Behavioural heterogeneity in ASX 200

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Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgments), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Acknowledgements

Abstract

This dissertation works on dynamic asset pricing with heterogeneous agents. The heterogeneous agent model assumes that public information is available to all investors and agents. However, the agents or the investors form different beliefs and different trading strategies based on the same information. Investors keep reallocating their money between different strategies depending on their beliefs. This dissertation assumes there are two strategies in the market, namely fundamentalist and chartist strategies. A strategy with a good performance is expected to attract more investors than other strategies. Fundamentalists believe that any mispriced asset adjusts its price back to fair value. Chartists believe that the trend of deviations from fundamental values continues in the next period. This dissertation estimates the model by collecting monthly Australian stock price from 1882 to 2008. Our estimated results support that there is heterogeneity in the stock market and the model with two types of investors outperforms a homogeneous expectation model. The fractions of investors using the chartists and fundamentalists forecasting rules show substantial time variation and switching between predictors. From the 1980s onwards, the investors in the stock market switch between two strategies more frequently than in the past.

1. Introduction

Traditional finance builds on rational expectations which should lead to efficient markets. The market is said to be efficient when the investors have no opportunities to make abnormal profits and the price of the asset should reflect both public and private information such as, price-dividends ratio (P/Y ratio) and insider information. However, investors in the stock market might have asymmetric information or interpret information differently. In other words, investors might have different information about their assets, or have the same information but interpret this differently. Therefore, they allocate their money differently (Li et al., 2008). This condition shows that not all the traders in the market are rational, and recently researchers start shifting to traders' psychology, which is called behavioural finance, to explain the different interpretation of the same information. This different interpretation of information forms the basis of this dissertation.

Behavioural finance does not maintain the assumptions of traditional thoughts of efficient markets, suggesting that investors could be irrational. And irrationality is a concept based on the fact that a rational investor is limited by the same information they interpret differently, the cognitive limitation of their minds, and the finite amount of time available to make decisions (Barberis and Thaler, 2002). Firstly, Barberis and Thaler (2002) talk about a representative agent model where the beliefs of investors reflect the consensus forecast, even if there are still some investors with different beliefs. Barberis et al. (1998) mention that investors in the market are not aware of earnings following a random walk and suggest that there are two possible behaviours that govern earnings. Two possible behaviours suggest that earnings are mean-reverting and the investors in the stock market follow the trend which means that they believe the earning would continue to rise or drop after an increase or a decrease. Barberis et al. (1998) provide a good example, which is when a positive earning

surprise is followed by another positive surprise, the investor is the trend follower. Secondly, there are several psychological biases in behavioural finance. Most importantly, this dissertation discusses overconfidence and biased self-attribution. In the first psychological bias, investors are overconfident, and biased self-contribution is when investors see a good performance of an asset and attribute it to their own skills, while if there is a poor performance of an asset they would not. Hence, investors in the stock market could interpret the same information differently. Because of these psychological biases in the market, some authors began taking investor behaviour into account rather than continuing to consider the theoretical issues. Therefore, this motivates why different groups can exist in the stock market.

A number of recent papers have extended the model from the representative agent model to the heterogeneous agent model. The assumptions of the heterogeneous agent model are that different investors with different beliefs can coexist and have different expectations about the next period's prices of risky assets. In the representative agent model, the investor is perfectly rational in the stock market and irrational investors will lose money and be driven out of the market by rational investors (Friedman, 1953). The traditional approach is a linear, stable model, which is driven by exogenous random news about fundamentals that investors in the market are unable to predict to obtain abnormal profits. In contrast, investors in the heterogeneous agent model are boundedly rational and are limited by the interpretation of the same information, or limited by the time to make decisions. In the heterogeneous model, the stock markets are complex adaptive and are nonlinear evolutionary systems (Shiller, 1984). In this dissertation, we assume that there are only two types of investors in the financial market, fundamentalists and chartists. Fundamentalists believe that the price of an asset is solely determined by fundamentals. Chartists, or technical analysts, believe that the asset prices are not fully determined by fundamental price but they may be determined by some

simple technical trading rules. These heterogeneous agent models are discussed in a theoretical framework by Hommes (2006).

In this dissertation, we use asset pricing theory and Gordon's growth model with behavioural heterogeneity. The dissertation is based on the model in Boswijk et al. (2007)'s paper and has been reformulated in terms of price to cash flow ratios. The first heterogeneous behaviour in our model has been identified as a trend-following, which is also called chartist whereas the second behaviour has been identified as mean-reversion, which is named fundamentalists. We estimate our model based on the monthly ASX 200 data from 1882 to 2008. The estimation of our model suggests that both first and second behaviours are statistically significant. When the mean-reversion behaviour corresponds to the situation, this means the market is dominated by fundamentalists, who have a strong belief that the mispriced asset will come back to its fundamental value. In other words, the majority of investors in the market are fundamentalists rather than chartists. The other behaviour suggests that the investors in the market are expected to have the same signs of earnings in the next period, or the deviations from the fundamental values are constantly growing over time, which also means that there are more chartist than fundamentalists in the stock market.

Our findings suggest that there are few significant decreases in the fundamental price to cash flow ratio and thus we have to recalculate the equity premium instead of using a constant equity premium for the whole sample period. We find that the equity premium for 1983-2008 is negative. This could be explained by the fact that there were more companies in the market paying share dividends instead of paying cash dividends. In addition, more recently, households have invested a large proportion of their money in mutual funds to achieve a better diversification of risk. Therefore, investors expect a lower required equity premium (Boswijk et al., 2007).

Since late 2007, there has been another global financial crisis. We consider that it is good motivation for investors to look for trading rules in the ASX 200 index, because investors want to make profits by predicting future price levels. This dissertation focuses on the accuracy of forecasting the next period's profit in the heterogeneous world. Traders will then switch between the two beliefs or trading strategies if one has performed relatively well compared to the other in the past in ASX 200. Furthermore, the non-linear model will be established by switching between the two beliefs. (Shiller, 1981 and Frijns et al., 2007) In addition, traders decide which strategies to be undertook by looking at traders' historical performance to the other strategies (Hommes, 2006).

Recent papers suggest that heterogeneity is relatively better in explaining the data; the models can provide good advices on the American stock markets (Barberis and Thaler, 2002 and Andrikopoulos, 2005). There is therefore a need to test the validity of the heterogeneous model in the ASX 200. This dissertation also examines whether either a single strategy, or a heterogeneous strategy with switching between two strategies, outperforms the other in the ASX 200. A possible future extension of this dissertation would be to apply the same model to the Australian foreign exchange and futures markets.

This dissertation is divided into five sections. Section 2 discusses some closely related literature. Section 3 describes the asset pricing model with heterogeneous beliefs and switching between two different beliefs. Section 4 presents our estimated findings. The final section provides conclusions.

2. Related literature

2.1 Background

The idea of modern finance is rationality, which means the investor is characterised by perfect self-interest and free to access perfect information (Andrikopoulos, 2005). The definition of rationality is: when new information arrives, investors correct their beliefs in the Bayes' law and investors make decisions on their investment, and because their beliefs are normative. The investor is characterised as having perfect self-interest and being free to access perfect information (Barberis and Thaler, 2002 and Andrikopoulos, 2005). The efficient market hypothesis (EMH) is a theory that still influences modern finance today. Markets are considered to be efficient if there are no opportunities to make abnormal profits on the basis of universally available information (Fama, 1970). Empirical testing of the theory has proved problematic because investors in the stock market might interpret the same information differently, as there is an existence of psychological biases. Recent papers prove to be the most challenging to modern finance as they provide an opportunity for a new theory known as behavioural finance (Andrikopoulos, 2005).

In this section, we firstly discuss behavioural finance. We then turn to the evolution of behavioural finance from the representative agent model of Barberis et al. (1998) to the heterogeneous agent model of Hommes (2006). Before we move to the heterogeneous agent model, this dissertation discusses the weakness of the representative agent model to show why many recent papers begin by studying heterogeneous agent models. Lastly, we focus on the main approach, which is the heterogeneous agent model where investors have heterogeneous expectations about symmetric information. Boswijk et al. (2007) discuss that investors in the market can coexist with heterogeneous expectations on future cash flows and are able to switch between two strategies, fundamentalist and chartist, and investors use different models of

market to value their investment, based on earnings news and this might lead to different beliefs by investors.

2.2 Behavioural finance

We already know from the previous section that behavioural finance can explain problems that cannot be explained by traditional finance. Therefore, this section focuses on behavioural finance and how it answers the problems that are produced by modern finance. There are two blocks of behavioural finance in the efficient market; cognitive psychology and the limits to arbitrage (Ritter, 2003). First, cognitive psychology is about how investors think. Not all the investors would have the same responses to similar situations. Second, limits to arbitrage is about predicting when arbitrage forces will take effect and when they will not. Behavioural finance is a new approach and occurs in the financial market to answer some problems that are caused by the traditional paradigm (i.e. modern finance). For example, behavioural finance helps to answer how and why the market is inefficient (Sewell, 2007). Broadly speaking, behavioural finance argues that some financial events can be easily understood using the models where investors are irrational and this is a reason for why many papers no longer refer to traditional finance. Because traditional approach of finance assumes that all investors in the market are rational, the traditional approach is a linear model while behavioural finance is a nonlinear model, which assumes that investors in the market have the same information but would interpret the information differently. Furthermore, investors in the market have the same information but would not always take the same actions because of their psychological biases. In addition, investors do not always access to the same information, therefore, based on different information they would react differently. For example, investors are said to be irrational if some investors do not update their beliefs with arrivals of new information, and the decisions investors make are not normatively acceptable. Also, if investors do not have perfect

information or even if they do but they interpret them in a different way eventually and there is no any opportunity to make abnormal profits. (Barberis and Thaler, 2002)

2.3 Representative agent model

This section covers the representative and risk neutral models proposed by Barberis et al. (1998) and Daniel et al. (1998) and explains the evolution of behavioural finance. Recent empirical studies support that the beliefs of the investors reflect "consensus forecasts", even if there are different investors with different beliefs. An assumption is made by Barberis et al. (1998) which is that investor are not aware that earnings follow a random walk, and that investors consider that the world moves only between two possible states which have different models governing earnings. In the first state, earnings are mean-reverting and in the second state, earnings continue the trend from the last period. The change in earnings today depends only on the last period of earnings. Under the first state, the earning shocks are likely to be reversed in the next period. For instance, a positive earning shock is more likely to be followed by a negative earning shock in the next period. Under the second state, earning shocks are likely to continue the same sign of earnings in the next period (Barberis et al., 1998).

The model by Barberis et al. (1998) provides two types of psychological behaviours, conservatism and representativeness heuristic, which are both good examples of the representative agent model in behavioural finance (Griffin and Tversky, 1992). Firstly, conservatism states that the investor reacts slowly, based on the arrival of the new announcement. However, if there is a long enough period, an investor is able to adjust his reaction perhaps to an overreaction from an underreaction. Secondly, representativeness heuristic views the event as a representative of some specific class and puts the law of probability aside in the process (Griffin and Tversky, 1992).

2.4 Weakness of representative agent model

From the background section, we know that the representative agent model has not been applied frequently and thus, this section will address this issue. Daniel et al. (1998) point out some weaknesses of the representative agent model and classify investors in the security market based on two psychological biases, overconfidence and biased self-attribution. Griffin and Tversky (1992) also state that professionals tend to be more overconfident than relatively unprofessional individuals. The second psychological bias is biased self-attribution. The confidence of the investor grows when public information confirms his beliefs, but it does not decline when public information contradicts his information. In the theory of Daniel et al. (1998), the authors assume that investors consider themselves better at valuing the security market than they actually are; therefore, they underestimate the error variance. In other words, evidence shows that investors overestimate their abilities. Because many psychological biases occur in the market, some authors have started taking these psychological factors of investors into account in their studies (Daniel et al., 1998). Bonaparte (2007) provides a weakness of some representative model analyses, which is that they are poor in empirical performance, so some macroeconomists then began using the heterogeneous model. Another significant reason for using the heterogeneous agent model is that the representative model is not good enough to answer some key questions, such as, explaining the skewed wealth distribution. For example, Bonaparte (2007) says that the representative agent model fails to explain the U.S. data when the sample sizes are large, with many different beliefs in the market, and then raises the necessity of using the heterogeneous agent model. Based on this reason, it has led macroeconomists to consider the market segmentation and start using the heterogeneous agent model instead of the representative agent model.

2.5 The evolution of heterogeneous agent model

In a recent study, Hommes (2006) extended the representative agent model into an interesting area; the heterogeneous agent model. Two typical types of traders can be distinguished here, fundamentalists and chartists. Fundamentalists believe that the asset price would eventually move towards the fundamental benchmark. Therefore, they like to invest by buying assets that are undervalued, that is, whose prices are under the benchmark price level and selling assets which are overvalued, that is, whose prices are above the benchmark price level. On the other hand, chartists do not take the fundamental value into account, but instead of that, chartists believe that they can forecast future asset prices by looking at the historical trends; therefore, they are also called trend followers (Hommes, 2006). There is a well-known example of chartists' decision making, which is the "moving average" trading rule. This states that investors should buy assets when a 1 week moving average (short term) is above a 12 week or longer moving average (long term) from below and vice versa (Hommes, 2006).

In the heterogeneous agent model, two assumptions have been set up; different groups of traders could coexist and individual traders have different beliefs on expectations about the next period's prices of risky assets based on the same information (Li et al., 2008). Hommes (2006) reviews some dynamic heterogeneous agent models in the area of economics and finance and most of these models focus on financial markets, but some of them deal with other markets, such as the commodity markets.

Zeeman (1974) provided an earlier example of the heterogeneous agent model, and more recent examples can be found in DeLong et al. (1990) and Dacorogna et al. (1995). Moreover, fundamentalists are pessimistic because they believe that the situation of a mispriced asset will soon be adjusted back to its fair or fundamental value when the market is currently overpriced and vice versa. However, chartists objectively believe that they will still have opportunities to

make some profits from mispriced assets in the short run, since the trend will continue and the mispriced asset will adjust in the long run (Fisher and Statman, 2002 and Vissing-Jorgensen, 2003).

The other explanations for being heterogeneous are asymmetry of information and different interpretation of the same information. Firstly, some information is public information, which means it is available for all market participants, but some information is private information which means it is not available for all market participants. Secondly, different traders will have different interpretations based on the same public signal in the market (Boswijk et al., 2007and Frijns et al., 2007). Beside that, Vissing-Jorgensen (2003) shows that the beliefs among market participants are different and thus they have different expectations of the stock market in the future.

Lastly, Friedman (1953) has pointed out an interesting question and argued that irrational traders can survive in the market, or whether they would lose money and be driven out of the market by rational investors, who would trade against them and drive asset prices back to the fundamental level in the heterogeneous agent model. Chiarella (1992) and Lux (1995) have also mentioned that heterogeneous beliefs may cause market instability and complicated dynamics, leading to chaotic fluctuations in the financial market. The weights of the fundamentalists and the chartists to the distance between the fundamental and the actual price level have led to asset price fluctuations in nonlinear models. When there are a large proportion of fundamentalists in the market, it stabilises prices, whereas a large proportion of chartists destabilises prices. Further discussion of nonlinear models in financial markets is given in Brock and Hommes (1997)'s paper.

In recent studies, DeLong et al. (1990) examine that in a finite horizon financial market model, chartists may on average gain higher returns than fundamentalists. A number of other studies have shown that a simple technical strategy could outperform few popular efficient market hypothesis (EMH), such as the random walk or Garch-model in the Dow Jones index (Brock et al., 1992).

2.6 The heterogeneous agent model

In this section, we consider the asset pricing model with heterogeneous beliefs introduced by Brock and Hommes (1997, 1998). One of the key assumptions in our model is based on Boswijk et al. (2007), who assume that investors adopt a belief based on past performance relative to other strategies. Here, we are switching strategies between fundamentalists and chartists; if one strategy is outperforming the other, as measured by realised profits, it will attract more investors. A recent paper has also suggested that combining difference in beliefs and short-sales constraints can explain the persistence of deviation of stock prices (Boswijk et al., 2007). Pessimistic investors, who are in the stock market with constraint of short-sales, cannot short the stocks and they do not hold them. However, optimistic investors will buy the stocks and the market price will only reflect the optimistic valuation. In our model, we follow the same assumption as Boswijk et al. (2007), which is that the fundamental value of the asset is available to all market participants. On the other hand, investors in the market with different beliefs will have a different speed of reversing asset prices to fundamental price levels. In other words, the horizons for adjusting the mispricing will be different. In addition, investors in our model are not rational but boundedly rational, because investors learn from past experience to avoid making the same mistakes and switch their strategies around to reduce their possibilities of making future errors.

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3. Methodology

This section discusses the empirical model that will be tested. The fundamentalists and the chartists are only considered by this dissertation. However, there could be many other types of beliefs in the stock market. Investors in the market keep switching between the two strategies over time by looking at the historical performance of each strategy. We focus on the asset price model and Boswijk et al. (2007) has reformulated the model in terms of price to cash flow to estimate the model on yearly S&P500 data. This dissertation replaces the Boswijk et al. (2007)'s data and estimates the asset price model on monthly ASX 200 data.

This dissertation obtains estimated fractions of trading strategies over time in a heterogeneous stock market by using few methodologies and techniques. The estimated fractions of both strategies can tell which one is outperforming the other according to their accuracy of forecasting the next period's profit from the past periods. This is because the investors will only allocate their money into the profitable strategy based on the investors' psychology (Daniel et al., 1998). The model only considers two types of assets in the market, risk-free asset and risky asset. The risk-free asset pays a stable and certain return, r and a risky asset pays uncertain cash flow, Y_t in each period. Therefore, the excess return of the risky asset is given by

$$R_{t+1} = P_{t+1} + Y_{t+1} - (1 + r)P_t \, , \tag{1}$$

where R_{t+1} is the excess return, P_{t+1} is the next period's price, Y_{t+1} is the next period's cash flow, and $(1 + r)P_t$ is the future value of the price at time t. We then introduce behavioural heterogeneity into our model. Again, our model assumes that there are only the fundamentalists and the chartists in the stock market. For convenience, we retain the same assumption that was made by Boswijk et al. (2007). Firstly, all investors have the same risk aversion parameter. We denote the risk aversion of investor h as α_h, thus $\alpha_h = \alpha$. The risk aversion is the reluctance of a

person to accept a bargain with an uncertain payoff like a stock, rather than another bargain with a more certain expected payoff, such as, a bond. Secondly, all investors also have the same expectations on conditional variances, $V_{h,t}[R_{t+1}] = V_t[R_{t+1}]$. The conditional variance is the variance of a conditional probability distribution which is given two jointly distributed random variables X and Y, the conditional probability distribution of Y given X (normally written as Y│X) is the probability distribution of Y when X is known to be a particular value.

The only behavioural heterogeneity in our model is the beliefs of investors about the future cash flow of the risky assets. The expectations of two investors on the mean are $E_{1,t}(R_{t+1})$ and $E_{2,t}(R_{t+1})$. We represent the fraction of two types of the investors in the market at time t by $n_{1,t}$ and $n_{2,t}$.

Because the risky asset is in the zero net supply, the market equation is given by

$$n_{1,t}\frac{E_{1,t}[P_{t+1}+Y_{t+1}]-(1+r)P_t}{\alpha V_t[R_{t+1}]} + n_{2,t}\frac{E_{2,t}[P_{t+1}+Y_{t+1}]-(1+r)P_t}{\alpha V_t[R_{t+1}]} = 0. \qquad (2)$$

According to (2), the equilibrium pricing equation is thus given by

$$P_t = \frac{1}{1+r}\big[n_{1,t}E_{1,t}(P_{t+1}+Y_{t+1}) + n_{2,t}E_{2,t}(P_{t+1}+Y_{t+1})\big]. \qquad (3)$$

Eq. (3) is the function of the expectations and of the proportion of different investors. After discounting and weighting average of investors' expectations for the next period's cash flows, the price at time t is obtained. In other words, more investors in the market think the next payoff will be higher then the equilibrium price will be. In contrast, the equilibrium price will be low if the most investors in the market are expecting lower cash flows in the next period. Cash flows

are typically non-stationary and assumed to have a constant exponential growth, that the cash flows would be unclear to illustrate their trend over time. So this dissertation assumes that $\log Y_t$ is a Gaussian random walk with drift, which is,

$$\log Y_{t+1} = \mu + \log Y_t + \nu_{t+1}, \qquad \nu_{t+1} \sim \text{i.i.d. } N(0, \sigma_\nu^2). \tag{4}$$

Eq. (4) can be rewritten as

$$\frac{Y_{t+1}}{Y_t} = e^{\mu+\nu_{t+1}} = e^{\mu+(\frac{1}{2})\sigma_\nu^2} e^{\nu_{t+1}-(\frac{1}{2})\sigma_\nu^2} = (1+g)\varepsilon_{t+1}, \tag{5}$$

where $g = e^{\mu+(\frac{1}{2})\sigma_\nu^2} - 1$ and $\varepsilon_{t+1} = e^{\nu_{t+1}-(\frac{1}{2})\sigma_\nu^2}$, which implies $E_t(\varepsilon_{t+1}) = 1$.

Therefore, we could get expected cash flow on the next period from (5) and both types of investors in the market are expecting the same cash flow, which is,

$$E_{h,t}[Y_{t+1}] = E_t[Y_{t+1}] = (1+g)Y_t E_t[\varepsilon_{t+1}] = (1+g)Y_t. \tag{6}$$

An important issue from Eq. (6) is that investors use the same information to make the same forecast for each cash flow, but they do not differ in their beliefs on fundamentals. Cash flow in Eq. (6) is determined by external factors; it is natural to assume that all investors have accurate beliefs on the next period's cash flow (Boswijk et al., 2007). On the other hand, a price is given out by expecting the next period's price and therefore we will take heterogeneous beliefs on future price into account later in our dissertation. By taking consideration of cash-flow ratio into the asset pricing model, a formula is formed as follows:

$$\delta_t = \frac{1}{R^*}\{1 + n_{1,t}E_{1,t}[\delta_{t+1}] + n_{2,t}E_{2,t}[\delta_{t+1}].$$ [1]

(7)

where δ_t is the price to cash-flow ratio i.e. $\delta_t = \frac{P_t}{Y_t}$ and $R^* = \frac{1+r}{1+g}$. The reason to take this step is that the original asset pricing model is not stationary. Price to cash flow ratios are a stationary model by reformulating the Eq. (3) which is the asset pricing equation in terms of the price to cash-flow ratio to test for stationary.

Because all the investors in the stock market have homogeneous expectations on the next period's cash flow, we could reformulate Eq. (3) to

$$P_t = \frac{1}{1+r}E_t(P_{t+1} + Y_{t+1}).$$

(8)

Gordon (1962) has provided that, the expectations fundamental price, P_t^* of the risky asset with a constant growth rate g for dividends becomes

$$P_t^* = \frac{1+g}{r-g}Y_t, \qquad r > g$$

(9)

The deviation from fundamental value is provided below by Boswijk et al. (2007)

$$X_t = \delta_t - \delta_t^* = \delta_t - m,$$

(10)

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[1] In this paper, we only consider two types of traders in the market, which are fundamentalist and chartist. The original equation is as follows: $\delta_t = \frac{1}{R^*}\{1 + \sum_{h=1}^{2} E_{h,t}[\delta_{t+1}]\}$.

where m is the fundamental price to cash flow ratio and δ_t^* is the fundamental price to cash flow ratio in Eq. (10). Since investors in the stock market have two different beliefs on the persistence of the deviation from the fundamental, we can therefore specify pricing Eq. (7) as

$$X_t = \frac{1}{R^*}\left[n_{1,t}E_{1,t}(X_{t+1}) + n_{2,t}E_{2,t}(X_{t+1})\right], \tag{11}$$

Eq. (11) is related to Eq. (7) under heterogeneity in expectations and Eq. (11) expresses the deviation at time t is the sum of the expectations of next period's deviation from the fundamental. Eq. (11) can be reformulated to

$$R^*X_t = n_{1,t}f_1(X_{t-1}\dots\dots X_{t-L}) + n_{2,t}f_2(X_{t-1}\dots\dots X_{t-L}). \tag{12}$$

The f(∘) could be explained how the beliefs of both types of investors change while the asset prices change over time. From the Eq. (12), it suggests that if the majority of investors have stable beliefs on the deviations from the fundamental values in the historical data, it is likely to take some time to adjust price to cash-flow ratio towards the fundamental ratio.

Boswijk et al. (2007) consider that the investors in the stock market switch their strategies between the two types of strategies according to the profitability. And the realised profits of each strategy become public at the beginning of each period. The equation of the realised profits is

$$\pi_{h,t-1} = R_{t-1}\frac{E_{h,t-2}[R_{t-1}]}{\alpha V_{t-2}[R_{t-1}]}, \tag{13}$$

where $\pi_{h,t-1}$ is the realised profits of type h of the investors at t - 1, R_{t-1} is the realised excess

return in Eq. (1), and $\frac{E_{h,t-2}[R_{t-1}]}{\alpha v_{t-2}[R_{t-1}]}$ is the demand of the risky assets by investor h at t - 2 in the

stock market.

To have a simple expression of the excess profits in terms of price to cash flow ratio, the

equation of the realised excess return could be transformed as

$$R_{t-1} = P_{t-1} + Y_{t-1} - (1+r)P_{t-2} = (\delta_{t-1} + 1)Y_{t-1} - (1+r)P_{t-2}$$
$$= (\delta_{t-1} + 1)(1+g)Y_{t-2} - (1+r)P_{t-2}$$
$$= (\delta_{t-1} + 1 - R^*\delta_{t-2})(1+g)Y_{t-2}, \tag{14}$$

In Eq. (14), we firstly divide P_{t-1} and Y_{t-1} by Y_{t-1} so we get $(\delta_{t-1} + 1)Y_{t-1}$ as $\delta_{t-1} = \frac{P_{t-1}}{Y_{t-1}}$, and

$Y_{t-1} = (1+g)Y_{t-2}$ which explains the cash flow at t - 1 is equivalent to the growth rate times

the cash flow at t - 2. According to Eq. (9), we could reformulate P_{t-2} to $\frac{(1+g)}{(r-g)}(1+r)Y_{t-2}$.

Because $R^* = \frac{(1+r)}{(1+g)}$ and $\delta_{t-2} = \frac{(1+g)}{(r-g)}$, we could simplify the equation to Eq. (14) as shown

above.

This dissertation already assumes that the conditional variance of the excess returns is the same

for both types of investors in the stock market so the equation of the excess returns is given by

$$V_{h,t-2}(R_{t-1}) = V_{t-2}[P^*_{t-1} + Y_{t-1} - (1+r)P^*_{t-2}]$$
$$= V_{t-2}[(m+1)Y_{t-1} - (1+r)mY_{t-2}]$$
$$= V_{t-2}[(m+1)(1+g)Y_{t-2}\varepsilon_{t-1}]$$
$$= Y^2_{t-2}\eta^2. \tag{15}$$

We put Eq. (1) into the conditional variance of the excess returns and as Eq. (9) we could get $P_{t-1}^* + Y_{t-1} = (m + 1)Y_{t-1}$ and $P_{t-2}^* = mY_{t-2}$. Because we are certain of what happened at t – 2 and we are uncertain of the next period, we could neglect the second term of the second step from Eq. (15). We get the final step of Eq. (15) according to $\eta^2 = (1 + m)^2(1 + g)^2 V_{t-2}[\varepsilon_{t-1}]$. Combining Eq. (13) with Eq. (14) and (15), the fitness measure can now be rewritten in terms of the price to cash flow ratio δ_t as

$$
\begin{aligned}
\pi_{h,t-1} &= R_{t-1}\frac{E_{h,t-2}[R_{t-1}]}{\alpha V_{t-2}[R_{t-1}]} \\
&= (\delta_{t-1} + 1 - R^*\delta_{t-2})(1 + g)Y_{t-2}\frac{(E_{h,t-2}[\delta_{t-1}]+1-R^*\delta_{t-2})(1+g)Y_{t-2}}{\alpha Y_{t-2}^2\eta^2} \\
&= \frac{(1+g)^2}{\alpha\eta^2}(\delta_{t-1} + 1 - R^*\delta_{t-2})\big(E_{h,t-2}[\delta_{t-1}] + 1 - R^*\delta_{t-2}\big).
\end{aligned}
\tag{16}
$$

In this dissertation, the performance of the next period is an important issue for us to forecast, and thus the previous studies have formed the forecasted profit of the next period's deviation from the fundamentals as

$$
\pi_{h,t-1} = \frac{(1+g)^2}{\alpha\eta^2}(X_{t-1} - R^*X_{t-2})(E_{h,t-2}[X_{t-1}] - R^*X_{t-2}).
\tag{17}
$$

Eq. (17) interprets that the investors are able to receive the profits if both actual and expected deviations from fundamental value at time t-1 are greater than R* times realized deviation from fundamental value in the last period. Conversely, investors lose their money if either of the actual or expected deviation from the fundamental value is less than the theoretical benchmark.

Since forecasted profit equation has been formed, investors will then switch to the other strategy, which will generate profits in the future. In order to estimate the weights of both

trading strategies over time in heterogeneity, an equation of fraction was created as shown below

$$n_{F,t} = \frac{e^{(\beta \pi_{F,t-1})}}{e^{(\beta \pi_{F,t-1})} + e^{(\beta \pi_{C,t-1})}}, \tag{18}$$

where $n_{F,t}$ represents the fraction of the fundamentalists at time t and $n_{C,t}$ represents the fraction of the chartists at time t. Here, β is called the intensity of choice, which means that it is an indicator to show how quickly the investor would react based on the new arrival of information. If β is larger, investors in the stock market will then react immediately to the most appropriate and the profitable strategy.

The key feature of Eq. (18) is that strategies with higher realised profits in the recent past attract more investors in the stock market to follow up. The investors are rational because they do not include beliefs with poor performances in the recent past, while investors capture performances.

Brock and Hommes (1998) suggest that the non linear model may produce some problem, such as chaotic asset price fluctuations around the unstable fundamental value. Boswijk et al. (2007) assume that both types of investors forecast the deviation in the next period by looking back at the past realisations in a linear way, which is

$$E_{h,t}[X_{t+1}] = f_h(X_{t-1})$$
$$= \emptyset_h X_{t-1}, \tag{19}$$

where $\emptyset_h$ is a coefficient of two types of strategy h.

Finally, the dynamic asset pricing model is therefore created as

$$R^*X_t = n_t \emptyset_1 X_{t-1} + (1 - n_t)\emptyset_2 X_{t-1} + \varepsilon_t, \tag{20}$$

where $\emptyset_1$ and $\emptyset_2$ represent the fundamentalists and chartists. We are unable to determine which one represents the fundamentalists and the same as the other one until we obtain the value of $\emptyset_h$. n_t are the weights of two types of investors, and ε_t is an error term. If the value of $\emptyset_h$ is smaller than 1, it is likely to suggest that the investors expect the stock price will return to the fundamental value and this type of investors is regarded as fundamentalists. On the other hand, if the value of $\emptyset_h$ is larger than 1, it suggests that the investors expect the deviation of the stock prices to keep growing at a constant growth rate, therefore, we will regard this type of investor as chartists. To get the weight of strategy h, an equation is listed below

$$n_t = \frac{1}{1 + \exp\{-\beta^*[(\emptyset_1 - \emptyset_2) X_{t-3}(X_{t-1} - R^*X_{t-2})]\}}, \tag{21}$$

where $\beta^* = \frac{\beta(1+g)^2}{a\eta^2}$. The weight depends on the difference between two coefficients of the two types of beliefs, deviation from the fundamental level and the difference from last period in deviations (Boswijk et al., 2007). And β^* is the only factor to decide the slope of weight of strategy h.

In addition, this dissertation compares the single strategy model to the two strategies model, thus we could estimate whether a combined two strategies into one strategy outperforms the simple strategy model over time. Moreover, we will forecast the price changes from 1982 to 2008 based on our estimations of 1882-1982 as the extension of this paper.

4. Data and results

4.1 Data and summary statistics

In this section, we work through the two type heterogeneous investor type in the nonlinear regression model and the single type strategy in the linear regression model. The data we use in this dissertation consists of monthly observations of the ASX 200 from 1882 to 2008 where we obtain these data from the global financial data. Figure 1 is the plot of total return over time and it suggests that the plot is not significantly clear to tell its movement over time. However, we can see from Figure 1 that the return begins increasing from the 1960s and then drops suddenly from the 2000s.

Figure 1 Plot of stock prices over time
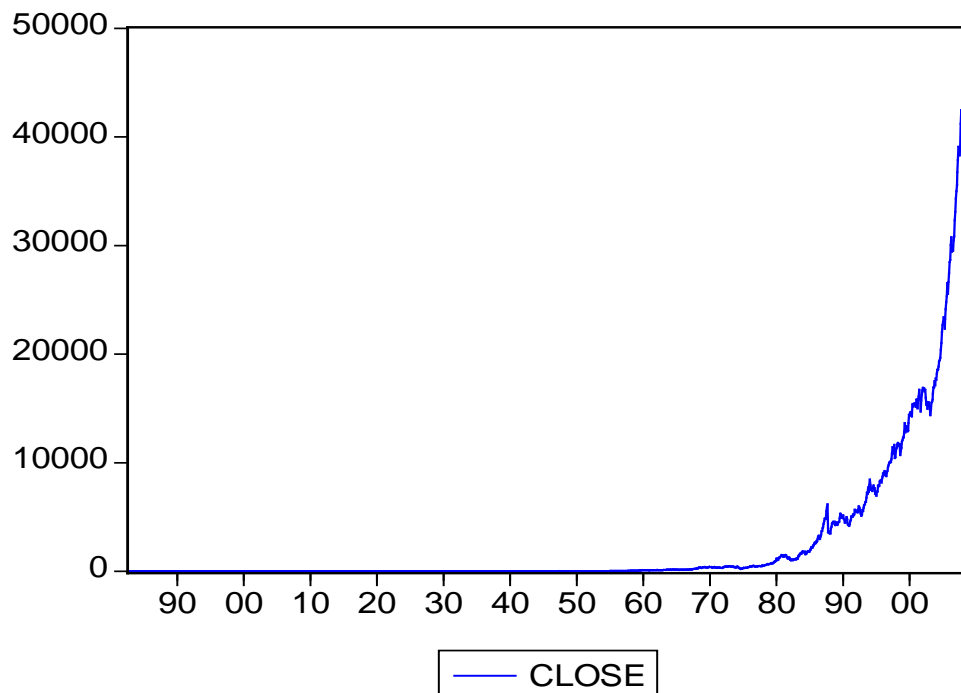
This dissertation considers that the dividend is the only source of cash flow in Australian stock market. Therefore, the valuation ratio in this dissertation is a price to dividends ratio. We have transformed formulae to the deviations from fundamental value. In the other words, if we could

be able to estimate the fundamental values, we are then able to estimate the whole model. Once we put all the figures back into the model, we could obtain the findings to see which strategy most investors are likely to put their money into by betting on the particular strategy at different time spots.

As we discussed earlier in the previous section, Boswijk et al. (2007) define the fundamental price by using the static Gordon growth model which is equivalent to the present value model with constant growth rate g and discount rate r, that is

$$P_t^* = \frac{1+g}{r-g},$$
(22)

where $m = \frac{1+g}{r-g}$ and P_t^* represents the fundamental price of the risky asset. Gordon (1962) assumes that fundamental price of risky asset is likely to depend on m multiply by cash flow whereas m depends on the constant growth rate and the discount rate.

R* in Eq. (20) is provided as $R^* = \frac{1+r}{1+g}$ by Boswijk et al. (2007) and this dissertation uses the risk premium, the difference between the expected market return and the risk-free interest rate. The discount rate, r is the risk-free interest rate plus the risk premium. Fama and French (2002) use the Gordon model with a constant growth rate to measure the magnitude of the equity premium on the same dataset used in our dissertation. The return could be rewritten as below

$$\frac{P_t + Y_t - P_{t-1}}{P_{t-1}} = \frac{P_t - P_{t-1}}{P_{t-1}} + \frac{Y_t}{P_{t-1}},$$
(23)

where $\frac{P_t - P_{t-1}}{P_{t-1}}$ is the rate of the capital gain and $\frac{Y_t}{P_{t-1}}$ is the cash flow yield. Because the growth

rate g in the Gordon model is constant and it is the same as the rate of the capital gain (Boswijk

et al., 2007). The equation could then be written as

$$RP = g + \frac{Y}{P} - i \text{ and } \frac{Y}{P} \text{ is the average cash flow yield of } \frac{Y_t}{P_{t-1}}, \qquad (24)$$

where i is the risk-free interest rate and the Australian government 10-year bond yield is used

as the risk free interest rate in this dissertation. The data is summarised and is in annualised

percentages in Table 1.

Table 1 Summary of data

	Y/P	g	r	R*	RP	m	i
1882-1930	0.0722	0.00989	0.0821	1.0715	0.0388	13.9893	0.0433
1931-1982	0.0613	0.00958	0.0709	1.0607	0.0152	16.4759	0.0557
1983-2008	0.0404	0.0109	0.0513	1.04	-0.0377	25.0191	0.0890

Y/P is the average dividend yield of Y_t/P_{t-1}, g is the average growth rate, r is the average

discount rate, y/p + g, R* is the gross rate of return $(1+r)/(1+g)$, RP is the risk premium, g +

Y/P - i, m is the constant price to cash flow ratio in the Gordon model, $(1+g)/(r-g)$, and i is the

Australian 10-year bond yield. Van Munster (2009) states that the average ASX 200 dividend

yields are around 4%-5% which exclude the franking credit. A franking credit is a nominal unit

of tax paid by companies paying tax in countries that have a dividend imputation system. Two

of three dividend yields in Table 1 are out of the range because the dividend yields in this

dissertation include the franking credit that are normally higher than the yields exclude the

franking credit.

The diagram of the ASX 200 price and the fundamental price is not clear to illustrate its trend over time, thus we use log ASX 200 price and log fundamental price. The graph of the log ASX 200 price and the log fundamental price has good property in that they can be interpreted as continuously compounded prices. We have done unit root test on the stock price in ASX 200 for stationarity, the null hypothesis in the unit root test is that price has a unit root. The outcome of the unit root test shows that the probability is 0.4720 which is considered too big at the 5% confidence level and thus there is no evidence to reject the null hypothesis, and it means that the stock price is non-stationary. This issue could be explained by the investors in the stock market being uncertain of future payoffs for a risky asset. To make the stock price stationary, we have to take account of the cash flow, which is the dividend in the stock market the reason is that investors in the market are certain of future cash flows. Therefore, this dissertation uses price to cash flow ratios.

Figure 2 Plot of the log of the stock price and of the fundamental value
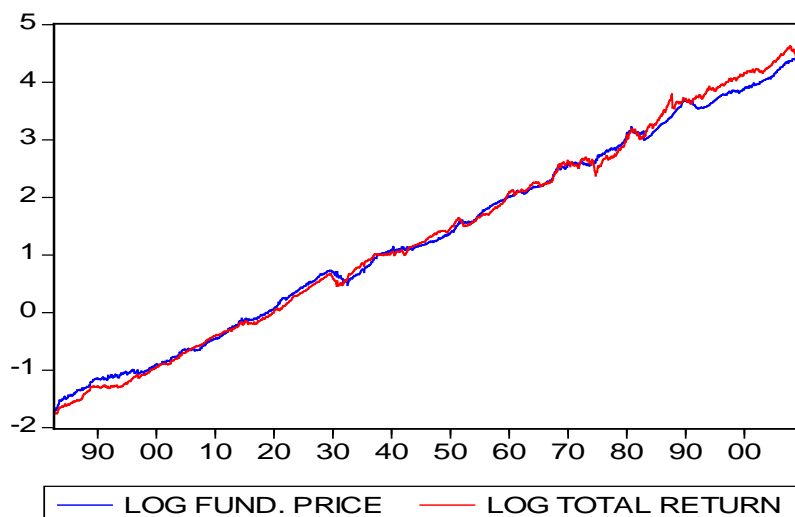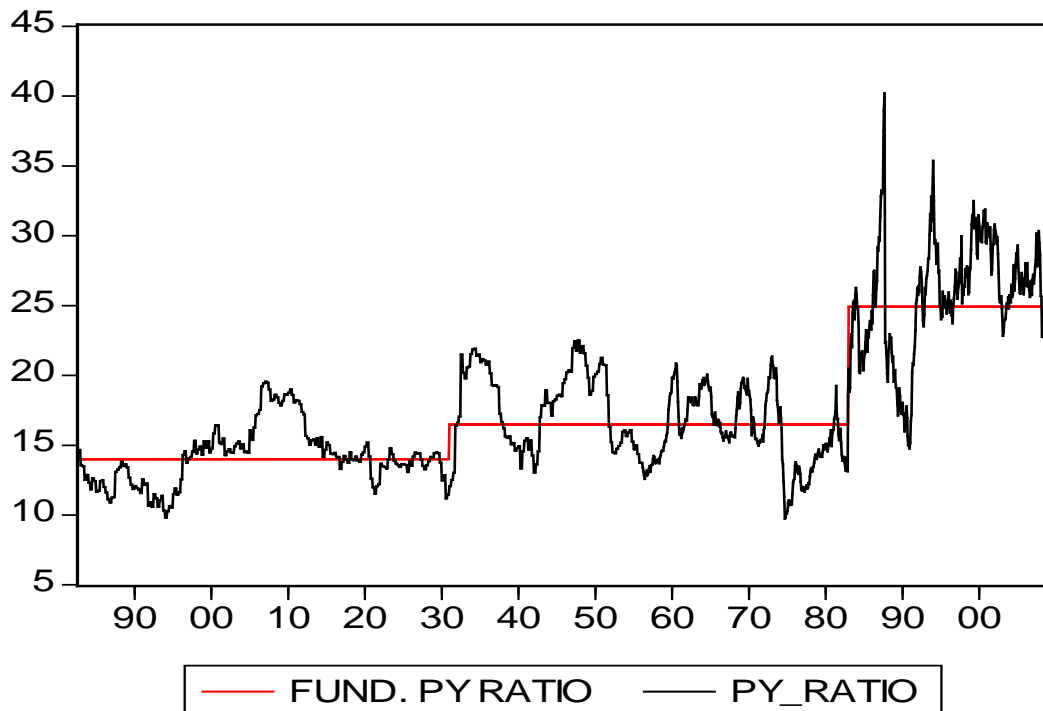

Figure 2 suggests that there is a clear long term movement. The plot of the log of the ASX 200 stock price and the fundamental price might tell us that the deviations between the ASX 200

stock price and the fundamental price level are not very significant except from the period in the 1970s.

Figure 3 The fundamental and realised price to cash flow ratio

From the plot of dividend yield ratio (Figure 3), there are few significant decreases in its value in 1930 and 1975. Therefore, we should recalculate the equity premiums into three time periods; an estimate of 3.88% in the period 1882-1930, an estimate of 1.52% in 1931-1982, and an estimate of -3.32% in the period 1972-2008. The only possible explanation for this decreasing equity premium over time might be the steady decline in the number of companies that pay out dividends instead of other alternatives (Fama and French, 2002). In addition, the price to dividend yield ratio swings persistently from the fundamental value. This movement could suggest that the dynamic of stock prices is not fully taken into account by the fundamental value (Boswijk et al., 2007). Here, we have used a unit root test to test our price to cash flow ratio in order to see whether the price to cash flow ratio is stationary. Based on the

outcome of the unit root test, it suggests that the null hypothesis should be rejected because the probability is 0.0257 which is sufficient to prove that the price to cash flow ratio is stationary at the 5% confidence level.

4.2 Model results

4.2.1 Estimation

To estimate three parameters $(\emptyset_1, \emptyset_2, \beta^*)$ of the equation (20) and (21), we firstly collect the monthly data of the ASX 200 index from 1882-2008 from the global financial data and then put them into the nonlinear regression model. We have also calculated the values of the deviations from the fundamental ratio in the different time periods which are x_t, x_{t-1}, x_{t-2}, and x_{t-3}. Table 1 shows that the value of R^* in the three periods which are 1.0715 for 1882-1930, 1.0607 for 1931-1982, and 1.04 for 1983-2008 so we could use the three corresponding values of R^* to value $R^* x_t$ and $R^* x_{t-2}$ in the equation (20) and (21). We obtain the R^2 of the regression, the value of akaike info criterion, the value of AIC in the linear model and the coefficient value of AIC in the linear regression model. The estimated results are as follows:

Table 2 Values of coefficients and statistical figures

	β^*	$\emptyset_1$	$\emptyset_2$	$\emptyset_1 - \emptyset_2$	R^2	AIC	$AIC_{AR(1)}$	$\emptyset_{AR(1)}$
Coefficient	-2.7017	1.0797	0.9473	0.1324	0.9239	2.5638	2.5725	1.0167
Standard error	3.1171	0.0064	0.0103	0.0553				

The coefficients $\emptyset_1$ and $\emptyset_2$ are statistically significant and different from each other at the 5% confidencae level because their p-values are both zero. The intensity of β^* is not strongly significant due to its p-value is 0.3862. Boswijk et al. (2007) have explained that it is common

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to see this outcome in the switching-type model and it also has large standard deviation because large changes in β^* cause only small variation of the fraction in Eq. (21) as shown in their paper.

As discussed earlier, if the value of $\emptyset_h$ is positive and smaller than 1 it suggests that investors expect the stock price to revert back to the fundamental value. This type of the investors is referred as fundamentalist because they expect the stock price to move back to the fundamental price level. If the $\emptyset_h$ is larger than 1, it implies that investors believe the deviation of the stock price will grow over time at a constant speed. We will refer to this type of investors as chartists. The estimation of the first coefficient in the equation (20) is 1.0797 which is greater than 1 which implies that the first regime is regarded as chartists because of the belief that the stock price constantly grows over time. Furthermore, if the value of the first estimated coefficient is greater than R^* in our results thus the asset prices will not move further away from the fundamental value.

The second estimated coefficient in the equation (20) is 0.9473 which is smaller than 1 and in this case we regard this type of investors as fundamentalist, with a strong belief that the stock price will reverse to the fundamental value. R^2 in our model is close to 1, which means the regression of our model fits almost perfectly. The value of AIC in our model is smaller than that of $AIC_{AR(1)}$, which is a linear regression model. This suggests that our model collects nonlinear data. We also run the wald test to confirm that there are two different beliefs of investors in the stock market. The result of the wald test is in Table 2.

The result of the wald test suggests that there are two different beliefs of investors in the stock market because of a significant probability value at a 5% confidence level.

4.2.2 Switching between two strategies

When the fraction of investors strongly believing in our model is close or equal to 1, that means most or all of investors in the market have the same beliefs, so the behaviour is extreme in price to cash flow ratio (Boswijk et al., 2007). In addition, because we only consider two types of investors in the stock market, we could expect investors in the stock market to switch between the fundamentalists and the chartists. If investors think the deviations from the fundamental value is a temporary issue, they would expect them to reverse to their fundamental value soon or in a short period. In other cases, if a sudden and rapid change of the stock price is not in parallel with the fundamental value, it might cause the fundamentalists to lose their returns and the chartists could gain some profits in this situation. Therefore, more fundamentals would change to chartists, which would cause the trend in prices to change again.

As discussed earlier, the investors in the stock market will switch their investment strategies between the fundamentalist and the chartist based on which strategy is making profits for the investors. Fig. 4 shows the time series of the changes of the fraction of the fundamentalists in a plot.

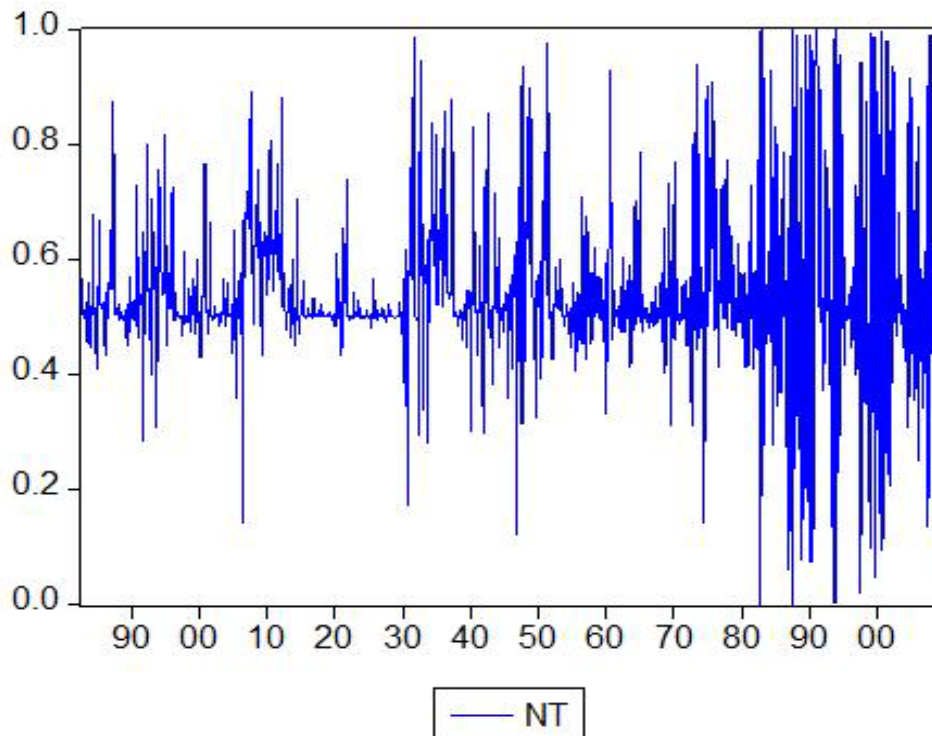**Figure 4 Time series of the fraction of the investors' population using trend-following belief, n_t**

Figure 4 is the plot of the changes in fraction of the chartists, which suggests that the investors in the Australian stock market switch their strategies frequently because of the scatter plot fluctuating over time. Switching their strategies has been more obvious and frequent from the late 1980s. In the 1980s, as the economic liberalisation increased in the developed world, multiple multinational corporations associated with the manufacturing industry relocated to South East Asian countries. Developing countries across the world faced increasing economic and social difficulties as they suffered from multiple debt crises in the 1980s, requiring many of these countries to apply for financial assistance from the International Monetary Fund (IMF) and the World Bank.

In the 1990s, personal incomes doubled from their levels during the recession in 1990 and there was higher productivity overall. However, there was an Asian financial crisis in July 1997,

which began with the floating of the Thai baht. The large and adverse economic shocks triggered by the Asian financial crisis could potentially have had a devastating effect on the Asian economy. Moreover, in the 2000s, the American economy had a recession from 2001 to 2002, following the 911 terrorists' attacks and the economy bounced back in 2003. According to the above events, the frequent switching between the two strategies from the late 1980s in our model could be well explained.

Figure 5 is the plot of the fraction of the chartists versus the difference in profits of the two strategies. We also find that the only factor that could change the slope of the plot is β^*. If the slope is steeper, in which β^* is large, it means the investors in the stock market would react quickly, corresponding to the new information arrivals or the profits changes. In figure 5, the plot is quite steep so this means that the fraction of the chatists would change significantly even if there is a small change in the realised profits.

Figure 5 The Scatter plot of n_t versus the difference in realised profits
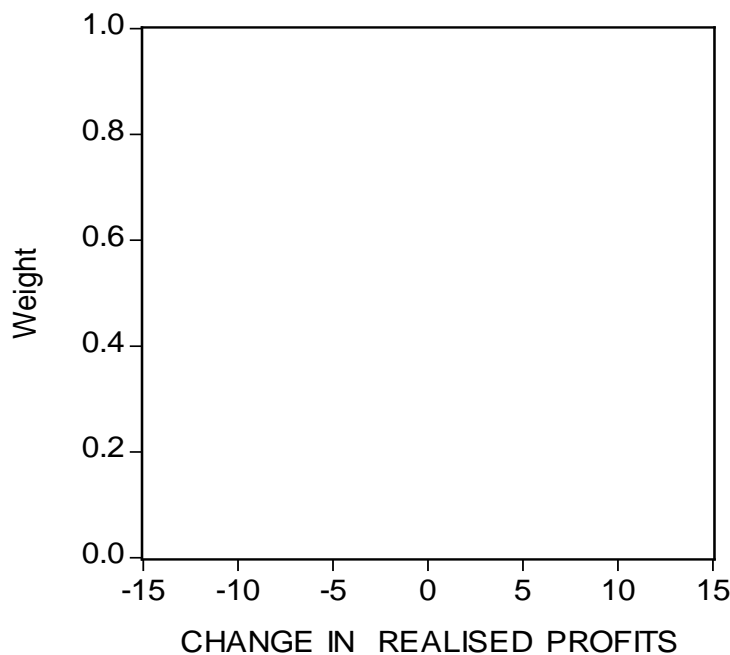
Figure 6 shows the time series of the average market sentiment at date t which is given by

$$\emptyset_t = \frac{n_t \emptyset_1 + (1-n_t)\emptyset_2}{R^*}.$$ (25)

Figure 7 clearly shows that the fraction of fundamentalists varies considerably over time. Figure 7 also offers an explanation for the late 1970s which is that before 1930 almost all investors in the market extrapolated aggressively believing the stock prices would revert back towards the fundamentals; this situation persisted until 1978 when the market changed direction and more investors in the market used the trend following belief. As we can see from Figure 7 the average market sentiment $\emptyset_t$ was larger than 1 for a number of years which drove stock prices further away from their fundamentals.

Figure 6 The time series of the average market sentiment at date t
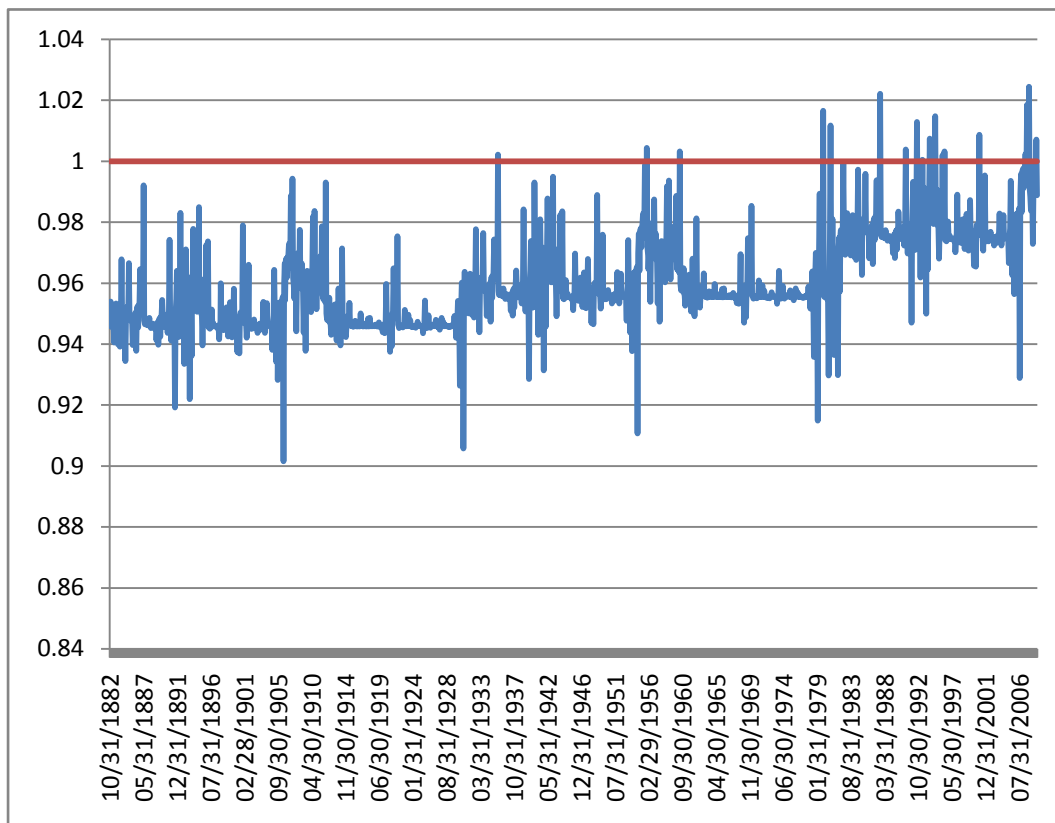
4.3 Robustness

This section summarises the data in Table 3 with the same fundamental price to cash flow ratios from 1882 to 2008.

Table 3 Summary of data

	Y/P	g	r	R*	RP	m	i
1882-1945	0.0690	0.0050	0.0784	1.0683	0.0363	14.6397	0.0422
1946-2008	0.0533	0.0104	0.0638	1.0528	-0.0098	18.9551	0.0735

Figure 7 The fundamental and realised price to cash flow ratio
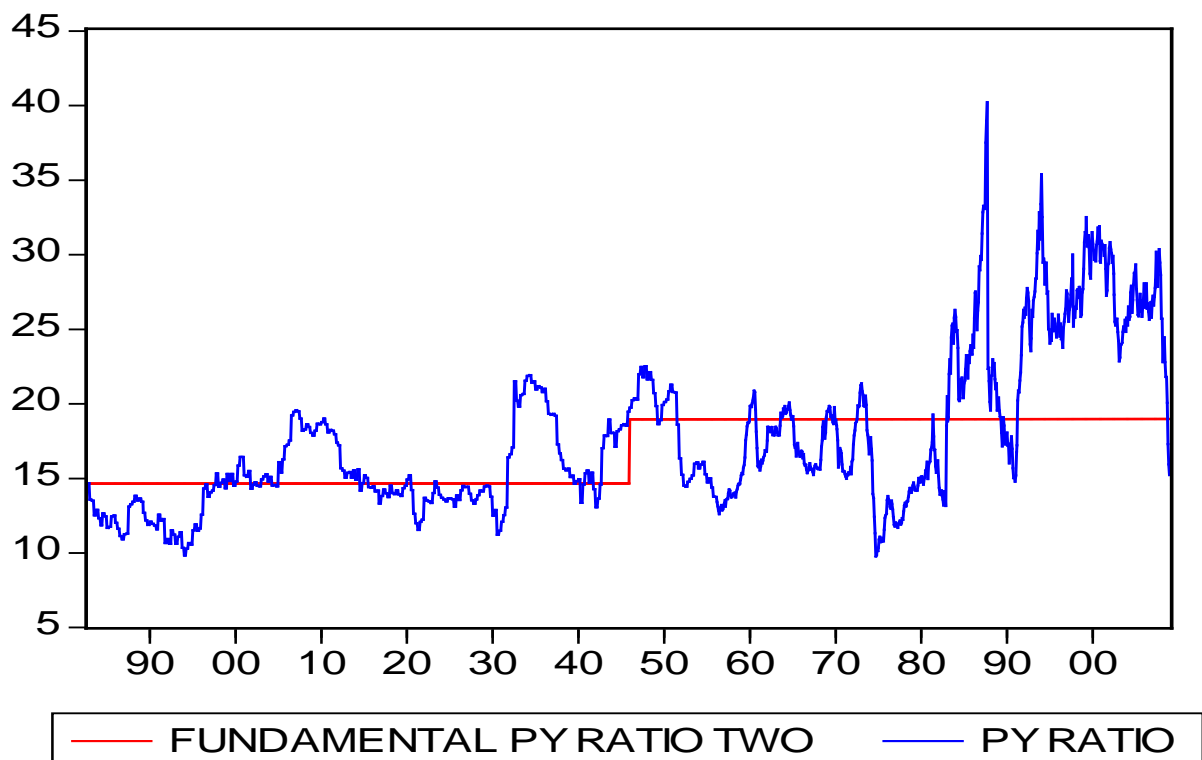
We assume that there are two fundamental price to cash flow ratios from 1882 to 2008 shown in Figure 7 by splitting the time period into two. Therefore, we have two equity premiums over

time; an estimate of 3.63% in the period 1882-1945 and an estimate of -0.98% in the period 1946-2008.

To estimate three parameters $(\emptyset_1, \emptyset_2, \beta^*)$ of the equation (20) and (21), we still use the monthly data of the ASX 200 index from 1882-2008 from the global financial data and apply them into the nonlinear regression model. We also have deviations from the fundamental ratios in the different time periods which are X_t, X_{t-1}, X_{t-2}, and X_{t-3}. Table 3 shows that the values of R^* in 1882-1945 and 1946-2008 are 1.0683 and 1.0528 so we could use these values to value $R^* x_t$ one and $R^* x_{t-1}$ in the equations (20) and (21). We therefore then have R^2 of the regression, the value of Akaike info criterion, the value of AIC in the linear model and the value of AIC in the linear model and the coefficient value of AIC in the linear regression model. The estimated results are as follows:

Table 4 Values of coefficients and statistical figures

	β^*	$\emptyset_1$	$\emptyset_2$	$\emptyset_1 - \emptyset_2$	R^2	AIC	$AIC_{AR(1)}$	$\emptyset_{AR(1)}$
Coefficient	-17.2226	1.0638	0.9990	0.0648	0.9664	2.5509	2.5659	1.0382
Standard error	15.6444	0.0081	0.0091	0.0138				

The coefficients $\emptyset_1$ and $\emptyset_2$ are statistically significant and different from each other at the 5% confidence level because again their p-values are both zero. The intensity of β^* is not strongly significant because its p-value is 0.2711. As discuessed earlier, if the value of $\emptyset_h$ is positive and smaller than 1 it suggests that investors expect the stock price to return to the fundamental value. And if $\emptyset_h$ is large than 1, it implies that investors believe the deviation of the stock price will grow over time at a constant speed. The estimation of the first coefficient in the equation

(20) is 1.0638 and the estimation of the second coefficient is 0.9990 which suggest that the first one is chartist and the second one is fundamentalist.

We then take the wald test to see whether the first coefficient is the same as the second coefficient. The result of the wald test is shown in Table 4. The wald test suggests that there are no different beliefs of the investors in the stock market when there are two fundamental price to cash flow ration from 1882 to 2008 because of an insignificant probability value ar a 5% confidence level. And this result contradicts to the estimated coefficients that are shown in Table 4. This result confirms that if there are two fundamental price to cash flow ratios, our assumption in this dissertation will be invalid as the two tests show the different results eventually. Since we know that the result of two fundamental price to cash flow ratios over time are invalid to our assumption, we are then able to test if there is only one fundamental price to cash flow ratio in the stock market over time.

This section also summarises the data in Table 5 with the same fundamental price to cash flow ratio from 1882 to 2008.

Table 5 Summary of data

	Y/P	g	r	R*	RP	m	i
1882-2008	0.0611	0.01	0.0711	1.0605	0.0133	16.5185	0 .0578

Figure 8 The fundamental and realised price to cash flow ratio
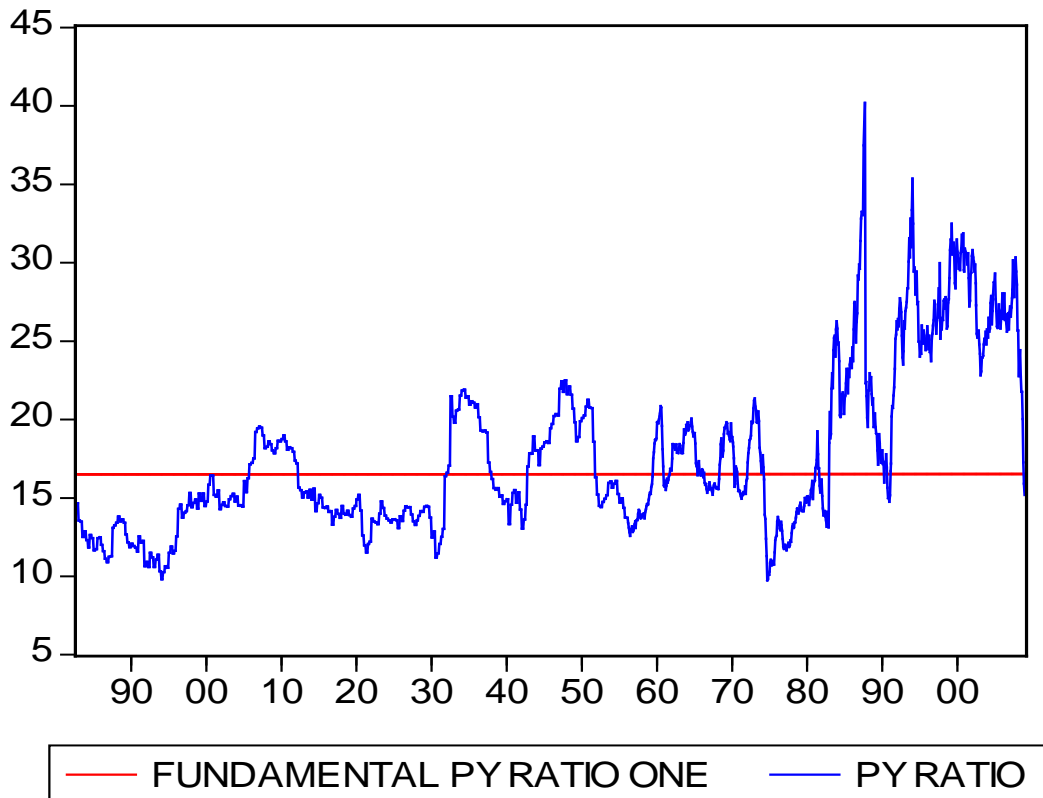
We assume that there is only one fundamental price to cash flow ratio from 1882 to 2008 shown in Figure 8, no matter whether there are few significant changes over time. Therefore, we have only one equity premium over time; an estimate of 1.33% in the period 1882-2008.

Again, we do the estimation of three parameters in the equation (20) and (21) as above. Table 5 shows that the value of R^* in 1882-2008 is 1.0605 so we could use this value to value $R^* x_t$ one and $R^* x_{t-1}$ in the equations (20) and (21). We therefore then have R^2 of the regression, the value of Akaike info criterion, the value of AIC in the linear model and the value of AIC in the linear model and the coefficient value of AIC in the linear regression model. The estimated results are as follows:

Table 6 Values of coefficients and statistical figures

	β^*	$\emptyset_1$	$\emptyset_2$	$\emptyset_1 - \emptyset_2$	R^2	AIC	$\text{AIC}_{AR(1)}$	$\emptyset_{AR(1)}$
Coefficient	-2.6347	1.0641	1.0253	0.0387	0.9748	2.5624	2.5611	1.0476
Standard error	6.5128	0.0179	0.0192	0.0361				

The coefficients $\emptyset_1$ and $\emptyset_2$ are statistically significant and different from each other at the 5% confidence level because again their p-values are both zero. The intensity of β^* is not strongly significant because its p-value is 0.6859. The estimation of the first coefficient in the equation (20) is 1.0641 and the estimation of the second coefficient is 1.0253 which suggest that both are chartists because of their belief that the stock price constantly grows over time. This result seems abnormal because we assume that there are two types of investors in the stock market in our dissertation.

We then take the wald test to see whether the first coefficient is the same as the second coefficient. The result of the wald test is displayed in Table 6. The wald test suggests that there are no different beliefs of the investors in the stock market when there is only one fundamental price to cash flow ratio from 1882 to 2008 because of an insignificant probability value at a 5% confidence level. This result also confirms that if there is the only one fundamental price to cash flow ratio, our assumption in this dissertation will be invalid as the fundamental price to cash flow ratio has to vary based on the market fluctuation. Since we know that the result of only one fundamental price to cash flow ratio over time is invalid to our assumption, we then have to focus on only the fundamental price to cash flow ratio which varies based on the market fluctuations.

4.4 Forecasting model

The focus of this dissertation is on the forecasting accuracy of monthly stock market prices by using the ASX 200 data from 1882 to 1982 to estimate the forecasting model. This dissertation uses both the root mean square error (also known as RMSE) and the mean absolute error (also known as MSE). They are commonly used measures of the differences between values predicted by a model and the values actually observed from the thing being estimated. RMSE is the most useful when large errors are particularly undesirable and MSE measures accuracy for continuous variables. The equations of RMSE and MAE are given by

$$RMSE = \sqrt{\frac{1}{n}\sum[F(R^*x_t) - R^*x_t)^2} \text{ , and} \tag{26}$$

$$MAE = \frac{1}{n}\sum|F(R^*x_t) - R^*x_t| \text{ ,} \tag{27}$$

where $F(\circ)$ is the forecasted estimator. The RMSE is a quadratic scoring rule which measures the average magnitude of the error. The difference between forecast and corresponding observed values are each squared and then averaged over the sample. Since the errors are squared before they are averaged, the RMSE gives a relatively high weight of large errors. In contrast, the MAE is a linear score, which means that all the individual differences are weighted equally in the average. There are other measures of the forecasting performance, such as, the mean squared error (MSE) but in our dissertation we mainly use RMSE and MAE to estimate the forecasting performance of our model. The estimations of nonlinear and linear models are in Table 7.

Table 7 Summary of data

	β^*	$\emptyset_1$	$\emptyset_2$	$\emptyset_1 - \emptyset_2$	$\emptyset_{AR(1)}$
Coefficient	-1.4072	1.1457	0.8932	0.2525	1.0251
Standard error	1.1294	0.0408	0.0337	0.0727	

We have the values of RMSE for our nonlinear and linear models in Table 8, which are 8.6172 and 7.8751, respectively. To see whether our forecasting model works, we have to compare the value of RMSE for the nonlinear model to the value of RMSE for the linear model. If the value of RMSE for the nonlinear model is smaller than that for the linear model then it means that our forecasting model works in our dissertation because the value of RMSE being closer to zero is better. As discussed earlier, the value of RMSE for the nonlinear model is 8.6172 and the value of RMSE for the linear model is 7.8751. We know that our forecasting model does not work because the value of RMSE for the nonlinear is larger than that for the linear model.

We also have values of MAE for our nonlinear and linear models in Table 8 which are 0.8575 and 0.4956. Again, we have to compare the MAE of the nonlinear model with that of the linear. We have the MAE of the nonlinear model which is larger than that of the linear as the value of MAE being closer to zero is better. Therefore, it proves that our forecasting model does not work. In the other words, our forecasting model is not an appropriate measure to predict future stock price trends in the Australian stock martket. However, the outcomes are not surprising because Meade (2002) and Brailsford and Faff (1996) provide evidence that the simple regression model is superior for forecasting stock prices, or there is no evidence found that a non linear generating process is better than a linear model.

Table 8 Summary of RMSE and MSE for nonlinear and linear

	RMSE nonlinear	RMSE linear	MAE nonlinear	MAE linear
Value	8.6172	7.8751	0.8575	0.4956

5. Conclusion

Investors believe that the stock price will drive back to its fundamental level in the long term, but they interpret the persistence of the deviation of stock prices from their fundamentals in a different way. Shiller (2000) says that if a recent increase in stock prices is observed, investors tend to consider that the mispricing will increase even further and put more money to the trend following belief. In contast, investors believe that the deviation is in trasition and will revert back to its fundamentals in periods of gradual price changes. We have used an asset pricing model with heterogeneous behaviour. We assume that there are two strategies that investors in the stock market could switch between according to their relative past performances and estimate the model on monthly ASX 200 data from 1882 to 2008.

The unit root test suggests to us that the stock price is non-stationary as its p-value is larger than 5% and the price to cash flow ratio is stationary as its p-value is smaller than 5% therefore, we decided to replace the stock prices by using the price to cash flow ratios in the model. Our estimation results show statistically significant behavioural heterogeneity and substantial time variation in the average sentiment of investors if we assume that there are three different equity premium over time. And if we assume that there is only one or two equity premiums over time, the estimation results show the assumption is invalid, because the estimation shows that there is a single type of investor in the market which contradicts our main purpose in this dissertation or both tests contradict each other.

The estimation of our model suggests that more investors had trend following beliefs about the persistence of the deviations from the fundamentals in the late 1970s. It is clearly to be explained that the investors neglected the role of fundamental news and continued to trade stocks for purely speculative reasons. The outcome of our model is consistent with the view that fundamentalists with mean-reverting expectations had limited capital to arbitrage the mispricing away and force stock prices back to its fundamentals. This dissertation estimates a forecasted model by using the ASX 200 data from 1882 to 1982 and it considers the RMSE and the MAE as two measures to forecast the stock market by looking at the difference between forecasted and actual values. The outcomes of both measures show that our forecasted model does not work in ASX 200 because the values of nonlinear RMSE and MAE are larger than that of linear RMSE and MAE as the values closer to zero are better. However, this is not surprising as recent papers have the evidence to support this situation.

Investors might be unable to use the forecasting model to predict future stock prices in order to make profits. However, some other forecasting models may be available within some sectors in the Australian stock market.

An important topic for future research is to apply the same model to the Australian foreign exchange market and futures market, to test whether a heterogeneous agent model outperforms a representative agent model in both markets and to test whether our forecasted model is valid in those markets to forecast future exchange rates and futures prices or test more types of behaviours in the market.

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