NBER WORKING PAPER SERIES

HERD ON THE STREET: INFORMATIONAL INEFFICIENCIES IN A MARKET WITH SHORT-TERM SPECULATION

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Working Paper No. 3250

NATIONAL BUREAU OF ECONOMIC RESEARCH
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February 1990

We thank Mike Fishman, Greg Mankiw, Stew Myers, Andre Perold, Julio Rotemberg, Andrei Shleifer, and seminar participants at Boston College, Columbia, NBER and the Russell Sage Foundation for helpful comments. We are also grateful for research support from the Olin and Ford Foundations, MIT's International Financial Research Center, and the Division of Research at Harvard Business School. This paper is part of NBER's research programs in International Studies and Financial Markets and Monetary Economics. Any opinions expressed are those of the authors not those of the National Bureau of Economic Research.

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ABSTRACT

Standard models of informed speculation suggest that traders try to learn information that others do not have. This result implicitly relies on the assumption that speculators have long horizons, i.e, can hold the asset forever. By contrast, we show that if speculators have short horizons, they may herd on the same information, trying to learn what other informed traders also know. There can be multiple herding equilibria, and herding speculators may even choose to study information that is completely unrelated to fundamentals. These equilibria are informationally inefficient.

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1. Introduction

How do speculators' trading horizons affect the informativeness of asset prices? Does a market with numerous short-horizon traders perform less efficiently than one in which traders buy and hold? The classical response is that if speculators are rational, trading horizons should not affect asset prices. Even if a trader plans to sell his stock in five minutes, he cares about the expected price at that time. That price, in turn, depends on the expected price five minutes hence, and so on. Simple backwards induction then assures that even very short-horizon traders behave as if they were speculating on fundamentals.

This traditional reasoning seems at odds with the way professional traders describe their jobs. Traders often emphasize that their objective is to predict near-term changes in asset prices. Rationally, they focus on learning anything that will help them do this more effectively. Often, it is claimed, such information has little to do with fundamentals. For example, according to one foreign exchange trader:[1]

> Ninety percent of what we do is based on perception. It doesn't matter if that perception is right or wrong or real. It only matters that other people in the market believe it. I may know it's crazy, I may think it's wrong. But I lose my shirt by ignoring it. This business turns on decisions made in seconds. If you wait a minute to reflect on things, you're lost. I can't afford to be five steps ahead of everybody else in the market. That's suicide.

This account corresponds closely to the skeptical view of short-term trading offered by Keynes (1936) in the General Theory:

> The actual, private object of most skilled investment today is to "beat the gun..." This battle of wits to anticipate the basis of conventional valuation a few months hence, rather than the prospective yield of an investment over a long term of years, does not even require gulls amongst the public to feed the maws of the professional; it can be played by professionals amongst themselves.

Keynes goes on to compare professional investors to beauty-contest judges who vote on the basis of expected popularity with other judges, and not on the basis of absolute beauty.

In this paper, we develop a model of short-term trading that accords closely with these informal descriptions. We start with the assumption that there are at least some

[1] Quotation from the head of foreign exchange operations at Manufacturers Hanover Trust, "Making Book on the Buck," Mossberg, *Wall Street Journal* September 23, 1988.

speculators who prefer to trade over short horizons. While we could explicitly model the rational behavior that gives rise to this assumption, in this paper we choose to take speculative horizons as given, and focus instead on the *implications* of short-term trading.[2]

We then show that the existence of short-term speculators can lead to informational inefficiencies. This occurs even though our model features fully rational traders. To see how such inefficiencies can arise, consider an informed trader who plans to liquidate his position in the near future, before any public news arrives. He can profit on his information only if it is subsequently impounded into the price by the trades of similarly-informed speculators. The trader therefore is made better off if there are others in the market *acting on the same information* that he is.

Positive informational spillovers of this sort are evident in the quotes above. In Keynes' beauty contest, the judges would be better off if they could coordinate their choices, even if they coordinate on somebody who is less than beautiful. Likewise, short-horizon traders would be better off if they could coordinate their research efforts on the same piece of information, even if that information is less revealing about the asset's long-run value. This is in sharp contrast with most information-based asset pricing models (which implicitly assume a long horizon).[3] In these models the informational spillover is *negative*: a given trader is made better off if *nobody else* is trading on his information.

As will become clear, negative spillovers ensure informational efficiency when traders have long horizons.[4] Negative spillovers lead to contrarian research behavior, which is essential for asset market efficiency. To take a concrete example, suppose that two variables, a and b, provide equally useful information about the value of a given security, and that an individual trader has the capacity to learn about either a or b, but not both. Informational efficiency requires that half of the traders study a, and the other half study b. And this is exactly what happens if traders have long horizons. If more than half are studying a, then

[2] There are two reasons why it might be rational for speculators to choose to trade over short horizons. First, some speculators such as money managers may need to prove to their clients or bosses that they are skilled investors. Promises of gains ten years hence would hardly justify a high current salary or the authority to continue managing a large portfolio. (See Narayanan, 1985 and Holmström and Ricart i Costa, 1986.) Second, speculators who face imperfections in the capital market may find it relatively costly to finance long-horizon investment strategies. In particular, if speculators tie up their money in long-horizon investments, and at some point become credit constrained, they will not be able to take advantage of investment opportunities that arise in the future. (See Shleifer and Vishny, 1989.)

[3] See, for example, Grossman (1976), Hellwig (1980), and Verrechia (1982).

[4] For a discussion of spillover effects, see Cooper and John (1988).

a is more heavily impounded in the price than *b*. This negative spillover in *a* reduces the profits to those who study *a*, and so leads some investors to study *b*. However, with short horizons, the outcome can be very different. Suppose everybody decides to study variable *a*. This can be an equilibrium, since there is no incentive to study *b*: even though *b* will affect the value of the asset when it is eventually liquidated, it will not be in its price in the near term, as nobody is trading on *b* information.

Thus, one sort of inefficiency created by short-horizon speculation is that traders may all tend to focus on one source of information, rather than on a diverse set of data. Moreover, the informational spillovers can be so powerful that groups of traders may choose to focus on very poor quality data, or *even on completely extraneous variables* that bear no relation at all to fundamentals.

Although its mechanism is very different, our model is not the first that attempts to capture Keynes' beauty-contest insight about the distinction between short and long trading horizons. Bubble models (Tirole, 1982; Blanchard and Watson, 1985) address the same basic phenomenon. So does the model of positive feedback trading by DeLong, Summers, Shleifer and Waldman (1990b). We will comment on these and other related work in what follows.

The paper is organized as follows. In Section 2 we lay out our basic model. Section 3 derives a series of propositions relating to the informational efficiency of asset prices when traders have long and short horizons. We show that with short horizons, there can be "herding" on particular sources of information. In Section 4 we show that with sufficiently short horizons, speculators will trade on, and actually choose to study, completely extraneous noise. Section 5 then relates our model to other work on the inefficiency of asset markets. Section 5 also discusses extensions and implications of our model, stressing the connection between short speculative horizons and short-term corporate behavior.

2. The Model

We consider trade in a market for a single asset which has a fixed supply. The asset's only payout is a liquidating dividend of v, which is the sum of two normally distributed random variables:

$$v = a + b, \tag{1}$$

where a and b have means of zero and variances of σ_a^2 and σ_b^2, respectively.

2.1. Types of traders

The analysis takes as its starting point Kyle's (1985) model of informed trading. There are three types of traders in this model, all of whom are risk-neutral and none of whom can observe v perfectly. The first type of traders are *market makers* who fill the orders of the two other types of traders: *speculators* and *liquidity traders*. Speculators and liquidity traders submit ("market") orders to buy (sell) the asset from (to) long-lived market makers. Market makers cannot distinguish speculators' informed orders from liquidity traders' uninformed orders; they can observe only the total "order flow". Because they are risk neutral and competitive, they earn zero profits. Thus, the market clearing price is the market makers' expectation of v, conditional on what they learn about v from the overall order flow. Since market makers do not have private information and are willing to hold until liquidation, they are best thought of as an uninformed fringe of long-term traders.

There are n speculators, n_a of whom have observed a and n_b of whom have observed b. Below, we allow speculators to choose which piece of information to become informed about, thereby endogenizing n_a and n_b. We assume that each speculator can costlessly observe a or b, but not both. This is intended to capture the idea that there are limits to how much any one trader can learn over short periods of time.[5]

As in the Kyle model, speculators are large enough to affect the market price and they take this into account when formulating their demands. If speculators did not anticipate their effect on price, they would want to take infinite long (short) positions when

[5] It would also be easy to endogenise the total number of speculators, N. We could, for example, assume that there are costs of becoming informed about a or b, and that these costs differ depending on how readily available the information is. If there is free entry into speculation, traders will then enter until their profits net of information-acquisition costs are driven to zero.

their price forecast is below (above) their forecast of value. While the assumption is an attractive simplifying feature of the model, it is by no means crucial. We could also assume that speculators are risk averse and behave competitively (although such a model is computationally more burdensome). Thus, the reader should not be misled into thinking that our results come from some form of market manipulation by a large strategic trader.

Liquidity traders, in contrast to speculators, have inelastic demands for the asset: they wish to buy or sell a fixed quantity regardless of its price. Liquidity traders play an important role in essentially all models of information acquisition (see, for example, Grossman and Stiglitz, 1980, and Kyle, 1985). In their absence, prices would reveal all the information in the economy, so there would be no returns to becoming informed. In our model, as in others, liquidity trades result in prices that are noisy indicators of v, thus creating returns to information.

2.2. Timing of trade

At an initial date 0, the n speculators choose whether to become informed about a or about b. Following this decision there are three trading periods. At date 1, speculators submit their asset demands. We assume that half of the traders have their orders executed at date 1 and that the other half have their orders executed at date 2. At the time they submit their orders, traders do not know at what date their orders will be executed. This assumption captures the notion that there are limits to how many trades can be executed at any point in time. More importantly for our analysis, the assumption implies that speculators' information is only gradually incorporated into prices. As we will see below, trades that are executed at date 1 can be profitable because more (of the same) information arrives at date 2. Traders that "beat the gun" are therefore able to profit.

All speculators close out their positions at date 3. As we explain below, this means that they have short horizons in that they may unwind their position before information is publicly released. What matters here is that the price at which informed traders get out of the market, even when they have short horizons, may contain more information than the price at which they get in.

Liquidity traders have date-1 and date-2 demands of ϵ_1 and ϵ_2, respectively. At time

3 they also unwind their positions, so that $\epsilon_3 = -(\epsilon_1 + \epsilon_2)$. We assume that ϵ_1 and ϵ_2 are normally distributed with mean zero and variance σ_ϵ^2.

Given these assumptions, the order flow at date t, F_t, for $t = 1, 2$, can be written:

$$F_t = \frac{n_a}{2} q_a + \frac{n_b}{2} q_b + \epsilon_t, \tag{2}$$

where q_a and q_b are the equilibrium demands of speculators informed about a and b, respectively.

Because the order flow at date 3 is just the negative of the cumulative order flows at dates 1 and 2, trade at date 3 contains no new information about v. All traders are simply closing out their positions from the previous two periods. This assumption simplifies the exposition greatly, but is of no qualitative importance. If, for example, we were to assume that liquidity traders at dates 1 and 2 did not close out their positions and that ϵ_3 was, like earlier realizations, drawn independently, there would be additional confirming evidence about v in date-3 orders. As a result, informed traders whose trades were executed at date 2 would have positive expected profits when they closed out their positions. All of our results continue to hold (at least qualitatively) under this alternative assumption about date-3 trade.

Our main objective is to consider the effects of short versus long speculative horizons. To do this in a simple way, we assume that with probability α, the dividend is publicly announced at date 3, so that the date-3 trading price is v. With probability $1-\alpha$, however, v does not become public until date 4. In that case, at date 3 the risk-neutral market makers simply reabsorb the supply of the asset and hold it until v is paid. The date-3 price is then equal to their conditional expectation of v, which - - since no information is contained in the date-3 flow – is equal to the price from date 2. This specification of the trading horizon allows us to consider the important special cases in which informed speculators have purely long horizons ($\alpha = 1$) and purely short horizons ($\alpha = 0$).

It should be noted that when speculators close out their positions at date 3 (and v is not publicly announced), they transact only with the uninformed market makers – not with a new set of informed short-term traders. If a new group of informed traders were to enter at date 3, they would wish to learn about both components of v, because they would be holding until liquidation. This would cause the date-3 price to reflect information about both of these components, much as if there had been a public release of news at date 3. Thus, in the current formulation of the model, assuming that a new batch of informed traders enter at date 3 is similar to assuming long horizons for the first group of informed traders – our results are overturned and informational efficiency is restored.

At first glance, this casts some doubt on the general applicability of the results. However, this second group of informed traders has such a strong effect only because they hold the asset until its liquidation with certainty. In Section 5.1, we argue that a more realistic (although more complex) steady-state version of the model would likely yield results similar to those we present below, without restrictions on the entry of new generations of informed traders.

2.3. Market-Maker Pricing Rules

Based on the observed order flows and their conjectures about the trading strategies of the speculators, market makers form beliefs about the expected value of the asset. Since q_a and q_b depend on the realized values of a and b, the order flows provide information about v. Given that market makers' priors are normally distributed around a mean of zero, their posterior belief having seen the date-1 order flow, F_1, is just F_1 multiplied by some constant, λ_1. This constant is equal to the probability limit of the coefficient in a regression of v on F_1. Thus, the price at date 1, p_1, equals $\lambda_1 F_1$, where

$$\lambda_1 = \frac{\text{cov}[v, F_1]}{\text{var}[F_1]} = \frac{\text{cov}[a + b, \frac{n_a}{2} q_a + \frac{n_b}{2} q_b + \epsilon_1]}{\text{var}[\frac{n_a}{2} q_a + \frac{n_b}{2} q_b + \epsilon_1]} \tag{3}$$

Similarly, the date-2 order flow provides information about the value of the asset. Given that the component of the order flow due to speculators' demands is the same at dates 1 and 2, and that the variances of ϵ_t are the same for the two periods, market makers put equal weight on these two order flows in forming their expectations about the asset's value at date 2. Thus, the market makers' conditional expectation of v is a function of the average order flow: $p_2 = \lambda_2(F_1 + F_2)/2$, where

$$\lambda_2 = \frac{\text{cov}\left[v, \frac{F_1+F_2}{2}\right]}{\text{var}\left[\frac{F_1+F_2}{2}\right]} = \frac{\text{cov}\left[a + b, \frac{n_a}{2} q_a + \frac{n_b}{2} q_b + \frac{1}{2}(\epsilon_1 + \epsilon_2)\right]}{\text{var}\left[\frac{n_a}{2} q_a + \frac{n_b}{2} q_b + \frac{1}{2}(\epsilon_1 + \epsilon_2)\right]}. \tag{4}$$

Since the information about v in the combined order flow is more precise than the information in F_1 alone, $\lambda_2 > \lambda_1$. Of course, the equilibrium value of λ_t depends on the trading strategies of the informed speculators, and these trading strategies, in turn, depend on the way in which the market maker sets prices.

2.4. Speculators' demands

Speculators' demands depend on the information they observe. In forming their demands they take as given the number of speculators who are informed about a and b, the trading strategies of these speculators, and the pricing strategy of the market maker.

Consider then the decision facing speculator i who has observed a. First suppose that the dividend is to be announced at date 3. Since the speculator's order of q_a^i is equally likely to be executed at date 1 as at date 2, he expects to purchase at the average price, $\frac{p_1+p_2}{2}$. Expected profits on each unit purchased are then $E[v - \frac{1}{2}(p_1 + p_2) \mid a]$. Next suppose that no announcement is made at date 3. If the order is executed at date 1, the speculator earns $E[p_2 - p_1|a]$, whereas if the order is executed at date 2 he earns nothing since he buys at p_2 and sells at date 3 at a price of p_2. Thus, in the case where the dividend is not announced until date 4, the speculators expected profits are $\frac{1}{2}E[p_2 - p_1|a]$. Since the dividend is announced at date 3 with probability α and at date 4 with probability $1 - \alpha$, the expected utility of speculator i conditional on the realization of a is:

$$U_a^i = q_a^i E\left[\alpha\Big(v - \frac{p_1 + p_2}{2}\Big) + (1 - \alpha)\frac{p_2 - p_1}{2} \;\Big|\; a\right], \tag{5}$$

where q_a^i is speculator i's demand.

The expectation of v for a speculator who has observed a is just a. The observed value of a also enables the speculator to forecast prices at dates 1 and 2, since he knows the realization of a and the trading strategies of the other speculators who have observed a. However, he knows nothing of the order flow generated either by liquidity traders or by speculators who have observed b. These flows have zero mean conditional on a. Thus, if the speculator's order is executed at time t, his expectation of the price at that time, $E[p_t|a]$, is given by:

$$E[p_t|a] = \lambda_t E[F_t|a] = \lambda_t\Big(q_a^i + (\frac{n_a}{2} - 1)\bar{q}_a\Big), \tag{6}$$

where $\bar{q}_a$ denotes the conjectured demands of the $\frac{n_a}{2} - 1$ other speculators who are informed about a and have their orders executed at date t.[6] In contrast, the speculator's expectation of the price at time, s, assuming his order is *not* executed at time s is

$$E[p_s|a] = \lambda_s E[F_s|a] = \lambda_s \frac{n_a}{2}\bar{q}_a. \tag{7}$$

Since speculator i's order is not executed at time s, the orders of $\frac{n_a}{2}$ other speculators are executed and he has no effect on price. Given these expectations, speculator i who has observed a chooses q_a^i to maximize:

$$U_a^i = \tag{8}$$

$$q_a^i \left\{ \alpha \left(a - \frac{\lambda_1 + \lambda_2}{2} \left(q_a^i + (\frac{n_a}{2} - 1)\bar{q}_a \right) \right) + \frac{1-\alpha}{2} \left(\lambda_2 \frac{n_a}{2}\bar{q}_a - \lambda_1 \left(q_a^i + (\frac{n_a}{2} - 1)\bar{q}_a \right) \right) \right\}.$$

This expression shows clearly how trade by other speculators who observe a has spillover effects on the utility of speculator i who also observes a. If informed traders have long-term horizons (i.e., $\alpha = 1$) , everything else being equal, more trade by other similarly informed speculators *lowers* speculator i's expected utility: $\frac{dU_a^i}{d\bar{q}_a} < 0$. Negative spillovers like these are standard in most information-based asset pricing models. Each agent expects to gain only to the extent that he can trade on information that is not already incorporated into price.

By contrast, if speculators have short horizons, and therefore liquidate their holdings before v is realized, spillovers are *positive*. In this case $(\alpha = 0)$, $\frac{dU_a^i}{d\bar{q}_a} > 0$. To see why this is so, consider the extreme case in which speculator i is the only one who trades on his information about a. He cannot hope to earn a profit since there is no way for a to get impounded further into the price before he liquidates his holdings.

If, however, other speculators who are informed about a trade aggressively, speculator i will earn profits if his order is executed at date 1. This occurs because a great deal of additional information about a is later impounded in the date-2 price, and speculator i will unwind his position at this price. Thus, if the speculator cannot hold the asset until it is liquidated, his expected profits increase in the amount of trade by similarly informed

[6] Note that we assume from the outset that the demands of all other speculators informed about a are equal. Thus, we are focusing on symmetric equilibria.

traders. Taking the demands of other "a-speculators" and the market depth parameters λ_1 and λ_2 as given, the first-order condition for q_a^i is:

$$q_a^i = \frac{2\alpha a + \left((1-\alpha)\left(\frac{n_a}{2}(\lambda_2 - \lambda_1) + \lambda_1\right) - \alpha(\lambda_1 + \lambda_2)(\frac{n_a}{2} - 1)\right)\bar{q}_a}{2(\lambda_1 + \alpha\lambda_2)}. \tag{9}$$

We can derive an analogous expression for speculators who are informed about b, replacing a with b throughout.

Equation (9) shows that if a-speculators hold the asset until liquidation (which occurs with probability α), their demands are "strategic substitutes" in the terminology of Bulow, Geanakoplos, and Klemperer (1985). As other traders become more aggressive, not only do i's expected profits fall (due to the negative spillover), but i also trades *less*: holding all else constant, $\frac{dq_a^i}{d\bar{q}_a} = -(\frac{n_a}{2} - 1)(\lambda_1 + \lambda_2) < 0$. This derives from the fact that more information about a is already in the price and so the marginal returns from trading on a are lower.[7]

The more interesting case is when speculators liquidate their holdings before the dividend is known ($\alpha = 0$). In that case, demands are "strategic complements". When rival speculators trade more aggressively, each speculator wishes to trade more aggressively as well: $\frac{dq_a^i}{d\bar{q}} = \frac{n_a}{2}(\lambda_2 - \lambda_1) + \lambda_1 > 0$. The marginal return from trading increases because more news about a will be in the price when speculators *sell*, and thus they stand to gain more at that time. In general, trading by similarly informed speculators is more likely to be a strategic complement the smaller is α. Strategic complementarity of this sort is the crucial feature of our model and it gives rise to the herding equilibria that we focus on below.[8]

[7] Many economic games exhibit strategic substitutability, most notably the Cournot model of product-market competition. When an industry rival increases its production, all firms reduce their production because the market price is lower and hence the marginal returns from production are lower.

[8] Strategic complementarities are present in numerous other models including the product-market model of Bertrand competition with differentiated goods. In that model, firms lower their prices in response to rivals' price decreases: in contrast to the Cournot model, a firm becomes more aggressive in response to increased aggressiveness by rivals. But note that while our model has positive spillovers, the Bertrand model has negative spillovers in that a rival's more aggressive pricing strategy lowers the firm's expected profits. In this sense, our model is closest to the technology adoption models of Farrell and Saloner (1985) and Katz and Shapiro (1985) which feature both strategic complementarities and positive spillovers: firms are made better off when others adopt the same technology and this leads them to coordinate their technology choices. Another example is Scharfstein and Stein (1990) who show that reputational concerns in the labor market can generate positive spillovers in investment and generate herd behavior among corporate managers. Spillovers and strategic complementarities in financial markets have also been explored. For example, Admati and Pfleiderer (1989) present a model in which liquidity traders prefer to trade at the same time as other liquidity traders while Pagano (1989) shows that they wish to trade in the same market. These agglomeration effects mitigate the adverse selection problem that liquidity traders typically face.

3. Equilibrium

In order to solve for the equilibrium of this game, we first focus on the "trading sub-game" which takes n_a and n_b as given. Then we move to the earlier research stage of the game and allow traders to choose which source of information to study. The solution to this research game endogenizes n_a and n_b. In equilibrium, the expected utilities of active a- and b-speculators are equalized; otherwise speculators would choose to study the information source that provides the higher expected utility. By itself, however, this condition on equilibrium turns out to be too weak: it allows for the possibility of inherently unstable outcomes. Thus, we impose an additional stability condition: if one speculator deviates and studies the other information source, others playing that strategy do not wish follow and deviate as well.

The main focus of this section is whether equilibrium in the research stage is informationally efficient: Do traders choose to learn about the right mix of information – that which maximizes the informativeness of prices – or do they herd together, focusing on the same variable? In our model, prices fully reflect all publicly available information; the price is equal to the market makers' best guess of value given their information about order flows. But, speculators' research choices do not necessarily maximize the informativeness of equilibrium prices. Below we show that when trading horizons are short, speculators' research decisions are grossly inefficient: all speculators study either a or b despite the fact that it is more informationally efficient for some speculators to study a while others study b. We start, however, by establishing that in the traditional model in which speculators have long horizons, the research equilibrium is informationally efficient. We then compare this with the inefficiency when $\alpha = 0$ and present some preliminary examples when $0 < \alpha < 1$.

3.1. Equilibrium with long horizons

To solve for speculators' asset demands when they have long horizons we set $\alpha = 1$ in equation (9) and in the analogous expression for b-speculators. Recall that we are first focusing on the sub-game once n_a and n_b have been determined. In a symmetric equilibrium of the trading game, $q^i_k = \bar{q}_k$ for $k = a, b$. Thus, solving (9) for an equilibrium

q_a, we have:

$$q_a = \frac{2a}{(\lambda_1 + \lambda_2)(\frac{n_a}{2} + 1)} \equiv \delta_a a, \tag{10}$$

where δ_a is defined by the equation. Similarly, in equilibrium,

$$q_b = \frac{2b}{(\lambda_1 + \lambda_2)(\frac{n_b}{2} + 1)} \equiv \delta_b b, \tag{11}$$

The variables δ_a and δ_b measure the aggressiveness with which a- and b-speculators trade.

These equations only tell us speculators' demands given their conjectures about λ_1 and λ_2 chosen by the market makers. But, the chosen λ_1 and λ_2 themselves depend on speculators' trading strategies. As discussed above, λ_1 is just the probability limit of the regression coefficient of v on F_1:

$$\lambda_1 = \frac{2(n_a \delta_a \sigma_a^2 + n_b \delta_b \sigma_b^2)}{n_a^2 \delta_a^2 \sigma_a^2 + n_b^2 \delta_b^2 + 4\sigma_\epsilon^2}. \tag{12}$$

Recall that δ_a and δ_b depend on both λ_1 and λ_2 so that this equation alone does not determine λ_1. A similar expression holds for λ_2:

$$\lambda_2 = \frac{2(n_a \delta_a \sigma_a^2 + n_b \delta_b \sigma_b^2)}{n_a^2 \delta_a^2 \sigma_a^2 + n_b^2 \delta_b^2 + 2\sigma_\epsilon^2}. \tag{13}$$

We have not been able to derive closed form expressions for the endogenous variables λ_1, λ_2, δ_a, and δ_b. However, it is worth noting from equations (12) and (13) that λ_2 is greater than λ_1 as we claimed earlier.

Provided the four equations, (10) - (13), have a solution, we can calculate the expected utilities of a- and b-speculators for any fixed n_a and n_b. Denote these expected utilities EU_a and EU_b, respectively. Note that these expected utilities are calculated before a and b are realized and are not to be confused with a speculator's expected utility conditional on observing a.

Given the expected utilities that follow from an arbitrary n_a and n_b, we wish to see what values of n_a and n_b are consistent with equilibrium in the earlier research stage of the game. In equilibrium, speculators cannot gain by studying a instead of b. Therefore, ignoring integer problems, we must have $EU_a = EU_b$: the expected utility from becoming informed about a must equal the expected utility from becoming informed about b.

In order to evaluate this equilibrium, we need a definition of informational efficiency. Suppose there is a social planner who has the authority to choose n_a and n_b, but takes as given the market trading mechanism. We call an allocation (n_a, n_b) "informationally efficient" if it is the same as would be chosen by a social planner seeking to minimize average variance of prices about true value. Average variance is simply

$$\frac{1}{2}E\left(v - p_1\right)^2 + \frac{1}{2}E\left(v - p_2\right)^2$$

or,

$$\frac{1}{2}E\left(v - \lambda_1 F_1\right)^2 + \frac{1}{2}E\left(v - \lambda_2 F_2\right)^2, \tag{14}$$

where the expectation is taken over all realizations of a, b and ϵ_1, and ϵ_2. The social planner chooses n_a and n_b to minimize this expectation, given the λ_1, λ_2, F_1 and F_2 that follow from this choice.

We prove the following proposition in the Appendix:

Proposition 1: If speculators have long horizons, the research equilibrium is informationally efficient.

The proof of the proposition proceeds roughly along the following lines. An increase in n_a (and therefore a decrease in n_b) affects both λ_t and F_t. However, a marginal increase in λ_t has only a second order effect on price informativeness. This is because for each realized value of F_t, λ_t already minimizes the forecast error, $(v - \lambda_t F_t)^2$. Thus, the only first-order effect of n_a is through its effect on F_t. One can show that an increase in n_a, increases price informativeness if and only if the expected utility from learning a exceeds the expected utility from learning b. Thus, in choosing n_a to maximize price informativeness, the social planner implicitly chooses the point at which the expected utility from learning a equals the expected utility from learning b. Since this is also a condition of equilibrium, the research equilibrium is informationally efficient.[9]

3.2. Equilibrium with short horizons

This section considers the extreme short-horizon case in which speculators always

[9] In a simple one-period version of this model, in which all initial orders are executed at the same time, the analog of Proposition 1 is more intuitive – the variance of $v - p_1$ is minimized by the competitive choice of research strategies.

liquidate their holdings before news about v is released ($\alpha = 0$). After building intuition for this case, we return to the more general case in which $0 < \alpha < 1$.

Consider equation (9) determining speculator i's trading strategy. In the short-horizon case, the simplified version of this equation does not pin down a trading strategy for each speculator. Indeed, equation (9) only tells us that if an a-speculator trades a non-zero finite amount (so that the equation is met with equality), then

$$n_a = \frac{2\lambda_1}{\lambda_2 - \lambda_1}. \tag{15}$$

Similarly, the analogous expression for a b-speculator states that if he is to trade a non-zero finite amount

$$n_b = \frac{2\lambda_1}{\lambda_2 - \lambda_1}. \tag{16}$$

Equations (15) and (16) imply that the only way both types of speculators trade non-zero amounts in the trading subgame is if $n_a = n_b$. If n_a is greater than n_b, then b speculators would not trade on their information: $q_b = 0$. The converse is true if $n_b > n_a$.

There are three candidate equilibria in research strategies: all speculators study a, all study b, or half study a and half study b. First consider the case in which all speculators study a, $n_a = n$. Since (9) still does not pin down a trading strategy for an a-speculator (only a condition on n_a, λ_2 and λ_1), we posit that a-speculators trade is given by $q_a = \delta_a a$. We then solve for the equilibrium δ_a.

From equations (12) and (13) we can write

$$\lambda_1 = \frac{2n}{n^2\delta_a^2\sigma_a^2 + 4\sigma_\epsilon^2}, \tag{17}$$

and

$$\lambda_2 = \frac{2n}{n^2\delta_a^2\sigma_a^2 + 2\sigma_\epsilon^2}. \tag{18}$$

Substituting (12) and (13) into (8) we can solve explicitly for δ_a:

$$\delta_a = \frac{\sigma_\epsilon(n-2)^{\frac{1}{2}}}{\sigma_a n}. \tag{19}$$

Using (8), (17), (18), and (19) it is straightforward to show that a-speculators receive strictly positive utility from trade.

This characterizes the equilibrium of the trading sub-game if all speculators become informed about a. Would any speculator wish to follow an a-speculator who deviated and learned b? The answer is no: n_a would still be greater than n_b, no b-speculator would trade, and so his expected utility would be zero.

We can therefore support a research equilibrium in which all speculators become informed about a. By an analogous argument we can also support a research equilibrium in which all speculators become informed about b. Thus, there are two herding equilibria in which all speculators choose the same strategies.

Finally, consider the only other possible research equilibrium: $n_a = n_b = \frac{n}{2}$. Although expected utilities are equal, the allocation is not stable. Suppose a speculator deviated and studied b rather than a. Now, $n_b > n_a$ and it does not pay for a-speculators to trade on a; they all have zero expected utility. Every a-speculator would now want to learn b instead of a.

We summarize these results in the following proposition.

Proposition 2: If speculators have short horizons ($\alpha = 0$), the only stable research equilibria are herding equilibria in which either all speculators learn a or all speculators learn b.

3.3. Equilibrium with intermediate horizons

The first two propositions focus on extreme cases in which speculative demands are based either on very long or very short horizons. In practice, traders' demands are likely to reflect both short- and long-run considerations. If, for example, there is uncertainty about whether news will come out between a speculator's transactions, speculative demands will contain both short- and long-horizon components. We therefore examine the intermediate case in which $0 < \alpha < 1$.

Recall that in any research equilibrium it is necessary that: *i*) a-speculators satisfy their first order conditions given in (9), and similarly for b-speculators; *ii*) market makers set market depth according to equations (12) and (13); and *iii*) neither type of speculator has an incentive to deviate and study the other source of information. If these three conditions are satisfied with a positive number of traders studying each type of information, $n_a > 0$, $n_b > 0$, then we must have that the utility levels of both types of traders are equal, $EU_a = EU_b$.

In order to determine the equilibrium in the trading sub-game, we solve (9) for symmetric trading strategies. This yields:

$$\delta_a = \frac{2\alpha}{\lambda_1 + \alpha\lambda_2 + (\lambda_1 - \lambda_2 + 2\alpha\lambda_2)\frac{n_a}{2}}, \tag{20}$$

and a comparable expression for b-speculators. These expressions, along with equations (12) and (13), form a set of four nonlinear equations in the unknowns, λ_1, λ_2, δ_a, and δ_b. We have so far been unable to derive explicit solutions for these variables with $0 < \alpha < 1$. Consequently, we have solved the model numerically. The solution exhibits the following features which we believe are general.

Conjecture 1: If $\alpha > \alpha^*$ there is a unique research equilibrium which is informationally efficient. If $0 < \alpha < \alpha^*$, then there are two stable research equilibria, both of which are informationally inefficient.

Conjecture 1 indicates that interior αs behave in ways similar to the extremes discussed in Sections 3.1 and 3.2 above: for α large the equilibrium is unique and efficient, for α small there are two herding equilibria both of which are inefficient. In addition, for small α the utilities of a- and b-speculators are equal at the informationally efficient allocation of research. However, just as in Section 3.2, this allocation is not a stable equilibrium.

Figures 1 and 2 help to understand the intuition behind the conjecture. They are constructed for an example in which $n = 20$, $\sigma_a^2 = \sigma_b^2 = \sigma_\epsilon^2 = 1$. In Figure 1, $\alpha = .25$; in Figure 2 $\alpha = .05$. In this example a and b are equally informative about v. Consequently, it is informationally efficient for half the speculators to study a and half to study b.[10]

On the figures' vertical axes are the levels of expected utility for a-and b-speculators. On the horizontal axes are the number of speculators informed about a, n_a, holding the total number of speculators n fixed.

[10] None of the qualitative properties of the conjecture appear to depend on the specific parameters used in constructing the Figures.

Figure 1 shows the expected utility levels of a- and b-speculators for a "large" value of α. Expected utility is clearly decreasing in the number of similarly-informed traders; for large values of α the usual "contrarian" effects in research dominate. The equilibrium with $EU_a = EU_b$ occurs at $n_a = \frac{n}{2}$. To see that this allocation is stable, and hence an equilibrium, suppose that more than half the speculators choose to study a, so that $n_a > n_b$. The figure shows that this conjectured allocation leads to $EU_a < EU_b$. Individual speculators would therefore strictly prefer to study b, pushing the distribution of information back toward $n_a = n_b$. An allocation in which $n_a > n_b$ cannot be an equilibrium, nor could an allocation in which $n_b > n_a$. In sum, even though speculators may trade out at short horizons before new informed speculators arrive, the negative spillovers and strategic substitutability effects can dominate, yielding an equilibrium that is similar to those in other information-based asset pricing models.

Figure 2 depicts the corresponding levels of utility when α is small. Expected utility is no longer monotonic in the number of similarly-informed traders. Indeed, it is increasing (which implies that the positive spillovers and strategic complementarities are dominant) when the allocation of information is approximately symmetric.

There are now three interior points at which $EU_a = EU_b$ in Figure 2. The efficient allocation $n_a = \frac{n}{2}$ is not a stable equilibrium: if a small number of b-speculators deviated to study a, others would want to follow suit since EU_a is positively sloped in the neighborhood of $\frac{n}{2}$. In contrast, the two other intersection points in Figure 2, designated as A and B, are equilibria. To see this, consider the A equilibrium. If a small number of additional b-speculators deviated to study a, others would *not* want to follow suit since EU_a is downward sloping in the neighborhood of A. Similarly, if a small number of a-speculators considered deviating to study b, they would make themselves worse off, and therefore other a-speculators would not wish to deviate. These herding equilibria are clearly inefficient. Note also that expected utility is much lower than at the efficient symmetric allocation. If α is smaller than in Figure 2, then the herding equilibria become more extreme, eventually reaching the points $n_a = n$ and $n_b = n$ – as we found in Section 3.2, where α was zero. If α is sufficiently large, then the herding equilibria eventually disappear, and the efficient allocation becomes the unique equilibrium.

4. Trading on Noise

In the discussion above, we assumed that a and b are components of v – each piece of information is actually helpful in predicting fundamental value. In this section, we relax this assumption. We ask whether the informational spillovers are strong enough to make possible herding on information *that is completely unrelated to fundamentals.*

Suppose that n_v traders know v and that $n_c = n - n_v$ traders know a variable c which is independent of fundamentals. Utility of v-speculators is essentially as discussed in earlier sections: it is given by (5), with a replaced everywhere by v. Similarly, the ith v-speculator's – or "fundamentalist's" – demand is given by an expression analogous to (9), which in the symmetric case $q_v^i = \bar{q}_v$ can be written as:

$$q_v^i = \frac{2\alpha v}{\lambda_1 + \alpha\lambda_2 + (\lambda_1 - \lambda_2 + 2\alpha\lambda_2)\frac{n_v}{2}} \equiv \delta_v^i v. \tag{21}$$

The comparable expression for the "chartist" trader who learns c is slightly different.[11] Because c is uncorrelated with v, the ith chartist's expected utility conditional on observing c is given by:

$$U_c^i = q_c^i \left\{ -\alpha\frac{\lambda_1 + \lambda_2}{2}\left(q_c^i + \bar{q}_c(\frac{n_c}{2} - 1)\right) + \frac{(1-\alpha)}{2}\left((\lambda_2 - \lambda_1)\bar{q}_c\frac{n_c}{2} + \lambda_1(\bar{q}_c - q_c^i)\right)\right\}, \tag{22}$$

which can be obtained from (5) by replacing a with c and noting that c is independent of v.

It is clear from (22) that chartist traders will not want to trade if α is sufficiently near one. If there is a high probability that speculators will sell out at a price equal to fundamentals, v, then chartists – who cannot forecast any component of v – would consistently lose money if they were to trade. Thus, chartists can participate in a trading sub-game only if there is a sufficiently high probability that they will be selling out before all information becomes public.

[11] Chartism is one example of trading on information unrelated to underlying value, or "noise." For a different model of the interaction between chartists and fundamentalists see Frankel and Froot (1989)

Assuming a symmetric equilibrium in the trading sub-game ($q_c^i = \bar{q}_c$), the first-order condition for the ith chartist implies:

$$\frac{\lambda_1 + \alpha\lambda_2}{\lambda_2 - \lambda_1 - 2\alpha\lambda_2} = \frac{n_c}{2}. \tag{23}$$

As in the example of Section 3.2 in which $\alpha = 0$, the speculators' first-order conditions do not pin down the amount they trade.

The market makers' problem is slightly changed, because v covaries only with the component of the order flow attributable to fundamentalists. Thus, market makers now set market depth parameters, λ_1 and λ_2, according to:

$$\lambda_1 = \frac{\text{cov}[v, F_1]}{\text{var}[F_1]} = \frac{2\delta_v n_v \sigma_v^2}{\delta_v^2 n_v^2 \sigma_v^2 + \delta_c^2 n_c^2 \sigma_c^2 + 4\sigma_\epsilon^2}, \tag{24}$$

$$\lambda_2 = \frac{\text{cov}[v, \frac{F_1+F_2}{2}]}{\text{var}[\frac{F_1+F_2}{2}]} = \frac{2\delta_v n_v \sigma_v^2}{\delta_v^2 n_v^2 \sigma_v^2 + \delta_c^2 n_c^2 \sigma_c^2 + 2\sigma_\epsilon^2}, \tag{25}$$

Of course, as before we have that with informed trading $0 < \lambda_1 < \lambda_2 < 1$.

As we have already mentioned, chartists cannot trade profitably in the pure long-horizon case, $\alpha = 1$. As a result, when $\alpha = 1$, there is a unique research equilibrium in which all speculators study fundamentals, $n_v = n$. Next, consider the pure short-horizon case in which $\alpha = 0$. In Proposition 2 above we found that the only equilibria in the trading sub-game are where all active speculators trade on the same information. With chartists and fundamentalists, it is clear that if all informed traders know v, they will trade with demands given by (21) and $\alpha = 0$. However, there can be no active trading equilibrium when all speculators are chartists. To see why, note that if all n speculators know nothing about fundamentals, then the order flow is completely uninformative about v, and market makers set $p_1 = p_2 = 0$. It follows that chartist trade cannot generate positive profits. Thus, when $\alpha = 0$, there is a unique equilibrium in which speculators trade – the efficient equilibrium of $n_v = n$.

Although it is not possible to support chartist trading with either pure short- or long-horizons, chartists will wish to trade for a range of intermediate horizons. For small, but positive α, speculators have a chance of trading out at v. Fundamentalists therefore have an incentive to trade, regardless of their number. However, once there are fundamentalists actively trading, the order flow is at least partly informative about v, so that $\lambda_2 > \lambda_1 > 0$. This can create room for chartists to trade profitably, provided there are enough of them to move the price with c in the short run.[12] We prove the following proposition in the appendix:

Proposition 3: If $n_c > n_v$ and α is sufficiently small, then there exists an equilibrium in the trading sub-game in which *both* chartists and fundamentalists submit positive market orders and earn positive expected profits $(EU_c^i > 0)$. Since chartists trade actively, this equilibrium is inefficient. There is a second trading equilibrium in which fundamentalists trade actively, but chartists do not. This latter equilibrium is efficient given n_v.

The positive spillovers and strategic complementarities allow chartists in the aggregate to bootstrap their way into profitable trading. Given that other chartists are trading, each expects the price to move with c and therefore each trades actively.[13]

Proposition 3 suggests that if a large enough number of traders are endowed with information about c, they will trade on it and earn profits. It does not say, however, that speculators will actually *choose* to study c if they could instead learn v. On the basis of numerical simulations, we state the following conjecture:[14]

Conjecture 2: If α is sufficiently small, then there exists an inefficient research equilibrium in which n_v traders choose to study v and $n_c > n_v$ traders choose to study c. For all values of α there exists an efficient research equilibrium in which all speculators choose to study v.

Figures 3 and 4 help to understand the intuition behind this conjecture. Once again, the vertical axes measure traders' expected utility levels, EU_v and EU_c, and the horizontal axes measure the number of chartist speculators n_c, given n. As before, the figures are

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[12] The presence of chartist trade itself makes the order flow less informative about v, and therefore increases the aggressiveness with which fundamentalists trade. If there are too many fundamentalists (a sufficient condition for which would be $n_v > n_c$) they will trade so aggressively as to make it unprofitable for chartists to trade at all ($U_c^i \leq 0$).

[13] The potential for traders who reduce the informational efficiency of prices to "create their own space" for profitable activity is also seen in Stein (1987) and DeLong et. al. (1990a).

[14] Numerical solutions were required because we have not been able to derive explicitly the roots of the polynomial expression given by $EU_c = EU_v$.

constructed for an example in which $n = 20$, $\sigma_a^2 = \sigma_b^2 = \sigma_\epsilon^2 = 1$; in Figure 3, $\alpha = .015$, and in Figure 4 $\alpha = .005$. Note that we graph only the relevant range, $n_c > \frac{n}{2}$.

Figure 3 demonstrates the case in which horizons are relatively long-term, i.e., α is relatively large. It is immediately clear that $EU_v > EU_c$, regardless of the number of traders informed about each. Nevertheless, chartists receive positive utility from trading and therefore trade actively, provided that n_c is sufficiently greater than n_v. However, once we allow speculators to choose which source of information to study, none chooses c. The only research equilibrium is $n_c = 0$, where all traders choose to study v.

Figure 4 is a comparable graph for the case in which α is relatively small. Here it is unlikely that new outside information arrives before the current v and c traders sell. As a result the informational complementarities are a more important factor in determining expected utility levels. As before, there is an efficient research equilibrium (not shown on the graph) where all traders choose to study v, $n_c = 0$. Note, however, that if speculators conjecture that a majority will become chartists, then there are two other points, shown in the graph, at which expected utilities are equalized. The point with fewer chartists is an unstable allocation: since EU_c is upward sloping at this point, v-speculators would wish to emulate an initial v-speculator who deviated and studied c. By contrast, the point labelled C in the figure is an equilibrium. Here, similar deviations would not induce others to follow. Interestingly, at point C, n_c is much greater than n_v: *if c is studied at all in equilibrium, the majority of traders will want to study it, even though c is completely unrelated to fundamental value.*

5. Discussion

5.1. Inefficiencies in markets with short-term trading

In typical models of informed trading, informational externalities are negative. In such models, which effectively feature speculators with long horizons, the returns to acquiring information fall as the number of other identically-informed traders increase. Negative externalities of this sort encourage contrarian information acquisition.

In contrast, our results are driven by *positive* informational spillovers: as more speculators study a given piece of information, more of that information disseminates into the market, and therefore, the profits from learning that information early increase. This implies that profit-maximizing speculators may choose to ignore some information about fundamentals. In equilibrium, speculators herd: they acquire "too much" of some types of information and "too little" of others.

There are other classes of models in which short-term speculation can lead to inefficiencies. The first – that of fads and noise trading – focuses on the implications of less-than-fully rational traders. DeLong, Shleifer, Summers, and Waldman (1990b), for example, features "positive- feedback" traders who predictably extrapolate past price trends. In their model, rational speculators can increase their overall profits by taking advantage of the short-horizon extrapolation of positive-feedback traders. In doing so they drive the asset price away from its fundamental value, further increasing their profits at the expense of positive-feedback traders.[15]

A second class of models in which inefficiencies arise from short-term speculative horizons is that of rational bubbles. These models employ only rational speculators, but prices nevertheless exhibit extraneous fluctuations. Traders have short-term horizons in that they are not able to enforce infinite-horizon arbitrage conditions. As a result, prices may contain an extraneous component which grows at the discount rate. If this component is present, the market will be "stuck" on an inefficient path along which prices eventually explode. The efficient equilibrium is also possible: if the initial price is equal to its present value level, then the bubble can never get started.

[15] Frankel and Froot (1989) present a model in which optimizing portfolio managers must choose between the advice of rational fundamentals traders and chartists.

One problem with this latter type of model is that it offers no mechanism for what drives the market away from efficiency. Indeed, in bubble models sensible candidates would if anything drive the economy toward the *efficient* allocation. The infinite-horizon transactions that are ruled out by assumption in such models become hugely profitable as the bubble – the wedge between prices and the present value of fundamentals – explodes. It is easy to believe that agents facing very large wedges would attempt such transactions, which by induction would eliminate bubble-type inefficiencies from the start. Our approach may be preferable in this regard, in that the positive spillovers drive the market away from the efficient outcome.

5.2. An infinite-horizon extension

As noted in Section 2, there would be no herd behavior in the current formulation of the model if were certain that a new group of informed speculators will enter at date 3. However, our model could be extended so as to handle overlapping generations of informed traders without losing the principal results. One possibility is an infinite-horizon, steady-state approach which we describe briefly.

Suppose that at the beginning of each period there are k pieces of information that speculators can study. At the end of the period, one of these pieces of information will be publicly announced, although it is not known initially which it will be. At the beginning of the next period a new piece of information, which was previously impossible to learn about, is then available to be studied. For example, suppose that a company is always engaged in k R&D projects, about which speculators may learn. In each period, one project reaches a conclusion and its results are revealed publicly, although speculators cannot predict in advance which project it will be. In the next period a new project is begun in its place.

Under these circumstances, herding equilibria like those described above can arise. Suppose that each generation herds on a single piece of information. At the time they make this choice, they are uncertain about what the next generation will happen to herd on. To see that this is an equilibrium, consider an individual speculator's incentive to deviate from the herd by studying a different piece of information. He can profit from the deviation only if the piece of information that he alone studies is publicly revealed or if the next generation herds on it. If k is large, neither outcome is likely, and his incentive to deviate is small.[16]

5.3. Empirical implications

Because the mechanism driving our results is different from that in related models, it has different empirical implications. First, our model implies that prices will follow a random walk: no publicly available information will help in predicting future price changes. (Of course, informed traders can partially predict future price changes because their information has not been impounded fully into prices.)

Second, the model can help to make sense of the often puzzling behavior of many market participants. In practice, short-term traders often use forecasting methods that appear at best tangentially related to fundamental values. Chartism is one example of such a method. Economists and even traders seem to agree that there are better methods of determining long-run value. Yet, the very fact that a large number of traders use chartist models may be enough to generate positive profits for those traders who already know how to chart. Even stronger, when such methods are popular, it is optimal for speculators to *choose* to chart. They rationally ignore opportunities to learn about v, the realization of which is a distant "five steps ahead." Such an equilibrium persists even if chartist methods contain no relevant long-term information.

The herding equilibria also suggest that traders may focus on different variables at different times. For example, in the infinite-horizon model above, each new generation of speculators switches to studying an entirely different source of information. This kind of behavior sounds reminiscent of markets which track certain variables closely for short periods of time. Of course, if the underlying valuation model is changing, one would expect this type of behavior anyway, but it seems to us that the market's romance with individual variables is often extremely brief and only tenuously connected with underlying fundamentals.

5.4. The Welfare Effects of Short Speculative Horizons

Short speculative horizons can affect social welfare through two distinct channels.

[16] Note that even in this infinite-horizon model, the herding equilibria are in no sense bubbles – the price is always equal to the expectation of present value (conditional on some information set) and no transversality conditions are violated.

First, short-term trading can, as we have demonstrated, have a direct negative impact on the informational quality of asset prices. This in turn can lead to less-informed allocational decisions if agents look to asset prices to guide production decisions.

Second, short-term trading can induce managers to spend too much time improving performance measures that the market happens to focus on and too little time on measures that the market ignores. To see this suppose that the manager is compensated on the basis of the firm's current stock price and that he can allocate his time between trying to increase the mean of a (say, current earnings) or of b (the benefits from R&D). Suppose also that long-run value is maximized if the manager devotes half his time to each.

If speculators all herd on a and none choose to study b, then the manager will spend all his time on a and ignore b. In this sense, managers have no choice but to sacrifice long-run value if they are to boost the current stock price.[17] Short-sighted speculative horizons may therefore drive short-sighted managerial behavior. Note that this inefficiency does not stem from market mispricing: the stock price is indeed the present value of expected fundamentals. As a result, the usual tests of "weak-form" efficiency may not be able to uncover the research inefficiencies that drive short-run managerial behavior.

[17] Stein (1989) presents a model in which managers face a similar tradeoff, except that he assumes that b is inherently unobservable. The model above demonstrates that even if the market *could* learn about b, it may not choose to do so.

6. References

Admati, Anat, and Paul Pfleiderer, "A Theory of Intraday Trading Patterns," *Review of Financial Studies,* 1 (Spring 1988), 3-40.

Blanchard, Olivier J., and Mark W. Watson, "Bubbles, Rational Expectations, and Financial Markets," in *Crises in the Economic and Financial Structure,* edited by Paul Wachtel. Lexington, MA: Lexington Books, 1982.

Bulow, Jeremy, John Geanakoplos, and Paul Klemperer, "Multimarket Oligopoly: Strategic Substitutes and Complements," *Journal of Political Economy,* 93 (June 1985), 488-511.

Cooper, Russell, and Andrew John, "Coordinating Coordination Failures in Keynesian Models," *Quarterly Journal of Economics,* 53 (August 1988), 441-464.

DeLong, J.B., Andrei Shleifer, Lawrence Summers, and Robert Waldman, "The Economic Consequences of Noise Traders," *Journal of Political Economy,* (forthcoming 1990a)

DeLong, J.B., Andrei Shleifer, Lawrence Summers, and Robert Waldman, "Positive Feedback Investment Strategies and Destabilizing Rational Speculation," *Journal of Finance,* (forthcoming 1990b).

Farrell, Joseph and Garth Saloner, "Standardization, Compatibility, and Innovation," *RAND Journal of Economics* 16, (Summer 1985).

Frankel, Jeffrey A. and Kenneth A. Froot, "Chartists, Fundamentalists, and the Demand for Dollars," in *Policy Issues for Interdependent Economies* (MacMillan: London), Anthony Courakis and Mark Taylor, eds., 1989.

Grossman, Sanford J., "On the Efficiency of Competitive Stock Markets Where Traders Have Diverse Information," *Journal of Finance,* 31 (May 1976).

Grossman, Sanford J., and Joseph E. Stiglitz, "On the Impossibility of Informationally Efficient Markets," *American Economic Review,* 70 (June 1980), 393-408.

Hellwig, Martin, F., "On the Aggregation of Information in Competitive Markets," *Journal of Economic Theory*, 22 (June 1980), 477-98.

Holmstrom, Bengt and Joan Ricart i Costa, "Managerial Incentives and Capital Management," *Quarterly Journal of Economics*, 101, (November 1986), 835-860.

Katz and Shapiro (1985), " Network Externalities, Competition, and Compatibility," *American Economic Review*, 75 (1985) 424-440.

Keynes, John M., *The General Theory of Employment, Interest and Money*, (London: Macmillan), 1936.

Kyle, Albert S., "Continuous Auctions and Insider Trading," *Econometrica*, 53 (November 1985), 1315-36.

Narayanan, M.P., "Observability and the Payback Criterion," *Journal of Business*, 58 (July 1985), 309-323.

Pagano, Marco, "Endogenous Market Thinness and Stock Price Volatility," *Review of Economic Studies*, 56 (1986), 269-288.

Scharfstein, David S., and Jeremy C. Stein, "Herd Behavior and Investment," forthcoming *American Economic Review*, (June 1990).

Shleifer, Andrei and Robert Vishny, "Equilibrium Short Horizons of Investors and Firms," University of Chicago (August 1989).

Stein, Jeremy C., "Informational Externalities and Welfare-Reducing Speculation," *Journal of Political Economy*, 95 (December 1987), 1123-45.

Stein, Jeremy C., "Efficient Stock Markets, Inefficient Firms: A Model of Myopic Corporate Behavior," *Quarterly Journal of Economics*, 104 (1989), 655-670.

Tirole, Jean, "On the Possibility of Speculation Under Rational Expectations," *Econometrica*, 50 (1982), 1163-1182.

Verrecchia, Robert, "Information Acquisition in a Noisy Rational Expectations Economy," *Econometrica*, 50, (November 1982) 1415-1430.

7. Appendix

Proof of Proposition 1. We can write the social planner's problem as:

$$min_{n_a,n_b}\frac{1}{2}E(v-\lambda_1F_1)^2+\frac{1}{2}E(v-\lambda_2F_2)^2. \tag{A.1}$$

The choice of n_a and n_b affects λ_1, λ_2, F_1, and F_2. Thus, the derivative of expression (A.1) with respect to n_a (recognizing that $n_a = n - n_b$ is given by:

$$E\left((v-\lambda_1F_1)(\frac{d\lambda_1}{dn_a}F_1+\frac{1}{2}(q_a-q_b))\right)+E\left((v-\lambda_2F_2)(\frac{d\lambda_2}{dn_a}F_2+\frac{1}{2}(q_a-q_b))\right). \tag{A.2}$$

The market depth parameter λ_t is chosen so that the price $p_t = \lambda_tF_t$, is the best forecast of value, i.e., λ_t minimizes $E(v-\lambda_tF_t)^2$, $t = 1,2$. Thus, the optimal λ_t sets $E(v-\lambda_tF_t)F_t = 0$. (Note, this equation implies $\lambda_t = \mathrm{cov(v,F_t)/var(F_t)}$ which we used in solving for λ_t. Using this expression, (A.2) becomes:

$$\frac{1}{2}E\left((v-\lambda_1F_1)+(v-\lambda_2F_2)\right)q_a-\frac{1}{2}E\left((v-\lambda_1F_1)+(v-\lambda_2F_2)\right)q_b. \tag{A.3}$$

The first term is the expected utility from learning a and the second term is the expected utility from learning b. These are equal in the research equilibrium so the social planner maximizes the informativeness of prices by choosing the equilibrium allocation.

Proof of Proposition 3. The first-order condition for c-speculators, (23), can be rewritten as $\lambda_2 = k\lambda_1$, where $k = \frac{2+n_c}{n_c-2\alpha(n_c+1)} > 1$. Using this expression, the first-order condition for v-speculators (21), and the market makers' optimal forecasts in (24) and (25), we can solve for the four endogenous variables, δ_v, δ_c, λ_1 and λ_2 as functions of α, n_v and n_c. Algebra yields:

$$\delta_v=\left(\frac{\sigma_\epsilon^2k_1}{n_v\sigma_v^2(k-1)}\right)^{1/2}, \tag{A.4}$$

$$\delta_c=\left(\frac{\sigma_\epsilon^2k(2-k_1n_v)-4(k-1)}{n_c^2\sigma_c^2(k-1)}\right)^{1/2}, \tag{A.5}$$

$$\lambda_1=\left(\frac{k_1(k-1)n_v\sigma_v^2}{k\sigma_\epsilon^2}\right)^{1/2}, \tag{A.6}$$

$$\lambda_2=\left(\frac{k_1(k-1)n_v\sigma_v^2}{\sigma_\epsilon^2}\right)^{1/2}, \tag{A.7}$$

where $k_1 = \frac{2\alpha}{(1+\alpha k)(1-\frac{n_v}{n_c})} > 0$. These expressions can be substituted into the expressions for expected utility:

$$EU_c=\frac{\delta_c^2\sigma_c^2(\lambda_2-\lambda_1-2\alpha\lambda_2)}{4}, \tag{A.8}$$

$$EU_v = \alpha\delta_v\sigma_v^2 + \frac{\delta_v^2\sigma_v^2(\lambda_2 - \lambda_1 - 2\alpha\lambda_2)}{4}. \tag{A.9}$$

Note that as n_c approaches n_v from above, the term k_1 becomes infinite. From (A.4) this would imply that v-speculators become infinitely aggressive, and from (A.5) that the aggressiveness of c-speculators would fall below zero. If both c- and v-speculators are to trade we require that both δ_c and δ_v be positive (this is equivalent to requiring that EU_c and EU_v be positive). Algebra verifies that a sufficient condition for this to be true is that $n_c > n_v$ and that $\alpha < 1/2$. This proves the first part of Proposition 3.

If $n_c < n_v$, a trading equilibrium exists in which $n_c = 0$. To see this use (A.4), (A.6) and (A.7) with $n_c = 0$ to show that $\delta_v^2 > 0$, and therefore that $EU_v > 0$. This proves the second part of Proposition 3.

Figure 1
Equilibrium when traders have relatively long horizons

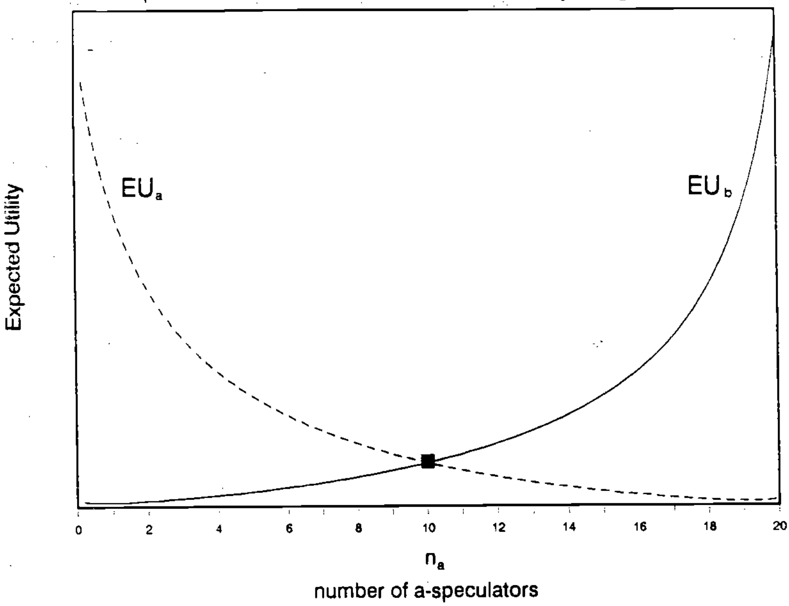

Figure 2
Equilibrium when traders have relatively short horizons

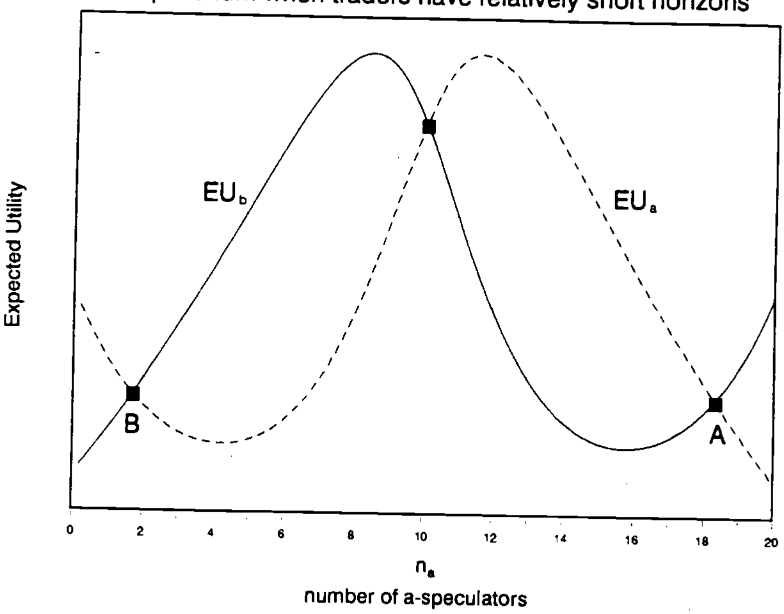

Figure 3

Equilibrium when fundamentalists and chartists have relatively long horizons

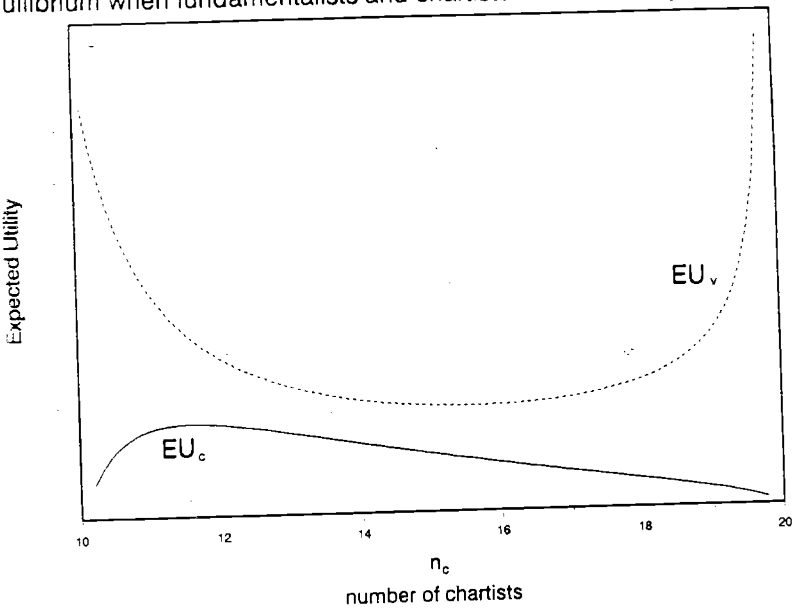

Figure 4
Equilibrium when fundamentalists and chartists have relatively short horizons