Manipulation and the Allocational Role of Prices*

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March 2005

*We would like to thank Oliver Board, Qi Chen, James Dow, Simon Gervais, Gary Gorton, Bruce Grundy, Robert Hauswald, Pete Kyle, Alan Morrison, Oren Sussman, and Sheridan Titman for helpful discussions and comments. A previous version of this paper was circulated under the title "Manipulation, The Allocational Role of Prices, and Production Externalities," and presented at Cass Business School, Duke University, HEC Paris, Lancaster University, London Business School, London School of Economics, Nuffield College, and the University of Amsterdam, and at the following conferences: The Oxford Finance Summer Symposium, the EFA Annual Meetings, the AFA Annual Meetings, and the Texas Finance Festival. All remaining errors are ours.

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Abstract

Prices in secondary financial markets are thought to play an important allocational role because they contain information that is relevant to the efficient allocation of resources. This paper identifies a limitation inherent in this role of prices. It shows that when prices have an allocational role there can be opportunities for market manipulation. When prices affect resource allocation they also affect the true value of the underlying asset. This feedback from price to asset value enables an uninformed trader to generate a negative self-fulfilling expectation by selling the asset short. The price impact of the short sales activity distorts asset allocation and further reduces the asset's true value. The manipulator can then close out the short position at a profit. It is shown that this type of manipulation is not profitable on the buy side, driving a wedge between the allocational implications of buy and sell side speculation. Moreover, when several agents with complemetary actions use the market price to infer information, the distortionary effects of manipulation can be so strong as to render the existence of publicly observable prices undesirable.

Keywords: Manipulation, speculation, market efficiency, production externalities.

JEL Classification: D62, D82, D84, G14

1. Introduction

One of the most fundamental roles of prices is to facilitate the efficient allocation of scarce resources (Hayek (1945)). Prices in financial markets perform their allocational role by channeling scarce capital towards the most productive investment technologies. This channel, however, only ascribes an allocational role to prices of financial assets when they are first issued to raise funds. Secondary market prices of these assets no longer play a direct allocational role (see Dow and Gorton (1997) for an excellent discussion of this issue). Nevertheless, prices in secondary financial markets are thought to play an important indirect allocational role, because they convey useful information about investment opportunities. This information can improve firm's investment choices. Leland (1992), Dow and Gorton (1997), Subrahmanyam and Titman (1999) and Dow and Rahi (2001) explore the implications of information revelation through prices on the efficiency of capital allocation decisions.

This paper identifies a limitation inherent in this role of prices. It shows that the very fact that prices play an allocational role opens up opportunities for market manipulation. When such manipulation occurs, the information conveyed by prices is misleading, and this distorts resource allocation. We show that this effect may be so strong as to render the existence of publicly observable prices undesirable.

The main mechanism of manipulation is modelled as follows. A firm faces an investment opportunity with uncertain net present value so that it is sometimes optimal to undertake the investment and sometimes not. There is a speculator who may have information about aspects of this opportunity that are relevant for the optimal investment decision and that are not yet known by the firm. Such information could be about the project's appropriate cost of capital, future demand in the economy or the firm's position relative to its competitors. The speculator can trade on his private information, which gets partially reflected in the stock price. The price formation process is endogenized in a market microstructure setting based on Kyle (1985). Information revealed by the price will then optimally be taken into account by the firm in its investment decision. We show that even when the speculator has no private information he may want to trade in order to affect the firm's investment decision. In particular, he may want to establish a short position in the firm and subsequently drive down the firm's stock price by further short sales. The firm infers that the lower price may reflect negative information about the investment opportunity and therefore not invest. On average this is the wrong decision and will in itself reduce the value of the firm. This enables the speculator to cover his short position at a lower cost and make a profit.

While modelling feedback from an asset's price to its value is not new, it has not been identified as a source of manipulative trading before. In our modeling approach of feedback we follow Leland (1992), Dow and Gorton (1997), Subrahmanyam and Titman (1999, 2001) and Dow and Rahi (2001): Managers can learn from the stock price when taking investment decisions. This mechanism has received empirical support in the recent work of Durnev, Morck, and Yeung (2004) and Chen, Goldstein, and Jiang (2003). Alternatively, feedback may arise from stock price effects on the firm's financing constraints (see the empirical papers of Baker, Stein, and Wurgler (2003), and Polk and Sapienza (2002)). In either case, prices play an allocational role, which is sufficient to generate our main result on manipulation.

As a result of manipulation, stock prices play an ambiguous role in our model. On the one hand they contain information, which can improve resource allocation. On the other hand their allocational role gives rise to manipulation and consequently to misallocation of resources. We investigate whether financial markets are overall desirable in contributing to ex-ante production efficiency, as is commonly believed. We show that even under strong manipulation a financial market may at worst be useless when one firm's decision does not affect the payoff of other firms. In this case the decision maker optimally chooses to ignore the price signal, if her private information is on average more accurate. Financial markets therefore never reduce investment efficiency.

Prices become more important when several decision makers with strategic complementarities operate simultaneously. We capture this by analyzing a model with two firms that share strategic complementarities. Such complementarities can be due to demand side spillovers when firms produce complementary goods or to technological spillovers that result from learning or infrastructure externalities. Alternatively, one could think of strategic complementarities across agents associated with the same firm (we elaborate on this point in Section 4 of the paper). With complementarities, the publicly observable price signal is important not only as a source of information on firm-specific fundamentals, but also as an indication of the information available to other agents. We show that the publicly observable price signal may become so important that agents ignore their private signal. Instead, they may follow the public signal even when they know it is manipulated. We show that in the multiple-agents case, the existence of a financial market may reduce the ex-ante efficiency of investment decisions due to manipulation. This result is related to Morris and Shin (2002) who point out that agents may ignore their private signals in favor of a less accurate public signal when there are strategic complementarities. Our paper endogenizes the public signal through price formation in a financial market. In our setting, the problem is aggravated because a strategic trader can manipulate the public signal so as to take advantage of the resulting misallocation of resources.

Aside from identifying a fundamental limitation inherent in the allocational role of stock prices, our paper makes two other novel contributions. First, it points to an important asymmetry between sell side and buy side speculation. This asymmetry arises from the fact that manipulation in our setting is only profitable when it is carried out through short sales. This is because, manipulation - whether it leads to over- or to underinvestment - distorts resource allocation and therefore reduces firm value. Only a trader who established a short position in an asset can profit from this value reduction. In the debate on short sales regulation such an asymmetry is implicitly understood to be relevant, for example by regulatory bodies (e.g., the SEC in the US), who introduced restrictions on short sales such as the 'up-tick' rule.[1] Our paper is, to our knowledge, the first to point out a theoretical justification for such concerns. In a wider context, our model can be linked to recent episodes of currency attacks, where speculators drove down the price of a currency, which led to subsequent economic collapse and further depreciation of a country's currency.[2] In the existing literature, the underlying feedback mechanism has not received much attention from currency-crises researchers, although practitioners appear to have a rudimentary understanding that it is crucial to episodes of currency attacks.[3]

Second, our paper identifies a new mechanism through which market manipulation can occur. In general, it is not straightforward to construct models where speculators

[1] Also, many firms complain about short sales arguing that they may be manipulative and therefore costly to shareholders. For example: in a letter to the SEC, Medizone International Inc. estimates that the short interest in their stock at one point exceeded 50% of the public float. The company claims that "[...] short-selling, [...] and other actions that have served to limit our access to capital, diminished or suppressed the value of our shares [...]. This short selling has proven extremely detrimental to our company and our shareholders." http://www.sec.gov/rules/concept/s72499/marshal2.txt.

[2] Corsetti, Pesenti, and Roubini (2001) show that short positions of large traders had a significant impact on currency depreciation during episodes of currency attacks. Corsetti, Dasgupta, Morris, and Shin (2004) analyze theoretically the effect of large traders on the probability and severity of currency attacks. Cheung and Chinn (2000) provide survey evidence that participants in foreign exchange markets believe that there are large traders in these markets, who have market power and sometimes trade in a manipulative way.

[3] For example George Soros (1994) argues that "Instead of fundamentals determining exchange rates, exchange rates have found a way of influencing fundamentals.[...] When that happens speculation becomes a destabilizing influence."

make a profit from trading without information. As Jarrow (1992) points out, such trading strategies are not profitable in standard models because either (i) the speculator's trade will move the price in an unfavorable direction relative to subsequently revealed information, or (ii) when no further information is revealed, the speculator's attempt to unwind his original trade at a later date will have a symmetric price impact. In our model, such a trading strategy can be profitable because of the feedback effect that prices have on the underlying asset value. When an uninformed speculator acquires a position he knows that his trade affects the underlying asset value in a way that on average will enable him to unwind the position at a profit.

A number of papers consider the possibility of manipulative trading strategies.[4] Kumar and Seppi (1992) show the possibility of manipulation in futures markets when contracts are settled in cash. A trader can profit by establishing a short position in the futures market and subsequently driving down the price through trade in the spot market. When spot trades have sufficient impact on the settlement price, the futures position can be closed out at a profit. In Allen and Gorton (1992) buy orders are more likely to reflect information than sell orders, which allows profitable manipulation by unwinding an existing position without a symmetric adverse effect on price. Allen and Gale (1992) show that an uninformed trader can manipulate by mimicking the behavior of an informed trader, when she knows the informed trader does not trade. Gerard and Nanda (1993) point out that manipulation around seasoned equity offerings can be profitable because it affects the degree of the offer underpricing. Finally, Brunnermeier (2001) and Vitale (2000) analyze manipulation by informed traders, who strategically trade more aggressively today in order to create a future informational advantage.

Our paper also relates to three recent papers that highlight the feedback effect from price to real value. Khanna and Sonti (2000) highlight the role of the feedback effect in the context of herding. Hirshleifer, Subrahmanyam and Titman (2002) discuss the

[4] Allen and Gale (1992) distinguish further between *action based, information based* and *trade based* manipulation. We are only concerned with trade based manipulation. In action based manipulation an agent's action directly affects the value of an asset (see, e.g., Bagnoli and Lipman (1996) and Vila (1989)). This type of manipulation is usually illegal due to restrictions on insider trading. In *information-based* manipulation an agent can spread rumors or false information (see, e.g., Benabou and Laroque (1992), and van Bommel (2003)).

role of the feedback in a model with irrational traders. Attari, Banerjee and Noe (2002) explore trading by institutional investors around corporate control changes and point to the possibility of manipulation when a value enhancing action is taken by a large trader conditional on stock price movements. A price drop leads to increased firm value, because it triggers shareholder activism. This contrasts with our result where a price drop has a negative impact on firm value rendering manipulation profitable for short sellers only.

The remainder of this paper is organized as follows: Section 2 presents the basic model with one firm. In Section 3, we study profitable manipulation strategies in this case. Section 4 extends the model to include several firms with production complementarities and analyzes profitable manipulation strategies in this case. In Section 5, we analyze the effect of financial markets on the ex-ante efficiency of investment decisions. Section 6 discusses robustness and Section 7 concludes. Proofs are relegated to the Appendix.

2. The Model

We first study a model with a single firm employing a technology of uncertain productivity. The manager of the firm takes an investment decision $I \in [0, K]$, so as to maximize the expected firm value, which is given by

$$V = (\theta_\omega - c)\, I, \tag{1}$$

where θ_ω denotes the firm's uncertain productivity parameter and c its marginal cost of investment (we sometimes refer to θ_ω as the fundamentals of the firm). One may think of θ_ω as either an attribute of the specific production technology employed by the firm, or as a more general factor that influences the desirability of investment. Since we analyze a model where an outside speculator may have private information about this parameter, we think of θ_ω as a more general factor, for example the future demand for a particular product or the future state of the industry.

Depending on the state of the world $\omega \in \{l, h\}$, the productivity may be high or low ($\theta_h > \theta_l$) with equal probability. We assume that the investment is worth undertaking when the state is high, but not when it is low, i.e.

$$\theta_h > c > \theta_l$$

Moreover, we assume that in the absence of information about realized productivity, it is worth undertaking the investment:

$$\frac{\theta_h + \theta_l}{2} > c. \tag{2}$$

There are four dates $t \in \{0, 1, 2, 3\}$ in the economy. At dates $t = 1$ and $t = 2$, a share of the firm is traded at publicly observable prices. There are three types of risk neutral traders in the financial market: a speculator, a noise trader, and a market maker. At date $t = 3$, before uncertainty regarding ω is realized, but after second period trading takes place and prices are made public, the firm manager takes the investment decision. This decision is made so as to maximize the expected value of the firm given the information that is available to the manager. In our simple structure, the optimal investment level is always a corner solution $I^* \in \{0, K\}$. We assume that the manager uses retained earnings to finance investment.[5]

At time 0, the manager receives with probability β a fully revealing private signal $s_M \in \{l, h\}$, concerning the productivity parameter θ_ω. With probability $1 - \beta$ she receives no signal, denoted by $s_M = \varnothing$. At the same time, the speculator receives a perfectly informative private signal $s_T \in \{l, h\}$ with probability α (T stands for trader). With probability $1 - \alpha$ he receives no signal, denoted by $s_T = \varnothing$. Neither the speculator nor the manager knows whether the other has observed a signal.

While the speculator can trade in the equity of the firm, the manager is prohibited from doing so. In most countries trade by the manager would constitute illegal insider trading, since she has privileged information regarding her own future investment decision. In addition to the speculator, there is a noise trader who submits orders $n_t \in \{-1, 1\}$ with equal probability. The noise trader's orders are serially uncorrelated, i.e., n_1 and n_2 are independent. The speculator submits orders u_t of the same size as the noise trader, or he does not trade at all, i.e. $u_t \in \{-1, 0, 1\}$.

Following Kyle (1985), in each round of trade orders are submitted simultaneously to a market maker who sets the price and absorbs order flows out of his inventory. The market maker sets the price equal to expected asset value, given the information contained in past and present order flows. This assumption is justified when the market making industry

[5]Note that these retained earnings can be easily included in the expression for the firm value in (1), without changing the analysis.

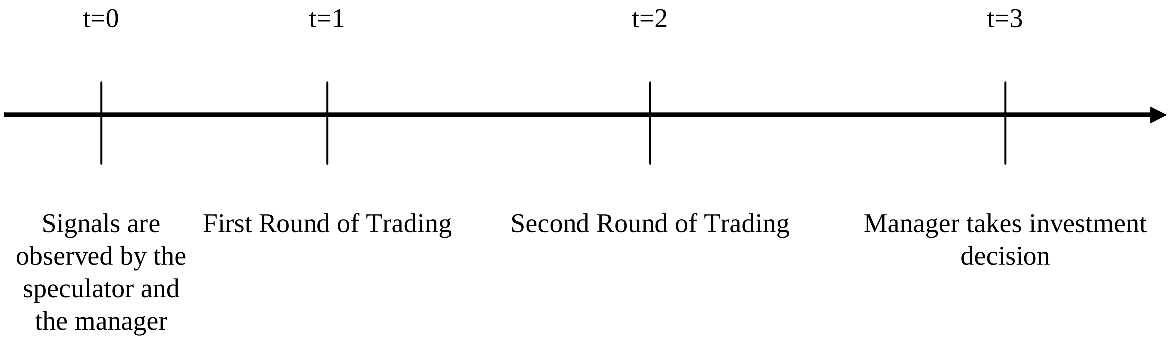

Figure 1: Sequence of Events

is competitive. The market maker can only observe total order flow $Q_t = n_t + u_t$, but not its individual components. Possible order flows are $Q_t \in \{-2, -1, 0, 1, 2\}$. At date $t = 1$, the price is a function of total order flow $p_1(Q_1) = E[V|Q_1]$. At date $t = 2$, the price depends on current and past order flows $p_2(Q_1, Q_2) = E[V|Q_1, Q_2]$. The manager may in turn use the information in the price when making her investment decision. The price equals the expected firm value and hence will reflect the effect it may have on the manager's investment decision. Figure 1 shows the sequence of events.

An equilibrium is defined as (i) a price and signal contingent trading strategy by the speculator $\{u_1(s_T)$ and $u_2(s_T, p_1)\}$ that maximizes his expected final payoff, given the price setting rule and the strategy of the manager,[6] (ii) a price and signal contingent investment strategy by the manager $g(s_M, p_1, p_2)$ that maximizes expected firm value given the market maker's price setting strategy and the speculator's trading strategy, (iii) a price setting strategy by the market maker $\{p_1(Q_1)$ and $p_2(Q_1, Q_2)\}$ that allows him to break even in expectation, given other strategies. In the next section, we show the existence of an equilibrium that features manipulation.

Before we turn to the next section, we wish to discuss some other possible interpretations of our basic set up related to the discussion in the introduction. One alternative way to interpret our model is to view the decision made at $t = 3$ as that of a lender on whether to lend money to the firm or not. In such a case, a decline in the price of the firm's share might indicate bad information about the fundamentals of the firm and

[6]Since the speculator does not know the price he is going to get for an order he submits, his order in each round of trading does not depend on the price in this round.

convince the lender not to make the loan. This will further reduce the value of the firm. Under this interpretation, the feedback effect will be based on financial constraints, as is studied by Baker, Stein, and Wurgler (2003). Similarly, one can think of other ways to interpret the decision made in $t = 3$. For example, it can be thought of as a customer decision whether to buy the firm's product.

Another alternative way to interpret our model is to view the traded asset as a currency rather than a firm's share. The value of the currency may depend on various fundamentals such as political outlook, soundness of the local banking system etc. A foreign investor may learn from currency movements in the local economy about future fundamentals and respond by adjusting the amount of investment. Currency depreciation might reflect short selling by informed speculators. This will depress foreign investment levels, which will themselves affect the performance of the local economy and hence the value of the currency.

3. Manipulation in the One-Firm Model

When the firm manager does not receive an informative signal ($s_M = \varnothing$), she may use the information contained in stock prices to update her belief on the productivity. In this way prices may affect the manager's investment decision and the value of the firm. In this section, we show that this feedback effect provides scope for profitable manipulation by the speculator. Manipulation is defined here as trading in the absence of private information in order to affect agents' beliefs and make a positive expected profit.

A. Characterization of Equilibrium with Manipulation

Let us describe the proposed manipulation equilibrium. In this proposed equilibrium, the speculator buys after he gets a high signal ($s_T = h$) and sells after he gets a low signal ($s_T = l$); this is standard in models of trade with asymmetric information. The unique feature in our proposed equilibrium is that the speculator trades even if he has not received any information ($s_T = \varnothing$). In particular, in the first trading round, he sells in the absence of information with the aim of establishing an initial short position from which he can profit once he has driven down firm value through further short sales in the second round. In subsection 3.D we discuss in detail why manipulation through buy orders is not an optimal trading strategy in this setting. First round trades are therefore given by:

$$u_1(s_T = h) = 1,\ u_1(s_T \in \{\varnothing, l\}) = -1. \tag{3}$$

Thus, given the possible realizations of noise trading, in equilibrium, total first round order flows are 2, 0, or -2. The respective equilibrium prices are p^+, p^0, or p^-. We refer to these prices as the high, medium, and low prices, respectively. Each price reflects the expected value of the firm given the corresponding order flow. Importantly, the price level accounts for the effect of the price on the investment decision of the manager. This makes the formation of prices in our model more involved than in a model that does not have a feedback effect from prices to real variables. The values of p^+, p^0 and p^- are derived in the proof of Proposition 1 in the Appendix.

In the second round, the speculator continues to trade in the same direction as his date 1 trade only when the first round trade did not reveal his order ($Q_1 = 0$). In this case, an informed speculator trades again in order to gain more from his private information, which was not yet revealed; an uninformed speculator can profit by selling again in the second round and driving down the price and the real value of the asset. If the speculator's first round trade was revealed by total order flow in the first round ($Q_1 \in \{-2, 2\}$), he cannot profit by trading again. This yields the following second round trades:

$$u_2(s_T, p^0) = u_1(s_T),\ u_2(s_T, p_1 \in \{p^-, p^+\}) = 0. \tag{4}$$

In case the price in the first round reveals the speculator's order, the total equilibrium order flows in the second round ($Q_2 \in \{-1, 1\}$) reveal no new information. Thus, the second round price remains p^+ (p^-), when the first round price is p^+ (p^-). When the price in the first round is not revealing, the second round price can be high, low or intermediate. Specifically, it will be p^+ when $Q_2 = 2$, p^- when $Q_2 = -2$, and $p^{0,0}$ when $Q_2 = 0$. Note that the intermediate price in the second round $p^{0,0}$ is different than the one in the first round p^0. These values are derived in the proof of Proposition 1.

To conclude the description of the proposed equilibrium, we need to specify the investment decision of the manager. It is given as follows:

$$
\begin{aligned}
g(s_M &= h, p_1, p_2) = K, \\
g(s_M &= l, p_1, p_2) = 0, \\
g(s_M &= \varnothing, p_1, p_2 \in \{p^{0,0}, p^{+}\}) = K, \\
g(s_M &= \varnothing, p_1, p_2 = p^{-}) = 0.
\end{aligned} \tag{5}
$$

The manager's investment decision is contingent on her own signal realization $s_M \in \{l, h, \varnothing\}$ and on the observed market prices. It is clear that if the manager receives an informative signal $s_M \in \{l, h\}$, she will ignore prices. In this case, she will invest after receiving a high signal and will not invest after receiving a low signal. If, on the other hand, she does not receive an informative signal, she will base her decision on the price. In this case, she will invest as long as the price is not low (p^{-}). The fact that the manager may not wish to invest after observing a low price is crucial for the existence of our proposed equilibrium. This generates the reduction in firm value that enables the uninformed speculator to make a profit on his short position.

Proposition 1 establishes the conditions under which our proposed equilibrium exists. The first two conditions are necessary for manipulation to be overall profitable, while the third one is necessary for the equilibrium strategies in the second round to be optimal. The proof (see Appendix) derives the equilibrium prices, specifies off-equilibrium beliefs and prices, and demonstrates that the equilibrium strategies are indeed optimal.

Proposition 1 *Suppose the following conditions hold:*

$$
\beta < \frac{2-\alpha}{5-\alpha} \tag{6}
$$

$$
\alpha > \frac{\theta_h + \theta_l - 2c}{\theta_h - c}, \tag{7}
$$

and

$$
\frac{2-\alpha-2\beta}{2-\alpha}\left(\theta_h - c\right) + \left(1-\beta\right)\left(\theta_l - c\right) > 0. \tag{8}
$$

Then there exists an equilibrium that features manipulation. In this equilibrium, the speculator's trading strategy is given by (3) and (4) and the firm manager's investment strategy is given by (5).

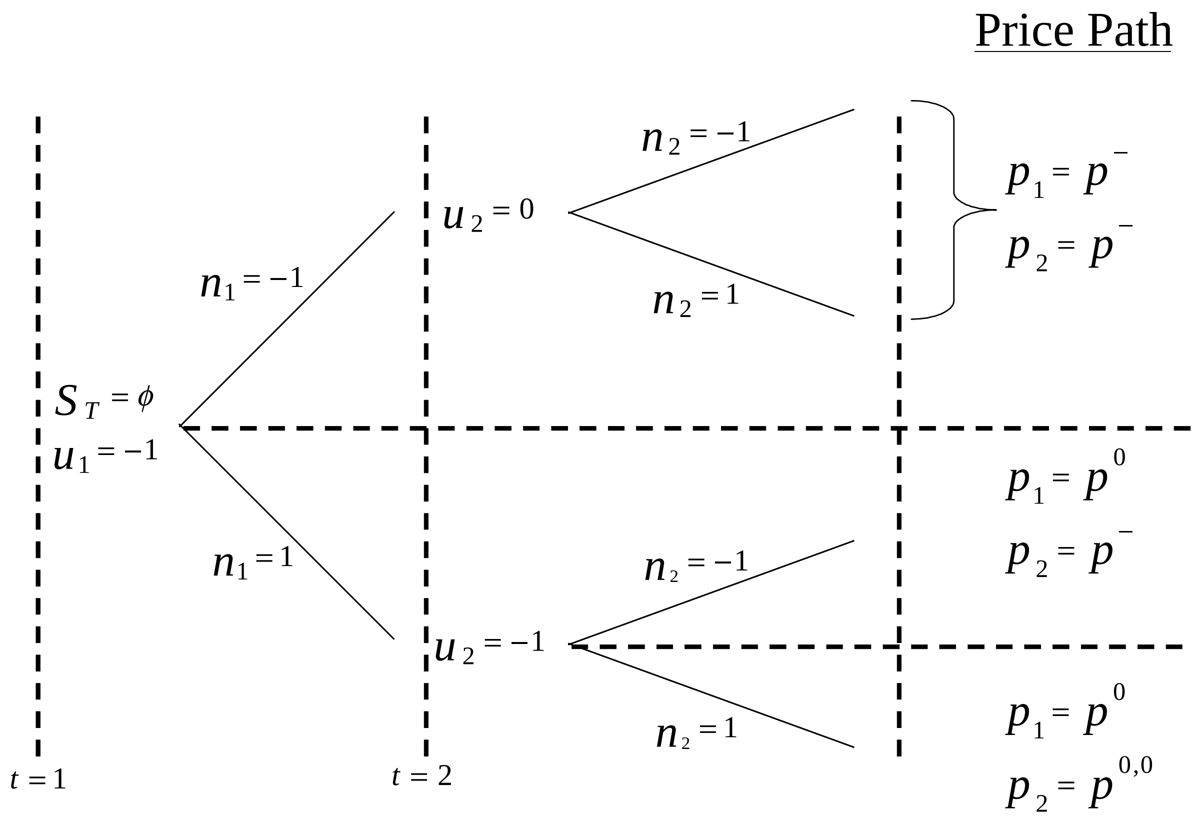

Figure 2: Prices under Manipulative Trading

B. The Profitability of Manipulation

We now explore the profitability of manipulation in more detail. An uninformed speculator who follows the strategy in (3) and (4) faces three possible price paths, which are summarized in Figure 2.

With probability $\frac{1}{2}$, the speculator's sell order is revealed in the first round ($Q_1 = -2$). In this case the speculator does not trade again in the second round and the price in both rounds is p^-. The speculator's expected payoff along this path is negative and is given by:

$$p^- - E\left(V \left| s_T = \varnothing, p_2 = p^- \right.\right). \tag{9}$$

This loss results from the standard disadvantage of trading in the absence of private information. The speculator's sell order moves down the price, reflecting the likelihood that the sell order was driven by bad news. Given that the speculator in fact had no bad news the expected value of the firm from his perspective is higher than its price. In expectation he therefore closes out the short position at a loss.

With probability $\frac{1}{4}$, the order flow of the speculator is revealed only in the second round ($Q_1 = 0$, $Q_2 = -2$). In this case, half of his short position is established at an intermediate price p^0 and the other half is established at the low price p^-. This yields the following net payoff:

$$p^0 + p^- - 2E\left(V \left| s_T = \varnothing, p_2 = p^-\right.\right) \tag{10}$$

Here, the speculator loses on his trade in the second round since the price p^- is lower than the expected value of the firm. However, he makes a profit on his first round trade: the price p^0 is higher than the expected value of the firm, which follows a low price in the second round. This profit results from the manipulative effect that the speculator has on the price and on the investment decision of the manager. When the manager observes a low price in the second round of trade and does not have private information on the level of productivity, she will not undertake the investment. Given that the speculator did not observe any signal on the fundamentals of the firm, the manager takes the wrong decision, and as a result the expected value of the firm decreases. This enables the speculator to profit on his initial short position.

Finally, with probability $\frac{1}{4}$, the order flow of the speculator is not revealed in either of the two rounds ($Q_1 = 0$, $Q_2 = 0$). In this case, the price in both rounds is intermediate: $p_1 = p^0$, $p_2 = p^{0,0}$ and the net payoff is given by:

$$p^0 + p^{0,0} - 2E\left(V \left| s_T = \varnothing, p_2 = p^{0,0}\right.\right) = p^0 - p^{0,0}. \tag{11}$$

Since $p^0 > p^{0,0}$, this net payoff is positive. To see why $p^0 > p^{0,0}$, note that the price p^0 in the first round of trade reflects the possibility that future prices will reveal private information and therefore improve resource allocation. If second round prices end up not revealing private information ($p_2 = p^{0,0}$), it is known that resource allocation will not be improved by prices and the expected firm value becomes lower than p^0.

Overall, there are two sources of profit for the uninformed speculator, both of which result from manipulation of beliefs related to the allocational role of prices. The first source of profit, reflected in (10), is the manipulation of the manager's belief that the investment is not worth undertaking. This is the source we wish to emphasize in this paper. The second source, captured by (11), is the manipulation of the market maker's belief that the second-round price may reveal information on the fundamentals and improve resource allocation. Interestingly, these two sources of profits rely crucially on the existence of more than one round of trade. To see why, consider a model with one round of trade, and assume that an uninformed trader submits a sell order. If his order is revealed, he gets a price p^- for an asset with an expected value of $E(V|s_T = \varnothing, p = p^-)$, and thus loses in expectation. Without a second round of trade, he cannot make a profit by establishing a short position at a relatively high price and then driving down the price and the firm's value. If he is not revealed, he gets a price $p^{0,0}$ for an asset with an expected value of $E(V|s_T = \varnothing, p = p^{0,0})$, and makes zero profit in expectation. Without a second opportunity to trade, he cannot make a profit by misleading the market maker to believe that future prices may reveal information and improve resource allocation, simply because there are no future prices.

Summing up all the possible gains and losses, and multiplying by the probabilities, we get that the uninformed speculator will find it profitable to follow the manipulative strategy when condition (6) in Proposition 1 holds. If this condition does not hold, the manager observes information with a high probability, and the speculator becomes unable to profit from manipulating the price. In this case, the allocational role of the price becomes less important, and the scope for manipulation decreases. Interestingly, according to this condition, when α increases, the speculator will be able to profit from manipulation under a lower range of values of β. The intuition is that when α is higher, the cost of manipulation increases, as the market maker expects that order flows will contain more information, and thus makes the price more sensitive to them. However, recall that in order to be able to manipulate the manager's beliefs, α must be above $\frac{\theta_h+\theta_l-2c}{\theta_h-c}$ (condition (7)). If this condition does not hold, the price has no allocational role, and an uninformed speculator cannot make a positive expected profit from trading. Thus, profitable manipulation will occur when α (which is a measure for the access of the speculator to information) is high enough but not too high, and when β (which is a measure for the access of the manager to information) is not too high. The two conditions are illustrated in Figure 3.[7]

Other interesting implications for the profitability of manipulation can be revealed by

[7] Note that Proposition 1 specifies another condition, but this condition is only important for the time consistency of the manipulation strategy and not for its overall profitability

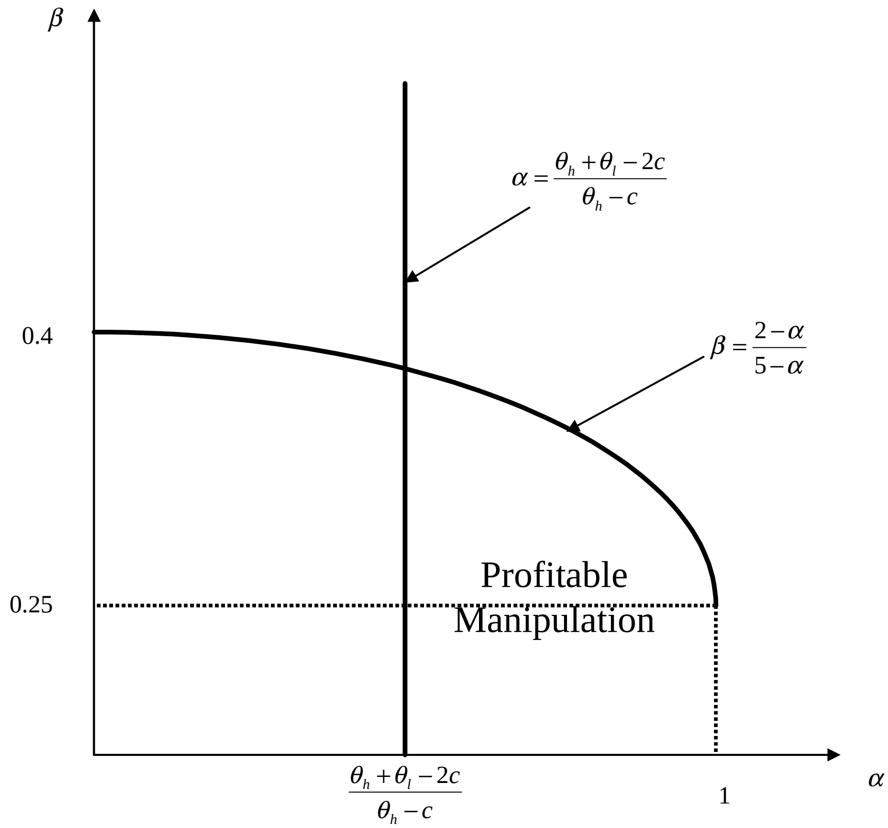

Figure 3: Profitable Manipulation

rewriting (7) in the following form:

$$\alpha > 2\frac{AVE}{AVE + VAR},$$

where $AVE \equiv \frac{\theta_h+\theta_l}{2} - c$ is the expected return on the investment project based on prior information, and $VAR \equiv \frac{\theta_h-\theta_l}{2}$ is a measure for the variability of the return. Using this new formulation, we can see that profitable manipulation becomes more likely when the expected return on the investment is lower (since then the project is less promising and thus the manager is more likely to abandon it after a low price), and when the variability of the return is higher (since then the manager can lose more by pursuing the project in the bad state of the world, and is thus more likely to learn from a low price).

C. Formation of Beliefs Off the Equilibrium Path

In equilibrium the trading strategy described by (3) and (4) is optimal given the beliefs of the market maker and the manager of the firm. To establish the result, the proof must specify beliefs off the equilibrium path. This warrants some discussion.

When $Q_1 = 0$, in equilibrium, the speculator will trade at time $t = 2$ (implying that $Q_2 \in \{-2, 0, 2\}$). In case the speculator does not trade, that is $Q_2 \in \{-1, 1\}$, we assume that the market maker and the manager believe that the speculator has no information regarding the fundamentals of the firm ($s_T = \emptyset$). This is because the uninformed speculator gains the least from trading again. The price and investment decision of the manager will be determined accordingly.

When $Q_1 = -2$, the speculator will not trade in equilibrium at time $t = 2$ (implying that $Q_2 \in \{-1, 1\}$). If he does, the market maker and the manager will believe that he has a low signal ($s_T = l$), unless the total order flow reveals that he bought, in which case the belief will be that he has a high signal ($s_T = h$). The reason for this updating rule is that the uninformed trader loses the most by trading after his order was revealed in the first round. Thus, given that the speculator sold in the first round, a trade by him in the second round suggests that he has a low signal, unless his order is clearly a buy order, in which case the updated belief is that he has a high signal. Similarly, In case $Q_1 = 2$, if $Q_2 \notin \{-1, 1\}$, the belief will be that the speculator has a high signal, unless the total order flow reveals that he sold, in which case the belief will be that he has a low signal.

Finally, in equilibrium, the total order flow in $t = 1$ is -2, 0, or 2. This is because the speculator always trades. If he does not ($Q_1 \in \{-1, 1\}$), the belief will be that he does not have private information regarding the fundamentals of the firm. The reason is that an uninformed speculator gains less than an informed speculator from trading.

D. Sell Side vs. Buy Side Manipulation

When a speculator trades in the absence of information he tends to distort resource allocation. In our paper the distortion takes the form of underinvestment due to short sales: following the realization of a low price, the firm does not invest when it would be profitable to do so. It would be easy to model the distortion in the form of overinvestment due to buy side manipulation. Suppose, for example, that no investment were to occur in the absence of any information over future productivity $\left(\frac{\theta_h+\theta_l}{2} < c\right)$. Then, a speculator without information could buy shares, drive up the stock price and get the firm to invest when in fact it should not, given the available information.

Such a trading strategy would be feasible, but not profitable. This is because manipulation tends to reduce firm value whether it leads to overinvestment or to underinvestment. The only way an uninformed speculator can profit from his effect on firm value is by holding a short position in the stock. Thus, our model suggests that there is an asymmetry between buy side and sell side speculation: manipulation of prices via reduction of firms' values can occur only with short sales. This raises interesting questions regarding the implications for short sales regulation. On the one hand, such regulation may prevent value destroying manipulation. On the other hand limiting short sales carries the cost of reducing the allocational role of prices when information is negative. We come back to this issue in Section 5.

An empirical implication of this analysis is that manipulation should be closely associated with the amount of short interest outstanding. We would expect manipulation to be a problem when feedback from price to value is important. In practice this should be the case when firms face new investment projects and stock price changes affect their decision to undertake the investment. Firms that announce their intent to raise significant amounts of capital are likely to be affected by such feedback. We would therefore expect firms that announce a significant capital increase to have a higher amount of short interest than firms that do not (or the same firms at other points in time).

4. Manipulation with Two Firms and Positive Externalities

In this section, we study a model with two firms that exhibit positive externalities. The existence of positive externalities changes the role of prices and thus the implications of manipulation in a fundamental way.

A. Positive Externalities

Firms may exhibit positive externalities due to spillovers in the demand side or due to technological spillovers. Spillovers in the demand side will exist if the firms produce complementary goods. For example, if Firm A develops computer hardware and Firm B develops computer software, the demand for Firm B's products will increase with the use of Firm A's products, and vice versa. As a result, when one firm produces more, the other firm will have a greater incentive to invest in new products. Technological spillovers can be a result of learning or of the need to establish infrastructure. Positive spillovers of this kind have been identified as an important factor in macroeconomics (see, e.g., Matsuyama (1991)). These spillovers are particularly important in emerging markets, and thus make our model even more relevant to the analysis of currency attacks in such markets.

Although we describe the model in the context of two firms with production externalities, it could also be formulated in the context of strategic complementarities between several agents associated with one firm. For example, strategic complementarities can exist between customers of a firm that develops products with network externalities. In such a case, manipulation can affect the decision of the customers on whether to use the product or not. This scenario can be relevant for internet companies or telecommunication companies. Subrahmanyam and Titman (2001) discuss the importance of such externalities for the feedback from stock prices to real firm value. Complementarities can also exist between workers - the benefit from working with the firm for a skilled worker increases with the number of skilled workers who work with the firm - or between suppliers.

B. The Model With Externalities

Suppose there are now two firms indexed by $i \in \{A, B\}$ that display a production externality. Each is controlled by a different manager. The managers take investment decisions simultaneously in $t = 3$. The value of production of firm i depends linearly upon the investment decision of firm j:

$$V_i = (\theta_\omega + \gamma I_j - c) I_i. \tag{12}$$

Here, $\gamma > 0$ measures the degree of externalities between the two firms. Note that from linearity and risk neutrality it follows that optimal investment levels are again a corner solution $I^* \in \{0, K\}$.

As before, trade in the financial market occurs at $t = 1$ and $t = 2$. The traded security is a claim on the combined payoff of both firms. This security can represent: a currency, the value of which depends on the value of several firms, a stock market index, or a share in a conglomerate with several divisions. Alternatively, we could assume that two separate claims on each firm are traded, but noise trade is perfectly correlated between the two assets. For example, this could be because noise traders hedge against exposure to the shock θ_ω. Given that both firms are subject to the same fundamental uncertainty, hedging demand and therefore noise trade should be the same. Finally, under additional restrictions, the model's predictions are robust even if noise trading is allowed to differ between the two traded securities. However, the analysis would be considerably more cumbersome because equilibrium trading strategies and investment would be contingent on a larger set of observable prices.

As before, there are three types of traders in the financial market: a speculator, a noise trader, and a market maker with identical characteristics as in Section 3. Again, the parameter θ_ω is unknown and may equal either θ_h or θ_l with probability $\frac{1}{2}$. At date $t = 0$, the speculator and each of the two managers may receive a perfectly informative signal regarding the future realization of ω. The probability of an informative signal is α for the speculator and β for each manager. The event of receiving a signal is independent across agents, and each agent does not know whether other agents observed a signal or not. We assume that the two managers cannot communicate with each other, and are therefore unable to coordinate their investment decisions.

As for the value of investment, we assume that even if the productivity level is high, a firm finds it optimal to invest only if the other firm does the same, i.e.

$$\begin{aligned} \theta_h + \gamma K - c &> 0, \\ \theta_h - c &< 0. \end{aligned} \tag{13}$$

Moreover, we assume that it is never worthwhile investing when productivity is low:

$$\theta_l + \gamma K - c < 0 \tag{14}$$

The definition of equilibrium in this model is similar to the definition in Section 2, except that each manager now has to take into account the strategy of the other manager when maximizing the expected value of her firm. Thus, we have a subgame played between the managers in $t = 3$ after the two rounds of trade. Because of strategic complementarities, this subgame sometimes has multiple equilibria. In the following, we will assume that the managers always play the Pareto-dominant equilibrium in the subgame between them. In our model, this is the equilibrium that features most investment. The equilibrium of the subgame will be part of the equilibrium of the model.

C. Characterization of Equilibrium with Manipulation

When firms display positive externalities there is a manipulation equilibrium in which the speculator's trading strategy is essentially identical to the one described in Section 3. It can therefore be described by (3) and (4), although differences in model specification will cause equilibrium prices to be different (see proof of Proposition 2 for actual values). As in the previous case, we therefore find that the equilibrium price in each round can be high, medium, or low, depending on total order flows. In this section, we add a superscript C to the prices in order to denote the case of complementarities. Thus, first round prices will be $p^{C,+}$, $p^{C,0}$, or $p^{C,-}$; and second round prices will be $p^{C,+}$, $p^{C,0,0}$, or $p^{C,-}$.

Proposition 2 establishes conditions for the existence of an equilibrium with manipulation.

Proposition 2 *Suppose the following conditions hold:*

$$\frac{(1-\alpha)\,\theta_h + \theta_l}{2-\alpha} + \left(1 - \frac{\beta}{2-\alpha}\right)\gamma K - c < 0, \tag{15}$$

$$\theta_h + \beta\gamma K - c < 0, \tag{16}$$

and

$$\frac{\theta_h + \theta_l}{2} + \left(1 - \frac{\beta}{2}\right)\gamma K - c > 0. \tag{17}$$

Then there exists an equilibrium that features manipulation where the trading strategy is given by (3) and (4), and the investment strategy is given by

$$\begin{aligned} g_i(s_M^i &= l, p_1^C, p_2^C) = 0 \\ g_i(s_M^i &\in \{\varnothing, h\}, p_1^C, p^{C,-}) = 0 \\ g_i(s_M^i &\in \{\varnothing, h\}, p_1^C, p^{C,0,0}) = K \\ g_i(s_M^i &\in \{\varnothing, h\}, p_1^C, p^{C,+}) = K. \end{aligned} \tag{18}$$

According to (18), in this equilibrium, each manager invests unless she receives a low signal or observes a low price. Conditions (15), (16), and (17) ensure that (18) is part of a Pareto dominant equilibrium in the investment subgame. Condition (15) states that in equilibrium, a manager will never invest after getting no private information ($s_M^i = \varnothing$) and observing a low price ($p^{C,-}$). This is because a low price is indicative of low fundamentals and increases the posterior probability that the other manager will not invest due to bad private information. Condition (16) states that it cannot be an optimal action for a manager to invest when the price is low ($p^{C,-}$), even though she knows that the state is high ($s_M^i = h$), given that condition (15) holds. This is the case because the likelihood that the other manager has no signal and therefore follows the low price (condition (15)) spoils the profitability of going ahead with the investment, even though one manager has a good signal.[8] Condition (17) implies that a manager invests in the absence of information and at a 'medium' price ($p^{C,0,0}$). This corresponds to condition (2) in the one firm case.

The crucial feature in the two firms case that did not exist in the one firm case is the lack of investment when the price is low but the private signal is high. To put differently, a speculator, who trades without information and drives down the price, can

[8] When these conditions hold, no other parameter restriction (such as condition (6) in Section 3) is required to ensure that manipulation is profitable. The fact that managers never invest after a low price mitigates the possible loss from manipulation and thus, manipulation is always profitable, even for high values of β.

cause managers not to invest even when they get high private signals. The reason for this result is that when there are complementarities, both managers look at the price in order to learn not only about the underlying fundamental but also about the other manager's likely behavior. This implies that a manager might optimally choose to ignore the perfectly informative high signal knowing that the other manager observed the low price. This has important implications for the efficiency of investment decisions. These implications are discussed in the next section.

5. Manipulation and Investment Efficiency

A. The Effect of Manipulation on Firm Value

Manipulation has a negative effect on the expected value of firms since it leads managers to make inefficient investment decisions. This effect can be quite large. To see this, consider again the model with one firm. The ex-ante expected value of the firm under the equilibrium developed in Section 3 is:

$$V_M = \frac{1}{8}\left(3\beta + 1 + 3\alpha - 3\alpha\beta\right)\left(\theta_h - c\right)K + \frac{1}{8}\left(1-\beta\right)\left(\theta_l - c\right)K. \tag{19}$$

On the other hand, had the speculator traded only when he had information on the fundamentals of the firm, that is, had he not attempted to manipulate the price, the ex-ante expected value of the firm would have been:

$$V_{NM} = \frac{1}{2}\left(\theta_h - c\right)K + \frac{1}{8}\left(1-\beta\right)\left(4 - 3\alpha\right)\left(\theta_l - c\right)K. \tag{20}$$

From (2), we know that $V_M < V_{NM}$. The expected reduction in value due to manipulation as a percentage of the expected value without manipulation can then be calculated as: $\frac{V_{NM}-V_M}{V_{NM}}$. Figure 4 demonstrates this proportional reduction in expected value as a function of β. The other parameters in this figure were set as follows: $\theta_h = 10$, $\theta_l = 4.5$, $c = 7$, $K = 1$, $\alpha = 0.2$.

As the graph shows, the reduction in expected value that is caused by manipulation can be significant in magnitude. In the graph, manipulation destroys 35% of expected value for low levels of β. Clearly, as β increases, manipulation causes less damage, but even then and even when β is larger than α, manipulation destroys a significant portion of value (16% for $\beta = 0.25$). Note that this example is not an extreme one; similar magnitudes have

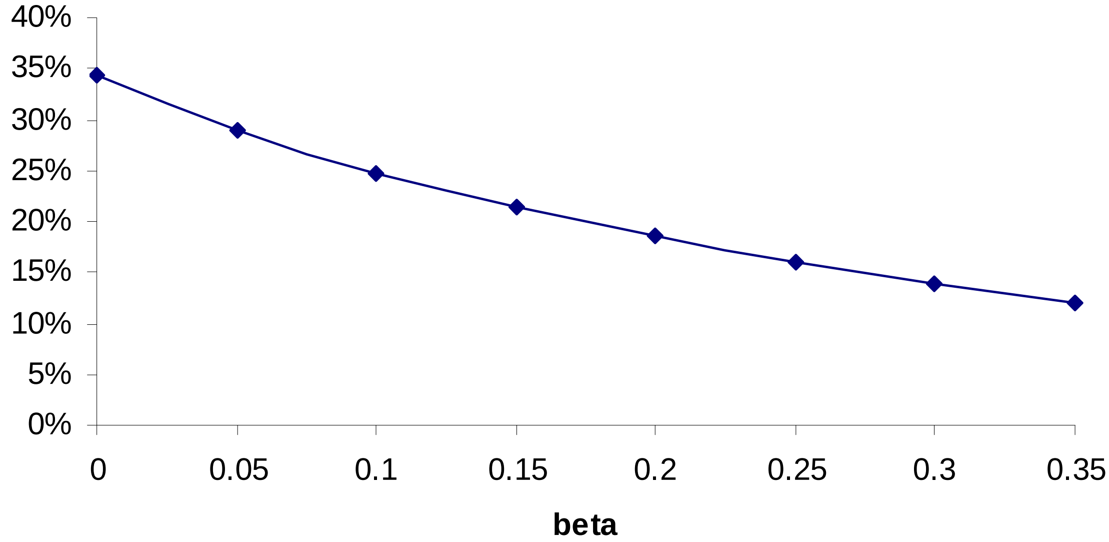

Figure 4: Proportional Reduction in Value Due to Manipulation

been obtained for other parameter values. Importantly, these magnitudes are calculated without conditioning on any event. If we condition, for example, on the event in which the speculator received no information on the fundamentals, the effect of manipulation on expected value will be much larger. In such a case manipulation can destroy almost 100% of firm value when β is small.

The obvious conclusion is that manipulation is an undesirable feature of financial markets since it reduces investment efficiency. The problem is that when financial markets exist, it might be difficult to prevent manipulation, as we show in Section 6. This opens up the possibility that investment efficiency may increase in the absence of financial markets.

B. Financial Markets and Investment Efficiency

Financial markets in our model may improve the efficiency of investment decisions since they provide information to managers. On the other hand, as we discussed above, financial markets provide scope for manipulation, which misleads managers and causes them to make inefficient investment decisions from time to time. In this subsection, we analyze whether financial markets improve the overall efficiency of investment decisions.

It is important to note that our analysis does not cover all roles of financial markets.

For example, one of the central roles of financial markets that is absent from our model is to channel funds from savers to investors, providing the former with opportunities to diversify risk and retain liquidity while the latter gain access to funds needed to carry out investment projects. The scope for welfare analysis in this paper is therefore clearly limited. Our goal is to focus on the role of financial markets in providing information and guiding managers in making efficient investment decisions, and explore whether, given the possibility of manipulation, markets indeed improve investment efficiency or not.

We assess investment efficiency by comparing expected firm values when there is a financial market to the ones when there is none. We start with the one firm scenario.

Proposition 3 *In the one-firm model, the existence of a market for the firm's equity never reduces the ex-ante efficiency of investment.*

The intuition behind this result is simple. The firm manager uses prices to learn about productivity and thus take a better investment decision. If a market were to be harmful, this would imply that it is preferable not to follow the price signals, because more often than not they lead to the wrong investment decision. However, a firm manager can always choose to ignore the price signal. If the level of manipulation in a market was so high as to render the price signal harmful in expectation, the manager would optimally choose to ignore prices. A market can in this case at worst be useless, but never harmful.

When there are two firms with production externalities (the model of Section 4), the analysis of the impact of financial markets on investment efficiency is complicated by the fact that the investment subgame displays multiple equilibria. In order to make meaningful comparisons between the scenarios with and without financial markets, we need to be careful in specifying the equilibrium that is played by managers in this subgame. In the following, we therefore stick to the assumption made in Section 4, i.e., we assume that in each regime the equilibrium played by the managers in the investment subgame is the Pareto-dominant equilibrium.

We also assume that conditions (14), (15), (16) and (17) hold, so that if a market exists, and the speculator engages in a manipulative strategy, the Pareto-dominant equilibrium between managers is the one described in (18). If a market does not exist, in the Pareto-dominant equilibrium, managers always invest unless they observe a bad signal. This is a direct result of (17).

Proposition 4 *In the two-firm model with production externalities, the existence of a financial market reduces the ex ante efficiency of investment for a non empty set of parameter values.*

With two firms and production externalities, a financial market can reduce the ex-ante efficiency of investment decisions, because manipulation can cause valuable information to be ignored. As shown in Section 4, a manager who observes a high private signal and a low price will not invest even though her private signal provides more accurate information about the fundamentals than does the price. The manager does not invest simply because she knows the other manager also observed the low price, and therefore will not invest.

So why do managers not simply ignore the public signal when they know that it reduces overall investment efficiency? Doing so is simply not optimal from the perspective of each individual manager. A manager who has not received a private signal always finds it beneficial to look at the price and learn about the fundamentals (under the conditions discussed in Section 4). Then, even a manager with an informative private signal will look at the price knowing that the other manager does too. Thus, learning from prices is not socially optimal, but must occur in equilibrium as long as managers cannot commit to ignore the price signal when they are privately uninformed. This result is related to Morris and Shin (2002), who show that in the presence of strategic complementarities, agents may ignore their private signals and follow a public signal, even though it is less accurate. A noisy public signal can then lead to a Pareto inferior outcome. Our paper adds to these results by endogenizing the production of the public signal through price formation in a financial market and by showing that this can generate excess noise in the public signal as a result of manipulation.

As derived in the proof of Proposition 4, the condition under which financial markets reduce the ex-ante efficiency of investment decisions is

$$\gamma > -\frac{(\theta_h - c)(1-\alpha) + (\theta_l - c)(1-\beta)}{K\left((1-\alpha) + (1-\beta)^2\right)}.$$

When α is high and the speculator has more frequent access to information on fundamentals, a financial market can contribute more to the efficiency of investment decisions. In this case, manipulation occurs with a smaller probability and the financial market transfers useful information more often. Therefore, an increase in α reduces the size of the parameter set under which a financial market reduces the ex-ante efficiency of investment. An increase in β on the other hand generates a larger range of parameters for which a financial market reduces investment efficiency. When β is higher, managers have more frequent access to information and the price signal becomes less important in transmitting information. A financial market is therefore less effective in improving resource allocation. Finally, when γ is higher, the externalities between the two firms are greater, and the negative effect of manipulation - preventing investments when the level of productivity is high - becomes more important.

Interestingly, the effect of financial markets on the ex-ante efficiency of investments can be significant in magnitude. Consider the following example: $\theta_h = 10$, $\theta_l = 7$, $c = 16$, $k = 1.012$, $\gamma = 7.9$, $\alpha = 0.1$, and $\beta = 0.1$. In this example, the existence of a financial market reduces the ex-ante value of firms by 35%. Again, similar magnitudes have been observed for other parameter values.

Our results in this section have interesting policy implications. In the context of currency markets, when financial markets reduce the ex-ante efficiency of investment decisions, governments may want to consider the possibility of intervention in order to deter manipulation, or to reduce the information contained in prices. This may be achieved, for example, by fixing the exchange rate. Another interesting policy implication that can apply to financial markets in general is related to short sales regulations. Since manipulation occurs in our model via short sales, it may be beneficial to restrict them.[9] A full analysis of such policy responses is left for future research.

6. Discussion

In this section we discuss issues related to the robustness and strength of the manipulation result in this paper. In particular we explore the effect of an additional strategic trader in the market, and we consider the possibility of other non-manipulative equilibria.

[9] Note that in a model where managers do not choose the Pareto efficient investment level, buy-side manipulation may be possible. Manipulation may then increase expected firm value by using the price to coordinate managers on a higher (and Pareto efficient) investment level. Thus, such manipulation is not harmful. As a result, our conclusion that only sell orders (and not buy orders) might be harmful is not altered if such manipulation is considered.

A. Additional Strategic Traders

Throughout the paper we assume that there is only one strategic trader in the financial market. Since this speculator makes a profit from trade even when he fails to get an informative signal, one may expect that any other uninformed strategic trader could do the same. This might interfere with the equilibrium discussed in this paper by reducing the expected profits of the original speculator. In this subsection we extend the model to include an additional strategic trader who is never informed about fundamentals and show that he cannot profit from trade. The equilibrium discussed in the paper is therefore robust to the introduction of additional uninformed strategic traders. The key reason for the result is that while an uninformed trader may profit from manipulation, he loses when trading against an informed speculator. This is unavoidable since he does not know when the speculator is informed. It turns out that the uninformed trader cannot make a profit in expectation.

We demonstrate this point using the two-firm model analyzed in Section 4. Suppose that a strategic uninformed trader tries to mimic the manipulative strategy of the potentially informed trader by selling in the first round, and then selling again in the second round, when the order of the potentially informed trader was not revealed in the first round (i.e., he trades according to (3) and (4)).[10] The total order flow with this additional uninformed trader is then -3, -1, or 1. These total order flows are off the equilibrium path. Assume that when the market maker observes such an order flow, he believes the deviation occurred because the additional uninformed trader submitted a sell order. Thus, the prices corresponding to order flows of -3, -1, or 1 off the equilibrium path will be equal to the prices corresponding to order flows of -2, 0, or 2, respectively, on the equilibrium path described in Section 4. In other words, the additional uninformed trader's orders do not affect the price. He thus may profit from 'free riding' on the effect that the potentially informed trader has on prices and real value.

Proposition 5 states that the uninformed trader does not make a profit from mimicking the manipulative strategy of the potentially informed trader.

[10] From the discussion in previous sections, it is clear that the uninformed speculator does not have a better strategy to follow. For example, trading after information was revealed is not profitable, nor is buying without information.

Proposition 5 *Suppose a speculator who is never informed and who faces agents behaving according to the equilibrium in Proposition 2, trades according to (3) and (4). Then this speculator makes a zero profit in expectation.*

From Proposition 5, we can conclude that a small trading cost is sufficient to deter the uninformed trader from attempting to trade. Therefore, his presence does not affect the equilibrium with manipulation.

B. Other Equilibria

We have focused in this paper on a particular equilibrium and shown that it features manipulation. We now analyze the possibility of other equilibria in the model. We focus on the two-firm model and the corresponding equilibrium in Proposition 2.[11]

The two-firm model has at least one more equilibrium.[12] The analysis of this additional equilibrium, however, is not particularly interesting since it also features sell side manipulation, and thus generates the same main implications as the original equilibrium: trade by the uninformed speculator sometimes distorts managers' investment decisions by leading them not to invest when investment is desirable. Any other equilibrium that features sell side manipulation will also have this same feature. We cannot rule out the existence of other equilibria of this type.

We thus focus on a more crucial question: whether there is an equilibrium without sell side manipulation, (i) either through buy side manipulation or (ii) through no manipulation at all. As already discussed in Section 3, buy side manipulation cannot be profitable, because manipulation generates a reduction in firm value, from which the speculator can benefit only if he holds a short position.[13] An equilibrium without manipulation will be a case in which an uninformed speculator never trades. The following Proposition addresses

[11] We stick to the assumption that in the subgame between the managers, the Pareto dominant equilibrium is played. Given this assumption, we analyze the possibility of different equilibria in the financial market.

[12] In this equilibrium, the speculator's first round trade is identical to the previous equilibrium (i.e., (3)). However, the speculator now always trades in the second round in the same direction as he did in the first round.

[13] Since in our two-firm model, managers choose the Pareto efficient allocation given their information, the analysis in subsection 3.D can be applied directly to this case.

the possibility of existence of such an equilibrium.

Proposition 6 *Suppose conditions (15), (16), and (17) are satisfied. Then there is no equilibrium in which the uninformed speculator never trades.*

Hence, sell side manipulation is a robust feature of equilibrium.

7. Conclusions

This paper investigates the scope for profitable trading strategies that are not based on private information regarding firms' fundamentals. A speculator's ability to affect the real value of an asset by changing its price is identified as a mechanism that allows such manipulative trading to be profitable. Importantly, the model endogenizes (i) optimal trading strategies, (ii) price determination and (iii) the channel through which prices affect real asset value in a setting where all agents are fully rational. Moreover, we show that the problem of manipulation is exacerbated when the real sector consists of several decision makers with positive spillovers. Shutting down a financial market might in that case increase the ex-ante efficiency of investment decisions in the economy, even though prices may contain information that is useful for decision makers. The analysis thus provides a basis for a discussion of policy implications of manipulation for short sales regulation in stock markets. Similarly, future research may be able to further investigate optimal exchange rate policy in light of the possibility of manipulation in currency markets.

8. Appendix

Proof of Proposition 1. **Derivation of Equilibrium Prices:** The price p^+ reflects the expected value of the firm following an order flow of 2 along the equilibrium path. When such an order flow is observed, it is known that $s_T = h$, and that the manager, after observing the high price, will invest. Thus,

$$p^+ = (\theta_h - c)K.$$

The price p^- reflects the expected value of the firm following an order flow of -2 along the equilibrium path. When such an order flow is observed, the market maker does not know whether the speculator's sell order is driven by underlying information ($s_T = l$ with ex-ante probability $\alpha/2$) or by a desire to manipulate the price ($s_T = \varnothing$ with ex-ante probability $1-\alpha$). He updates his belief about the fundamentals using Bayes' rule:

$$E[\theta_\omega | Q = -2] = \frac{\theta_h(1-\alpha) + \theta_l}{2-\alpha}.$$

Using the assumption that α is sufficiently large, such that condition (7) in Proposition 1 holds, we get that after observing a low price, the manager will invest if and only if she receives a private signal $s_M = h$. Therefore,

$$p^- = \frac{1-\alpha}{2-\alpha}\beta(\theta_h - c)K.$$

The price $p^{0,0}$ reflects the expected value of the firm after the total order flows in both rounds were 0. In this case the updated productivity level is identical to the prior, meaning that the manager will invest K, unless she observed a low signal. Thus, $p^{0,0}$ is given by:

$$p^{0,0} = \frac{1}{2}\left(\theta_h - c + (1-\beta)(\theta_l - c)\right)K.$$

Finally, the price p^0 reflects the expected value of the firm after the total order flow in the first round of trade was 0. This price is calculated as a probability-weighted average of possible period-2 prices:

$$p^0 = \frac{\alpha}{4}p^+ + \frac{1}{2}p^{0,0} + \frac{1}{2}\left(1 - \frac{\alpha}{2}\right)p^-.$$

Optimal Strategies and Off-Equilibrium Prices: We now show that the speculator's strategy is optimal given the price setting behavior. This is shown using backward induction - starting from $t = 2$ and going back to $t = 1$. Throughout the proof we specify the market maker's and the manager's beliefs off the equilibrium path. The general rule used to determine off-equilibrium prices is describe in the text. We start by analyzing the optimal trading decision of the speculator at date $t = 2$ for each feasible order flow $Q_1 \in \{-2, -1, 0, 1, 2\}$. We use the notation $\Pi_2(s_T, Q_1, u_1, u_2)$ to denote the total expected profit (i.e., the profit from two rounds of trade) that the speculator makes for each date-2 order, given his signal, and the order flows at $t = 1$.

Suppose that $Q_1 = -2$: Equilibrium prices are: $p_2(Q_1 = -2, Q_2 \in \{-1, 1\}) = p^-$. Off-equilibrium prices are: $p_2(Q_1 = -2, Q_2 \in \{-2, 0\}) = 0$, and $p_2(Q_1 = -2,\ Q_2 = 2) = p^+$. Then, if the speculator observed $s_T = h$, his expected profits under the different strategies are: $\Pi_2(h,-2,-1,0) = p^- - \beta p^+$, $\Pi_2(h,-2,-1,-1) = p^- - 2\beta p^+$, and $\Pi_2(h,-2,-1,1) = p^- - \frac{1}{2}p^+$. Using (6), the speculator will choose $u_2 = 0$. If the speculator observed $s_T = l$, his expected profits under the different strategies are: $\Pi_2(l,-2,-1,0) = p^-$, $\Pi_2(l,-2,-1,-1) = p^-$, and $\Pi_2(l,-2,-1,1) = p^- - \frac{1}{2}p^+$. The speculator will choose $u_2 = 0$. If the speculator observed $s_T = \varnothing$, his expected profits under the different strategies are: $\Pi_2(\varnothing,-2,-1,0) = p^- - \frac{1}{2}\beta p^+$, $\Pi_2(\varnothing,-2,-1,-1) = p^- - \beta p^+$, and $\Pi_2(\varnothing,-2,-1,1) = p^- - \frac{1}{2}p^+$. The speculator will choose $u_2 = 0$.

Suppose that $Q_1 = 2$: Equilibrium prices are: $p_2(Q_1 = 2, Q_2 \in \{-1,1\}) = p^+$. Off-equilibrium prices are: $p_2(Q_1 = 2, Q_2 \in \{2,0\}) = p^+$, $p_2(Q_1 = 2, Q_2 = (-2)) = 0$. Then, if the speculator observed $s_T = h$, his expected profits under the different strategies are: $\Pi_2(h,2,1,0) = 0$, $\Pi_2(h,2,1,-1) = -\frac{1}{2}p^+$, and $\Pi_2(h,2,1,1) = 0$. The speculator will choose $u_2 = 0$. If the speculator observed $s_T = l$, his expected profits under the different strategies are: $\Pi_2(l,2,1,0) = -2p^+ + 2p^{0,0}$, $\Pi_2(l,2,1,-1) = -\frac{1}{2}p^+$, and $\Pi_2(l,2,1,1) = -4p^+ + 4p^{0,0}$. The speculator will choose $u_2 = -1$. If the speculator observed $s_T = \varnothing$, his expected profits under the different strategies are: $\Pi_2(\varnothing,2,1,0) = -p^+ + p^{0,0}$, $\Pi_2(\varnothing,2,1,-1) = -\frac{1}{2}p^+$, and $\Pi_2(\varnothing,2,1,1) = -2p^+ + 2p^{0,0}$. The speculator will choose $u_2 = -1$.

Suppose $Q_1 = 0$: Equilibrium prices are: $p_2(Q_1 = 0, Q_2 = -2) = p^-$, $p_2(Q_1 = 0, Q_2 = 2) = p^+$ and $p_2(Q_1 = 0, Q_2 = 0) = p^{0,0}$. Off-equilibrium prices are: $p_2(Q_1 = 0, Q_2 \in \{-1,1\}) = p^{0,0}$. When $Q_1 = 0$, either a buy or a sell order could have been submitted by the speculator at date $t = 1$. Consider first the case where $u_1 = -1$. If the speculator observed $s_T = h$, his expected profits under the different strategies are: $\Pi_2(h,0,-1,0) = p^0 - p^+$, $\Pi_2(h,0,-1,-1) = p^0 + \frac{1}{2}p^- + \frac{1}{2}p^{0,0} - (1+\beta)p^+$, and $\Pi_2(h,0,-1,1) = p^0 - \frac{1}{2}p^+ - \frac{1}{2}p^{0,0}$. The speculator will choose $u_2 = 1$. If the speculator observed $s_T = l$, his expected profits under the different strategies are: $\Pi_2(l,0,-1,0) = p^0 - 2p^{0,0} + p^+$, $\Pi_2(l,0,-1,-1) = p^0 + \frac{1}{2}p^- - 1\frac{1}{2}p^{0,0} + p^+$, and $\Pi_2(l,0,-1,1) = p^0 - \frac{1}{2}p^+ - \frac{1}{2}p^{0,0}$. The speculator will choose $u_2 = -1$. If the speculator observed $s_T = \varnothing$, his expected profits under the different strategies are: $\Pi_2(\varnothing,0,-1,0) = p^0 - p^{0,0}$, $\Pi_2(\varnothing,0,-1,-1) = p^0 + \frac{1}{2}p^- - \frac{1}{2}p^{0,0} - \frac{1}{2}\beta p^+$, and $\Pi_2(\varnothing,0,-1,1) = p^0 - \frac{1}{2}p^+ - \frac{1}{2}p^{0,0}$. Using (8), we get that the speculator will choose $u_2 = -1$.

Now, consider the case $u_1 = 1$. If the speculator observed $s_T = h$, his expected profits under the different strategies are: $\Pi_2(h,0,1,0) = -p^0 + p^+$, $\Pi_2(h,0,1,-1) =$

$-p^0 + \frac{1}{2}p^- + \frac{1}{2}p^{0,0}$, and $\Pi_2(h,0,1,1) = -p^0 + 1\frac{1}{2}p^+ - \frac{1}{2}p^{0,0}$. The speculator will choose $u_2 = 1$. If the speculator observed $s_T = l$, his expected profits under the different strategies are: $\Pi_2(l,0,1,0) = -p^0 - p^+ + 2p^{0,0}$, $\Pi_2(l,0,1,-1) = -p^0 + \frac{1}{2}p^- + \frac{1}{2}p^{0,0}$, and $\Pi_2(l,0,1,1) = -p^0 - 2\frac{1}{2}p^+ + 3\frac{1}{2}p^{0,0}$. The speculator will choose $u_2 = -1$. If the speculator observed $s_T = \varnothing$, his expected profits under the different strategies are: $\Pi_2(\varnothing,0,1,0) = -p^0 + p^{0,0}$, $\Pi_2(\varnothing,0,1,-1) = -p^0 + \frac{1}{2}p^- + \frac{1}{2}p^{0,0}$, and $\Pi_2(\varnothing,0,1,1) = -p^0 - \frac{1}{2}p^+ + 1\frac{1}{2}p^{0,0}$. The speculator will choose $u_2 = 0$.

Suppose $Q_1 \in \{-1,1\}$: Off-equilibrium prices are $p_2(Q_1 \in \{-1,1\}, Q_2 \in \{-1,1\}) = p^{0,0}$, $p_2(Q_1 \in \{-1,1\}, Q_2 = 2) = p^+$, $p_2(Q_1 \in \{-1,1\}, Q_2 = -2) = p^-$, $p_2(Q_1 \in \{-1,1\}, Q_2 = 0) = p^{0,0}$. Then, if the speculator observed $s_T = h$, his expected profits under the different strategies are: $\Pi_2(h, Q_1 \in \{-1,1\}, 0, 0) = 0$, $\Pi_2(h, Q_1 \in \{-1,1\}, 0, -1) = \frac{1}{2}p^{0,0} - \frac{1}{2}(1+\beta)p^+ + \frac{1}{2}p^-$, and $\Pi_2(h, Q_1 \in \{-1,1\}, 0, 1) = -\frac{1}{2}p^{0,0} + \frac{1}{2}p^+$. The speculator will choose $u_2 = 1$. If the speculator observed $s_T = l$, his expected profits under the different strategies are: $\Pi_2(l, Q_1 \in \{-1,1\}, 0, 0) = 0$, $\Pi_2(l, Q_1 \in \{-1,1\}, 0, -1) = -\frac{1}{2}p^{0,0} + \frac{1}{2}p^+ + \frac{1}{2}p^-$, and $\Pi_2(l, Q_1 \in \{-1,1\}, 0, 1) = 1\frac{1}{2}p^{0,0} - 1\frac{1}{2}p^+$. The speculator will choose $u_2 = -1$. If the speculator observed $s_T = \varnothing$, his expected profits under the different strategies are: $\Pi_2(\varnothing, Q_1 \in \{-1,1\}, 0, 0) = 0$, $\Pi_2(\varnothing, Q_1 \in \{-1,1\}, 0, -1) = -\frac{1}{4}\beta p^+ + \frac{1}{2}p^-$, and $\Pi_2(\varnothing, Q_1 \in \{-1,1\}, 0, 1) = \frac{1}{2}p^{0,0} - \frac{1}{2}p^+$. The speculator will choose $u_2 = 0$.

Next, we analyze the strategies in period 1, knowing the contingent strategies in period 2, as were derived above. Equilibrium prices in period 1 are: $p_1(2) = p^+$, $p_1(-2) = p^-$, $p_1(0) = p^0$. Off-equilibrium prices in period 1 are: $p_1(-1) = p_1(1) = p^{0,0}$. We use the notation $\Pi_1(s_T, u_1)$ to denote the total expected profit (i.e., profit from two rounds of trade) that the speculator makes for each date-1 order, given his signal.

Then, if the speculator observed $s_T = h$, his expected profits under the different strategies are: $\Pi_1(h,0) = -\frac{1}{2}p^{0,0} + \frac{1}{2}p^+$, $\Pi_1(h,-1) = \frac{1}{2}(p^- - \beta p^+) + \frac{1}{2}\left(p^0 - \frac{1}{2}p^+ - \frac{1}{2}p^{0,0}\right)$, $\Pi_1(h,1) = \frac{1}{2}(0) + \frac{1}{2}\left(-p^0 + 1\frac{1}{2}p^+ - \frac{1}{2}p^{0,0}\right)$. The speculator will choose $u_1 = 1$. If the speculator observed $s_T = l$, his expected profits under the different strategies are: $\Pi_1(l,0) = -\frac{1}{2}p^{0,0} + \frac{1}{2}p^+$, $\Pi_1(l,-1) = \frac{1}{2}(p^-) + \frac{1}{2}\left(p^0 + \frac{1}{2}p^- - 1\frac{1}{2}p^{0,0} + p^+\right)$, $\Pi_1(l,1) = \frac{1}{2}\left(-\frac{1}{2}p^+\right) + \frac{1}{2}\left(-p^0 + \frac{1}{2}p^- + \frac{1}{2}p^{0,0}\right)$. The speculator will choose $u_1 = -1$. If the speculator observed $s_T = \varnothing$, his expected profits under the different strategies are: $\Pi_1(\varnothing,0) = 0$, $\Pi_1(\varnothing,-1) = \frac{1}{2}\left(p^- - \frac{1}{2}\beta p^+\right) + \frac{1}{2}\left(p^0 + \frac{1}{2}p^- - \frac{1}{2}p^{0,0} - \frac{1}{2}\beta p^+\right)$, $\Pi_1(\varnothing,1) = \frac{1}{2}\left(-\frac{1}{2}p^+\right) + \frac{1}{2}\left(-p^0 + p^{0,0}\right)$. Using (6), the speculator will choose $u_2 = -1$.

To sum up, in equilibrium, the traders will choose the strategies in (3) and (4).

Proof of Proposition 2. **Equilibrium Prices:** The values of $p^{C,-}$, $p^{C,+}$, $p^{C,0,0}$, and $p^{C,0}$ can be calculated using similar reasonings to those we used in the proof of Proposition 1. They are given as follows:

$$
\begin{aligned}
p^{C,-} &= 0 \\
p^{C,+} &= 2\left(\theta_h + \gamma K - c\right) K \\
p^{C,0,0} &= \left(\theta_h + \gamma K - c\right) K + \\
&\quad (1-\beta)^2 \left(\theta_l + \gamma K - c\right) K + \\
&\quad (1-\beta)\beta\left(\theta_l - c\right) K \\
p^{C,0} &= \frac{1}{4}\alpha p^{C,+} + \frac{1}{2}\left(1 - \frac{1}{2}\alpha\right) p^{C,-} + \frac{1}{2} p^{C,0,0}.
\end{aligned}
$$

Optimal Strategies: As in the proof of Proposition 1, we analyze the optimal strategy of the speculator by backward induction. We start by analyzing the actions of the trader in period 2, given the outcomes in period 1. We use the notation $\Pi_2^C\left(s_T, Q_1, u_1, u_2\right)$ to denote the total expected profit that the speculator makes in the case of complementarities, for each date-2 order, given his signal, and the order flows at $t = 1$. The prices (off and on the equilibrium path) are based on the same rule as in Proposition 1, and thus are not repeated here.

Suppose that $Q_1 = -2$: If the speculator observed $s_T = h$, his expected profits under the different strategies are: $\Pi_2^C\left(h, -2, -1, 0\right) = 0$, $\Pi_2^C\left(h, -2, -1, -1\right) = 0$, and $\Pi_2^C\left(h, -2, -1, 1\right) = \frac{1}{2}p^{C,+}$. The speculator will choose $u_2 = 0$. If the speculator observed $s_T = l$, his expected profits under the different strategies are: $\Pi_2^C\left(l, -2, -1, 0\right) = 0$, $\Pi_2^C\left(l, -2, -1, -1\right) = 0$, and $\Pi_2^C\left(l, -2, -1, 1\right) = -\frac{1}{2}p^{C,+}$. The speculator will choose $u_2 = 0$. If the speculator observed $s_T = \varnothing$, his expected profits under the different strategies are: $\Pi_2^C\left(\varnothing, -2, -1, 0\right) = 0$, $\Pi_2^C\left(\varnothing, -2, -1, -1\right) = 0$, and $\Pi_2^C\left(\varnothing, -2, -1, 1\right) = -\frac{1}{2}p^{C,+}$. The speculator will choose $u_2 = 0$.

Suppose that $Q_1 = 2$: If the speculator observed $s_T = h$, his expected profits under the different strategies are: $\Pi_2^C\left(h, 2, 1, 0\right) = 0$, $\Pi_2^C\left(h, 2, 1, -1\right) = -\frac{1}{2}p^{C,+}$, and $\Pi_2^C\left(h, 2, 1, 1\right) = 0$. The speculator will choose $u_2 = 0$. If the speculator observed $s_T = l$, his expected profits under the different strategies are: $\Pi_2^C\left(l, 2, 1, 0\right) = -2p^{C,+} + 2p^{C,0,0}$, $\Pi_2^C\left(l, 2, 1, -1\right) = -\frac{1}{2}p^{C,+}$, and $\Pi_2^C\left(l, 2, 1, 1\right) = -4p^{C,+} + 4p^{C,0,0}$. The speculator will choose $u_2 = -1$.

If the speculator observed $s_T = \varnothing$, his expected profits under the different strategies are: $\Pi_2^C(\varnothing, 2, 1, 0) = -p^{C,+} + p^{C,0,0}$, $\Pi_2^C(\varnothing, 2, 1, -1) = -\frac{1}{2}p^{C,+}$, and $\Pi_2^C(\varnothing, 2, 1, 1) = -2p^{C,+} + 2p^{C,0,0}$. The speculator will choose $u_2 = -1$.

Suppose that $Q_1 = 0$: Assume first that the speculator submitted $u_1 = -1$. Then, if the speculator observed $s_T = h$, his expected profits under the different strategies are: $\Pi_2^C(h, 0, -1, 0) = p^{C,0} - p^{C,+}$, $\Pi_2^C(h, 0, -1, -1) = p^{C,0} + \frac{1}{2}p^{C,0,0} - p^{C,+}$, and $\Pi_2^C(h, 0, -1, 1) = p^{C,0} - \frac{1}{2}p^{C,+} - \frac{1}{2}p^{C,0,0}$. The speculator will choose $u_2 = 1$. If the speculator observed $s_T = l$, his expected profits under the different strategies are: $\Pi_2^C(l, 0, -1, 0) = p^{C,0} - 2p^{C,0,0} + p^{C,+}$, $\Pi_2^C(l, 0, -1, -1) = p^{C,0} - 1\frac{1}{2}p^{C,0,0} + p^{C,+}$, and $\Pi_2^C(l, 0, -1, 1) = p^{C,0} - \frac{1}{2}p^{C,+} - \frac{1}{2}p^{C,0,0}$. The speculator will choose $u_2 = -1$. If the speculator observed $s_T = \varnothing$, his expected profits under the different strategies are: $\Pi_2^C(\varnothing, 0, -1, 0) = p^{C,0} - p^{C,0,0}$, $\Pi_2^C(\varnothing, 0, -1, -1) = p^{C,0} - \frac{1}{2}p^{C,0,0}$, and $\Pi_2^C(\varnothing, 0, -1, 1) = p^{C,0} - \frac{1}{2}p^{C,+} - \frac{1}{2}p^{C,0,0}$. The speculator will choose $u_2 = -1$.

Now, assume that the speculator submitted $u_1 = 1$. Then, if the speculator observed $s_T = h$, his expected profits under the different strategies are: $\Pi_2^C(h, 0, 1, 0) = -p^{C,0} + p^{C,+}$, $\Pi_2^C(h, 0, 1, -1) = -p^{C,0} + \frac{1}{2}p^{C,0,0}$, and $\Pi_2^C(h, 0, 1, 1) = -p^{C,0} + 1\frac{1}{2}p^{C,+} - \frac{1}{2}p^{C,0,0}$. The speculator will choose $u_2 = 1$. If the speculator observed $s_T = l$, his expected profits under the different strategies are: $\Pi_2^C(l, 0, 1, 0) = -p^{C,0} - p^{C,+} + 2p^{C,0,0}$, $\Pi_2^C(l, 0, 1, -1) = -p^{C,0} + \frac{1}{2}p^{C,0,0}$, and $\Pi_2^C(l, 0, 1, 1) = -p^{C,0} - 2\frac{1}{2}p^{C,+} + 3\frac{1}{2}p^{C,0,0}$. The speculator will choose $u_2 = -1$. If the speculator observed $s_T = \varnothing$, his expected profits under the different strategies are: $\Pi_2^C(\varnothing, 0, 1, 0) = -p^{C,0} + p^{C,0,0}$, $\Pi_2^C(\varnothing, 0, 1, -1) = -p^{C,0} + \frac{1}{2}p^{C,0,0}$, and $\Pi_2^C(\varnothing, 0, 1, 1) = -p^{C,0} - \frac{1}{2}p^{C,+} + 1\frac{1}{2}p^{C,0,0}$. The speculator will choose $u_2 = 0$.

Suppose that $Q_1 \in \{-1, 1\}$: If the speculator observed $s_T = h$, his expected profits under the different strategies are: $\Pi_2^C(h, Q_1 \in \{-1, 1\}, 0, 0) = 0$, $\Pi_2^C(h, Q_1 \in \{-1, 1\}, 0, -1) = \frac{1}{2}p^{C,0,0} - \frac{1}{2}p^{C,+}$, and $\Pi_2^C(h, Q_1 \in \{-1, 1\}, 0, 1) = -\frac{1}{2}p^{C,0,0} + \frac{1}{2}p^{C,+}$. The speculator will choose $u_2 = 1$. If the speculator observed $s_T = l$, his expected profits under the different strategies are: $\Pi_2^C(l, Q_1 \in \{-1, 1\}, 0, 0) = 0$, $\Pi_2^C(l, Q_1 \in \{-1, 1\}, 0, -1) = -\frac{1}{2}p^{C,0,0} + \frac{1}{2}p^{C,+}$, and $\Pi_2^C(l, Q_1 \in \{-1, 1\}, 0, 1) = 1\frac{1}{2}p^{C,0,0} - 1\frac{1}{2}p^{C,+}$. The speculator will choose $u_2 = -1$. If the speculator observed $s_T = \varnothing$, his expected profits under the different strategies are: $\Pi_2^C(\varnothing, Q_1 \in \{-1, 1\}, 0, 0) = 0$, $\Pi_2^C(\varnothing, Q_1 \in \{-1, 1\}, 0, -1) = 0$, and $\Pi_2^C(\varnothing, Q_1 \in \{-1, 1\}, 0, 1) = \frac{1}{2}p^{C,0,0} - \frac{1}{2}p^{C,+}$. The speculator will choose $u_2 = 0$.

Next, we analyze the strategies in period 1, knowing the contingent strategies in period

2, as were derived above. We use the notation $\Pi_1^C(s_T, u_1)$ to denote the total expected profit that the speculator makes in the case of complementarities for each date-1 order, given his signal.

Then, if the speculator observed $s_T = h$, his expected profits under the different strategies are: $\Pi_1^C(h, 0) = -\frac{1}{2}p^{C,0,0} + \frac{1}{2}p^{C,+}$, $\Pi_1^C(h, -1) = \frac{1}{2}\left(p^{C,0} - \frac{1}{2}p^{C,+} - \frac{1}{2}p^{C,0,0}\right)$, $\Pi_1^C(h, 1) = \frac{1}{2}\left(-p^{C,0} + 1\frac{1}{2}p^{C,+} - \frac{1}{2}p^{C,0,0}\right)$. The speculator will choose $u_1 = 1$. If the speculator observed $s_T = l$, his expected profits under the different strategies are: $\Pi_1^C(l, 0) = -\frac{1}{2}p^{C,0,0} + \frac{1}{2}p^{C,+}$, $\Pi_1^C(l, -1) = \frac{1}{2}\left(p^{C,0} - 1\frac{1}{2}p^{C,0,0} + p^{C,+}\right)$, $\Pi_1^C(l, 1) = \frac{1}{2}\left(-p^{C,0} + \frac{1}{2}p^{C,0,0} - \frac{1}{2}p^{C,+}\right)$. The speculator will choose $u_1 = -1$. If the speculator observed $s_T = \varnothing$, his expected profits under the different strategies are: $\Pi_1^C(\varnothing, 0) = 0$, $\Pi_1^C(\varnothing, -1) = \frac{1}{2}\left(p^{C,0} - \frac{1}{2}p^{C,0,0}\right)$, $\Pi_1^C(\varnothing, 1) = \frac{1}{2}\left(-p^{C,0} + p^{C,0,0} - \frac{1}{2}p^{C,+}\right)$. The speculator will choose $u_1 = -1$.

To sum up, in equilibrium, the traders will choose the strategies in (3) and (4). ■

Proof of Proposition 3. Knowing the outcomes of the equilibrium strategies described in Section 3, we know that the ex ante expected value of production in the economy when a financial market exists is:

$$\begin{aligned} & \frac{1}{2}\alpha(\theta_h - c)K + \frac{1}{8}\alpha(1-\beta)(\theta_l - c)K + \\ & \frac{1}{8}(1-\alpha)(3\beta+1)(\theta_h - c)K + \frac{1}{8}(1-\alpha)(1-\beta)(\theta_l - c)K \\ = & \frac{1}{8}(3\beta + 1 + 3\alpha - 3\alpha\beta)(\theta_h - c)K + \frac{1}{8}(1-\beta)(\theta_l - c)K. \end{aligned}$$

Absent a financial market, the manager will make decisions on the basis of her information only. Then, the ex ante expected value of investment is:

$$\frac{1}{2}(\theta_h - c)K + \frac{1}{2}(1-\beta)(\theta_l - c)K.$$

Suppose that the first expression is smaller than the second one. This implies that $\frac{\theta_h(1-\alpha)+\theta_l}{2-\alpha} > c$. If this condition holds, however, the manager does not change her investment decisions according to the price, and then the expected value of investment is the same, no matter whether a financial market exists or not: a contradiction. ■

Proof of Proposition 4. First, consider the ex ante expected value of investment when there is no market and managers play the Pareto dominant equilibrium, given information constraints. By assumption (17), each manager will invest unless she has received a signal $s_M^i = l$. Thus, the expected value of the two firms is:

$$E[V_A + V_B|\text{no market}] = \frac{1}{2} \cdot 2 (\theta_h + \gamma K - c) K + \frac{1}{2} \begin{pmatrix} \beta^2 \cdot 0 + 2\beta(1-\beta)(\theta_l - c) \\ +2(1-\beta)^2 (\theta_l + \gamma K - c) \end{pmatrix} K.$$

The expected value of investment when there is a market and the equilibrium in Proposition 2 is played is:

$$\begin{aligned} E[V_A + V_B|\text{market}] = {} & \alpha (\theta_h + \gamma K - c) K + \\ & \frac{\alpha}{8} \left(\beta^2 \cdot 0 + 2\beta(1-\beta)(\theta_l - c) + 2(1-\beta)^2(\theta_l + \gamma K - c)\right) K + \\ & \frac{1-\alpha}{4} \begin{pmatrix} \left(\frac{1}{2} 2 (\theta_h + \gamma K - c)\right) + \\ \left(\frac{1}{2} \begin{pmatrix} \beta^2 \cdot 0 + 2\beta(1-\beta)(\theta_l - c) + \\ 2(1-\beta)^2(\theta_l + \gamma K - c) \end{pmatrix}\right) \end{pmatrix} K. \end{aligned}$$

Comparing the two expressions, we get that $E[V_A+V_B|\text{no market}] > E[V_A+V_B|\text{market}]\, iff$

$$\gamma > -\frac{(\theta_h - c)(1-\alpha) + (\theta_l - c)(1-\beta)}{K\left((1-\alpha) + (1-\beta)^2\right)}.$$

One can show that this condition does not contradict any of the conditions that establish the equilibrium in Section 4 as the Pareto optimal equilibrium given a financial market (i.e., conditions: (14), (15), (16) and (17)). Thus, we have shown that there exists a non-empty set of parameter values for which the existence of a financial market reduces the ex ante efficiency of investment decisions. ■

Proof of Proposition 5. The payoffs of the uninformed speculator under the manipulative strategy are given as follows:

With probability $\frac{\alpha}{2}$, the potentially informed trader gets a low signal and sells, in which case the expected net payoff of the uninformed trader is:

$$\frac{1}{4} \begin{pmatrix} 2\left(p^{C,-} - E\left(V \left| s_T = l, p_2 = p^{C,-}\right.\right)\right) + \left(p^{C,0} + p^{C,0,0} - 2E\left(V \left| s_T = l, p_2 = p^{C,0,0}\right.\right)\right) \\ + \left(p^{C,0} + p^{C,-} - 2E\left(V \left| s_T = l, p_2 = p^{C,-}\right.\right)\right) \end{pmatrix}. \tag{21}$$

With probability $1-\alpha$, the potentially informed trader does not get information and sells, in which case the expected net payoff of the uninformed trader is:

$$\frac{1}{4} \begin{pmatrix} 2\left(p^{C,-} - E\left(V \left| s_T = \varnothing, p_2 = p^{C,-}\right.\right)\right) + \left(p^{C,0} + p^{C,0,0} - 2E\left(V \left| s_T = \varnothing, p_2 = p^{C,0,0}\right.\right)\right) \\ + \left(p^{C,0} + p^{C,-} - 2E\left(V \left| s_T = \varnothing, p_2 = p^{C,-}\right.\right)\right) \end{pmatrix}. \tag{22}$$

Finally, with probability $\frac{\alpha}{2}$, the potentially informed trader gets a high signal and buys, in which case the expected net payoff of the uninformed trader is:

$$\frac{1}{4}\left(\begin{array}{c} 2\left(p^{C,+}-E\left(V\left|s_T=h,p_2=p^{C,+}\right.\right)\right)+\left(p^{C,0}+p^{C,0,0}-2E\left(V\left|s_T=h,p_2=p^{C,0,0}\right.\right)\right) \\ +\left(p^{C,0}+p^{C,+}-2E\left(V\left|s_T=h,p_2=p^{C,+}\right.\right)\right) \end{array}\right). \tag{23}$$

Taking expectations over (21), (22), and (23), we get that the expected net payoff of the uninformed trader from mimicking the manipulative strategy is 0. ■

Proof of Proposition 6. One possible manipulation-free equilibrium would feature no trading by the speculator. Equilibrium prices would then be $p_t(Q_t \in \{-1,1\}) = p^{C,0,0}$. Suppose the off-the-path belief is that additional trade originates from an uninformed speculator. Then all off-the-path prices would also be $p^{0,0}$ and an informed speculator will clearly have an incentive to trade on his information. Suppose instead that a deviation from equilibrium is attributed to an informed speculator. Then, $p_t(Q_t = 2) = p^{C,+}$, $p_t(Q_t = 0) = p^{C,0,0}$, and $p_t(Q_t = -2) = 0$. Hence, an informed speculator will not lose when his order is revealed and will profit when it is not. Since the non revealing state $Q_t = 0$ occurs with positive probability, the informed speculator strictly prefers to trade. It is easy to see that the same argument applies for off-the-path beliefs that assign a probability strictly between 0 and 1 that the deviation is attributable to an informed trader. Therefore, no trade by the speculator cannot be an equilibrium. Note moreover, that the above argument applies regardless of whether we consider first or second round trade. Hence, we can rule out all strategies in which the informed speculator does not trade on his private information (that is, does not buy when he has good information, or does not sell when he has bad information).

The other possible equilibrium without manipulation is an equilibrium where the speculator trades only after receiving an informative signal regarding the fundamentals (buys after $s_T = h$ and sells after $s_T = l$), but does not trade without information. This would constitute the trading strategy in the standard set up of trade on private information in the absence of a feedback from price to real value. Under this strategy, in equilibrium, first period prices are given by: $p_1(Q_1 = 2) = p^{C,+}$, $p_1(Q_1 = 1) = p^{C,0,0}$, $p_1(Q_1 = 0) = \frac{1}{4}p^{C,+} + \frac{1}{2}p^{C,0,0}$, $p_1(Q_1 = -1) = p^{C,0,0}$, and $p_1(Q_1 = -2) = 0$. Second period prices remain the same as first period prices if $Q_1 \in \{-2,-1,1,2\}$, and in case $Q_1 = 0$, they are given by: $p_2(Q_1 = 0, Q_2 = 2) = p^{C,+}$, $p_1(Q_1 = 0, Q_2 = 1) = p^{C,0,0}$,

$p_1(Q_1 = 0, Q_2 = 0) = p^{C,0,0}$, $p_1(Q_1 = 0, Q_2 = -1) = p^{C,0,0}$, and $p_1(Q_1 = 0, Q_2 = -2) = 0$.

Suppose now that the uninformed trader deviates from the proposed equilibrium by selling at date $t = 1$, and selling again at date $t = 2$ only if the date 1 price was not revealing, i.e.$Q_1 = 0$. (Note that this deviation yields order flows that are along the equilibrium path and therefore we do not need to specify out-of-equilibrium beliefs here.) The proposed deviation yields the following expected profits:

$$\begin{aligned} E[\pi] &= \frac{1}{2}\left(0 - E\left(V\left|s_T = \varnothing, p_2 = 0\right.\right)\right) \\ &+\frac{1}{4}\left(\frac{1}{4}p^{C,+} + \frac{1}{2}p^{C,0,0} + p^{C,0,0} - 2E\left(V\left|s_T = \varnothing, p_2 = p^{C,0,0}\right.\right)\right) \\ &+\frac{1}{4}\left(\frac{1}{4}p^{C,+} + \frac{1}{2}p^{C,0,0} + 0 - 2E\left(V\left|s_T = \varnothing, p_2 = 0\right.\right)\right) \\ &= \frac{1}{8}p^{C,+} > 0 \end{aligned}$$

Thus, the speculator will deviate and trade when he has no information. ■ ■

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