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Does Herd Behavior Make the Market More Efficient?

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Abstract: This study aims to analyze information asymmetry, uncertainty to market efficiency, information asymmetry, uncertainty to herd behavior, and herd behavior to market efficiency. This study examines the gap of previous research by the testing mechanism of disseminating information using experimental design. Therefore, the relationship between herd behavior and stock market efficiency can be clearly analyzed. It exercised an experimental design that includes a stock market treatment with the help of Hand-run Double Auction software. The analytical method used was the mean difference test, which shows that information asymmetry results in herd behavior occurrence, whereas market uncertainty does not cause herding. This contrasting situation also occurs when discussing the effect of information asymmetry and market efficiency uncertainty. The experiment used informants who acted as investors and totaled 60 persons. The simulation was divided into five sessions with different manipulations. The results show that uninformed investors who knew the price formation information could quickly adjust their investment decisions. Compared to uninformed investors, the insiders' inefficient predicted prices supported the fact that uninformed investors became smarter in capturing information contained in actual prices through trading running texts. Meanwhile, uncertainty negatively affects market efficiency, and herd behavior positively affects market efficiency. When communication permitted and herd behavior was detected, the market became more efficient. Some of the research results are contrary to the empirical studies due to smarter investors and the individual investors' learning process. The psychological factors of each investor can also influence investment decision-making.

Keywords: experimental design, information asymmetry, uncertainty, herd behavior

从众行为会让市场更有效率吗？

摘要：本研究旨在分析信息不对称、市场效率的不确定性、信息不对称、从众行为的不确定性以及从众行为对市场效率的影响。本研究通过实验设计传播信息的测试机制来检验以往研究的差距。因此，从众行为与股市效率之间的关系可以清晰地分析出来。它进行了一项实验设计，其中包括在手办双重拍卖软件的帮助下进行的股票市场处理。所采用的分析方法是均值差检验，表明信息不对称导致羊群行为的发生，而市场不确定性不会导致羊群行为。在讨论信息不对称和市场效率不确定性的影响时，也会出现这种对比情况。实验以知情人为投资者，共计 60人。模拟分为五个具有不同操作的会话。结果表明，了解价格形成信息的不知情投资者可以迅速调整其投资决策。与不知情的投资者相比，内部人士对价格的低效预测支持了这样一个事实，即不知情的投资者通过交易运行文本更聪明地捕捉实际价格中包含的信息。同时，不确定性对市场效率产生负面影响，从众行为对市场效率产生积极影响。当允许沟通并检测到从众行为时，市场变得更有

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效率。由于更聪明的投资者和个人投资者的学习过程，一些研究结果与实证研究相反。每个投资者的心理因素也会影响投资决策。

关键词：实验设计、信息不对称、不确定性、群体行为.

1. Introduction

The quality of a decision made depends on the quality of information that investors have. Not a few decision-makers make inappropriate decisions because of the low-quality information they have. The low-quality information held is likely caused by imperfect information spread, which leads to information asymmetry. The consequences of information asymmetry in the stock market have been widely examined, but the mechanism for information dissemination behavior and its relation to price formation are poorly understood.

When facing information asymmetry, investors may make bad decisions and stimulate information search because when making decisions, investors are influenced by information that will affect their confidence. Moreover, it is believed that these conditions can also stimulate the spread of misleading information and rumors, endorse noise trading and imitative behavior, and eventually cause herd behavior.

The behavior of copying other people's decisions and ignoring personal information can be defined as imitative behavior. Imitative behavior can lead to herd behavior if the decision-makers copy other investors' decisions. In fact, because of their human instinct, investors tend to know and copy what other investors are doing. Furthermore, people who regularly interact may have similar patterns of thinking and behavior where the actions of others are better than the decisions of individuals [1]. Investors ignore their personal information and act upon the signals received by observing the actions and judgments of other investors. Investors are confident that other investors have more accurate and reliable sources of information [2]. If herd behavior lasts longer and the stock prices fail to adjust towards their fundamental values, it may lead to an unstable market [3]. Herd behavior decreases heterogeneity between investors [4]. Herd behavior arises due to uncertain conditions, such as rumors and information asymmetry; allow it to be recreated in an experimental study so that it is possible to extract information about the behavioral processes.

The price formation by the tug-of-war between supply and demand is an integral part of market efficiency. A market is said to be efficient if all prices of securities fully and quickly reflect all relevant information. One of the things that can affect market efficiency is humans' or investors' behavior in the market, which is the key to stock price movements [5]. The possibility of the market becoming inefficient depends on the uncertainty of investors' irrational decisions [6]. Behavioral finance emphasizes the existence of market anomalies caused by emotional factors. It helps explain the psychological aspects of the relationship between investors' reasons for buying and selling stocks. Investor behavior that imitates other investors' decisions can increase market volatility and instability [7], price bubbles, and collapse. This research makes several contributions to the current literature. First, various research on herding has been conducted with empirical evidence that herding contributes to an inefficient market.

Individual cognitive profiles have different interactions based on the limited information they have. The high availability of information with a low number of transactions indicates that investors do not pay the same attention to publicly available information, causing uncertainty. A high level of uncertainty causes herd behavior. Therefore, the topic used in this study is still acceptable as a feasible model to be investigated. Stipulate empirical evidence regarding the impacts of market participation on investors' herd behavior in the Chinese stock market [8]: the test herd behavior and its impact on the NYSE, AMEX, and OTC markets.

Second, previous studies have not observed the subject; thereby, another experimental design approach is needed as an alternative solution. In this study, the experimental design replicated the research conducted by [9]. The novelty of this study is that the variables used are different from those used by [9], where this study uses group bias behavior, namely herding.

This study will fill the gaps in the existing literature by explaining the mechanism of disseminating information in depth by applying experimental design so that the relationship between herd behavior and stock market efficiency can be clearly analyzed. The specific objectives of this study are analysis of information asymmetry and uncertainty to make markets more efficient, analysis on information asymmetry and uncertainty that lead to herd behavior, and analysis on herd behavior to make the market more efficient using an experimental design. In this study, information asymmetry was simulated and manipulated to facilitate

the information and rumors spread, leading to herd behavior.

This study is organized as follows: we review relevant literature and explain the hypotheses used for testing in Section 2. Sections 3 and 4 present the data and methodology of this study. The empirical research results are described in Section 5. Section 6 summarizes the conclusions of this study.

2. Literature Review

2.1. Information Asymmetry

The information asymmetry hypothesis rationalizes the existence of imperfect information between market participants. Information asymmetry increases the risk of uninformed investors, and uninformed investors cannot really adjust their portfolios [10].

Information asymmetry describes information imbalances that create barriers to obtaining an accurate measure of assessing a company. Information asymmetry can occur because issuers get substantial rewards by exaggerating positive information [11]. Investors who are not entirely rational will be more prone to errors in decision-making because they have little information. Thus, information asymmetry stimulates information search by selecting detrimental and beneficial information from the investor's point of view [9].

The information asymmetry makes the company's return pattern difficult to predict and assess due to uncertainty. Uncertain conditions can trigger risks. Practically, we face much uncertainty in this world. As a simple example, it could or could not rain today. The uncertainty inherent in an investment instrument (stocks) is the stock price fluctuation influenced by market risk and the stock issuer's performance. Meanwhile, uncertainty concerning stock market conditions can be explained by the uncertainty of information on the stock market.

In uncertain contexts, investors tend to think that other investors have more information and important information than other investors. Thus, investors attempt to infer what information those other investors have by observing their decisions. Investors who are uncertain in responding to new information, the quality of the information, and the spread of misleading information led to noise trading.

2.2. Herd Behavior

The behavior of copying other people's individual decisions, so-called imitative behavior, is considered the beginning of herd behavior. Herd behavior can be defined as the actions of someone who imitates several people's decisions and ignores their personal information. The behavior describes how individuals in a group can move or act together without a pre-planned direction. It is considered the most pronounced behavioral biases demonstrated by imitating investment decisions intentionally and unintentionally [12]. Herding occurs when individuals ignore or underestimate their experiences and making them more concerned with the choices of other investors.

Herding occurs when an investor incurs informational losses that imitate other investors' trading decisions. The term refers to animals' behavior in herds and human behavior in activities such as stock market bubbles and crashes, street demonstrations, sporting events, religious gatherings, and daily decision making. In its most common form, herd behavior can be represented as a mass behavior pattern. This behavior is a form of individual interaction that regularly tends to think and behave the same way. In general, this behavior occurs when decisions are made under uncertain conditions. The herding theory's essence can be stated that an investor may ignore his private information in a trading sequence and choose action by following his predecessors [5].

2.3. The Relationship between Market Uncertainty, Herd Behavior, and Stock Market Efficiency

Uncertainty is a rational source of herd behavior. This behavior seems to be one of the principles of making shortcuts that humans often carry out when decisions must be made in uncertain conditions. Every individual involved in herd behavior realizes that most individuals' behavior does not necessarily contributes something significant to other individuals who have more accurate information because the behavior is pure imitation. Therefore, herd behavior can be vanished by other individuals who have more accurate information. The external shock from an individual with more accurate (or perceived accurate) information can change many individuals' behavior.

There is decision optimization behavior by investors who receive informational noise or rumors from other traders. Herd behavior may be influenced by the information spread that is noise or rumor dispersed between uninformed investors. The more informational noise or rumor, the higher market uncertainty is, and the higher the market uncertainty, the higher the probability of herd behavior to occur. Managers tend to follow the

majority to maintain and manage their portfolios in uncertain conditions [1].

The definition of an efficient capital market has been used in several contexts to describe the characteristics of capital market operations. A capital market is efficient when the stock prices adjust quickly to the arrival of new information so that the current stock prices reflect all information about the capital market. An efficient market will quickly and accurately reflect information on stock prices.

The term "all information" above refers to information about past and present events or events that have been announced but have not occurred yet. Market efficiency describes as the relationship between stock prices and information available to investors. An efficient market is defined as a condition in which the price of all securities quickly and fully reflects all relevant information, and it does not allow investors to beat the market or obtain profit levels above normal unless luck occurs.

Based on these arguments, the following hypotheses can be stated:

H1: Market uncertainty has a positive effect on the existence of herd behavior

H2: Market uncertainty has a negative effect on stock market efficiency.

2.4. The Relationship between Information Asymmetry and Uncertainty on Stock Market Efficiency

Herd behavior is a phenomenon that occurs due to information asymmetry and market uncertainty. The ambiguity of non-transparent information is a cause of uncertainty [13]. In this condition, ownership of investor information is heterogeneous or asymmetric. The phenomenon of information asymmetry is not in line with the efficient market assumption because certain investors are better informed than others in that market. Information is a key parameter in economic activity and acts as a key factor in market efficiency [10]. In this study, insiders refer to investors with public and private information about a company, while outsiders refer to investors who only have public information about a company signifying that insiders have more information than outsiders, leading to information asymmetry. Thus, when employees communicate with insiders or outsiders about the unpublished technical information under the audit procedures, they have the notion of information security to avoid negligent or excessive disclosure [13]. The more heterogeneous the information that investors have, the higher information asymmetry will be.

Although transactions are random and independent, there should also be differences in their predicted prices if there are differences in information ownership in a market.

Imperfect information needs to be evaluated because it affects investment decisions. Therefore, it is assumed that the stock price cannot correctly reflect all the available information because achieving this price balance requires enormous resources to obtain information. If information uncertainty prevails in the market, investors increase the level of risk for the information they get [10]. When risk increases, investors demand a higher return on investment resulting in a higher cost of capital for the company.

On the other hand, when information is relatively stable, there is almost no excess correlation. When market uncertainty is high, the efficiency level of the stock market will be lower. For example, in an IPO case, due to the uncertainty of the IPO company value, investors cannot fully identify high-value and low-value IPOs [11]; thereby, uncertainty increases information asymmetry and changes investors' price preferences in the capital market. Based on these arguments, the following hypothesis can be stated:

H3: Information asymmetry negatively affects stock market efficiency.

2.5. The Relationship between Herd Behavior and Stock Market Efficiency

The existence of herd behavior generates the difference in decision efficiency. When an individual can only observe his predecessor's actions, the resulting decisions are thought to be inefficient.

Trading in the context of an incomplete regulatory framework with high information asymmetry and limited information disclosure produces an investment environment that could facilitate herd behavior [12] because investors cannot rely on high-quality information concerning fundamentals.

Based on the causes of herd behavior, namely market uncertainty and information asymmetry that make the market more inefficient, herd behavior also causes the market to become more inefficient. Herd behavior makes the Vietnam market to be more inefficient [4]. Based on these arguments, the following hypothesis can be stated:

H4: Herd behavior has a negative effect on stock market efficiency.

3. Method

3.1. Research Instruments

The research instruments used in this study consist of two forms, namely computer program, and printout. The hand-run double auction program supported the application of the experimental design method in this study. The hand-run double auction is one of the most

eminent classroom experiments, and it can be used in various settings to illustrate several economic concepts. The HandDA program is another way to organize a hand-run double auction in the classroom and is not a computer network program that enables buyers and sellers to do transactions via computers.

The experimental design method exercised in this study was supported by the hand-run double auction (HandDA) program. HandDA is software in capital market experiments that can be used with various scenarios to illustrate the hypothesis to be tested. The software has various features of bids, asks, and trades information and data storage. The scenario prepared with the software through the distribution of information to informants or investors in the experiment will affect the supply and demand of the traded assets. In the HandDA software, investors are divided into two groups, namely buyers and sellers; as done by both buyers and sellers have different information but trade for similar assets. Supply and demand for assets were controlled through information for investors and the HandDA software to manipulate price movements to create market uncertainty over a certain period. A group chat for informants (investors) was also exercised to support the HandDA software so that researchers can provide general information to all informants and certain information to specific informants.

3.2. Manipulation Check

Manipulation check is intended to measure the experimental treatment effectiveness [14] and ascertain whether all subjects understand the entire experimental procedure and carry out the task correctly. To measure experimental treatment effectiveness, participants were given a questionnaire that asked questions regarding their understanding of the experimental manipulation and procedures. The questionnaire employed a 5-point Likert Scale from 1 (strongly disagree) to 5 (strongly agree). The questionnaire in printout form was given during the break between trading sessions.

3.3. Experimental Design

This present paper exercised experimental design research because determining the behavior of investors in making decisions requires direct observation. In this study, an experimental design, namely within-subject, was designed, with the experimental group acting as the control group [9]. The number of informants or investors in this study was sixty people. As explained in the research instrument, informants or investors were grouped into buyers and sellers, with each group consisting of thirty investors. The two groups were each further divided into three small groups so that the total number of small groups was six, consisting of ten people. Each group had leaders, namely IL, FR, BS, AM, FF, and DA. The six groups were formed to improve the dynamics of price movements. Meanwhile, group pressure was exercised as part of the personification of herding and the emergence of a group of insiders on the informants.

The instrument used for trading transactions was twelve imaginary stocks with initial letters A to L. Each stock had its characteristics. The actual price on all the stocks was determined using the imaginary value of 1 to 14 and did not use any currency. The use of initial stocks and imaginary prices aimed to give all investors a similar starting point. Besides, at the time of the transaction, each investor would not think that stock A is cheaper than stock B, and they were given incentives if, at the end of the session, they made a profit. This strategy was aimed to encourage investors to have the initiative or dare to take the opportunity to move and make decisions. The establishment of the session aimed at seeing the investors' response or movement with the treatment in the form of different information within each session; the experimental design features are summarized in Table 1.

Table 1 Experimental design summary

Activity	Duration (seconds)	Insiders Yes/No	Specification and Treatment through HandDA	Function of Session
Training	600	No	Training	Training
Session 1	1,500	No	● All traders have homogeneous information ● Communication between traders is not permitted	Baseline
Session 2	1,020	Yes	● All traders do not know anonymous insiders exist ● All traders have homogeneous information ● Communication between traders is not permitted	Test
Session 3	1,020	Yes	● All traders know anonymous insiders exist ● Communication between traders is not permitted ● All traders have identical information	Test

Session 4	1,200	Yes	● All traders know insiders exist ● Insiders are given more information than non-insiders ● Communication between traders is not permitted but allowed to receive informational noise	Test
Session 5	2,400	Yes	● All traders know insiders exist ● Insiders are given more information than non-insiders ● Communication between traders permitted	Test

The within-subject design aimed to compare the effect of different treatments on the same subject using repeated measures design. The experiment was carried out in six sessions, including one pre-baseline training session and five experimental sessions (including the baseline session).

Insiders were determined randomly from the sixty informants (investors), and between the informants, none knew who is and is not the insider. When trading, insiders received different information from non-insiders which implicated information asymmetry. Afterward, insiders were expected to move and make decisions based on their information and take advantage of information asymmetry. Moreover, researchers also manipulated impelled the market conditions by creating market uncertainty through price fluctuations and information gaps. In this case, HandDA was used to simulate the bid and ask on the trade. In Sessions 3-5, the researchers informed insiders in the group but did not reveal their identities so that outsiders did not know who the insiders were between them.

3.4. Analytical Methods

To test whether market efficiency is increasing due to herd behavior, when price predictions are carried out under uncertainty conditions and information asymmetry, the following procedures are required: (i) determining the test basis, (ii) detecting herd behavior, (iii) determining the deviation value, and (iv) conducting statistical mean difference test. Session 1 of this experiment is the basis of comparison for testing price efficiency affected by treatment, which is carried out in the subsequent sessions. The experimental results in this session are expected to be efficient market conditions. Informational price efficiency shows the homogeneity of the price prediction results and reflects all relevant information.

4. Results

4.1. Characteristics of the Research Subjects

The number of subjects or investors in this experiment was 60 subjects who had investment knowledge. The number of male investors was 40 (67%), and female investors were 20 (33%), with an average age of 20.83 years. The subjects' educational backgrounds varied: 50% were undergraduate students majoring in science, and the remaining 50% were majoring in social studies. Observing the condition of subjects who had investment management knowledge but had no real experience in stock trading is in line with the research expectations that require well-educated but poor experience investors (i.e., non-professional investors). Other factors that can affect the dependent variable, such as experience, can be reduced with such investors.

4.2. Manipulation Check

Manipulation checks were done to identify investor responses in understanding stock trading aspects after participating in stock simulations. When answering Question 1, which asked to what extent investors understand stock transaction instructions, subjects responded that they understand it, which is indicated by the response value above the mean (> 2.5), within 1 (strongly disagree) to 5 (strongly agree) range. When answering Question 2, the subjects stated that they had no difficulty predicting stock prices as indicated by the response value above the mean.

Table 2 Manipulation check results

No	Question	Mean
1.	I understand the instructions on how to trade stocks	4.33
2.	I do not find it difficult to determine a predictive price for a stock that is close to the stock price	4.17
3.	Information on price trends is very important & influences my decision in determining the stock price prediction	4.83
4.	New information influences my decision in determining the stock price prediction	4.83
5.	I cannot predict the duration of a condition will last due to good or bad news	4.33
6.	Among all experimental investors, I have a profit above the average	4.17
7.	I feel no pressure when determining a predictive price for the stock price	4.00
8.	The duration given for each round of trading sessions is adequate	2.33
9.	I feel that the training sessions provided are sufficient	4.17

Regarding manipulation in experiments related to stock prices (good and bad news), the subjects admitted that they could not predict the duration of a condition will last due to the new information provided. This result can be seen from values that are above the mean. Meanwhile, for the extra variable that needs to be controlled, the subjects stated that they did not feel any pressure when determining the stock price prediction (Question 7). This is in line with the research expectations, which signifies that the subject feels comfortable with the conditions during the experiment. Another reason is the disuse of the subjects' funds in this study. The subjects also felt that the duration given for

each session was adequate (Question 8), as evidenced by values that are below the mean. If the duration given is overly lengthy for the subjects, it is feared that the subjects get bored, making their price prediction results not optimal. Subjects also clearly understood the experimental procedures, as evidenced by values that are above the mean.

4.3. Analytical Results

4.3.1. Results of Research Experiments

Based on the experimental design (Table 1), five market situations (S-1 – S-5) resulted from five treatments are as follows:

The market situation which is the baseline in this study:

S-1: The market not treated (i.e., no insiders, homogeneous traders, and communication between traders not permitted).

In Session 1, all investors were homogenous traders and received the same information. This session's results indicate the experimental manipulation (treatment) in the subsequent sessions. The trading results of Session 1 can be seen in Fig. 1.

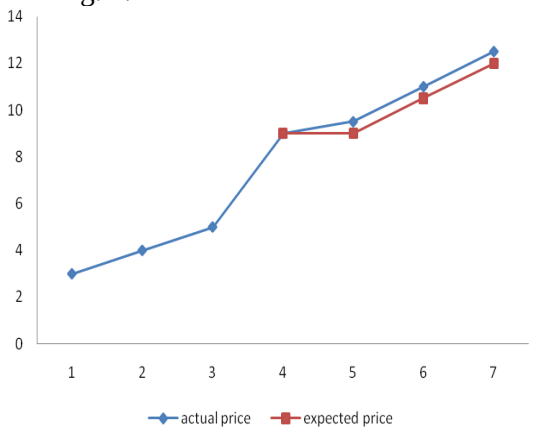

Fig. 1 Session-1 trading results (Primary data processing by researchers)

Note: The x-axis is the duration (seconds), and the y-axis is the price.

While it is evident that market prices can respond quickly to new information, there is also evidence of an overreaction, where the actual prices remained above the expected price following good news. The authors speculate that this is consistent with trading motivated by investors' diversity in taking risks but concede that there could be other explanations for this. Deviations from expected value pricing may be caused by uncontrollable factors (i.e., investor's degree of risk-taking, prohibition of short sales, and trade barriers caused by the computer program) and do not of themselves indicate informational inefficiency. When viewed from individual psychological factors, scrutinize that many people tend to overreact to information on dramatic and unexpected events. The results of this session are expected to show efficient market results, especially after providing good news.

The equilibrium price can be analyzed and tested by the deviation value determination procedure. Deviation (D_1^t) is defined as the absolute difference between actual (AP_1^t) and expected prices (EP_1^t), denoted $D_1^t = |AP_1^t - EP_1^t|$. The calculation is presented in Table 3.

Table 3 Session 1 descriptive statistics

Session	Type	Mean	SD	T	Difference of
1	D_1^t	0.4167	0.144	0.4743	D_1^t and 0

Fig. 1 exhibits that the mean in Session 1 was different from zero. Assuming no change in incentives to trade over the experiment, changes in mean deviation across sessions may indicate changes in informational efficiency prompted by the experimental treatments. This assumption is used because incentives to trade will encourage investors to act based on information. When investors act, changes in the average price during the session will occur to affect the deviation of the asset value from its intrinsic value.

Since normal risk and homogeneous expectations cannot be a basis for trade, expected value pricing cannot be used as a benchmark to measure market efficiency.

If both the actual and expected prices are non-stationary data I (1), this indicates that the two series must have a stationary I (0) co-integrating relationship Table 4). To generate sufficient observations for this test, an actual price and an expected price were allotted to each second of the session.

Table 4 Results of co-integration tests

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value 5 %	Critical Value 1 %
None *	0.588170	29.09783	25.32	30.45
At most 1 *	0.517802	13.12922	12.25	16.26

The sequential ADF (Augmented Dickey-Fuller) tests led to no unit root with an actual price of 1.14 and an expected price of 0.84.

Based on the results of the co-integration test given in Table 4, it appears that the trace statistic value is greater than the critical value of 5%. This result indicates that

actual and expected prices are co-integrated, and therefore, the market can be considered efficient.

S-2: The market is treated (i.e., All traders do not know anonymous insiders exist, all traders have homogeneous information, and communication between traders is not permitted).

In Session 2, a change in price formation was not expected to occur, but it was expected that insiders would earn higher profits than uninformed investors. Table 5 exhibits the profits earned by all investors across all experimental sessions. In this session, insiders earned greater profits than other investors, as expected. The experimental results in Session 2 are shown in Fig. 2.

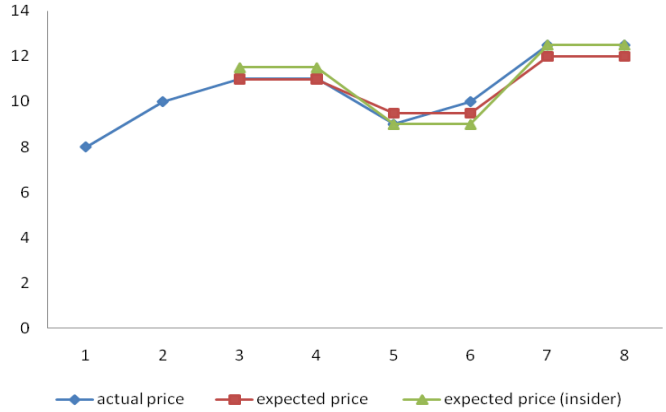

Fig. 2 Session -2 trading results (Primary data processing by researchers)

Note: The x-axis is the duration (seconds), and the y-axis is the price.

Table 5 Results for individual subjects; rank

I*	Session 1		Session 2		Session 3		Session 4		Session 5	
	p ($)	R	*p* ($)	R	*p* ($)	R	*p* ($)	R	*p* ($)	R
IL (1)	8.8	4	13.8	2	14.7	1	12.8	4	13.8	3
FR (2)	4.8	6	11.7	5	12.8	5	13.7	2	15.3	1
BS (3)	6.2	5	11.7	6	13.2	4	12.7	5	14.2	2
AM (4)	32.3	1	12.8	3	9.8	6	13.3	3	9.8	6
FF (5)	15.5	2	12.8	4	13.3	3	15.5	1	10.8	5
DA (6)	14.5	3	15	1	14.5	2	9.8	6	12	4

Note: I* - groups of ten investors per team; IL, FR, BS, AM, FF, and DA are team leaders' initial names, *p*($) - profit($), R - rank

When comparing Figures 2 and 1, it is evident that insider information was not effectively disseminated, and increased price volatility occurred. Interestingly, insiders were able to earn profit in price situations that were inconsistent with their own information, and insiders tried to disguise their status by not issuing strong price signals. This is supported by Fig. 2, which shows that the insiders' actual price does not always align with the expected price. The price set by insiders tends to be identical to non-insiders even though their position is far superior.

S-3: The market is treated (i.e., All traders know anonymous insiders exist, all traders have homogeneous information, and communication between traders is not permitted).

In Session 3, the existence of unknown insiders was informed. This fact was aimed to increase the informational transparency of the market by reducing the naivety of uninformed investors. Uninformed investors realized the existence of superior investors between them. Unknown insiders made other investors pay more attention to the trading screen information. Unusual price signals could identify the existence of unknown insiders. There is a small possibility of herd behavior occurring because it was found that investors follow insider decisions.

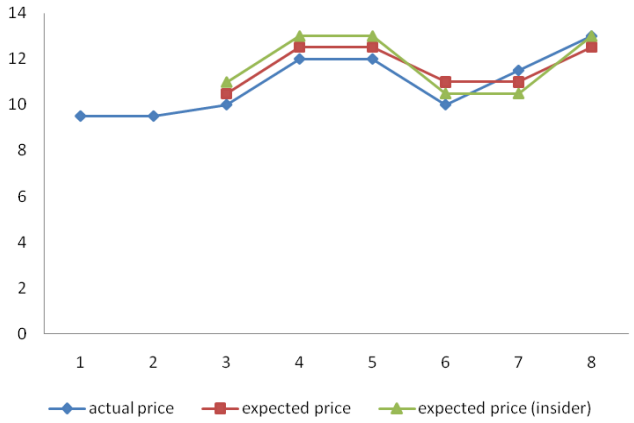

Fig. 3 Session-3 trading results (Primary data processing by researchers)

Note: The x-axis is the duration (seconds), and the y-axis is the price.

S-4: The market is treated (i.e., All traders know insiders exist, insiders have more information than other investors, communication between traders is not permitted, and traders are not allowed to receive rumors).

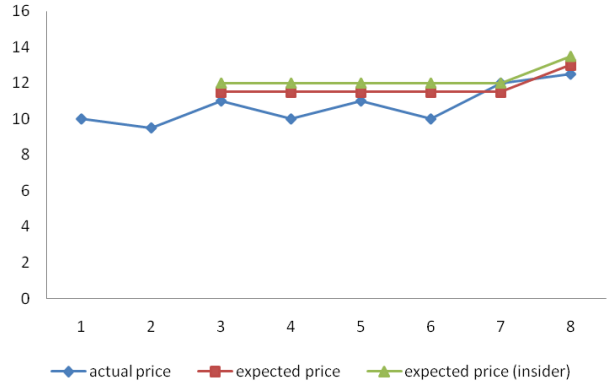

Fig. 4 Session-4 trading results (Primary data processing by researchers)

Note: The x-axis is the duration (seconds), and the y-axis is the price.

The existence of insiders in this session was aimed to give better informational transparency than the previous sessions. Assuming uninformed investors see insiders as investors with better information, and then uninformed decisions should be influenced by insiders' decisions. In this session, rumors were also spread to bring uncertainty

to the market. In these uncertain conditions, tests were conducted to examine whether uninformed investors follow the market information or imitate insiders' decisions.

Fig. 4 exhibits that herd behavior did not occur in this session. Even though not all of the information they believe is relevant in reality, uninformed investors still make decisions based on the information they believe. Uninformed investors' decisions could be based on investor psychological factors such as the level of confidence, desire to avoid losses, and short-term emotional factors.

S-5: The market is treated (All traders know insiders exist, insiders have more information than other investors, and communication between traders permitted)

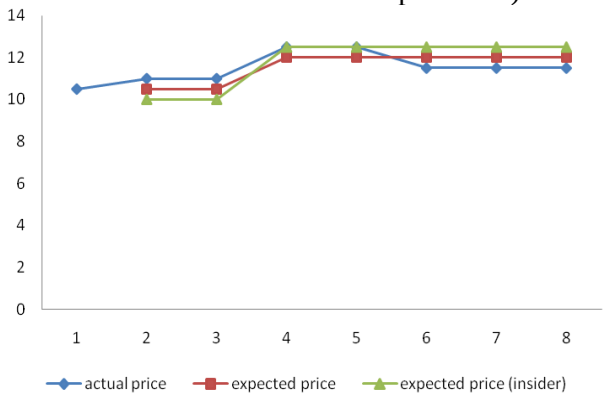

Fig. 5 Session-5 trading results (Primary data processing by researchers)

Note: The x-axis is the duration (seconds), and the y-axis is the price.

The transparency of information in the previous session was further refined by permitting traders to communicate freely. It was also tested whether free communication between traders decreases or increases the market's uncertainty. If insiders can communicate the extra information, then the information received by uninformed investors will be superior. Therefore, it was expected that uninformed investors would copy the insider decisions. Fig. 5 shows that herd behavior tendency to occur is very high because many uninformed investors made the same decisions as insiders.

4.3.2. Descriptive Statistics

Table 6 shows the descriptive statistics for all sessions. The table depicts the mean of the deviations for all sessions and the mean of the deviations of uninformed and insider investors for all sessions that have been manipulated.

Session 2: Notation of price deviation for uninformed and insider investors in Session 2 with DN_2^t and DI_2^t, where IP and NP are notations of the expected prices on insiders and non-insiders (uninformed). Table 7 shows the uninformed deviation for Session 2 DN_2^t is not significantly different from baseline D_1^t, a t-test for the difference between independent sample means, indicating little or no change in the process of price formation. This also occurs in the insider deviation for Session 2 DI_2^t with baseline D_1^t, indicating that the insiders were indirectly spreading their personal information to other investors. Insider conditions with the same market power as other investors or insiders who attempted not to show themselves can be one of the main reasons there was no significant difference between DI_2^t and baseline D_1^t.

Table 6 Descriptive statistics results for Sessions 1 to 5

Session	Investor Type	Mean	SD	t	Difference of
1	D_1^t	0.4167	1.581	0.4743	D_1^t and 0
2	D_2^t	0.167	0.289	1.342	D_1^t and D_2^t
	DN_2^t	0.333	0.289	0.447	D_1^t and DN_2^t
	DI_2^t	0.75	0.354	-1.265	D_1^t and DI_2^t
				-1.464	$DN_2^t$and DI_2^t
3	D_3^t	0.4375	0.125	-0.205	D_1^t and D_3^t
	DN_3^t	0.4375	0.125	-0.205	D_1^t and DN_3^t
	DI_3^t	1	0	0**	D_1^t and DI_3^t
				-4.025*	DN_3^t and DI_3^t
4	D_4^t	0.833	0.288	-2.236	D_1^t and D_4^t
	DN_4^t	0.833	0	0**	D_1^t and DN_4^t
	DI_4^t	1	1	-1	D_1^t and DI_4^t
				-0.145	DN_4^t and DI_4^t
5	D_5^t	0.3	0.283	0.635	D_1^t and D_5^t
	DN_5^t	0.333	0.235	0.506	D_1^t and DN_5^t
	DI_5^t	0.5	0.707	-0.164	D_1^t and DI_5^t
				-0.316	DN_5^t and DI_5^t

Note: D denotes the deviation per session, DN denotes the deviation for uninformed investors, and DI denotes the deviation for insiders. Mean Deviations were calculated as the mean of the absolute differences between averaged actual prices and expected prices.
* Significant at 0.005% level,
** Significant at 0.01% level. SD: standard deviation

Table 7 Results of Session-2 mean difference test

H_0	Calculation Results	Remarks
$H_0: D_2^t - D_1^t \geq 0$	0.167 – 0.4167 < 0	The existence of information asymmetry makes prices more efficient
$H_0: DI_2^t - DN_2^t \geq 0$	0.75 – 0.333 > 0	The insiders' predicted prices are less efficient compared to the uninformed ones.

Session 3: The existence of unknown insiders was announced to the market in this session. This situation was aimed to increase the informational transparency of the market by reducing the naivety of uninformed investors. Table 8 exhibits that insiders generate relatively high profits compared to others in this session.

Another surprising fact is that several uninformed investors were able to generate relatively high profits in this session.

Baseline deviation D_1^t and insider deviation DI_3^t are significantly different in this session, whereas when compared with uninformed deviation DN_3^t, the t-test results showed the opposite, indicating no difference.

Table 8 Results of Session-3 mean difference test

H_0	Calculation Results	Remarks
$H_0: D_3^t - D_1^t \geq 0$	0.4375 – 0.4167 > 0	With Information asymmetry through herd behavior, market prices are increasingly inefficient
$H_0: DI_3^t - DN_3^t \geq 0$	1 – 0.4375 > 0	With information asymmetry and herd behavior, the insiders' predicted prices are less efficient than the uninformed ones.

Session 4: This session was nearly the same as Session 3, except that the insiders had more information than other investors and insiders known to exist. In this session, it was expected that insiders get a higher profit than other investors. However, the fact shows the opposite, where insiders earned the lowest profit than the others because the market also received rumors in addition to getting more information. The rumors were meant to create uncertainty in the market. The existence of these rumors can influence the decisions of uninformed and insider investors. In this session, communication was not permitted; thus, the insiders could not share their information with other investors (Table 9).

Table 9 Results of Session-4 mean difference test

H_0	Calculation Results	Remarks
$H_0: D_4^t - D_1^t \geq 0$	0.833 – 0.4167 > 0	Market uncertainty without herd behavior makes market prices more inefficient.
$H_0: DI_4^t - DN_4^t \geq 0$	1 – 0.8333 > 0	When there is uncertainty and herd behavior, the insiders' predicted prices are less efficient than the uninformed ones.

Table 10 Results of Session-5 mean difference test

H_0	Calculation Results	Remarks
$H_0: D_5^t - D_1^t \geq 0$	0.3 – 0.4167 < 0	Information asymmetry and uncertainty through herd behavior make the market more efficient
$H_0: DI_5^t - DN_5^t \geq 0$	0.5 – 0.333 > 0	When information asymmetry and uncertainty cause herd behavior, the insiders' predicted prices are less efficient than the uninformed ones.

Session 5: In this session, the treatment given was almost the same as the previous session, except for allowing communication between investors. This situation was aimed to enable insiders to disseminate the extra information they have. According to Table 10, price deviation for insiders and uninformed traders was not significantly different from baseline in this session. Price deviation for insiders and uninformed traders are not significantly different, indicating that the insider's information has been disseminated to other investors.

5. Discussion

Market efficiency across sessions can be detected from the transaction's stock price deviation for the baseline session. For other treated sessions, market efficiency was detected by the deviation across sessions. The greater the deviation, the less efficient the market is. This present study examines whether when information asymmetry and market uncertainty occur, the market, either with herding or not, becomes increasingly inefficient. Hypothesis testing was carried out sequentially according to the order of the treated trading sessions (treatment).

Session 2: HE1 experimental hypothesis testing (when the market is in a condition of information asymmetry, predicting stock market prices is increasingly inefficient). Market efficiency was measured by the deviation between the baseline and this session. In this session, information asymmetry was applied to determine the trend of efficiency in such conditions. The difference in deviations was calculated to answer experimental Hypothesis 1 (HE1), as shown in Table 7.

Session 3: HE2 experimental hypothesis testing (information asymmetry makes herd behavior greater, and the stock market price is increasingly inefficient). In this session, information asymmetry on herd behavior and its effect on the efficiency of stock prices were examined. This session aimed to analyze whether herd behavior due to information asymmetry can increase market inefficiency. The description of the calculation results is presented in Table 8.

Session 4: HE3 experimental hypothesis testing (market uncertainty makes herd behavior greater, and the price prediction is less efficient). In the previous session, we tested the effect of information asymmetry on herd behavior and market inefficiency. In this session, manipulation was carried out through insiders being given more information, thereby increasing market power. The results of this session are presented in Table 9.

Session 5: HE4 experimental hypothesis testing (information asymmetry and uncertainty make the existence of herd behavior greater, and the price prediction is less efficient).

In this session, the treatment given was similar to the previous session, except that communication between

investors was permitted. Insiders were expected to share the extra information they had with other investors. However, as rumors were also spread in this session, uninformed investors had to sort out and choose which information to trust. The results of the experimental hypothesis in Session 5 are presented in Table 10.

According to the Session 2 trading results, the stock price fluctuation was much higher than the baseline session. The speed of market reaction to the entry of new information in Session 2 was also relatively fast. What is interesting in this session is that the overreaction in the baseline session began to decrease drastically. This is because the actual prices contained some information recognized by uninformed investors who are smarter. In fact, the information regarding stocks and markets owned by insiders and uninformed investors was relatively the same. The only difference was that uninformed investors did not know insiders' existence during the trading session. This fact had an impact on the insiders and uninformed investors' predicted prices. The price predicted by insiders was relatively inefficient when compared to uninformed investors. Compared to uninformed investors, the insiders' inefficient predicted prices support the fact that uninformed investors are smarter in capturing information contained in actual prices through trading screens. The exact form of this information could not be determined further in this study.

The results of Hypothesis 2 in this study can be seen from the results of experimental Hypothesis 4 testing (HE4). The HE4 results show that when the market uncertainty was high, the predicted price efficiency was low. These results are in line with the initial hypothesis. When market conditions are uncertain (i.e., rumors exist), investors' information is uncertain. This situation can lead investors to make bad decisions. Bad decisions and slow responses to information changes make predicted prices inefficient.

According to the initial hypothesis of this study, the existence of information asymmetry and uncertainty in the stock market leads to herd behavior. The relationship between information asymmetry and uncertainty on herd behavior is known through the results of H3 and H4 tests.

This hypothesis' results can be seen from the results of experimental hypothesis 3 (H3) testing. HE3 tested whether the information asymmetry led to greater herd behavior. According to the trading results in Session 3, there was a tendency for herd behavior to occur even though it is small. Information asymmetry that causes herd behavior results in insiders' predicted prices being less efficient than uninformed investors.

The experimental hypothesis testing results in Session 4 (HE4) show the results of hypothesis testing in Session 4. The trading results in Session 4 show that although uncertainty in the market was high, herd behavior was not detected in this session. These results contradict the initial theory. Investors in the market, especially uninformed investors, prefer to use their information, even though it is not necessarily correct. There is a belief that herd behavior may lead to lower market efficiency. This is based on the idea that decisions through herd behavior are less than optimal because they are not based on relevant information and previous analytical processes.

Hypothesis testing in this study comes from experimental hypothesis testing in Sessions 4 and 5 (HE3 and HE4). Both information asymmetry and market uncertainty were introduced to the stock market in these sessions. The effect of herd behavior on the stock market's efficiency was answered through the results of hypotheses 3 and 4. In fact, herd behavior was not detected in Session 4; thus, the results of experimental hypothesis 5 testing can be used as a basis for determining the results of the hypothesis testing. The existence of information asymmetry and market uncertainty makes market price prediction to be more efficient. This result contradicts the initial hypothesis of this study because the communication factor starts to have an impact in this session. It is feared that the transfer of information through communication based on this research hypothesis will lead to misleading information.

Nevertheless, in reality, in this experimental Session 5, the transfer of information could actually improve investors' decisions. Herd behavior in this session also made insider predictions to be less efficient than the uninformed ones. This can be due to uninformed investors becoming increasingly smarter, and the learning process occurs between investors.

6. Conclusions

The research results suggest that information asymmetry positively affects market efficiency. The greater the information asymmetry, the more efficient the market is. These results are contrary to the theory and initial hypothesis due to the increasingly smarter uninformed investors in processing information and making decisions. Uncertainty was negatively correlated with market efficiency. When the market uncertainty became greater in the market, the market became less efficient. Information asymmetry was positively

correlated with the existence of herd behavior. When the market was in a state of information asymmetry, and no communication between investors permitted, herd behavior was detected even though it was small. Market uncertainty negatively affects the existence of herd behavior. When market uncertainty was high, and no communication permitted, no herd behavior was detected. These results are not in line with the theory and initial hypothesis of the present study because uninformed investors prefer to follow the information circulating in the market rather than insider decisions.

Herd behavior has a positive effect on market efficiency. When communication permitted and herd behavior was detected, the market became more efficient. These results are not in line with the theory and initial hypothesis of the study because the transfer of information between investors can improve investors' decisions. Communication that can spread misleading information was not found in this study. This research shows a tendency that uninformed investors produce more efficient predicted prices than insiders, signifying that uninformed investor is smarter than insiders. This smarter uninformed investor condition can be due to the individual investors' learning process.

The high availability of information with a low number of transactions indicates that investors do not pay the same attention to publicly available information, leading investors to make bad decisions. This study will fill the gaps in the existing literature by explaining the mechanism of disseminating information by applying experimental design. Therefore, the relationship between herd behavior and stock market efficiency can be clearly analyzed. The novelty of this study is the experimental design approach and the non-financial approach that support the behavioral finance theory and focus on stock simulations. So far, the approach that is relied upon is the investors' approach with a non-experimental research orientation. The limitation of the study relates to the finding that herd behavior does not make the market more efficient because insiders tend to quickly share information with uninformed investors. Future research should add the time of absence of information for uninformed investors or the effect of information divided into good and bad news.

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