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Stock market over and under–reaction: Evidence from investor psychology

1. INTRODUCTION

There is evidence, of an empirical nature, that financial markets tend to overreact to some types of information but under-react to others. Under-reaction is said to occur if the market price does not move upward far enough following a signal of good news or, downward enough following bad. Overreaction, on the other hand, is said to occur if the market moves upward too far following good news or, moves downward too far after bad. The relevant empirical studies on under-reaction include post-earnings announcement drifts (Bernard & Thomas, 1989; 1990) and the success of momentum trading strategies (Jegadeesh & Titman, 1993; Chan, Jegadeesh & Lakonishok, 1996). Evidence of overreaction has been presented through the study of long-term negative serial correlations in prices (De Bondt & Thaler, 1985; 1987) and overly extreme responses to sales growth (Lakonishok, Shleifer & Vishny, 1994). More complete reviews of this literature have been provided by Daniel, Hirshleifer & Subrahmanyam (1998a; 1998b) and Fama (1998).

Considered separately, either type of anomaly presents a significant challenge to the efficient market hypothesis but, as Fama (1998) points out, improving on the hypothesis requires the ability to predict when one type of anomaly should arise instead of the other. This study makes an attempt toward that, by demonstrating that whether prices in laboratory financial markets appear to overreact or under-react to information is dependent on the reliability of information investors have.

The experiments are motivated with a model in which a representative Bayesian investor only has a noisy signal of information reliability. The investor is considered to be in a market that is order, rather than price driven. Under those circumstances the investor tends to overestimate the reliability of highly unreliable information and underestimate the reliability of highly reliable information, congruent with Griffin & Tversky's (1992) findings on individual decision-making. This phenomenon has been called "moderated confidence" because investor confidence tends to be moderated to an average level that is insufficiently extreme.

As a result of this type of confidence, researchers may be able to identify price biases by forming a portfolio based on the realization of the informative signal. If the signal is a relatively reliable one (such as a recent earnings announcement), a systematic under-reaction to it should be found and if the signal is relatively unreliable (e.g., a long-term earnings pattern), a systematic overreaction to it should occur. As a general rule, the more reliable the signal used to form the portfolio, the larger would be the observed under-reaction or smaller the observed overreaction.

2. IMPORTANCE OF THE STUDY

The model developed here posits that under and over-reactions can be consistent with rational Bayesian behaviour. If investors learn about the reliability of their information with error, moderated confidence is rational. If this error arises because they attend to irrelevant cues to assess the reliability of that information [as Griffin & Tversky (1992) contend] then the moderated confidence they exhibit is not rational. The rationality of moderated confidence aside, the model predicts that market prices will under-react more (or overreact less) the more reliable the information. In this study, these propositions are tested by two experiments. In both, investors are provided with perfect information on the reliability of their information. Still, it is expected that they will exhibit moderated confidence.

In the first experiment the coin-flipping exercise Griffin & Tversky (1992) used is adapted to determine securities' values. Moderated confidence is tested for by manipulating the reliability of information through manipulating the sample size of the coin flips the investors see. Market price errors are then measured by comparing a portfolio of market closing prices with the expected value of the security being traded, given all the information that is available to the market. This allows the testing for pricing anomalies. The first experiment compares price errors in markets where all investors have highly reliable information with those in which all investors have highly unreliable information. Consistent with moderated confidence, markets would be expected to under-react more to more-reliable information than to less-reliable information.

The second experiment examines whether moderated confidence persists with more experienced traders who simultaneously hold a more reliable and a less-reliable signal. Holding these two different signals at the same time highlights the difference in reliability levels, making it easier for subjects to respond appropriately. Their experience could also be expected to reduce price biases. Still, if moderated confidence were to be validated, the results obtained would be

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similar. Prices would under-react to more-reliable information and overreact to less-reliable information.

The second study also investigates the effect the portfolio-formation rule has for researchers' interpretation of anomalies. Evidence that high prices are too high and low prices too low should be reported. Such violation of weak-form efficiency being analogous to the overreaction De Bondt & Thaler (1985; 1987) and others have observed. However, it would be incorrect to suggest that the investors studied were overreacting to information, if large under-reactions to more reliable information and only slight overreaction to unreliable information were to be found (violations of semi-strong-form efficiency). The two tests would yield different results as under-reactions to reliable information in the presence of unreliable information often lead prices to move in the wrong direction. Such movements would then appear as overreactions in weak form tests simply because high prices are too high and low prices too low.

As a whole this study has a number of implications for empirical research. Evidence of moderated confidence would suggest that markets should under-react more to events that yield more reliable information. Extant event studies that show a preponderance of under-reactions may have occurred simply because researchers have focused on reactions to relatively informative events (*e.g.,* earnings announcements, dividend announcements and analyst recommendations). The study should also highlight that the same type of error can reveal under-reactions in semi-strong-form efficient tests while revealing overreactions in weak-form efficiency tests. Hence, it may not be appropriate to conclude [as Fama (1988) has done] that empirical evidence of under and over-reactions offset each other.

The rest of the paper is organized as follows: Section 3 presents the academic foundations and the hypotheses to be tested. Sections 4 and 5 describes the methodology used and results obtained, while Sections 6 and 7 explore how the experimental results arrived at can organize an understanding of extant empirical results and provide the basis for new empirical tests.

3. LITERATURE REVIEW

Recently behavioural finance has advanced a number of models that assume investors are overconfident in their responses to information and subsequently use this assumption to predict both over and under-reactions. For instance Odean (1998), Gervais & Odean (1997) and Daniel *et al.,* (1998a; b) apply overconfidence to models of rational expectations, while Benos (1998), Kyle & Wang (1997), Odean (1998), Wang (1998) and Fisher & Verrecchia (1999), following Kyle (1985), apply overconfidence to order-driven markets. Barberis, Shleifer & Vishny (1998) consider a representative investor who behaves in a manner typical of that described in the overconfidence literature. The overconfidence assumption is supported by decades of research establishing the tendency of individuals to believe they have more information/knowledge than they actually do (*C.f.:* Lichtenstein & Fischhoff, 1977; Lichtenstein, Fischoff & Phillips, 1982). However, psychology research also produces evidence of under-confidence (*C.f.:* Lichtenstein *et al.,* 1982; Peterson & Pitz; 1986). As a whole the individual decision-making literature has been unsure when decision makers will be over or under-confident, just as the finance literature has not spoken clearly as to when markets will over or under-react.

Griffin & Tversky (1992) provide an explanation capable of predicting both under and over-confidence in individual decision-making settings. They distinguish information according to two characteristics: strength and weight. In their terminology, the strength of evidence is the degree to which it appears favourable or unfavourable. The weight refers to its statistical reliability. Their evidence shows that people pay too much attention to strength and not enough to weight. This results in overreactions being observed when evidence is of high strength but low weight and, under-reactions occurring when evidence is of low strength but high weight.

Such reactions are captured within the framework of Bayesian rationality by assuming that a representative investor has a prior belief regarding the reliability of available information and subsequently receives a noisy but unbiased signal of that reliability. Within the context of Griffin and Tversky's explanation, the noise arises due to an imperfect correlation between strength and weight; investors then inappropriately attend to the former to assess the latter. However, noise could arise even with perfectly rational investors, if they had insufficient knowledge to assess information reliability perfectly.

For simplicity these concepts were formalized in a model with a symmetric binary state space and symmetric binary variables[1]. Although it can be difficult to characterize uncertainty about quantities (such as signal precision) that must be positive, the basic intuition of this process would extend readily to all models with continuous probability distributions, since it is not possible to use the normal distribution.

Of course the question of whether moderated confidence is rational occurs. The answer depends largely on the reason for the investor's uncertainty about the reliability of the signal. The uncertainty may simply reflect the impossibility of knowing the true reliability of the information at the time of the investor's decisions. The model of moderated confidence applied in this study was useful in predicting the behaviour of irrational investors, as long as their irrationality appears as if they are rational investors with noisy signals about the reliability of their information. This would occur whenever investors' impressions of reliability are influenced by characteristics that are imperfectly correlated with true reliability, such as the information's strength or salience. Hence, a family of models could be created that vary in the characterization of the imperfect correlation between perceived and actual reliability.

If the investors are presumed to have more information about reliability than they actually use, then moderated confidence would not be congruent with Bayesian rationality. The Bayesian model would still be useful, because uncertainty regarding signal reliability would still accurately reflect the types of errors that will arise: specifically, investors will under-react to data that are relatively reliable and overreact to data that are relatively unreliable. In this study, two experiments were conducted to test these predictions in which investors have perfect information on the reliability of their information. Hence, evidence of moderated confidence would suggest irrationality. Nevertheless, support for the predictions of the Bayesian model were anticipated. The next section describes the experiments in detail.

4. METHODOLOGY

In the laboratory market created, 'cohort' refers to a group of three investors who always trade together. A 'security' (a claim on a terminal dividend) is denominated in 'Denares' a fictitious currency ultimately converted into cash. 'Trading round' refers to each time that all investors in a cohort enter orders to trade shares of a security. Trading is a batch process – all investors in a cohort choose an action in each trading round, and the cohort moves together to the next round. 'Market' refers to a sequence of trading rounds for a single security, while 'clearinghouse' is the system used for settling indebtedness between investors. 'Session' refers to a two-hour laboratory trading session. All investors are MBA students at the University of Durban-Westville's Graduate School of Business.

4.1 Experiment 1

The five securities used in the market were closely modeled after five coin-flipping problems presented in the first study of Griffin & Tversky's (1992) examination of individual decision-making biases. In the current experiment, investors were told that computer simulations were used to characterize the following process: First, a large equal number of two types of coin were generated. 'Heads-based' coins have a 60% chance of coming up heads when flipped, while 'tail-based coins' have a 40% chance of doing so. Each coin was then flipped some number of times, and placed in a bucket with all those coins that achieved the same result. Each bucket determines the security's value; the value (in Denares) is equal to the proportion of coins (in percent) in the bucket that are heads-based. As an example, subjects were told that they might be presented with a bucket that contains all of the coins that came up with one head and one tail when flipped twice. As such a large number of coins is simulated, Bayesian analysis reveals that 50% of the coins in the bucket should be heads-based, so the value of the security would be 50 Denares.

Each group of investors was presented with the five different securities described in Table 1. Three of the securities were based on the outcome of 17 coin flips; the other two were based on the outcome of three coin flips. The difference in coin flips impacting the perceived reliability of the observations. 'Signal difference' refers to the absolute difference between the number of heads and number of tails. 'Signal extremity' denotes the absolute difference between the proportion of heads observed and the prior expected proportion of 50%. 'Value extremity' indicates the absolute difference between the security value and the prior expected value of 50 Denares. For instance, 10 heads and 7 tails result in a signal difference of three, a proportion of 58,8 %, a signal extremity of 8,8, a security value of 77 and a value extremity of 27. Three heads and no tails would likewise result in a signal difference of 3, a proportion of 100%, a signal extremity of 50 a security value of 77 and a value extremity of 27.

Table 1: Securities used in Experiment 1

Signal reliability	Signal difference	Signal extremity	Value extremity
Low (3)	3 (3 – 0)	50,0	27
Low (3)	1 (2 –1)	16,7	10
High (17)	5 (11 – 6)	14,7	38
High (17)	3 (10 - 7)	08,8	27
High (17)	1 (9 - 8)	02,9	10

As in Friedman & Ostroy (1995); Gillette, Stevens, Watts & Williams (1998); and, van Boening, Williams & LamMaster (1993), investors trade securities through a clearinghouse. The market being most similar to that used in Bloomfield & Wilks (2000). In each round of trading, each investor estimates the value of the security and chooses a linear demand schedule by choosing a reservation price and a slope. The reservation price is the price below/above that which the investor wishes to buy/sell securities. The slope of the demand schedule determines how many shares the investor will buy/sell for a price that is a given distance below (above) his/her reservation price. Trades were limited to 50 shares per investor per trading round. Once all three investors have entered a demand schedule, a computer determines the market-clearing prices at which supply equals demand. If a range of prices exists, the computer chooses the midpoint of the range as the market-clearing price.

Each investor then learns the market-clearing price, the number of shares traded at that price, the total trading volume and his/her current balance in shares and cash. Trading in each security lasts for four rounds. Investors start with 0 shares and 0 Denares at the beginning of round 1. The first round of trade occurs before investors observe the coin flips, allowing an opportunity for risk sharing. Investors observe the coin flips before trading in round 2. Trading concludes after the fourth round of trade, at which point, investors move to round 1 of the next security (if any). There were no restrictions on short selling or cash balances.

The experiment used nine cohorts of three investors each. Each cohort traded the same five securities shown in Table 1. To control for order effects, five of the cohorts traded with more reliable information first and the other four cohorts traded with less-reliable information first. The order in which various securities appeared within each reliability setting was also randomized between cohorts. Information on a given reliability and extremity is favourable about half the time (more heads than tails) and unfavourable about half the time (more tails than heads) and, about half the securities traded by each cohort had favourable information, while the other half had unfavourable information.

Subjects gained or lost Denares by trading shares of each security. Gain or loss from trading each round was calculated by multiplying the number of shares a subject purchased by the difference between the true security value and that round's current market price. Subjects who purchase/sell securities earn Denares if value is greater/lesser than the price and lose Denares if value is lesser/greater than price. Gains from trading were not revealed until trading in all securities was completed, this so that the correct interpretation of the available information was not revealed. At the end of the experiment, the total number of Denares gained or lost was multiplied by a 'conversion rate' of 1 cent per Denares. [Obviously participants needed to be paid in real currency]. The resulting Rand amount was added to the promised average payment of R30 to determine the subject's payment (a minimum participation-incentive of R10 being guaranteed). To avoid risk-seeking behaviour by investors who may be near or below the floor, subjects were told neither the floor nor the conversion rate. All they were told was that the average winnings would be about R30 per session.

4.2 Experiment 2

In the second experiment several aspects of the first were changed so as to increase the likelihood that investors will be able to avoid biases. First, the same subjects who participated in experiment 1 were used again, so that the subjects have greater experience in experiment 2 than they had previously. Second, all subjects were provided with both a highly reliable signal and a highly unreliable signal for each security (all investors receiving the same information). As they could compare the more and less reliable information directly, this within-markets manipulation should make differences in information reliability more salient to investors, helping them avoid any miss weighting that would occur given a between-subjects manipulation (Kahneman & Tversky, 1996).

At the end of experiment 1, subjects were provided an additional screen of instructions explaining the manner in which security values would be determined in experiment 2. The only difference being that security value (in Denares) in experiment 2 is equal to the average of the percentages of heads-based coins in *two* buckets. For instance, if one bucket had 30% heads-based coins and the other 50% heads-based coins, then the average proportion is 40% and the value of the security correspondingly 40 Denares.

For each security, one bucket consisted of coins that achieved a certain result after being flipped 17 times, while the other bucket consisted of coins that achieved a certain result after being flipped three times. Thus, all investors have one relatively reliable signal (the outcome of the 17 flips in one bucket) and one relatively unreliable signal (the outcome of 3 flips in the other bucket). All other aspects of the task being identical to the first experiment.

Each group of investors were presented with six different securities as shown in Table 2. The securities were formed by crossing two levels of the less-reliable (3-flip) signal with three levels of the more reliable (17-flip) signal. The signal difference of the more-reliable signal taking on the value of 5, 3 or 1. The less reliable signal always had a sign opposite that of its more reliable counterpart. Securities with conflicting information were focused on as it allowed the more powerful testing of whether markets react differently to the two different signals. When both signals are of the same sign, an overreaction to one could counteract an under-reaction to another. Thus, subjects could be over- (under-) reacting to the less- (more-) reliable signal, just as predicted by moderated confidence, but these effects would offset each other making them unobservable. Rather, with signals of opposite signs, under-reaction to one signal combines with overreaction to other signals to create a single cumulative unidirectional effect that is easier to detect.

To balance the design about half of the securities seen by each cohort included a favourable less-reliable signal and an unfavourable more-reliable signal, while the remaining securities included an unfavourable less-reliable signal and a favourable more-reliable signal.

Table 2: Securities used in Experiment 2

Signal difference (extremity) of less reliable signal	Value extremity (indicated by less-reliable signal)	Signal difference (extremity) of more-reliable signal	Value extremity (indicated by more-reliable signal)	Security value extremity
3 (50,0)	27	5 (14,7)	38	5,5
3 (50,0)	27	3 (8,8)	27	0,0
3 (50,0)	27	1 (2,9)	10	8,5
1 (16,7)	10	5 (14,7)	38	14,0
1 (16,7)	10	3 (8,8)	27	8,5
1 (16,7)	10	1 (2,9)	10	0,0

5. RESULTS AND DISCUSSION

The analyses of the first experiment examined three different variables. First, errors in investors' estimates of value, as estimates allow the linking of results most closely with prior studies in psychology (*e.g.,* Griffin & Tversky, 1992) where such measures are used almost exclusively. As such estimates do not affect participant's winnings, they should reflect only expectations of value, without being systematically influenced by risk preferences or other factors. Second, the associated errors in reservation prices were examined. These should reflect investor's risk preferences and trading strategies, as well as their expectations of security value. Reservation prices also permit the examination of errors that arise even though they reduce participant winnings. Third, errors in market prices were examined. This should present averages of investor's reservation prices, weighted by the slope of their demand functions.

It was felt that simply testing for overreactions to less-reliable information and under-reactions to more-reliable information would not be a satisfactory test of moderated confidence for two primary reasons:

- It is not possible to know in advance what levels of information reliability are sufficiently low to create overreactions or sufficiently high to create under-reactions.

- There might be other factors at work in both settings that lead investors to under- or over-react to any signal, regardless of its reliability.

Both these issues were addressed by testing for differences in error across treatments, rather than simply testing for deviations from point predictions within treatments. Any treatment effect would be readily attributable to information reliability, as all other factors were either held constant or balanced across treatments.

Table 3 reports the results of experiment 1. The calculation of errors in estimates, reservation prices and market prices, was achieved by calculating returns to a strategy of buying one share whenever the available signal was unfavourable and selling whenever the signal was favourable. The table reports returns to this strategy under three different assumptions concerning the price at which transactions occur: investors' average final-round estimate of value (column 3), investors' average final-round reservation price (column 4) and the closing final-round market price (column 5). Overreactions are indicated by positive returns, while negative returns indicate under-reactions.

As expected, investors estimate a confidence level that is always less extreme than would be appropriate for the reliable and unreliable information. These results support Griffin & Tversky's (1992) work on individual decision-making. Using the confidence ratings they report, this study estimates that Griffin & Tversky would have measured returns of –15,5 (compared to –15,36 in the current study) in the high reliability setting and 5,5 (compared to 4,72 in this study) for the low-reliability setting.

Table 3: Results from Experiment 1

Signal reliability	Signal difference (extremity)	Return to a contrarian strategy using: Estimate as market price proxy	Reservation price as proxy	Final round market price
Low	3 (50,0)	3,70	-1,81	-2,88
Low	1 (16,7)	5,74	2,85	4,01
Mean low		4,72*	0,52	0,56
High	5 (14,7)	-22,26***	-26,37***	-25,64***
High	3 (8,8)	-15,81***	-13,15***	-13,69***
High	1 (2,9)	-8,00***	-5,70***	-5,96***
Mean high		-15,36***	-15,07***	-15,10***
Difference		20,08***	15,59***	15,66***

*** $p < 0{,}01$; *$p < 0{,}10$. All p values resulting from one sided t tests

Computing the mean difference in returns across the two reliability settings for each of the nine cohorts and subsequently a t-test on those nine differences provided a more formal test of moderated confidence. Returns to the contrarian strategy are significantly greater when investors have less-reliable information than when they have more reliable information, regardless of the dependent measure used. Analyses of variances provided similar results.

Irrespective of the dependent measure, signal reliability and signal difference was significant, supporting the moderated confidence proposition and indicating that under and over- reactions were more severe, the more extreme the information. The reliability x difference interaction was insignificant. These results provide strong support for moderated confidence in investor's estimates, in their reservation prices and in the market prices that result from their trades. This finding of moderated confidence in estimates extends the prior work in psychology to the financial markets.

Finding moderated confidence in reservation prices indicates that the biases apparent in estimates do not arise simply because estimates are not linked to investors' winnings as such biases are also clearly evident when measured with reservation prices which are tied to winnings. Rather, finding moderated confidence in market prices shows that 'smart-traders' do not trade aggressively enough to drive market prices to a less-biased closing value.

The statistical significance of moderated confidence was also examined within each reliability setting. Again, irrespective of which dependent variable was examined, significant under-reactions in the high reliability setting was identified. For example, with respect to estimates, the mean return over all cohorts was –15,36 in the high reliability setting, which is significantly less than zero (t = -16,37, p = 0,0001), suggesting that investor's estimates under-react to more reliable information. When the information is favourable/unfavourable estimates are not high/low enough.

In contrast, significant overreaction in the low-reliability setting could only be identified with respect to individual estimates [mean return of 4,72 in the low reliability setting (t = 5,64; p = 0,0182)]. Overreactions were not statistically different from zero with respect to reservation and market prices. Paired t-tests also showed insignificant differences between returns when based on estimates, reservation and market prices.

Why would overreactions to less-reliable information be less pronounced than under-reactions to more-reliable information? Within the Bayesian context of moderated confidence; this asymmetry could have arisen because investors' prior beliefs were that their data would be relatively unreliable. Alternatively, floor and ceiling effects may have contributed to the asymmetry. In particular, observed estimates probably reflect the investors' true estimates with error. Such error cannot be completely symmetric, because observed estimates would have to be no less than 0 and no greater than 100. Hence, random error would systematically bias observed estimates toward 50 and will do so all the more as true estimates become more extreme. Regardless, returns to the contrarian strategy are always significantly larger in the high-reliability setting than they are in a low-reliability one. Thus, moderated confidence is supported for each dependent variable.

The initial analysis of the data from experiment 2 computed the returns to portfolios that should yield positive returns if investors overreact to less reliable information and under-react to more-reliable information (as moderated confidence would have). Remember, that the more- and less- reliable information was always of opposite sign (one indicated a value above 50, while the other a value below that). Buying whenever the less-reliable signal was unfavourable and the more reliable signal favourable and, selling whenever the less-reliable signal was favourable and the more-reliable one unfavourable, constructed the portfolios.

Table 4 shows the return to this strategy is both positive and statistically significant whenever the transaction price equaled investors' fourth-round average estimates (return = 9,24; t = 7,82; p = 0.0001), reservation prices (return = 10,00; t = 7,87; p = 0.0001) or market prices (return = 8,72; t = 4,77; p = 0,0007). For all measures, the return was statistically significant for at least five of the six securities at the p < 0,10 level. These results were similar whenever estimates, reservation prices or market prices were used to compute returns. Hence, the data from experiment 2 provides strong support for moderated confidence.

The difficulty of the more- and less- reliable signals always having opposite signs is in determining how much of the return arises from under-reactions to more-reliable information. It is probable that most of the returns are under-reactions to less-reliable information, these being much larger in the first experiment than overreactions to less-reliable information. An analysis of variance in experiment 2 revealed a similar result. When market prices were used to compute returns it was found that changes in the more-reliable signal significantly influenced portfolio returns (F = 5,00; p = 0,0205), while changes in the less-reliable signal did not (F = 0,19; p < 0,6707). The interaction between the signals was also insignificant (F = 0,04; p = 0,9644). Results using estimates or reservation prices as a price proxy were very similar. Therefore, the pattern of results was quite similar to those obtained in experiment 1.

Table 4: Results of Experiment 2

Signal difference (extremity) of less-reliable signal	Signal difference (extremity of more-reliable signal	Return to a contrarian strategy using		
		Estimate as market price proxy	Reservation price as market price proxy	Final round market price
3 (50,0)	5 (14,7)	15,28***	11,91***	11,30**
3 (50,0)	3 (8,8)	12,15***	10,30***	9,25**
3 (50,0)	1 (2,9)	5,35*	4,57*	2,75
1 (16,7)	5 (14,7)	10,07***	15,63***	14,61***
1 (16,7)	3 (8,8)	8,57***	12,13***	10,05*
1 (16,7)	1 (2,9)	4,04***	5,44***	4,34***
Mean		9,24***	10,00***	8,74***

***p < 0,01; **p < 0,05; *p < 0,10 – All p-values resulting from one sided t tests.

Taken together, the analyses suggest that markets strongly under-react to more reliable information but overreact only slightly (if at all) to less reliable information. More specifically, experiment 2 even though investors had a greater level of experience and within-subjects manipulation of signal reliability should have helped investors avoid unintended miss weighting of information, moderated confidence was reinforced.

All of these tests have been ones of semi-strong form efficiency. Portfolios were formed based on the information presented to investors. Weak-form efficiency may also be examined by forming contrarian portfolios that involve selling whenever prices rise above 50 Denares and buying whenever price fall below that. Such an analysis being similar to that used in De Bondt & Thaler (1985; 1987). Overall returns to this strategy were 10,34 (t = 4,29; p < 0,001), suggesting that high prices were too high and low prices too low. The return to this contrarian strategy was significantly positive (at p < 0,001) for five of the six securities. Therefore, the analysis suggests strong overreaction to information.

At first this result might seem to conflict with the claim that markets under-react to reliable information. Such an inconsistency arises because under-reactions to more-reliable information often cause prices to rise when they should fall, and *vice versa*. For instance, assume that, as in line 1 of Table 4 investors observe 0 heads out of 3 flips (signal difference = 3) and 11 heads of out of 17 flips (signal difference 5). In that case the security value should be 55,5 as the unreliable bad news is outweighed by the reliable good. However, the closing market price averaged just 44,2 (yielding a price error of 11,3). Now, while this price error could have arisen entirely from an under-reaction to reliable information, a weak-form test would call it an unambiguous overreaction: the price being much too low.

Weak-form overreactions are exacerbated by the relatively central values of other securities. If a security has a value of 50 Denares, any price other than that would be a weak-form over-reaction. These might be less strong if securities for which both the reliable and unreliable signal were favourable (or both unfavourable) but because such securities would probably yield roughly equal over- and under-reactions in weak form tests, it is unlikely that they would eliminate the overall tendency toward weak-form overreactions. Weak-form efficiency tests may lead to conclusions very different than those drawn from semi-strong form tests. Thus it would be inappropriate to conclude that investors in experiment 2 overreacted strongly to their information.

As weak-form tests form portfolios on the basis of price rather than information they can be subject to a variety of extraneous factors. For instance, if price reflects investors' value estimates with random error that error could induce weak-form overreactions if high prices tended to include positive random error, while low prices included negative random error. Hence, this study takes the position that the most accurate way to assess information-related biases is through event study methods that condition trading portfolios on the specific information in question.

6. CONCLUSIONS

Fama (1998) argued that the roughly equal prevalence of under- and over-reactions in empirical research implies that market prices are informational efficient. This claim is correct only if it is impossible to predict whether under- and over-reactions will result. The experiments documented in this study showed that such predictions could be made in the laboratory, simply by knowing the reliability of investors' information.

Consistent with moderated confidence, both experiments 1 and 2 showed that prices and investors' value estimates tend to under-react more as the reliability of information increases. Any anomaly arising in the laboratory leads one to ask whether the same results would be observed among investors with greater experience. Several arguments supported by this study suggest that they would. First, when the current data was analyzed to search for experience effects, none were found. Two different analyses were performed. For experiments 1 and 2 results were compared between the first and last securities traded by each cohort. In experiment 1 the results between those cohorts that traded low-reliability signals first (and high-reliability signals second) and those that traded high-reliability signals first (and low-reliability signals second) were compared. In all these analyses, experience was never significant, neither was there any systematic evidence to suggest that effect magnitudes decreased with experience. Note must also be made that experiment 2 was conducted with the same participants as in experiment 1. Hence, the experience that participants get in the experiments did not seem to have much effect on the results. Most experiments that examine experience, as well as most formal learning models show that experience effects are largest when learners are first getting their experience. After some time, the learning curve flattens.

Many papers in psychology have shown that overconfidence is a highly robust result, one that is not easily eliminated with experience in a variety of settings. Flowing from this analysis, this study proposes that it is unlikely the results observed would vanish in additional trading sessions. Moreover, to the extent that experience might affect additional session results, it seems more likely that they would reduce the magnitude of the observed effects rather than their directions. Hence, experience is unlikely to affect the pattern of over- and under-reactions that have been observed across cells of the experimental design.

As it is such differences across treatments, rather than absolute levels, that have been interpreted through the experiments, there is little to suggest that data from more experienced participants would change the inferences drawn. Rather, it is likely that investors would be more prone to under-react and less likely to overreact to information as that information became more reliable. Even if experience did reduce the magnitude of the effects, such a result would not make those reported here automatically uninteresting. This is because financial markets always have a mix of more and less experienced traders, and it would still be useful for research to shed light on the errors they are likely to make. The efficient markets hypothesis suggests that more-experienced traders would compete to eliminate such errors, although experimental evidence and theoretical models suggest this might not always occur (*e.g.,* Benos, 1998; Camerer, 1987; De Long, Shleifer, Summers & Waldmann, 1991; Fisher & Verrecchia, 1999; Kyle & Wang; 1997). While that is an interesting question, it is quite distinct from the questions this study sought to examine.

Overall, the experimental results reported here have interesting implications for how anomalies reported in the literature should be interpreted. Many studies that condition on non-price-related information show under-reactions. Markets appear to under-react to earnings announcements (*e.g.,* Bernard & Thomas, 1989; 1990), dividend changes (Michaely, Thaler & Womack, 1995), analyst reports (Womack, 1996) and measures of earnings quality (Sloan, 1996). In contrast, Lakonishok *et al.* (1994) are exceptional in that they show an overreaction using purely non-price information portfolios: [they showed over-reactions to five year sales growth rates]. The prevalence of under-reactions in event studies might arise because researchers direct their attention toward information releases and events that contain relatively reliable information about future performance. Also it is possible that whatever effect causes under-reactions to be more severe than overreactions in this study as in Bloomfield's (1996a; b) and Gillette *et. al's .,* (1998) markets, also has a similar effect in larger markets. However, the experiments designed here were not intended to explore this tendency.

Many empirical studies show overreactions from portfolios formed on the basis of market prices rather than information. For instance De Bondt and Thaler (1985, 1987) claimed to observe overreaction, as stocks with high past returns were priced too high and those with low past returns priced too low. The second experiment reported here shows a similar pattern of results, even though investors are in this case actually strongly under-reacting to reliable information and overreacting to unreliable information slightly, if at all. This paper argues that weak-form overreactions are driven by noise in prices that are unrelated to available information. While these overreactions cancel out when information is used to form portfolios, they result in systematic biases when price levels or returns are used instead (this as high prices are associated with positive price errors).

7. IMPLICATIONS FOR FURTHER RESEARCH

This study presents several ways in which empirical research could test directly for moderated confidence. Its results suggest that market prices will overreact to information determined to be unreliable and under-react to that determined to be reliable. For instance, if markets under-react to earnings, as earnings are a relatively reliable indicator of value, then under-reactions to earnings changes should be larger for firms and industries where earnings changes are more reliable value indicators. Conversely, overreactions to widely publicized events should be larger when those events have less value relevance.

Empirical researchers could also attempt to assess the extent to which moderated confidence in financial markets is rational. In the laboratory any evidence of moderated confidence was seen as irrational because investors had perfect information on signal reliability (knowing the number of times the relevant coin was flipped). Evidence of moderated confidence in empirical studies could be rational if investors assessed information reliability as accurately as possible given the information available to them. The first step in this testing would be to use information available at the time of portfolio formation to assess the reliability of the information. If investors could have assessed the reliability of information then, they should have been in a position to exploit overreactions to unreliable information and under-reactions to that which is reliable.

Lastly, future research may attempt to integrate the view of moderated confidence presented here with models of overconfidence in the literature. For instance, moderated confidence might also be used to re-examine Barberis *et al.* (1998) 'regime-shifting' model. Their work had earnings following a random walk, with investors believing that the earnings process switches between a mean-reverting regime (in which earnings changes are negatively autocorrelated) and a continuing regime (where such changes are positively autocorrelated). This model is roughly equivalent to assuming that investors overestimate the reliability of the (relatively unreliable) information about the time-series parameters of earnings that can be extracted from a short sequence of earnings changes.

Also the 'overconfidence' models of Daniel *et al.* (1998a, b) Gervais & Odean (1997) and Odean (1998) hold that investors will overreact to all information as its reliability is overestimated. The results presented here suggest this assumption may not generalize to settings where investors have information of high reliability. It would be helpful to know how a more generalized view of inaccurate confidence would affect those models' results.

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