A Dynamic Model of Investor Decision-Making: How Adaptation to Losses Affects Future Selling Decisions

Lee, K.M.C.; Kraussl, R.G.W.; Lucas, A.; Paas, L.J.

2008

TI 2008-112/2
Tinbergen Institute Discussion Paper

A Dynamic Model of Investor Decision-Making

Carmen Lee[1]
Roman Kraeussl[2]
André Lucas[2,3,4]
Leonard J. Paas[1]

[1] *Marketing Dept., VU University Amsterdam;*
[2] *Finance Dept., VU University Amsterdam;*
[3] *Tinbergen Institute;*
[4] *Duisenberg School of Finance.*

Tinbergen Institute

The Tinbergen Institute is the institute for economic research of the Erasmus Universiteit Rotterdam, Universiteit van Amsterdam, and Vrije Universiteit Amsterdam.

Tinbergen Institute Amsterdam
Roetersstraat 31
1018 WB Amsterdam
The Netherlands
Tel.: +31(0)20 551 3500
Fax: +31(0)20 551 3555

Tinbergen Institute Rotterdam
Burg. Oudlaan 50
3062 PA Rotterdam
The Netherlands
Tel.: +31(0)10 408 8900
Fax: +31(0)10 408 9031

A Dynamic Model of Investor Decision-Making:

How Adaptation to Losses Affects Future Selling Decisions**

Carmen Lee[*], Roman Kraeussl[†], André Lucas[†‡], Leonard J. Paas[*]

[*] *Marketing department VU University Amsterdam*

[†] *Finance department VU University Amsterdam*

[‡] *Tinbergen Institute and Duisenberg school of finance*

** Preliminary results were presented in the 2008 IAREP/SABE World Meeting in Rome, Italy and at the Association for Consumer Research Annual North American Conference, held from October 23–26, 2008, in San Francisco, CA. We appreciate the helpful comments from the participants.

Corresponding author: Carmen Lee, Faculty of Economics and Business Administration, VU University Amsterdam, De Boelelaan 1105, 1081 HV Amsterdam, The Netherlands. Tel. +31 20 59 89862, Fax +31 20 59 89870. E-mail address: clee@feweb.vu.nl (C. Lee)

Abstract

The disposition effect postulates that individuals hold losing investments too long. However, many investors eventually sell at a loss. This paper integrates prospect theory, reference point adaptation and cognitive-experiential self-theory to provide more insight on such investor's capitulation. We empirically study the contribution of each component as well as their inter-relationships in two dynamic experiments. Consistent with utility maximization, we find a major effect of positive expectations. Second, a larger total loss size and a longer time in a losing position are related to a downward shift in the reference point. The dynamically adapting reference point indirectly increases the probability to capitulate. Also, a recent loss leads to more negative emotions, which also indirectly increases the probability to capitulate.

JEL Classifications: C91, D03, D81.

Keywords: investments; adaptation; reference point; capitulation; selling decisions; disposition effect; financial markets.

I. INTRODUCTION

In a recent JCR paper Zhou and Pham (2004) point out that consumer financial behavior is understudied in the field of consumer research. One of the most intriguing phenomena in decision making under risk, particularly in financial markets, is the disposition effect. Shefrin and Statman (1985) propose that investors tend to hold their losers (depreciated investments) too long and sell their winners (appreciated investments) too soon. This proposition has received empirical support both in the laboratory setting (Weber and Camerer 1998) and in the market place (Odean 1998). Odean analyzes individual trading accounts from a large discount brokerage house and finds investors sell winners 1.6 times more often than losers. The prominent explanation for the disposition effect is based on prospect theory (Kahneman and Tversky 1979). Prospect theory posits that the influence of a gain or loss on wealth is not measured in absolute terms. Rather, the perceived value of each outcome depends on its distance to a reference point. Thus, when facing a paper gain, investors tend to be risk-averse and choose the less risky option by selling the winners. By contrast, when facing paper losses investors tend to choose the risky option and keep on to the losers.

Prospect theory, however, is relatively silent about the dynamic aspect of financial decision-making. For example, it tells us little about why many investors eventually do capitulate on their loosing investments if the losses accumulate too much or extend over too long a period. We address this gap in the existing literature by proposing a dynamic model for investor decision-making. The model disentangles the effects of time in a losing position and size of loss on reference point adaptation by combining different theories in this field. Adaptation of the reference point (from prospect theory) is modeled as a change in the adaptation level (from adaptation level theory), which is influenced by the time and size of each stimulus. These two building blocks are linked to investors' emotions using the framework of cognitive-experiential self-theory, which suggests there are two systems in decision-making: experiential and rational.

We extend the results of a recent study by Arkes, Hirshleifer, Jiang and Lim (2008). They show that investors adapt to financial gains and losses as their reference point shifts after the value of the investment changes. The focus in their study is a single value change. In practice, however, individuals are faced with a chain of decision moments: the decision to hold on to an investment today may account for the fact that one can reconsider this decision tomorrow. To understand how investors' deal with these multiple decision moments, it is necessary to understand how the reference point shifts each time new information is received by the decision maker. We examine this issue by carrying out two dynamic investment experiments. We study how shifts in the investor's reference point influence this individual's emotions and expectations about the investment's future performance. The different effects are combined to investigate their influence on the final decision to hold on to or to capitulate on a losing investment.

Our main contribution is the integration of prospect theory, reference point adaptation theory and cognitive-experiential self theory in order to explain why individuals eventually do sell losing investments, despite the disposition effect. We find a major effect of positive expectations on the decision to hold. This is in line with (rational) expected utility maximization. Second, a larger total loss size and a longer time in a losing position are related to a downward shift in the reference point. The dynamically adapting reference point indirectly decreases the probability to continue to hold the investment via its impact on expectations. Moreover, we find that a recent loss leads to more negative emotions, which also indirectly decreases the probability to hold the investment, also via its effect on expectations.

The remainder of this paper is organized as follows. Section 2 reviews prospect theory, adaptation level theory and cognitive-experiential self-theory. Section 3 integrates these three theories and postulates a dynamic model of investor decision-making. Sections 4 and 5 present our experimental designs and results. Section 6 concludes and provides implications for future research on the adaptation of reference points.

II. THEORETICAL BACKGROUND

2.1. Prospect theory and reference point dependence

Prospect theory postulates that investors evaluate outcomes with regard to a reference point. This is the salient neutral point on the evaluation scale, at which the slope of the value function shows a sharp transition. If the outcome is above (below) this point, it is considered as a gain (loss). Furthermore, prospect theory suggests investors experience loss aversion: losses impose approximately double the psychological effect of equal-sized gains. In addition, investors show risk aversion in the gain domain, while risk seeking behaviour in the loss domain. This is reflected in concavity of the value function above the reference point and convexity below. Concerning the latter, although selling a losing investment can prevent one from incurring additional losses, actually realizing the loss is psychologically painful. Therefore, investors tend to choose the risky option (holding on to the losing investment, i.e. keeping just "paper losses") in order to retain the possibility of avoiding pain. Weber and Camerer (1998) and Odean (1998) among many others report empirical support for the tendency of holding losing investments.

A fundamental and non-trivial issue in prospect theory concerns the determination of the reference point. Kahneman and Tversky (1979) state that the reference point can be the status quo, but also the expectation or aspiration level, and that it is unclear where the reference point actually lies. In financial decision-making, there is no consensus which price determines the reference point. Some authors suggest the initial purchase price of an investment (Weber and Camerer 1998; Odean 1998). By contrast, the experimental results by Gneezy (2005) suggest investors most likely use the historical peak of a stock price as their reference point. Alternatively, Köszegi and Rabin (2006) and Yogo (2008) propose that the reference point is one's expected value of the future outcome. In the field of consumer price perception, Lichtenstein and Bearden (1989) find that the basis of an internal reference price range remains largely unknown, as each consumer may perceive prices and form their basis differently.

Baucells, Weber and Welfens (2007) point out that in relation to test past prices as reference points, there is a wide range of reference point candidates, for instance, purchase price, historical peak, weighted averages. One may argue for choosing one reference point candidate over another, but since reference point adaptation is a subjective experience, it appears that the potential reference points tested by previous studies are all valid. Moreover, these reference point candidates (prices) may have high correlations with each other in a normal dataset. This makes it even more difficult for researchers to disentangle the effects of these reference point candidates. In fact, Baucells et al. (2007) suggest that in most previous studies on the disposition effect, authors could also have applied an alternative reference point without altering their findings.

Empirically, measurement issues may explain why alternative prices have been proposed as reference points. Inferring the reference point from investors' trading behavior or from purchase prices may result in a noisy proxy. Thus, recent studies propose alternative ways to elicit reference points. For instance, Baucells et al. (2007) asks subjects to report the selling price for which they would feel "neither happy nor unhappy". A limitation of this measure is that participants have to understand the concept of indifference and be able to express that psychological state in terms of stock prices. Arkes et al. (2008) inquire participants to imagine how happy (sad) they would feel due to a previous gain (loss). In a second step, they ask participants to report how much the investment has to appreciate (depreciate) to make them feel equally happy (sad). The limitation here is that subjects may have difficulty imagining how they precisely would feel about future gains and losses, leading to inaccuracy in their estimates.

Affective forecasting studies demonstrate that people's predictions of their own hedonic reactions to future events are susceptible to errors and biases (Wilson and Gilbert 2003). Although people often predict the valence of their emotional reaction (good vs. bad), or even the specific emotions (e.g. joy) correctly, they overestimate the intensity and duration of their emotional reactions. Another limitation of former studies such as Baucells et al. (2007) and Chen and Rao (2002), is that a series of outcomes is presented and participants are then asked to report their reference point. The use of this type of retrospective evaluation can be highly biased (Freedman, Thorton, Camburn, Alwin and Young-DeMarco 1988). Moreover, this methodological approach does not allow researchers to observe how reference points change over the course of the study.

In the experiments reported in this paper, we ask investors to report at what price level they would feel satisfied and at what level they would be willing to sell their invested security. We choose to measure the adaptation of the reference point through these in-direct measures, because the question asked can readily be understood by respondents. We conjecture that investors do not lower their goals unless their reference point is lowered. By comparing the reported price levels at multiple points in time, we are able to infer the extent of adaptation. Previous studies in the management literature show that the aspiration level is adaptive and that the current aspiration level is reflected in aspiration levels and performance feedback (Mezias, Chen and Murphy 2002). Our measure of reference point adaptation requires less cognitive pressure compared to previous studies. Given similar outcomes of different operationalizations, we find that such a low cognitive pressure is highly relevant for an experiment in which subjects have to provide answers on the adapted reference point for multiple points in time.

2.2. Adaptation of the reference point

The empirical evidence that investors tend to avoid the realization of losses combined with the phenomenon that many investors eventually do sell their losing investments, leads to the question what are the precise determinants of this capitulation decision. This is particularly of interest in a dynamic setting, where investors can opt to sell or hold every time they receive new information about a stock's performance. We argue that a prime candidate determinant of the capitulation decision is the investors' dynamic adaptation to losses. Adaptation is a process in which the effect of a constant or repeated stimulus reduces over time. Previous studies have shown that individuals are able to adapt to various kinds of losses or other unpleasant situations (Frederick and Loewenstein 1999).

Kahneman and Tversky (1979) propose that one's current level of perceived wealth is determined by one's adaptation to past and present stimuli, in a similar way as the adaptation level is affected by past stimuli. The adaptation of a reference point is also sometimes referred to as a shift of the reference point or an updated reference point. All definitions imply that the reference point is not static. Instead, it is affected by previous outcomes. As gains (losses) accumulate, reference points adapt upwards (downwards). Thus, a subsequent price of a security is judged relative to this adapted reference point. Their difference in value becomes an input in the investors' decision process whether to hold on to or to capitulate the investment. Since the perceived value of each price level in a time series is dependent on the reference point, it is important to get a clear signal of where the reference point lies and how investors adapt.

Chen and Rao (2002) suggest that people immediately but incompletely update their reference point after experiencing an event. They find that by holding the economic outcome constant, the sequence of events (either loss-followed-by-gain or gain-followed-by-loss) affects one's psychological appraisal of the outcome differently. Nonetheless, their study does not account for the dynamics and uncertainties in decision-making since outcomes are presented explicitly and evaluated retrospectively. Arkes et al. (2008) show adaptation of the reference point exists, and people adapt to gains faster than to losses of the same magnitude.

Adaptation level theory suggests that the perceived magnitude of a stimulus depends on its relation to an adapted level that is determined by preceding stimuli. According to Helson's formula (1964), the adaptation level (*AL)* is the average of past stimuli levels, while X_t represents the current stimulus level, and *t* represents time:

$$AL_t = \frac{1}{t} \sum_{\tau=0}^{t} X_\tau \tag{1}$$

By comparing adaptation level theory with prospect theory, we can see that the adaptation process is similar to a shift in the reference point along the value function proposed by prospect theory. For instance, suppose one initially invests in a stock and its share price drops immediately, while the reference point and the adaptation level are the initial purchase price. The current change in value is then judged to be a loss. Over time, if one adapts to the loss, the adaptation level is the average of the initial price and the current price. In the framework of prospect theory, the reference point shifts downwards along the value function towards the loss, restoring the investors' emotional state. Later if the stock price bounces back, but only to a level below the initial purchase price, investors may already feel pleased again since they perceive the change of price to be a gain, although in terms of overall wealth they are still in a losing position.

Adaptation level theory originates from studies of the sensory systems, e.g. how people adapt to weight and pain. Adapting to psychological pain caused by a financial loss is not a purely sensory experience. It is unlikely that investors adapt to losses precisely based on Helson's formula. In fact, his theory has been criticized on several issues. Sarris (1967) argued that extreme stimuli do not affect the adaptation level as much as Helson (1964) suggested. Parducci (1968) suggested that the judgement of a stimulus is influenced by the rank of the stimulus within a group of stimuli.

In our paper we do not literally follow the original framework of Helson (1964) by constraining the adaptation level to be the time average of all past stimuli. Rather, we argue that the effects of time and size of the stimulus on the reference point may be disentangled separately. More precisely, we argue that the total size of losses affects how much the reference point shifts. In addition, it takes time for one to adapt to losses, such that the number of occasions over which the total loss has occurred also affects the change in the reference point. As such, equation (1) is insufficient in the sense that it does not account for the possibly separate effect of time. For example, it does not differentiate how a more distant loss experienced 2 years ago and how a more recent loss experienced 2 days ago may affect the adaptation level differently. To account for this temporal component, Hardie, Johnson and Fader (1993) propose the following formula to model the adaptation level:

$$AL_t = \alpha X_{t-1} + (1-\alpha) AL_{t-1} \tag{2}$$

Although the parameter α now allows recent stimuli to receive more weight than past stimuli, it still does not allow for a full separation of time and stimuli. Our contribution to the modelling of adaptation level is that we examine the unique effect of time and past stimuli on adaptation level separately to allow for more flexibility at the modelling stage.

2.3. Dual processes decision-making models

Although Kahneman and Tversky (1979) point out that the location of the reference point influences whether an outcome is perceived as a gain or loss, they do not specify how adaptation of the reference point is related to decision-making. The standard finance and economics literature have produced a large set of rational, descriptive models for decision-making. However, they have just limited predictive power. The growing body of the behavioral finance literature has highlighted some of the major shortcomings of the standard approach: economic agents are not as rational as typically assumed. For instance, prior outcomes affect people's subsequent risky choices (Thaler and Johnson 1990), and myopic loss aversion affects investment behavior (Benartzi and Thaler 1995).

Since the rational approach does not fully explain investors' trading behavior, our study adopts the dual processing approach. Instead of solely focusing on the rational process, we also consider the automatic/emotional process in financial decision-making. That is, the decision-making process can be divided into two parts – intuition versus reasoning (see Chaiken and Trope (1999) for overview). Cognitive-experiential self-theory (Epstein 1994) clearly distinguishes between the experiential system and the rational system. The experiential system can automatically and effortlessly process information. It also interacts with the rational system as a source of intuitive wisdom and creativity. On the other hand, the rational system is a deliberative and effortful system, processing at high levels of abstraction and handling long-term delays of gratification. However, it is not an efficient system for processing the vast amount of information in everyday life. Therefore, the rational approach may only account for part of what is going on in the investors' mind. This may be the reason why the expected utility framework sometimes fails to describe or predict actual trading behaviour.

Figure 1 demonstrates the application of cognitive-experiential self-theory on modelling of investment decisions. Every price change can be seen as stimulus, which is processed by the rational system and the experiential system. These systems interact with each other; eventually a decision to hold on to or to capitulate an investment is produced.

INSERT FIGURE 1 ABOUT HERE

By synthesizing prospect theory, adaptation level theory and cognitive-experiential self-theory, we argue that when an investor experiences a loss, a new adaptation level is created. The value of this new adaptation level lies between the original reference point and the value of the loss. This adaptation level can be seen as an adapted reference point in the framework of prospect theory. By providing comparison to other stimuli (i.e. subsequent changes in stock prices), the adapted reference point creates input values to both the rational and experiential systems, and eventually affects an investor's decision to hold or to capitulate on the losing investment.

III. CONCEPTUAL MODEL

3.1. The effect of loss size and time on reference point adaptation

Equation (1) implies that the adapted reference point is determined as a recursive average of all preceding stimuli. Thus, the adapted reference point is updated at every point in time. According to equation (1), we expect the adapted reference point to be positively related to the sum of all previous changes in the stock price($X_t = p_t - p_{t-1}$), and negatively to the number of time points (t). The sum of past stimuli in our setting thus collapses to the size of the total loss since t = 0, i.e.,($p_t - p_0$). As the stock price drops more, the size of the total price change becomes more negative and the adapted reference point is expected be lower as well. For instance, if a stock's price starts at $10 and drops to $8 in the next period, the adapted reference point should equal to

(\$10+\$8)/2 = \$9. It is important to note that for a losing investment a higher adapted reference point actually indicates a smaller extent of reference point adaptation. We do not expect that the adaptation process follows the precise dynamics of equation (1), but we do expect a significant relationship from the total sum of past stimuli and the elapsed time to the final adapted reference point. Thus, we hypothesize:

H1: A larger total loss and a longer time in a losing position predict a lower adapted reference point.

We model the effect of total loss and time on adaptation as:

$$AL_t = \alpha + \beta_1 \cdot t + \beta_2 \cdot TL_t + \varepsilon_t \tag{3}$$

where AL denotes the adapted reference point, t the time in a losing position, and TL_t the size of the total loss. Instead of having one parameter for the average loss (based on equation (1)), this model consists of two parameters β_1 and β_2. Thereby, we disentangle the unique effects of time in a losing position and size of total loss. The model in (3) is a generalization in our setting of Helson's adaptation level theory in equation (1).

3.2. A dynamic model of investment decision-making

In this section we link the adaptation of the reference point, through its effect on the rational and experiential systems, to the capitulation decision. As a first step, we look into the relation between the adapted reference point and the expectation about a stock's future performance. In the field of management, Lant (1992) shows that models applied to expectation formation are also useful for describing aspiration formation. Cyert and March (1963) suggest an organizations' aspiration level is determined by what is deemed possible. The perception of what is possible results from the organizations' desires. Thus, there is a positive relation between goals and expectations.

We conjecture there is also a relation between an investor's adapted reference point (investment goal) and this person's expectation about the stock's future performance. That is, when an investor adapts to experienced losses, this person's adapted reference point is lowered, while at the same time her/his expectations about the stock's future performance also changes. Second, we examine the relation between size of the previous loss and emotion. Since it takes time for investors to adapt to losses, we anticipate that the size of the most recent loss affects the emotions of most investors. We have no theoretical grounds to suggest any effect of the most recent loss on the expectation of the security's future performance. The gambler's fallacy (Ayton and Fischer 2004) would suggest individuals experience a negative recency when presented with a random sequence, which means that investors may expect the stock price to bounce back. By contrast, findings on the hot-hand-fallacy (Ayton and Fischer 2004) suggest individuals could also expect a positive recency.

In a next step we address the relation between expectation and emotion to the decision to hold or capitulate the investment. From a standard finance point of view, it is only rational to sell a (losing) investment when one does not expect its price to go up sufficiently in the future to off-set the risk of the investment. As proposed earlier, a lower adapted reference point predicts less optimistic expectations, which is positively related to the tendency to capitulate on a losing investment according to a rational agent's perspective. We thus hypothesize that a lower adapted reference point is related to a stronger tendency to capitulate. On the other hand, Shiv et al. (2005) found that when compared normal participants to patients with stable focal lesion in brain regions related to emotion, the normal participants were more likely than the patients to avoid risks and not to invest further when they have incurred previous loss or gain. Perhaps investors who experience more negative emotion from their losses are more likely to choose to riskless option, i.e. to capitulate the losing investment. Since the experiential and rational systems interact, negative emotions induced by large previous losses are related to the cognitive processes in the rational system. Therefore, we expect that previous losses not only predict less positive emotions, but also predict less optimistic expectations, which relates to the investor's stronger tendency to capitulate.

Thus, the effect of the adapted reference point and previous losses on the decision to hold or to capitulate on an investment, through their respective influence on expectation and emotion, is stated formally as follow:

H2a: A lower adapted reference point predicts less optimistic expectations about the losing investment.

H2b: In turn, less optimistic expectations lead to a larger probability of capitulation.

H3a: A larger previous loss predicts a less positive emotion towards the losing investment.

H3b: In turn, less positive emotions lead to a larger probability of capitulation.

This implies that the effect of the adapted reference point on an investor's expectations and the effect of loss since the previous period on emotions are modelled as follow:

$$EX = \alpha + AL \cdot \beta_1 + \varepsilon \tag{4}$$

and

$$E = \alpha + PL \cdot \beta_2 + \varepsilon \tag{5}$$

where EX denotes the expectation, AL is the adapted reference point, E is emotion, and PL denotes the previous loss.

INSERT FIGURE 2 ABOUT HERE

We argue that the process of capitulation takes place as follows: when an investor adapts to losses, his or her adapted reference point is lowered. As the adapted reference point drops, the investor's expectations about the stock's future performance decreases as well. As it is only rational to hold a currently losing investment if the investor expects a bounce-back in the stock's future price, we anticipate that if the investor's expectations of the future stock price development become excessively pessimistic, he or she is likely to capitulate this losing investment. On the other hand, as we assume the psychological impact of total losses diminishes over time, we do not expect any effect of total loss on emotion, but we do anticipate that losses from previous periods lead to less positive emotions. As the rational and experiential systems interact, previous losses are also expected to predict pessimistic expectations and a higher tendency to capitulate. The effect of the adapted reference point, previous losses, emotions and expectations regarding the further holding or capitulation decision on the investment is modelled as:

$$H/C = \alpha + AL \cdot \beta_1 (EX \cdot \beta_3) + p_{t-1} \cdot \beta_2 (E \cdot \beta_4) + \varepsilon \quad (6)$$

where H denotes holding, *C* capitulating, *AL* the adapted reference point, *EX* the expectation, p_{t-1} the loss since the previous period, and E emotion.

IV. EXPERIMENT 1

4.1. Introduction

This experiment tests the prediction that adaptation to losses affects investors' decision to hold on to or to capitulate a losing investment. Respondents were presented with a stock and they have to make multiple decisions of whether to hold or sell such investment. The amounts and timing of losses varied across respondents. It is predicted that, a larger total loss and a longer time in a losing position predict a lower adapted reference point. The adapted reference points, together with the change of stock price since previous period, are then processed by the rational and experiential systems. Participants with pessimistic expectation and negative emotions are expected to be more likely to capitulate.

4.2. Method

In our first experiment, 111 students at a large university in The Netherlands (72 male, 39 female) participated, with a chance to win a €100 prize by enrolling in a lottery. Regarding their investment experience, 44% of the subjects reported to have some general experience in investing in financial markets, while 36% of the overall participants had experience investing in stocks. Participants arrived at the lab and were assigned to individual cubicles. They were presented with the scenario that they recently started investing in a single stock – stock X. The amount invested in stock X was predetermined and equal for every investor. We specified up to 10 investment periods in the experiment. After each period, participants received information on the stock's performance and were asked to hold or sell the stock. They could only choose to sell or to hold the whole invested amount. Before deciding to hold or sell, they answered a short questionnaire.

All participants incurred losses with their investment in stock X. With random assignment, participants first received 5%, 10%, 20% or 40% maximum losses, and these losses were incurred during a losing period of 1, 3 or 5 periods. Next the participants who were still holding the stock experienced a flat price period (up or down stock price movements by a maximum of 1%) of either 2 or 4 periods. After that, a second loss of 5%, 10% or 15% took place, after which the experiment ended. In total, we specified 72 possible price change patterns: 4 (loss size: 5%, 10%, 20% or 40%) x 3 (losing period: 1 vs. 3 vs. 5 periods) x 2 (flat period: 2 vs. 4 periods) x 3 (second loss: 5% vs. 10% vs. 15%). We used this design because it consists of larger variations of price changes for each participant. This provides a suitable basis for disentangling the effects of time in a losing position and size of the loss.

We derived five measures based on Zeelenberg and Pieters (2004); Arkes et al. (2008); Ayton and Fischer (2004). The investment goal was reflected by two measures. The first measure assesses the satisfy price of investors: "In the next period, what is the price of stock X that would make you feel satisfied?" (mean = 32.75, *s.d.* = 5.35). The second measure is an estimate of the selling price: “In the next period, if the stock price increases, what is the price you would sell at?” (mean = 35.64, *s.d.* = 6.26). The third measure assesses the participants’ feelings for the experiential system: “How does the performance of stock X make you feel?” Answers are reported on a 9-point scale (1 = very bad, 9 = very good), (mean = 3.84, *s.d.* = 1.87). The fourth measure assesses their expectation for the rational system: “How do you think the price of stock X will change in the next period?”; answers were also reported on a 9-point scale (1 = surely decrease, 9 = surely increase), (mean = 5.68, *s.d.* = 1.66). Our final measure indicates whether participants chose to hold on to or to capitulate their losing investment: “Do you want to hold or sell stock X now?” (frequency of hold = 497, frequency of capitulate = 55). Our measure of the reference point requires some additional discussion. We argue that investors have a specific investment goal. For example, one may expect the price of a stock to increase from $30 to $35. This $5 increase is required to provide a positive psychological value to the investor. Thus, we asked subjects what stock price in the next time period would make them feel satisfied (satisfy price). We also asked them at what price they would sell the stock, assuming that the stock will appreciate over the next period (selling price). These two prices serve as our investment goal measures.

The investment goal measures are used to estimate the adapted reference point, as in Arkes et al. (2008). To illustrate, if the adapted reference point at T_0 is AL_0 and the satisfy price is S_0, the difference between AL_0 and S_0 should be the same as the difference between AL_1 and S_1 at T_1, assuming that the shape of the prospect theory value function remains unchanged:

$$S_0 - AL_0 = S_1 - AL_1 \rightarrow \Delta \text{AL} = AL_t - AL_{t-1} = S_t - S_{t-1} \quad (7)$$

For example, if one participant reports a satisfy price at $37 at T_0 and $35 at T_1, the adapted reference point is expected to have shifted $2 downwards. Although neither the satisfy price nor the selling price is the reference point *per se*, by holding the prospect theory value function constant, any difference in the adapted reference point is reflected by the difference between satisfy price and selling price. Thus, by keeping track of the differences in satisfy price and selling price over the course of the experiment, we capture the movement of the adapted reference point. We argue that this is a suitable means for measuring the adapted reference point since we make use of an experimental setting in which subjects actually experience the losses, instead of just imagining losses (gains) as in previous studies. As mentioned earlier, the low cognitive load is relevant in eliciting answers for measuring the adapted reference points. Thus, we believe that asking for satisfy selling prices is more understandable to the subjects than indifferent prices as in Baucells et al. (2007), or asking for the price subjects would feel equally happy (sad) about due to a previous gain (loss) as in Arkes et al. (2008).

4.3. Results

The partial least squares (PLS) approach was used for the analysis. Only the adapted reference point has two measures. The remaining variables have only one measure, such that reliability and validity tests are not applicable. A total of 552 decisions were pooled and analysed together. Structural coefficients were computed (see Figure 3). Standard errors and significance were estimated using the bootstrapping method, with 500 bootstrapping runs.

INSERT FIGURE 3 ABOUT HERE

Figure 3 indicates that statistically significant effects were observed from the time in a losing position and the size of total price change on reference point adaptation. Participants reported both a lower satisfy price and selling price, that is, their adapted reference points had shifted downwards more strongly when total price change became more negative (beta = 0.355, t = 8.187, $p < .001$) and time in losing position increased (beta = -0.081, t = 1.996, p = .046). These results give strong empirical support to our hypothesis 1, i.e., size of total price change and the time in a losing position are negatively related to investors' adapted reference points.

To test the hypotheses 2a and 3a, the effects of an adapted reference point on investors' expectations and previous price changes on emotions were examined. A higher adapted reference point (higher satisfy and selling prices) predicts more optimistic expectations about the stock's future performance (beta = 0.156, t = 3.445, p < .001), while previous price changes also affect investors' expectation of the stock's future performance (beta = 0.185, t = 4.006, p < .001). Moreover, negative previous price changes are related to negative emotions (beta = 0.432, t = 12.053, p < .001), while the adapted reference point does not significantly predict emotions (beta = 0.065, t = 1.898, p = .06). These results give support to our hypotheses 2a and 3a, i.e. the adapted reference point is positively related to one's optimistic expectations, and larger previous losses lead to less positive emotions.

To test hypotheses 2b and 3b, we examine the relation among emotion, expectation and the decision to hold or capitulate on a losing investment. We find less optimistic expectations about the stock's future performance are positively and significantly related to the tendency to capitulate stock X, (beta = -0.277, t = 6.777, p <. 001, with 0 = hold, 1 = capitulate), while more positive emotions do not significantly predict a stronger tendency to hold (beta = -0.034, t = 1.037, p = .30) on to the losing investment. Thus, hypothesis 2b is supported, but hypothesis 3b is not.

Logistic regressions were run to test if individual differences (age, sex, fields of studies and investment experiences) among subjects affect their tendency to sell. No significant effect is found.

4.4. Discussion

Contrary to findings of previous studies (Shiv et al., 2005), we do not find a direct effect of emotions on the decision to hold or sell a losing investment. We suggest that the participants' experiential system does not produce the final decision directly, but that it interacts with the rational system, i.e., when investors feel bad about their losses, their expectation becomes less optimistic so that their tendency to capitulate increases. This line of reasoning is supported by our empirical results as we find significant evidence of interactions between these two systems: positive emotions predict more optimistic expectations (beta = 0.242, t = 4.974, p < 0.001), while optimistic expectations also predict more positive emotions (beta = 0.205, t = 5.296, p < 0.001). This interaction is consistent with experiential self-theory (Epstein, 1994).

Concerning expectations, when the total price change is more negative, participants report significantly more optimistic expectations (beta = -0.258, t = 6.016, p < .001). This reflects the bounce-back effect, i.e. that the participants expect a fallen (risen) stock price to raise (decline) in the future. At the same time, when the previous price change is more negative, participants report pessimistic expectations (beta = 0.185, t = 4.006, p < .001). These findings are in line with our assumption that both the gambler's fallacy and the hot-hand-fallacy may occur.

The PLS results demonstrate that investors do adapt to losses as their adapted reference point shifts downwards over time. Furthermore, larger total losses and a longer time in a losing position lead to a lower adapted reference point. Such a lower adapted reference point is related to a more pessimistic expectation about the losing investment, which predicts a stronger tendency of capitulation. Our empirical results are consistent with the findings by Arkes et al. (2008) as investors do adapt to losses. However, we contribute that a lower adapted reference point is predicted by a larger size of loss and/or a longer time in a losing position. Our empirical results have also added more insight into the separate effects of time in a losing position and the size of losses as we have disentangled the unique effect of past stimuli and time in a losing position. Our findings support the conclusion of Hardie et al. (1993) that the temporal component plays a critical role in (financial) decision-making.

V. EXPERIMENT 2

5.1. Introduction

In a second experiment, we aim to test the applicability of the proposed model both in the domain of gains and losses. We expect the model to be more relevant for the loss domain. Due to the convexity (concavity) of the value function in the domain of losses (gains) proposed by prospect theory, the effect of emotions is expected to be opposite in these domains. In the gain domain, because of the diminishing marginal value, investors are expected to sell the investments after reaching a certain level of positive value (positive emotion) derived from their gains. In the loss domain, less positive emotions should lead to a larger probability of capitulation (hypothesis 3b). Therefore, a quadratic relation is hypothesized. Stronger positive and negative emotions both lead to a higher tendency of capitulation. Thus, hypothesis 3b is proposed to be applicable to the loss domain only. On the other hand, there are no theoretical grounds to suggest that the other hypotheses (1, 2a, 2b, 3a) would be inapplicable in the domain of gains.

5.2. Method

The experimental method is similar to experiment 1, except that participants were randomly assigned to 4 experimental conditions: 2 (price development: gains vs. losses) x 2 (volatility regimes: high vs. low). We added high or low volatility conditions into the design to introduce some variations of price movements in both gain and loss conditions, in order to increase the generalizabilty of our findings.

Ninety-five students (56 male, 39 female) participated in the experiment in return for cash payment. Participants were paid depending on the profit or loss they incurred. Regarding investment experience, 37% of the subjects reported to have some experience in investing in financial markets, while 27% of the participants had experience investing in stocks.

There is one more measure for each of the systems. For the rational system, apart from participant's expectations about whether the stock price will increase or decrease, we also asked them to report the price that they expect to be most likely in the next period (mean = 35.02, *s.d.* = 9.20). For the experiential system, apart from feeling, we also asked subjects to report their (dis)satisfaction level on a 9-point scale (mean = 4.72, *s.d.* = 2.28). We derived these measures from Ferrari and Lozza (2005); Zeelenberg and Pieters (2004). These additional measures were incorporated in Experiment 2 in order to allow assessment of the effects of more specific emotions and expectations.

5.3. Results

The PLS analysis was run to estimate the proposed model. In total, 627 decisions were collected from 95 subjects, 303 responses from the gain conditions and 324 responses from the loss conditions. Two participants did not provide selling price and satisfy price at T_0. We applied case wise deletion on the 13 decisions from these participants. Structural coefficients were computed, their standard errors and significance were estimated with 500 bootstrapping runs. Figure 4 summarizes our empirical findings.

INSERT FIGURE 4 ABOUT HERE

Figure 4 shows there is a significant and positive relation between total price change and adapted reference point (beta = 0.214, t = 5.773, p < .001). That is, positive (negative) price change leads to higher (lower) satisfy and selling prices. However, time does not predict adaptation of the reference point (beta = 0.016, t = 0.617, p = .537).

Thus, Hypothesis 1 received partial support. As for hypothesis 2a, a higher (lower) adapted reference point predicts more optimistic (pessimistic) expectations about the stock's future performance (beta = 0.112, t = 2.014, p = .044), while previous price changes do not affect investors' expectations of the stock's future performance (beta = 0.016, t = 0.483, p = .629). As for hypothesis 3a, positive (negative) previous price changes predict more positive (negative) emotions (beta = 0.726, t = 34.348, p < .001); higher (lower) adapted reference point also predicts more positive (negative) emotions (beta = 0.078, t = 2.531, p = .012). These results give support to our hypotheses 2a and 3a, i.e. that the adapted reference point is positively related to one's expectations, and previous price changes are positively related to one's emotions.

As for hypothesis 2b, our empirical results show that more optimistic expectations about the stock's future performance are positively and significantly related to the tendency to hold stock X, (beta = -0.190, t = 2.228, p = .026, with 0 = hold, 1 = capitulate). Thus, hypothesis 2b is supported. As for hypothesis 3b, it is found that there is a significant linear relation between positive emotions and a stronger tendency to sell (beta = 0.112, t = 2.526, p = .012). Nonetheless, the proposed quadratic relation between emotion and decision to sell is also found to be statistically significant (beta = 0.232, t = 5.297, p <. 001). In fact, the effect size and statistical significance of the quadratic relation are stronger than those of the linear relation.

5.4. Discussion

The overall results of Experiment 2 are largely consistent with those of Experiment 1. The adapted reference point is predicted by the total change of price, but not by time. Then the adapted reference point predicts an individual's expectation about the stock price and in turn affects the hold/sell decisions. On the other hand, size of previous price change affects subjects' emotions, which in turn affects the decisions. In Experiment 1, hypothesis 3b did not receive support that negative emotions do not significantly predict a tendency to capitulate in the domain of loss. However, in Experiment 2, a significant quadratic relation is found between emotion and tendency to sell, which implies that negative emotion does relate to the tendency to capitulate. However the effect is only significant when data from the gain conditions are taken into account as well. One possible reason is that since participants' payoff is around 3 to 5 Euros, which does not impose a real financial impact on the subjects, the negative emotion evoked and the urge to cut losses is limited.

Compared to Experiment 1, the effect of time in Experiment 2 is no longer significant. This may be partly due to the price developments in Experiment 2 being different from those in Experiment 1. In Experiment 1, upward price movements were less frequent and the size of upward movement is limited to around 1% of initial price. In Experiment 2, however, more frequent and larger upward (downward) movements were presented in the loss (gain) conditions. Perhaps the effect of time is more relevant when a more obvious trend occurs, a phenomenon more easily recognized by individuals in Experiment 1 compared to 2.

VI. CONCLUSION

We investigated why most individuals eventually do sell their losing investments, despite the disposition effect. We formulated a conceptual model that integrates prospect theory, reference point adaptation theory, and cognitive experiential self-theory. The model is tested using two laboratory experiments.

Experiment 1 shows a larger loss size and a longer time in a losing position are related to a more downwardly shifted adapted reference point. This downward shifted adapted reference point leads to less optimistic expectations about the stock's future performance, which predicts a larger likelihood of capitulation. The actual decision to capitulate a losing investment, however, only depends directly on the expectation about the stock's future performance. The adapted reference point affects the actual investment decision indirectly via its impact on expectations. Results from Experiment 2 generally point in the same direction, except that the effect of time on adaptation becomes insignificant. We also find that there is a quadratic relation between emotion and the decision to sell, implying that both very positive and negative emotions lead to a significantly higher tendency to sell.

Thus, we have demonstrated the link between reference point adaptation and (financial) decision-making. Most studies of the disposition effect use various purchase prices (e.g. average, FIFO, LIFO) as proxies for the reference point (Odean 1998; Weber and Camerer 1998). We provide new implications in measuring the strength of the disposition effect by locating the reference points, and. thus contribute to the literature in predicting when investors' capitulation takes place.

Our experimental findings are consistent with those by Chen and Rao (2002). People immediately but incompletely update their reference point after experiencing an event. We found the adapted reference point depends on the time spent in a losing position. That is, it takes time for investors to fully or at least mostly adapt to a financial loss. Moreover, the adapted reference point's indirect (via expectation) effect on the investment decision is in line with models proposed by Köszegi and Rabin (2006) and Yogo (2008) that the reference point is one's expectation about future outcomes. To estimate the expected value of future outcome, one needs to be aware of one's own perceived current state, i.e. adapted reference point. Therefore, it is not surprising that investors' expectation for the stock's future performance relates to their adapted reference point. Our result is also consistent with findings by Odean (1998) and Weber and Camerer (1998) that the initial purchase price is an appropriate reference point in investors' decision-making process, but its significance is stronger right after a security is acquired compared to later points in time.

In sum, the answer to the question on why losing investments are eventually sold is that the reference point is adjusted downward when the total losses increase and the investor is longer in a losing position. A lower adapted reference point leads to lower expectations and hence an increased chance of capitulation. The effect of time-point on expectations is fully mediated by the adapted reference point change. However, this does not apply for the effect of total price change on expectations. Thus, further research should address the mechanism linking total price change to expectations using other variables besides the adapted reference point. Nevertheless, such research should incorporate the adapted reference point next to these other variables. A particularly pressing question is when time in a losing has an important role, next to the size of the total loss. Our results with regard to time were mixed, although we can conclude that there are conditions under which time in a losing position is relevant. Perhaps time in a losing position is only relevant in the presence of clear trends, such as those in the October 2008 collapse of stock exchange markets or perhaps it also occurs under other conditions. The latter is a topic for further investigation.

The conducted experiments were conducted within a short time frame, while in reality investors may have more time in-between receiving each piece of information, thus the effect of time cannot be fully examined in such an experimental setting. Future studies should try to replicate these findings with larger samples and adopt more natural settings. Moreover, finding meaning (learning a lesson) from an experienced loss might help people to better adapt (Taylor 1983). We suggest that future studies should test if there is a better adaptation when investors have a sufficient time frame to "learn" from their experienced losses. Zeelenberg and Pieters (2004) suggest that there are two approaches: the valence-based approach (i.e. overall (dis)satisfaction) and the specific emotions approach, to model impact of emotions on consumer satisfaction and behavior. Future studies may investigate how specific emotions, for example, regret and disappointment, may affect investors' capitulation tendency. In addition, recruiting participants outside the university environment and/or from the population of undergraduates will also increase the validity of the findings.

References

Arkes, Hal R., David Hirshleifer, Danling Jiang and Sonya Lim (2008), "Reference Point Adaptation: Tests in the Domain of Security Trading," *Organization Behavior and Human Decision Processes,* 105, 67-81.

Ayton, Peter and Ilan Fischer (2004), "The Hot Hand Fallacy and the Gamble's Fallacy: Two Faces of Subjective Randomness?" *Memory and Cognition, 32 (8),* 1369-78.

Baucells, Manel, Martin Weber and Frank Welfens (2007), "Reference Point Formation Over Time: A Weighting Function Approach," Working paper, University of Mannheim.

Benartzi, Shlomo and Richard Thaler (1995), "Myopic Loss Aversion and the Equity Premium Puzzle." *Quarterly Journal of Economics,* 110 (February), 73-92.

Chaiken, Shelly and Yaakov Trope Eds. (1999), "*Dual-Process Theories in Social Psychology,"* New York: Guilford Press.

Chen, H., & Rao, A. (2002), "Close Encounters of Two Kinds: False Alarms and Dashed Hopes," *Marketing Science,* 21(2), 178–96.

Cyert, Richard M. and James G. March (1963), *"A Behavioral Theory of the Firm,"* Englewood Cliffs NJ: Prentice-Hall.

Epstein, Seymour (1994), "Integration of the Cognitive and the Psychodynamic Unconscious," *American Psychologist*, 49 (August), 709-24.

Ferrari, Luigi and Edoardo Lozza (2005), "Psychological Consequences on Prices Expectations of the Currency as a Unit of Account," *Journal of Economic Psychology, 26*, 313-25.

Frederick, Shane and George Loewenstein (1999), "Hedonic Adaptation," in *Well-being: The Foundations of Hedonic Psychology,* ed. Daniel Kahneman, Ed Diener and Norbert Schwarz, New York: Russell Sage Foundation.

Freedman, Deborah, Arland Thornton, Donald Camburn, Duane Alwin and Linda Young-DeMarco (1988), "The life-history calendar: A Technique for Collecting Retrospective Data," *Sociological Methodology*, 18, 37-68.

Gneezy, Uri (2005), "Updating the Reference Point: Experimental Evidence," in *Experiential Business Research,* Vol. 3, ed. Rami Zwick and Amnon Rapoport, Massachusetts: Kluwer Academic Publishers.

Hardie, Bruce G. S., Eric J. Johnson and Peter S. Fader (1993), "Modelling Loss Aversion and Reference Dependence Effect on Brand Choice," *Marketing Science*, 12 (Fall), 378-94.

Helson, Harry (1964), "*Adaptation Level Theory,*" New York: Harper and Row.

Kahneman, Daniel and Amos Tversky (1979), "Prospect Theory: An Analysis of Decision Under Risk," *Econometrica*, 47 (March), 263–92.

Köszegi, Botond, and Matthew Rabin (2006), "A Model of Reference-dependent Preferences," *Quarterly Journal of Economics*, 121(4), 1133–65.

Lant, Theresa K. (1992), "Aspiration Level Adaptation: an Empirical Exploration," *Management Science, 38*, 623-44.

Lichtenstein, Donald R. and William O. Bearden (1989), "Contextual Influences on Perceptions of Merchant-Supplied Reference Prices," *Journal of Consumer Research*, 16 (June), 55-66.

Mezias, Stephen, Ya-Ru Chen and Patrice R. Murphy (2002), "Aspiration-level adaptation in an American finance services organization," *Management Science, 48*, 1285-1300.

Odean, Terrance (1998), "Are Investors Reluctant to Realize their Losses?" *Journal of Finance, 53 (October)*, 1775-98.

Parducci, Allen (1968), "The Relativism of Absolute Judgments," *Scientific American, 219 (December)*, 84-90.

Sarris, Viktor (1967), “Adaptation Level Theory: Two Critical Experiments on Helson’s Weighted-averaged Model.” *American Journal of Psychology, 80 (3),* 331 – 44.

Shefrin, Hersh and Meir Statman (1985), “The Disposition to Sell Winners too Early and Ride Losers too Long,” *Journal of Finance*, 40 (July), 777-90.

Shiv, Baba, George Loewenstein, Antoine Bechara, Hanna Damasio, and Antonio R. Damasio (2005), “Investment Behavior and the Negative Side of Emotion,” *Psychological Science*, 16 (June), 435-39.

Taylor, Shelley E. (1983), “Adjustment to Threatening Events: A Theory of Cognitive Adaptation,” *American Psychologist,* 38, 1161-73.

Thaler, Richard H. and Eric J. Johnson (1990), “Gambling with the House Money and Trying to Break Even: The Effects of Prior Outcomes on Risky Choice,” *Management Science,* 36 (June), 643-60.

Wilson, Timothy D. and Daniel T. Gilbert (2003), “Affective Forecasting,” in *Advances in Experimental and Social Psychology,* Vol. 35, ed. Mark P. Zanna, New York: Elsevier, 345-411.

Weber, Martin and Colin F. Camerer (1998), “The Disposition Effect in Securities Trading: an Experimental Analysis,” *Journal of Economic Behavior and Organization*, 33 (January), 167-84.

Yogo, Motohiro (2008), “Asset Prices Under Rising Aspirations and Reference-dependent Preferences,” *Journal of Business and Economic Statistics, 26,* 131-43.

Zeelenberg, Marcel., & Rik Pieters (2004), “Beyond Valence in Customer Dissatisfaction: A Review and New Findings on Behavioral Responses to Regret and Disappointment in Failed Services,” *Journal of Business Research, 57,* 445–55.

Zhou, Rongrong and Michel Tuan Pham (2004), "Promotion and Prevention Across Mental Accounts: When Financial Products Dictate Consumers' Investment Goals," *Journal of Consumer Research*, 31 (June), 125-35.

Figure 1. Framework of cognitive-experiential self-theory applies on decision process of holding/capitulating on losing investments

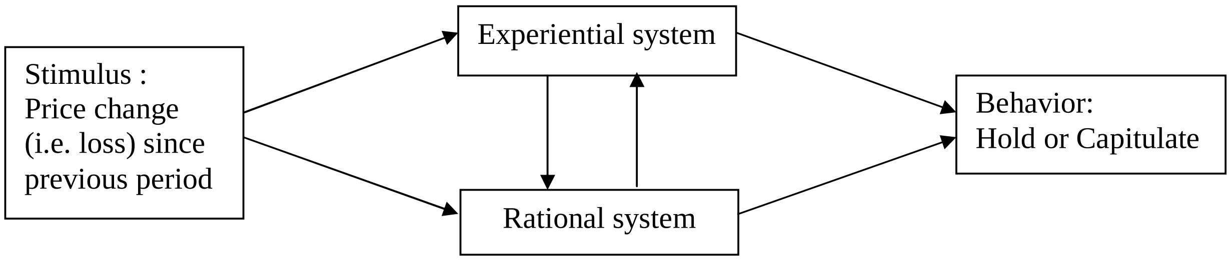


Figure 2. Proposed model of decision-making in holding/capitulating on losing investment

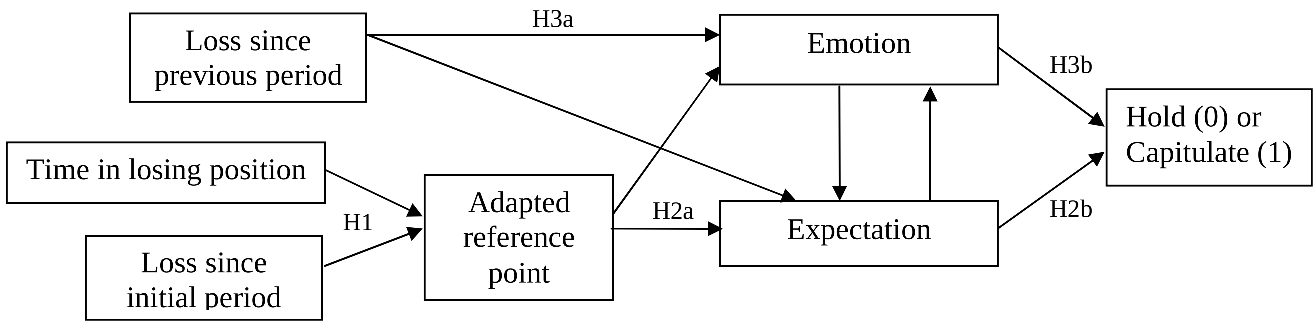
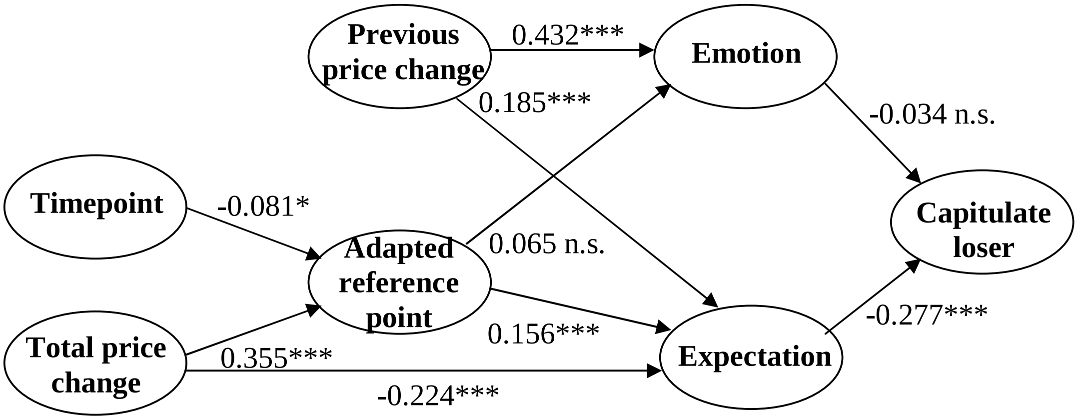
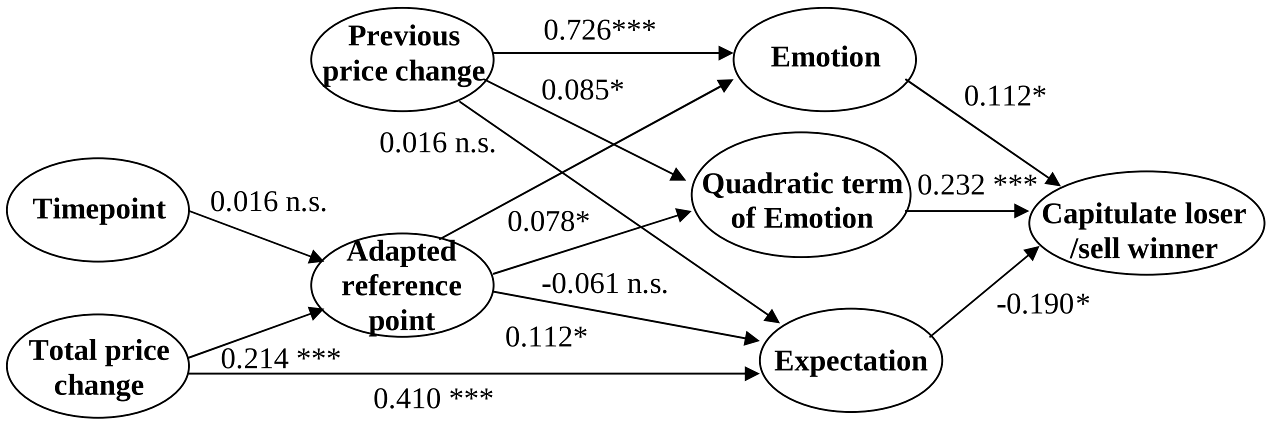


Figure 3. Results of Experiment 1



Note. * p < .05; *** p < .001; n.s. = not significant.

Figure 4. Results of Experiment 2



Note. * p < .05; *** p < .001; n.s. = not significant.