] A total of close to 630 million restricted shares of Beijing Capital Development (600376) will be unlocked on January 12, reports yicai.com, citing a company filing. With the unlocking of these shares, all of the company's shares will be tradable. Of the total, 79.64 million shares were restricted due to stock reform

Given that the project's expected NPV, why would the firm invest in it? The only way the firm will invest is if its prior beliefs regarding the NPV are revised by new information. The firm's source of information is the price of its stock at t_2. This price will be affected by trading because the informed speculator can trade in the secondary market and she has private information regarding the investment's prospects.

2.3. Informed speculator's information structure

Informed speculator receives two types of private signal: One type we call 'informative.' This type of signal is perfectly correlated with the true state. There are two informative private signals: good, G, and bad, B. If the informed speculator receives a signal G, then the updated likelihood of state g is 1; whereas, if the informed speculator receives a signal B, then the updated likelihood of state g is 0. The informed speculator may also receive an uninformative signal uncorrelated with the true state of the world. If the informed speculator gets the 'uninformative' private signal, N, then the updated likelihood of state g is same as the unconditioned likelihood of state g, which is q. The probability of that the informed speculator receives the uninformative N signal is $1-\theta$. Thus, θ is a measure of the informed speculator's information precision. We assume that $0 < \theta < 1$[9]. This implies that the informed speculator always has a chance of being informed. Note that even when the informed speculator has received signal N, and thus, has no fundamental information about the project, the informed speculator still has superior information advantage – she knows that she does not have private information and the market does not know this. We will see that the informed speculator can make good use of this seemingly worthless bit of information. The ex-ante likelihood of a good private signal, bad private signal, and an

while 550 million shares were restricted due to a private placement. Of the restricted shares due to stock reform, Shenzhen Jinyang Investment holds 12.96 million shares, accounting for 0.56% of total equity while Beijing Capital Development Tianhong Group has 48.79 million shares, accounting for 6.37% of total equity. See also, for example, `http://www.nyse.com/financials/1108407157456.html`.

[9] We do not consider $\theta = 0$, because it implies no informed trader and thus, trading in period 1 has no information content.

uninformative private signal, denoted by p_g, p_b and p_n respectively, are

$$p_g = \theta q;\ p_b = \theta(1-q);\ \text{and},\ p_n = (1-\theta) \tag{4}$$

Signals G, B and N are mutually exclusive and exhaustive; hence, $p_g + p_b + p_n = 1$. The informed speculator has no direct means of credibly communicating her private signal-type to other agents of the model. Hence, the only way other agents can learn about the private signal-type is by observing the secondary market price of the firm's shares.

2.4. Trading and pricing mechanisms

There are two types of traders in our model: A strategic trader (or informed speculator) and a nonstrategic trader (or liquidity trader). The informed speculator trades in the quest for profits, whereas the liquidity trader trades for liquidity reasons. We assume that the liquidity trader is equally likely to buy, sell or does not trade and, whenever she trades, she trades a block of Y shares. Each trader submits a market order to a risk-neutral market-maker in a competitive market. Orders arrive randomly, that is, each trader's order has an equal likelihood of arriving first at the marketmaker's desk. Thus, the marketmaker cannot distinguish between orders from informed or uninformed agents. The resulting aggregate order flow is observed by the marketmaker. Based on the observed order flow, the marketmaker clears the market by setting the secondary market price and end up with ex-ante breaking even. After trading closes, aggregate order flow is observable to the market, i.e., all agents including the firm manager, similar to Goldstein and Guembel (2008) because the pricing function of the marketmaker is a one-on-one mapping between aggregate order flow and the stock price when the marketmaker's conjecture on the investor's trading strategy is fixed. The marketmaker's price setting decision depends both on the conjectured quality of the project as well as its likelihood of being undertaken by the firm. Since the firm manager's objective is to maximize the firm's profit, the marketmaker knows that the firm will invest whenever management believes that the NPV of the potential project is positive and not invest when it is nonpositive. The informed speculator's information relates only to the ex-post liquidation value of the project, while if the project is rejected, both the intrinsic and market value of a share equal P_0. In contrast, if the firm expects, based on the realized aggregate order flow, that the project has a positive NPV, then the project will be accepted, and thus the market price of the firm's share will depend on the expected NPV of the project conditioned on public information. The resulted price may not be the expected NPV from the informed speculator's perspective since the marketmaker may not be able to identify her private signal accurately.

Because the marketmaker observes order flow, any order submitted by the informed speculator that does not mimic the Y-share pattern favored by the liquidity trader would identify the trade as the informed speculator's trade, and thus reveal the informed speculator's private information. Hence, such trading cannot by definition be manipulative and thus, will not occur in the equilibria we analyze (although we will have to check to identify the conditions under which deviations to such strategies do not overturn manipulation equilibria). Thus, in manipulation equilibria, when the informed speculator submits an order, she submits for $\pm Y$-shares.[10] For simplicity, we denote buying, selling and not trading of both informed speculator and liquidity trader $+1$, -1 and 0 respectively. The aggregate order flow Q is defined as the sum of the market order submitted by the informed speculator Q_I and that by the liquidity trader Q_L, i.e., $Q = Q_I + Q_L$.

The market's assessment of project quality, in turn, will fix the open market price and determine the project accept/reject decision. Thus, the informed speculator's payoff is determined by her private signal of project quality and the market's assessment of project quality. The informed speculator's problem is that when she places an order, she does not know the

[10]The trading environment is similar to that of Kyle (1985) in that the marketmaker observes a disaggregated order flow. It is also similar to Glosten and Milgrom (1985) and Attari et al. (2006) in that the marketmaker processes all order flows for a given date at the same time. However, unlike in Kyle, the marketmaker observes volumes as well as net order flow. All our results can also be obtained under Kyle's assumption except that only net order is observed.

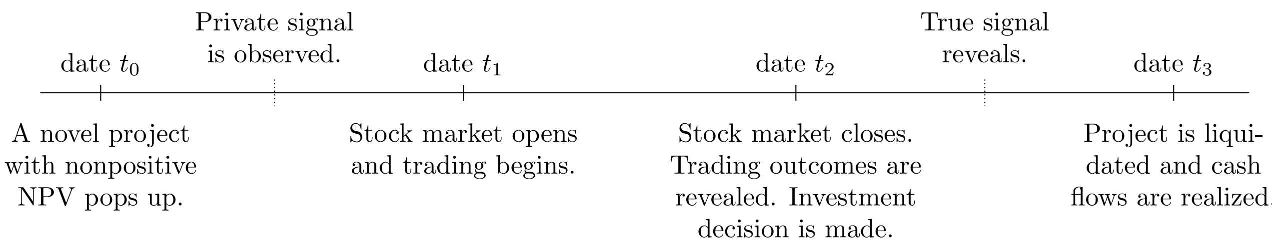

Fig. 1. Time line of events with no SEO

order placed by the liquidity trader, and hence the market assessment that her trade will produce. However, she can use her private information regarding the size of her own order and the equilibrium relation between order flow and market assessments to compute the expected gain from her trading strategy. The temporal evolution of events in our model is depicted in figure 1.

3. Trading strategy with no SEO

For expositional simplicity, we standardize the number of shares m to 1 and the stock price prior to trading P_0 to 0 without loss of generality. The postulated NPV of the project conditional on the trading outcome will be given by $\mathrm{E}\big[V|Q\big]$. Since the trading outcomes become publicly observable at the beginning of t_2, the firm manager decides to invest in a positive NPV project and reject a nonpositive NPV one to maximize the total share value. Thus, we express the firm's investment decision rule as follows.

$$I(Q) = \begin{cases} +1 & \text{if} \quad \mathrm{E}\big[V|Q\big] > 0; \\ -1 & \text{otherwise,} \end{cases} \tag{5}$$

where $I(Q) = +1$ and $I(Q) = -1$ represent the project is accepted and rejected respectively given the aggregate order flow Q.

The informed speculator's private assessment of the liquidation value of project depends on two variables: the investment decision of the firm manager and the private signal she acquired. Thus, the private valuation of the informed speculator at t_3 is as follows.

$$\mathbb{E}\big[V|s,Q\big] = \begin{cases} y-\gamma & \text{if} \quad s=G, I(Q)=+1 \\ -\gamma & \text{if} \quad s=B, I(Q)=+1 \\ qy-\gamma & \text{if} \quad s=N, I(Q)=+1 \\ 0 & \text{if} \quad I(Q)=-1. \end{cases} \tag{6}$$

Under a competitive marketmaking environment, the marketmaker sets the security price as its fair value as a risk neutral agent. Then, the pricing rule of the marketmaker is

$$P(Q) = \begin{cases} \mathrm{E}\big[V|Q\big] & \text{if} \quad I(Q)=+1 \\ 0 & \text{if} \quad I(Q)=-1. \end{cases} \tag{7}$$

Note that $\mathrm{E}\big[V|Q\big] > 0$ implies $I(Q)=+1$ and thus the aggregate order flow Q can decide the security price without ambiguity.

The number of shares traded by submitting a market order is Y and the number of existing restricted shares of the informed speculator is $\frac{(1-\alpha)m}{2}$. To simplify the notations, we define

$$\lambda := \frac{Y}{m}\Big/\frac{(1-\alpha)}{2}$$

as the trading-holding ratio. A small λ implies that the necessary trading size to move the stock price to a favorable direction is relatively small compared with the existing share size from the speculator's perspective. Intuitively, small and less liquid firms have smaller λ compared with large or liquid firms, which require much larger trading block size to move the stock price.

Furthermore, we assume that the updated market assessment of the project's NPV is positive when the publicly observable aggregate order flow Q at t_2 can only eliminate the possibility that the informed speculator possesses private signal $s = B$. Consequently, the firm manager will invest in the project when she can not distinguish between signal $s = G$ and $s = N$ possessed by the informed speculator. This assumption is then summarized as follows.

Assumption 3.1. *The probability that the speculator gets an informed signal, θ, is large enough so that the conditional NPV of the project is strictly positive when the market cannot distinguish the informed speculator's private signal between $s = G$ and $s = N$, and hence the firm manager invests in the project, i.e.,*

$$\mathrm{E}\big[V|s = \{G, N\}\big] > 0 \quad \Longleftrightarrow \quad \hat{q} > \frac{\gamma}{y} \quad \Longleftrightarrow \quad \theta > \frac{\gamma - qy}{\gamma(1-q)} \tag{8}$$

where $\hat{q} = \frac{q}{\theta q + (1-\theta)}$ denotes the updated market belief on the likelihood that the project is in state g when they cannot distinguish between private signal $s = G$ and $s = N$ from aggregate order flow Q.

To ease exposition and reflect the change of the strategic speculator's wealth, we standardize the ratio of the informed speculator's restricted shares and the total share outstanding of the firm to 1, i.e. $\frac{(1-\alpha)}{2} = 1$. Then the expected profit of the informed speculator with private signal s at the end of t_2 is thus given by

$$\begin{aligned} W\big[Q_I|s\big] &= \textit{Trading profit/loss } + \textit{Value change on restricted shares} \\ &= \sum_{Q_N} \mathbb{P}(Q_N)\Big[\lambda\Big(\mathrm{E}\big[V|s, Q\big] - P(Q)\Big)Q_I + \mathrm{E}\big[V|s, Q\big]\Big] \end{aligned} \tag{9}$$

where $Q = Q_I + Q_N$ denotes the aggregate order flow and $Q_N = \{+1, 0, -1\}$ represents the order submitted by the liquidity trader. The first term on the right-hand side of equation (9) represents the expected trading profit/loss of the informed speculator and the second term denotes the expected value of the existing restricted shares held by the informed speculator.

Assumption 3.2. *The marketmaker can only observe the aggregate order flow and cannot* *observe the aggregate trading volume.*

We make the above assumption to avoid that the marketmaker extrapolates further information on speculator's private signal from the trading volume. For example, in any strategic trading equilibrium that the informed speculator always trades, the speculator's deviation can be identified when zero aggregate trading volume occurs. Lemma 3.1 then provides the first formal equilibrium analysis with no SEO.

Lemma 3.1. *In any equilibria with no SEO, the informed speculator buys, $Q_I = +1$, with probability 1 if her private signal is $s = G$; the informed speculator sells, $Q_I = -1$, with probability 1 if her private signal is $s = B$.*

There are three admissible trading strategies for the strategic speculator, $Q_I = \{+1, 0, -1\}$, when her private signal is uninformative, i.e., $s = N$. The proof shows that, whatever the strategic speculator has private signal $s = N$, she does not have any incentive to deviate from her committed trading strategies in all three equilibria with $s = G$ or $s = B$.

The intuition of Lemma 3.1 is as follows. The informed speculator maximizes her total wealth at the end of t_3 from two components: the trading profit/loss and the value change on her restricted shares. When $s = G$, her buying action will be partially covered by liquidity trader's trading, and thus brings her strictly positive profit; consequently, the buying increases the probability of the firm to take a good project which brings her higher expected value on existing restricted shares compared with selling and not trading.

On the selling side, we first note that the informed speculator's selling never leads the firm to invest in the project in any equilibria. Thus, when she detects the project is in state b, i.e., $s = B$, her selling action prevents the firm from spending money on a bad project which protects the value of her existing restricted shares, while buying and not trading always lead strictly positive probability for the firm to invest. Since the marketmaker knows that the firm will not invest, the stock price will stay at the previous close price, i.e., P_0, which makes her selling action harmless to her wealth. We then derive the result of the trading equilibrium for a strategic speculator with $s = N$ when SEO will happen and proposition 1 summarizes it formally.

Proposition 1. *In any equilibria with no SEO, the trading strategy of the informed speculator with uninformative private signal $s = N$ is as follows: she sells $Q_I = -1$, with probability 1 if the unconditional NPV of the project is strictly negative, i.e. $q < \bar{q}$; she is indifferent between selling and not trading $Q_I = \{-1, 0\}$, if the unconditional NPV of the project is 0, i.e. $q = \bar{q}$.*

Corollary 1. *In any equilibrium with no SEO, the strategic speculator never buys with uninformative private signal $s = N$.*

Whenever the speculator with $s = N$ deviates to buying or staying at buying strategy, she has $\frac{2}{3}$ chance to suffer losses from both trading and restricted shares. If the project has a zero NPV, staying at or deviating to not trading leads to 0 profit which is equal to the profit of selling. One important and direct property we can get from Proposition 1 is that the informed speculator with $s = N$ never buys and it is summarized in corollary 1. In the next section, we show how the potential SEO opportunity changes the informed speculator's trading strategy in a fundamental way.

4. Trading strategy with SEO

In this section, we model a firm which has a potential project but has insufficient internal capital to fund the project. The firm is highly leveraged, and thus SEO is a better option to raise fresh capital. We depict the timeline of the events in figure 2.

If the firm decides to invest in the project conditional on its stock performance in the secondary market, an investment of $c > 0$ is required. Given the aggregate order flow revealed at the beginning of date t_2, $\frac{c}{P(Q)}$ new shares will be issued via SEO if the firm decides to invest, where $P(Q)$ is both the stock price and the offering price of the SEO. It is important to note that the expected NPV of the project will be incorporated in the stock price before

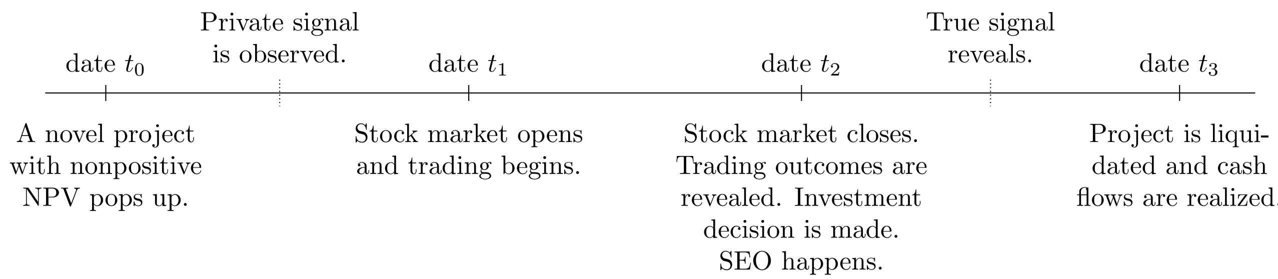

Fig. 2. Time line of events with SEO

the equity offering and the investors successively bid in the SEO do not share the expected NPV of the project. The above argument can be easily observed in the following equation,

$$\frac{V_0 + \mathbb{E}\big[NPV|Q\big] + c}{m + \frac{c}{P(Q)}} = P(Q) \qquad \text{if} \quad I(Q) = +1$$

which gives us

$$P(Q) = \frac{V_0 + \mathbb{E}\big[NPV|Q\big]}{m} \qquad \text{if} \quad I(Q) = +1$$

Basically, the above equation is saying that the market reacts to the new information in a timely fashion and new investors pay fair price for obtained shares in the SEO.

In this section, we do not consider the SEO "discount", which models the stock price drop after a firm announces the SEO decision. In the selling-initiated manipulation model derived by Gerard and Nanda (1993), selling at a relatively high price prior to SEO and covering the short position at a lower price by bidding in the SEO provides the incentive for the strategic speculator to short sell prior to the SEO even she has positive information about the project's prospects. The empirically documented SEO "discount", however, is negligible in magnitude compared to the pre-offering run-up. It is also noteworthy that SEC strengthened Rule 105 in 2007 to increase the cost of short sales prior to SEO.

In addition to the primary offering, the firm decides to release a $\kappa \in (0,1)$ portion of restricted shares from the original restricted shareholders to outside investors.[11] The

[11] We do not model the incentives for using secondary offers to liquidate restricted share positions. However, these liquidations can be rationalized either by hedging or liquidity needs.

informed speculator then sells $\kappa\frac{(1-\alpha)m}{2}$ restricted shares to the outsiders if the firm invests in the project and thus her proceeds from the secondary offering is $\kappa\frac{(1-\alpha)m}{2}P(Q)$. The value of the remaining restricted shares that informed speculator has is given by $\lambda(Q)(1-\kappa)V(s,Q)$

Similar to the last section, we standardize $\frac{(1-\alpha)}{2}$ to 1 for notation simplicity. Then the total expected profit of the informed speculator with private signal s at the end of t_3 can thus be given by

$$\begin{aligned} W\big[Q_I|s\big] &= \textit{Trading profit/loss } + \textit{Proceeds from the SEO } + \textit{Value change on remaining shares} \\ &= \sum_{Q_N} \mathbb{P}(Q_N)\Big[\lambda\Big(\mathrm{E}\big[V|s,Q\big] - P(Q)\Big)Q_I + \kappa P(Q) + (1-\kappa)\mathrm{E}\big[V|s,Q\big]\Big] \end{aligned} \tag{10}$$

where $Q = Q_I + Q_N$, $Q_N = \{+1, 0, -1\}$ and we assume that the informed speculator does not bid in the SEO. Thus, her remaining shares is $\frac{(1-\kappa)(1-\alpha)m}{2}$ after selling a κ portion to the outsiders in the SEO.

Following a similar proof of lemma 3.1, it is easy to show that the informed speculator with $s = G$ has no incentive to deviate in all three admissible equilibria. We then start to investigate how the SEO changes the informed speculator's trading strategy when her private signal is $s = N$ or $s = B$.

4.1. Buying-initiated manipulative equilibrium

In this subsection, we show that under some conditions the speculator has incentive to buy even she has no useful information regarding the project's prospects, i.e., $s = N$, which is not an equilibrium when there is no SEO as we derived in the last section. The existence of buying manipulative equilibrium predicts the stock price run-up prior to the SEO and the underperformance of the firm in the long-term. Previous hypothesis argues that the firm managers issue equity opportunistically by timing the market and the investors can not reevaluate the firm's prospects in months. However, in our rational model, the existence of buying manipulative equilibrium only requires the firm manager to have an explicit investment decision rule and optimally decide to do SEO to raise fresh capital.

The buying-initiated manipulation equilibrium exists in the tension between selling a portion of the restricted shares at a higher price in the SEO and taking potential losses from both trading and the firm's bad investment. The following proposition summarizes the existence condition of the buying-initiated manipulation.

Proposition 2. *Under conditions* (11)*, and* (12)*, the strategic speculator buys with probability* 1 *when her private signal is* $s = G$ *or* $s = N$ *and sells with probability* 1 *when her private signal is* $s = B$*, conditional on the firm will do the SEO when deciding to invest in the project.*

$$(\kappa - 2\lambda)(\hat{q} - q)y > \gamma - qy \tag{11}$$

$$\kappa \hat{q} y < \gamma \tag{12}$$

The condition (11) imply that the informed speculator with $s = N$ has no incentive to deviate to not trading, and thus selling, when the market conjectures that she will buy if she has no useful information, i.e., $s = N$. Both trading price and the equity offering price are $\hat{q}y - \gamma$ given the aggregate order flow is $Q = \{+1, +2\}$. Thus, $(\hat{q} - q)y$ represents the difference between the market conjectured price conditional on the secondary trading result prior to the SEO and the private valuation of the informed speculator with $s = N$. Since κ is the standardized portion of the speculator's restricted shares that she can sell in the SEO and λ is the standardized trading size, $(\kappa - 2\lambda) > 0$ then implies that the SEO sale portion of the informed speculator has to be larger than twice of the trading portion. In addition, $\gamma - qy$ denotes the negative part of the unconditional NPV of the project.

It is important to note that condition (11) can provide a parameter space on $(\lambda, \kappa, \theta)$ in which the informed speculator with $s = N$ has no incentive to deviate to both not trading and selling. The condition to prevent the speculator from deviating to selling is $(\kappa - \lambda)(\hat{q} - q)y > \gamma - qy$ which is a weaker condition than (11), since all κ, λ, $(\hat{q} - q)y$

and $\gamma - qy$ are positive. Intuitively, by not trading in the secondary market, the strategic speculator with $s = N$ can keep one third chance that the firm will invest in the project due to the liquidity trader's buying without taking the trading loss. Thus, in order to prevent her from deviating to not trading, the profit she can make by selling in the SEO has to be larger which causes the stricter condition, i.e., condition (11).

Due to the different wealth function the speculator has under potential SEO, the informed speculator may have incentive to buy when she actually has $s = B$. The deviation will happen when selling in the SEO can bring a huge profit for the speculator. However, this requires a larger κ, i.e., a larger selling portion in the SEO, or a higher λ, i.e., a higher likelihood of the informative signal which leads to a more informative aggregate order flow. Condition (12) then sets a maximum value of κ to prevent the firm from buying with $s = B$. To prevent the informed speculator with $s = B$ from deviating to not trading, the loss on the remaining restricted shares has to be larger than the profit from selling in the SEO, and this gives us condition (11). Furthermore, buying with $s = B$ induces trading loss which requires a less strict condition than condition (11) Detail proof of the proposition is attached in the appendix.

4.2. Separating trading equilibrium

As a pure strategic trading equilibrium, the separating equilibrium is defined as follows: *If the firm does SEO to raise capital, the informed speculator buys with $s = G$, sells with $s = B$ and does not trade with $s = N$.*

In this subsection, we investigate the conditions that result in a separating equilibrium. The informed speculator with private signal $s = N$ has to make a non-negative profit by committing to the separating trading strategy since selling always leads to a 0 change in the total wealth of the informed speculator. In addition, the profit from the SEO proceeds is not sufficiently large to provide incentive for her to deviate to buying. Proposition 3 then summarizes the existence condition of the separating equilibrium.

Proposition 3. *Under conditions* (13)*,* (14)*,* (15) *and* (16)*, the strategic speculator always buys with private signal $s = G$, does not trade with $s = N$, and sells with $s = N$, conditional on the firm will do SEO when deciding to invest in the project.*

$$\kappa(\hat{q} - q)y > \gamma - qy \tag{13}$$

$$(\kappa - \lambda)(1 - q)y < (\gamma - qy) + \lambda(\hat{q} - q)y \tag{14}$$

$$(\kappa - \lambda)(\hat{q} + 1)y < \gamma \tag{15}$$

$$\kappa\hat{q}y < \gamma \tag{16}$$

The condition (13) and (14) imply that the informed speculator with $s = N$ has no incentive to deviate to selling and buying respectively when the market knows she does not trade when $s = N$. When $Q = +2$ the informed speculator's private signal is fully identified, and the stock price will be adjusted to $y - \gamma$ for both trading and equity offering. When $Q = +1$, the market, however, cannot distinguish between $s = N$ and $s = G$ and thus the price will be $\hat{q}y - \gamma$.

The left-hand side of equation (14) is the expected profit from SEO proceeds minus the expected loss from buying in the secondary market when the aggregate order flow is +2. The right-hand side terms represent the loss from the firm undertaking the project when $Q = +2$ and the trading loss when $Q = +1$. Combining condition (13) and (14), we will have a parameter space on $(\lambda, \kappa, \theta)$ in which the informed speculator with $s = N$ has no incentive to deviate from the separating equilibrium.

Also, condition (15) and (16) make the informed speculator with private signal $s = B$ better off with selling compared with buying and not trading respectively.

Intuitively, the firm never invests in the project when the informed speculator sells and there is no trading loss for the informed speculator when she does not trade. Thus, the difference in the total profit of the informed speculator between not trading and selling is simply the sum of SEO proceeds difference and the difference in the value of the remaining restricted shares.

4.3. Selling equilibrium

Even though we focus on the buying side manipulation equilibrium which can explain a spectrum of empirical findings, we also show the conditions of the selling strategic equilibrium to appear in our model for comparison. It is not appropriate to consider the selling equilibrium as manipulation in our model when the unconditional NPV of the project is strictly negative and the private signal of the informed speculator is $s = N$ since her selling decreases the probability of the firm to invest in a strictly negative NPV project. We also show that the informed speculator with $s = N$ does not have any incentive to sell when the unconditional NPV of the project is zero. Intuitively, when the informed speculator's selling portion in the SEO, i.e., κ, is small enough, and the unconditional NPV of the project is too negative, she may have the incentive to sell even she has no information regarding the project's prospects. The informed speculator sells in this scenario to protect the value of her restricted shares from discouraging the firm to invest in a negative NPV project. The following proposition summarizes the existence conditions of the selling equilibrium.

Proposition 4. *Under conditions* (17), (18) *and* (19), *the informed speculator with uninformative private signal* $s = N$ *sells with probability* 1, *if the firm does SEO when deciding to invest in the project.*

$$(\lambda - \kappa)(q - 1)y < \gamma - qy \tag{17}$$

$$\kappa(1 - q)y < \gamma - qy \tag{18}$$

$$\kappa y < \gamma \tag{19}$$

The condition (17) and (18) guarantee that the informed speculator with $s = N$ has no incentive to deviate to buying and not trading respectively. Also, condition (19) gives a maximum value that κ can take.

4.4. Numeric example

In this subsection, we use numeric examples to elaborate the model. The difference of the project's unconditional NPV between state g and state b is fixed at 100, i.e. $y = 100$. The project has a unconditional probability $q = 0.45$ to end up with state g and $1-q = 0.65$ to end up with state b. The numeric example tests the loss of the project in state b with two values, $\gamma = -48$ and $\gamma = -45$, which denotes a strictly negative and a zero unconditional NPV project respectively.

In figure 3, we further fix the likelihood of the speculator to be informed at four different levels, i.e. $\theta = \{0.3, 0.5, 0.7, 0.9\}$. Consistent with the intuition, the buying-initiated manipulation equilibrium is located at the region with large κ and small λ. As θ increases, the grey triangle which denotes the region of buying manipulation moves leftward which implies a smaller κ, and this is caused by two effects. First, as the probability of the speculator to be informed increases, her trading becomes more informative which leads to more informative aggregate order flow Q. Her informative trading increases the stock price when the marketmaker cannot distinguish between $s = G$ and $s = N$, which makes manipulation more profitable. Second, as the stock trading price increases, the informed speculator with $s = B$ has stronger incentive to deviate from selling which causes the left-hand side cutoff.

A similar result can be found at figure 4, which uses $\gamma = 45$ for a zero NPV project. Consistent with the implication of the model, the selling equilibrium does not exist for a zero NPV project since not trading always makes her better off.

For easy comparison, we also plot the parameter space $\{\kappa, \theta\}$ for all three pure strategic equilibria in figure 5. Clearly, as λ increases, i.e., trading in the secondary market to move the price is getting more costly, the buying-initiated manipulation region is getting smaller and eventually disappears when $\lambda = 0.3$ in our numeric example (bottom right panel in figure 5). For each panel (with all three regions), selling equilibrium, separating equilibrium and

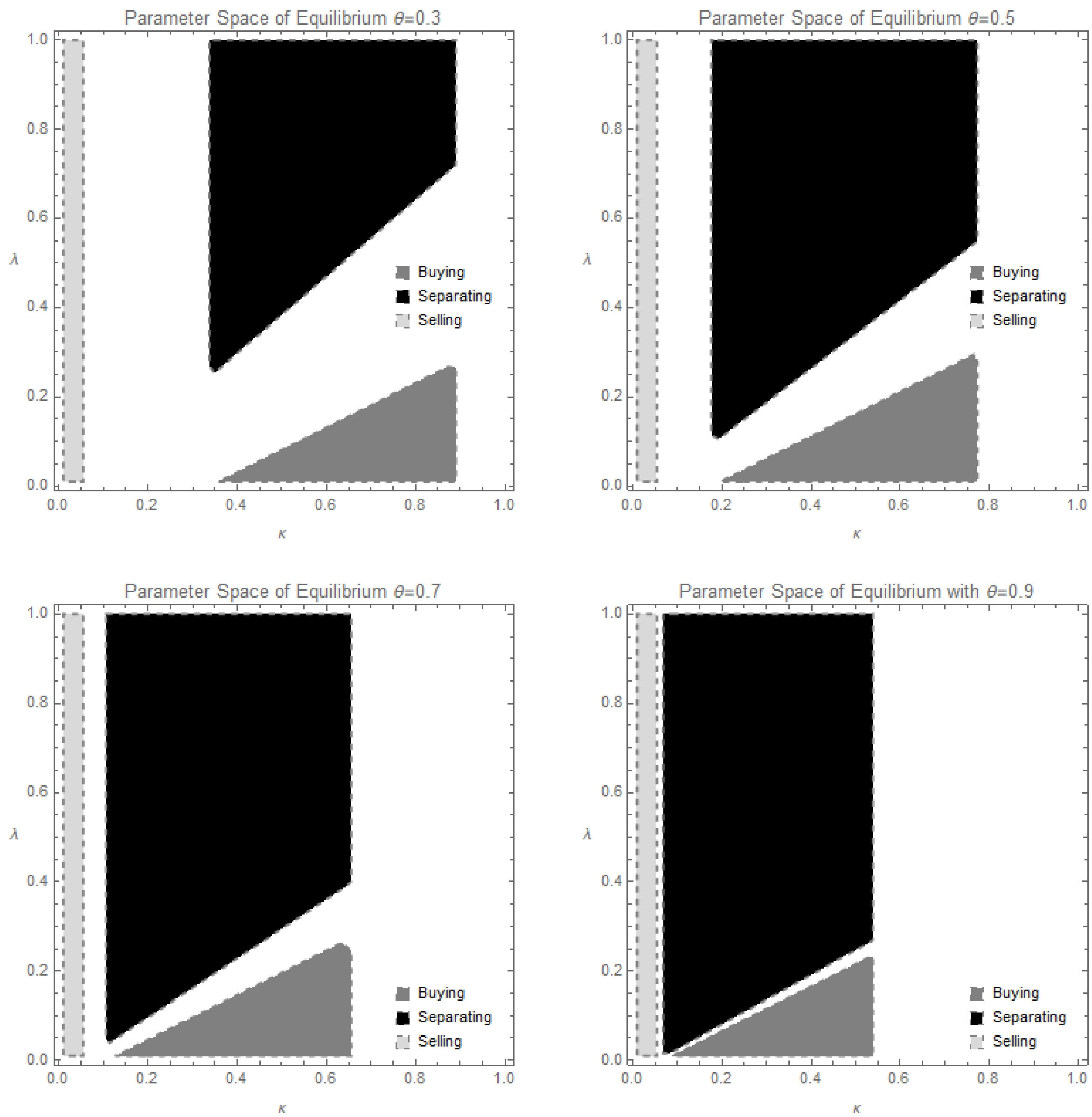

Fig. 3. **Parameter space $\{\kappa, \lambda\}$ for the existence of all three pure strategic trading equilibria when the unconditional NPV of the project is negative.** This figure plots the parameter spaces of κ and λ, where κ denotes the standardized pre-committed selling portion of the informed speculator's restricted shares in the SEO and λ denotes the standardized trading portion prior to the SEO, for all three pure strategic trading equilibria, i.e., buying-initiated manipulation, separating trading equilibrium and selling-initiated manipulation, given θ is equal to 0.3, 0.5, 0.7 and 0.9, where θ denotes the probability of the speculator to be informed. The fixed parameters are $q = 0.45$, $y = 100$ and $\gamma = 48$, where q denotes the unconditional probability of the project to be in state g, γ denotes the loss from undertaking a new project is state b, and y denotes the difference of the payoff between the project is in state g and the project is in state b.

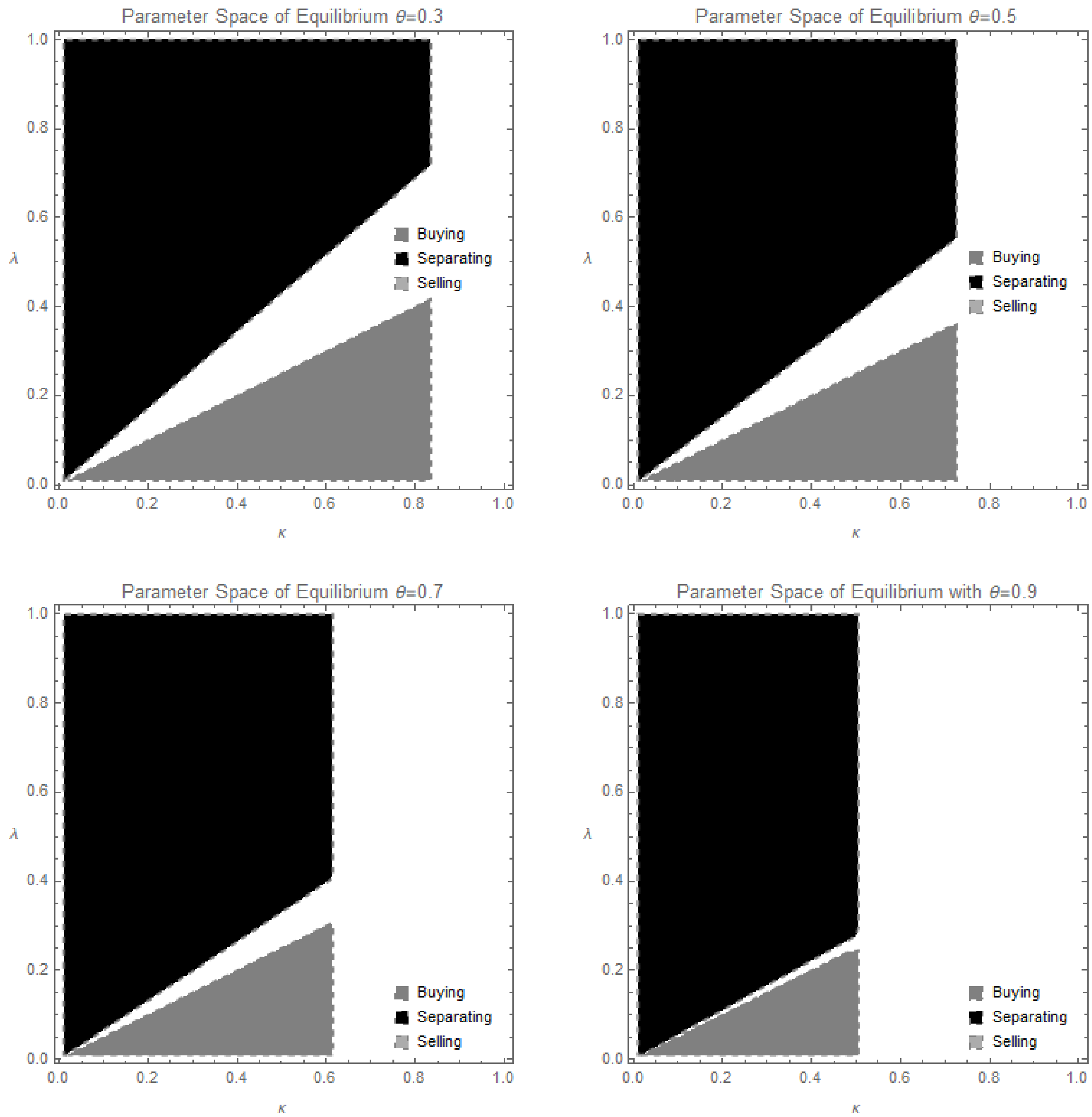

Fig. 4. **Parameter space $\{\kappa, \lambda\}$ for the existence of all three pure strategic trading equilibria when the unconditional NPV of the project is zero.** This figure plots the parameter spaces of κ and λ, where κ denotes the standardized pre-committed selling portion of the informed speculator's restricted shares in the SEO and λ denotes the standardized trading portion prior to the SEO, for all three pure strategic trading equilibria, i.e., buying-initiated manipulation, separating trading equilibrium and selling-initiated manipulation, given θ is equal to 0.3, 0.5, 0.7 and 0.9, where θ denotes the probability of the speculator to be informed. The fixed parameters are $q = 0.45$, $y = 100$ and $\gamma = 45$, where q denotes the unconditional probability of the project to be in state g, γ denotes the loss from undertaking a new project is state b, and y denotes the difference of the payoff between the project is in state g and the project is in state b.

buying manipulation equilibrium appear in order as κ increases due to the higher profitability of selling in the SEO.

We decompose the existence conditions for the buying-initiated manipulation equilibrium in figure 6. The top right, bottom left and bottom right panel plot the region of $\{\kappa, \theta\}$ when informed speculator has no incentive to deviate from the manipulative equilibrium with $s = N$, $s = G$ and $s = B$ respectively. Assumption 3.1 requires the updated NPV of the project is positive, and thus demands a minimum level for θ. The bottom blank region among all panels violates the assumption 3.1. Consistent with the implications of the model, the left-hand side blank region on top right panel implies that the SEO selling portion is too small and the speculator can not benefit enough from SEO by committing to buying manipulation. Furthermore, as κ increases, the available range for θ, and thus $\hat{q}$, increases since θ determines how profitable to sell in the SEO. The blank triangular region in the bottom right panel implies that the informed speculator with private signal $s = B$ may deviate when selling in the SEO is very profitable.

The top left panel shows the overlapping colored region of all three other plots. γ is fixed at 48 for a strictly negative NPV project and λ is fixed at 0.1 for easy comparison.

5. Robustness of the model

In this section, we examine the robustness of the model by analyzing other possible strategic equilibria.

Also, we investigate the effect of the public signal intervention on the existence conditions for the pure buying-initiated manipulative equilibrium. In our model, a trustful public signal has a positive probability to occur, τ, to be released after the trading session while before the firm making the investment decision. We find that the government intervention causes a shift on the parameter space of the manipulation existence conditions. For example, for a fixed θ, the probability of the speculator to be informed, by increasing τ which denotes the

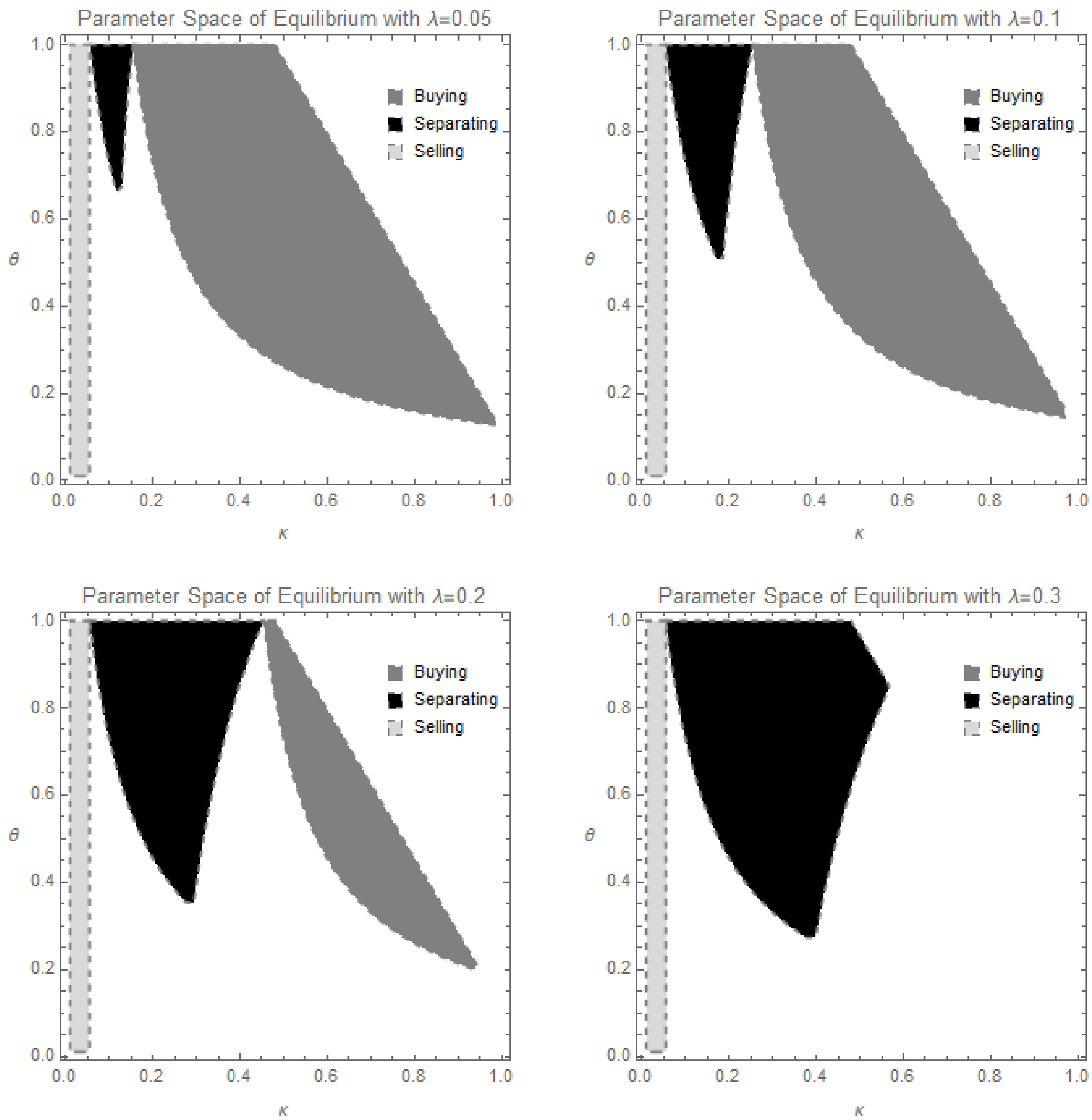

Fig. 5. **Parameter space $\{\kappa, \theta\}$ for the existence of all three pure strategic trading equilibria when the unconditional NPV of the project is negative.** This figure plots the parameter spaces of κ and θ, where κ denotes the standardized pre-committed selling portion of the informed speculator's restricted shares in the SEO and θ denotes the probability of the speculator to be informed, for all three pure strategic trading equilibria, i.e., buying-initiated manipulation, separating trading equilibrium and selling-initiated manipulation, given λ is equal to 0.05, 0.1, 0.2 and 0.3, where λ denotes the standardized trading portion prior to the SEO. The fixed parameters are $q = 0.45$, $y = 100$ and $\gamma = 48$, where q denotes the unconditional probability of the project to be in state g, γ denotes the loss from undertaking a new project is state b, and y denotes the difference of the payoff between the project is in state g and the project is in state b.

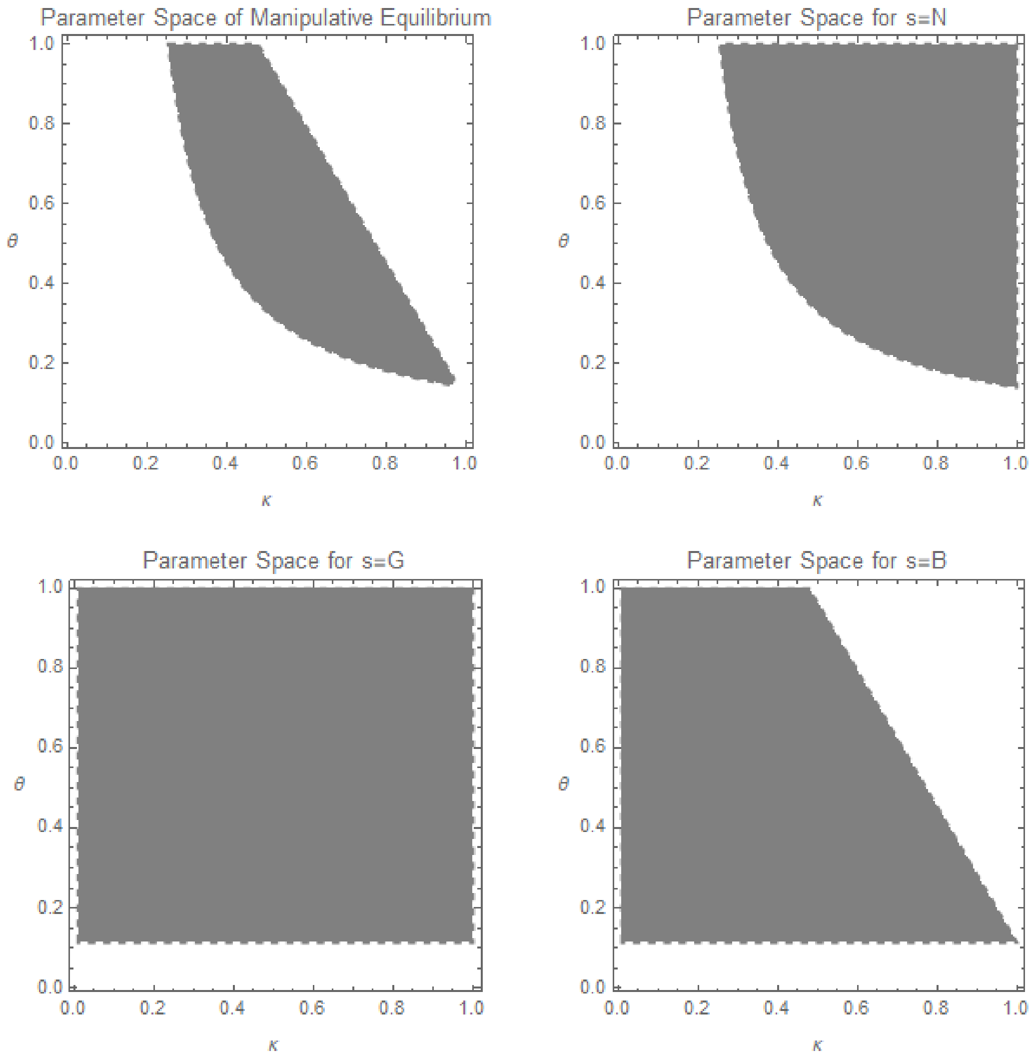

Fig. 6. **Parameter space $\{\kappa, \theta\}$ for the existence of buying-initiated manipulation equilibrium when the unconditional NPV of the project is negative.** This figure plots the parameter spaces of κ and θ, where κ denotes the standardized pre-committed selling portion of the informed speculator's restricted shares in the SEO and θ denotes the probability of the speculator to be informed, for the buying-initiated manipulation given λ is fixed at 0.1, where λ denotes the standardized trading portion prior to the SEO. The top right, bottom left and bottom right panel plot the region of $\{\kappa, \theta\}$ when informed speculator has no incentive to deviate from the manipulative equilibrium with $s = N$, $s = G$ and $s = B$ respectively. The top left panel shows the overlapping colored region of all three other plots. The fixed parameters are $q = 0.45$, $y = 100$ and $\gamma = 48$, where q denotes the unconditional probability of the project to be in state g, γ denotes the loss from undertaking a new project is state b, and y denotes the difference of the payoff between the project is in state g and the project is in state b.

probability of the public signal, the available range on λ, the standardized trading portion, decreases while the possible range on κ, the standardized SEO-selling portion, increases. Detail model and proof can be found at appendix B.

5.1. *Other possible strategic equilibria*

Instead of following an action space with buying, selling and not trading, i.e., $\{+1, -1, 0\}$, the action space may be limited to action space with buying and not trading $\{+1, 0\}$ or selling and not trading $\{-1, 0\}$. Following similar arguments and proof, we show the parameter space for the buying equilibrium and selling equilibrium with an action space is limited to $\{+1, 0\}$. The buying equilibrium is defined as following: *the informed speculator buys when $s = \{G, N\}$ with probability 1, and sells when $s = B$ with probability 1.* The selling equilibrium is defined as following: *the informed speculator buys when $s = G$ with probability 1, and sells when $s = \{N, B\}$ with probability 1.*

The existence conditions for both equilibria can be derived in a manner similar to that of buying-initiated manipulation and selling equilibrium in section 4. Figure 7 plots the parameter space $\{\kappa, \lambda\}$ for both equilibria. The left panel denotes the scenario for a strictly negative NPV project with $\gamma = 48$, and the right panel denotes the scenario for a zero NPV project with $\gamma = 45$.

6. Implications and extensions

Even though the restricted shares held by the informed speculator is crucial in the model introduced in previous section. We argue that the formal analysis can also be applied to a "deep pocket" informed speculator with a large enough amount of normal shares of the issuing firm. Once the speculator's trading in the secondary market convince the firm's manager and other investors that they project has strong potential, the firm does SEO and the speculator can sell the share inventory gradually after the SEO. A set of literature focusing on the

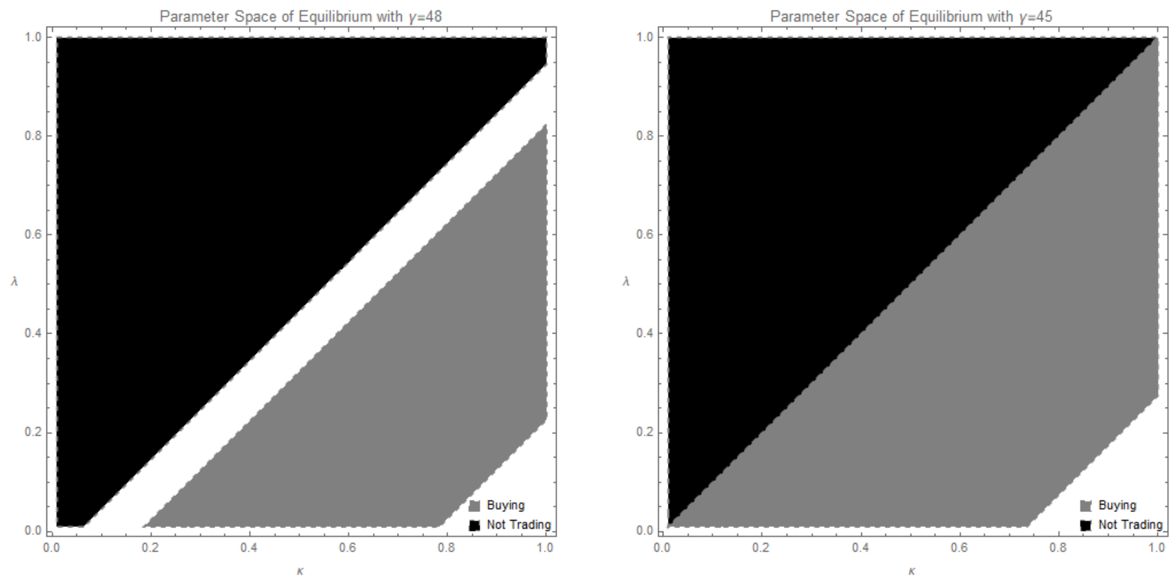

Fig. 7. **Parameter space $\{\kappa, \lambda\}$ for the existence of both pure strategic trading equilibria.** This figure plots the parameter spaces of κ and λ, where κ denotes the standardized pre-committed selling portion of the informed speculator's restricted shares in the SEO and λ denotes the standardized trading portion prior to the SEO, for both pure strategic trading equilibria, i.e., buying equilibrium and selling equilibrium, given θ is equal to 0.5, where θ denotes the probability of the speculator to be informed. The fixed parameters are $q = 0.45$, $y = 100$, where q denotes the unconditional probability of the project to be in state g, and y denotes the difference of the payoff between the project is in state g and the project is in state b. The left panel uses $\gamma = 48$ denoting a strictly negative NPV project and the right panel uses $\gamma = 45$ denoting a zero NPV project, where γ denotes the loss from undertaking a new project is state b.

behaviors of institutional investors prior to the SEOs find that the institutions are mostly net purchasers of the issuing firms' shares prior to the successful SEOs (e.g., Hovakimian and Hu (2016), Chemmanur et al. (2009)). However, the institutions' slowly selling after SEOs, which is consistent to our analysis, may actually lead to the documented long-term underperformance of issuing firms.

Field and Hanka (2001) document the negative abnormal return around the expiration of IPO share lockups. This phenomenon can be generated by the investors' worry on the massive liquidation of restricted shares by insiders. The IPO share liquidation of managers and other insiders will reduce their incentives to actively manage the firm, and convey possible adverse information about the firm, and at the same time, generate large supply pressure in the market. We argue that the secondary offering in SEOs, as another popular form of the unlock of restricted shares, should also draw ordinary investors' attention due to similar risks. Of course, any price runup prior to the expiration of IPO lockups may come from similar types of buying manipulation motivated by our model.

In our formal model, given condition (11) and (12) of proposition 2, as the right-hand side term $\gamma - qy$, which denotes the negative value of the unconditional NPV of the project, getting smaller, the manipulative equilibrium is more likely to exist. However, as the unconditional NPV of the project becomes less negative, the buying manipulation becomes less harmful for the investors, e.g., the SEO bidders. It is also important to note that when the unconditional NPV of the project is zero, the selling equilibrium is impossible to exist since condition (18) does not satisfy.

The role of $\hat{q}$ is controversial on the existence of buying manipulation. The value of $\hat{q}$ is determined by θ, which indicates the informativeness of the private signal and the trading behavior of informed speculator. Condition (11) and (12) show that as $\hat{q}$, and thus θ increases the buying manipulation is more likely to exist since selling in the SEO is more profitable. However, condition (12) sets a ceiling for the $\hat{q}$ since when selling in the SEO is too profitable, the informed speculator with a bad signal will deviate from selling.

Then, note that $\kappa - 2\lambda$ has to be positive. This condition has important empirical implications for the existence of the buying manipulation since κ is determined by the firm and λ indicates how costly for the strategic speculator to move the trading price. First, the SEOs combined with a larger portion of secondary offering, experience larger pre-offering run-ups and worse long-term underperformance afterward; Second, compared with matched large and liquid issuers, small and less liquid issuers should have higher returns prior to the equity offering and perform worse in the long-run after the equity offering.

The model also have several testable implications. First, since firms with lower liquidity are more likely to be subject to the buying manipulation around SEO, the underperformance of these firms after SEOs are generally more severe than the others. Second, the postissue operating performance of firms with a larger portion of secondary offering in the SEO is worse, in general, than that of firms with a smaller or no portion of secondary offering in the SEO. Third, the larger portion of restricted shares the informed speculator can sell via SEO, the more likely the buying manipulation is going to happen, and thus more severe underperformance and overinvestment.

7. Conclusion

Financial markets provide information that helps to streamline real investment decisions. Most of the literature in finance assumes that the value of traded firms is exogenous and thus, real investments are not affected by the information contained in prices. We explicitly incorporate the impact of learning from the financial market prices on the real economy in a standard trading environment.

We show in an environment where managers learn from stock prices, the scope for speculation changes real investment in a fundamental way. We study the behavior of an informed speculator who may or may not be informed about the state of the world. At times when the informed speculator is really uninformed, she may have an incentive to buy to move up the stock price. By doing this, the informed speculator loses on two accounts: Accumulates trading loss and value of her residual holdings deteriorates. But the informed speculator endowed with restricted shares can liquidate part of it at higher than fundamental value, and gain is large enough to outweigh the losses.

The model implies that buying-initiated manipulation is more likely to happen on small and less liquid firms. Price run-up prior to the SEO and long-run underperformance after SEO are predicted by the buying-initiated manipulation equilibrium. A successful buying manipulation leads to real losses on the economy and stock investors.

Appendix A. Proof

Proof of Lemma 3.1. There are three admissible strategies for the strategic speculator, $Q_I = \{+1, 0, -1\}$, when her private signal is uninformative, i.e., $s = N$. We show that the informed speculator with $s = G$ or $s = B$ does not have incentive to deviate from their trading strategies in all three admissible equilibria.

A. The informed speculator does not trade, $Q_I = 0$, if $s = N$.

In this strategic trading equilibrium, when the firm manager observes aggregate order flow $Q = +1$, his conjecture about the likelihood that the private signal held by the speculator is $s = B$ is zero, while cannot further distinguish between private signal $s = G$ and $s = N$. Under assumption 3.1, the firm will decide to invest in the project when $Q = +1$ Conditional on $I(+1) = +1$, the marketmaker will set the stock price as $P(+1) = \hat{q}y - \gamma$ which is larger than 0. The informed speculator has $\mathrm{E}\big[V|G, +1\big] = y - \gamma$, $\mathrm{E}\big[V|N, +1\big] = qy - \gamma$ and $\mathrm{E}\big[V|B, +1\big] = -\gamma$.

When $Q = 0$, the market, however, cannot extract any useful information from the aggregate order flow and thus the conditional NPV of the project keeps the same as its unconditional NPV, i.e., $qy - \gamma$. We then summarize the equilibrium results of this trading strategy in table 1.

s	$\mathbb{P}(s)$	Q_I	Q_L	Q	$\mathbb{P}(Q_L)$	$I(Q)$	$P(Q)$	$\mathrm{E}\big[V\|s,Q\big]$
G	θq	$+1$	$+1$	$+2$	$1/3$	$+1$	$y-\gamma$	$y-\gamma$
		$+1$	0	$+1$	$1/3$	$+1$	$\hat{q}y-\gamma$	$y-\gamma$
		$+1$	-1	0	$1/3$	-1	0	0
N	$(1-\theta)$	0	$+1$	$+1$	$1/3$	$+1$	$\hat{q}y-\gamma$	$qy-\gamma$
		0	0	0	$1/3$	-1	0	0
		0	-1	-1	$1/3$	-1	0	0
B	$\theta(1-q)$	-1	$+1$	0	$1/3$	-1	0	0
		-1	0	-1	$1/3$	-1	0	0
		-1	-1	-2	$1/3$	-1	0	0

Table 1: Investment decision $I(Q)$, stock price $P(Q)$ and private valuation $\mathrm{E}\big[V|s, Q\big]$ on trading strategy A of the informed speculator: the informed speculator buys $Q_I = +1$ if $s = G$; does not trade $Q_I = 0$ if $s = N$; and sells $Q_I = -1$ if $s = B$

First, if the speculator with $s = G$ buys, her expected profit is $\frac{1}{3}\lambda(1-\hat{q})y + \frac{2}{3}(y-\gamma)$; if she does not trade with $s = G$, her expected profit is $\frac{1}{3}(y-\gamma)$; if she sells with $s = G$, her expected profit will be 0. Since $\hat{q}$ is strictly less than 1, it is easy to see that the speculator with $s = G$ has no incentive to deviate from the equilibrium strategy.

Second, if the speculator with $s = B$ sells, her expected profit is 0; if she does not trade with $s = B$, her expected profit will be $-\frac{1}{3}\gamma$; if she sells with $s = B$, it is $-\frac{1}{3}\lambda(1+\hat{q})y - \frac{2}{3}\gamma$. Thus, the speculator with $s = B$ has a strictly negative profit to earn when she deviates.

B. The informed speculator buys, $Q_I = +1$, if $s = N$.

Following this trading strategy, the market cannot identify the exact private signal of the informed speculator between $s = G$ and $s = N$ when aggregate order flow is $Q = \{+2, +1\}$, . Under assumption 3.1, the firm will invest when observing $Q = \{+2, +1\}$, and thus the marketmaker sets the stock price as $P(Q) = \hat{q}y - \gamma$ if $Q = \{+2, +1\}$.

s	$\mathbb{P}(s)$	Q_I	Q_L	Q	$\mathbb{P}(Q_L)$	$I(Q)$	$P(Q)$	$\mathrm{E}\big[V\vert s,Q\big]$
		$+1$	$+1$	$+2$	$1/3$	$+1$	$\hat{q}y-\gamma$	$y-\gamma$
G	θq	$+1$	0	$+1$	$1/3$	$+1$	$\hat{q}y-\gamma$	$y-\gamma$
		$+1$	-1	0	$1/3$	-1	0	0
		$+1$	$+1$	$+2$	$1/3$	$+1$	$\hat{q}y-\gamma$	$qy-\gamma$
N	$(1-\theta)$	$+1$	0	$+1$	$1/3$	$+1$	$\hat{q}y-\gamma$	$qy-\gamma$
		$+1$	-1	0	$1/3$	-1	0	0
		-1	$+1$	0	$1/3$	-1	0	0
B	$\theta(1-q)$	-1	0	-1	$1/3$	-1	0	0
		-1	-1	-2	$1/3$	-1	0	0

Table 2: Investment decision $I(Q)$, stock price $P(Q)$ and private valuation $\mathrm{E}\big[V|s,Q\big]$ on trading strategy B of the informed speculator: the informed speculator buys $Q_I=+1$ if $s=\{G,N\}$; sells $Q_I=-1$ if $s=B$

Similar to trading strategy A, zero aggregate order flow, i.e., $Q=0$, does not help the market to extrapolate the informed speculator's private signal, and thus no investment happens under $Q=0$. We then summarize the results of trading strategy B in table 2.

If the speculator with $s=G$ buys, her expected profit is $\frac{2}{3}\lambda(1-\hat{q})y+\frac{2}{3}(y-\gamma)$; if she does not trade with $s=G$, the expected profit equals $\frac{2}{3}(y-\gamma)$; if she sells with $s=G$, it is 0. It is clear that the informed speculator with $s=G$ has no incentive to deviate from her trading strategy.

If the speculator with $s=B$ sells, her expected profit is 0; if she does not trade with $s=B$, her expected profit will be $-\frac{2}{3}\gamma$; if she sells with $s=B$, her expected profit is $-\frac{2}{3}\lambda\hat{q}y-\frac{2}{3}\gamma$. Thus, the speculator with $s=B$ always suffers a loss when she deviates.

C. The informed speculator sells, $Q_I=-1$, if $s=N$.

In this strategic trading equilibrium, the market can perfectly identify the informed speculator's private signal $s=G$ when they observe aggregate order flow $Q=\{+2,+1\}$. Intuitively, this eliminates her trading profit when $s=G$. The firm will invest in the positive conditional NPV project under $Q=\{+2,+1\}$. $Q=0$ is still uninformative to all other market participants, and thus no investment occurs. The results of trading strategy C are then summarized in table 3.

If the speculator with $s=G$ buys, the expected profit is $\frac{2}{3}(y-\gamma)$; if she does not trade with $s=G$, her expected profit is 0; if she sells with $s=G$, it becomes 0. Thus, only buying brings positive profit for the informed speculator when $s=G$.

If the speculator with $s=B$ sells, her expected profit is 0; if she does not trade with $s=B$, the expected profit stays at 0; if she sells with $s=B$, her expected profit will be $-\frac{2}{3}\lambda y-\frac{2}{3}\gamma$. Thus, the speculator with $s=B$ has no incentive to deviate. □

Proof of Proposition 1. Following the proof of Lemma 3.1, there are three admissible strategies $Q_I=\{+1,0,-1\}$ the strategic speculator can take when her private signal is uninformative, i.e., $s=N$. We first show that the speculator always has incentive to sell in all equilibria with $s=N$. Then the case of zero NPV project, i.e. $q=\bar{q}$, follows a similar proof.

A. The informed speculator does not trade, $Q_I=0$, if $s=N$.

First, if the speculator with $s=N$ does not trade, her expected profit is $\frac{1}{3}(qy-\gamma)$ which is strictly negative when $q<\bar{q}$. If she deviates to buying, the expected profit becomes

s	$\mathbb{P}(s)$	Q_I	Q_L	Q	$\mathbb{P}(Q_L)$	$I(Q)$	$P(Q)$	$\mathrm{E}\big[V\vert s,Q\big]$
G	θq	$+1$	$+1$	$+2$	$1/3$	$+1$	$y-\gamma$	$y-\gamma$
		$+1$	0	$+1$	$1/3$	$+1$	$y-\gamma$	$y-\gamma$
		$+1$	-1	0	$1/3$	-1	0	0
N	$(1-\theta)$	-1	$+1$	0	$1/3$	-1	0	0
		-1	0	-1	$1/3$	-1	0	0
		-1	-1	-2	$1/3$	-1	0	0
B	$\theta(1-q)$	-1	$+1$	0	$1/3$	-1	0	0
		-1	0	-1	$1/3$	-1	0	0
		-1	-1	-2	$1/3$	-1	0	0

Table 3: Investment decision $I(Q)$, stock price $P(Q)$ and private valuation $\mathrm{E}\big[V|s,Q\big]$ on trading strategy C of the informed speculator: the informed speculator buys $Q_I=+1$ if $s=G$; sells $Q_I=-1$ if $s=\{N,B\}$

$\frac{1}{3}\lambda(2q-1-\hat{q})y+\frac{2}{3}(qy-\gamma)$. Since $q<\hat{q}<1$, the speculator with $s=N$ has no incentive to buy. And if she sells, her expected profit is 0. Clearly, selling with $s=N$ makes the speculator better off.

B. The informed speculator buys, $Q_I=+1$, if $s=N$.

If the speculator with $s=N$ buys, her expected profit is $\frac{2}{3}\lambda(q-\hat{q})y+\frac{2}{3}(qy-\gamma)$; if she does not trade with $s=N$, her expected profit becomes $\frac{1}{3}(qy-\gamma)$; if she sells with $s=N$, her expected profit will be 0. Clearly, under trading strategy B, the informed speculator with $s=N$ will short sell the stock.

C. The informed speculator sells, $Q_I=-1$, if $s=N$.

If the speculator with $s=N$ sells, the expected profit is 0; if she deviates to buying, her expected profit will be $\frac{2}{3}\lambda(q-1)y+\frac{2}{3}(qy-\gamma)$; if she does not trade, it becomes $\frac{1}{3}(qy-\gamma)$. Thus, deviating to buying or not trading brings the speculator strictly negative profit when $s=N$ under trading strategy C. □

Proof of Proposition 2. In the buying manipulative trading strategy equilibrium, the market believes that the informed speculator will buy if her private signal is $s=N$. Thus, aggregate order flow $Q=+1$ and $Q=+2$ convey the same information about the informed speculator's private signal. When the firm manager observes aggregate order flow $Q=+1$ or $Q=+2$, he cannot distinguish between private signal $s=G$ and $s=N$ and the firm decides to invest in the project based on assumption 3.1. Conditional on $I(+1)=+1$, the marketmaker will set the stock price $P(+1)=P(+2)=\hat{q}y-\gamma>0$. We then summarize the results of this trading strategy in table 4.

If the speculator with $s=N$ buys, her expected profit is

$$\frac{2}{3}\Big[\lambda(q-\hat{q})y+\kappa(\hat{q}y-\gamma)+(1-\kappa)(qy-\gamma)\Big]; \tag{20}$$

if she does not trade with $s=N$, her expected profit becomes

$$\frac{1}{3}\Big[\kappa(\hat{q}y-\gamma)+(1-\kappa)(qy-\gamma)\Big]; \tag{21}$$

s	$\mathbb{P}(s)$	Q_I	Q_L	Q	$\mathbb{P}(Q_L)$	$I(Q)$	$P(Q)$	$\mathrm{E}\big[V\vert s,Q\big]$
G	θq	$+1$	$+1$	$+2$	$1/3$	$+1$	$\hat{q}y-\gamma$	$qy-\gamma$
		$+1$	0	$+1$	$1/3$	$+1$	$\hat{q}y-\gamma$	$qy-\gamma$
		$+1$	-1	0	$1/3$	-1	0	0
N	$(1-\theta)$	$+1$	$+1$	$+2$	$1/3$	$+1$	$\hat{q}y-\gamma$	$qy-\gamma$
		$+1$	0	$+1$	$1/3$	$+1$	$\hat{q}y-\gamma$	$qy-\gamma$
		$+1$	-1	0	$1/3$	-1	0	0
B	$\theta(1-q)$	-1	$+1$	0	$1/3$	-1	0	0
		-1	0	-1	$1/3$	-1	0	0
		-1	-1	-2	$1/3$	-1	0	0

Table 4: Investment decision $I(Q)$, stock price $P(Q)$ and private valuation $\mathrm{E}\big[V|s,Q\big]$ on the manipulative trading strategy: the informed speculator buys $Q_I=+1$ if $s=\{G,N\}$; sells $Q_I=-1$ if $s=B$

if she sells with $s=N$, her expected profit is 0.

By letting equation (20) be positive, i.e., better than the expected profit when $Q_I=-1$, we get

$$(\kappa-\lambda)(\hat{q}-q)y>\gamma-qy \tag{22}$$

; By letting equation (20) subtracting equation (21) larger than 0, we have condition (11) which is a stricter condition than (22).

Different from the scenario with no SEO, buying in the secondary market prior to the SEO may bring the strategic speculator positive profit when she has $s=B$. The expected profit of the speculator, when she buys with $s=B$, is

$$\frac{2}{3}[(\kappa-\lambda)\hat{q}y-\gamma]; \tag{23}$$

when she does not trade with $s=B$, her expected profit is

$$\frac{1}{3}[\kappa\hat{q}y-\gamma]; \tag{24}$$

and it is 0 when she sells with $s=B$. Since λ is positive, we have the equation (A) being negative stricter than the equation (23) being negative. By letting the profit of selling larger than that of not trading, we get the condition (12).

It is easy to see that the speculator has no incentive to deviate from buying with $s=G$ and it completes the proof.

□

Proof of Proposition 3. In the separating equilibrium, the informed speculator is supposed not to trade if her private signal is $s=N$. Then, aggregate order flow $Q=+2$ reflects that the informed speculator's private signal is $s=G$. However, the market cannot identify between private signal $s=G$ and $s=N$ when the aggregate order flow is $Q=+1$. Consequently, the firm decides to invest in the project under $Q=+1$ due to the assumption 3.1. Conditional on $I(+1)=+1$, the marketmaker will set the stock price $P(+1)=P(+2)=\hat{q}y-\gamma>0$. We then summarize the results of this trading strategy in

s	$\mathbb{P}(s)$	Q_I	Q_L	Q	$\mathbb{P}(Q_L)$	$I(Q)$	$P(Q)$	$\mathrm{E}\big[V\|s,Q\big]$
G	θq	$+1$	$+1$	$+2$	$1/3$	$+1$	$y-\gamma$	$qy-\gamma$
		$+1$	0	$+1$	$1/3$	$+1$	$\hat{q}y-\gamma$	$qy-\gamma$
		$+1$	-1	0	$1/3$	-1	0	0
N	$(1-\theta)$	0	$+1$	$+1$	$1/3$	$+1$	$\hat{q}y-\gamma$	$qy-\gamma$
		0	0	0	$1/3$	-1	0	0
		0	-1	-1	$1/3$	-1	0	0
B	$\theta(1-q)$	-1	$+1$	0	$1/3$	-1	0	0
		-1	0	-1	$1/3$	-1	0	0
		-1	-1	-2	$1/3$	-1	0	0

Table 5: Investment decision $I(Q)$, stock price $P(Q)$ and private valuation $\mathrm{E}\big[V|s,Q\big]$ on the separating trading strategy: the informed speculator buys $Q_I=+1$ if $s=G$; sells $Q_I=-1$ if $s=B$; and does not trade $Q_I=0$ if $s=N$

table 5.

If the speculator with $s=N$ does not trade, her expected profit is

$$\frac{1}{3}\Big[\kappa(\hat{q}y-\gamma)+(1-\kappa)(qy-\gamma)\Big]; \tag{25}$$

if she buys with $s=N$, her expected profit becomes

$$\begin{aligned}&\frac{1}{3}\Big[\lambda(q-1)y+\kappa(y-\gamma)+(1-\kappa)(qy-\gamma)\Big]\\&\quad+\frac{1}{3}\Big[\lambda(q-\hat{q})y+\kappa(\hat{q}y-\gamma)+(1-\kappa)(qy-\gamma)\Big];\end{aligned} \tag{26}$$

if she sells with $s=N$, her expected profit will be 0.

By letting equation (25) be positive and equation (25) subtracting equation (26) larger than 0, we get condition (13) and (14).

The expected profit of the speculator, when she buys with $s=B$, is

$$\frac{1}{3}[(\kappa-\lambda)y-\gamma]+\frac{1}{3}[(\kappa-\lambda)\hat{q}y-\gamma]; \tag{27}$$

when she does not trade with $s=B$, it is

$$\frac{1}{3}[\kappa\hat{q}y-\gamma]; \tag{28}$$

when she sells, it is 0. Both equation (27) and (28) have to be negative and we get condition (15) and (16) respectively.

□

Proof of Proposition 4. In the selling equilibrium, the marketmaker conjectures that the informed speculator will sell if her private signal is $s=N$. Thus, when the aggregate order flow is $Q=-1$ and $Q=-2$, the marketmaker cannot distinguish further between private signal $s=N$ and $s=B$. The firm manager decides not to invest accordingly due to the

s	$\mathbb{P}(s)$	Q_I	Q_L	Q	$\mathbb{P}(Q_L)$	$I(Q)$	$P(Q)$	$\mathrm{E}\big[V\vert s,Q\big]$
G	θq	$+1$	$+1$	$+2$	$1/3$	$+1$	$y-\gamma$	$qy-\gamma$
		$+1$	0	$+1$	$1/3$	$+1$	$y-\gamma$	$qy-\gamma$
		$+1$	-1	0	$1/3$	-1	0	0
N	$(1-\theta)$	-1	$+1$	0	$1/3$	-1	0	0
		-1	0	-1	$1/3$	-1	0	0
		-1	-1	-2	$1/3$	-1	0	0
B	$\theta(1-q)$	-1	$+1$	0	$1/3$	-1	0	0
		-1	0	-1	$1/3$	-1	0	0
		-1	-1	-2	$1/3$	-1	0	0

Table 6: Investment decision $I(Q)$, stock price $P(Q)$ and private valuation $\mathrm{E}\big[V|s,Q\big]$ on the selling trading strategy: the informed speculator buys $Q_I = +1$ if $s = G$; sells $Q_I = -1$ if $s = \{N, B\}$

project has a negative conditional NPV, and thus the stock trading price does not change. We then summarize the results of this trading strategy in table 6.

If the speculator with $s = N$ buys, her expected profit is

$$\frac{2}{3}\Big[\lambda(q-1)y + \kappa(y-\gamma) + (1-\kappa)(qy-\gamma)\Big]; \tag{29}$$

if she does not trade with $s = N$, her expected profit becomes

$$\frac{1}{3}\Big[\kappa(y-\gamma) + (1-\kappa)(qy-\gamma)\Big]; \tag{30}$$

if she sells with $s = N$, her expected profit is 0.

By letting both equation (29) and (30) be negative, we get condition (17) and (18) respectively.

When the speculator's private signal is $s = B$, she is supposed to sell in the secondary market prior to the potential SEO. The expected profit of the speculator, when she buys with $s = B$, is

$$\frac{2}{3}[-\lambda y + \kappa(y-\gamma) + (1-\kappa)(-\gamma)]; \tag{31}$$

when she does not trade with $s = B$, her expected profit is

$$\frac{1}{3}[\kappa(y-\gamma) + (1-\kappa)(-\gamma)]; \tag{32}$$

and it is 0 when she sells with $s = B$. Since the expected profit of not trading with $s = B$ is always larger than that of buying with $s = B$, we only have to compare the profit of not trading and selling to get the condition of preventing the speculator deviating from selling with $s = B$. By letting the expected profit of selling larger than that of not trading, we get the condition (19). □

Appendix B. The presence of public signal

In this section, we allow an agent, e.g., government and federal reserve, to reveal the true type of the project prior to the SEO and investigate the effect of a public signal on the manipulation equilibrium. We assume a public signal s_p might be released with probability τ by the trustful agent at t_2 when the trading outcomes have been revealed and the firm has not made the investment decision yet. Thus, $1-\tau$ is the probability that no public signal reveals, and we denote it as $s_p = N$. The public signal is consistent with the private signal observed by the speculator and is independent of the aggregate order flow. Equivalently saying, the public signal can only be $s_p = G$ or $s_p = N$ when the private signal is $s = G$; be $s_p = B$ or $s_p = N$ when the private signal is $s = B$; be $s_p = G$, $s_p = N$ or $s_p = B$ when the private signal is $s = N$. Clearly, the informed speculator's private signal provides her superior information on predicting the type of public signal. Figure 8 demonstrates an example of the conditional probability of the public signal when the aggregate order flow is $Q = 0$, which provides no information about the informed speculator's private signal for the market. The public signal is more trustful than private signal revealed by aggregate order flow even when they have conflicts. Thus, the firm manager will undertake the investment opportunity if the public signal is $s_p = G$ or if the public signal is $s_p = N$ and the conditional NPV of the project is strictly positive. With an informative public signal, the equity offering price of the SEO should be able to reflect the true type of the project and is no longer only determined by the close price of the trading session. The postulated NPV of the project conditional on the revealed public signal and the trading outcome is

$$\mathrm{E}\big[V|s_p, Q\big] = \begin{cases} y-\gamma & \text{if} \quad s_p = G \\ \hat{q}y-\gamma & \text{if} \quad s_p = N, Q = \{+2, +1\} \\ qy-\gamma & \text{if} \quad s_p = N, Q = 0 \\ -\gamma & \text{if} \quad s_p = B \text{ or } s_p = N, Q = \{-1, -2\}. \end{cases} \tag{33}$$

Then the investment decision rule of the firm is given as follows:

$$I(s_p, Q) = \begin{cases} +1 & \text{if} \quad \mathrm{E}\big[V|s_p, Q\big] > 0; \\ -1 & \text{otherwise.} \end{cases} \tag{34}$$

The SEO price conditional on the released public signal and the aggregate order flow is

$$P(s_p, Q) = \begin{cases} \mathrm{E}\big[V|s_p, Q\big] & \text{if} \quad I(s_p, Q) = +1 \\ 0 & \text{if} \quad I(s_p, Q) = -1 \end{cases} \tag{35}$$

considering that the number of total share outstanding is standardized to 1.

Since the public signal could only be released after the trading session, the stock price in the trading session only depends on the aggregate order flow received by the marketmaker and it is irrelevant to the public signal s_p. In this section, we are concerned with the difference in the existence conditions of the manipulation equilibrium with and without potential public signal. The pricing mechanism of the marketmaker is more complicated when τ is strictly

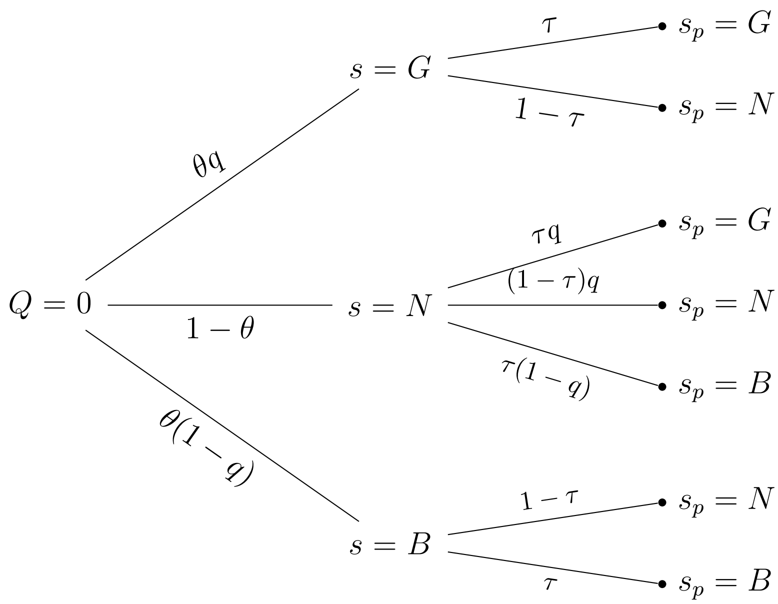

Fig. 8. The conditional probability of the public signal given the aggregate order flow $Q = 0$

positive than that when $\tau = 0$.

When the aggregate order flow is $Q = +1$ or $Q = +2$, the marketmaker can not distinguish the informed speculator's private signal between $s = G$ and $s = N$ so that the stock price of the firm is given by

$$\begin{aligned} P(+1) = P(+2) &= \frac{\theta q(y-\gamma) + (1-\theta)[\tau q(y-\gamma) - 0 + (1-\tau)(qy-\gamma)]}{\theta q + (1-\theta)} \\ &= \frac{q}{\theta q + (1-\theta)} y - \left(1 - \frac{(1-\theta)(1-q)\tau}{\theta q + (1-\theta)}\right)\gamma = \hat{q}y - \hat{\gamma} \end{aligned} \tag{36}$$

where $\hat{\gamma} = \left(1 - \frac{(1-\theta)(1-q)\tau}{\theta q + (1-\theta)}\right)\gamma < \gamma$. Intuitively, equation (36) implies that all market participants expect the trustful agent to provide further evidence on the type of the project after the trading session closes. Whenever the public signal is $s_p = B$, the firm does not invest. In such case, the public signal prevents the firm from undertaking a bad project when the private signal of the informed speculator is $s = N$ or $s_p = B$. Similarly, the stock price when the aggregate order is $Q = 0$ is

$$P(0) = \theta q\tau(y-\gamma) + (1-\theta)\tau q(y-\gamma) = \tau q(y-\gamma). \tag{37}$$

Clearly, the stock price $P(Q)$ when $Q = \{+2, +1, 0\}$ is strictly higher if the probability of the public signal τ is strictly positive, compared with what we derived when there is no public signal in section 4.1. When $Q = \{-1, -2\}$, the marketmaker knows that the private signal of the informed speculator can only be $s = B$ in the manipulation equilibrium and thus the public signal will not provide any new information. The firm is never able to issue equity at the close stock price when τ is strictly positive. This is because the public signal can correct the stock price when $s_p = \{G, B\}$ and it disappoints investors when $s_p = N$. When $s_p = N$, setting the price at the close stock price which is too high leads to failure on SEO due to insufficient bidders. When $s_p = G$, the firm is not going to leave money on the table by setting the price at the close stock price which is too low. It is also clear that $s_p = B$ leads to no SEO.

The informed speculator sells $\kappa\frac{(1-\alpha)m}{2}$ restricted shares to the outsiders in the SEO if it happens. Conditional on her trading action Q_I, the expected total profit of the informed speculator with private signal s at the end of t_3 can thus be given by

$$\begin{aligned} W\big[s, Q_I\big] &= \textit{Trading profit/loss } + \textit{Proceeds from the SEO } + \textit{Value change on remaining shares} \\ &= \sum_{Q_N} \mathbb{P}(Q_N) \sum_{s_p} \mathbb{P}(s_p|s) \Big[\lambda\Big(\mathrm{E}\big[V|s_p, s, Q\big] - P(Q)\Big)Q_I + \Big(\kappa P(s_p, Q) + (1-\kappa)\mathrm{E}\big[V|s_p, s, Q\big]\Big)\Big] \end{aligned} \tag{38}$$

where $\mathrm{E}\big[V|s_p, s, Q\big]$ is the private valuation of the informed speculator after observing the public signal and $\mathrm{E}\big[V|G, s, Q\big] = y - \gamma$, $\mathrm{E}\big[V|B, s, Q\big] = 0$, $\mathrm{E}\big[V|N, s, Q\big] = \mathrm{E}\big[V|s, Q\big]$ where $\mathrm{E}\big[V|s, Q\big]$ is given by equation (6).

We then summarize the results of the manipulative trading strategy with public signal in table 7.

The expected profit of the informed speculator with $s = N$ when she buys $Q_I = +1$ is

$$\begin{aligned} W\big[+1|N\big] = &\ \frac{2}{3}\tau q \Big[\lambda\Big((y-\gamma) - (\hat{q}y - \hat{\gamma})\Big) + \Big(\kappa(y-\gamma) + (1-\kappa)(y-\gamma)\Big)\Big] \\ &+ \frac{1}{3}\tau q \Big[\lambda\Big((y-\gamma) - \tau q(y-\gamma)\Big) + \Big(\kappa(y-\gamma) + (1-\kappa)(y-\gamma)\Big)\Big] \\ &+ \frac{2}{3}(1-\tau) \Big[\lambda\Big((qy-\gamma) - (\hat{q}y - \hat{\gamma})\Big) + \Big(\kappa(\hat{q}y-\gamma) + (1-\kappa)(qy-\gamma)\Big)\Big] \\ &+ \frac{1}{3}(1-\tau) \Big[\lambda\Big(0 - \tau q(y-\gamma)\Big) + 0\Big] \\ &+ \frac{2}{3}\tau(1-q) \Big[\lambda\Big(0 - (\hat{q}y - \hat{\gamma})\Big) + 0\Big] \\ &+ \frac{1}{3}\tau(1-q) \Big[\lambda\Big(0 - \tau q(y-\gamma)\Big) + 0\Big]. \end{aligned} \tag{39}$$

The expected profit of the informed speculator with $s = N$ when she does not trade $Q_I = 0$ is

$$\begin{aligned} W\big[0|N\big] = &\quad \tau q\Big[0 + \Big(\kappa(y-\gamma) + (1-\kappa)(y-\gamma)\Big)\Big] \\ &+ \frac{1}{3}(1-\tau)\Big[0 + \Big(\kappa(\hat{q}y-\gamma) + (1-\kappa)(qy-\gamma)\Big)\Big]. \end{aligned} \tag{40}$$

The expected profit of the informed speculator with $s = N$ when she buys $Q_I = -1$ is

$$\begin{aligned} W\big[-1|N\big] = &\ \frac{1}{3}\tau q \Big[-\lambda\Big((y-\gamma) - \tau q(y-\gamma)\Big) + \Big(\kappa(y-\gamma) + (1-\kappa)(y-\gamma)\Big)\Big] \\ &+ \frac{2}{3}\tau q \Big[-\lambda\Big((y-\gamma) - 0\Big) + \Big(\kappa(y-\gamma) + (1-\kappa)(y-\gamma)\Big)\Big]. \end{aligned} \tag{41}$$

s	Q_I	Q	$\mathbb{P}(Q\|Q_I)$	s_p	$\mathbb{P}(s_p\|s)$	$I(s_p,Q)$	$P(Q)$	$P(s_p,Q)$	$\mathrm{E}\big[V\|s_p,s,Q\big]$
G	$+1$	$+2$	$1/3$	G	τ	$+1$	$\hat{q}y-\hat{\gamma}$	$y-\gamma$	$y-\gamma$
		$+1$		G	τ	$+1$	$\hat{q}y-\hat{\gamma}$	$y-\gamma$	$y-\gamma$
		0		G	τ	-1	$\tau q(y-\gamma)$	$y-\gamma$	$y-\gamma$
		$+2$		N	$1-\tau$	$+1$	$\hat{q}y-\hat{\gamma}$	$\hat{q}y-\gamma$	$qy-\gamma$
		$+1$		N	$1-\tau$	$+1$	$\hat{q}y-\hat{\gamma}$	$\hat{q}y-\gamma$	$qy-\gamma$
		0		N	$1-\tau$	-1	$\tau q(y-\gamma)$	0	0
N	$+1$	$+2$	$1/3$	G	τq	$+1$	$\hat{q}y-\hat{\gamma}$	$y-\gamma$	$y-\gamma$
		$+1$		G	τq	$+1$	$\hat{q}y-\hat{\gamma}$	$y-\gamma$	$y-\gamma$
		0		G	τq	-1	$\tau q(y-\gamma)$	$y-\gamma$	$y-\gamma$
		$+2$		N	$1-\tau$	$+1$	$\hat{q}y-\hat{\gamma}$	$\hat{q}y-\gamma$	$qy-\gamma$
		$+1$		N	$1-\tau$	$+1$	$\hat{q}y-\hat{\gamma}$	$\hat{q}y-\gamma$	$qy-\gamma$
		0		N	$1-\tau$	-1	$\tau q(y-\gamma)$	0	0
		$+2$		B	$\tau(1-q)$	-1	$\hat{q}y-\hat{\gamma}$	0	0
		$+1$		B	$\tau(1-q)$	-1	$\hat{q}y-\hat{\gamma}$	0	0
		0		B	$\tau(1-q)$	-1	$\tau q(y-\gamma)$	0	0
B	-1	0	$1/3$	N	$1-\tau$	-1	$\tau q(y-\gamma)$	0	0
		-1		N	$1-\tau$	-1	0	0	0
		-2		N	$1-\tau$	-1	0	0	0
		0		B	τ	-1	$\tau q(y-\gamma)$	0	0
		-1		B	τ	-1	0	0	0
		-2		B	τ	-1	0	0	0

Table 7: Investment decision $I(Q)$, stock price $P(Q)$ and private valuation $\mathrm{E}\big[V|s_p,s,Q\big]$ on the manipulative trading strategy with public signal: the informed speculator buys $Q_I=+1$ if $s=\{G,N\}$; sells $Q_I=-1$ if $s=B$

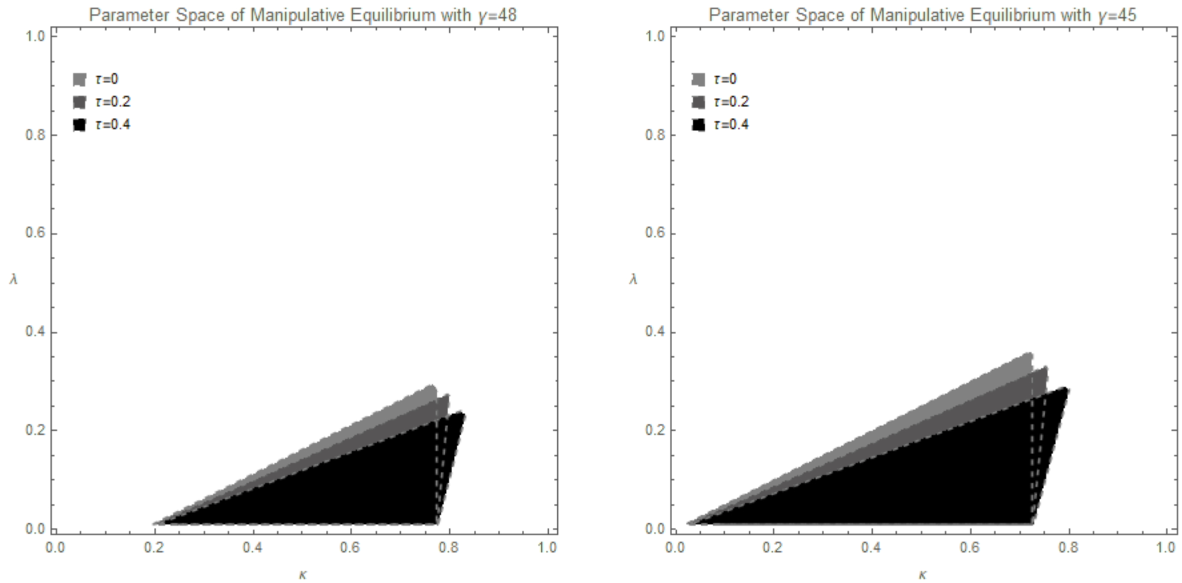

Fig. 9. **Parameter space $\{\kappa, \lambda\}$ for the existence of buying-initiated manipulation under different level of public signal intervention.** This figure plots the parameter spaces of κ and λ with different level of public signal intervention, $\tau = \{0, 0.2, 0.4\}$, for the buying-initiated manipulation given θ is fixed at 0.5. κ denotes the standardized pre-committed selling portion of the informed speculator's restricted shares in the SEO, λ denotes the standardized trading portion prior to the SEO, and θ denotes the probability of the speculator to be informed. The fixed parameters are $q = 0.45$, $y = 100$, where q denotes the unconditional probability of the project to be in state g, and y denotes the difference of the payoff between the project is in state g and the project is in state b. The left panel uses $\gamma = 48$ denoting a strictly negative NPV project and the right panel uses $\gamma = 45$ denoting a zero NPV project, where γ denotes the loss from undertaking a new project is state b.

Thus, the manipulation equilibrium exists as long as the following two conditions are satisfied

$$\begin{aligned} W\big[+1|N\big] - W\big[0|N\big] = \quad & \frac{1}{3}\Big[(y-\gamma)\Big(2\tau q\lambda\Big) + (\hat{q}y-\gamma)(1-\tau)\kappa \\ & + (qy-\gamma)(1-\tau)\Big(2\lambda + (1-\kappa)\Big) - (\hat{q}y-\hat{\gamma})2\lambda\Big] > 0. \end{aligned} \tag{42}$$

$$\begin{aligned} W\big[+1|N\big] - W\big[-1|N\big] = \quad & \frac{1}{3}\Big[(y-\gamma)\Big(\tau q\lambda(5-\tau q)\Big) + (\hat{q}y-\gamma)(1-\tau)2\kappa \\ & + (qy-\gamma)(1-\tau)2\Big(\lambda + (1-\kappa)\Big) - (\hat{q}y-\hat{\gamma})2\lambda\Big] > 0. \end{aligned} \tag{43}$$

The existence conditions of buying manipulation equilibrium for the informed speculator with private signal $s = B$ can be derived in a similar manner. Figure 9 plots the parameter space of $\{\kappa, \lambda\}$ for a numeric example with $\tau = \{0.05, 0.1, 0.2, 0.3\}$. The shifting parameter space is clear in figure 9 as we mentioned in section 5

References

Asquith, P., Mullins Jr, D. W., 1986. Equity issues and offering dilution. Journal of Financial Economics 15, 61–89.

Attari, M., Banerjee, S., Noe, T. H., 2006. Crushed by a rational stampede: Strategic share dumping and shareholder insurrections. Journal of Financial Economics 79, 181–222.

Baker, M., Stein, J. C., Wurgler, J., 2003. When does the market matter? stock prices and the investment of equity-dependent firms. The Quarterly Journal of Economics 118, 969–1005.

Baker, M., Wurgler, J., 2000. The equity share in new issues and aggregate stock returns. The Journal of Finance 55, 2219–2257.

Bayless, M., Chaplinsky, S., 1991. Expectations of security type and the information content of debt and equity offers. Journal of Financial Intermediation 1, 195–214.

Bayless, M., Chaplinsky, S., 1996. Is there a window of opportunity for seasoned equity issuance? The Journal of Finance 51, 253–278.

Bond, P., Edmans, A., Goldstein, I., 2012. The real effects of financial markets. Annu. Rev. Financ. Econ. 4, 339–360.

Carlson, M., Fisher, A., Giammarino, R., 2006. Corporate investment and asset price dynamics: Implications for seo event studies and long-run performance. The Journal of Finance 61, 1009–1034.

Chemmanur, T. J., He, S., Hu, G., 2009. The role of institutional investors in seasoned equity offerings. Journal of Financial Economics 94, 384–411.

Chen, Q., Goldstein, I., Jiang, W., 2006. Price informativeness and investment sensitivity to stock price. The Review of Financial Studies 20, 619–650.

Clarke, J., Dunbar, C., Kahle, K. M., 2001. Long-run performance and insider trading in completed and canceled seasoned equity offerings. Journal of Financial and Quantitative Analysis 36, 415–430.

Cohen, D. A., Zarowin, P., 2010. Accrual-based and real earnings management activities around seasoned equity offerings. Journal of Accounting and Economics 50, 2–19.

Daniel, K., Hirshleifer, D., Subrahmanyam, A., 1998. Investor psychology and security market under-and overreactions. The Journal of Finance 53, 1839–1885.

DeAngelo, H., DeAngelo, L., Stulz, R. M., 2010. Seasoned equity offerings, market timing, and the corporate lifecycle. Journal of Financial Economics 95, 275–295.

Denis, D. J., Sarin, A., 2001. Is the market surprised by poor earnings realizations following seasoned equity offerings? Journal of Financial and Quantitative Analysis 36, 169–193.

Dittmar, A., Thakor, A., 2007. Why do firms issue equity? The Journal of Finance 62, 1–54.

Durnev, A., Morck, R., Yeung, B., 2004. Value-enhancing capital budgeting and firm-specific stock return variation. The Journal of Finance 59, 65–105.

Edmans, A., Goldstein, I., Jiang, W., 2015. Feedback effects, asymmetric trading, and the limits to arbitrage. American Economic Review 105, 3766–97.

Field, L. C., Hanka, G., 2001. The expiration of ipo share lockups. The Journal of Finance 56, 471–500.

Gerard, B., Nanda, V., 1993. Trading and manipulation around seasoned equity offerings. The Journal of Finance 48, 213–245.

Gibson, S., Safieddine, A., Sonti, R., 2004. Smart investments by smart money: Evidence from seasoned equity offerings. Journal of Financial Economics 72, 581–604.

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

Goldstein, I., Guembel, A., 2008. Manipulation and the allocational role of prices. The Review of Economic Studies 75, 133–164.

Healy, P. M., Palepu, K. G., 1990. Earnings and risk changes surrounding primary stock offers. Journal of Accounting Research 28, 25–48.

Hovakimian, A., Hu, H., 2016. Institutional shareholders and seo market timing. Journal of Corporate Finance 36, 1–14.

Jenter, D., 2005. Market timing and managerial portfolio decisions. The Journal of Finance 60, 1903–1949.

Jo, H., Kim, Y., 2007. Disclosure frequency and earnings management. Journal of Financial Economics 84, 561–590.

Kahn, C., Winton, A., 1998. Ownership structure, speculation, and shareholder intervention. The Journal of Finance 53, 99–129.

Kyle, A. S., 1985. Continuous auctions and insider trading. Econometrica pp. 1315–1335.

Loughran, T., Ritter, J. R., 1995. The new issues puzzle. The Journal of Finance 50, 23–51.

Loughran, T., Ritter, J. R., 1997. The operating performance of firms conducting seasoned equity offerings. The Journal of Finance 52, 1823–1850.

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

Lyandres, E., Sun, L., Zhang, L., 2005. Investment-based underperformance following seasoned equity offerings. Tech. rep., National Bureau of Economic Research.

Mikkelson, W. H., Partch, M. M., 1986. Valuation effects of security offerings and the issuance process. Journal of Financial Economics 15, 31–60.

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

Rangan, S., 1998. Earnings management and the performance of seasoned equity offerings. Journal of Financial Economics 50, 101–122.

Schultz, P., 2003. Pseudo market timing and the long-run underperformance of ipos. The Journal of Finance 58, 483–517.

Spiess, D. K., Affleck-Graves, J., 1995. Underperformance in long-run stock returns following seasoned equity offerings. Journal of Financial Economics 38, 243–267.

Teoh, S. H., Welch, I., Wong, T. J., 1998. Earnings management and the underperformance of seasoned equity offerings. Journal of Financial Economics 50, 63–99.

Walker, M. D., Yost, K., 2008. Seasoned equity offerings: What firms say, do, and how the market reacts. Journal of Corporate Finance 14, 376–386.