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An Experimental Study of the Disposition Effect: Evidence From Macau

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The disposition effect—the tendency to sell winning transactions too soon and hold losing transactions too long—is examined experimentally in Macau. The findings show that the disposition effect exists strongly under the modified version of the experiment designed by Weber and Camerer [1998]. This study also points out that a psychological factor, the locus of control, can partly explain the disposition effect observed in this experiment.

We study experimentally the existence of the disposition effect in Macau when the belief in mean reversion is under control. We also evaluate the extent of the disposition effect relating to a personality factor, internal–external locus of control.

The disposition effect—the tendency to sell winning transactions too soon and hold on to losing transactions too long—has been widely documented in investment markets. Such behavior is not described accurately by the rational decision-making theory that states rational investors make investment decisions with regard to risk and return rather than to paper gains or losses. Therefore, it is an individual anomaly from the viewpoint of investors seeking profit maximization.

Behavioral finance scholars have borrowed from psychology to explain such investment behavior. Loss aversion, which is depicted in the value function of the prospect theory by Kahneman and Tversky [1979], is the most widely accepted explanation. Investors judge gains and losses relative to their reference point; the most common is purchase price. Investors in the gain domain liquidate their winning investments soon because it guarantees "locking in" these gains. Those in the loss domain, however, hold on to their losing investments because they continue to hope they will come out ahead. The disposition effect also implies that, on average, the number of sales in winning transactions should exceed those in losing transactions.

Another competing psychological explanation is the belief in mean reversion, which states that investors believe poorer-performing stocks will rebound, and that better-performing stocks will decline in price. Investors who keep their losing stocks may do so out of a belief in price rebounds, or because of their loss aversion, or both. When traders receive information that stocks are likely to follow an upward or downward trend, the belief in mean reversion should disappear and the effect of mean reversion on the disposition effect should also be minimized.

An important unexplored area in the study of the disposition effect is to identify who is likely to exhibit the disposition effect, and precisely which personality factor(s) can influence the magnitude of such behavior. For instance, Rotter's [1966] internal–external locus of control, which measures the extent of feelings on the control of any event, might be an important driving force of the disposition effect. Internal traders are those who feel that outcomes are under their control. They might tend to make more of a commitment to their investment decisions than external traders, who feel that outcomes are out of their control. As a result, we believe internal traders may exhibit stronger disposition effects than external traders.

The results of this study show that, compared with similar works based on Weber and Camerer [1998], the disposition effect is much stronger in Macau, a non-Western culture city. Even after controlling for the belief in mean reversion, the disposition effect is still very pronounced. And as predicted, it is stronger for internal traders than for external traders.

Literature Review

The studies of the disposition effect can be divided into two groups: those conducted on the basis of individual data, and those conducted on the basis of market data (the aggregate of individuals). Based on the market data in mutual fund performance, Shefrin and Statman [1985] first documented the disposition effect. By comparing the trading volume between winning and losing stocks on the NYSE and the AMEX, Lakonishok and Smidt [1986] and Ferris, Haugen, and Makhija [1988] pointed out that volume for winners exceeds that for losers. Similar results have been observed by Bremer and Kato [1996] for Japanese stocks.

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Some important studies analyzing individual behavior have also been conducted. Odean [1998] examined the disposition effect by analyzing trading records for 10,000 individual accounts of a large discount brokerage house. The results demonstrate a stronger preference for realizing winners than losers based on the fact that investors held losers longer (a median of 124 days) than they held winners (a median of 104 days).

But an important drawback of this study is that the tendency for the number of shares sold at loss to exceed those at gain is not only attributable to the value function in the prospect theory. It can also be attributed to the belief in mean reversion proposed by Andreassen [1988], which, as discussed earlier, states that investors believe poorer-performing stocks will rebound, and that better-performing stocks will decline in price.

Odean [1998] pointed out that investors themselves might not fully recognize the underlying reason why they won't sell a stock at a loss. For instance, investors may persuade themselves that the stock price will rebound soon instead of acting upon their loss aversion characteristics.

Weber and Camerer [1998] attempt to isolate these two competing explanations using an experimental approach. Their experiment is well designed, first because the probabilities of stock prices increasing are fixed and kept constant over the entire trading period. Therefore, it is expected that stocks will move on an autocorrelation basis rather than on a mean reversion basis. Second, subjects are free to trade stocks in the market, and are not informed of the predetermined underlying probabilities of stocks prior to the launching of the experiment. As a result, trading based on a mean reversion strategy in this experimental setting is not an issue, provided that stock predictions are correct.

Besides using an experimental approach to investigate the existence of the disposition effect, three additional contributions are made here. First, we examine whether the decision-making behavior described in the value function can be observed in a particular trading period, given that the stock prediction is perfectly correct. Second, we examine whether participants' disposition effects correlate with their own personality, in particular with the internal–external locus of control variable. Locus of control is typically measured through a twenty-nine-question test in which, under the questionnaire's original design, six questions are specifically ignored. It is measured in the external direction, ranging from 0 (a perfect internal individual) to 23 (a perfect external individual). An example of a pair of choices in this questionnaire is below.

A. Becoming a success is a matter of hard work; luck has little or nothing to do with it.
B. Getting a good job depends mainly on being in the right place at the right time.

Those who pick A are considered internal, while those who pick B are considered external.

The results of three early studies relating locus of control to risk decision-making in some investment settings are inconsistent. McInish [1982] found that "externals chose more risky portfolios." McInish [1980] and Maital, Filer, and Simon [1982], using a game simulation approach, found that "internals chose more risky portfolios than externals." Our study will hopefully provide additional insight into the significance of locus of control in investment decision-making behaviors, such as the disposition effect observed here.

The third contribution this experiment aims to make is to provide insight into investor behavior in Macau. Since most studies on the disposition effect have been conducted in North America and Europe, the results of this experiment may shed new light on the disposition effect. Our main objective in the next sections is to examine whether the disposition effect exists under a controlled experiment. If so, can it be explained by locus of control?

Experimental Design

This experiment basically applies the framework of Weber and Camerer [1998], but with two modifications: the introduction of a loss penalty for participants' poor trading performance, and a computerized trading sheet streamlining the computation process in the numerous transactions that take place during the trading periods.

Each participant is given $50,000 in an account at the beginning of the experiment/game. There are six different stocks in the game, labeled A to F. The game is divided into fourteen periods. During each of the first thirteen periods, participants can trade in these six stocks. All stocks on hand in the last period (Period 14) must be liquidated. Participants are not permitted to borrow money or sell assets short, and there are no transaction costs.

Stock prices for each period are predetermined rather than being set by the trading actions of participants. There are two stages in the process of stock price formation.

1. **The direction of price movement for each stock.** Two of the six stocks are more likely to perform better, with a 65% and 55% chance of a price increase. Two are more likely to perform worse, with a 45% and 35% chance of a price increase. The remaining two have an equal chance of increasing or decreasing in price. These probabilities remain fixed for each stock during the entire fourteen periods of the game. The price never stays the same from one period to another. And the chance for a price decrease is equal to 100% minus the chance for an increase.

2. **The magnitude of price change for each stock.** During each period, the price for each stock can rise or fall by $1, $3, or $5. Each outcome is equally likely and independent across assets. Note that the magnitude of price changes is unrelated to the direction or the probability of a stock price increase.

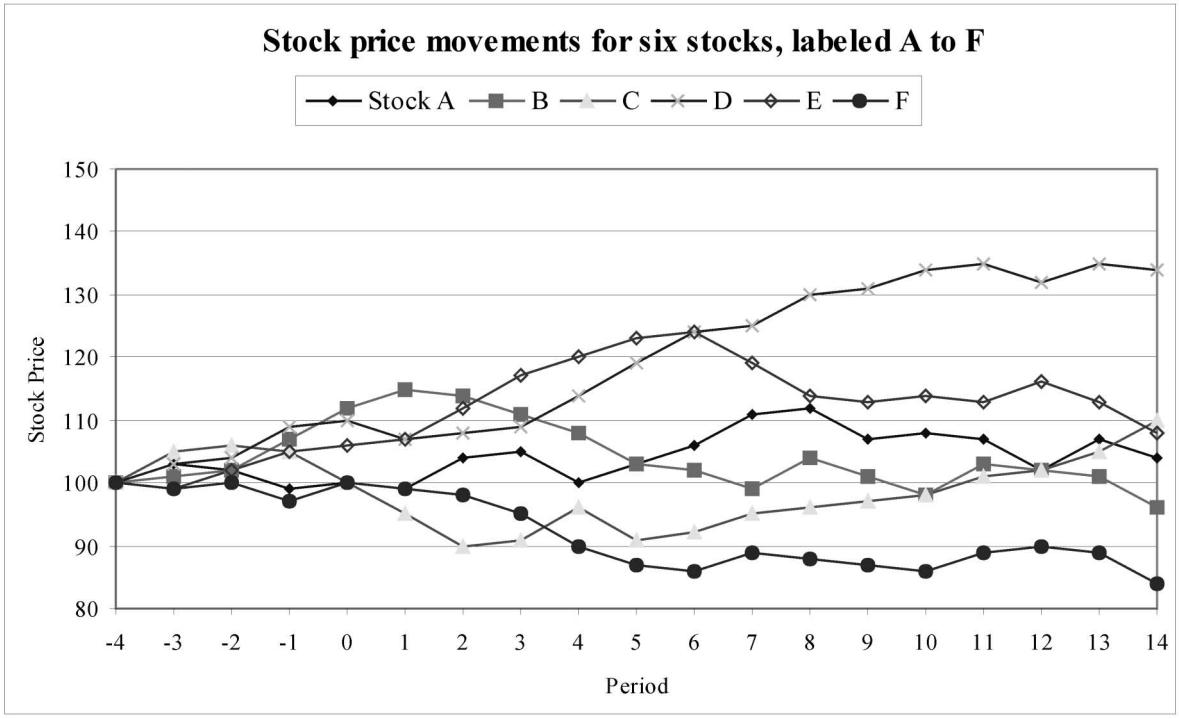
Traders are allowed to observe previous stock price movements and stock predictions in making investment decisions. In order to give some idea of the price trend for each stock at the beginning of the experiment, the price for Periods –4 to 0 is given and the first trading takes place in Period 1. Complete price movements for each stock from Period –4 to 14 are depicted in Figure 1.

Because they are informed of the price generating process at the outset of the experiment, traders can easily and quickly identify which stocks have good or bad performance from the prior history of the sign of price changes, rather than from other determinants such as the current price level or the actual magnitude of price changes. The awareness of the process should help traders decide whether to hold on to the good stocks and whether to sell off the poor ones. Again, trading on mean reversion is not an issue.

Because we wanted to model the experiment as much as possible on a real market, we added a penalty system to Weber and Camerer's [1998] process to better simulate real-life feelings of depression or joy. Under Weber and Camerer's experiment, the most a participant could lose is the endowment they are given, which might not cause subjects to behave as they would in reality. To better reflect the loss feeling, the penalty for the worst three performers in our experiment is that they have to pay back the initial endowment of $50,000 to the instructor and can only earn the net change of their wealth. For example, they would have to pay a real amount of $10 if the net change is –$10,000 (final wealth 40,000 minus initial endowment 50,000). The reward is that at the end of the game, each participant may win a sum equivalent to 0.1% of his/her final portfolio value. However, any idle cash during the game will not earn interest.

We also installed a computer program in each computer to streamline the computation process for each trade and cash balance at each period.

FIGURE 1
Stock Price Movements for Six Stocks



Note: Stock price movements from Periods –4 through 14, during which traders are free to trade stocks from Periods 1 to 13, but must liquidate everything in Period 14. The data from the initial five periods (Periods –4 to 0) are the reference for stock predictions. For each of these periods, all six stocks will go up or down by $1, $3, or $5. Two of the stocks have a likelihood of better performance, with a probability of increasing of 65% and 55%. Two have a likelihood of poorer performance, with a probability of increasing of 45% and 35%. The remaining two have an equal chance of going up or down.

In this experiment there were forty-seven fourth-year undergraduate business students, with twenty-eight females and nineteen males. All of them had already studied some basic statistics course. In addition, two-thirds had taken part in a simulated investment game in an investment course at the University of Macau. Their ages ranged from 21 to 26, with an average of 23. The experiment took about three hours.

Hypothesis Testing

Testing the Disposition Effect

Three tests are used to examine the existence of the disposition effect using the experiment data. Two assumptions are made in the estimation of the number of shares that are sold at gain, break-even, or loss. First, the purchase price is used as the participant's reference point, from which gains and losses are measured. Second, when the purchase prices for those selling shares cannot be readily determined, their identification is based on the FIFO accounting approach, which assumes that the shares that are sold are the ones that were purchased first.

According to the experiment design, there are fourteen periods. During the first thirteen, participants can make their own trading decisions (to buy, sell, or hold stocks), and in the last period, all are forced to liquidate their shares. Based on this setting, if people are eager to hold their losing stocks and liquidate their winning stocks earlier, the number of shares that are sold at a profit should be greater than those sold at a loss during the first thirteen periods. However, the disposition effect should be relatively weaker in Period 14.

Another possible test of the disposition effect is to compare the average profit from shares sold during Periods 1 through 13 with that from Period 14, when all shares must be sold. According to the experiment design, those stocks whose performance has been poor (good) in the past will be more likely to perform poorly (well) in the future. Therefore, if the disposition effect—participants sell winning stocks earlier and continue to hold losing shares until Period 14—exists, the average profit for shares sold from Periods 1 through 13 should be greater than for those sold in Period 14.

In addition, we employ an alpha index, created by Weber and Camerer [1998], to examine the disposition effect on an individual basis. The higher the scale of the individual index, the stronger the disposition effect. The index is formulated as follows:

$$\text{Alpha Index}_I = (G_I - S_I)/(G_I + S_I)$$

where G and S stand for the number of shares sold at a profit and loss, respectively, for each individual participant I.

Hypothesis 1 (2)

H_0: The average alpha index for all participants is equal to or less than zero in Periods 1–13 (P1–14).

H_A: The average alpha index for all participants is greater than zero in Periods 1–13 (P1–14).

The Belief in Mean Reversion and Buying Behavior

The observation of buying behavior in this experiment is important because from it we can infer whether participants believe in mean reversion. If they do, they should buy more shares after losses than after gains. Otherwise, the disposition effect observed here should be explained by other reasons, such as the value function predicted by the prospect theory.

Accuracy of Stock Prediction

Inaccurate predictions of the direction of stock movements in this experiment may lead to the disposition effect. For instance, poorer-performing stocks misperceived as higher-performing ones will continue to be kept; higher performers misperceived as bad will be dropped.

According to the measure-of-fit approach adopted by Weber and Camerer [1998], stocks with 65%, 55%, 50%, 45%, and 35% are assigned the numbers of 2, 1, 0, –1, and –2, respectively. The accuracy of stock prediction can then be estimated based on the absolute difference between the best estimate and a subject's actual guess, respectively. And the best estimate is to count the number of times a stock's price increased. The stock whose price has risen the most is the most profitable one. This measure should be within the range of 0 (a perfect match) to 12 (the worst match).

To further support the value function as a correct decision-making model to explain the disposition effect, we examine subjects who made perfect stock predictions. In Period 7, for example, do they continue to hold on to their worst (losing) stocks, or do they sell their most profitable stocks?

Disposition Effect/Loss Aversion and Locus of Control

According to the concept of locus of control, external people are not unduly concerned about losses (the symptom of failures/errors) because they believe they are not fully responsible for them. They have little need to defend themselves against failure, and are therefore more risk aggressive or less loss-averse. On the other hand, internal people feel their losses more strongly, as they believe their failures are directly related to their own judgments. They should be more risk-averse/loss-

averse in making investment decisions, particularly in selling stocks. We hypothesize that if the disposition effect is mainly caused by loss aversion characteristics, then the disposition effect observed in the experiment may be driven by the participant's locus of control.

A correlation test between these two variables is conducted for Periods 1–13, during which participants are free to make their own investment decisions. The locus of control will be measured based on the questionnaire designed by Rotter [1966], and risk attitude determined based on the individual alpha index, that is, the proportion of shares sold at a gain/loss relative to the aggregate. The index ranges from –1 to +1.

Hypothesis 3

H_0: There is no relationship between the locus of control and the disposition effect.

H_A: There is a relationship between the locus of control and the disposition effect.

Results

Table 1 shows the number of shares sold over Periods 1–13 and during Period 14. The results support the disposition effect. The number of shares sold at a profit is 3.5 times as many as those sold at a loss for the first thirteen periods (31,621 gains versus 8,984 losses). The effect also exists across all stocks except B and F. This inconsistency may be attributable to the fact that they are the worst-performing stocks, with ten decreases in price and only three increases during the thirteen periods.

The disposition effect is much weaker in Period 14 than in Periods 1 to 13. The number of gains is just 36% larger (6,977 gains versus 5,127 losses) than losses in Period 14, compared with 370% in Periods 1–13.

Ignoring the best performing stock, Stock C, the inversion of the disposition effect can exist in Period 14, which means the number of shares sold at loss exceeds those sold at gain. Even after accounting for the uneven distribution of the total number of price increases and decreases (45 increases versus 39 decreases) over the entire fourteen periods, the disposition effect still exists (857 share gains versus 361 share losses).

Table 2 shows that the average profit realized by participants across stocks in Periods 1–13 outperforms that in Period 14 (MOP $3.6 per transaction in Periods 1–13, versus MOP $2.1 per transaction in Period 14).

Table 1. *Total Number of Shares Sold in the Free-to-Trade Period (Periods 1–13) and in the Forced-to-Sell Period (Period 14)*

	Type of Trading?							
	"Free to Trade" in Periods 1–13				"Forced to Sell" in Period 14			
Type of Stock	Gain	Loss	Even	Total	Gain	Loss	Even	Total
A	4,849	1,721	310	6,880	210	550	0	760
B	2,596	2,978	35	5,609	200	775	0	975
C	6,011	155	180	6,346	5,470	0	0	5,470
D	10,583	20	314	10,917	1,087	1,182	170	2,439
E	5,442	1,366	50	6,858	10	1,919	0	1,929
F	2,140	2,744	285	5,169	0	701	0	701
Total	31,621	8,984	1,174	41,779	6,977	5,127	170	12,274

Note: Total number of shares sold at gain, loss, and even for each individual stock and across stocks in the periods of "free to trade" and "forced to sell." Traders sell a higher proportion of shares at gains than at losses in the "free to trade" periods. However, such a high proportion disappears in Period 14, when all winning and losing stocks are forced to be liquidated.

Table 2. *Average Profit Earned During the "Free-to-Trade" Periods 1–13 and "Forced-to-Sell" Period 14*

	Type of Trading?					
	"Free to Trade" in Periods 1–13			"Forced to Sell" in Period 14		
Type of Stock	No. of Transactions	Profit	Average Profit	No. of Transactions	Profit	Average Profit
A	6,880	$20,321	3.0	760	–$2,140	–2.8
B	5,609	–7,386	–1.3	975	–5,240	–5.4
C	6,346	20,894	3.3	5,470	42,833	7.8
D	10,917	99,006	9.1	2,439	11,202	4.6
E	6,858	27,531	4.0	1,929	–16,288	–8.4
F	5,169	–8,979	–1.7	701	–4,860	–6.9
Total	41,779	151,387	3.6	12,274	25,507	2.1

Note: Average profits (total profits divided by number of transactions) realized for each stock and across stocks in Periods 1–13 and Period 14. Traders on average earn greater profits in Periods 1–13 than in Period 14 both on an individual stock and an aggregate basis.

The same phenomenon exists for each individual stock with the exception of C, the best performing stock. Its price peaked in Period 14 and there are consecutive increases over the last nine periods. These findings reconfirm a general tendency to keep losing stocks until forced to sell.

The results show that in Periods 1–13, only five of forty-eight participants have a negative index. This means that the number of losses exceeds the number of gains. And the mean of the individual index is 0.495. The one-tail t-test also shows that the mean is significantly greater than zero at a 99% confidence interval (t value: 9.368, p-value: 1.74E–12, which is much less than the 5% or 1% significance level).

However, in Period 14, the disposition effect has disappeared. Four participants are not considered at all because they don't have any stocks left in this period. Out of the remaining forty-four participants, twenty-five have a negative individual index. And the mean of the individual index is –0.163, which implies that many participants held their losing stocks until forced to dispose of them. The average individual index from Periods 1–14 is 0.36, statistically greater than zero, with a p-value of 1.04E–08 and a t value of 6.73.

The results of these three tests support the disposition effect. More importantly, the disposition effect is much stronger in this study than in Weber and Camerer [1998] with respect to the above three measurements. For example, in terms of the percentage of shares sold at gain from Periods 1 through 13, 71% sold at gain in this study versus 59% in Weber's. This strong disposition effect may be attributable to the penalty function imposed in this experiment or to the different scale of locus of control between the two studied areas of Germany and Macau.

Mean Reversion and Buying Behavior

The results show that the belief in mean reversion does not exist here because both on an aggregate basis and a per occurrence basis, the number of shares bought at gain in the past periods exceeds those bought at loss. The same conclusion can also be drawn by comparing the number of shares bought at gain/loss in the past two consecutive periods, as shown in Table 3. Therefore, it does not seem that the disposition effect is attributable to the belief in price reversion.

Accuracy of Price Prediction

We note that, at the end of Period 7, thirty-seven subjects are assigned to match the six stocks with their respective probability. The results indicate that the mean of the estimate is 2.4 and the standard deviation is 2.2, compared with 2.11 and 2.40, respectively, in Weber and Camerer's [1998] experiment. Although, on average, two places from the best guess are mismatched, the number of wrong guesses is quite significant and not equally distributed across stocks. Because of the high consistency in the direction of previous price changes, the most and the least profitable stocks got the best guesses, with accuracy of 88% and 77%, respectively.

Twenty-four subjects make a perfect guess on these two stocks at Period 7. Half these subjects, however, either continue to hold the worst-performing stock or to sell the best-performing stock in Period 7. The results of this one-period test provide further evidence that the value function describes how subjects behave in decision-making situations where gains and losses are presented.

Disposition Effect and Locus of Control

The results in Table 4 show that the average scale of locus of control is 12.83, with the maximum (minimum) scale of 21 (3) in a full score of 23. The result of the correlation test between these two variables shows that a weak form of correlation of –0.31 exists between them.

Suppose all the individual alpha indices are categorized into three groups, G1 to G3, according to the scale of their locus of control. The sample size is sixteen students per group. G1 (G3) represents the group with the smallest (biggest) scale of locus of control. The results show that the degree of loss aversion is more pronounced in G1 (the internal group with an

Table 3. *Frequency of Shares Bought Across Stocks After Gain/Loss in the Past Period and the Past Two Consecutive Periods*

Type of Price Change	Aggregate Shares Bought	Average Frequency
G (n = 45)	29,175	648
L (n = 39)	25,114	643
GG (n = 30)	22,245	742
LL (n = 22)	13,719	624

Note: G and L stand for the price gain and loss in the last period. GG and LL stand for the price gain and loss in the past two consecutive periods. Both on an aggregate and an average frequency basis, the number of shares bought at a gain in the past period and the past two consecutive periods exceeds those bought at loss. As a result, it seems that the belief in price reversion is not an issue.

Table 4. *Means of Alpha Scale for Each of These Three Groups, Categorized by Locus of Control*

	G1 Group With the Lowest Locus of Control (mean = 8.97, n = 16)	G2 (mean = 12.87, n = 16)	G3 Group With the Highest Locus of Control (mean = 16.75, n = 16)
Average Scale of the Alpha Index for Each Group	0.63	0.54	0.32

Note: All the individual alpha indices are categorized into three groups, G1 to G3, according to the scale of their locus of control. The mean of the alpha scale in G1, G2, and G3 are 8.97, 12.87, and 16.75, respectively. The descriptive data show a negative relationship between locus of control and the disposition effect. That is, the disposition effect is stronger in the internal group than in the external group. And the hypothesis that there is no difference in the average scale of the alpha index for these three groups is rejected at the 5% significance level with an f-value of 3.23.

average alpha scale of 0.627) than in G3 (the external group with an average alpha scale of 0.319). A one-way ANOVA test is used to examine the null hypothesis that the average alpha index is the same for all three subgroups. The result indicates that the hypothesis is rejected at the 5% significance level with an f-value of 3.23, implying a negative relationship between the locus of control and the disposition effect. That is, the disposition effect is weaker for external subjects than for internal subjects. The data do not, however, indicate that trading volume is subject to their locus of control.

Conclusion and Recommendations

This experimental research sheds more light on the study of the disposition effect from different aspects. First, the disposition effect observed based on both aggregate data and individual data can be further confirmed experimentally in Macau, a city with a mixture of Eastern and Western cultures. Second, after controlling for the belief in mean reversion, the disposition effect is still very pronounced. Third, as predicted, the disposition effect is stronger for internal traders than for external traders.

One of the big problems in investment theory is that investors themselves may not be able to clearly identify the magnitude of their own disposition effect. For example, those with a strong disposition effect may forgo profitable investments while keeping their losers. In the worst case, they may eventually be left with poor-performing stocks in their portfolio. Therefore, in order to avoid all these irrational behaviors, the identification of a personality profile should be explored. Based on our results, the locus of control should be one of the components in this profile. Further study, however, is needed to identify other factors in this profile.

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