THE EFFECT OF TRADERS' COGNITIVE BIASES ON PSYCHOLOGICAL ATTRIBUTES AND CONFIDENCE AND ITS SOLUTIONS: AN EXPERIMENTAL STUDY

by

CHIN PHAIK NIE

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ABSTRAK

Pedagang saham cenderung menbuat keputusan berdasarkan intuisi mereka yang menjurus bias kognitif seperti "confirmation bias", "self-serving bias" dan "hindsight bias". Bias ini membuat pedagang saham mempamerkan sifat-sifat psikologi terlalu yakin seperti "miscalibration", "better than average effect" dan "illusion of control" dan demikian, mempamerkan bias terlalu yakin dalam pembuatan keputusan mereka di pasaran sekuriti. Tesis ini bertujuan untuk memeriksa hubungan antara bias kognitif, sifat-sifat psikologi terlalu yakin dan bias terlalu yakin, dan mekanisme-mekanisme meminimumkan bias terlalu yakin antara pedagang saham individu, dengan jumlah perdagangan dan ralat ramalan harga sebagai proksi. Kajian ini dibahagikan kepada dua peringkat uji kaji makmal iaitu tiga rawatan kawalan dan enam rawatan utama. Mata pelajaran di semua rawatan dipengaruhi dengan bias kognitif. Ukuran sifat-sifat psikologi terlalu yakin dikumpulkan melalui soal selidik di eksperimen, manakala jumlah perdagangan dan ralat ramalan harga dikumpulkan dari mekanisme dagangan mudah. Mekanisme "Feedback" dan "Contradicting Reason" diuji atas keberkesanan mereka dalam mengurangkan bias terlalu yakin di pedagang saham individu. Keputusan eksperimen menyimpulkan bahawa terdapat hubungan penting antara "confirmation bias" dan "miscalibration", dan "self-serving bias" dan "better than average effect". Mata pelajaran dengan pengesahan "confirmation bias" membuat ralat ramalan harga yang lebih besar dibandingkan dengan mata pelajaran tanpa "confirmation bias" dan mata

pelajaran dengan “self-serving bias” mempunyai jumlah perdagangan yang lebih daripada mata pelajaran tanpa “self-serving bias”. Mekanisme-mekanisme penyelesaian berkesan dalam mengurangkan tahap keyakinan terutamanya bagi mata pelajaran dengan pengesahan “confirmation bias”.

THE EFFECT OF TRADERS' COGNITIVE BIASES ON PSYCHOLOGICAL ATTRIBUTES AND CONFIDENCE AND ITS SOLUTIONS: AN EXPERIMENTAL STUDY

ABSTRACT

Traders tend to make decisions based on their intuition, which leads to cognitive biases such as confirmation bias, self-serving bias and hindsight bias. These biases cause traders to display psychological attributes of overconfidence such as miscalibration, better than average effect and illusion of control over a decision, and thus, display overconfidence bias in their decision-making in the securities market. This thesis aims to examine the relationship between cognitive biases, psychological attributes of overconfidence and overconfidence bias, and solution mechanisms so as to minimise overconfidence bias among individual traders, with trading volume and price prediction error as the proxy. The study consists of three experimental series. Each series again is divided into a control treatment and two sub-main treatments. Each treatment consists of two main periods, where in the sub-main treatments subjects are treated by mechanism before the second period starts to reduce cognitive biases. The measurement of psychological attributes was collected through a questionnaire in the experiment, and the trading volume and price prediction error were deduced from a simple trading mechanism. Feedback and contradicting reason mechanism were tested as to their effectiveness in reducing overconfidence bias in individual traders. The results suggested that there is significant relationship between confirmation bias and miscalibration, and self-

serving bias and better than average effect. Subjects with confirmation bias made larger price prediction errors compared with subjects without confirmation bias, and subjects with self-serving bias traded more than subjects without self-serving bias. Solution mechanisms were effective in reducing the psychological attribute, trading volume and price prediction error especially for subjects with confirmation bias.

CHAPTER 1 – INTRODUCTION

This thesis studies the issues of cognitive biases in the psychological attributes, and trading behaviours of traders, and its effects on overconfidence bias exhibited by traders in the securities market. The literature has highlighted the role of overconfidence bias, and this thesis is interested in looking at overconfidence bias from a cognitive and psychological perspective, particularly the cognitive and psychological reasons underlying overconfidence bias. Measurements of confidence levels are always given in the literature as miscalibration, the better than average effect and the illusion of control.

The thesis suggests that understanding the cognitive reasons of psychological attributes (i.e. miscalibration, better than average effect and illusion of control) will enable identification of the reasons for overconfidence bias, and help in suggesting ways to mitigate the bias in stock trading. The thesis adopts psychological solutions such as the feedback method (Lichtenstein & Fischhoff, 1980) and the contradicting reason method (Koriat, Lichtenstein & Fischhoff, 1980) in overcoming overconfidence bias influenced by cognitive bias at an individual level. These two methods were selected because they are simple and can be carried out easily by an individual trader or securities firm at minimum cost.

The thesis aims to conduct an in-depth study on the direct relationship between cognitive bias and its psychological attributes. It has been noted that overconfidence is a consequence of psychological attributes such as miscalibration, better than average effect and illusion of control (Merkle & Weber, 2011), and therefore, it is important to examine the psychological roots of the overconfidence phenomenon in the securities market. The controlled laboratory experimental method was used to

conduct this research because an experimental setting has the advantage of allowing for a direct test of the relationship between cognitive bias, psychological attribute and trading behaviours. This chapter will start with a background of the study (Section 1.1), an introduction to the definitions of cognitive bias, psychological attributes and overconfidence bias adopted in this thesis (Section 1.2), followed by Section 1.3 to Section 1.6, which will explain the problem statement, research questions, objectives of the study and significance of the study, respectively.

1.1 Background of the Study

The efficient market hypothesis (EMH) assumes that the agents are always rational and efficient. EMH hypothesises that the prices of securities will always "fully reflect" all available information in the market and that there is no arbitrage opportunity (Fama, 1970). Traditional economic theory manifested in EMH assumes that traders are always rational, by incorporating all relevant information into the decision-making process to generate optimal financial decisions. This hypothesis dominated the financial market around the world until the Black Monday crash in 1987 when U.S. stock prices fell over 20% in a day without any important news (Shiller, 1987).

The inability of EMH to explain the Black Monday crash, and also empirical evidence such as the deviation of prices from fundamental values, including stock and market bubbles around the world (e.g. Holland's Tulip Mania (1634), the South Sea Bubbles in England (1720), the ASEAN financial crisis (1997), the Dot.com bubble (2000) and the severe recession in 2007-2008) have led scholars in behavioural finance to relax the rationality assumption of individual traders and use

overconfidence bias to explain anomalies in the financial market (e.g. Shiller, 1987, 2000; Odean, 1999; Dittrich, Güth & Maciejovsky, 2005; Glaser & Weber, 2007; Deaves, Luders & Luo, 2009; Smith, 2012; Merkle, 2013; Prosad, Kapoor & Sengupta, 2013; Broihanne, Merli & Roger, 2014).

Overconfidence bias is pervasive in the securities market, and it has been shown to be one of the major causes of financial instability in the world. Shefrin (2000, p.xii) says that "most traders are overconfident about their vulnerability to psychological induced errors, and although intelligent, not as intelligent as they believe themselves to be." People are always over-optimistic in the stock market, and this behaviour leads to boom and bust (Shiller, 2000). Overconfidence bias is not only committed by individual traders or novice traders; institutional advisors and professional traders also exhibit different degrees of overconfidence bias (Deaves, Lüders & Schröder, 2010; Chou & Wang, 2011; Chuang & Susmel, 2011; Menkhoff, Schmeling & Schmidt, 2013; Broihanne et al., 2014).

Chuang and Lee (2006) summarised the characteristics and behaviours of traders with "overconfidence bias" as follows. *First*, overconfident traders overestimate the precision of their information received (e.g. Kyle & Wang, 1997; Benos, 1998; Daniel, Hirshleifer & Subrahmanyam, 1998; Chuang & Lee, 2006; Ko & Huang, 2007; Yeh & Yang, 2011). *Secondly*, traders trade more aggressively in the period subsequent to a gain (e.g. Kyle & Wang, 1997; Benos, 1998; Gervais & Odean, 2001; Chuang & Lee, 2006; Deaves et al., 2009; Hsu & Shiu, 2010; Kliger & Levy, 2010; Chou & Wang, 2011; Michailova, 2011; Yeh & Yang, 2011). *Thirdly*, excessive trading of overconfident traders in the securities market contributes to observed excessive volatility (e.g. Odean, 1998; Chuang & Lee, 2006; Yeh & Yang, 2011; Huisman, van der Sar & Zwinkels, 2012) and *fourth*, overconfident traders

underestimate risk and trade more in riskier security (e.g. Merkle, 2013). Overconfident traders also tend to make higher price prediction errors (e.g. Bondt & Thaler, 1985; Shiller, 1987; Smith, Suchanek & Williams, 1988; De Long, Shleifer, Summers & Waldmann, 1990; Shiller, 2000; Scheinkman & Xiong, 2003; Friesen & Weller, 2006; Hilary & Menzly, 2006; Michailova, 2011) and perform badly compared to traders who are not overconfident (e.g. Barber & Odean, 2000; Gervais & Odean, 2001; Dittrich & Maciejovsky, 2002; Dittrich et al., 2005; Hsu & Shiu, 2010; Michailova, 2010). The thesis uses excessive trading (i.e. trading volume) and price prediction (i.e. price prediction error) as proxies for overconfidence bias.

Scholars have also studied ways to reduce investment mistakes in the securities market, such as by providing more financial information to less informed traders (Bloomfield, Libby & Nelson, 1999; Forbes & Kara, 2010) and improving the financial knowledge of traders (Chou & Wang, 2011). Other recommendations include providing general guidelines to understand and identify investment objectives and constraints, developing qualitative investment to avoid investing based on emotion, rumour, and stories, diversifying investment portfolios and performing annual reviews to reallocate assets (Baker & Nofsinger, 2002). Overconfidence bias persists in the market (Shiller, 2014), however, and so far, there has been limited work on the solution to overconfidence bias in traders.

1.2 Definition of Cognitive Bias, Psychological Attributes and Overconfidence Bias

As Wilke and Mata (2012, p.531) note, "**Cognitive bias:** Systematic error in judgment and decision-making common to all human beings, which can be due to

cognitive limitations, motivational factors, and/or adaptations to natural environments." This thesis studied cognitive biases of overconfidence such as confirmation bias, self-serving bias and hindsight bias. Confirmation bias means that people tend to look for confirming evidence that supports their decisions, and to reject that evidence that does not support their belief or hypothesis (Koriat et al., 1980). Self-serving bias refers to people's tendency to attribute success to their internal or personal factors but attribute failure to external or situational factors (Taylor & Brown, 1988; Alicke, Klotz, Breitenbecher, Yurak & Vredenburg, 1995). Hindsight bias happens when people tend to distort their previous judgment, memory, actual facts or previous information, based on information received after knowing the actual outcome (Thompson, Armstrong & Thomas, 1998).

Psychological attributes, in this thesis, are psychological attributes of overconfidence such as miscalibration, the better than average effect, and the illusion of control. These are also known as psychometric measures of judgment biases (Glaser & Weber, 2007). Miscalibration is a systematic overestimation of the precision of own knowledge, and an underestimation of the variance of random variables (Koriat et al., 1980; Lichtenstein, Fischhoff & Phillips, 1981). Better than average effect refers to the boundless ability, as a human being, to think that ones own self is smarter or more capable than others (Taylor & Brown, 1988; Smith, 2012). The illusion of control happens when people overestimate personal success probabilities (Langer, 1975).

In this thesis overconfidence bias is reflected in the trading behaviours of overconfident traders in securities markets, such as larger price prediction errors and excessive trading volume. Both large price prediction errors and excessive trading volume are used as proxies for the trading behaviours of overconfident traders

because first, they could be collected easily from the experiment and second, individual traders decided the predicted price and number of stock to trade in the experiment. This could ensure that the data was really reflecting the behaviours of individual traders. Price prediction error refers to the price difference between the predicted price and the actual price, and trading volume refers to the number of shares traded by traders.

1.3 Problem Statement

On many occasions, traders do not act as postulated by the expected utility (EU) theory or efficient market hypothesis (EMH), in which traders always maximise income, taking into account all available information about the market. What has been widely observed instead, is that traders tend to make decisions based on intuition, and are vulnerable to cognitive biases, such as confirmation bias, self-serving bias and hindsight bias, which affect their decision-making processes. It has been noted in the literature that these biases play an important role in the investment process and are the main culprits in causing overconfidence among traders.

The causal relationship between cognitive biases and overconfidence has been widely reported in the literature, but the mechanism underlying the relationship is not widely known. What has been studied so far indicates that cognitive biases can affect an trader's confidence, but how the confidence is built and how the information is processed have not been widely explored in the economics literature. Although the psychology literature has pointed out that people miscalibrate information due to confirmation bias, perceive themselves as better than others due

to self-serving bias, and perceive a situation as perfectly under their control due to hindsight bias, the impact on investment decisions is not empirically proven (Skata, 2008).

It has been widely suggested in the literature that enhancing one's financial knowledge could help to reduce mistakes and biases in making investment decisions, but instead of reducing biases, the knowledge gained may sometimes aggravate a situation; traders may feel more confident at the time when decision is made. Traders who suffer from confirmation bias may become more overconfident in their predictions and trading. What is required is a mechanism that can help to mitigate the cognitive bias that causes overconfidence bias.

This thesis tests two solution mechanisms, feedback and contradicting reason mechanisms, to minimise the effect of the cognitive biases on psychological attributes and their impact on overconfidence in the securities market. Finding ways to minimise overconfidence has always been the biggest challenge in financial markets, but so far, most of the solution mechanisms focus on financial knowledge enhancement instead of the underpinning psychological reasons.

1.4 Research Questions

This thesis specifically aims to answer three research questions.

i. Is there any significant difference in psychological attributes between subjects with and without cognitive bias?

ii. Is there any significant difference in trading behaviours between subjects with and without cognitive bias?
iii. Do feedback and contradicting reason mechanisms help to reduce overconfidence bias? Which is the best method to minimise the level of overconfidence bias?

1.5 Objectives of the Study

This thesis explores the impact of psychological bias on economic decision-making and the application of trading in the securities market in a laboratory experimental design. The study examines the relationship between confirmation bias and miscalibration, self-serving bias and better than average effect, hindsight bias and illusion of control, and measures the correlation with economic variables such as price prediction and trading volume (i.e. as a proxy for overconfidence bias). The specific objectives are listed as the following:

i. To determine the relationship between confirmation bias and miscalibration, self-serving bias and better than average effect, and hindsight bias and illusion of control.
ii. To investigate the relationship between trading behaviours such as trading volume and price prediction error with confirmation bias, self-serving bias and hindsight bias.
iii. To determine which mechanism, feedback or contradicting reason mechanism, is an effective solution to reduce overconfidence bias in individual subjects influenced by cognitive bias.

1.6 Significance of the Study

So far, very few studies in the current literature have examined the relationship between cognitive bias and psychological attributes, and offered possible solutions to reduce overconfidence bias during decision-making in the securities market. The thesis contributes to the current research in the following ways.

i. The existing literature focuses on either the relationship between psychological attributes such as miscalibration, better than average effect and illusion of control with overconfidence bias, or cognitive biases such as confirmation bias, self-serving bias and hindsight bias with overconfidence bias. Detailed explanations for the reasons for, or factors underlying, the psychological attributes, have not been offered. In the second relationship, cognitive biases and overconfidence bias, details are not provided of how the subjects react to and process information. This thesis relates the cognitive biases to the psychological attributes to provide a better understanding of the cognitive reasons behind psychological attributes of overconfidence and the effect of cognitive biases on trading behaviour.
ii. The thesis identifies different types of psychological attributes of overconfidence (i.e. miscalibration, better than average effect and illusion of control) influenced by respective cognitive bias (i.e. confirmation bias, self-serving bias and illusion of control) and their impact on trading behaviours, which has not been explored before.
iii. The existing solutions for overconfidence bias in the financial market focus on financial knowledge and knowledge enhancement. This study explores psychological solution methods, such as the feedback mechanism and

contradicting reason mechanism, in order to identify possible solutions to overcome the psychological roots of overconfidence. These two mechanisms were chosen because they are simple, and can be executed by individual traders and securities firms.

1.7 Summary

Based on the above, Chapter One summarises that overconfidence bias is pervasive in stock markets and therefore, it is important to understand the cognitive reasons for overconfidence bias so that an appropriate solution mechanism can be developed to minimise it among individual traders and improve their trading behaviour. This might contribute to the stability of financial market.

The thesis is structured in the following manner: Chapter Two presents the conceptual framework, Chapter Three discusses related literature on overconfidence in psychology and finance, Chapter Four describes the experimental design and organisation, Chapter Five presents the experimental results and discussion and conclusions follows in Chapter Six.

CHAPTER 2 - CONCEPTUAL FRAMEWORK

This chapter discusses the frameworks of expected utility theory, violation of expected utility theory and prospect theory, and then relates them to cognitive biases, psychological attributes and overconfidence bias in the securities market.

2.1 Expected Utility (EU) Theory and Violation of Expected Utility Theory

In standard economic theory, people are said to make a rational choice if they choose an alternative whereby the marginal benefit is more than the marginal cost. One of the most prominent works in rationality is "Expected Utility Theory" by Neumann and Morgenstern (1944) (a.k.a. VNM). Under VNM's EU theory, choices are evaluated based on a known probability of various possible outcomes. For instance, U( ) is the utility function; $u(X_A)$, $u(X_B)$ ….are the utilities obtained from each possible outcome X_A, X_B,… and P_A, P_B....are the known probabilities for each outcome. People will choose the alternative yielding the highest expected utility by multiplying probabilities with possible outcomes as follows:

$$U\ (G) = \ P_A.U(X_A) + \ P_B.U(X_B) + \ldots + P_n.U(X_n)$$

The model assumes that people know the correct probability for each state under a risky situation and that they make decisions based on the stated probability. EU theory assumes that humans are rational; it facilitates people in making choices by allowing them to rank all the choices from the highest utility to the lowest utility. It also assumes that people can make decisions rationally without the influence of emotions.

Table 2.1 Experiments by Maurice Allais (1953)

Experiment 1				Experiment 2			
S_1		S_2		S_3		S_4	
1.00	\$1million	0.89	\$1million	0.89	\$0	0.90	\$0
		0.01	\$0	0.11	\$1million	0.10	\$5million
		0.10	\$5million				

In a seminal paper by Allais (1953), however, showed that humans did not act as predicted in EU theory. The first example of violations of EU theory can be seen in the example given in Allais Paradox, as in the experiment findings detailed in Table 2.1. In Experiment 1, subjects were asked to choose between option S_1 and S_2. Based on EU theory, people should choose the investment with the highest return. The expected payoff from S_1 was 1*\$1 million = \$1 million and S_2 was 0.89*\$1 million + 0.1*\$5 million = \$1.39 million. The experimental result showed that participants in the experiment preferred S_1 to S_2. The order of preference can be written as $1 \cdot u(\$1million) > 0.89 \cdot u(\$1million) + 0.01 \cdot u(\$0) + 0.1 \cdot u(\$5million)$ in Experiment 1.

In Experiment 2, participants were asked to choose between options S_3 and S_4, and the experimental result showed that the majority of the subjects chose S_4. The preference can be written as $0.89 \cdot u(\$0) + 0.11 \cdot u(\$1million) < 0.9 \cdot u(\$0) + 0.1 \cdot u(\$5\ million)$ or $0.11 \cdot u(\$1million) < 0.01 \cdot u(\$0) + 0.1 \cdot u(\$5\ million)$. Substituting $0.11 \cdot u(\$1million)$ with $1 \cdot u(\$1\text{million}) - 0.89 \cdot u(\$1\text{million})$ from experiment 1, we get $1 \cdot u(\$1million) < 0.89 \cdot u(\$1million) + 0.01 \cdot u(\$0) + 0.1 \cdot u(\$5million)$. The preference contradicts that made by the same subjects in Experiment 1. The violation in Experiment 1 was caused by the certainty effect (Kahneman & Tversky, 1979b). The certainty effect involves a situation where

people overweigh sure outcomes and under weigh outcomes that are uncertain, as seen in Experiment 1.

Kahneman and Tversky (1979b) also found that risk behaviours are domain specific, in which people are risk-averse in a gain domain, but risk-seeking in loss domain. The second example of violations of the EU theory can be explained by the reflection effect (Kahneman & Tversky, 1979b). The reflection effect implies that people are risk-averse in a gain domain and risk-seeking in a loss domain. Table 2.2 shows that people are risk-averse by choosing S_2 in a gain domain and risk-seeking by choosing S_1 in a loss domain.

Table 2.2 Reflection effect by Kahneman and Tversky (1979b)

	S_1	S_2
Gain Domain N =100	(0.80, $4000) 20	(1, $3000) 80*
Loss Domain N =100	(0.8, -$4000) 92*	(1, -$3000) 18

Note: N is the total number of subjects and * is the dominant choice.

Based on the gain domain in Table 2.2, the expected payoff for S_1 was $3,200 and S_2 was $3,000. Based on EU theory, people should choose S_1 with a higher expected payoff, but because people were risk-averse in a gain domain, they chose S_2 instead of S_1. In the loss domain in Table 2.2, the expected payoff for S_1 was -$3,200 and S_2 was -$3,000. Based on EU theory, people should choose S_2, with lower potential loss, however, people were risk-seeking by selecting S_1 in the loss domain.

The third example of violations of EU theory is overweighing very low probability and under weighing high probability (Kahneman & Tversky, 1979b). The experimental findings showed that people tend to overweigh very low probability in a gain domain and preferred a very small loss in a loss domain. Table 2.3 shows that people choose S_1 in a gain domain and S_2 in a loss domain.

Table 2.3 Probability weighing anomalies by Kahneman & Tversky (1979b)

	S_1	S_2
Gain Domain N =100	(0.001, $5000) 72*	(1, $5) 28
Loss Domain N =100	(0.001, -$5000) 17	(1, -$5) 83*

Note: N is the total number of subjects and * is the dominant choice

Based on Table 2.3, in a gain domain, the expected payoff for S_1 is $5 and S_2 is $5. Both choices had the same expected payoff but people preferred S_1 to S_2. This showed that people overweighed very low probability (i.e. 0.001) in the gain domain, and explained why people still buy lottery tickets even though the probability of winning is very low. In a loss domain, the expected payoff for S_1 is -$5 and S_2 is -$5. Both choices had the same losses but people preferred S_2 to S_1. This showed that people under weighed high probability and preferred a very small loss in the loss domain, which explained why people are willing to pay excessive insurance premiums despite the low probability of a large loss.

2.2 Prospect Theory

Prospect theory (Kahneman & Tversky, 1979b) provides a descriptive framework for the way people make choices in risky and uncertain situations (Baker & Nofsinger, 2002). Kahneman and Tversky (1979b) believe that humans make decisions based on the magnitude of the change in their gain and loss for each investment from their reference point, which is an asset's initial position. There are two key assumptions in prospect theory. First, a value function is concave for gain (meaning risk aversion), convex for loss (risk seeking) and steeper for loss than gain (loss aversion). Second, low probabilities are generally overweighed but moderate, and high probabilities are under weighed in rare events, especially in a loss domain.

We first explain the first assumption of prospect theory, that the subjective value or utility is a concave function of money. In such a function, the difference between the utility of $200 and $100, for example, is greater than the utility difference between $1,200 and $1,100. It follows from concavity that the subjective value attached to a gain of $800 with probability 100% is more than the expected value of $1,000 with probability of 80%. Consequently, the concavity of the utility function entails a risk averse preference for a sure gain of $800 over an 80% chance to win $1,000 in the gain domain, although the two prospects have the same expected monetary value (Kahneman & Tversky, 1984). People do not react to the stated outcome (i.e. $money$) but are influenced by subjective probability (v). According to Kahneman (2011), diminishing sensitivity to changes in wealth causes human to behave in accordance to the first assumption.

In EU theory, the value or utility of an uncertain prospect is obtained by adding the probable outcomes or utilities, weighted by probability. People are assumed to weigh probability linearly, however, in prospect theory, the carrier of the value is gain and loss, not final outcome, and the value of each outcome is multiplied by a decision weight instead of an additive probability. Decision weight is the function of p that expresses the subjective evaluation of the objective probabilities, but it is not a probability and should not be interpreted as a measure of degree of belief (Tversky & Kahneman, 1992; Li, 1995).

The value of the prospect is not a linear function for the probability of winning. Instead, the change of probability from 0% to 5% and 95% to 100% appears larger than a similar change of probability from 5% to 10% or 60% to 65% on the same scale. The change of probability from 0% to 5% creates a possibility effect that causes people to overweigh small probability by paying more than the expected value, such as when buying lottery ticket. The change of probability from 95% to 100% creates a certainty effect, which causes people to under weigh outcomes that are certain compared with the justified probability. Possibility effect and certainty effect have greater impact in loss domain than gain domain (Kahneman, 2011).

2.3 Prospect Theory and Trading Behaviours

In prospect theory, trading behaviours are influenced by the initial wealth position and not the final outcome of the trade. Traders tend to be loss averse over fluctuations in the value of their financial portfolio, and the degree of loss aversion depends on the previous gains or losses in their investment. Traders are more sensitive to a reduction of their wealth compared with an increase in their wealth (i.e.

concavity in gain and convex in loss in the value function, in prospect theory). This suggests that traders are less risk averse when they have made prior gains, which motivate them to purchase more, which contributes to the deviation of stock price from its fundamental value. This is because the stock price is determined by the supply and demand of the stock in the securities market. When there is an increase in the demand of the stock, the price will increase and deviate from its fundamental value. Traders become risk averse when they have made prior losses, they become hesitant in their decision-making and tend to buy less (Barberis, Huang & Santos, 2001).

Probability weighing behaviour in prospect theory has been used to explain the fourfold pattern of risk attitudes as follows: risk seeking for gains and risk aversion for losses of low probability; risk aversion for gains and risk seeking for losses of high probability. Risk seeking for low probability gains can help to explain the popularity of gambling, and risk aversion for low probability losses to explain people's tendency to buy excessive insurance to avoid loss (Tversky & Fox, 1995).

Overconfidence bias is exhibited by traders (Odean, 1998; Chuang & Lee, 2006) when traders overreact to private information and underreact to public information, trade more excessively after gains, cause excessive volatility in market and underestimate risk. These behaviours are inconsistent with the rationality assumption in EU theory that people can make decisions rationally without the influence of emotion, and with perfect information. Traders become risk seeking after a history of gain because of the effect of diminishing sensitivity, and this leads them become more confidence and trade more.

2.4 Relationship Between Prospect Theory, Cognitive Biases, Psychological Attributes and Overconfidence Bias

Confirmation bias happens when people tend to look for confirming evidence that supports their beliefs, and ignore information that does not support their beliefs, especially when the decision is complex and uncertain. People with confirmation bias tend to miss important or useful information, which leads them to be miscalibrated and poor at decision-making. It has been suggested that confirmation bias could result from information processing bias (Koriat et al., 1980; Nickerson, 1998).

When people suffer from information processing bias, they may suffer from probability-weighing anomalies by overweighing information that conforms to their beliefs or overweighing recent information, although the probability of the unexpected information impacting the market is unknown or very small. This leads them to be miscalibrated and exhibit overconfidence bias. People with bias overreact to unexpected and dramatic news instead of observing the historical trends of dividend payout which cause stock prices to deviate from their fundamental values (details can be found in Bondt & Thaler, 1985, Thaler, 1999, Tversky & Kahneman, 1974, Kahneman & Tversky, 1979a and Kahneman & Tversky, 1979b).

Self-serving bias involves people's tendency to attribute positive outcomes to their own internal or personal factors, but attribute failure to external or situational factors. People with self-serving bias tend to give others less credit for success, and blame them more for failure than they ascribe to themselves (as cited in Taylor & Brown, 1988). It is noted that self-serving bias increases, especially after a history of gains or successes (Campbell & Sedikides, 1999). According to the theory of self-

serving bias, traders who have self-serving bias attribute their success in trading to their personal efforts and skills, and value themselves more highly than other traders, however, when they are not doing well in trading, they blame the failure to bad luck, or external factors such as feng shui. Individuals who always think they are better than others are overconfident of their success. They will then overestimate their ability and judgment, resulting in poor decision-making. Traders tend to become overconfident and then increase their stock trading after gain, and then excessive trading leads to low or negative profit at the end of trading days (Odean, 1998, 1999; Barber & Odean, 2000, 2001; Dittrich et al., 2005; Chuang & Lee, 2006).

Hindsight bias refers to situations where people distort their previous judgment, memory, actual facts or previous information based on the latest information received once an actual outcome is known. There are three levels of hindsight bias: memory distortion (I knew it would happen), inevitability (it had to happen) and foreseeability (I said it would happen) (Roese & Vohs, 2012).

The memory distortion level (I knew it would happen) involves a failure in the recollection of previous judgment, which is caused by cognitive input such as the operation of memory. According to the operation of memory, hindsight bias can be induced during the stage of recollection and knowledge updating. Recollection errors happen when people fail to retrieve an answer and depend on what they now know to be the correct answer. Errors in knowledge updating are affected by the human memory system, which tends to adapt when taking new information and connecting it with what is already known. When people cannot recall their previous answer, they tend to overweigh current information that causes them to believe that they have made the right decision and leads them to be overconfident. This is related to probability weighing anomalies in prospect theory.

Hindsight bias also leads traders to have positive illusions about their previous judgment and think they can control the outcome. Traders compare new information with their prior beliefs. For example, traders compare the new information to their previous beliefs after earnings announcements. In comparing the information, traders consider the difference between the latest and previous information. Memory distortion, inevitability and foreseeability means traders fail to retrieve their previous beliefs, which leads them to distort their initial beliefs, and consequently, believe the new information is the original beliefs. When traders with hindsight bias believe that they are always making a right judgment, this will lead them to be overconfident. "Hindsight bias may yield overconfidence that incites a reluctance to reassess one's own past actions" (Roese & Vohs, 2012). This subsequently leads to errors in an trader's subsequent decision-making, and poor performance, especially in risky and uncertain environments like the stock market (Shiller, 2000; Biais & Weber, 2009).

2.5 Summary

There are much evidence for violations of EU theory, as discussed earlier, however, this thesis is not attempting to deny EU theory. This thesis focuses on the application of cognitive biases such as confirmation bias, self-serving bias and hindsight bias, to explain psychological attributes such as miscalibration, better than average effect and illusion of control. The relationship between cognitive biases and psychological attributes may help in understanding trading anomalies in the financial market as outlined earlier, and suggest solutions to minimise these misbehaviours in investment. In the next chapter, the thesis focuses on the related literature on overconfidence in psychology and finance, and solutions to the problem.

CHAPTER 3 - LITERATURE REVIEW

Overconfidence is often studied/discussed in the psychology literature. This thesis will fill the gaps in the current literature by examining the cognitive reasons for overconfidence, such as confirmation bias, self-serving bias and hindsight bias, and their relationship with psychological attributes such as miscalibration, better than average effect and illusion of control. This chapter begins with a review of literature related to overconfidence from the psychological perspective (Section 3.1), followed by a review of research on the issue of overconfidence in financial markets (Section 3.2). Section 3.3 discusses related literature on solutions to overconfidence in the financial market, and Section 3.4 describes the gaps in the literature.

3.1 Overconfidence in Psychology Theory

Overconfidence is "excessive confidence." The overconfidence effect involves a condition when someone's subjective confidence of their judgment is reliably greater than their objective accuracy, especially when confidence is relatively high. Pulford (1996) says that confidence is a feeling of certainty, and that the strength of this feeling reflects the level of confidence. There is an associated level of confidence with people's answers or decisions, whenever they make a prediction or decision. Self-confidence reflects a person's beliefs about their own abilities, self-worth and value at any one time, and as belief changes, self-confidence can change too.

Moore and Healy (2008) define overconfidence as overestimation, overplacement and overprecision. Overestimation is when an individual thinks they are better than they really are. In overplacement, an individual thinks they are better than everyone else. Overprecision involves excessive precision in one's beliefs, such that the individual underestimates the noise in their information. In psychology, overconfidence is measured by miscalibration (Koriat et al., 1980; Lichtenstein et al., 1981; Russo & Schoemaker, 1992; Brenner, Koehler, Liberman & Tversky, 1996; Alba & Hutchinson, 2000), better than average effect (Svenson, 1981; Fischhoff & MacGregor, 1982; Taylor & Brown, 1988) and illusion of control (Langer, 1975; Taylor & Brown, 1988). These three psychological attributes have been adopted in the economics and financial literature since 2000 (Glaser & Weber, 2007; Merkle & Weber, 2011; Smith, 2012).

It is found that the confirmation bias is associated with miscalibration (Koriat et al., 1980), self-serving bias is associated with better than average effect (Alicke et al., 1995 & Alicke & Govorun, 2005) and hindsight bias is associated with illusion of control (Langer, 1975; Thompson et al., 1998). This thesis therefore focuses on these psychological attributes and their cognitive reasons as follows: confirmation bias and miscalibration, self-serving bias and better than average effect and hindsight bias and illusion of control. Overconfidence has been widely recognised in psychology since the 1960s, and in economics and finance since the 1980s. Three main psychological attributes of overconfidence in psychology literature are miscalibration, better than average effect and illusion of control.

3.1.1 Overconfidence Operationalised as Miscalibration

Miscalibration emerged from the theory of subjective probability judgment. The subjective expected utility (SEU) assumes that people act to maximise their SEU, which equals the sum of the utilities of the outcomes weighted by their subjective probability of occurrence instead of the objective probability of occurrence in expected utility (Tversky, 1967). Objective probability is based on some basis of fact, analysis or experimentation, whereas subjective probability is based on people's intuition or guesses. Subjective probability is also defined as the subject's degree of belief in the correctness of a judgment or decision (Pulford, 1996).

According to Nau (2007), the formula of SEU can be written as $SEU(x) = E_p[v(x)] = \sum_{n=1}^{n} p_i v(x_i)$. Uncertainty about the future is represented by a finite set of states of the world, which is (E_1,..., E_n), and possible outcomes are represented by a set of consequences. A decision alternative, known as an act, can be written as a vector x = (x_1,..., x_n), where x_i is the consequence that is received in state E_i. P_i is the subjective probability of E_i, which means the belief of the decision maker about the state of the world, and their value of consequences is represented by a utility function $v(x)$, in term of which the value they assign to an act x for decision-making purposes is their subjective expected utility (SEU(x)).

Kahneman and Tversky (1972) concluded that the deviations of subjective probability from objective probability are proven, systematic and unavoidable. This is because people tend not to follow the principles of probability theory in judging the likelihood of uncertain events. Calibration study emerged as a measurement of the difference between the estimated subjective probability and actual objective

probability, because good calibration is critical in making good decisions (see Lichtenstein et al., 1981). A person is miscalibrated if the estimated subjective probability is not equal to the actual objective probability. A person is well calibrated if the estimated subjective probability is equal to the actual objective probability. Miscalibration has been used as a tool to measure confidence levels.

Miscalibration is defined as overestimation, based on Moore and Healy (2008). If the subjective probability of evaluating a probability assessment of a decision is higher than the objective probability, then a person is considered to be overconfident. If the objective probability of evaluating a probability assessment of a decision is higher than subjective probability, then a person is considered to be underconfident. In other words, people have poor calibration (are overconfident or underconfident) when they over- or underestimate the validity of their beliefs (Pulford, 1996).

According to Lichtenstein et al. (1981), "Calibration measures the validity of probability assessments. Being well calibrated is critical for optimal decision-making and for the development of decision aiding techniques." A person is well calibrated if all statements are assigned a given probability, and in the long run, the proportion that is true is equal to the probability assigned. For example, if an individual assigns a probability of 0.75 to a probability assessment, in the long run, if it turns out to be true 75% of the time, the individual is considered well calibrated. If only 65% of the time it turns out to be true, the individual is not well calibrated, and is considered to be "overconfident." If 85% of the time it turns out to be true, the individual is considered "underconfident." The concept of calibration is the most widely adopted in literature, and it will be adopted in this thesis too.