

# INVESTOR OVER- AND UNDER-REACTION TO EARNINGS ANNOUNCEMENTS:

## AN EXPERIMENTAL STUDY



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### INTRODUCTION

Investors do not react appropriately to earnings reports: this is the conclusion of many researchers in the field of finance. In this regard it has been amply demonstrated that the inappropriate reactions of investors are expressed in two main phenomena in cases where studies have been made out of errors in assessing risks, frictions in financial markets, and procedural shortcomings. The first anomaly is described as underreaction. It leads to the extension of stock-market prices over the short term (Bernard and Thomas, 1989; Theobald and Yallup, 2004; Nguyen, 2005). Conversely, the second anomaly is described as overreaction. It is more of a long-term matter, following certain specific phenomena. These include, for example, the occurrence of consecutive good or bad news (Barberis et al., 1998) or the “persistence” of the performance of the securities<sup>1</sup> (DeBondt and Thaler, 1985; Chopra et al., 1992). This under- and over-reaction may be attributed to various factors. According to Bernard and Thomas (1989) and Ball and Bartov (1996), it reflects ignorance or incorrect assessment of the auto-correlation between the quarterly components of a series of earnings over time. In contrast, according to Bloomfield et al. (2003), the inadequate or excessive market reactions persist even if we consider series of annual earnings only. They all arise from the over-reliance of investors on the preceding announcement<sup>2</sup>.

As part of the efficient-market theme, this article seeks to investigate whether this underreaction and overreaction on the part of investors manifests itself in an information structure consisting of annual reports. It attempts to refine these anomalies by connecting them both to the current and previous earnings, and to expectations about future earnings. Examination of this trilogy allows us to assess the “overall” rationality of investors, i.e., both in terms of market decision and prediction. It is based on the fact that investors react according to their

predictions about a company’s prospects, but these are premised on the earnings already disclosed. This seems consistent with the findings of Brown and Han (1992) concerning the “current earnings/future earnings” relationship. Publication of the current earnings does indeed allow to improve the accuracy of future earnings forecasts, being a signal of the total cash-flows received by the company during a reference period. It implies that the biased reaction of the operators should arise just as much from earnings already reported as from incorrect estimates of future earnings. The introduction of these latter figures is all the more relevant since, in fact, the profits on investments are determined only some time after the investment is made. In particular, in our experimental markets, the market profits are accumulated until the end of each session, which means that the investors are acting “for the future”.

In comparison with earlier reaction studies, our investigations of under- and over-reaction were conducted within a structure that may, firstly, be described as “direct” and “pure”. It is “direct” in that all of the profit reports are made on the spot, during the trading periods. This approach explicitly differentiates our research from previous experimental works that predetermined a portion of the earnings, said to be “past”, and released them to the participants before the market opening. This then enabled the development of the operators’ reactions and especially any “jumps” to be monitored. It is “pure” since the information structure that was set up did not include any additional variables likely to impact the true nature of the anomalies at the psychological level<sup>3</sup>.

Secondly, the information structure thus established is described as “favorable” towards anomalies in the first half of the market, and “neutral” towards later ones. It really consists of a series of “programmed” earnings followed by four random earnings. The “programmed” series of earnings is set up so that a succession of three earnings of the same type (good or bad news) is preceded by earnings of opposite sign. In accordance with this rule we create two types of series, as follows. While the series said to contain “good news” include one item of bad news followed by three items of good news, the

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“bad news” series comprise one item of good news, and then three items of bad news. The four components of each information series are determined and distributed in turn during the first four trading periods of an experimental market consisting of eight periods. Next, four random earnings are drawn by lot for the second half of the market, from among the figures provided in advance, and are not made available to the participants. In such an information structure, special attention is paid to the effect of the information series while ignoring the effect of the last four earnings. However, the concept of determining these earnings in advance but not communicating them is intentional. It enables the intrinsic value of a financial asset to be established in a normal manner, so as to standardize the investors’ reaction without altering the effect of the four initial releases.

In the information structure aforementioned, the study leads to a number of findings. The general perception is that the behavior of investors is far from efficient. Underreaction is detected in each of the periods 2, 3, and 4 at the end of which three good or three bad news items are announced in turn. This finding remains true in almost all cases, whether we consider the opening, closing or average prices. As for overreaction, it seems to appear only in the opening price, beginning in the fifth period, *i.e.*, after all the items in the news series have been announced. This overreaction tends to be progressively corrected by the end of each of the last four trading rounds. Taking all the periods together, the opening price appears to be more erroneous than the other ones. This is moreover what might be expected, since the operators possess less information at the start of the period. More detailed studies of investors’ expectations show that they are biased, regardless of the duration of the period considered. These biases are partially transferred to the market prices, and account for a portion of the observed anomalies of under- and over-reaction.

The rest of this article is organized as follows. Section 2 presents the hypotheses to be tested. Section 3 contains a description of the experimental markets. Section 4 is a discussion of the results obtained and the last section presents the article’s conclusion.

## ■ I. TESTING HYPOTHESES

As described in the preceding section, a large number of anomalies have been identified and discussed at length in the financial literature. They are the focus of a vigorous debate between those who uphold and those who oppose the concept of efficient markets. For the former, the anomalies found do not raise questions about efficiency, for several reasons. Fama (1998) in particular shows that under- and over-reactions are random in nature and cannot be exploited: they balance each other and disappear at equilibrium. Conversely, the opponents of efficiency tend to attribute anomalies to the irrationality of market agents. Thus they seek to prove that the abnormal phenomena are significant, and likely to provide openings for winning strategies. Empirical evidence is often effectively provided by means of experimental markets

(see, for example, Theissen, 2000). These are supposed to minimize the procedural errors of empirical studies, and to bring out the irrational qualities of investors. In fact, it is desirable to perform a combined test of two hypotheses, namely the overall efficiency of the market and the existence of under- and over-reactions. Our first hypothesis therefore consists of examining whether, in general, investors process information properly. It may be posited as follows:

**Hypothesis 1:** *The market is not fully efficient.*

Kahneman and Tversky (1973) show that investors take time to become aware of new trends, but that they retain said trends for a long time once they are aware of them. This idea suggests that underreaction exists over the short term, while overreaction is more of a long-term condition (Barberis *et al.*, 1998). We test these theoretical predictions in the present study by assuming that the underreaction occurs within a single period, following the second round of trading, during which the operators belatedly react to the first published earnings. This underreaction may remain strongly significant until the fourth period, at the end of which the last item in the series of the same type of news is announced. This leads to positing the second hypothesis, below:

**Hypothesis 2:** *In the short term (one period) during periods 2, 3, and 4 (where the announced earnings belong to a series of news items of the same type), there is an underreaction.*

The publication of a series of earnings of the same type during the first four periods clearly generates a certain pressure on prices. This normally resembles the reference information series (*cf.*, upward trend for a series of good news and downward trend for a bad-news series). These trends should cause an overreaction that then leads to a correction. Looked at in this way, the overreaction is assumed to emerge over the long term, during the second half of the experiment, after all the items in the series of positive or negative signals have been disclosed. The experimental confirmation of the predictions that we make here is provided by testing Hypothesis 3:

**Hypothesis 3:** *Over the long term (several periods), during the last four periods (after all the earnings that make up the series of news of the same type have been disclosed), there is an overreaction.*

In order to clearly identify the direction of investor reaction, a number of authors have been led to describe the nature of the information released (good or bad news). Some pioneering studies, specifically including Ball and Brown (1968), have concluded that an effect of this type can be seen in the variation of market prices. Our study imposes transparency of information throughout the first four periods, since the participants are aware of the details of the earnings released. If they do not react in a symmetrical manner to conflicting information, this should be observed over said periods. In this way we can identify a more marked difference between the impact of good news and that of bad news. However, this is not the case for the last half of the experiment, during which the operators do not know the nature of the periodic earnings,

since they are not made public. The respective effects of positive and negative signals should logically balance each other: their difference trends gradually towards zero. The above reasoning leads to the definition of the following hypothesis:

**Hypothesis 4:** *The effects of good news and bad news on the investors' reactions are significantly different during the first four periods, and come together over the last four.*

The premise of a rational world amounts to saying that the investors' expectations are unbiased, and that they cause them to have relevant reactions. However, this is not true of inefficient markets, in which these expectations are often qualified of biased. An abundance of studies have in fact testified to the existence of various forecasting biases, such as optimism (Dreman and Berry, 1995), pessimism (Brown, 1996), "overreaction" (DeBondt and Thaler, 1990), and "underreaction" (Abarbanell, 1991). These biases depend not only on the nature of the information available, but also on the "non-informational" aspects of the individual, such as over-confidence. These psychological factors play a part even in the absence of reference information, but are all the more pronounced in the presence of specific signals (favorable or unfavorable news). Moreover their effect may vary according to the duration of the period studied (short or long term). As a result, in this paper we will simultaneously examine various assessment biases, and their impact on the abnormal reactions of the agents. Hypothesis 5 may then be posited as follows:

**Hypothesis 5:** *Investors' expectations about earnings are biased. These biases create reaction anomalies.*

## ■ II. DESCRIPTION OF EXPERIMENTAL PROCEDURES

Our experiment was carried out at the Centre for Inter-university Research and Analysis on Organizations (CIRANO) in Montreal, using the "z-Tree" (Zurich Toolbox for Readymade Economic Experiments) software. It comprised eight markets, each of which lasted approximately two hours. The first four markets were based on a series of good news, and the last four on a series of bad news. Each market consisted of eight market periods, each representing one year. We thus have eight years.

The experiment involved 65 participants divided among the eight markets, each comprising seven to ten students<sup>4</sup>. The students received written instructions and took part in a preparatory session during which the rules of the game were explained orally. They could ask questions in order to better understand the experimental process. Each of them was then given an initial stake of ten shares and 1,000 UMEs (Experimental Currency Unit). The participants were paid out according to their final profits, including the profits obtained from their transactions and bonuses based on the accuracy of their earnings forecasts. These final profits were supplemented by a participation bonus to make up the total payment. The forecasting bonus was intended to encourage the

subjects to make good forecasts of the earnings. It is never a negative figure, and is as large as how close the individual expectations made at the start of each period are to the earnings during the round in question. The market profits are higher in proportion to the amounts by which the sales prices of the participants' securities exceed their underlying value, or by which the purchase price is less than this value. The latter is determined periodically and is assumed to be equal to the earnings for the corresponding period. On average, each participant received 25 Canadian dollars per session.

By design, our markets employ only one trading mechanism, that of double auction, which is widely used in many real stock markets, and is particularly applicable to experimental finance. It is experimentally recognized to be more efficient than other mechanisms both in terms of information (Theissen, 2000) and in terms of allocation (Gode and Sunder, 1993). Consequently, its anomalies are more "authentic" in the sense that they are less dependent on market microstructures and more on individual behavior, conditioned by preferences for risk and the psychology of the economic agents.

### II.1. INFORMATION STRUCTURE

The information employed in this experiment consists of annual earnings statements. Quarterly publications are intentionally ignored in order to reduce the variety of information and thereby enable a better identification of the errors made by individuals. They also throw light on explanations for the under- and over-reactions that do not involve investors' "naive" quarterly expectations (Bloomfield et al., 2000). In fact, if the market trend arises from incorrect assessment by investors of the auto-correlation between quarterly changes in prices, it will disappear as soon as only annual data are considered (see Bernard and Thomas, 1990). Conversely, the fact that they still persist signifies that these trends arise from other variables, such as individual psychological and cognitive features.

Our annual earnings are expressed in the form of Earnings per Share (EPS) so as to make it easier for the investors to analyze the information. After each announcement, the operators have one trading period to react. The first four earnings are controlled, so that they create a predetermined information structure, i.e., so that a succession of three good or three bad news items is preceded by a result of the opposite kind. For information purposes, the four items in the series of good or bad news are respectively of the following form: [-, (+, +, +)] and [+ , (-, -, -)]. The "+" sign here identifies a positive signal, and the "-" sign a negative signal. We define a good (bad) item of news by earnings that are above (below) the results in the preceding period<sup>5</sup>. This latter item may theoretically be considered as the best forecast of the actual earnings in a weakly efficient market. It was used empirically as a standard of the earnings surprise degree in a majority of the previous studies. Here we assume that the earnings for the first period are standardized against their expected objective value, which is the average of the possible values of these earnings.

The annual earnings belong to the family of whole numbers from 60 to 140, with an average of 100. This average is the estimated objective value of the earnings in the absence of other sources of information. The establishment of the information structure follows the approach described below. We first construct two sub-families A and B from all the possible values of the earnings. A comprises the numbers equal to or greater than 100. B contains the numbers up to and including 100. We then remove from A three groups of numbers: A<sub>1</sub> (100, 101, 102); A<sub>2</sub> (110, 111, 112); A<sub>3</sub> (120, 121, 122), and from B the three groups B<sub>1</sub> (100, 99, 98); B<sub>2</sub> (90, 89, 88); and B<sub>3</sub> (80, 79, 78). The construction of sub-families is intended to establish earnings with ascending or descending trends. In fact, for the series of good news, the first earnings figure is drawn by lot from among the components of sub-family B to be an item of bad news. The components of the next three rounds are defined such that the next one exceeds the previous one. They are in fact taken from sub-family A in the following manner: the second result is drawn by lot from the components of A<sub>1</sub>, the third from the components of A<sub>2</sub>, and the fourth from among the possible values of A<sub>3</sub>. This procedure is repeated for four markets.

For the series of bad news, the earnings for the first period are drawn from sub-family A, and the others from B such that the second result is taken from B<sub>1</sub>, the third from B<sub>2</sub>, and the fourth from B<sub>3</sub>. This procedure is repeated for four markets. In spite of being drawn by lot, the information structure thereby established for our first four years is fairly well constrained (non-random). In fact, each of the drawings by lot is conducted in a sub-family with only three possible values. This process is designed to ensure the predetermined characteristics of the information<sup>6</sup>.

In contrast with the first earnings, which were set up to form a predetermined order, the last four are compiled in a completely random manner. They are respectively drawn by lot at the end of periods 5, 6, 7, and 8 from all the whole numbers between 60 and 140. These numbers are not directly made known to the participants, but can be deduced from the market profits announced at the end of each corresponding period. This choice enables the underlying value of a financial asset to be established in a normal manner, so as to standardize the reaction of the investors without altering the effect of the four initial releases. In other words, the influence of earnings other than the first four on the behavior of the markets is minimized. We are thus able to test, in an uncontaminated manner, whether successive good or bad news reports are likely to create an overreaction over the long term.

## II.2. EXPERIMENTAL PROCEDURE

All the trading periods begin in the same way, *i.e.*, with the formulation of the investors' expectations about earnings. This stage is mandatory, and continues until all the participants have given their forecasts. The subjects can then trade with each other, knowing the average price, and the best selling and buying prices. The buy and sell orders are placed as limit orders. They are characterized by

the quantity, price, and time of placement, and are continuously displayed on the subjects' screens in increasing order for offers to buy, and decreasing order for sell offers. Trades are made as soon as compatible buy and sell orders occur. A buy order with a limit price  $p$  means that it is executed only at a price less than or equal to  $p$ . A sell order with a limit price  $p$  means that it takes place only at a price greater than or equal to  $p$ . An operator can offer a sell order in response to a buy order, and vice versa. He can also choose an order directly, from the list of buys and sells on offer. When two orders both have the same limit, priority is assigned on the basis of their time of placement. Failing this, a proportional execution will apply to all orders that are similar in terms of price, quantity, and entry time. Short sales are not allowed. Completed orders are removed from the list of offers and entered on the list of trades. Orders that have not yet been executed during one round may be changed or canceled. However, they are no longer valid for the following periods, so that the periods are independent.

At the end of each of the first four periods, the participants are informed of the annual earnings, but are not told how they are determined. Conversely, during the last four periods, we reveal that the earnings are obtained by random drawings among the natural numbers from 60 to 140, but that they are not announced. However, the participants are still informed of their trading performance and of the accuracy of their earnings forecast. Once the trading periods are concluded, they are invited to comment on the experiment and to answer questions about their trading strategy.

## III. RESULTS AND INTERPRETATION

Before presenting and interpreting the results, the way in which the variables are measured will be described. First of all, the mean variation of expectation is measured by two variables: the variation of the mean anticipation from one period to another, compared either to the mean of the previous expectations or to current earnings. Similarly, the variation of the mean price from one period to another is standardized either by the previous mean price or by the current earnings. By definition, the expectation error refers to the difference between the reference expectation and the annual earnings. However, it is used as a proportion in the linear-regression models in order to obtain a measurement that is consistent with the others in terms of units. Two measurements of the mean expectation error are therefore suggested: each is equal to the difference between the mean expectation and the annual earnings, but divided by one or other of these two indicators<sup>7</sup>.

### III.1. DISCUSSION OF THE OVERALL EFFICIENCY OF MARKETS

We begin our analysis with an overview of the market prices during each period, including the average, opening and closing prices. The indicators are all expressed in the form of an average of the data for the same period, all trades

taken together. It appears at first sight that the opening price is, in most cases, higher than the rest, whatever the nature of the news released. This finding is particularly marked in markets where bad news is announced. Of the three prices mentioned, the opening price is obviously established with less information. The fact that it is higher than the other prices may mean that investors are more optimistic at the start of the period. They then seek to correct their mistakes as they continue to gather information on the behavior of others by watching the orders placed and completed on the market. This correction implies that the average price is less than the opening one. In the event of bad news, the adjustment is progressive, over the course of the period, leading to a closing price that is below the opening and average prices.

The second finding is that in general the average and opening prices in the bad-news series gradually fall as the trading rounds continue. This same trend is also somewhat visible in the closing prices. The price decrease is especially clear in years 2, 3, and 4, during which three bad-news items were published. The rate at which the prices fall seems to decline during the session. It ends by giving way to a contrary trend during the final periods of the experimental session. In contrast to the series of bad news, the positive surprises do not cause any upward trend, or any significant decrease, in prices. The results

plainly show that investors are more sensitive to bad news than to good. A negative signal announced in the early trading periods can effectively influence individual decisions over the long term. Such an observation is of course not a new finding, but it is nevertheless interesting in that it provides support for certain results suggested by past empirical studies (see, for example, Ball and Brown, 1968). In other words, it allows confirmation of the other authors' findings, using a different information structure and a different method of research.

We now consider whether our experimental markets are globally efficient. This investigation amounts to determining whether the equilibrium prices are strictly connected to the fundamental value of the asset. Rejecting this presupposition would suggest that absurd reactions can exist. Indeed, the second stage of the study consists of identifying the nature of these abnormal phenomena (particularly under- or over-reaction).

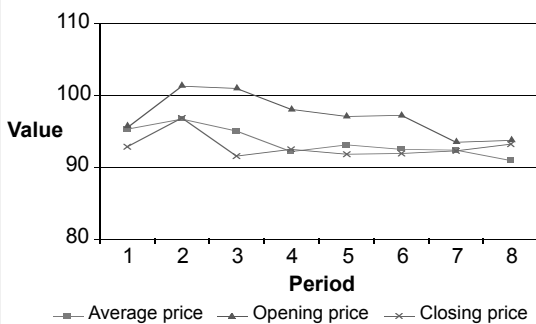
To the extent that we have perfect knowledge of the intrinsic value of the security, we have at our disposal a measure of the informational inefficiency, in absolute figures (MIIA) used by Theissen (2000). It represents the mean of the price errors in absolute figures, as described by the following formula:

$$MIIA = \frac{1}{n} \sum_{t=1}^n \frac{|p_t - v_t|}{v_t} \quad (1)$$

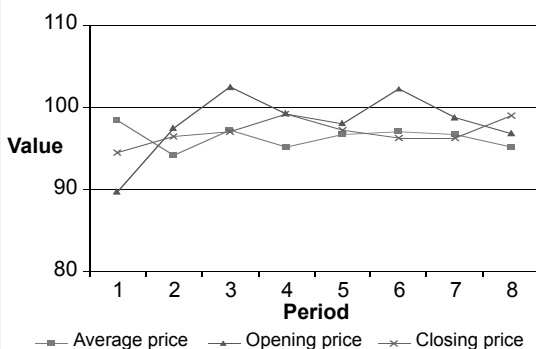
Where  $p_t$  and  $v_t$  respectively are the price and underlying value of the share in period  $t$ ;  $t$  varies from 1 to  $n$  where  $n$  is the number of trading periods in the market, i.e., 8 periods. However,  $n$  may be less than 8 if the objective is to analyze the efficiency of the markets over a sub-family of reference periods.

In order to refine the analyses, the measurement of informational inefficiency given above is respectively calculated for all the periods, for the first four, and for the last four periods. For each case, it is also determined for all the results together, and then only for the good and only for the bad news. The results obtained are presented

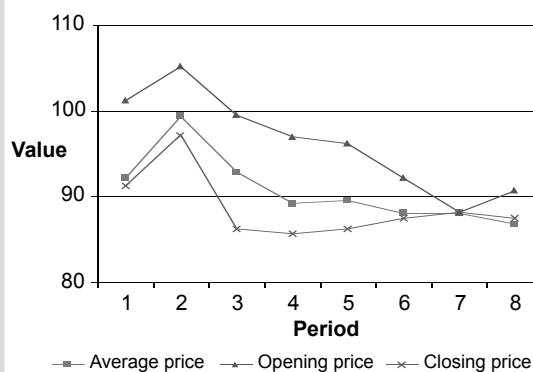
**Figure 1a: Variation of market prices (all data)**



**Figure 1b: Variation of market prices (good news)**



**Figure 1c: Variation of market prices (bad news)**



Note: The figures show the variations of the opening, closing and average prices. These prices are the averages of the corresponding prices, all markets included. There are eight markets in Figure 1a and four markets in Figures 1b and 1c.

in Table 1. As regards these results, the MIIA is generally significant whatever the nature of the information or type of price considered. Hypothesis 1 therefore seems to be confirmed for this measurement. However, there are three contrary scenarios corresponding to the data for the last four periods of bad-news markets. The investors probably corrected their mistakes better in these cases than in the earlier periods, and behaved in a more rational manner.

According to Fama (1998), even if under- and over-reaction are actually present in the market, they cancel each other out and are not reflected in the prices that are formed at equilibrium. In other words, the anomalies disappear at the aggregate level. In this regard, the evidence for the existence of “true” biases in the equilibrium prices cannot be limited to the question of the mean of individual errors in absolute value, but must also be based on the mean in relative value. Called the “measurement of inefficiency in relative value (MIIR)”, this calculation can be written algebraically as follows:

$$MIIR = \frac{1}{n} \sum_{t=1}^n \frac{p_t - v_t}{v_t} \quad (2)$$

It is important to note that the relative mean measured on the whole series of news taken together does not always provide a relevant indicator. More specifically, it does not allow for an assessment of the size of the reaction bias in

the market, but only provides a general idea of the dominance of one piece of information or one reaction with respect to other information or reactions. The controversial nature of various pieces of information can in fact make it appear insignificant, even though the investors do not behave correctly after each announcement. It accordingly appears that the relative mean is only informative when good and bad news are considered separately.

By design, the investors can begin to react to the items in the news series only in the second period, which is why the first is omitted from the calculations of the MIIR. The latter is therefore measured for periods 2 to 8, 2 to 4, and then 5 to 8. Table 2 presents the results concerned.

In the first place it should be noted that since all the data are considered, MIIR is always significantly different from zero. While it is negative with respect to the average and closing prices, it is positive with respect to the opening price. The result is that the actors display optimism at the beginning of the period, and become more pessimistic towards the end - a result in accordance with the variation of the price curves shown in Figure 1. Secondly, by separating information of different kinds, the MIIR is generally rendered negative by the series of good signals and positive by the others, whatever the number of reference periods and the type of price considered. It also turns out to be significant for the grouped data of periods 2 to 4 and

**Table 1: Measurement of informational inefficiency in absolute figures (MIIA)**

	All data	Good news	Bad news
<i>8 periods</i>			
Average price	0.19**	0.18**	0.19*
Opening price	0.18**	0.17**	0.20*
Closing price	0.18**	0.17**	0.19*
<i>Periods 1-4</i>			
Average price	0.16**	0.19*	0.13*
Opening price	0.16*	0.15*	0.17*
Closing price	0.14**	0.16*	0.12*
<i>Periods 5-8</i>			
Average price	0.22*	0.18**	0.25
Opening price	0.21*	0.18*	0.23
Closing price	0.22*	0.18*	0.26

Note: This table shows the value of MIIA given by the following equation:

$$MIIA = \frac{1}{n} \sum_{t=1}^n \frac{|p_t - v_t|}{v_t}$$

There are three price measurements: average, opening, and closing prices. The underlying value of the share at a given period is given by the earnings for that period. The tests were carried out on the data from all the periods, from periods 1 to 4, and from periods 5 to 8 respectively. The superscripts (\*), (\*\*), and (\*\*\*) indicate the significance of the various MIIAs at the 10%, 5%, and 1% thresholds.

**Table 2: Measurement of informational inefficiency in relative figures (MIIR)**

	All data	Good news	Bad news
<i>Periods 2-8</i>			
Average price	-0.03**	-0.11*	0.05*
Opening price	0.01**	-0.08*	0.10*
Closing price	-0.03**	-0.09*	0.02*
<i>Periods 2-4</i>			
Average price	-0.04**	-0.14*	0.06*
Opening price	0.02*	-0.10*	0.14*
Closing price	-0.05**	-0.12*	-0.08*
<i>Periods 5-8</i>			
Average price	-0.02*	-0.09	0.04
Opening price	0.01	-0.06	0.08
Closing price	-0.02*	0.01	0.03

Note: This table shows the value of MIIR given by the following equation:

$$MIIR = \frac{1}{n} \sum_{t=1}^n \frac{p_t - v_t}{v_t}$$

There are three price measurements: average, opening, and closing prices. The underlying value of the share at a considered period is given by the earnings for that period. The tests were carried out on the data from all the periods, from periods 1 to 4, and from periods 5 to 8 respectively. The superscripts (\*), (\*\*), and (\*\*\*) indicate the significance of the various MIIRs at the 10%, 5%, and 1% thresholds.

2 to 8, but this is no longer so in trading rounds 5 to 8, during which the earnings are randomly determined. This finding seems to prove that investors behave more rationally when they are in a random situation, with no systematic release of information.

### III.2. DISCUSSION OF UNDERREACTION

Underreaction leads to a gradual adjustment of prices to the intrinsic value. In other words, the variation of prices in period  $t$  is less than the difference between the underlying value for this period and the price in the previous period ( $t - 1$ ). This difference may be divided into two parts, one representing the change in the intrinsic value and the other being the difference between the previous price and the equivalent underlying value. We can describe this relationship by using the following equation<sup>8</sup>:

$$p_t - p_{t-1} = \alpha + \beta(v_t - v_{t-1}) + \lambda(p_{t-1} - v_{t-1}) + \varepsilon_t \quad (3)$$

The above equation is the one employed by Theissen (2000). In this equation,  $\beta$  is assumed to be less than 1 when there is an underreaction, while  $\lambda$  must be negative if the agents even partially correct the mistakes they made earlier.

Underreaction seems to emerge covertly in the second year, during which the prices are assumed to adjust to the first earnings disclosed. It may persist into the years that follow. In this regard, our discussion theoretically begins in the second period when all the markets are included, whatever the direction of the surprise announced. They then progressively consider the following years until the underreaction is no longer seen. Moreover, since the earnings are released only up to the fourth period, the first discussions go only that far. Moreover, we do not consider period 2 by itself, because of the rather low number of observations compared to the number of variables.

In accordance with the results shown in Table 3, the coefficient  $\gamma$  is always significantly negative, proving that the markets correct the errors in the formation of earlier prices. However, the amount of this correction does not lie at its optimal level. On the contrary, it seems to be excessive, since the absolute value of  $\gamma$  is greater than  $\beta$ . When we analyze the data covering periods 2 and 3, and then 2, 3, and 4, the coefficient  $\beta$  is well below 1, thereby demonstrating the existence of an underreaction. This anomaly is seen to be more pronounced when the number of periods studied is increased. This is no doubt due to the fact that the investors are more optimistic at the beginning of a session than at its end. They offer prices that are closer to the underlying value. Moreover, this observation is consistent with what was shown in the previous section regarding pricing errors. The fading of the effect of optimism over time (or during the period in question) seems to be due to the gradual disclosure of information on the fundamentals of the company, as well as on the reactions of the other participants.

The final proof of underreaction is provided by the data from periods 2, 3, and 4, which enable confirmation of Hypothesis 2. We now gradually add the subsequent

periods. Although the coefficient  $\beta$  becomes non-significant, showing the disappearance of the underreaction,  $\gamma$  still remains significantly less than zero. For this reason the investors are constantly attempting to rectify the mistakes that they made earlier. This correction may be seen as one of the reasons why the underreaction completely disappears at the end of the session, both for the average prices and for the opening and closing prices.

It is essential to observe that the technique applied in this article, aimed at detecting underreaction by examining the direct adjustment of the price to the underlying value, is consistent with another method commonly used in this area. This is the measurement and comparison of two "extreme" portfolios, one of which consists of the securities of companies that have recently announced good news, and the other comprising securities from firms that have released bad news. An excessive short-term performance of the first portfolio in comparison with the second is evidence of underreaction. In fact, although market prices have a tendency to increase progressively when there are good signals and to decrease in the contrary case, the good-news portfolio should logically display a better performance in comparison with the other portfolio.

The earlier findings have shown the existence of underreaction to the publication of earnings in the short term. The plan now is to investigate whether this behavior appears in an asymmetric manner upon contrary news. If it is present, this asymmetry of reaction should be observed in the first half of the session, where there is transparency of the information distributed. A binary variable NEWS is therefore created, which takes the value 1 when the announcement carries a good signal and zero if it does not. Naming the coefficient of this variable  $\phi$ , we present the results obtained in Table 4.

**Table 3: Explanations of the price variations in periods 2 to 4**

Variables	$\alpha$	$\beta$	$\gamma$	$R^2$ (adjusted)
<b>Years 2 and 3</b>				
Average price	-1.979	0.297**	-0.473**	60%
Opening price	1.167	0.751***	-1.049***	64%
Closing price	-4.312	0.645***	-0.722***	48%
<b>Years 2, 3, and 4</b>				
Average price	-2.243	0.096*	-0.292***	34%
Opening price	0.443	0.409**	-0.727***	39%
Closing price	-2.653	0.321**	-0.412***	28%

Note: This table shows the results of estimation using the linear-regression model:

$$p_t - p_{t-1} = \alpha + \beta(v_t - v_{t-1}) + \gamma(p_{t-1} - v_{t-1})$$

There are three price measurements: average, opening, and closing prices. The underlying value of the share during a given period is given by the annual earnings for that period. The tests were carried out on the data from periods 2 and 3, and from periods 2, 3, and 4 respectively. The superscripts (\*), (\*\*), and (\*\*\*) indicate the significance of the coefficients at the 10%, 5%, and 1% thresholds. The coefficients  $\beta$  that are significantly different from 1 are placed in italics.

**Table 4: Explanations of the price variations in periods 2 to 4: good news versus bad news**

Variables	$\alpha$	$\beta$	$\gamma$	$\phi$	$R^2$ (adjusted)
<b>Years 2 and 3</b>					
Average price	- 2.42	0.26	0.46**	1.01	56%
Opening price	19.26**	1.73***	- 1.30***	- 37.23**	73%
Closing price	3.06	1.29**	- 1.001***	- 17.79	51%
<b>Years 2, 3, and 4</b>					
Average price	- 2.76	0.06	- 0.28	1.17	31%
Opening price	22.21**	1.69***	- 1.10***	44.33***	55%
Closing price	2.80	0.80*	- 0.61***	- 13.51	30%

Note: This table shows the results of estimation by the following linear-regression model:

$$p_t - p_{t-1} = \alpha + \beta(v_t - v_{t-1}) + \gamma(p_{t-1} - v_{t-1}) + \phi * NEWS$$

Price has three measurements: average, opening, and closing prices. The underlying value of the share during a period is given by the earnings for that period. *NEWS* is a binary variable that takes the value 1 if the announcement carries good news and zero if it does not. The tests were carried out on the data from Periods 2 and 3, and from periods 2, 3, and 4 respectively. The superscripts (\*), (\*\*), and (\*\*\*) indicate the significance of the coefficients at the 10%, 5%, and 1% thresholds.

By using the variable *NEWS*, whose coefficient is significant only for the opening price, we can conclude that the effects of good and bad news on the operators' behavior are different only at the start of the period. After that, they cannot be distinguished. Similarly, the opening price better reflects the nature of the announcements. This is understandable, since it is formed at the moment when the recent information that the agents most heavily rely upon consists of the earnings published at the end of the previous period. This effect is all the more pronounced because the trades on our experimental markets are organized according to the double auction procedure, in which the first transaction can take place early in the session, and often earlier than other procedures such as fixing.

During and especially towards the end of the trading round, the information available to the participants expands. It includes not only the earnings already announced, but also information on the behavior of their fellow investors, revealed in the orders placed and executed on the market. The creation of an effective strategy should therefore be based less and less on the fundamentals such as annual earnings and intrinsic value, and more on the behavior of the other operators. The difference between the effects of good and bad news diminishes, and approaches zero.

### III.3. DISCUSSION OF OVERREACTION

Overreaction can, in theory, also be understood by the model of underreaction mentioned above. That being so, we only have to assume that the coefficient  $\beta$  is greater than 1, to consider the periods after all the announcements of the items in the series of good or bad news, and finally to extend the duration of the test period<sup>9</sup>. That is, to take into account the price variations over a time interval lon-

ger than one period. This technique seems, however, to work less well for overreaction. As regards our own study in particular, the reason is essentially that during the last four periods the earnings are not published. The operators thus do not know the underlying value of the securities for these periods; their reaction cannot, therefore, be standardized against this value. As regards studies of overreaction in general, Bloomfield et al. (2000) show that, contrary to underreaction, which is more pronounced when it is based on the nature of the information, overreaction is expressed more clearly in price changes. According to these authors the reason is that overreaction arises from the inability of investors to take into account the effect of the mean-reverting random error contained in the prices, rather than the information identified by researchers.

Because each of the abnormal reactions can be better characterized by some strategies than by others, we have employed another technique designed to detect overreaction. This consists of examining the relationship between the prices themselves instead of the "price/annual earnings" ratio. It is worth noting that examining only the prices is also helpful in reaching the goal of our study, which seeks to dissect the reaction of the investors surrounding the release of earnings figures. In fact, the price movements in our experimental markets are not spontaneous, but are the direct result of the information released. In other words, they reflect the effect of the announcements on the behavior of the investors.

In a situation of overreaction, the investors actually amplify the implications of the trend of past prices (upward or downward) for the development of the future price. As soon as they recognize this mistake they attempt to correct it, which leads to a reversal of the changes in price. Applying this theory, DeBondt and Thaler (1985) do indeed show that overreaction causes the preceding good-performance portfolio to become less profitable than the previous bad-performance one over a period of three years from the time they were assembled. It thus appears that, over a sufficiently-long period, the security prices in the first portfolio tend to fall, while those in the second portfolio improve.

Let  $(t - m)$  and  $t$  respectively be the first and last period where the share in question displays a good (bad) consecutive performance, and  $(t + n)$  the period where overreaction begins to be corrected; we then have:

$$(p_{t+n} - p_t) = v + \lambda(p_t - p_{t-m}) + \varepsilon_t \quad (4)$$

where  $\gamma$  is assumed to be negative. It should also be noted that the data from the series of bad news are multiplied by  $(-1)$ , since the changes in their prices are normally in the opposite direction to those of the good-news series.

As regards the model described by Equation 4, we will first show that overreaction can appear only over the long term: no result obtained being significant using the data from the first half of the experiment. It is able to appear after the fourth period, when all the items in the series of good or bad news have been released. The longer the reference period, the more pronounced is its effect. Following this approach, we begin the analyses of overreaction in period 8, and then progressively add the preceding

periods until the overreaction is no longer significant. The results obtained are presented in Table 5.

Using the opening price, the coefficient  $\lambda$  is significantly negative, which suggests an overreaction by the investors. The same coefficient changes direction in the case of the closing price. One possible reason for this is that the participants acquire more experience and information as the period goes by. That being so, they seek to rectify the mistakes they made earlier. This correction nevertheless seems to exceed the level of efficiency, causing the closing price to fall too much. The fact that the operators behave in different ways at the opening and the closing of the market provides a rational explanation of the "neutral" trend in the average price. In fact, its coefficient  $\lambda$  appears to be neither significantly negative or positive, whatever the length of time considered: one, two, three, or four periods after the last earnings announcement.

The tests unambiguously show that the opening price is the only one that demonstrates the overreaction of the markets. Thus, Hypothesis 3 seems to be only partially confirmed. In contrast to underreaction, this phenomenon cannot be explained by the closeness in time of the opening price to the earnings announcements, because they are not released during the last four periods. It arises instead from the fact that this price is closer to the average price and the best buying and selling prices in the preceding period (cf., published prices). This appears reasonable, given that overreaction is measured on the basis of price movements standardized against the prices themselves.

As with underreaction, a binary variable is now introduced, in order to test whether the preceding good and bad signals produce different results as regards the operators' overreactions. It takes the value 1 when the first four periods are based on the series of good news, and zero if they are not. The result obtained invalidates its explanatory role, thereby proving that the difference between the effects of positive and negative surprises diminishes over the long term. Hypothesis 4 cannot be rejected.

It is quite obvious that the overreaction demonstrated in this experiment is not as strong as the underreaction. This observation seems consistent with the findings of Bloomfield et al. (2000) on the behavior of financial markets in the presence of a confidence-moderating mechanism. When reacting in accordance with this mechanism,

**Table 5: Explanations of long-term price variations**

Variables	$v$	$\lambda$	$R^2$ (adjusted)
<b>Period 8</b>			
Average price	1.138	0.030	-7.1%
Opening price	8.103**	-0.906**	62%
Closing price	-4.782	0.738**	46%
<b>Periods 8 and 7</b>			
Average price	1.214	-0.089	-6%
Opening price	7.647**	-0.676**	31%
Closing price	-5.418**	0.691***	40%
<b>Periods 8, 7, and 6</b>			
Average price	1.292	-0.125	-3%
Opening price	7.181***	-0.566***	27%
Closing price	-5.083***	0.593***	37%
<b>Periods 8, 7, 6, and 5</b>			
Average price	1.104	-0.156	-0.5%
Opening price	4.774**	-0.344**	9%
Closing price	-4.670***	0.551***	28%

Note: The regression model employed is  $(p_{t+n} - p_t) = v + \lambda(p_t - p_{t-m})$

For bad news, we multiply the data by (-1) before performing the regression. The prices used have three measures: average, opening, and closing prices. The superscripts (\*), (\*\*), and (\*\*\*) respectively indicate the significance of the coefficients at the 10%, 5%, and 1% thresholds.

agents under-estimate reliable information (the observed underreaction) and over-estimate its opposite (the recorded overreaction). Since the profit announcement is judged to be credible, it should lead rather to underreaction than to overreaction. Studies by Chan (2003) and Theobald and Yallup (2004) also demonstrate the greater effect of underreaction in comparison to overreaction. Chan (2003)

**Table 6: Variations in investor expectations during periods 2 to 4**

Variables	$\alpha$	$\beta$	$\gamma$	$R^2$ (adjusted)
Periods 2 and 3	-0.617	0.418***	-0.853***	87%
Periods 2, 3, and 4	-0.779	0.331***	-0.774***	86%

Note: This table shows the results of estimates using the following linear regression model:

$$a_t - a_{t-1} = \alpha + \beta(r_t - r_{t-1}) + \gamma(a_{t-1} - v_{t-1})$$

In this model,  $a_t$  and  $r_t$  are respectively the mean of the individual expectations formed at the start of period  $t$  and the annual earnings determined at the end of period  $t$ . The tests were carried out on the data from periods 2 and 3, and periods 2, 3, and 4 respectively. The superscripts (\*), (\*\*), and (\*\*\*) respectively indicate the significance of the coefficients at the 10%, 5%, and 1% thresholds. The coefficient  $\beta$  is shown in italics when it is significantly different from 1.

**Table 7: Variations in investor expectations during periods 5 to 8**

Variables	$v$	$\lambda$	$R^2$ (adjusted)
Period 8	1.551	-0.745*	37%
Periods 8 and 7	-1.108	-0.442*	15%
Periods 8, 7, and 6	0.743	-0.524**	23%
Periods 8, 7, 6, and 5	1.979	-0.498**	16%

Note: The linear regression model has the following form:  $(a_{t+n} - a_t) = v + \lambda(a_t - a_{t-m})$

The superscripts (\*), (\*\*), and (\*\*\*) respectively indicate the significance of the coefficients at the 10%, 5%, and 1% thresholds.

**Table 8: Impact of expectation biases on anomalies**

<i>Part A: Price variations and expectation variations</i>			
<i>Variables</i>	<i>Constant</i>	<i>Variation of expectations</i>	<i>R<sup>2</sup> (adjusted)</i>
<b><i>Periods 1, 2, 3, and 4</i></b>			
Variation of average price	- 1.407	0.300***	34%
Variation of opening price	0.193	0.606**	17%
Variation of closing price	- 0.378	0.225*	12%
<b><i>Periods 5, 6, 7, and 8</i></b>			
Variation of average price	- 0.244	0.178**	16%
Variation of opening price	- 1.112	- 0.062	- 3%
Variation of closing price	0.236	0.163	1%
<b><i>All periods</i></b>			
Variation of average price	- 0.701	0.277***	29%
Variation of opening price	- 0.374	0.394**	9%
Variation of closing price	- 0.010	0.203**	9%
<i>Part B: Price errors and expectation biases</i>			
<i>Variables</i>	<i>Constant</i>	<i>Expectation error</i>	<i>R<sup>2</sup> (adjusted)</i>
<b><i>Periods 1, 2, 3, and 4</i></b>			
Average price error	2.789	0.978***	76%
Opening price error	- 1.244	0.918***	59%
Closing price error	4.461**	0.840***	69%
<b><i>Periods 5, 6, 7, and 8</i></b>			
Average price error	6.601***	0.941***	86%
Opening price error	3.479	0.910***	70%
Closing price error	6.548***	0.975***	86%
<b><i>All periods together</i></b>			
Average price error	4.720***	0.951***	81%
Opening price error	1.128	0.909***	65%
Closing price error	5.431***	0.924***	76%

*Note:* This table presents the results of the regression of the periodic change (error) in the average price on the mean variation (error) of individual expectations formed at the beginning of each period. There are three price measurements: average, opening, and closing prices. The tests were performed on the data from periods 1, 2, 3, and 4, periods 5, 6, 7, and 8, and then for all the periods. The superscripts (\*), (\*\*), and (\*\*\*) respectively indicate the significance of the coefficients at the 10%, 5%, and 1% thresholds. Coefficients significantly less than 1 are shown in italics.

shows in particular that overreaction is weak, because of the influence of the securities' liquidity.

### III.4. EXPECTATIONS AND REACTION ANOMALIES

This sub-section consists first of all of a breaking down of the nature of the investors' prediction biases, if they

exist, and more specifically of an examination of whether they should be described as "under-" or "over-" reactions, by applying price-prediction models (cf., models described by Equations 2 and 3), replacing the prices by the expectations. It then discusses the impact of these biases on the reaction anomalies identified.

In accordance with what is shown in Table 6, "under-reaction" is demonstrated in the operators' predictions

during periods 2 and 3, and periods 2, 3, and 4. In a similar manner, the agents form expectations lower than the annual earnings when they constitute good news, and higher ones when they are bad news. This finding, which is consistent with the observations on price, suggests that biased expectations are one of the probable causes of pricing errors.

“Overreaction” is clearly the product of long-term expectations. This result, which agrees with the behavior of the opening price (*cf.*, Table 7), is not surprising, since the considered price was established just after the expectations about the earnings. Consequently, it faithfully reflects them.

The operators undoubtedly display expectation biases about the earnings, whose influence on the anomalies identified earlier can now be proved by using the variation and the errors in the market prices.

On the one hand it is demonstrated that the mean variation and the expectation biases are respectively major determinants of the changes and of the mean error of the prices from one period to another. This result seems to lead to the confirmation of Hypothesis 5. More detailed analyses indicate that the coefficient of determination  $R^2$  is generally low in the variation regression and that the coefficient of the explanatory variable is significantly less than 1 in the case of the errors. Such findings support the idea that investors only partially rely on their own expectations when trading. In other words, the motivations for trading go beyond the forecasts of the company’s earnings. This is also the conclusion reached by the majority of past studies. For instance, Nam *et al.* (2001) report that a portion of the erroneous behavior of investors is related to their irrational expectations.

On the other hand, the relationship between variations in expectations and changes in price is specifically confirmed in the context of the first four periods, but rejected in the last four, if we consider the opening and closing prices. It seems to vary according to the uncertainty of the information. In fact, in the first half of the experiment, where this is lower, the participants have greater confidence in their own expectations about the earnings. The prices that they offer are better correlated. Conversely, the second part of the experiment is more uncertain owing to the randomized process for determining the earnings and the absence of announcements. Lacking any foundation, the participants cannot assess the accuracy of their own forecasts and therefore rely on them less.

#### ■ IV. CONCLUSION

By considering a one-year period, this study is intended to examine whether investors react correctly to annual earnings announcements, or to put it differently, whether the market prices represent unworkable trends. In this regard, the study is directly related to the theory of efficiency. Here we have eight experimental markets of eight periods, whose first four periods contain earnings established such that the second, third, and fourth form a series of good or bad news. The last four earnings figures are randomly selected from among predetermined values and are not made public.

Overall, the study reveals that our experimental markets do not seem to be entirely efficient. The prices deviate significantly from the intrinsic value of the securities whatever the nature of the information distributed: good news or bad news. The participants react progressively but significantly to the announcements of earnings during periods 2, 3, and 4. This is expressed by the progressive adjustment of the average, opening, and closing prices to the published earnings. As regards overreaction, this arises from trends in the opening price, after all the components of the series of good or bad news have been distributed. In fact, the changes in this price tend to turn around during the last four periods, heading towards the level it occupied initially, *i.e.*, in the first period. The obtained results clearly justify a need for the introduction, into the models used for assessing financial assets, of variables that are capable of capturing the under- and over-reactions of the agents.

In order to investigate the relationship between investor expectations and the imperfections of the prices they determine, we asked them to predict the earnings for each trading period. It was demonstrated that their expectations are biased, revealing biases of both kinds: under- and over-reaction. A portion of these biases is transmitted to the prices that form at equilibrium. Implicitly, investors rely only partially on their expectations when trading. Their decisions thus also depend on factors other than their earnings forecasts. ■

- 1 This means that the securities exhibit a good or bad performance over a long period.
- 2 In the article by Bloomfield *et al.* (2003), the excessive trust assigned by investors to the previous report is due to the moderated-confidence mechanism. According to this mechanism, investors underreact to credible information and overreact to less-reliable news.
- 3 There are countless variables capable of generating anomalies. By way of example, Atkins and Dyl (1990) find that sectorial differences in transverse sections such as the size and range of prices appear to be determinants of overreaction.
- 4 While economic and financial experiments often use students in economics and management, our current experiment used only persons with some scientific background. No specific knowledge is required. In fact, a number of experimental studies at CIRANO have shown that having participants with advanced qualifications is not a critical condition for a successful experiment.
- 5 In the empirical literature, the annual earnings’ level of surprise may also be standardized against the expectations of financial analysts.
- 6 The information structure thus constructed is such that the first four trading periods cannot be considered to be uniform. The participants’ learning process over the course of a session is bound to be difficult. Its effect on the reactions of the test subjects will therefore not be measured, since it would not be relevant. This is especially true because, owing to recruitment problems, we do not use the same groups of participants when repeating the experiment.
- 7 The use of more than one measurement is intended to strengthen the robustness of the results obtained. Nevertheless, to keep it simple, the results reported in the following tables represent only the first measurement of the variables. The other measurements lead to the same results.
- 8 In order to ensure the robustness of the results obtained from multiple-regression models, we perform a check of the multicollinearity of the explanatory variables, which calculates the statistic called *Tolerance* and the one called *VIF* (*Variance Inflation Factor*). *Tolerance* measures the proportion of the variance of an explanatory variable that cannot be explained by the regression’s other explanatory variables. A low value for this statistic (less than 0.10) requires the multicollinearity to be corrected. The *VIF*, defined by  $1/Tolerance$ , should therefore not exceed 10. Our results show an absence of collinearity in Equation (3) and the equation where the binary variable *NEWS* is introduced to test the impact of the nature of the information on the underreaction of investors. The *Tolerances* are in fact always greater than 0.483.
- 9 See the model of Barberis *et al.* (1998) for further details.

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