**School of Economics and Finance**

# Testing International Arbitrage: Evidence from Chinese and Australian Markets

**Santosh M Abraham**

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Doctor of Philosophy
of
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## Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any person except where due acknowledgement has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

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## Recent Publications

The following publications were taken verbatim from the text of this dissertation. They were submitted and approved to be published prior to the completion of the dissertation:

Abraham, S.M. 2014. "Testing International Momentum Strategies between Chinese and Australian Financial Markets". *International Journal of Financial Research,* 5, 1, Forthcoming January 2014.[1]

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Abraham, S.M. 2013b. "Testing for Over-reaction and Under-reaction in Chinese Shanghai Composite Index Constituent Stocks and Australian Resource Stocks'. *International Journal of Economics and Finance*, 5, 10: 51-57.[3]

In addition, the following paper based on the contrarian parts of the thesis was presented at the 26th Australasian Finance and Banking Conference:

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[1] This recent publication by the writer is based on this dissertation's pages: 17; 46; 49-52; 119; 127; 137; 148-149.
[2] This recent publication by the writer is based on this dissertation's pages: 49-52; 86-94; 107; 116; 118; 121-123; 125; 127; 133; 144-146.
[3] This recent publication by the writer is based on this dissertation's pages: 38-42; 137-138.

## List of Tables

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# List of Acronyms

| | |
|---|---|
| **CAPM** | Capital asset pricing model |
| **CSC** | Chinese Shanghai Composite Index |
| **DFP** | Davidson-Fletcher-Powell |
| **EMA** | EM Algorithm |
| **EMH** | Efficient market hypothesis |
| **LOP** | Law of One Price |
| **MAM** | ASX 200 Metals and Mining Index |
| **MPT** | Modern portfolio theory |
| **PAM** | Partial Adjustment Model |

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Santosh Mon Abraham

# ABSTRACT

International arbitrage opportunities between Australia and China are studied. This is important because it allows investors to make abnormal profits and increase their diversification. The aim of the dissertation is to study international arbitrage opportunities between Australia and China and not a single economic event between both countries. A common 'event study' does not prove economic interconnectedness between Australia and China over a period of time. A time series analysis over a period of time provides evidence of sustained interconnectedness over the time period. This dissertation studies international arbitrage. In a perfectly efficient market there would be no opportunities for arbitrage. The fact that there are arbitrage opportunities between Australian stocks and Chinese stocks (matched into pairs) show that both markets are inefficient and economically linked.

The study did not consider structural breaks, so a significant event such as the global financial crisis is already included in the analysis. The motivation of the study is not to consider specific economic events common to both countries, but to consider opportunities for statistical arbitrage. Whilst it has been proposed that such opportunities arise because of trade linkages between the countries, which result in a log-run equilibrium relationship between Australian and Chinese stocks, these economic links are not the focus of the study.

If the stock markets are inefficient in the short-run, then these inefficiencies can be exploited through international arbitrage opportunities. The models used to test for arbitrage are the LOP, Markov, index tracking and enhanced indexing. This study provides improved models and methodology to effectively analyse international arbitrage opportunities utilising the evidence in stock market data from China and Australia. The study also develops a framework to hedge the China Shanghai Composite Index (CSC) and a portfolio of Australian resource stocks for the purpose of eliminating systematic risk. The two countries selected for this study are topical in light of their strongly growing economic and trade relationships. China has become Australia's major trading partner with this relationship dominated by Australia's exports of mining products to China. China's economy continues to grow strongly at in excess of almost 7.5%. At some stage during the next fifteen years, it is expected to become the World's largest economy.In2040, the Chinese economy will reach $123 trillion. China's share of global GDP will be 40 percent.

The theoretical basis of the thesis is that in the long-term rational expectations may be proven, indicating long-term equilibrium relationships and market efficiency. However, in the short-term arbitrage opportunities exist where differing stochastic trends are identified. Such trends indicate a lack of short-term efficiency and, therefore, the opportunity to generate abnormal returns. The study examines and compares share price and sectoral share price indices, and in doing so, the study effectively investigates hypothetical, yet fully diversified share portfolios in its analysis of investor arbitrage opportunities. This thesis demonstrates that future universal application of these strategies for investors, speculators and business people in the generation of abnormal returns in internationally diversified share portfolios and hedging international portfolio risks is feasible on the basis that there is a strong economic relationship between the pairs of countries selected.

The thesis consists of three parts. The first part, presents the Partial Adjustments Model which tests for market efficiency using the speed of adjustment. The second part considers two contrarian strategies; a Law of One Price (LOP) strategy and a Markov switching strategy. Part three concerns two momentum strategies; an index tracking strategy and an enhanced indexing strategy. This is a hypothetical study; in reality foreigners are currently prohibited from buying most stocks in China. However, Chinese traders are generally free to implement the trading strategies outlined in this thesis as they are subject to little or no restrictions.

Whilst even the most developed market are not efficient and do have anomalies, this dissertation employs a new methodology. It is accepted that international arbitrage opportunities are available in most developed markets and investment banks make significant profits through algorithmic trading due to prevalent international arbitrage opportunities. The uniqueness of the dissertation lie in new ways of studying the phenomenon, including a new innovation in the PAM and in addition collective opportunities of arbitrage between Australia and China is enhanced. Therefore, the uniqueness of the study lies in a new derivation of the PAM; a new LOP strategy, and a new Australian and Chinese dataset.

If international markets are inefficient, then there may be international arbitrage opportunities. This study seeks to answer the question of whether the Australian and Chinese markets are efficient. It does this by using a partial adjustments model to calculate the speed of adjustments of the top 33 Australian resources stocks and the top 33 China Shanghai Composite Index (CSC) and constituent stocks. The reason why these stocks were chosen was to allow meaningful comparison of stocks. For instance, the CSC has far more constituent stocks than the MAM. In order to find CSC/MAM pairs that were cointegrated or had regime switching characteristics, in the time period for all constituents would be time consuming. Also, it is thought that stocks with similar market capitalisation rankings in their respective indices may share other common characteristics.

Stocks with the highest capitalization are chosen because they are considered less volatile than small stocks. The MAM index is quite thin, therefore the largest 33 stocks by market capitalization include small cap stocks. Also, it is thought that stocks with similar market capitalisation rankings in their respective indices may share other common characteristics. Stocks with the highest capitalization are chosen because they are considered less volatile than small stocks.

A new formulation of the Partial Adjustments Model has been used which transforms the Nerlove (1958) model by incorporating the Single Index Model. Within efficient markets, stock prices are expected to adjust quickly to economic news, which will be captured by the speed of adjustment. Using 10 years of daily data from the Australian and Chinese financial markets, it was found that Australian resource stocks and CSC stocks were not weak-form efficient. This has implications for predicting the successful implementation of contrarian and momentum strategies.

Based on this model (the speed of adjustment), and on the behaviour of noise traders and institutional traders in small-cap and large-cap stocks respectively, the author develops a new theory of pairs trading, which is a contrarian trading strategy. Two contrarian strategies are tested; one based on the Purchasing Price Parity Stage Three Trivariate Co-integration test model which the author calls the LOP strategy and one using a Markov switching methodology. These are statistical arbitrage strategies. The author tests two other statistical arbitrage strategies comprising of two momentum strategies; an index tracking strategy and an enhanced indexing strategy. The LOP and the index tracking and enhanced indexing strategies used the cointegration methodology. Ten years of weekly data from Australian and Chinese financial markets was used.

The LOP strategy and the Markov strategy had mixed profitability. Stocks with slower speed of adjustments were more profitable than faster stocks. Small-cap stocks were more profitable than large-cap stocks. The index tracking and enhanced indexing strategies were both profitable. These results are to be expected in markets that are not weak-form efficient.

Hedge funds, Chinese and Australian investors and mining companies can use the long-short market neutral index tracking and enhanced indexing strategies to hedge in the direction of exchange rate risk. Future research will identify other arbitrage and hedging opportunities between other countries in other stock market sectors. The results in this study show that there are benefits from international diversification and active management. Also, the CSC index was able to be replicated by a bundle of Australian resource stocks. That being the case, the subsequent portfolio has diversified away its' idiosyncratic risk, leaving only systematic risk, which, in turn, has been eliminated through the implementation of a long-short equity hedge.

The cointegration results reveal that the Australian and Chinese markets are internationally efficient in the long-run, but inefficient in the short-run, leading to arbitrage opportunities. What is good for arbitragers is bad for policy makers and regulators who hope for efficient markets, especially if the mis-pricing comes from misinformation or market manipulation, or if markets are too volatile. It is often thought that if stocks are followed by analysts their prices will be close to fundamentals, thus explaining the relative efficiencies of large-cap stocks and the relative inefficiencies of small-cap stocks. There needs to be better dissemination of economic firm-specific news in small-cap stocks, as well as more financial education for noise traders, so that they may behave more rationally.

The Single Index model is more suitable for solving the PAM than multi-factor models. This is because a multi-factor model introduces too many terms in the PAM, whilst the single index model transforms to a first order autoregressive model which can be solved simply. Thus far, there have been no multi-factor models included in any PAM that the author is aware of. It is agreed that the single index model as well as the multi-factor problem suffer from the joint hypothesis problem (as does every asset pricing model). In this instance the problem is corrected with the use of the single index model used to calculate the speed of adjustment characteristics of Australian and Chinese stocks and not as a mechanism for asset pricing.

This thesis, as well as providing feasible strategies for arbitrageurs and hedgers, also recommends that Governments should act to reduce frictions and barriers to financial integration between strongly trading countries such as, China and Australia. This would allow both these countries to benefit economically from the growing relationship.

# CHAPTER ONE

# INTRODUCTION

The Efficient market hypothesis (EMH) model is essential for the theoretical base of this dissertation. It has a long history, but is greatly influenced by the work of Fama (1970); who stated that a market is efficient if stock prices incorporate all information. The Behaviourist critique is a reaction against the assumptions of the EMH; namely, that investors are rational, homogenous, utility maximisers and was greatly influenced by the work of Kahneman and Tversky (1972, 1973). When a consensus emerged in favour of the EMH, it was thereafter challenged by Behaviourists. Further, there has been a growing body of literature (cf., Khaneman and Tversky, 1972; Bodie et al., 2011) supporting the Behaviourist critique.

There is a gap in the literature, as little is known about how noise trading behaviour intersects with contrarian strategies and momentum strategies in the international context and specifically, international arbitrage. Furthermore, there is little research into how cointegration techniques can be used to implement international statistical arbitrage using models based on purchasing price parity (as implied in the LOP strategy), or Markov switching. This study demonstrates how the partial adjustments model (PAM) and the speed of adjustment coefficient can identify noise trading, and test for weak-form market efficiency which predicts the profitability of contrarian and momentum strategies. The PAM is the glue that unites contrarian and momentum profitability. Cointegration implies a long-run equilibrium between stock prices, meaning that, in the long-run markets are efficient. In the short-run, where prices diverge, there are arbitrage opportunities and markets are inefficient. Markov switching allows financial stocks to adjust from the current state to the new state, reaching its fundamental value with each new innovation.

## 1.1 International Arbitrage

International arbitrage opportunities provide greater diversification for retail investors to increase their efficient frontiers and improve expected returns for a given level of risk. The strengthening economic and trade relationship between China and Australia has meant that the two financial markets are becoming increasingly integrated. In the future this integration will allow Chinese and Australian investors to exploit the economic relationship for financial gain. There are international arbitrage opportunities in the short-run, and investing internationally reduces risks through diversification. The area of research into international arbitrage has been largely overlooked in the finance literature. This is a hypothetical study in respect to the pair of countries selected for share market analysis; in reality, Australians as foreigners are as yet prohibited from buying most stocks in China. However, Chinese traders are generally free to implement the trading strategies outlined in this thesis, as there are few or no restrictions for them.

This is a three-part study,examining and testing forms of international arbitrage opportunities, with particular reference to Chinese and Australian data and the growing economic relationship between China and Australia. Part One of the study discusses a new test for market efficiency using a partial adjustments model (PAM). This is important in the study as the PAM is used to select stock pairs in order to test contrarian strategies in the international context of China and Australia. The contrarian strategies to be tested are the LOP (Law of One Price) strategy and the Markov switching strategy. The momentum strategies to be tested in Part Three are the index tracking strategy and the enhanced indexing strategy. The PAM will measure the speed of adjustment towards long-run equilibrium for momentum stocks in order to ascertain whether they under-react to economic information. Each of these strategies will be considered in the light of past literature, identifying gaps in the literature and methodologies. The study also develops a framework to hedge the China Shanghai Composite Index (CSC) and a portfolio of Australian resource stocks for the purpose of eliminating systematic risk. The S&P/ASX 300 MAM index was only constructed in 2007. This explains why the analysis began in 2007.For Part One of this study, the data was made up of daily data from 1 January 2003 to 1 March 2013. For Parts Two and Three of the study the data was made up of weekly data from 1 January 2007 to 1 March 2013. Missing values were replaced with the previous day’s values. If data for the stock were not available in the given time period, the stock was discarded from the sample. The data was accessed from Yahoo Finance. There were 2353 daily price observations and 532 weekly observations.

### 1.2 Efficient Markets

In respect to the degree of long-run efficiency (or the degree of inefficiency), arbitrage opportunities may still present themselves due to of the fact that the markets are not strong-form efficient, and it is the degree of inefficiency of the markets that provide such opportunities. Some of the literature, for example that relating to noise trading, is included in the theoretical base as it flows directly from earlier financial economics theory, such as behavioural theory.

The concepts of efficiency and equilibrium are central of Finance. If a market is efficient, then relevant economic news is revealed quickly in stock prices. Stock price equilibrium is the result of interaction between buyers and sellers in competitive markets. If markets are efficient, then economic agents must be rational, homogeneous and fully informed. Information must be costless and freely available to all economic agents so that they respond quickly to the same information set. This ensures that no agent has superior information to others.

Samuelson (1965) stated that prices in financial markets reflect a fundamental value with each price shock, and that stock prices quickly transform from the current state to a new state with the arrival of new economic information. Analysts cannot beat the market because, at any time period, they are only able to calculate fundamental value based on the current information set.

Fama (1970) describes financial markets as being competitive, where the interaction of informed buyers and sellers result in an equilibrium price. The price is revealed in the fundamentals, and adjusts rapidly to new information. In the absence of transaction costs, the price will reflect past and present information (Fama, 1970). Any past information is included in the stock price, and any attempt to predict prices is futile.

According to Fama (1970), the EMH is characterised by weak-form, semi-strong-form, and strong-form types. The weak-form states that current prices reflect past information and that this cannot be used to make abnormal returns. The semi-strong-form proposes that all prices incorporate public information. The strong-form proposes that all prices incorporate all information, public or private, and cannot be used to make abnormal returns (Fama, 1970).

Equilibrium models are commonly employed to see if EMH contradicts the performances of stock returns based on trading strategies.  Results from these models are subject to the joint hypothesis problem (Fama, 1991). That is, abnormal returns may indicate the equilibrium model adopted is inappropriate, instead of implying market efficiency.

The behaviourists critique proposes that anomalies are consistent with irrationalities, typical of individuals making complex decisions (Bodie et al., 2011). Individuals do not always process information the right way and so make mistakes in determining the probabilities of future returns. Even if individuals are given correct probabilities, they make sub-optimal decisions (Bodie et al., 2011).

Economic agents tend to over-estimate the accuracy of their forecasts. They also over-estimate their abilities (Aduda et al., 2011). Barber and Odean (2000, 2001) compare trading activity and returns of men and women (as cited in Aduda et al., 2011). They state that men trade far more actively than women, because men are over-confident. Trading frequency is a predictor of poor investment performance (Osler, 1998).

When economic agents take too long to update their beliefs in response to new information, meaning they under-react to firm-specific economic news; stock prices then only gradually adjust to new information (Aduda et al., 2011). Such a conservative bias may result in a momentum effect in financial market returns (Bodie et al., 2011).Economic agents also have a propensity to disregard the sample size, believing that data from a small sample represents the true population as well as data from a large sample (Aduda et al., 2011).

Economic agents make less than rational decisions because they have biases that interfere with risk versus return calculus. Examples of these include framing, mental accounting, regret avoidance and prospect theory. The decisions of economic agents may be affected by how choices are framed. In many instances, the choices in regard to risks and returns may be arbitrary, depending on how the choices are originally presented. A particular type of framing is termed ‘mental accounting’ in which economic agents separate certain decisions, such as where people take risky positions in one investment vehicle, while at the same time taking a conservative position in another investment. Rationally, both vehicles should be viewed as one overall portfolio.

Economic agents may regret decisions which turn out badly, especially if that investment decision was in some way unconventional. This is typical of agents’ focus on the losses of one particular stock, rather than concentrating on a broadly-diversified portfolio. The standard risk-return calculus in Finance does not consider prospect theory. This theory states that higher wealth produces higher utility, but does so at a diminishing rate, resulting in risk aversion.

Perfect efficiency is unrealistic; greater returns have to exist to compensate investors for their information gathering expenses (Grossman and Steiglitz, 1980; Lai, 2008). Trading strategies go back to the origins of stock trading. This study examines the momentum strategy, which is based on trend continuations, and the contrarian strategy, based on price reversals. The momentum strategy buys past winners and sells past losers; the contrarian strategy buys past losers and sells past winners (Lai, 2008).

## 1.3 Contrarian Strategies

Contrarian strategies were found to be profitable in the short-run (Jegadeesh, 1990). However, De Bondt and Thaler (1985, 1987) stated investors over-react to economic news in the short-run. Momentum strategies were profitable in the medium-term (3-12month) and Jegadeesh and Titman (1993) stated that companies with good returns during the past 3-12 months continued to outperform companies with low returns throughout that sample period (Lai, 2008). Economic agents react and over-react in definitive ways to rising and falling financial markets. The disposition effect, where economic agents have a tendency to hold on to losing stocks because they are reluctant to realise losses, can lead to the momentum effect. Gervais and Odean (2001) state that when economic agents become over-confident and over-estimate their capacities, they may trade more, leading to a negative relationship between trading volume and market returns.

### 1.3.1 Prospect Theory

Extending the prospect theory (Kahneman and Tversky, 1979), Jegadeesh and Titman (1993) proposed a momentum model to examine market efficiency and find that stock prices are predictable under this model. In addition, the development of prospect theory by Daniel and Titman (2000) find that certain stocks could generate greater over-confidence among investors, resulting in stronger momentum effect. Further studies show that momentum returns only appear in up-market conditions rather than in down-market.

Chan et al. (1996 and 1999) demonstrated that under-reaction to economic news on earnings explain profits from momentum strategies. Jegadeesh and Titman (1993) studied the relationship between earnings announcements and momentum profits. They used an event study to determine the existence of momentum effects (Hamalainen, 2007). Chan et al. (1996) examined past returns and shocks due to unexpected earnings, and were able to determine subsequent returns over a six-monthly period. Chan et al. (1996) find that these strategies yielded significant profits (as cited in Hamalainen, 2007).

Momentum strategy involves the buying of stocks which have a positive historical performance and selling stocks with negative performance over a discrete period. De Bondt and Thaler (1985) argued that contrarian strategy outperforms the market, and as cited in Hamalainen (2007).

The explanation for profitability of contrarian strategies lies in the propensity of noise traders to make decisional errors, and informed investors to have a preference for prior winner stocks, this allows previous stocks which have performed poorly to become under-priced relative to their risks and returns. However, Lo and MacKinlay (1990) argued that abnormal returns from the contrarian approach are due to the under-reaction of some stocks to new information, which reflects how lead-lag effects can result in evidence supporting the contrarian effect (as cited in Hamalainen, 2007). Jegadeesh and Titman (1995) reduced the contrarian returns into firms' specific information and common factors. They stated that the prices of stocks have delayed reaction to common factors and over-reaction to firm-specific factors (as cited in Hamalainen, 2007).

### 1.3.2 Over-reaction Hypothesis

Baytas and Cakici (1999) challenge the over-reaction hypothesis. The foundations of their hypothesis lie in Behaviourist Theory; investors are not rational when making decisions and over-react to information surprises. De Bondt and Thaler (1985) were the first investigate the contrarian strategy, and considered that it earned abnormal returns. These researchers developed the over-reaction hypothesis, and investigated the impact of such behaviour on stock prices. Jegadeesh and Titman (1993) were the first researchers to demonstrate that momentum may produce significant abnormal returns.

The strongest evidence of the existence of noise traders was produced by Kelly (1997), who stated that one-year U.S. stock returns are less, following periods of high participation in the market by uninformed investors. The results of Kelly's research suggest that people on low or average incomes may act as 'uninformed' traders (Osler, 1998).Noise traders are retail investors. They are uninformed, irrational, over-confident, undiversified investors in small-cap stocks who over-estimate their abilities (c.f. Black, 1986; Kurov and Sancetta 2008; Chakravarty, 2001; Odean, 1998a, 1998b, 1999; Mitchell et al 2002).Informed traders, on the other hand, are informed, rational investors who trade stocks close to their fundamental values (Podolski-Boczar et al., 2009), and respond quickly to fundamental shocks. For noise traders, both fundamental and non-fundamental shocks carry valuable information which leads them to frequently trade on incorrect beliefs (Grossman and Stiglitz, 1980).

Noise traders undertake trade using behaviouristic heuristics, such as representativeness, over confidence, framing and mental accounting. They do not process information correctly leading to sub-optimal decisions and mis-pricing through their over-reaction to firm-specific news. Informed traders mainly trade in large-cap stocks, selling past losers and buying past winners, largely through momentum strategies. This research develops a new trading theory to explain the behaviour of noise traders and institutions in pairs trading, which is a contrarian strategy.

If economic agents were rational, homogenous and fully informed, there would be no noise traders. Noise traders cause temporary disequilibrium in pairs of stocks as they quickly over-react to news. After a period of time the pairs of stocks return to their fundamental values. Institutions, on the other hand, act on private information gleaned through superior information gathering and sophisticated analysis. As they act on this private information, the pairs of stocks diverge and then slowly converge to their mean value or to a new mean regime. This process of divergence and convergence happens much more slowly for noise traders than it does for informed traders. Noise traders affect temporary changes in the stock pairs, while institutional traders affect more permanent changes. Noise traders trade in small-cap stocks, have slower speed of adjustments and are negatively correlated which makes them good candidates for contrarian strategies. Since informed traders trade in stocks close to their fundamental values, it is expected that they will produce small returns using a contrarian strategy.

If investors were homogeneous, rational and fully informed, there would be no noise traders. As they trade on information that does not reflect any fundamental value, they add additional volatility to the market (Black, 1986). Noise traders may have the greatest impact in small-cap stocks because these traders are retail investors with relatively small sums of money. As such, they are drawn to and have a potentially bigger influence on small-cap stocks. Noise traders provide market makers with profit, which compensates them for subsequent losses with informed traders. Black (1986) stated that noise trading makes trading in stock markets viable. Copeland and Galai (1983) find that noise traders are required to allow the market maker to finance their losses from trades with informed traders.Chakravarty (2001), Kurov and Sancetta (2008) contend that noise traders are retail investors, and introduce liquidity into the financial markets. Mitchell et al. (2002) state that since small-cap stocks are not covered as comprehensively by analysts as large-cap stocks, they introduce the costs of information gathering. This places limits on arbitrage which leads small-caps being more volatile than large-cap stocks.

### 1.4 Information Gathering

The ‘market selection hypothesis’ is that traders who do not behave rationally will eventually are driven out of the market (Alchian, 1950). Grossman and Stiglitz (1980) contended that when obtaining information is costly there cannot be market equilibrium where prices are at intrinsic values. Investors might observe stock prices and determine all relevant information without incurring a cost. In that case, no one would allocate the resources necessary to become informed, and therefore prices would not reflect information. Grossman and Stiglitz (1980) maintained that informed traders can make a profit by using information if they take the opposite sides of trades to uniformed traders.

Kyle (1985) proposed a model which consisted of informed investors, noise traders, and a uniformed rational investor who is the market maker. Kyle examined a large trader who has long-lived private information about stocks that are gradually made public at a specific moment and trades stocks to maximise his/her profits.Milgrom and Stokey (1982) find that if in the absence of noise trading in the stock market, trade would not occur even though traders receive different signals in relation to the stocks’ fundamental value. This implies that stocks are actively traded because of the noise traders who trade for irrational reasons that cannot be explained by finance theory.

Retail investors are noise traders or individual investors who invest in a manner that is inconsistent with rationality. These investors are undiversified (Benartzi and haler, 2001), loss averse (Odean, 1998a) and over-confident (Odean, 1999). Investor over-confidence leads to excessive trading (Benos, 1998; Odean 1998b). De Long et al. (1990) note that when information becomes available, not all investors respond the same way. Some investors are informed and respond only to fundamental shocks. Informed traders have rational expectations from fundamental shocks, purchasing stocks when information indicates stocks are undervalued and selling when information reveals stocks are overvalued. Such traderspush prices towards their fundamental values. Noise traders, however, act on the premise that fundamental and non-fundamental shocks carry true information. They buy and sell stocks based on their incorrect beliefs.The volatility of stock prices can be explained in terms of fundamental and non-fundamental shocks (Wang, 1994; Campbell, Grossman and Wang, 1993).

In the debate over market efficiency, the question remains as to whether or not noise traders distort stock prices. If they do, it may be contended that noisy traders misread available information or trade for irrational purposes. Further, noise traders will distort stock prices. When, in the long-run, stock prices return to their mean value, noise trader actions will predict future asset returns.

### 1.5 Partial Adjustment Model (PAM)

In an efficient market, prices incorporate economic news quickly. There are, however, many approaches to measuring the speed of adjustment. Previous studies developed a theory which measures the speed of adjustment. Subsequent diverse approaches drew from the research of Dimson (1979) who used beta, or the sensitivity of the stock to market risk. The Partial Adjustment Model (Amihud and Mendelson, 1987) and its re-formulation by Theobald and Yallup (2004) measure the speed of adjustment and trading irregularities in emerging markets. Amihud and Mendelson's (1987) original Partial Adjustment Model incorporated the factor of 'noise'. The subsequent approach of Amihud and Mendelson (1987) calculated the speed of adjustment, with reference to the micro-structure of a market or stock. This thesis calculates the speed of adjustment of large and small-capitalised stocks in the top 33 Australian resources stocks and the China Shanghai Composite Index. The researcher draws from the work of Amihud and Mendelson (1987) but further develops the Partial Adjustment Model by incorporating the single index model. The estimation of the speed of adjustment means that stocks can be compared using the speed at which they move to their fundamental value. This research estimates the speed of adjustment to the arrival of all information, using continuous time series information.

This research proposes that there are two types of traders; noise traders (Black, 1986) and informed traders. Noise traders are uninformed investors who cause temporary deviations from their fundamental value. Informed investors have access to better private information and methods. As informed traders act on this information, the pairs of stocks are in disequilibrium. Once this private information becomes public, market forces drive the pairs into a new equilibrium. Both noise traders and informed traders cause deviations in stock prices. Noise traders cause deviations in pairs that are long-lived and informed traders cause deviations which are shorter-lived, prior to the pairs returning to their original long-run mean value or new long-run mean regime.

This research uses the Nerlove (1958) [4]Partial Adjustment Model to determine how quickly large-cap and small-cap stocks adjust to new information. As noise traders trade in small-caps, the researcher expects them to have a slower speed of adjustment. This is further confirmed by analysing the speed of adjustment in the Engle-Granger cointegration Model for both large-cap and small-caps.

The momentum effect is important in that it indicates the predictability of the future return. The momentum strategy can reduce the systematic and total risk of an investment portfolio because the strategy holds the long and short positions simultaneously.This research implements two contrarian strategies and two momentum strategies. The contrarian strategies are the Law of One Price (LOP) strategy and the Markov switching strategy. Both strategies are pairs trading approaches. The momentum strategies are index tracking and enhanced indexing strategies.

Based on the above discussion, attention is given in this research as to whether or not short-term arbitrages profits are available, contrarian or momentum strategies are appropriate, and the efficacy of small or large-cap stocks for different categories of investors using different arbitrage strategies, and the applicability of those strategies to noise traders or informed investors.

Chapter Two provides background on the Chinese and Australian trading and economic relationship and the Shanghai Stock Exchange and the Australian Stock Exchange. Chapter Three overviews of conceptual and empirical research associated with modern portfolio theory modern portfolio theory, the Capital asset pricing model, the EMH and behavioural finance. Chapter Four presents the models and hypotheses examined in this research. Chapter Five outlines the methodology used to gather the research data. The results of the data analyses are provided in Chapter Six followed by a discussion of those results in Chapter

[4] Nerlove introduced the partial adjustment model (1958).

Seven. The concluding Chapter Eight examines the significant findings and implications of this research, identifies the limitations, and provides recommendations for future research.

# CHAPTER TWO

# BACKGROUND

## 2.1 Introduction

The Chinese and Australian stock markets are inexorably linked to the real economies of China and Australia. Monetary and fiscal policies affect the market, as do economic growth measured by Gross domestic product (GDP). Australian economic growth has, in recent times, benefited from bilateral trade between China and Australia. High levels of Chinese economic growth have boosted demand for Australia's mining and resources stocks. China's stocks have also benefited from a reliable supply of Australian metals, minerals and energy products which have allowed it to industrialise, urbanise and manufacture goods for export. These facts demonstrate that the Australian and Chinese economies are linked, as both benefit from trade. In view of what appears to be an integrated economic relationship between China and Australia, this research examines how investors in both countries can exploit this relationship through arbitrage strategies. The following is a discussion of stock markets, in particular the ASX and the Chinese Shanghai Stock Exchange (CSC), and the bilateral relationship between China and Australia.

## 2.2 Australian-Chinese Trade

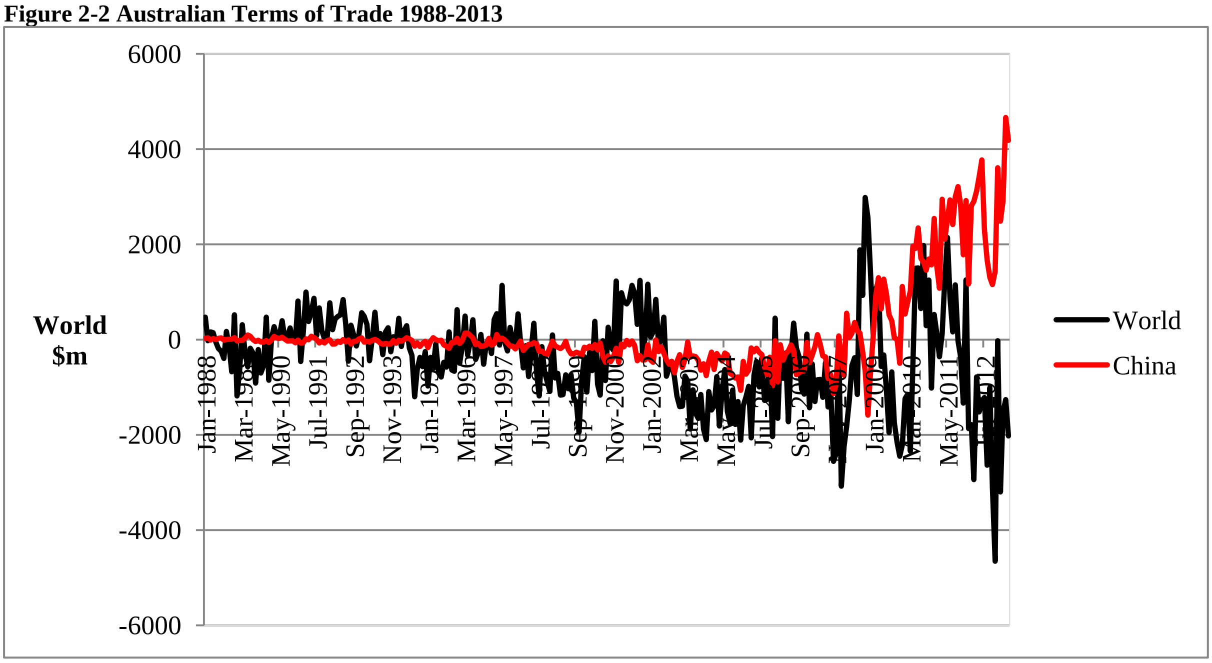
Figure 2-1 compares the China Shanghai Composite Index (CSC) and the S&P/ASX 300 Metals and Mining Index (MAM). As can be seen, the two indices closely track each other, indicating that a close relationship exists between China and Australia.

**Figure 2-1The comparison of the Chinese Shanghai Composite index and the S&P/ ASX 300 Metals and Mining index**


*Note:* the daily data of the CSC is measured in Yuan and the daily data of the MAM is measured in Australian dollars. The data on the CSC is sourced from Yahoo Finance whilst the data on the MAM is sourced from Standard and Poor's. The latter source contains the full price history of the MAM.

Figure 2-1 implies that the CSC and MAM indices are strongly correlated and that there is a close economic relationship between Chinese and Australian stock markets.

**Figure 2-2 Australian Terms of Trade 1988-2013**

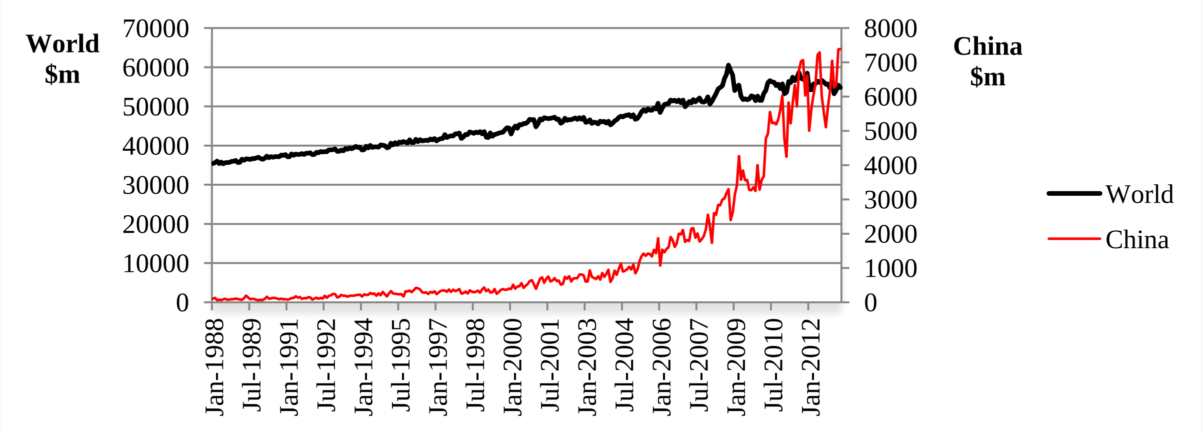



*Source:* ABS Catalogue 5368014a and 5368014b.

Figure 2-2 shows the growing terms of trade for Australian trade with China compared to its trade with the rest of the world. As can be seen, Australia in recent years has had very strong terms of trade with China as compared with the rest of the world.

Figure 2-3 shows Australia exports from 1998-2013 to the rest of the world and also to China.

**Figure 2-3 The Australian exports 1988-2013**

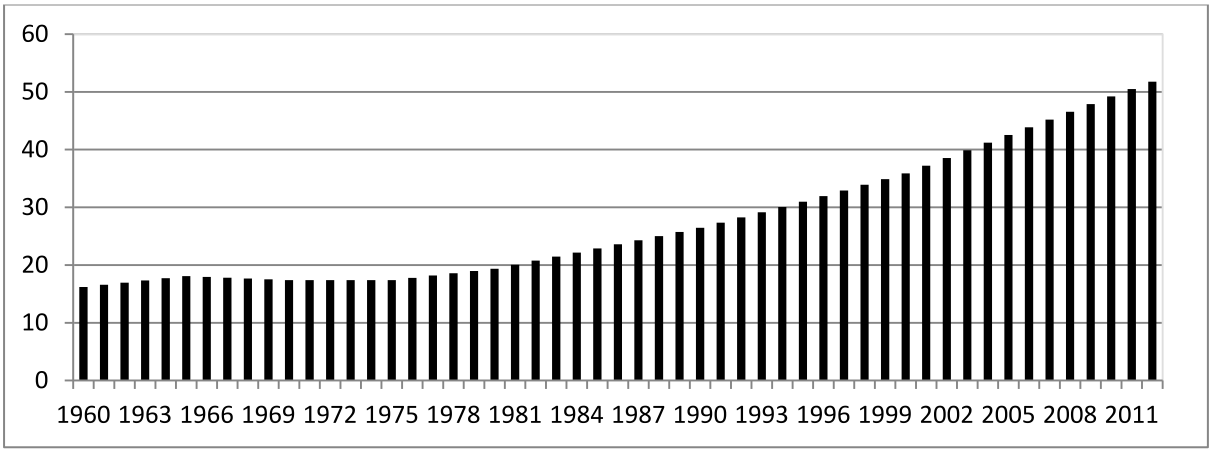



Source: ABS Catalogue 53680.14a

Figure 2-3 shows the growth in exports due to Chinese demand. As can be seen from the figure Australia's exports to the rest of the world increased steadily during this period, however, its exports to China have grown almost exponentially during this period.

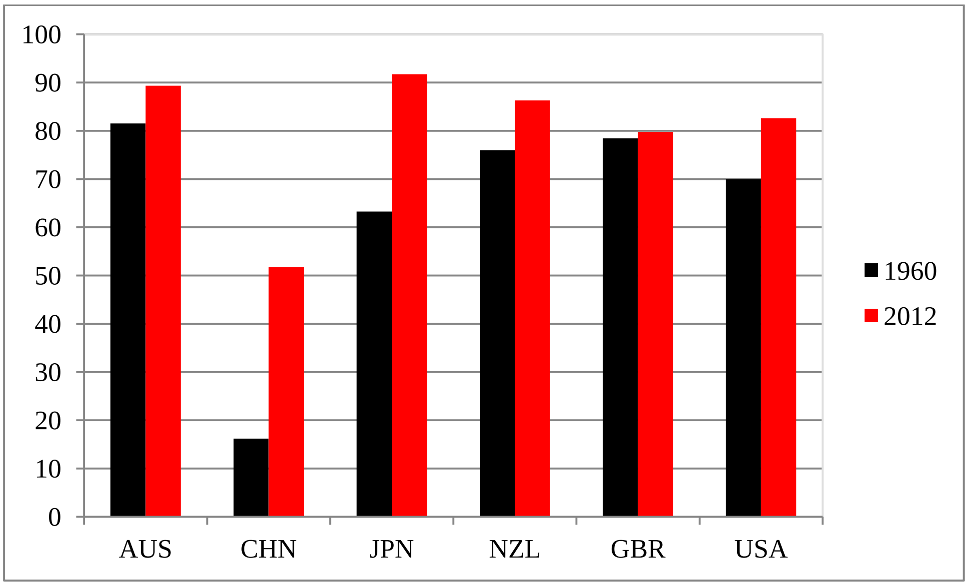
Figure 2-4shows China's urbanization rate from 1960-2012. As can be seen from the figure, China's urbanization rate was fairly constant until 1978. Since 1978 the urbanization rate has increased dramatically, coinciding with the advent of China's economic reforms.

**Figure 2-4 China's urbanization rate 1960-2012**




*Source:* World Bank – World Development Indicators

**Figure 2-5The urbanization rate of China and selected countries**




*Source:* World Bank – World Development Indicators

China’s industrialisation, and capital intensive development, has resulted in high demand for iron ore, coal and other export prices (National Australia Bank, 2012).

The bilateral economic and trade relationship between China and Australia continues to grow. China is Australia's largest trading partner in goods and services (valued at A$127.8 billion in 2011-12 financial year), Australia’s largest exports (A$76.8 billion in 2011-12 financial year), and Australia’s largest imports (A$43.4 billion in 2011-12 financial year). Resources accounted for almost 90% of Australia’s merchandise exports to China (Department of Foreign Affairs and Trade 2012, www.dfat.gov.au/geo/china/china_brief.html).

Iron ore, coal and crude petroleum were Australia’s three largest export products to China in 2010/11. Mineral products and base metals together accounted for over 80% of Chinese imports from Australia where 60% of which was iron ore in 2010/11 (National Australia Bank, 2012).

## 2.3 The Role of Stock Markets

A stock exchange is where financial assets are bought and sold. The buyer of financial asset may postpone the consumption and reserve a right to receive an amount of money at some time in the future. The investor expects these assets to generate future income and accumulate. The allocation of these financial resources occurs in stock markets. It is assumed that the markets are efficient and allocate the resources to projects which are most capable of generating the highest return. Stock markets can be divided into primary and secondary markets. Primary markets allocate the newly created financial assets from investors to users (issuers) of capital, whereas in secondary markets the assets are reallocated between investors. The liquidation of assets occurs in the secondary markets, which are for existing financial assets (Gitman et al, 1995).

The fundamental question is whether stock markets are efficient. If the stock markets were perfectly efficient, there would never be any arbitrage opportunities. Even when markets have a discrepancy in pricing between two stocks, there is not always an arbitrage opportunity. Transaction costs can turn a possible arbitrage situation into one that has no benefit to the potential arbitrager. If stock markets are inefficient then there are problems for investors in terms of how to interpret information on stocks. In this case, arbitrageurs provide a useful role in that they 'trade away the mis-priced stocks' and return them to their fundamental values eventually by buying under-priced stocks and simultaneously selling over-priced stocks.

## 2. ASX and the Australian Economy

The first formal stock exchange, the Sydney Stock Exchange was established in 1871. Exchanges in each of the other five State capital cities came into being between 1882 and 1889, but each Exchange operated independently. In 1937, the Australian Associated Stock Exchanges (AASE) was created to act as a national coordinating body. The move towards full unification of the Exchanges began in 1977, when the Sydney and Melbourne Exchanges implemented a joint trading floor. The Australian Stock Exchange (ASX) began operation on 1 April 1987, following an agreement between the six independent Exchanges (Gittman et al., 2001).

Australia is a trillion dollar economy (Blanchard and Sheen, 2009). Monetary policy is developed and implemented by the Reserve Bank of Australia (RBA) which adjusts the cash rate. In 2007-2009 there was the prospect of a major financial crisis and the collapse of major

American banks owing to defaults in sub-prime mortgages. Initially, the RBA's focus was on containing inflation at this time and raised the cash rate. Later the RBA adopted a more expansionary monetary policy (Blanchard and Sheen, 2009).Australia's fiscal policy is mostly decided by the Federal Government. The Rudd Government announced in October 2008 that it would reduce the surplus in response to the financial crises. There was a difference in the average growth rate of output per worker of 1.1% from 1974 to 2000 and by 1.4% from 2001 to 2008. This difference represented a dramatic increase in the standard of living for Australians in this period (Blanchard and Sheen, 2009).

The ASX 200 Stock Price Index rose from 513 in January 1980 to more than 1536 in March 1990, peaking at 6568 in September 2007. From December 2008, the Stock Price Index fell rapidly to 3510. In real terms, the performance of the Stock Index was dismal. It slumped for six years after the 1987 Crash, and only began to perform well again from 1992. The Real Index peaked in September 2007 at 1933. In the next 14 months it fell to 944, the same value from 11 years earlier. This fall was due to the credit crunch following the financial crises (Blanchard and Sheen, 2009). Recently, in early 2013 the Stock market has surged, following a period of expansionary monetary policy (lower interest rates) and strong economic growth, leading to increased national output, increased company profits and dividends.

## 2.5 China Stock Market

The stock market was necessary for China's economic development (Xu and Oh, 2010). Firstly, the stock market provides investment for industrial, service and utility companies, eventually leading to a separation of ownership and control in State Owned Enterprises (SOEs). Secondly, the stock market relieves state banks' non-performing loans (NPLs). Finally, the stock market offers various risk-return portfolios for savers to invest in (Xu and Oh, 2010). From 1984 to 1990, China transitioned from a centrally planned to a market economy and shares were introduced into SOEs.In 1989, the political instability resulting from 'Tiananmen Square' adversely affected the stock market (Xu and Oh, 2010).

Share trading dates back to 1986 in China. The period from 1991 to 1996 saw the establishment of national infrastructure and new regulations, along with the establishment of two Exchanges: Shanghai Stock Exchange on 19 December 1990; and Shenzhen Stock Exchange on 3 July 1991.The period from 1999 to 2001 began with a recession in China in

1999. The Government expanded the stock market to help to achieve high GDP growth (Xu and Oh, 2010).The period from 2002 to 2005 saw further steps towards enforcing the regulations of 1997-99. The Government began to allow foreign financial institutions to invest in China's stock market during this period (Xu and Oh, 2010).The SSE has become the most important stock market in China in terms of number of listed companies, number of shares listed and total market value. A large number of companies (including infrastructure and high-tech sectors) have raised capital, and improved their operating capacity through listing on the SSE.

**Shanghai Stock Exchange (SSE) Composite Index**

The SSE Composite Index is an index of all stocks (A shares and B shares) that are traded at the Shanghai Stock Exchange. The B share stocks are generally denominated in US dollars for calculation purposes (Shiyuan, 2011).

**A-Shares**

In general, foreign individuals are not allowed to directly invest in A-shares. However, some large foreign entities, known as Qualified Foreign Institutional Investor (QFII), have been permitted by the Chinese Government to buy A-shares (Shiyuan, 2011).

**B-Shares**

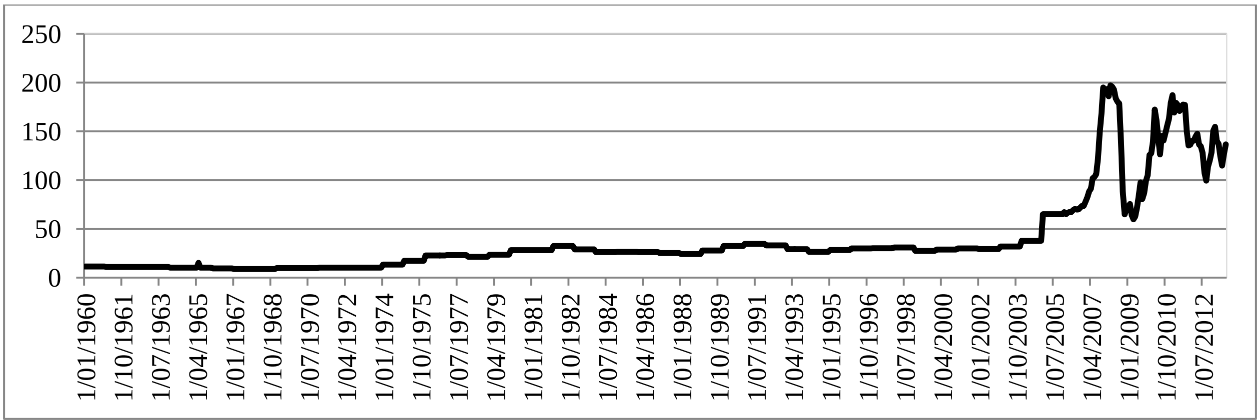
B-shares on the Shanghai (SSE) and Shenzhen Stock Exchanges (SZES) refer to those that are traded in foreign currencies. Nevertheless, foreign individuals are forbidden to trade B-shares, even with their own currency. Only some listed companies of SSE and SZES issue B-shares (Shiyuan, 2011).

## 2.6 Summary

The previous discussion covered the history of the ASX and CSC, the bilateral relationship between China and Australia, and the relationship between The Australian and Chinese stock markets and their respective economies. The role of the Stock market is to bring investors (buyers) and sellers together to allocate resources and provide liquidity. The Stock market is linked to the real economy. In China's case, the Stock market promotes economic growth and helps the Government to manage NPLs. The Chinese stock market is dominated by individual investors. Australia is important to China. Australia's metals, minerals and energy exports have allowed China to industrialise, urbanise and manufacture goods for export. Nonetheless, the benefits flow both ways. China is important to Australia, as its demand for Australian goods has led to a resources boom and a growing Australian economy.

Figure 2-6shows the world iron ore prices from 1960 to 1 October 2013. As can be seen from the figure, iron ore prices were relatively flat until 2000. They rose dramatically in 2005 and peaked at about 2008. Towards the end of 2008 prices crashed as a result of the Global Financial Crises, however, prices rebounded and were quite high in 2010-2011. In 2012, and again in 2013 prices tumbled. However, iron ore prices have proven to be resilient, and in the latter half of 2013 have begun increasing again.

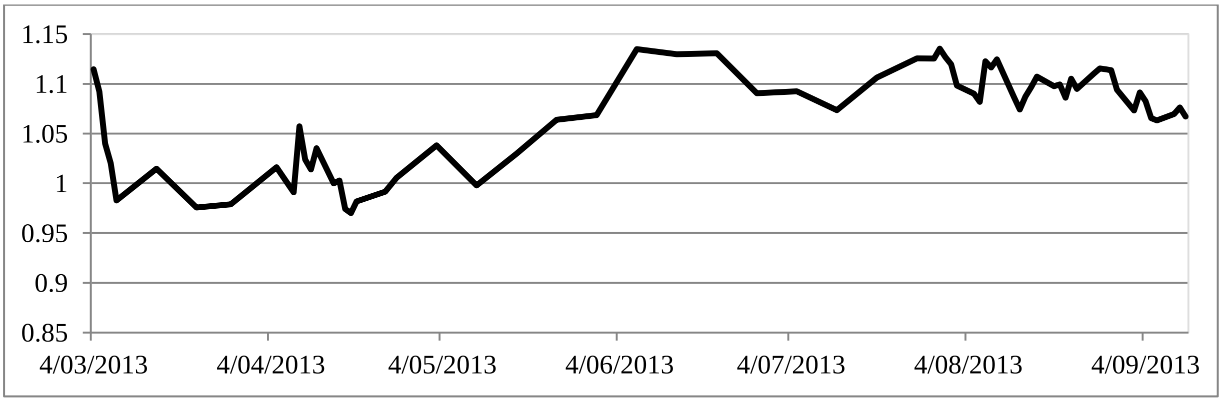
**Figure 2-6 World iron ore prices 1960-2013**




*Source:* World Bank – World Development Indicators

Figure 2-7 shows the ratio of the All Resources Index and the All Industrial Index in Australia in 2013. As can be seen from the figure, the ratio fell in the first half of 2013, coinciding with the decline in iron ore prices, and reflecting the under-performance of Resources Stocks. The ratio increased in the latter half of 2013, coinciding with an increase in iron ore prices.

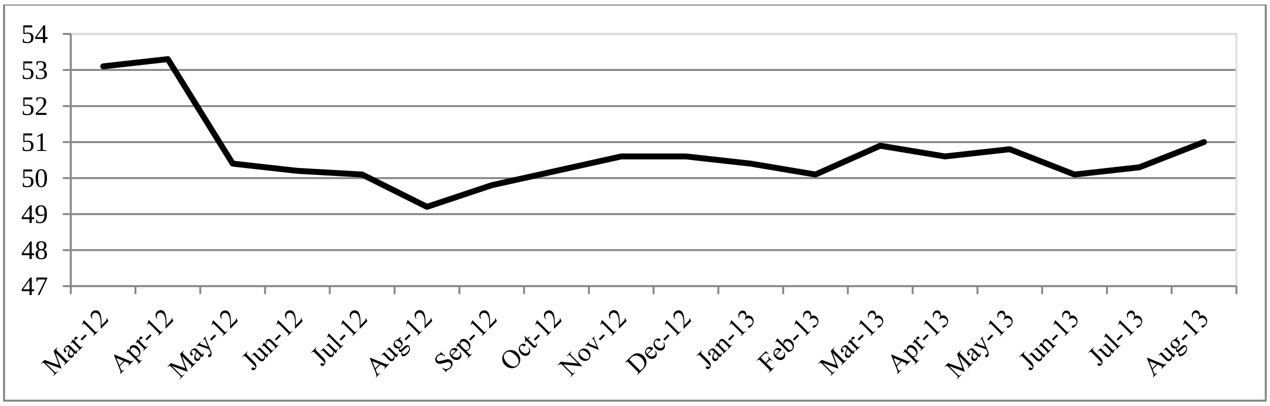
**Figure 2-7 Ratios of All Resources to All Industrials 2013**




Source: Yahoo Finance Australia

Figure 2-8 shows the Chinese Purchasing Managers Index (PMI) from January 2012 to October 2013. Generally speaking the PMI was in decline throughout 2012 and the first half of 2013, rising in the second half of 2013. This implies that during the latter half of 2013 Chinese manufacturing was expanding, thus in part explaining the rise in iron ore prices and increase in the Australian resources sector.

**Figure 2-8 Chinese Purchasing Managers' Index 2012-2013**




*Source:* Investmundi website

These figures imply that Chinese demand for Australian resources is resilient and will continue for several years to come. In fact, China may be regarded as a long-term growth opportunity with room more urbanised development (Hanrahan, 2013a). China's GDP growth from 2006-2012 saw the size of its economy double, thus the growth rate in 2013 of 7.5% represents a bigger growth of economic activity than in 2007 (Hanrahan, 2013b; Economist, 2013). At some stage during that period it is expected to become the World's largest economy. In 2040, the Chinese economy will reach $123 trillion. China's share of global GDP will be 40 percent (Fogel, 2010).

# CHAPTER THREE

# THEORY AND LITERATURE

## 3.1 Introduction

This Chapter is divided into two sections; the theory and literature. The strengthening economic and trade relationship between China and Australia has meant that the two financial markets are becoming increasingly integrated. This integration allows Chinese and Australian investors to exploit the economic relationship for financial gain. There are international arbitrage opportunities in the short-run, and investing internationally reduces risks through diversification. The area of research into international arbitrage has been largely overlooked in the finance literature.

This is a three-part study to examine and test forms of international arbitrage opportunities with particular reference to Chinese and Australian data, and the growing economic relationship between China and Australia. Part One of the study presents a new test for market efficiency using a partial adjustments model (PAM). This is important in the study, as the PAM will be used to select stock pairs in order to test contrarian strategies in the international context of China and Australia. The contrarian strategies to be tested are the Law of One Price (LOP) strategy and the Markov switching strategy. The momentum strategies to be tested in Part Three are the index tracking strategy and the enhanced indexing strategy. The PAM will measure the speed of adjustment towards long-run equilibrium for momentum stocks, to ascertain whether they under-react to economic information. Each of these strategies will be considered in the light of past literature, identifying gaps in the literature and methodologies.

The theoretical bases for the study lies in modern portfolio theory (Markowitz, 1952), the Capital asset pricing model (Sharpe, 1964), behavioural theory (Tversky and Kahneman, 1974), and the efficient market hypothesis (EMH) developed by Fama (1970). International investment increases the ability to reduce unsystematic risks. Indices may be regarded as sectoral diversified investment portfolios, assuming they are representative of companies in that sector. In addition, different country markets and country market sectors, in the long-run,may be proven to be informationally efficient in exhibiting properties of cointegration and rational expectations. However, in the short-term, properties demonstrate a lack of equilibrium and dissimilar stochastic trends, which may be attributed to short-term effects of economic and financial policy differences, leading to an emergence of international arbitrage opportunities. In respect to the degree of long-run efficiency (or the degree of inefficiency), arbitrage opportunities may still present themselves due to the fact that the markets are not strong-form efficient, it is the degree of inefficiency of the markets that provide such opportunities. Some of the literature, for example that relating to noise trading (c.f. Black, 1986), is included in the theoretical base as it flows directly from earlier financial economics theory such as behavioural theory.

## 3.2 Theoretical Bases

The following theories are of direct importance in the context of studies into international arbitrage strategies. Modern portfolio theory (MPT) and the Capital Assets Pricing Model (CAPM) are strongly connected and contribute to this study because they are central to the theory of diversification and reward-risk calculation. The Efficient Markets Hypothesis (EMH) is also of importance in studying international arbitrage, because there are no arbitrage opportunities in efficient markets. Behavioural theory also contributes to the theoretical base because it questions whether investors act rationally and as a homogeneous group. The irrational behaviour of investors leads to mis-pricing of stocks, without limits being placed on arbitrage amongst cointegrated stocks; this short-run inefficiency is corrected in the long-run.

### 3.2.1 Modern portfolio theory and the Capital asset pricing model

The following discussion of modern portfolio theory, and the capital asset pricing model (CAPM), are approaches that provide superior trade-off between risk and return. Diversification reduces risk, and it depends on the correlation assets. This section underlies Part Three of this study, in which an index tracking and enhanced indexing strategies using the China Shanghai Composite Index (CSC) and a portfolio of Australian resource stocks are implemented. The index is a well-diversified portfolio, with systematic risk present, and unsystematic risk eliminated. However, the use of a long-short equity hedge means that systematic risk is also eliminated.

Modern portfolio theory was developed by Markowitz (1952). He proposed that diversification across industries with different economic conditions could achieve risk reductions for investors. The Markowitz model is based on the following assumptions of investor behaviour;

1. investors are rational and risk-averse;
2. investments are selected on the probability of expected returns;
3. investors want to maximise utility;
4. risk is based on the variance in expected returns;
5. utility curves are a function of expected returns and variance; and
6. Investors seek higher returns for a given level of risk and they seek less risk instead of more risk.

Given the above assumptions, it is therefore rational to hold a well-diversified portfolio. Holding perfectly positively correlated stocks does not provide any reduction in risk. When shares of different firms are combined in a portfolio, the effects of firm-specific factors tend to cancel out and reduce the risk of the portfolio. This is a reduction in unsystematic risk or diversifiable risk. However, diversification cannot eliminate systematic risk, because all stocks are related to each other in some manner (Peirson et al., 2009).

Sharpe (1964) finds that diversification will allow the investor to eliminate all of the risk except systematic risk (Peirson et al., 2009). The following observations can be made about CAPM (Gitman et al., 2001);

1. investors may eliminate unsystematic risks by choosing stocks in many regions and sectors;
2. systematic risk cannot be diversified away;
3. investors who invest in a risky asset earn higher returns;
4. systematic risk is measured by beta, which relates investment's risk to the market's risk;
5. the beta of the market is 1.00;

The returns on a firm's stocks can vary for many reasons, some are firm-specific factors and others are macro-economic factors (Peirson et al., 2009).

The above discusses the unlikely case of a portfolio comprised of only two assets. When an increasing number of less than perfectly-correlated assets are added to a portfolio, the overall portfolio standard deviation will decrease.

The market never guarantees returns. There is a risk attached to practically every investment. The portfolio of international assets has several risk factors;

1. market risk (systematic risk) concerns the overall movement in the markets. As the future is uncertain, an investor bases his/her strategies on expectations of the global market situation, specific conditions, and the industry risk inherent in the market. Such factors may include the currency, the investment which is made, the risk associated with the specific stock, bond or other asset, the expected share dividend or bond interest and the cost of leverage to hold a position;
2. diversification to protect a portfolio from fluctuation contains risk as well. Diversification risk occurs when a portfolio is spread between too many assets. This over-diversification makes the management of the portfolio very difficult, and the risk of mismanagement increases;
3. investments made in currencies other than the investor's base currency are exposed to foreign exchange risk. when acquiring assets denominated in a foreign currency, an investor can minimise the risk by diversifying the assets across several important currencies;
4. furthermore, investments may be affected by political risk, liquidity risk, manipulation risk, information risk and inflation risk. While international investment increases the risks, it also provides new possibilities.

The main reasons for investing in overseas equities are as follows;

1. the size of the market, this is an important consideration. Market capitalisation provides opportunities for investors. The domestic market capitalisation has to be set in relation to the market capitalisation of the whole world in order to determine the global allocation;
2. performance of the markets has an impact on investors' behaviour. If attractive new markets are observed, investments are assumed to pour into these markets. However, differences between markets allow various performance outcomes, which lead to effective allocation of financial assets;
3. the performance of a single market is also interdependent with other markets. If an investor cannot define a single best performing market from year to year, there is a need to invest all over the world;
4. risk diversification is one reason to invest abroad. In theory, diversification provides benefits, either by reducing risk or increasing returns. By investing overseas, an

investor can diversify his/her overall portfolio risk. International investment provides a counterbalance to a purely domestic portfolio.

The lower risk comes from the fact that international diversification eliminates the non-systematic risk without changing the level of expected return. This happens when the domestic market is relatively uncorrelated or negatively correlated with the foreign market. There may not be arbitrage opportunities if markets are completely integrated. In international markets, an investor can benefit in two ways. The first is that the investment opportunity set is larger and there are benefits from international arbitrage, so long as the markets are not integrated.

Globalism is the result of technology, which results in the increase in the rapidity of communication equipment, economic liberalism, and the rise of international trade. The preceding discussion highlights the central issue of diversification. Foreign stocks can be a valuable addition to any well-diversified portfolio. In Part Three of this study an index tracking and enhanced indexing strategy is implemented using the CSC index as the benchmark, and Australian resource stocks as elements of the strategy. These portfolios are well-diversified and have eliminated unsystematic risk.

### 3.2.2 Efficient Markets Hypothesis

According to the efficient markets hypothesis (EMH) theory, change in and random movement of prices in response to new information, is evidence of the EMH. Prices which are slow to adjust to new economic news result in stock prices that do not reflect that information. If the price adjustment is above or below the mean value, some investors would have an advantage over the other investors. The non-random movement in prices is also a violation of EMH.

The following discussion concerns the EMH. Fama's (1970) seminal contribution will be discussed as well as more recent literature. The assumptions of the EMH will be presented along with the criticisms directed towards this model. In Part One of this study there is examination of the degree of market efficiency in the CSC constituent stocks and the Australian resource stocks. This study considers implications for the EMH for financial decision making. If markets are efficient then there will be no profits from contrarian and momentum strategies.

There are two technical trading strategies, based on historical returns that have been identified in the literature: The first is the contrarian strategy; buying past losing stocks and selling past winning stocks, based on the stocks over-reaction to information. The second is the momentum strategy; buying past winning stocks and selling past losing stocks.

This study tests how efficiently stocks reflect economic news in order to develop a new approach to explain contrarian trading. If economic agents are rational, homogenous and fully informed there will be no noise traders. Noise traders cause temporary disequilibrium in the pairs of stocks as they quickly over-react or under-react to news. After a period of time, the pairs of stocks return to their fundamental values. Informed traders, on the other hand, act on private information gleaned through superior information gathering and sophisticated analysis. As they act on this private information, the pairs of stocks diverge and then slowly converge to their mean value, which may be the original regime or a new mean regime. Noise traders affect temporary changes in the stock pairs, while informed traders affect more permanent changes.

The researcher described financial markets as being competitive where the interaction of informed buyers and sellers result in equilibrium price which is revealed in the underlying fundamentals. The price adjusts rapidly to new information. In the absence of transaction costs, the price determined through market forces will reflect past and present information (Fama, 1970). Any past information is inherent in into the stock price. Therefore, any attempt to predict prices is futile.

Equilibrium models are commonly employed to see if the EMH contradicts the performances of stock returns based on trading strategies.  Results from these models are subject to the joint hypothesis problem (Fama, 1991). Abnormal returns may indicate the equilibrium model adopted is inappropriate, rather than implying market efficiency. According to the EMH, in a market which is increasingly efficient, the more random is the price changes in a market. This results from the activities of many active buyers and sellers of stocks. If information is instantaneously incorporated in prices, then prices must always fully reflect that information (Lo, 2008). Rational expectations imply that people form expectations as rationally as they are able to do so, based on the information they have. They use their information to form expectations of the future that is people look to the future and use all the information at their disposal to predict it (Blanchard and Sheen, 2009).

The EMH is based on the following three assumptions (Soares and Serra, 2005 and Burghardt, 2010);

1. investors are rational and value securities rationally;
2. if investors are not fully rational, they act in different ways, and cancel each other out; and
3. ifirrational investors act in the same way, there are many arbitrageurs who will bring prices back to fundamentals.

Critics of the EMH state that people do not want to realise their losses (Odean 1998) trade too much (Odean 1999), fail to divest themselves of losing stocks and prefer to sell winning stocks (Shefrin and Statman, 1985;as cited in Soares and Serra, 2005 and Burghardt, 2010).

Deviations from the expected behaviour occur due to the following reasons (Soares and Serra, 2005 and Burghardt, 2010);

1. individuals are not rational, but rather develop preferences according to prospect theory and display loss aversion;
2. investors do not follow the concepts of Bayes' rule. They put greater weight on recent events and over-estimate events that demand their attention;
3. framing Effects cause people to change their minds depending on how a problem is presented to them.

Barberis et al. (1998) stated that evidence showed that security prices tend to under-react to news announcements. This phenomenon is also called momentum. The over-reaction evidence showed that, over longer time periods, security prices over-react, especially if there is a longer pattern of the same type of news (Soares and Serra, 2005 and Burghardt, 2010).

The study by De Bondt and Thaler (1985) is an example of over-reaction; investors over-reacted to good or bad news, and as a result, winners underperformed and losers outperformed in the following years. Eventually, prices reverted to the mean. The model of Barberis et al. (1998) is based on the heuristics of conservatism and representativeness. Conservatism means that investors are slow to change their beliefs in response to new information (Edwards, 1968), but the change is small leading to an under-reaction to the new information. The representativeness heuristic (Tversky and Kahneman, 1974) states that people think that believe they perceive trends in random sequences (Soares and Serra, 2005; Burghardt, 2010).

#### 3.2.2.1 Assumptions of the EMH

The EMH assumes that investors behave rationally, have rational expectations and make choices based on Bayes' theorem. The implication of the EMH is that a passive buy and hold strategy outperforms an active strategy of stock selection. Therefore, it is impossible to make abnormal profits consistently using active strategies. However, the EMH has been challenged by Black (1986) who stated that noise trading is not rationally-based on the arrival of new information about stock values. Noise trading might allow securities markets to exist, in that it makes information gathering by rational speculators a profitable activity. Their presence can support Grossman and Stiglitz's concern (1980) that informationally efficient markets are impossible. Noise traders 'behaviour may result in the formation of market-making processes and possibly cause a permanent divergence between prices and fundamentals (De Long et al., 1990; cited in Osler, 1998).

There is no agreement on whether the Chinese stock market was weak-form efficient. Firstly, Laurence et al. (1997) and Lima and Tabak (2004) find that the Chinese markets are efficient as their respective stock returns are not predictable. However, Mookerjee and Yu (1999) state the markets were inefficient. In between these two positions are studies that find evidence of returns predictability (Lim et al., 2009).The tradable A- and B-shares markets are characterised by having many individual investors acting as market participants with Chinese informed traders, such as the pension funds, insurance companies and securities companies accounting for less than 10% of the total market capitalisation. A study that discusses the various disturbances in asset prices in China (Chen et al., 2005) showed that Chinese investors have a tendency to over-react to good (bad) news and under-react to bad (good) news in a bullish (bearish) market (as cited in Lim et al., 2009).

This study tests for efficiency using the PAM, the speed of adjustment coefficient of which is used for matching stock pairs. The PAM establishes how fast changes in returns adjust to changes in abnormal returns, using the single-index model. The following discussion considers the relationship between cointegration and the EMH. Cointegration plays a central role in this study, as it is implemented in the LOP contrarian strategy in Part Two, and the index tracking and enhanced indexing strategies in Part Three. Cointegration is the long-term co-movement find between non-stationary time series, leading to a general equilibrium of the variables. Granger (1986) stated that there should not be a cointegration between price series in an efficient market, as it means that one of the series can be used to predict the other. A cointegrating relationship is stable and long-running in which variables are in equilibrium and there are no arbitrage opportunities. This means that there is market efficiency in the long-run. Nonetheless, in the short-run, there is disequilibrium as prices temporarily diverge, producing arbitrage opportunities. In the short-run, therefore, there is market inefficiency.

The above discussion outlines Fama's (1970) contribution to the EMH, as well as more recent research. The assumptions and criticisms of the EMH are also discussed. The discussion of market efficiency is important because this study investigates market efficiency holds, and under what circumstances it fails to do so. In Part One of this study a partial adjustments model is developed to tests relative market efficiency amongst CSC constituent stocks and the Australian resource stocks. This study proposes that the markets are efficient in the long-run; however, they are inefficient in the short-run, leading to arbitrage opportunities. The speed of adjustment coefficient will identify stocks which are, relatively, more or less efficient than others. More efficient stocks will have faster speed of adjustment to economic information. This coefficient will be used to match pairs of stocks for the contrarian strategies in Part Two of this study.

The preceding discussion outlined some criticisms of the EMH. Most of the criticisms are drawn from behavioural finance. In a concept that will be further considered below. behavioural finance seeks to explain and account for investor sentiment. It uses psychological theory (Kahneman and Tversky, 1973) to explain why investors may not always behave rationally, and why arbitrageurs may not eliminate the impact of irrational investors on stock prices.

Through its discussion of investor sentiment, behavioural finance uses the concept of noise traders introduced by Black (1986), thus supporting criticism of the EMH on two fronts; namely, that investors are not rational, nor are they homogeneous. This is an important concept in this study, as noise traders' trading behaviour is central to the implementation of contrarian pairs trading strategies and momentum strategies. Noise trading leads to under-reaction, and over-reaction, to economic news about stock prices, and arbitrageurs can subsequently take advantage of such mis-pricing can be taken advantage of by arbitrageurs. The elimination of anomalies identified by behavioural finance makes financial markets was efficient in the long-run, as long as there are no limits to arbitrage. If stocks are cointegrated, mean reversion is guaranteed, and there will be no limits to arbitrage.

### 3.2.3 Behavioural Finance

Investors do not always react quickly to new information. In some cases investors may over-react, pushing prices beyond their rational market value, requiring rational investors bring prices back to their fundamentals, implying price reversals. Another implication is that contrarian investment strategies will earn superior returns (Lo, 2008).An examination of monthly returns of New York Stock Exchange (NYSE) stocks from 1926 to 1982 by De Bondt and Thaler (1985) find that winners and losers in one 36-month period tended to reverse their performance over the next 36-month period. Many of these reversals occurred in January. Chopra et al. (1992) confirmed these findings, after correcting for market risk and the size effect (Lo, 2008).

Grossman and Stiglitz (1980) contended that perfectly informationally efficient markets are impossible because if markets are perfectly efficient, there is no profit in gathering information. Further, there is no incentive to trade and markets will be extinguished. Barberis et al. (1998) proposed that when a company announces surprisingly good earnings, conservatism forces result in investors reacting insufficiently, pushing the price up too little. Subsequent returns will be higher on average, generating momentum. After a number of good earnings announcements, however, representativeness causes people to over-react and push the price up too high. The following returns are too low, generating long-term reversals (Sudak and Suslova, 2010).

The above reveals how some investors over-react, and others under-react to information. The belief that efficient markets have perfect information precludes this from occurring. Perfect information about stocks has been called into question, as has investors' rational decision making. Investors may be conservative and make decisions that are not based on representative samples; they may also be over-confident and trade too much. All of these scenarios cast doubts on the EMH.

The Behaviourists' critique centres on anomalies, consistent with irrationalities that are typical of individuals making complex decisions (Bodie et al., 2011). Individuals do not always accurately process information and so make mistakes in determining the probabilities of future returns. Even if individuals are given correct probabilities they make sub-optimal decisions (Bodie et al., 2011). Information processing errors lead economic agents to incorrectly estimate the correct probabilities of likely events or returns. These may be the result of forecasting errors, over-confidence, conservatism, and sample size neglect and representativeness. Kahneman and Tversky (1972, 1973) stated that agents put too much emphasis on recent experiences rather than past performances when making forecasts, which are in turn extreme given the informational uncertainty. Economic agents tend to over-estimate the accuracy of their forecasts, as well as their abilities. Barber and Odean (2000, 2001) stated that men trade far more actively than women because they are over-confident. Trading frequency is a predictor of poor investment performance (Osler, 1998).When economic agents takes too long to decipher or make sense of new information they may under-react to firm specific economic news so that stock prices only gradually adjust to that new information. Such a conservatism bias may further result in a momentum effect in financial market returns (Bodie et al., 2011; Osler, 1998).Economic agents also have a propensity to disregard the sample size, believing data from a small sample size is as representative as data from a large sample. They may infer a pattern in the stock returns too quickly based on a small sample, and perceive apparent trends too far into the future (Osler, 1998).Economic agents make less than rational decisions because they have biases that interfere with risk versus return calculus. Examples of these include framing, mental accounting, regret avoidance and prospect theory. The decisions of economic agents may be affected by how choices are framed. In many instances the choices in relation to risks and returns may be arbitrary, depending on how the choices were originally presented (Osler, 1998).

A particular type of framing is termed ‘mental accounting’; in which economic agents separate certain decisions. Examples include economic agents who take risky positions in one investment vehicle, while at the same time taking a conservative position in another investment. Rationally, both vehicles should be viewed as one overall portfolio. Economic agents may regret decisions which turn out badly, especially if that investment decision was in some way unconventional. This is typical of agents’ focus on the losses of one particular stock rather than focusing on a broadly diversified portfolio. The risk-return calculus in finance textbooks does not consider prospect theory. This theory states that higher wealth produces higher utility; however, it does so at a diminishing rate, resulting in risk aversion.

According to behavioural finance, investors are not homogeneous. The EMH asserts that when noise traders buy a stock, informed traders subsequently sells; and when noise traders sell a stock, informed traders buy, thereby eliminating the effect of irrational traders. Proponents of behavioural finance argue that movements in stock prices away from their fundamental value are the result of the presence of noise traders. In contrast, the

EMHproponents claim that rational investors undo any disturbances caused by irrational investors. Whenever a mis-pricing occurs, a potentially profitable situation arises, which in turn motivates rational market participants to take advantage of and correct the mis-pricing. Nonetheless, behavioural finance proposes that correcting the mis-pricing in the market can be both risky and costly (Barberis and Thaler, 2003).

#### 3.2.3.1 Arbitrage Strategies

An arbitrageur buying a ‘cheap’ asset faces the risk of that stock decreasing further in value due to bad news. To prevent this scenario, the arbitrageur can hedge the asset by shorting a substitute security. Unfortunately, perfect substitutes rarely exist and part of the fundamental risk remains unhedged. The arbitrageur is risk-averse; he or she does not want additional risk without additional return. The assumption of risk aversion makes it almost certain that mis-pricing will not be corrected by the actions of a single large arbitrageur taking a large position in relation to the mispriced stock. In addition, even if a perfect substitute asset exists, the stock in question may also be mis-priced as well. In this case, the mis-pricing of the asset originally being exploited can worsen in the short-run. The arbitrageur may be faced with the risk that the irrational and pessimistic investors become more so, decreasing the price even more, and creating losses for the investor (Shleifer and Vishny, 1997). It is assumed that markets are not efficient if arbitrage opportunities exist.

The preceding discussion of behavioural finance argues that investors do not always behave rationally and they are not a homogeneous group. The anomalies highlighted by behavioural finance lead to mis-pricing of assets, which can nonetheless be corrected by arbitrageurs if there are no limits to arbitrage. If stocks are cointegrated, then mean reversion is guaranteed and there will be no limits to arbitrage. If assets are cointegrated, there will be long-run equilibrium and efficiency. However, in the short-run, they will diverge, and lead to arbitrage opportunities. This scenario is perfectly consistent with Behaviourist thinking. The anomalies highlighted by behavioural finance leads to short-term mis-pricing; when these anomalies are corrected by arbitrageurs, there is long-run equilibrium where markets are efficient. Therefore the question is not whether markets are efficient or inefficient, but rather, to what degree they are efficient?

## 3.3 Literature

In this section, empirical evidence in relation to international arbitrage is to identify and define the central issues from which the hypotheses in this study are developed. It is recalled that the central issue of the study is to identify international arbitrage opportunities and strategies in the diversified Chinese stock market and the Australia mining sector. China and Australia have been selected due to the growing interdependence of these two countries in trade and investment. The study's, fully described in Chapter Four, involves testing for market efficiency using a PAM, and identifying contrarian strategies through a speed of adjustment coefficient. The latter involves using an LOP strategy and a Markov switching strategy (pairs- trading strategies) to directly illustrate arbitrage opportunities. Therefore, momentum strategies are identified using cointegration techniques as well as the PAM, and confirmed using index tracking and enhanced indexing.

A literature review in relation to the PAM is presented below.

### 3.3.1 Partial Adjustment Model

Investors are assumed to be rational in the formation of their expectations of future events. However this basic assumption of the EMH has been challenged by Behaviourists who state that people do not always behave rationally. Rather, investors are seen by Behaviourists to under-react and over-react to news, trading too much, and holding onto losing stocks for too long. Investors are over-confident and over-estimate their abilities. Noise traders are identified as irrational retail investors who make markets function properly by taking opposite trades with informed investors. Noise traders may explain some market anomalies. The PAM accounts for the effects of noise traders in calculating the speed of adjustment of stocks towards market equilibrium. If stocks are efficient, they can adjust quickly to new economic news. The speed of adjustments calculated in the PAM will be used to match stock pairs for the contrarian strategies.

In an efficient market, the observed price should include new information to reflect changes to fundamental value. Such an adjustment should be immediate if the market is strongly efficient (Fama, 1991). Thus the adjustment speed of stock price to the changed fundamental value due to economic news determines the degree of efficiency in the stock market (Marisetty, 2003). Differences exist in ways to measure the speed at which stocks adjust. Often, an event study is used to ascertain the dynamics of pricing around the time of a macroeconomic shock. However, speed is only determined for a predefined known event (Boulter, 2007). Amihud and Mendelson (1987) propose a model of price adjustment in which observed prices adjust towards their intrinsic values.

The purpose this paper is to estimate speed of adjustment within a new partial adjustment model (PAM), in order to investigate the efficiency of the Chinese Shanghai Composite index constituent stocks and the Australian resources stocks. The results have many implications for both researchers and practitioners. First, the price adjustment process in Chinese and Australian markets is mixed. Some stocks over-react, some under-react, and some fully adjust to new economic information. Second, price over-reaction and under-reaction indicates inefficiencies in the information dissemination process in these markets. Third, the PAM demonstrates that these inefficiencies are short-term and that in the long-term there is equilibrium and the markets are efficient.

Black (1986) stated that the stock price consists of two factors, noise and the intrinsic value. Noise is intrinsic value minus the observed price. Amihud and Mendelson (1987) reduced the variance of noise into two parts; the intrinsic value variance which is the result of dissimilar valuations due to heterogeneous beliefs among investors and that which is the result of pure noise due to irrational behaviour. Amihud and Mendelson (1987) state that stock prices tend towards fundamentals by way of price adjustment. According to Marisetty (2003) that adjustment process is represented as follows:

$$P_t - P_{t-1} = g(V_t - P_{t-1}) + \mu_t \tag{3.1}$$

where ($V_t$) and ($P_t$) are in logarithms where $V_t$ is the intrinsic value of the stock. ($P_t$-$P_{t-1}$) is the observed price change, ($V_t$-$P_{t-1}$) represents the information-induced change in price which adjusts by ($g$) with value 1 represents full price adjustment towards the intrinsic value. The value of $g$ between $0<g<1$ represents partial adjustment towards the intrinsic value. ($g$) with value 0 represents no adjustment and $g>1$ represents over-reaction of the price towards change in the intrinsic value to economic news (Marisetty, 2003).

Damodaran (1993) extended Amihud and Mendelson’s (1987) model (and the representation of that model by Marisetty, 2003) by measuring the speed of adjustment of stocks in response to macroeconomic shocks. He makes the assumption that speed of adjustment is not immediate. Damodaran (1993) divided time into daily units. He also assumes that the maximum time for price adjustment is 20 days based on experimental data. He derived his estimator from reducing the observed return variance into three parts (Marisetty, 2003; Boulter, 2007):

$$Var(R_t) = v^2 + 2\sigma^2 + [\left(\frac{g}{2-g} - 1\right) v^2 + \left(\frac{2}{2-g} - 2\right)\sigma^2] \quad (3.2)$$

$$v^2 + 2\sigma^2 \quad (3.3)$$

$$[\left(\frac{g}{2-g} - 1\right) v^2 + (\frac{2}{2-g} - 2)\sigma^2] \quad (3.4)$$

Where ($v^2$) is the variance of the intrinsic value, ($2\sigma^2$) is the noise variance, and (3.4) is the variance relating to the price adjustment process (Boulter, 2007).

The estimator (*g*) arises from observed return variances that are calculated over different time intervals. Thus ($R_{jt}$) would be the return in time period (*t*) in which the return interval is (*j*) (Boulter, 2007). The variance:

$$Var(R_{jt}) = [\frac{g_j}{2-g_j} j v^2 + \frac{2}{(2-g_j)}\sigma^2] \quad (3.5)$$

It is assumed that an amount of return unit-intervals are enough to calculate the variances, so that (*j* = 1, 2, ...*k*), and that the limiting interval (*k*) is enough to allow (*g*) to equal one, allowing the variances in (*j*) and in (*k*) interval returns to be as follows (Boulter, 2007).

$$Var(R_{jt}) - \frac{Var(R_{kt})}{k} = v^2 \left[\frac{g_j}{(2-g_j)} - 1\right] + 2\sigma^2[\frac{1}{(2-g_j)} - \frac{1}{k}] \quad (3.6)$$

where ($v^2$) and ($\sigma^2$) are functions of the covariance and variance in (*k*) intervals as follows:

$$v^2 = \frac{Var(R_{kt}) + 2Cov(R_{kt}, R_{kt-1})}{k} \quad (3.7)$$

$$\sigma^2 = -Cov\,(R_{kt}, R_{kt-1}) \quad (3.8)$$

Substituting ($v^2$) and ($\sigma^2$), in equation (5), and solving for (*g*), Damodaran's (1993) estimate of the speed of adjustment is as follows (Boulter, 2007):

$$g = \frac{\frac{Var(R_{j,t})}{j} + \frac{Var\left(R_{k,t}\right)}{k}(j-1) + \frac{Cov(R_{k,t}, R_{k,t-1})}{j}}{\frac{Var(R_{j,t})}{j} + \frac{Var\left(R_{k,t}\right)}{k}(2j-1) + \frac{2Cov(R_{k,t}, R_{k,t-1})}{k}} \tag{3.9}$$

If the market is efficient, then the faster ($g$) should converge to (1). Brisley and Theobald (1996) find an error within Damodaran's calculation which they correct. Their estimator is as follows (Boulter, 2007):

$$g = \frac{\frac{2[Var(R_{j,t})}{j} + \frac{2Cov\left(R_{k,t}, R_{k,t-1}\right)]}{j}}{\frac{Var(R_{j,t})}{j} + \frac{Var(R_{k,t})}{k} + \frac{2Cov(R_{k,t}, R_{k,t-1})}{k}} \tag{3.10}$$

The Damodaran (1993) estimator overstates the price response towards intrinsic value when adjustment is incomplete (Boulter, 2007). When the interval ($j$) approaches ($k$), the errors within the numerator and denominator increasingly dominate the equation, forcing the speed of adjustment coefficient towards one. The Brisley and Theobald (1996) derive an estimator that adjusts for this error.

Theobald and Yallup (2004) construct two estimators without the use a limiting interval, which assume a lagged price response caused by traders initially under or over-reacting to information (Boulter, 2007).

Partial adjustment may be caused by non-synchronous trading as pointed out by Lo and MacKinlay (1990). They state that the speed of adjustment is a function of the autocorrelation and cross-autocorrelation terms within returns, caused by trading that is which is cyclical due to recurrences in trading activity. The under-reaction of stock prices will cause the series will be positively correlated and the over-reaction results in negative correlation. The time taken for intrinsic value to adjust is how long it takes to allow the positive or negative autocorrelation within the observed return series to dissolve.

Theobald and Yallup (2004) state that auto-covariances for lags one and two can be derived as:

$$Cov\{R_t, R_{t-1}\} = \frac{g}{2-g}[(1-g)v^2 - \sigma^2] \tag{3.11}$$

and lag two (-2) as:

$$Cov\{R_t,R_{t-2}\}= g\,\frac{(1-g)}{2-g}[(1-g)v^2-\sigma^2] \tag{3.12}$$

Since the cross-covariance between them is zero at all lags, the coefficient ($g$) may be expressed as a function of the auto-covariance structure:

$$1-g=\frac{Cov\{R(t),R(t-2)\}}{Cov\{R(t),R(t-1)\}} \tag{3.13}$$

The auto-covariance estimator is easy to estimate. A problem is the effect of non-synchronous trading. This occurs when thin trading occurs prices do not change over a long time, which leads to runs of zeros within the return series. This could result in autocorrelation that is distinct from traders under or over-reaction to information (Boulter, 2007).The basic procedure developed by Theobald and Yallup (2004) to adjust the covariance ratios estimators to nonsynchronous trading consists in lagging thecovariances for $q$ periods. Although, this removes the nonsynchronous trading effect, it is quite an *adhoc*procedure because it implies that there is prior knowledge on which lags to include in the calculation. The reportingof lags depends on the time needed to gather information for all the constituent stocks and to resolve the computation algorithm. On the other hand, the PAM is a straightforward calculation and achieves the same result (Helder and Sebastiao, 2009).The Single Index model is more suitable for solving the PAM than multi-factor models. This is because a multi-factor model introduces too many terms in the PAM, whilst the single index model transforms to a first order autoregressive model which can be solved simply. Thus far, there have been no multi-factor models included in any PAM that the author is made aware. It is agreed that the single index model as well as the multi-factor problem suffer from the joint hypothesis problem. In this instance the use of the single index model is not directly associated with asset pricing but with calculating the speed of adjustment characteristics of Australian and Chinese stocks. All asset pricing models suffer from the joint hypothesis problem. However, the incorporation of the Single Index Model in the PAM is not to facilitate asset pricing, but rather, to calculate the speed of adjustment. Therefore it appears the joint hypothesis problem does not directly affect the PAM.

The PAM assumes the long-run equilibrium equation is given by the single-index model:

$$R_t = a + \beta R_m + e \tag{3.14}$$

Where $R_t$ is the target return; a is the excess return; $\beta$ is the sensitivity of the stock to the market, $R_m$ is the market return; and e is the residual.

Similar to the model of Amihud and Mendelson (1987), the impact from noise trading is the difference between the fundamental return and the observed return.

The following hypothesis known as the PAM is postulated:

$$R_t - R_{t-1} = \delta(R_t - R_{t-1}) \tag{3.15}$$

$$R_t - R_{t-1} = \delta\big((a + \beta R_m + e) - R_{t-1}\big) \tag{3.16}$$

$$R_t = \delta a + \delta\beta R_m + (1 - \delta)R_{t-1} + \delta e \tag{3.17}$$

$$R_t = \delta a + \delta\beta R_m + (1 - \delta)\beta R_{m_{t-1}} + \delta e \tag{3.18}$$

Where $\beta R_{m_{t-1}}$ is used as a proxy for $R_{t-1}$.

Where $R_t$ is the return in time period t, $R_{t-1}$ is the return in time period t-1, δ is the speed of adjustment coefficient and e is the error term E[e]=0 and E~ N(0, $\sigma^2$). When δ equals 0 there is no adjustment, when δ equals 1 there is full adjustment and the market is efficient, when δ is greater than 1 there is an over-reaction to economic information and when δ lies between 0 and 1 there is partial adjustment or under-reaction to economic information.

There should be no opportunity to use information gathered in period t-1 to provide a correct assessment of the expected return. The information available at t-1, the time series of past returns, should not be able to be used to correctly determine the expected return. In utilising past information in this way the model makes this approach a test of weak-form market efficiency.

The first step is to calculate the alpha (excess return) and beta (systematic risk) by regression the stock's return against the market return. The beta is multiplies by the market return and added to alpha. The proxy used for the lagged return is $\beta R_{m(t-1)}$. The stochastic explanatory variable $R_{t-1}$ may be correlated with the error term, which would make the OLS estimator biased and inconsistent so that the estimates would not approximate their true population values. This correlation can be removed by finding a suitable proxy for $R_{t-1}$. Such a proxy is $\beta R_{m(t-1).}$

The single-index model is used in the PAM instead of a multi-factor model because the object of the PAM is to calculate the speed of adjustment coefficient. A multi-factor model would introduce too many terms in the PAM and would lead to difficulties in finding an appropriate proxy for $R_{t-1}$.

There is no autocorrelation or auto-covariance structure in this formulation of the PAM. It therefore avoids the problem of nonsynchronous or infrequent trading that effect many of the other models which estimate the speed of adjustment. In an efficient market, observed price should include new information to reflect changes to its fundamental value. Such an adjustment should be immediate if the market is strongly efficient (Fama, 1991). Thus the adjustment speed of stock price to the changed fundamental value due to economic news determines the degree of efficiency in the stock market (Marisetty, 2003).

Chiang et al. (2008) examines the speed of price adjustment in Chinese A- and B-share stock markets, using a VAR model to show that A-shares, which are owned primarily by domestic individual investors, adjust to information faster than do B-shares, which are owned primarily by foreign institutional investors. Their findings suggests that the speed of stock price adjustment for A shares is related to earnings per share, while that for B-shares is related to firm size and that A-shares react more quickly to bad news, while B-shares react more quickly to good news. The larger the firm size, the more prominent the stock. Thus, when a stock is known by more investors, it tends to increase the speed of adjustment. Empirical analyses of the determinants of the speed of adjustment based on both weekly and daily data indicate that stocks with higher information flows and more prominent status in the market adjust to information faster. For A-shares, stocks with higher earnings adjust to information faster, while the speed of adjustment for B-shares is correlated with firm size.

Black (1986), Amihud and Mendelson (1987), and Damodaran (1993) provided important evidence to enable the exploration of the PAM in this study and particularly in relation to the first issue of whether or not an adapted PAM is be useful in identifying and confirming pairs trading (contrarian) strategies. Therefore, based on the above discussion on the EMH, the following research questions have been formulated:

1. Are the Chinese (CSC) and the Australian resources markets weak-form efficient in the short-term?
2. Are the top 33 resources stocks in Australia (ASX) are weak-form efficient in the short-term?
3. Can cointegration and PAM identify contrarian strategies?
4. Can cointegration and PAM identify momentum strategies?

**3.3.2 Contrarian strategies and pairs trading**

As stated previously, contrarian strategies may be implemented on the basis of results from both cointegration and PAM analysis. This section presents the literature relating to contrarian strategies, with reference to the EMH. This focus is given due to the premise that if markets are weak-form efficient, then contrarian strategies will not be possible. The EMH proposes that rational investors will undo any disturbances caused by irrational investors; however, correcting mis-pricing can be risky and costly (Barberis and Thaler, 2003). Pairs trading take advantage of short-term mis-pricing with long-term mean reversion in order to produce profits. Pairs trading define a contrarian strategy of buying past losers and selling past winners. These actions are on the basis that herd behaviour from other traders can lead to mis-pricing (Lakonishok et al., 1994). This section will therefore concentrate on pairs trading, and evidence relating to contrarian strategies, including LOP and Markov switching.

The different approaches to Pairs trading will be outlined, and these include; the distance approach, cointegration approach, stochastic approach and stochastic residual approach. Then the LOP and Markov switching strategies will be discussed. Thereafter, LOP approach adapts the stage three trivariate cointegration test for Purchasing Price Parity (PPP) to a pairs trading strategy.

A Markov switching approach was previously utilised by Bock and Mestel (2009). Nonetheless, this study takes a different approach. It utilises the approach used by Brooks (2008) in modelling equity and bond yields (gilts). In doing so, a relative price ratio of the two stocks will be taken and checked for regime switching characteristics. A trading rule will be implemented based on this ratio.

The EMH asserts that financial markets are informationally efficient. All information is public and known by market participants and new information is immediately reflected in stock prices. The EMH states that an individual cannot consistently out-perform the market by using information already reflected in stock prices (Brearley, Myers and Allen, 2006). Therefore, prices are expected to follow a random walk and the equity market has no apparent memory. This means that asset prices do not follow any systematic pattern to be utilised by potential arbitrageurs in the short-term. The EMH states that all financial markets are fully efficient because prices always reflect fundamental values. This implies that no investment strategy based on current public information can beat the market and earn excess returns. According to the EMH, the best strategy is to passively hold the market portfolio and refrain from using any resources for active money management (Shleifer, 2000).

The EMH is based on a number of underlying assumptions. One assumption is that agents are utility maximisers with rational expectations. In finance, rational decisions are optimal ones, and investors are often described as rational if they pursue utility maximization. Rational choices should be consistent and coherent (Tversky and Kahneman, 1981);individual rationality is assumed. This means that, according to Bayes' theorem, market participants update their beliefs correctly when new information is received. Bayesian thinking contends that agents assign probabilities to unique events. It is assumed that these agents revise their probabilities in accordance with new information. Another assumption relates to consistent beliefs, which holds that market participants use new information in a correct manner and that they correctly allocate resources using their precise economic information. As a result, participants make correct decisions and forecast future unknown variables (Barberis and Thaler, 2003).

Rational expectations are based on the fact that all the participants have full and correct information about all particulars of a given situation and they reach the correct and most efficient conclusions in a given scenario. Such participants are often seen as rational agents, who always choose to act so that the expected utility is optimised from the given information. The prices in markets are therefore established by economic agents who act according to Bayes' theorem and have rational preferences.

The EMH can apply in the long-run, even if some market participants over-react and others under-react in the short-run when faced with new information. In order for the EMH to apply, traders must react randomly, trusting that their reactions are normally distributed so that abnormal returns are not possible. Investors make systematic errors, which are exploited in the market by arbitrageurs, and this eliminates their influence on market prices. This implies that one investor can be mistaken, but the market and the prices are always correct because the market is efficient. If markets are cointegrated then participants have rational expectations in the long-run and the market is efficient. In the short-term, there is stochastic volatility and inefficiency which allows for arbitrage opportunities.

#### 3.3.2.1 EMH in Emerging Markets

The findings of weak-form efficiency studies from developing and less developed markets are conflicting. The less developed markets suffer from ‘thin’ trading. Large traders may also manipulate the market. Emerging markets are less efficient. The findings can be split into two groups: The first group shows evidence of weak-form efficiency in developing and less developed countries (c.f. Chan, Gup and Pan, 1992, Dickinson and Muragu, 1994; Ojah and Karemera, 1999).The latter group find that developing and less developed markets are not weak-form efficient (Abdullah and Ullah, 2008). Lo and MacKinlay (1990) find that contrarian profits could also be driven by lead-lag effects between winner and loser stocks. Their results showed that around 50% of contrarian profits are generated by such lead-lag effects (Bolgun et al., 2009).

#### 3.3.2.2 Contrarian Strategies and Abnormal Returns

The contrarian strategy is believed to earn abnormal returns. De Bondt and Thaler (1985) were the first researchers to investigate the contrarian strategy. They developed the over-reaction hypothesis, and examined the impact of such behaviour on stock prices. Levy (1967) examined momentum, but the results are controversial. Jegadeesh and Titman (1993) were the first to demonstrate clear evidence that momentum effect is able to generate significant abnormal returns (as cited in Hamalenian, 2007). Jegadeesh and Titman (1995) find that contrarian profits are, in part, due to over-reaction to company specific information shocks rather than price reactions to common factors. Jegadeesh and Titman (1995) extended Lo and MacKinlay’s (1990) research by associating lead-lag effects with the dynamics of price reaction to common factors. Jegadeesh and Titman (1995) find that most of the contrarian profit is driven by over-reaction to idiosyncratic news (as cited in Bolgun et al.,2009). Baytas and Cakici (1999) challenged the over-reaction hypotheses. They contended, using international data, that long-run investment strategies, based on size and price, produce higher returns than those based on prior performance(as cited in Hamalenian, 2007). Pairs-traders can take advantage of the undisciplined over-reaction displayed by individual investors. Pairs trading exploits short-term mis-pricing, present in a pair of securities (Vidyamurthy, 2004).

Several empirical studies have shown that it is actually possible for one group of stocks to out-perform another group. This has caused frustration for the proponents of the rational paradigm, because rational models are unable to explain this tendency. For many years, researchers argued that this strategy can outperform the market in the long-run. Contrarian investment strategies work, because investors do not know their limitations as forecasters. As long as traders think they can forecast favoured and unfavoured stocks, returns are possible using contrarian strategies (Dreman, 1997).

A contrarian trader invests when it is believed that the consensus opinion appears to be wrong. They believe that herd behaviour from other traders can lead to mis-pricing. As previously mentioned, contrarian investment strategies are based on long positions in value assets that will appear under-valued and, additionally, short positions in growth assets that will appear overvalued (Lakonishok, Shleifer and Vishny, 1994). Widespread pessimism about a stock will, for example, lead the stock price down and as a consequence over-state the risk of the company and under-state the likelihood of returning to profitability. The contrarian looks to buy and sell assets when the herd appears to do the opposite. This may indicate a possibility of long-term profitability.

The EMH has been violated by the performances of stock returns in some studies. Equilibrium models are commonly employed to examine these contradictions. These models are subject to the joint hypotheses problem; abnormal returns may indicate the equilibrium model used is incorrect, rather than showing market inefficiency. Fama (1998) also argued that the determination of long-term inefficiency is sensitive to statistical methodology. A clear violation of the EMH lies in the profitability of pairs trading strategies. Pairs trading rely on the existence of strong arbitrage forces so that the mis-pricing of the stocks in a pair is eliminated soon after the position is opened. Traditionally, pairs trading have identified trading pairs based on correlation and other non-parametric rules. This study selects trading pairs based on long-term cointegrating relationships between two stocks. Cointegration techniques allow the formation of pairs in a linear process so that the combined pair is stationary (Caldeira and Moura, 2013). An extrapolation of pairs trading strategies consists of the operation of a group of stocks against another group of stocks; or, in other words, a strategy of generalised pair trading (Caldeira and Moura, 2013).

#### 3.3.2.3 Pair Trading

Gatev et al. (1999) studied pairs trading by using Wall Street data from 1967 to 1997. They find that over a six-month trading period, the pairs-trade produced a return of about 12% per annum. Their test controlled for transaction costs and used randomly selected pairs. They constructed a cumulative total returns index for each stock, and chose a matching pair for each stock by finding the security that minimises the sum of squared deviations between the two price series. Stock pairs are formed by matching in daily prices, and prices include dividends. They also include results by sector, thus restricting stocks to the same industry. A trade was opened when prices diverged by more than two historical standard deviations. Opened positions were closed out at the next crossing of the prices.

Do, Faff and Hanmza's (2006) research also investigated pairs trading. Their pairs trading strategy modelled mis-pricing at the return level and not on the price level. The strategy begins with the assumption that there is equilibrium in the relative valuation of the two stocks measured by a spread. Mis-pricing is a state of disequilibrium, quantified by the residual spread function $G\ (R_tA, R_tB, U_t)$, where $U$ denotes some exogenous vector which captures the mis-pricing. The residual spread function captures any excess over a long-term spread. Market forces lead to mean-reversion of the spread in the long-run. Trading positions are opened once the mis-pricing is large and the expected correction time is short.

Pairs trading are also referred to as statistical arbitrage, which is an equity trading strategy that uses time series methods to identify relative mis-pricing between pairs of stocks (Do et al., 2006). In statistical arbitrage, mean-reversion is expected to take place based on historical patterns (c.f., Vidyamurthy, 2004). Statistical arbitrage seeks to profit by trading two highly correlated stocks, typically from the same sector by going long in one, and short in the other. A widening in the spread between the two stock prices represents an opportunity to buy the lesser one, and short sell the higher one. Once the spread reverts to its fundamental value, it will yield a profit (Vidyamurthy, 2004).

In order to develop the LOP and Markov strategies under the contrarian approach, it is first necessary to discuss the existing pairs trading methods. This section describes three main methods to implement pairs trading, which Do et al. (2006) refer to as the distance method, cointegration method and stochastic spread method. The distance method is used in Gatev et al. (1999) and Nath's (2003) research; the cointegration method is detailed in Vidyamurthy (2004). The stochastic spread approach is detailed in Elliot et al. (2005).

The distance method measures the co-movement in a pair by the sum of squared differences between the two normalised price series. Trading occurs when the distance reaches a certain threshold, determined during the formation period. Gatev et al. (1999), chose the pairs by selecting a matching partner for each stock that minimised the distance. Trading is initiated when two historical standard deviations have been reached during the formation period. Nath (2003) kept a record of distances for each pair in the sample population, so that each time an observed distance crossed a trigger of 15 percentile, a trade was entered for that pair.

The cointegration approach is demonstrated by Vidyamurthy (2004) who explored the possibility of using cointegration (Engle and Granger, 1987). If two time series that are both integrated of order d, can be linearly combined to produce a single time series that is integrated of order d − b, b >0, the most simple case of which is when d = b = 1, then they are cointegrated. To test for co-integration, the log price of stock A is first regressed against log price of stock B, in what is called cointegrating regression:

$$\text{Log}\ (pA_t)\ \gamma \log\ (pB_t) = \mu + \varrho_t \tag{3.19}$$

where $\gamma$ represents the cointegration coefficient, and the constant term $\mu$ capture some sense of “premium” in stock A versus stock B. The estimated residuals are then tested for stationarity, hence cointegration, using the Augmented Dickey-Fuller test.

The stochastic spread method was proposed by Elliott et al. (2005) model, the mean reversion behaviour of the spread between the paired stocks in a continuous time setting, where the spread is defined as the difference between the two prices. The spread is driven by a latent state variable x, assumed to follow a Vasicek[5] process:

$$dx_t = \kappa\ (\theta - x_t)\ dt + \sigma dB_t \tag{3.20}$$

where $B_t$ is a standard Brownian motion[6] in some defined probability space. The state variable is known to revert to its mean $\theta$ at the speed $\kappa$. By making the spread equal to the state variable plus a Gaussian noise, or:

$$y_t = x_t + H\omega_t \tag{3.21}$$

the trader asserts that the observed spread is driven mainly by a mean reverting process, plus some measurement error where $\omega_t \sim N(0, 1)$.The stochastic residual spread method in pairs trading was proposed by Do et al. (2006) who consider that pairs trading to be based on the

[5] The Vasicek model (Vasicek, 1973) describes the evolution of betas using weights.
[6] Brownian motion is a continuous version of a random walk (its short-term behaviour is unpredictable). Batchelier developed the theory in 1900; if a stock evolves by a random walk, its short-term path is unpredictable, and leads to the EMH’s proposition that the future prices of stocks are random (Rice, 2007).

existence of mean reversion in relative mis-pricing between two assets. The method here starts with an assumption that there exists some ‘equilibrium’ in the relative valuation of the two stocks. Mis-pricing is construed as the state of disequilibrium, quantified by a residual spread function G (RAt ,RBt , Ut) where U denotes some exogenous vector. The ‘residual spread’ function captures any excess over and above some long-term spread. Through the market forces, the relative valuation should mean revert to equilibrium in the long-run.

Identifying and understanding scenarios in which pairs are, ex ante, more likely to converge appears crucial to understand the price formation process. In the international context, Andrade et al. (2008) documented annual excess returns of about 10% for the Taiwanese stock market between 1994 and 2002. They show that uninformed trading shocks are a major driver of the strategy's profitability.

#### 3.3.2.4 The Law of One Price strategy (LOP)

As previously stated, one of the pairs trading/contrarian strategies involves the use of the LOP. The law of one price (LOP) is one of the most frequently tested economic laws. Some factors, such as transaction costs, tariffs, nontariff barriers, pricing to market, exchange rate risk, and trade regionalization, may prevent convergence of international prices (Milkovic, 1999). The law of one price (LOP) states that once prices are converted to a common currency, the same good should sell for the same price in different countries. Evidence does not support the hypothesis that the deviations from the LOP dampen quickly (Milkovic, 1999).

Caporale et al. (2006) ran tests of PPP using the stage-three trivariate cointegration test. In its absolute form, the PPP condition suggested that the nominal exchange rate should be proportional to the ratio of the domestic to the foreign price level, that is:

$$S_t = \alpha + \beta_0 P_t - \beta_1 P_t^* + \mu_t \qquad (3.22)$$

$S_t$ is the nominal exchange rate, $P_t$ is the Australian resources stock; $P_t^*$ is the CSC stock; and $\mu_t$ stands for the regression errors. This is known as a trivariate relationship.

When national and international markets are performing well arbitrageurs will eliminate any mis-pricing between geographical locations. If goods and services follow the law of one price, then it is argued that the absolute level of the exchange rate should cause traded goods and services to have the same price in all countries when measured in the same currency (Appleyard et al., 2010). The stage three trivariate model tests the absolute version of purchasing price parity, which is the reason for the use of the nominal exchange rate.

The next step is to consider the LOP strategy, which is appropriate when this study focuses on international indices. If stocks in the CSC Index and Australian resources stocks are good substitutes for each other they should be priced to the same fundamental value in efficient markets in the long-term. If one of the stocks in one index is mispriced in the short-run, rational investors will take advantage of this mis-pricing by selling the relatively over-priced one and purchasing the relatively under-priced one to earn a profit. Consequently, their prices will eventually revert to the fundamental value. There should be a long-run equilibrium, and the spread between them should be stationary. If they are indeed cointegrated, trading strategies which exploit the mean reverting property of the spreads between the pairs of stocks should result in a profit. The LOP strategy has been adapted from the stage three trivariate cointegration test of purchasing price parity[7] and has been applied to pairs trading. As LOP accounts for exchange rates, it is particularly suited to pairs trading between different countries. The LOP is a new model for pairs trading developed specifically for this study.

If the variables in the LOP model are find to be non-stationary, then the Engle-Granger (1987) co-integration method will be applied. Given that Equation (2) represents a bivariate relationship, the Engle-Granger two-step method may be appropriate. This method involves estimating the long-run PPP equation by the standard regression method, and then the residuals are recovered for co-integration tests. These residuals are then tested for stationarity by applying the Augmented Dickey-Fuller and the Phillips-Perron unit root tests.

The contrarian strategy was discussed. Two new strategies were developed based on the theory of noise traders and informed traders. Noise traders are irrational, over-confident retail investors who trade on misinformation. This misinformation causes the stock pairs to diverge temporarily and then converge back to the (mean) long-run equilibrium. This is captured by the LOP strategy.

The issue is whether or not arbitrage profits produced with LOP strategies?

[7] The PPP states that any given commodity tends to have the same price world-wide when measured in the same currency (Appleyard et al., 2010).

### 3.3.2.5 Markov switching strategies

Kyle (1985) contended how an informed trader trades strategically and gradually to make a profit and their information is gradually incorporated into the stock's price until the information becomes public, because that the announcement dates, there is unexpected surprise at that time.

According to Wang (1994), informed investors trade on their private information. However, uninformed investors are unable to immediately identify the private information. Learning permits uninformed investors to revise their initial assessment of informed trading. Thus, they gradually become informed and cause return continuation in prices. However, the absence of private information leads to return reversals (Hameed et al., 2008).

Numerous studies have applied Markov regime switching models in studying the behaviour of the stock market. The first among these studies is that of Hamilton (1989) who modelled regime shifts through the Markov switching autoregressive model.

This current study analyses pairs trading statistical arbitrage between 33 pairs of stocks from the CSC Index and the Australian resources stocks. The pairs of stocks are selected using market capitalisation information and cointegration. After identifying potential pairs in this way 5 pairs had regime switching characteristics. These were all large-cap stock pairs. The cointegrated pairs were transformed in to a relative price ratio and Markov switching models were employed.

The Hamilton (1989) Markov switching process proceeds as follows (Chan, 2012);

1. the two regimes are characterised by different probability distributions of the prices.
2. the log of the prices of both regimes is represented by normal distributions, except that they have different means and standard deviations;
3. there are transition probabilities among the regimes;
4. the study determines the parameters that specify the regime probability distributions and the transition probabilities by fitting the model to past prices, using maximum likelihood estimation;
5. Based on this model, the author determines the expected regime of the next time step.

The pairs were transformed in to a relative price ratio and Markov switching models was employed. The price ratio $Rat_t = (P_t^A/P_t^B)$ of two assets A and B are assumed to follow a mean reverting process, which implies that short-term deviations from the equilibrium ratio are balanced after a period of adjustment (Bock and Mestel, 2009). The ratio exhibits a switching means (Bock and Mestel, 2009). The regime shifts are governed by a Markov chain. The current regime $s_t$ is determined by an unobservable variable. The inference of regimes is based on state probabilities (Bock and Mestel, 2009). The price ratio exhibits a long-run equilibrium. Deviations from this equilibrium result in short-run arbitrage opportunities. The ratio divides the Australian stock by the Chinese stock. If the ratio is high, Australian stocks are overvalued and Chinese stocks are under-priced. The strategy is to sell Australian stocks and simultaneously purchase Chinese stocks. If the ratio is low, Australian stocks are under-priced and Chinese stocks are over-priced. The strategy then is to sell Australian stocks and purchase Chinese stocks.

Informed traders' trades are captured by the Markov switching strategy. Informed traders are fundamental or feedback traders. They are also rational traders. They use proprietary methods and sophisticated analysis and research to inform their investments. When informed traders they act on this private information, this causes the stock pairs to diverge and then converge to their fundamental values which may be the original mean value or to a new mean regime.

The theory of pairs trading developed in this study assumes that there are two types of traders, noise traders and informed traders. Noise traders are irrational and uniformed traders who trade on misinformation. Informed traders are rational traders who trade on private information. Both the trades of noise traders and informed traders cause the stock pairs to diverge. Noise trader's under-react or over-react to economic news which causes the stock pairs to diverge. Informed traders trade on private information gleaned through sophisticated methodologies and analysis, which causes the stock pairs to diverge and then converge once this private information, is revealed publicly. This divergence is only transitory for noise traders, whose divergence self-corrects and returns to the mean value. For informed traders, this divergence is more permanent; the stock pairs may return to the original mean or to a new mean regime. The effects of noise traders are assumed to be captured by the LOP strategy, whilst those of informed traders are assumed to be captured by the Markov switching strategy.

The issue is whether or not profits produced by Markov switching strategies arbitrage.

### 3.3.3 Momentum Strategies

It is recalled that momentum strategies are the opposite of contrarian strategies. These strategists buy past winners and sell past losers, and strategies include use of cointegration and PAM analysis. This section deals with the literature relating to momentum strategies that include index tracking and enhanced indexing.

Extending the prospect theory of Kahneman and Tversky (1979), Jegadeesh and Titman (1993) proposed a Model of Momentum to examine market efficiency and find that stock prices are predictable under that Model. In addition, the further developed prospect theory by Daniel and Titman (2000) on over-confidence also indicates that certain stocks could generate greater over-confidence among investors, resulting in stronger momentum effect. Jegadeesh and Titman (1993) studied the connection between earnings announcements and momentum profits within event study method, and find evidence in favour of momentum effects. Chan et al. (1996; 1999) demonstrated that under-reaction to economic news on earnings explains the momentum profits. Chanet al. (1996) study the ability of past returns and public earnings surprises and were able to predict subsequent returns at a six monthly horizon (as cited in Hamalainen, 2007).

Momentum strategy buys stocks which have a strong historical performance and sells stocks which have done poorly. De Bondt and Thaler (1985) argued that contrarian strategy outperforms the market. Jegadeesh and Titman (1996) conducted an out-of-sample test for their 1993 study over the period, 1990-1998. They find similar results as Jegadeesh and Titman (1993) study (as cited in Hamalainen, 2007).Contrarian strategy advocates buying losers and selling winners based on historical data (Conrad and Kaul, 1998). There is ample empirical evidence of success of both strategies.

Conrad and Kaul (1998)studied the profitability of 120 different rule-based trading strategies on the NYSE and the AMEX from 1926 to 1989. Using a methodology that differed from the one used by Jegadeesh and Titman (1993), that is;

1. they include the shares contained in their test sample in their portfolios, as distinct from Jegadeesh and Titman (1993) who selected only one “winner” and one “loser” decile from the whole sample.
2. they assigned each share a weighting according to its relative performance to the “market portfolio”. The market portfolio comprised all stocks contained in the test sample. If a share performed better than the market portfolio it received a long weight

scaled upwards by how much the share outperformed the market portfolio. The opposite applied for the short position.

3. if a share significantly underperformed in the market portfolio, it was assigned a relatively large percentage of the total short positions.
4. the overall stock position weights were confined in such a manner that the sum of all long position was equal to all short positions, in effect creating a zero-cost strategy.

Conrad and Kaul (1998) tested momentum strategies with holding and formation periods (K and J) of 1 to 36 months, and they implemented strategies with equal holding and formation periods. They confirm Jegadeesh and Titman's (1993)results.

Rouwenhorst (1998)studied momentum profits across 12 European markets using 2190 shares over the period, 1978-1999. He investigated whether the momentum anomaly, documented by Jegadeesh and Titman (1993), was the result of data mining processes. Schlieric, De Bondt and Weber (1999)replicated Rouwenhorst's (1998) study, but used a larger sample of stocks and a slightly different ranking method. The study involved a sample of 375 companies listed in the Prime segment of the Frankfurt Stock Exchange, for the period 1961-1991. They ranked the stocks in the sample according to their returns in excess of a market index over the past J months. They used formation periods of one, three, six, and 12 months Schiereck et al. (1999) formed winner and loser portfolios with 10, 20 or 40 shares, containing the top and bottom 10, 20 or 40 ranked shares in terms of cumulative excess returns. Again a zero cost strategy was created by buying the winner portfolio and selling the loser portfolio short. They find that all their momentum strategies were profitable.

Ryan and Obermeyer (2004) used an approach similar to Jegadeesh and Titman (1993) on a sample of a replicated DAX 100 index of Germany's 100 largest and most liquid stocks during the period 1990 and 1999. They find that the momentum profits generated were statistically significant, even after transaction costs.

#### 3.3.3.1 Joint Hypothesis Problem

Equilibrium model is the most common model employed to examine the apparent contradiction between the EMH and the profitability of momentum strategies. Results from these models, however, are subject to the potential problem of 'joint hypotheses as pointed out in Fama (1998). Abnormal returns may indicate the equilibrium model adopted is inappropriate, instead of implying market inefficiency. Fama (1998) also argued that determination of long-term inefficiency is sensitive to statistical methodology.

The prospect theory of Kahneman and Tversky (1979) and Jegadeesh and Titman (1993) propose a model of momentum to examine market efficiency; both studies find that stock prices are predictable under the momentum model. After being adjusted by equilibrium models of CAPM or the Fama-French Three-Factor Model, momentum strategy generated significant excess returns. In addition, the extension of prospect theory by Daniel and Titman (2000) on over-confidence also indicated that certain stocks generate greater over-confidence among investors, resulting in a stronger momentum effect.

To the extent that the momentum strategy has been supported by various studies based on equilibrium concept regardless of the joint-hypothesis criticism, this study seeks to examine momentum-related effects through an alternative model based on the concept of statistical arbitrage. Statistical arbitrage can be used to extend findings in the existing empirical literature on anomalies out of disposition and over-confidence effects. Therefore, tests of market efficiency based on the statistical arbitrage approach avoid the joint-hypothesis problem of equilibrium models (Sudak and Sudova, 2010).

#### 3.3.3.2 Index Tracking and Enhanced Indexing

Alexander (1999) introduced the cointegration approach for portfolio modelling. Alexander et al. (2002) examined the performance of various long-short trading strategies using the S&P 500 index. The S&P 100, which is a subset of the S&P 500, measures the performance of 100 companies in the US Stock market, which exhibit the highest market capitalisation. Alexander et al. (2002) constructed long-short portfolios optimised on different model parameters, such as training period, composed tracking error, and number of stocks contained in the portfolio. Their models based on cointegration, exhibited robust alphas with low volatility and absence of autocorrelation.

The issue is whether or not cointegration and PAM can identify momentum strategies in the context of this study.

#### 3.3.3.3 Index Tracking

Index tracking involves constructing a portfolio of stocks in such a way that it replicates the behaviour of a given stock index, with fewer stocks being used to replicate the index. Alexander (1999) used such a tracking procedure based on cointegration between the index and its constituent series. In fact, the procedures suggested in the present thesis are directly connected to Alexander’s (1999), the main difference being that this study applies the technique to an international benchmark (the CSC) using a portfolio of Australian resource stocks.

The issue here is whether or not index tracking strategies are profitable and whether or not they closely track the CSC Index?

**3.3.3.4 Enhanced Indexing**

The popularity of index funds can be attributed to their performance. Over the long-run, index funds have outperformed actively managed funds, once costs are taken into account. It is possible, however, that some active fund managers can consistently add value. Enhanced indexing was developed in response to the difficulty in beating there market. The purpose of the funds is to track the index closely, while still providing some value added. Enhanced indexing provides greater control of risk over other active strategies as they allow investors to maintain a diversified portfolio.

While it is clear that enhanced indexing is an active strategy, what is not as clear is that index tracking is also an active strategy. It actively selects stocks to replicate a portfolio and the portfolio needs to be rebalanced from time to time.

The enhanced indexing strategy involves going long in one portfolio and simultaneously shorting another portfolio. A global portfolio consisting of daily returns is the sum of the daily returns of the long and short portfolios. The study uses 16 combinations of artificial benchmarks to implement different long/short equity market neutral portfolios; (1) plus 5% vs. minus 5%; (2) plus 10% vs. minus 10%; (3) plus 15% vs. minus 15% (Dunis and Ho, 2005).

This thesis proposes that stocks be examined through use of the PAM for under-reaction and over-reaction. It is expected that index tracking and enhanced indexing strategies consist of stocks which exhibit under-reaction. This is because index tracking and enhanced indexing are momentum strategies. This may be explained using theory proposed by Wang (1994) which states that as the private information of informed investors is revealed and becomes public and available to uninformed investors these investors replicate the strategies of informed investors leading to herding behaviour.

The issue is whether or not enhanced indexing strategies are profitable and whether they closely track the CSC index.

Gitman et al. (2001) define a hedge as “a combination of two or more securities into a single investment position for the purpose of reducing or eliminating risk” (p.375). It may involve buying an underlying asset and simultaneously buying a derivative security, for example, a put or a future. In the case of futures, hedgers are commodity producers or processors who use futures to protect their underlying investment in the commodity. A fundamental characteristic of a hedge is that the two assets chosen must have opposite pay-offs. Their combination, allows the hedger to hedge in the direction of exchange rate risk. This is important, as commodity prices are volatile; it brings certainty in an uncertain transaction. The other clear benefit of a long-short investment hedge, such as the index tracking or enhanced indexing strategies mentioned above, lie in risk reduction. By going long in a replicated index and going short in a replicated index, simultaneously, the strategy eliminates systematic risk. However, there is still risk. In this study, cointegration is used to implement the index tracking and enhanced indexing strategies. As long as the cointegrating relationship is maintained, the strategies should perform well. If the relationship breaks down, however, then the strategy will fail.

### 3.3.4 Gaps in the literature

The fundamental difference between this study and previous studies lies in the fact that international arbitrage strategies are examined between two countries’ stock markets where the two countries have strongly growing trade and investment relationships. However the study also differs from previous studies in the method data. A new PAM was formulated incorporating the single-index model, because the previous model proposed by Amihud and Mendelson (1987) discounted future cash-flows to determine intrinsic value, and future cash-flows and discount rates are uncertain. This leads to uncertainty about the accuracy of speed of adjustment coefficient values as to over-reaction and under-reaction of stocks to economic news. The re-formulated PAM uses the adjustment lagged abnormal return to the target return; so its values are more certain than those used by Amihud and Mendelson (1987) and are also a test of weak-form efficiency.

The study uses two different approaches to pairs trading. A LOP strategy is employed for the first time. This approach adapts the Stage Three Cointegration Tests for PPP. A Markov switching strategy is also used. Changes in the regime in a stock market can be due to external shocks caused by a shock in another market. This study uses a Markov regime switching model to identify trading opportunities between Chinese and Australian stocks. The choice of Markov switching as a methodology is not new; what is new is the data set of the top 33 Chinese and Australian stocks, and the use of Markov switching for pairs trading. Whilst it is true that Bock and Mestel (2009) used Markov switching for pairs trading, this study uses an approach used by Brooks (2008) who traded equity yields and bond yields. The study therefore uses a new dataset, and a new approach for pairs trading.

The index fund offers individual investors the lowest fees, to avoid trying to outsmart the market and to represent the market with as little distortion as possible. Index funds attempt to track the overall market without bias. The index tracking and enhanced indexing strategies use the CSC as the benchmark and a portfolio of Australian resources stocks as the constituents. This is a new approach to international asset trading. It utilises a completely new data set and has implications for conclusions regarding the integration of the Chinese and Australian markets. Typically, studies such as Alexander (1999) and Alexander et al. (2002) have used domestic benchmarks (an Index) and the constituents of that index, as elements of the index tracking/enhanced indexing strategy. The implication is that markets are segmented by national borders. This approach provides a test of whether the growing trading and financial integration between China and Australia extend to their stock markets.

### 3.4 Additional evidence

Individual investors are noise traders. They are motivated by psychological heuristics and biases; mental accounting and risk seeking may lead investors to hold onto losing investments and sell winners; representativeness may lead to buying securities with strong recent returns because they view recent return patterns to be representative of the underlying distribution of returns; and over-confidence may cause investors to trade too aggressively and lead to momentum in stock returns (Barber, Odean and Zhu, 2009). In this section, additional evidence is provided on the EMH, behavioural finance, and pairs trading.

#### 3.4.1 Efficient Markets

It has been already observed that a market is weak-form efficient if its past information cannot be utilised to produce future returns (Fama, 1970). According to the EMH, an efficient market is one that adjusts to economic news instantaneously. If investors are not irrational, then random stock price movements are evidence of market efficiency. The EMH holds that investors incorporate all available information into their decisions on the price at which they are willing to purchase or sell financial stocks. Therefore, at any point in time, the current stock price incorporates all available information. Due to the keen competition between investors, when new information becomes known, the stock price adjusts quickly. The adjustment is not always perfect. Sometimes it is too large, and at other times too small. In the long-run it balances out. The new stock price is set after investors have fully assessed the likely impact of the new information.

The weak-form of market efficiency holds that past data on stock prices are of no use in predicting future stock price returns. If this is correct, then there will be no profits made from contrarian and momentum strategies. The implications of the EMH are profound. It has considerable bearing on security analysis and stock valuation procedures and on the way stocks are selected for investment purposes. One proposition is that investors should not try to beat the market. They should spend less time analysing stocks and more time on reducing taxes and transaction costs, eliminating unnecessary risk and construct a widely diversified portfolio. The only way to increase returns is to invest in riskier stocks.

### 3.4.2 Information Gathering

Grossman and Stiglitz (1980) find that when obtaining information is costly there cannot be market equilibrium where prices are at intrinsic values. If prices always reflect economic information, and this information is costly to obtain, there is no incentive for economic agents to be informed; they can simply observe prices at no cost. Milgrom and Stokey (1982) find that if there were not noise trading in the stock market, no trade would happen even though traders receive different signals in the stocks' fundamental value. Shleifer and Vishny (1997) examined a case where an arbitrageur borrowed money from a uniformed investor, who attempted to determine whether the arbitrageur's position was sound by observing earnings. A temporary shock may lead to the investor recalling the loan, even though the arbitrageur's position has not changed from the time when the initial loan was made. This suggests that the assumptions of the EMH may not hold. Retail investors are noise traders or individual investors who invest in a manner that is inconsistent with the rational construct. These investors are undiversified (Benartzi and Thaler, 2001), loss averse (Odean, 1998a) and over-confident (Odean, 1999). Investor over-confidence leads to excessive trading (Benos, 1998; Odean 1998b).

The volatility of stock prices can be explained in terms of fundamental and non-fundamental shocks (Wang, 1994; Campbell, Grossman and Wang, 1993). Fundamental shocks induce price changes by affecting earnings, dividends or discount factors. De Long et al. (1990) note that when information arrives, all investors do not respond the same way. Some investors are informed, and respond only to fundamental shocks. Informed traders have rational expectations from fundamental shocks, purchasing stocks when their gathered information indicates stocks are under-valued and selling when information reveals stocks are overvalued. They push prices towards their fundamental values. Noise traders falsely believe that fundamental and non-fundamental shocks carry true information. They buy and sell stocks based on their incorrect beliefs. Therefore, there are two types of traders; noise traders and informed traders. The behaviours of noise traders may push stocks away from their fundamental values in the short-term, but these stocks will be efficient in the long-run.

In Wilson and Marashdeh's (2007) research, a two country example is given, which shows that the real exchange rate will follow a martingale process so that PPP cannot hold. It is explained that this result does not only rely on not correctly distinguishing the levels of prices from the growth in prices. Using Johansen's methodology, the vector error correction model (VECM), shows the short-run dynamic responses of the exchange rate and stock prices. This demonstrates that the correction to long-run equilibrium allows systematic profits to be obtained in the short-run. Market inefficiency in the short-run ensures market efficiency in the long-run.

### 3.4.3 EMH and Rationality

If individual rationality is assumed, it means that market participants update their beliefs correctly, using new information in accordance to Bayes' Theorem.[8] Probabilities are interpreted as a subjective measure of belief. Bayesian thinking allows agents to assign probabilities to unique events. It is assumed that these agents revise their probabilities in accordance with new information. Consistent beliefs entails that market participants use new information in a correct manner and that they can correctly allocate resources using their precise economic information. This will enable participants to make correct decisions and forecast future unknown variables (Barberis and Thaler, 2003).Rationality Choice theory is based on the premise that all the participants reach goals in an optimal manner. They have full and correct information about all the particulars of a given situation, and therefore reach the right and most efficient conclusions in a given scenario. These kinds of participants are often seen as rational agents, who always choose to act so that the expected utility is

[8] A Bayesian approach views an individual's approach to forming their beliefs about the world can be reduced to probabilities which can be elicited by different odds (Rice, 2007).

optimised from the given information. The prices in markets are established by economic agents who act according to Bayes' Theorem and have rational preferences.

The EMH can be right even if some market participants over-react, and others under-react, when faced with new information. Investors make systematic errors which are exploited in the market by arbitrageurs and eliminate the influence on market prices. This implies that one investor can be wrong, but the market and the prices are always right and the market is efficient. Behavioural finance is an alternative to the EMH. The concept of behavioural finance proposes that movements in stock prices away from their fundamental value occur as a result of to the presence of rational traders. In contrast, EMH proponents claim that rational investors will quickly undo any disturbances caused by irrational investors. Whenever a mis-pricing occurs, a profitable event is generated, which rational market participants take advantage of and correct the mis-pricing. If a stock has lost a significant part of its value, nervous investors might settle early to avoid further losses (Shleifer and Vishny, 1997). Proponents of behavioural finance contend that correcting the mis-pricing in the market can be both risky and costly and, therefore, highly unattractive (Barberis and Thaler, 2003).

In addition, even if a perfect substitute asset exists, this security might be mispriced as well. Likewise, the mis-pricing of the original asset being exploited can worsen in the short-run (noise trader risk). The arbitrageur will be faced with the risk that irrational, pessimistic investors become more so, decreasing the price even more, this can create losses for the investor. Noise trader risk is an important issue, as it can force the arbitrageur to settle the position earlier than he or she initially wants to. If the risk is systematic, either fundamental or noise trader risk, limits to arbitrage will exist in the sense that many individual arbitrageurs adding a small percentage of the stock to their portfolios will not effectively eliminate the mis-pricing (Barberis and Thaler, 2003). The different risk factors are considerable, as they may restrain investors from correcting the mis-pricing in the market and consequently force rational investors not to act completely rationally, as the theory predicts.

Arbitrageurs may be reluctant to correct the mis-pricing due to excess risk and additional costs, which the investment give rise to. In conclusion, the behaviour of irrational investors affects pricing in the market and the behaviour of the rational investors. Therefore, the EMH seems to be violated. However, in this research cointegration and Markov switching is implemented. Both these methodologies take into account the view that in the short-run, there may be divergences from the fundamental value; but in the long-run, there is equilibrium. That being the case, it is not expected that arbitrage will be limited in these circumstances.

### 3.4.4 Prospect Theory

The prospect theory of Kahneman and Tversky (1979), Jegadeesh and Titman (1993) propose a model of momentum to examine market efficiency. It finds that stock prices are predictable under the momentum model. The extension of prospect theory by Daniel and Titman (2000) on over-confidence also indicates that certain stocks could generate greater over-confidence among investors, resulting in a stronger momentum effect. Other studies argue that momentum returns only appear in a bullish market rather than in a bearish market.

Momentum strategies have been supported by various studies based on equilibrium model regardless of the joint-hypothesis criticism. This study intends to examine momentum related effects through an alternative model based on the theory of statistical arbitrage. Statistical arbitrage is a long-term horizon trading strategy that produces riskless profits. Therefore, tests of market efficiency based on the statistical arbitrage approach avoid the joint-hypothesis problem of equilibrium models.

The statistical arbitrage approach in this thesis explores the disposition and over-confidence effects for possible causes of tested results. The author find significant momentum effects, and concluded that investor over-confidence is the primary reason causing the bullish market momentum effects. The significant bullish market momentum phenomenon is a result of similar behaviour of the two major investor groups, while the absence of bearish market momentum is due to the difference between them in trading pattern there. Findings of this thesis contribute to the understanding of long-term market anomalies and their major driving factors. The model free statistical arbitrage analysis adds to those based on equilibrium asset prices in providing conclusions free of the joint hypothesis problem.

Chan et al. (1996) show that stock prices respond sluggishly to earnings news and that a substantial portion of the momentum effect is focused on subsequent earnings announcements (Chan, Hameed and Tong, 1999). Hong, Lim, and Stein (1989) demonstrate that under-reaction of stock prices is reliant upon analyst coverage. Also, investors tend to flock together. The herding behaviour is documented by Grinblatt et al (1989). Pension fund managers buy and sell in herds, and that they herd around small stocks (Chan, Hameed and Tong, 1999).

The method of statistical arbitrage frees us from getting benchmark return via an equilibrium model suffering the joint hypothesis criticism. The statistical arbitrage analysis, carried out through along horizon trading strategy, identifies momentum effect and helps us perform subsequent examinations and explorations. The momentum strategies are seen to prevail in an up market especially, but behave inconclusively in a down market. The introduction of the disposition effect and the over-confidence effect helps greatly in identifying the over-confidence effect as a major driving factor for the momentum effect. The analysis of the disposition and over-confidence effects tells how the two factors affect momentum returns in more details and clarity. The study of momentum effect in this study benefits the understanding of trading behaviour especially in the emerging markets. Our adoption of statistical arbitrage is also more desirable in markets where high volatilities twist greatly the distribution of equilibrium returns. There are more behavioural factors that can be extended in studying the momentum phenomenon. This study serves as a fruitful step in that continuum.

## 3.5 Summary

This study investigates international arbitrage in cointegrated markets. Markets are proposed to have a long-run equilibrium, and so are efficient in the long-run. In the short-run, however, markets are inefficient and provide arbitrage opportunities that may be exploited by investors. The trading behaviour of noise traders leads to over-reaction and under-reaction in stock prices, which in turn leads to mis-pricing in stocks. If cointegration amongst the variables exists, then there is a long-run equilibrium relationship between them and they are long-run efficient. If there are no limits to arbitrage then, in the short-run, mis-pricing provides arbitrage opportunities that may be exploited. If two stocks are cointegrated, then mean reversion will be guaranteed and there will be no limits to arbitrage. This may be exploited through contrarian strategies such as the LOP and the Markov switching strategy. The speed of adjustment towards long-run equilibrium was used to match the stock pairs. The LOP strategy uses the stage three trivariate cointegration test for PPP to implement a pairs trading strategy. This is the first time it has been used for this purpose.

The Markov switching approach is useful for modelling the time-series behaviour of the Australian and Chinese stock ratio, which is the ratio of Australian resource stocks to the CSC constituent stocks. The ratio is assumed to have a long-run equilibrium, deviations from which are taken as a signal that the Australian or Chinese stocks are mispriced. If the ratio becomes high, relative to the long-run level, Australian stocks are over-priced and Chinese stocks are under-priced. If the ratio becomes low relative to its long-run value, Australian stocks are under-priced and Chinese stocks are overpriced.

A new approach to pairs trading has been developed based on the behaviour of noise traders and informed traders. Noise traders are irrational and over-confident. They trade on misinformation as if it was economic news. Their over-reaction and under-reaction to information causes the stock pairs to temporarily diverge, only to return to their long-run equilibrium value later. Informed traders have private information based on sophisticated methodologies and analysis. As they act on this private information, the stock pairs diverge, only to return to the mean value of the original regime or to a new mean regime. Where noise traders affect temporary changes captured by the LOP strategy, informed traders who are rational traders, affect more permanent changes captured by the Markov switching strategy.

### 3.5.1 Inefficient Markets

This thesis proposes that stocks be examined through use of the PAM for under-reaction and over-reaction. It is expected that index tracking and enhanced indexing strategies consist of stocks which exhibit under-reaction. This is because index tracking and enhanced indexing are momentum strategies. The methodology used for the index tracking and enhanced indexing strategies was developed by Alexander (1999), but applied internationally through the use of the CSC Index as the benchmark and a portfolio of Australian resource stocks. These strategies are not profitable if markets are internationally and domestically efficient. This study tests for efficiency using the PAM whose speed of adjustment coefficient matches stock pairs for a contrarian strategy.

A review of the literature on market efficiency and the EMH is conducted in this thesis. This invariably necessitates a thorough discussion of weak-form market efficiency and Chinese and Australian evidence on market efficiency. The PAM reveals that there are short-term inefficiencies in the Chinese and Australian financial markets. The profitability of the contrarian and momentum strategies is further evidence against weak-form market efficiency in China and Australia.

This thesis proposes that stocks are informationally efficient in the long-run, however in the short-run they are inefficient, leading to arbitrage opportunities. It was previously discussed in this Chapter that Behaviourists criticised the basic assumptions of the EMH; namely, that investors are rational utility-maximisers and homogenous. Biases and psychological heuristics (Kahneman and Tversky, 1979), and the existence of noise traders (Black, 1986), results in stocks that over-react, and under-react, to new information. This leads to mis-pricing in the short-run. This thesis departs from the Behaviourists' critique, in that the former states that there are limits to arbitrage. If stocks are cointegrated, then mean-reversion is guaranteed and there will be no limits to arbitrage and there will be equilibrium in the long-run.

Chen et al. (2005) find that Chinese investors have a tendency to over-react to good (bad) news and under-react to bad (good) news in a bullish (bearish) market. Lee and Rui (2000) argued that foreign investors may lack the knowledge of Chinese market, and when considering other research in this area, leads to the belief that asset prices in China may not be trading at their desired fundamental values. Our research explores whether these divergence in asset prices can be explained by the noise trading theory.

Studies into stock returns are dominated by investigation of random walk properties. The presence or an absence of a random walk has important implications for investors and trading strategies (Worthington and Higgs, 2006).When returns are characterised by random walks or by positive autocorrelation over short horizons, or negative autocorrelation over long horizons, an investor would invest more in stocks if the relative risk aversion is greater than unity, than if the returns were serially independent (Worthington and Higgs, 2006). Worthington and Higgs (2006) research examined the weak-form market efficiency of the Australian stock market. Serial correlation tests rejected the presence of a random walk. The unit root tests determined that unit roots are absent in the differences of either series. Finally, the multiple variance ratio procedure rejects the presence of random walks in the daily series. They conclude that monthly Australian returns from 1975 to 2005 follow a random walk, but that daily returns from 1958 to 2006 do not because of short-term autocorrelation in returns.

As the random walk is a test of market efficiency the discussion that follows, outlines and summarises the PAM which is the test of market efficiency used in this study because the PAM is also used to select stock pairs for analysis. As discussed earlier, the PAM is used to identify stock pairs for the LOP and Markov contrarian/Pairs trading strategies. The PAM also examines the stocks for the index tracking strategy to ascertain whether they over-react, under-react or fully adjust to economic information. This adjustment it is recalled is measured by a coefficient. A speed of adjustment of 1 means the stocks fully adjust to new information, and that they are efficient. A speed greater than 1 means the stocks over-react and a speed of $0 < \delta < 1$ means the stock under-react. Further, over-reaction leads to contrarian strategies and under-reaction leads to momentum strategies. The speed of adjustment coefficient derived from the PAM reveals heterogeneity amongst investors, which is evidenced in the different coefficient values for small-cap stocks as opposed to large-cap stocks, for both Chinese and Australian markets. The heterogeneity amongst investors is a challenge to the EMH assumption of investors as a homogenous group. This study assumes that there are two categories of investors, namely, noise traders, and informed investors. The characteristics of noise traders and informed investors are discussed. As previously mentioned, the PAM reveals short-term inefficiencies amongst Chinese and Australian stocks. This study proposes that these inefficiencies are due to the behavioural biases and psychological heuristics of investors.

### 3.5.3 Behavioural Finance

A brief review of behavioural finance ensues. This study departs from the Behaviourists in one crucial respect; that is, there is no limit to arbitrage. This is the direct result of a cointegrating relationship in the LOP, index tracking, and enhanced indexing strategies, as well as a Markovian relationship in the Markov switching strategy. Both cointegration and Markov switching hold that there is a long-run equilibrium relationship between stocks, which implies market efficiency in the long-run.

### 3.5.4 The Partial Adjustment Model

In the following discussion, the development of the new PAM is outlined. This is important because it is the PAM which identifies stock pairs for the LOP and Markov switching strategies. As a comparison, the LOP and Markov switching strategy were also implemented, where the stock pairs were chosen on the basis of their market capitalisations.

In an efficient market, prices incorporate economic news quickly. There are, however, many approaches to measuring the speed of adjustment. Previous studies have developed a theory which measures the speed of the adjustment. The Partial Adjustment Model of Amihud and Mendelson (1987) and its reformulation by Theobald and Yallup (2004) measure the speed of adjustment and trading irregularities in emerging markets. Amihud and Mendelson’s (1987) Partial Adjustment Model incorporates noise in the Model. Their approach calculates the speed of adjustment with reference to the microstructure of a market or stock. This studycalculates the speed of adjustment of large- and small-cap Australian resource stocks and the China Shanghai Composite Index. The researcher draws from the work of Amihud and Mendelson (1987), but transforms the partial adjustment model by incorporating the firm specific return from the single index model. The estimation of the speed of adjustment means that stocks can be compared, using the speed at which they move to their fundamental value. This thesis estimates the speed of adjustment to the arrival of all information using continuous time series information.

The fact that the results of the PAM show different speed of adjustments (reaction) for small-cap and large-cap stocks reveals that there is heterogeneity amongst traders. If investors are homogeneous, rational, and fully informed, there will be no noise traders. As noise trader's trade on information that does not reflect any fundamental value noise traders introduce volatility to the market (Black, 1986). Chakravarty (2001) and Kurov and Sancetta (2008) state that noise traders are retail investors, and introduce liquidity into the financial markets (Black, 1986). Mitchell et al. (2002) state that since small-cap stocks are not covered as comprehensively by analysts as large-cap stocks, they introduce costs of information gathering. This places limits on arbitrage, which leads small-caps to be more volatile than large-cap stocks (Podolski-Boczar et al., 2009).

Thus the question remains; if some stocks under-react, others over-react and still others fully adjust, is that evidence of informational inefficiency? If so, then inefficiency can be exploited for profit. If small-caps are more profitable than large-caps, the reason may be that large-caps are followed by many analysts, and so trade close to their fundamental values. Also, small-caps are more susceptible to the impact of noise traders, who trade on mis-information as if it were noise. Therefore, if noise traders' exercise their influence on small-caps it will be expected that those stocks will have slower adjustment to fundamentals, making them ideal vehicles for arbitrage.

### 3.5.5 Noise Traders and Informed Traders

The following discussion points to the existence of two types of investors; namely, noise traders and informed investors. The characteristics of noise traders are such that they are suited to contrarian (pairs trading) strategies through their trades in small-cap stocks. It is assumed that informed investors trade in large-cap stocks and so trade stocks close to their fundamental values. Therefore, informed traders should not be profitable under contrarian strategies.

Noise trading frequently pushes stock values away from fundamentals. Bagehot (1971) observed that market makers lose in their transactions with informed traders because these traders can decide not to transact if prices are not right. If it were not for noise traders, market making would not be possible. Noise traders provide market makers with profit which compensates them for subsequent losses with informed traders. Black (1986) stated that noise trading makes trading in stock markets viable. Copeland and Galai (1983) find that noise traders are required to allow the market maker to finance their losses from trades with informed traders.

The notion of formulation of prices through interaction of the forces of supply and demand is fundamental in economics. There is a tremendous amount of information contained and synthesised in market prices. For large institutional investors, the stock market is not perfectly competitive in the short-run. These investors have private information about prices, their trading strategies, and other factors. The private information may cause the prices of pairs of stocks to be in disequilibrium in the short-run. However, in the long-run, as private information becomes publicly known, market forces, through the buying and selling activities of arbitrageurs, will drive pairs of stocks towards a long-run equilibrium. On the other hand, noise traders cause temporary divergences of stock pairs, which then return to their fundamental values.

It may be recalled that this research employs two contrarian strategies namely, a LOP strategy and a Markov switching strategy. Both strategies use stock pairs which are formed through the use of the PAM, having similar speed of adjustments coefficients. The LOP strategy then involves the establishment of a cointegrating relationship. The Markov switching strategy establishes a regime-switching relationship between the stock pairs. Both of these approaches state that, in the short-term, there are inefficiencies due to behavioural biases and psychological heuristics which manifest themselves as divergences from the long-run equilibrium. Therefore, in the short-run, stocks may be inefficient; but in the long-run, they are efficient.

Cointegration states that there will be a long-run equilibrium relationship between two stocks. In the short-run, these stocks may diverge; but in the long-run, they will revert to their mean value. The PAM can be used to measure the speed of adjustment of stocks toward a long-run equilibrium. Contrarian strategies are characterised by over-reaction of stock prices to new information. Momentum strategies are characterised by under-reaction of stock prices to new information. Markov switching also states that the pairs of stocks will move towards a long-run equilibrium; however, means reversion may be to the original mean or to a new mean regime.

The following is a discussion of contrarian and pairs trading strategies and their intersection. This study takes the view that pairs trading is a particular instance of a contrarian strategy. The profitability of contrarian approaches is a blow to the EMH and rational choice theories. As mentioned previously, this study finds that investors are heterogeneous, comprised of noise traders and informed investors. The impact of noise traders should be captured by the LOP strategy, which accounts for transitory changes. The impact of informed traders should be captured by Markov switching strategy, which accounts for permanent changes in stock prices. The first step in answering the hypotheses entails a discussion of contrarian and pairs trading strategies and their intersection.

Contrarian investment strategies are achieved when investors buy under-priced stocks and short over-priced stocks. The under-priced stocks may be value stocks, while the overpriced stocks may be growth stocks. Lakonishok, Shleifer, and Vishny (1994), Chan and Lakonishok (2004) provide evidence of successful contrarian strategies in the US stock markets. Chan et al. (1992) find better performance of investment strategies based on contrarian strategies in the Japanese stock market and Fama and French (1998) find a value premium in international stock markets. Fama and French stated that markets are efficient and that the superior performance of the contrarian strategies through value investing is the result of value stocks being riskier. However, Lakonishok et al. (1994) find no evidence that value stocks are riskier. They state that the value premium is best explained by preference of investors for growth stocks over value stocks because investors suffer from cognitive biases, resulting in extrapolation of past growth rates of glamour stocks and subsequent purchase of them at the going price.

### 3.5.6 Criticism of EMH

The EMH is based on a number of underlying assumptions, including agents who are utility maximisers with rational expectations. In finance, rational decisions are optimal ones, and investors are often described as rational if they pursue the utility maximization optimally. Rational choices should be consistent and coherent (Tversky and Kahneman, 1981). The profitability of the pair-trading methodology is a blow to the EMH and rational expectations. This study states that short-run inefficiencies are due to behavioural biases and psychological heuristics. In the discussion that follows the relevant literature on behavioural finance is discussed.

The fundamental criticism of the EMH is that market participants are not rational. Behaviouralfinance has outlined many ways for irrationality to exert its influence in the investment decision. These are considered in the discussion that follows. As stated, in general, human beings possess bounded rationality, meaning that there are limits to the computational complexity that individuals are able to handle, and only smaller parts of the available information, can be processed at the same time. This will lead investors to focus on some aspects of the available information and disregard others. The increased amount of information has worsened analytic capabilities of the investor, as the investor to a greater degree has to sort the valuable information from noise. Therefore, limited cognitive capacity may prevent investors from acting rationally in some situations. The decision-making processes of human beings render them incapable of sorting available information properly. Kahneman and Tversky (1979) developed prospect theory in an attempt to reconcile theory and behavioural reality. Prospect theory is an approximate, incomplete and simplified description of how risky prospects are evaluated. The theory identifies gains and losses, but not wealth, which is normally used in financial models. Further the theory assumes that subjective decision-making criteria replace the probabilities and loss aversion rather than risk aversion, is the main criteria (Tversky and Kahneman, 1979).

Another issue is the way in which agents characterise the problem called ‘mental accounting’. Framing is the way an investor characterises a transaction in their mind determining the wellbeing they expect to receive. This means that when information is perceived, agents form different decisions due to dispersed perceptions and evaluations of the received input, and will also perceive the outcome differently from one another. Apart from the above-mentioned framing problem, agents also tend to form the problem differently within their minds, making it even harder to believe that people all make identical rational choices based on the available information. Mental accounting involves narrow framing, treating individual investments separately from initial wealth. This leads to the consideration that when a gamble is set, people forget all about the rest of the other gambles faced in the world, and thereby fail to elaborate on the total value of the merged gambles.

Investors who tend to frame decisions narrowly will likely make short-term decisions; when a gamble is evaluated individually, the effect of a loss or gain seems very strong compared to a group of gambles where some win and others lose some. Consequently investors tend to evaluate their gains and losses on a frequent basis when framing narrowly (Thaler, 1999). There is a tendency to evaluate outcomes frequently and to be more responsive to losses than to gains. As mentioned this will lead investors to evaluate gains and losses frequently and make short-sighted decisions, based on irrationality and resulting in non-optimal investment outcomes.

The purpose of this discussion on behavioural finance was to make it clear that psychological heuristics and behavioural biases may result in mis-pricing of stocks, and that this can lead stock pairs to diverge from their fundamental values. Such divergence may be exploited by arbitrageurs and if there are no limits to arbitrage, the trading behaviour of arbitrageurs will force the stock pairs to converge to their fundamental values. This may explain the profitability of contrarian/pairs trading strategies. Despite the strong arguments put forward by the Behaviourists, this thesis argues that irrationalities cause short-term mis-pricing in stocks and that in the long-term these irrationalities average out, making the markets efficient in the long-run.

### 3.5.7 Pair Trading

Gatev et al (1999), Vidyamurthy (2004), and Elliott, van der Hoek and Malcolm (2005) are the most referenced papers on pairs trading. The first paper is uses a simple standard deviation strategy to show pairs trading after costs can be profitable. The second of this paper outlines an implementation strategy based on co integration. The last paper applies a Kalman filter to estimating a parametric model of the spread (Do et al., 2006). Market neutral investing seeks limited exposure to systematic risks, whilst retaining two active returns, from the long position and from the short position in the losers (Do et al., 2006). Pairs trading, on the other hand, exploits short-term mis-pricing, present in a pair of securities (Vidyamurthy, 2004).

A contrarian trader invests when it is believed that the consensus opinion appears to be wrong. They believe that herd behaviour from other traders can lead to mis-pricing. Contrarian investment strategies are based on long positions in value assets that are undervalued and short positions in growth assets that are overvalued (Lakonishok, Shleifer, and Vishny, 1994; Do et al., 2006).

In the following discussion a summary of the over-reaction and under-reaction hypotheses and momentum strategies, is presented. Under-reaction to economic news may lead stocks to display the momentum effect. The results in this thesis show that pairs trading profits can be made when the stocks under-react or over-react. Both under-reaction and over-reaction cause divergences from the mean, which later converge towards their equilibrium value, because they are cointegrated. A test was implemented to ascertain the effects of lead-lag relationships by pairing the stocks with the quickest speed of adjustments with those that had the slowest speed of adjustments. The results show that there was no discernible trend, thus providing evidence against lead-lag relationships.

A discussion of the EMH and the Behaviourist’s critique of it are outlined. This is followed by a discussion of the momentum effect, which has roots in behavioural biases and psychological heuristics. A brief review of statistical arbitrage also follows. Then the index tracking and enhanced indexing strategies are specifically discussed. The deviation from the EMH by the profitability of the momentum strategies is discussed. The reasons for momentum effects are also discussed. Prospect theory and under-reaction play a major role in this explanation. Efficient market hypothesis has been violated by the performances of stock returns in some studies. Equilibrium model are commonly employed to examine these contradictions. These models are subject to the joint hypotheses problem (Fama, 1998). Abnormal returns may indicate the equilibrium model used is wrong instead of showing market inefficiency.

This thesis examines the profitability of momentum strategies formed based on past returns of Australian/Chinese indices. In this section, role of trading volume in momentum strategies is examined. Wang (1994) studied the link between heterogeneity among traders and the behaviour of trading volume. Uninformed investors trade against informed investors and will re-evaluate their positions when they realise their mistakes.

In summary, based on the theory and literature, the following research questions have been developed:

1. Whether or not the Chinese (CSC) markets are weak-form efficient in the short-term?
2. Whether or not the Chinese (CSC) and the top 33 resources stocks in Australia (ASX) markets are weak-form efficient?
3. Whether or not the top 33 resources stocks in Australia (ASX) are weak-form efficient in the short-term and or long-term?

4. Whether or not cointegration and PAM can identify contrarian strategies?
5. Whether or not cointegration and PAM can identify momentum strategies?
6. As part of contrarian strategies, are arbitrage profits produced with LOP strategies?
7. The issue is whether or not arbitrage profits produced by Markov switching strategies?
8. As part of momentum strategies, the issue here is whether or not index tracking strategies are profitable and whether or not they closely track the CSC Index?
9. As part of momentum strategies, the issue here is whether or not enhanced indexing strategies are profitable and whether or not they closely track the CSC Index?

It is important to demonstrate that the study shows that Australian and Chinese markets are efficient in the long-run but are inefficient in the short-run. The dissertation also shows the greater benefit of combined momentum and combined contrarian strategies.

# CHAPTER FOUR

# HYPOTHESES AND MODELS

## 4.1 Introduction

This chapter is divided into two parts; the first is the development of hypotheses, and the second is development of the models. The study itself is comprised of three parts. Part One is the test of market efficiency through the use of the PAM to identify stocks for the contrarian and momentum strategies. Part Two tests two contrarian strategies; the LOP strategy and a Markov switching strategy. Part Three tests two momentum strategies, an index tracking strategy, and an enhanced indexing strategy.

The previous chapter described the theory and related literature, and concluded that the assumptions of the EMH are questioned by Behaviourists, in particular the assumptions that investors are rational utility maximisers and that they are homogenous. It was proposed that investors are heterogeneous do not always behave rationally. Investors have psychological biases and often use heuristics, such as representativeness and conservatism; further they are thought to have loss aversion and perform mental accounting. These biases cause stocks to be mis-priced and informationally inefficient in the short-run. Furthermore, the trading behaviour of noise traders causes stocks to over-react and under-react to economic news. This leads to contrarian and momentum effects.

According to behavioural finance, there are limits to arbitrage, so mis-pricing continues unchecked. That is not the case in this study. The use of cointegration and Markovian methodologies ensures that there will be mean reversion. Therefore, the mis-pricing will always be corrected by arbitrageurs in these scenarios. The following section presents the development of the PAM, LOP, Markovian, the index tracking and enhanced indexing models, and the development of the hypotheses.

There is not much literature on statistical arbitrage, with only a handful of published papers in existence. This is because most of the research is proprietary in nature. Therefore, the Hypotheses section in this study is relatively concise.

## 4.2 Hypotheses

The first three issues which relate to the EMH are as follows:

1. Whether or not the Chinese (CSC) markets are weak-form efficient in the short-term.
2. Whether or not the Chinese (CSC) and the top 33 resources stocks in Australia (ASX) markets are weak-form efficient. It is important to demonstrate that the study shows that Australian and Chinese markets are efficient in the long-run but are inefficient in the short-run.
3. Whether or not the top 33 resources stocks in Australia (ASX) are weak-form efficient in the short-term and or long-term.

The above questions are important because if these markets are efficient then the contrarian strategies in Part Two, or the momentum strategies in Part Three, will not result in abnormal returns. That is, international arbitrage opportunities will not be available to investors. There is a strong economic relationship between China and Australia. China is Australia's biggest trading partner. Australian exports of iron ore, coal and other resources have been instrumental in providing China with the materials to allow them to industrialise, urbanise and manufacture goods for export. China's demand has witnessed record high terms of trade for Australia, which in turn has benefitted the Australian economy greatly.

An efficient market is a market in which prices always fully reflect available information (Fama, 1970). The reaction of market prices to new information will be instantaneous and unbiased (Fama, 1970). Any past information is included into the stock price. Any attempt to predict prices is futile. In the research on emerging countries, some support the existence of weak-form efficiency (cf., Chan, Gup and Pan, 1992; Dickson and Muragu, 1994; Ojah and Karemera, 1999), while others do not (Abdullah and Ullah, 2008). In Australia, Worthington and Higgs (2005) found the ASX is not weak-form efficient. If markets are not efficient they can be exploited by arbitrageurs in the short-tern, ensuring efficient markets in the long-term.

The EMH has been challenged by Behaviourists. Kahneman and Tversky (1972, 1973) observed that investors have biases and use psychological heuristics when making investment decisions. The PAM allows the speed of adjustment coefficient to be calculated. This reveals how quickly stocks adjust to economic news. That is, being able to measure the speed at which stock prices adjust to economic news means that the relative efficiency of stocks can be examined by comparing the speed at which they move to fundamental value. The speed of adjustment coefficient states the degree of over-reaction or under-reaction or full adjustment of returns to the arrival of new information.

Black (1986) introduced the concept of noise traders who are retail investors who trade on mis-information. The behaviours of noise traders, and behavioural finance Theories, explain why there is mis-pricing in the values of stocks. This mis-pricing moves stocks away from their fundamental values. This represents a short-term inefficiency which can be exploited through arbitrage. As arbitrageurs trade by shorting over-priced stocks and going long in under-priced stocks that return stocks which have similar characteristics, to their fundamental values. Inefficiencies in the short-run, may lead to long-run efficiency. This tends to support Wilson and Marashdeh (2007).

Market efficiency can be tested through the use of a PAM. Amihud and Mendelson (1987) did not actually calculate the speed of adjustment coefficient in their paper. Damodaran (1993) was the first to make such an attempt. Brisley and Theobald (1996) corrected Damodaran's error in formulating the coefficient. Theobald and Yallup (2004) developed a new model based on Amihud and Mendelson's (1987) theory. The approaches outlined above suffer from 'thin' or nonsynchronous trading problems, which give inaccurate values for the speed of adjustment coefficient. This study has implemented a new PAM which does not suffer from 'thin' trading.

Based on the theory and literature and on the above information, the hypotheses to be tested are as follows:

**H1: There is weak-form inefficiency in the top 33 CSC constituent stocks.**

**H2: There is weak-form inefficiency in the top 33 Australian resources stocks.**

Hypotheses 1 and hypothesis 2 will be tested using the PAM.

The next two issues which relate to the PAM are as follows:

4. Whether or not cointegration and PAM can identify contrarian strategies.
5. Whether or not cointegration and PAM can identify momentum strategies.

The issues are important because stock pairs are difficult to identify. If PAM can be used to identify stock-pairs for contrarian/pairs trading strategies it will introduce a new approach to pairs trading. Most previous studies, such as Gatev et al. (1999) used non-parametric (the distance approach) methods, or chose pairs from the same industry with similar betas. This method, using the PAM, characterises stocks into three states; over-reaction, under-reaction, or full-adjustment. If stocks over-react they may be suited to contrarian strategies. If they under-react then maybe they are suited to momentum strategies. Finally stocks fully-adjust to economic news they are efficient. This study investigates international arbitrage in cointegrated markets. Markets are proposed to have a long-run equilibrium and so are efficient in the long-run. In the short-run, however, markets are inefficient and provide arbitrage opportunities that may be exploited by investors. Individual investors are noise traders. The trading behaviour of noise traders leads to over-reaction and under-reaction in stock prices, which in turn leads to mis-pricing in stocks. If cointegration amongst variables exists, then there is a long-run equilibrium relationship between them and they are long-run efficient. If there are no limits to arbitrage, then in the short-run, mis-pricing provides arbitrage opportunities that may be exploited. If two stocks are cointegrated, mean reversion will be guaranteed and there will be no limits to arbitrage. This may be exploited through contrarian strategies such as the LOP and the Markov switching strategy. The speed of adjustment towards long-run equilibrium will be used to match the stock pairs.

There are many trading strategies that have been developed to exploit mis-pricing or market inefficiencies. Gatev et al. (1999) and Nath (2003) introduced the distance method; choosing pairs of stocks by minimising the sum of squared differences between them. Gatev a colleagues (1999) pairs trading strategy produced a 12% return over a six month period. Gatev et al. (1999) and Nath (2003) were not the only ones to use a pairs trading approach to exploit inefficiencies. Elliot et al. (2005) used a stochastic approach and Do et al. (2006) used a stochastic residual spread method.

As previously mentioned, this study uses two new approaches to pairs trading; which takes into account international arbitrage and regime switching characteristics. The LOP strategy uses the AUD/CNY exchange rate in a pairs trading strategy. The Markov switching strategy uses regime changes between a high-mean state and a low-mean state into account; which better accounts for the relative mis-pricing between pairs of stocks which are linked.

The mis-pricing represents inefficient markets. Such inefficiencies may be due to deviations away from rational behaviours. According to Soares and Serra (2005) and Burghardt (2010), individuals do not make rational decisions; instead they develop preferences using prospect theory. They also put greater weight on recent events. Framing effects cause them to make decisions depending on how a problem is presented to them. This explains why some stocks under-react and others over-react. Barberis et al. (1998) provided evidence of under-reaction, whilst Soares and Serra (2005) and Burghardt (2010) showed that stock prices tended to over-react in the medium to long-term. Furthermore, De Bondt and Thaler (1985) find that investors over-react to good or bad news, which can be exploited by contrarian strategies for profit. This is a direct consequence of conservatism by investors and also ‘representativeness’ or the ability to perceive apparent trends, when in fact there are none.

De Bondt and Thaler (1985) findings were subsequently confirmed by Chopra et al. (1992). The above evidence calls into question the existence of perfect information as indicated by the EMH. In fact, individuals do not always accurately process information and make mistakes in assessing probabilities of the likelihood of events occurring (Brodie et al., 2011). The premise of rational expectations is that investors have full and correct information of a situation and have the ability to arrive at correct and efficient conclusions, given their initial information. In fact, there may be long-run efficiency, and rational expectations, even while there exists short-term inefficiencies, because of the trading behaviours of arbitrageurs.

In summary the above; there is under-reaction and a momentum effect in the short-run, there is over-reaction and a contrarian effect in the long-term and there is equilibrium in the long-run if the stocks are cointegrated.

If the speed of adjustment coefficient in the PAM is greater than one the stock over-reacts to economic news. If the speed of adjustment coefficient is less than one, then, the stocks under-react to economic information. If the speed equals one, there is full adjustment and the stock is efficient. This leads to the following hypotheses:

**H3: Cointegration and PAM can identify contrarian strategies.**

Hypothesis 3 will be tested using the Engle-Granger cointegration methodology for the LOP model and the PAM.

**H4: Markov switching and PAM can identify contrarian strategies.**

Hypothesis 4 will be tested using the Markov switching methodology for the Markovian model and the PAM.

**H5: Cointegration and PAM can identify momentum strategies.**

Hypothesis 5 will be tested using the Engle-Granger cointegrationstrategy for the index tracking and enhanced indexing models and the PAM.

The next issues which relate to contrarian strategies are as follows:

6. As part of contrarian strategies, are arbitrage profits produced with LOP strategies.
7. The issue is whether or not profits produced by Markov switching strategies arbitrage.

The issues are important because this thesis is about international arbitrage opportunities. If Chinese and Australian markets are inefficient in the short-run, there may be profit-making opportunities. The PAM measures whether stocks over-react, under-react, or fully adjust to economic news. A contrarian trader invests when he/she believes that the consensus opinion is wrong. That is, a contrarian trader believes that herd behaviour from other traders can lead to mis-pricing. As previously mentioned, contrarian investment strategies are based on long positions in value assets that appear undervalued and, additionally short positions in growth assets appear overvalued (Lakonishok, Shleifer and Vishny, 1994). Widespread pessimism about a stock will, for example, lead the stock price down and as a consequence over-state the risk of the company and under-state the likelihood of returning to profitability. The contrarian looks to buy and sell assets when the herd appears to do the opposite. This may indicate a possibility of long-term profitability. The LOP strategy uses the Engle-Granger (1987) cointegration methodology. The Markovian strategy uses the Hamiltonian two-state regime switching model. Both of these techniques propose that in the long-run there is equilibrium, but in the short-run there is divergence due to mis-pricing, which can be exploited through a pairs trading approach. The stock pairs may diverge in the short-run due to market inefficiencies, but in the long-run mean reversion is guaranteed, even though the Markov approach states that reversion may be to the original mean or to a new mean regime. Therefore, in the short-run there is the possibility of arbitrage.

This study uses two different approaches to pairs trading. A LOP strategy is employed for the first time. This approach adapts the stage three cointegration test for Purchasing Price Parity (PPP). The LOP strategy is utilised because this study is testing international arbitrage opportunities. A Markov switching strategy is also used. Financial market exhibits upward and downward trends which are categorised as bull and bear markets. The occurrence of these regimes is often attributed to several factors that can be broadly grouped into systematic and non-systematic risks. This study uses a Markov regime switching model to identify trading opportunities between Chinese and Australian stocks. The choice of Markov switching as a methodology is not new, what is new is the data set of the top 33 Chinese and Australian stocks, and the use of Markov switching for pairs trading. Whilst it is true that Bock and Mestel (2009) used Markov switching for pairs trading, this study uses an approach used by Brooks (2008) who traded equity yields and bond yields. This study therefore uses a new dataset and a new approach for pairs trading. The following hypotheses are presented:

**H6: There are arbitrage profits to be made from the LOP strategy.**

Hypothesis 6 will be tested with the LOP model.

**H7: There are arbitrage profits to be made from the Markov switching strategy.**

Hypothesis 7 will be tested using the Markovian model.

The next issues which relate to momentum strategies are as follows:

8. As part of momentum strategies, the issue here is whether or not index tracking strategies are profitable and whether or not they closely track the CSC Index.
9. As part of momentum strategies, the issue here is whether or not enhanced indexing strategies are profitable and whether or not they closely track the CSC Index.

These issues are important because if momentum strategies are profitable then Chinese and Australian markets are weak-form inefficient in the short-run. It is expected that if these strategies are profitable the constituent stocks will under-react according to PAM.

As discussed above, momentum strategies are the opposite of contrarian strategies. These strategists buy past winners and sell past losers and the strategies included using cointegration and PAM analysis. The following section deals with the literature relating to momentum strategies that include index tracking and enhanced indexing.

People may over-react to unexpected events, and De Bondt and Thaler (1985) tested this contention. Their study finds that a portfolio of prior ‘losers’ dramatically outperforms prior ‘winners’ even if the latter are more risky. In other words, the work of De Bondt and Thaler find a long-horizon return reversal.

Extending the prospect theory of Kahneman and Tversky (1979), Jegadeesh and Titman (1993) proposed a model of momentum to examine market efficiency and find that stock prices are predictable under the momentum model. A further development of prospect theorybyDaniel and Titman (2000)concluded that over-confidence also indicates certain stocks can generate greater over-confidence among investors, resulting in a stronger momentum effect.

Chan, Jegadeesh and Lakonishok (1999) demonstrated that under-reaction to economic news on earnings explain momentum profits. Further, Jegadeesh and Titman (1993) studied the nexus between earnings announcements and momentum profits within event study method. They find evidence in favour of momentum effects. Chan et al. (1996) studied the ability of past returns and public earnings surprises and were able to predict subsequent returns at a six monthly horizon. Those researchers also find that these strategies yielded significant profits.

Momentum strategy buys stocks which have a strong historical performance, and sells stocks which have performed poorly. Contrarian strategy advocates buying losers and selling winners based on historical data (Conrad and Kaul, 1998). There is ample empirical evidence of success using both strategies. De Bondt and Thaler (1985) argued that contrarian strategy outperforms the market. Jegadeesh and Titman (1996)conducted an out-of-sample test from their study of the period 1990 to1998. They find that relative strength momentum strategies continued to be profitable in the same order as in their previous 1993 study. Conrad and Kaul (1998) studied the profitability of 120 different rule-based trading strategies on the NYSE and the AMEX, from 1926 to 1989. They find that only 55 of these strategies have provided statistically significant returns different from zero, including eight basic momentum strategies.

The index Fund offers individual investors the lowest fees, in order to avoid trying to outsmart the market, and to represent the market with as little distortion as possible. Therefore, Index Funds attempt to track the overall market without bias. The managers of enhanced funds appreciate the core theory of index investing, but perhaps believe that better returns can be achieved, or variations can be reduced, by refraining from holding such a high percentage of the largest stocks by market cap. Such managers eschew the passive approach to tracking an index in favour of a semi-active approach to portfolio management. The increasing role of index investment has created much interest in its asset pricing. The index tracking and enhanced indexing strategies use the CSC as the benchmark, and a portfolio of Australian resources stocks as the constituents. This is a new approach to international asset trading. It utilises a completely new data set and has implications for conclusions regarding the integration of the Chinese and Australian markets. Typically, such studies, (c.f., Alexander, 1999; Alexander et al., 2002) have used domestic benchmarks (an Index), and the constituents of that index, as elements of the index tracking/enhanced indexing strategy. The implication is that markets are segmented by national borders. This approach provides a test of whether the growing trading and financial integration between China and Australia extend to their stock markets. The impact of noise traders is to cause over-reaction and under-reaction of stock prices to economic information. This in turn results in mis-pricing between the CSC index and its Australian stock constituents. This short-run divergence can be exploited to make profits using long/short strategies.

In this study, two momentum approaches were implemented; an index tracking strategy and an enhanced indexing strategy. Both strategies replicate the CSC benchmark index with a portfolio of Australian resource stocks, and, as such, by their construction, represent well-diversified portfolios (Markowitz 1952). They have diversified away their unsystematic risk. That is not all; the enhanced indexing strategy has no systematic risk. That is because it consists of a global portfolio that combines a long portfolio and a short portfolio, both based on the CSC benchmark index.

The following hypotheses are presented:

**H8: There are profits to be made from the index tracking strategy.**

Hypothesis 8 will be tested using the index tracking model.

**H9: The index tracking strategy closely tracks the CSC index.**

Hypothesis 9 will be tested using the index tracking model.

**H10: There are profits to be made from the enhanced indexing strategy.**

Hypothesis 10 will be tested using the enhanced indexing model.

**H11: The indexing strategy closely tracks the CSC index.**

Hypothesis 11 is tested using the index tracking model.

**H12: The enhanced indexing strategy closely tracks the CSC index.**

Hypothesis 12 is tested using the index tracking model.

**H13: The combined momentum strategy is more profitable than the combined contrarian strategy.**

The dissertation also shows the greater benefit of combined momentum and combined contrarian strategies.

Hypothesis 13 will be tested using the LOP, Markov, index tracking and enhanced indexing models.

## 4.3 Model

### 4.3.1 The Partial Adjustments Model

This study uses a different approach to that of Amihud and Mendelson (1987) due to the difficulty in obtaining a correct value for the discount rate and the uncertainty in determining future cash flows, in the calculation of an intrinsic value of a security. The partial adjustments model (PAM) assumes there is a long-run equilibrium which is the "target" return (the expected stock return in an efficient market). The long-run equilibrium equation is given by the single-index model:

$$R_t = a + \beta R_m + e \tag{4.1}$$

Where $R_t$ is the target return; $a$ a is the excess return; $\beta$ is the sensitivity of the stock to the market, $R_m$ is the market return; and e is the residual. Where $e$ is the firm-specific surprise in the security return. Deviations of observations from the regression line in any period are called the residual. The residual is the difference between the actual stock return and the return that would be predicted from the regression equation; therefore residuals measure the impact of firm-specific events during a period of time. In this formulation, e represents the impact of noise traders who cause mis-pricing, anomalies, imperfect information and market frictions. This formulation of the model was used because it is incorporated in the PAM, and as such, contains less terms to be dealt with.

The following hypothesis known as the PAM is postulated:

$$R_t - R_{t-1} = \delta((a + \beta R_m) - R_{t-1}) \text{or simply} \tag{4.2}$$

$$R_t - R_{t-1} = \delta(R_t - R_{t-1}) \tag{4.3}$$

The PAM model above uses $R_{t-1}$, instead of $R_t$, in calculating the firm-specific event or abnormal return. If markets are efficient, then security prices will reflect all available information. There is be no opportunity to use information gathered in period t-1 to provide a correct assessment of the expected return.The information available at t-1, the time series of past returns, will not be used to correctly determine the expected return. By using past information in this way, this approach is a test of weak-form market efficiency. If the variance of e is high, then that is be evidence ofweak-form market efficiency, in addition to the value of the speed of adjustment.

The $\delta$ is the speed of adjustment of the actual return towards the desired return. The $(R_t-R_{t-1})$ is the actual change, and $(R_t^*-R_{t-1})$ is the desired change. The actual change in returns in any given time period is a fraction of the desired change for the period. If $\delta=1$, it means the actual returns are equal to the desired returns; that is, actual returns adjust to the desired returns instantaneously. However, if $\delta=0$, nothing changes since actual return at time t is the same as that observed in the previous period. The $\delta$ is also the sensitivity of the actual change in returns to firm specific events. If $\delta=1$, then the change in actual returns is completely responsive to firm-specific events (or abnormal returns).

If $\delta=1$, the speed of adjustment is quick, and the market is efficient. If the speed of adjustment is slow, then that is evidence of market inefficiency which may be caused by anomalies or market rigidities. For example, the slow speed may be due to investors having imperfect knowledge, or using heuristics such as conservatism or representativeness, or over-reaction and under-reaction; these responses may be a reaction to news announcements, loss aversion, trading excessively, investors being too over-confident and/or over-estimating their abilities, forecasting and sampling errors, noise trading, restrictions on short-selling. There may also be transaction costs and which prevent prices from adjusting quickly.

If there is no firm-specific event surprise, or no abnormal profit, then there will be no marginal revenue and no price. This reflects the fact that actual returns equal expected or predicted returns. Therefore, the market is efficient and there are no superior profits to be made. Such a market will be perfectly competitive, as there are many buyers and sellers, each with no market power and no superior information on the behaviour of stock prices. In essence, the predictions of rational expectations will be met.

In relation to this theory, there are two types of traders; noise traders and institutional traders. Noise traders are retail investors who over-react to economic news. Economic news causes the stock pairs to temporarily diverge, after which they converge towards their mean (equilibrium) value. These temporary changes will be captured by the LOP strategy. Noise traders cause under-reaction and over-reaction in stock prices. Therefore, stocks with excessively slow speed of adjustments and quicker speed of adjustments will feel their influence.

Institutional traders behave rationally. They use sophisticated analysis and proprietary information to determine their trading behaviour. As they act on this information, the stock pairs diverge only to converge to their equilibrium value, which may be the original regime or a new mean regime. These permanent changes are captured by a Markov switching strategy.

**4.3.2The LOP Model**

If stocks in the CSC Index and MAM are good substitutes for each other, they should be priced to the same fundamental value in efficient markets. If one of the stocks in one index is mis-priced, rational investors will take advantage of this mis-pricing by selling the relatively over-priced one and purchasing the relatively under-priced one to earn a profit. Consequently their prices will eventually revert to the fundamental value. There will be a long-term equilibrium and the spread between the prices which will be stationary. If they are indeed cointegrated, trading strategies which exploit the mean reverting property of the spreads between the pairs of stocks will result in a profit. The PPP strategy has been adapted from the stage three trivariate cointegration test of PPP and applied to pairs trading. As it accounts for exchange rates, it is particularly suited to pairs trading between different countries. This is a new model for pairs trading; 35 pairs were examined based on their market capitalisations and 32 were co integrated.

The adapted stage three trivariate cointegration test of PPP starts with the following model:

$$S_t = \alpha + \beta_0 P_t - \beta_1 P_t^* + \mu_t \qquad (4.4)$$

$S_t$ is the nominal exchange rate, $P_t$ is the Australian stock, and $P_t^*$ is the CSC stock, and $\mu_t$represents for the regression errors. The Engle-Granger Cointegration Method was implemented. Engle and Granger (1987) stated that a linear combination of two or more non-stationary series may be stationary and, if such a stationary linear combination exists, the non-stationary time series are said to be co integrated. The cointegrating equation may be interpreted as a long-run equilibrium relationship among the variables (Dunis and Ho, 2005). Cointegration of stock markets means there is a long-run relationship between them; if Y and X are I(1) time series and are co integrated so that $u = Y - \alpha - \beta x$ is I(0) (4), then, in the long-run, Y and X do not drift apart, since u has a constant mean, which is zero. $Y = \alpha + \beta X$ (5)

can be interpreted as an equilibrium or long-run relationship between these markets and u is referred to as the error correction term and the deviation from equilibrium which, in the long-run, is zero (Dunis and Ho, 2005). Engle and Granger (1987) propose a two-step estimation method, where the first step consisted of estimating a long-run equilibrium relationship, and the second is the estimation of the dynamic error-correction relationship using lagged residuals (Dunis and Ho, 2005).

The time series {lnPt} and {lnPt*} are non-stationary. The first step is to use unit root tests to determine whether they are integrated in the same order. If this is so, the next step involves the estimation of the regression equation $S_t = \alpha + \beta_0 P_t - \beta_1 P_t^* + \mu_t$, and to take the unit root of the residual series {ut}. They are cointegrated if the test is successful. The residual equation is $\mu_t = S_t - \alpha - \beta_0 P_t + \beta_1 P_t^*$, which is the log spread of the two series {lnPt} and {lnPt*}. This study used the following Signal Index to determine when to enter and exit a trade.

$$RESID=E[\mu_t])+/-\delta\sigma_{\mu t} \qquad (4.5)$$

The SI is based on the 95% confidence interval, where $E[\mu_t]=0$ $\delta=1.96$. Enter the trade if the RESID (the residual) value is greater than $\delta\sigma_{\mu t}$, or less than - $\delta\sigma_{\mu t}$, standard deviations from the mean and exit the trade by reversing positions if the $+/-\delta\sigma_{\mu t}$ standard deviation is less than RESID.

If RESID ≥ $+\delta\sigma_{\mu t}$, the trading rule is to go long in Pt and short Pt*. If RESID ≤ $-\delta\sigma_{\mu t}$, the trading rule is to short Pt and go long in Pt*.

### 4.3.3 Markov Regime Switching Model

Many financial time series appear to experience episodes in which the behaviour of the series changes quite dramatically, compared to that exhibited previously. The series can change over time in terms of its mean value, volatility, or to what extent its current value is related to its previous value. The change may be once and for all, known as a ‘structural break’, or it may change for a period of time before reverting back to its original behaviour, or switching to yet another style of behaviour. In the case of the latter, is termed a ‘regime shift’ (Brooks, 2008).

The Markov switching process proceeds as follows (Chan, 2012);

1. the two regimes are characterised by different probability distributions of the prices;

2. the log of the prices of both regimes is represented by normal distributions, except for different means and standard deviations;
3. there are transition probabilities among the regimes;
4. the researcher determines the parameters that specify the regime probability distributions and the transition probabilities, by fitting the model to past prices, using maximum likelihood estimation;
5. Based on this model, the researcher determines the expected regime of the next time step.

In this study, the researcher conducted a pair trading statistical arbitrage between 35 pairs of stocks from the CSC Index and the MAM index. The pairs of stocks were selected using market capitalisation information and cointegration. These were all large-cap stock pairs.The cointegrated pairs were transformed into a relative price ratio and Markov switching models were employed. The price ratio $Rat_t = (P_t^A/P_t^B)$ of two assets A and B, were assumed to follow a mean reverting process, which implies that short-term deviations from the equilibrium ratio are balanced after a period of adjustment (Bock and Mestel, 2009). The ratio exhibits a switching mean. The regime shifts are governed by a Markov chain. The current regime $s_t$ is determined by an unobservable variable. The inference of regimes is based on state probabilities. The applied model has two-states, and is a first-order Markov-switching process with a switching mean and a switching variance.

### 4.3.4 Index Tracking Model

The portfolio holdings in each of the stocks selected are estimated, based on ordinary least squares coefficients of the cointegration equation that regresses the index log price on the portfolio stocks log prices over a given calibration period prior to the portfolio's construction moment. The log transformation is applied to produce a more homogenous series.

$$Log(CSC_t) = a_0 + \sum_{k=1}^{n} a_k.LogP_{kt} + e_t \tag{4.6}$$

The index is the CSC Index and $P_{K,t}$ is the price of the Australian stock $P_K$ at time t. If the series CSC Index is cointegrated with $P_{K,t}$ the residual series (the tracking error) will be stationary. The use of log prices means that the tracking error is in return format, and the $\alpha_K$ coefficients are the portfolio weights. The weights will be normalised to sum up to one to give the percentage weight of each selected stock in the index tracking portfolio. The index tracking portfolio daily returns are computed as the weighted sum of the daily returns of its constituent stocks. The residuals of each cointegration regression were tested for stationarity following the Engle-Granger methodology for cointegration testing.

### 4.3.5 Enhanced Indexing Model

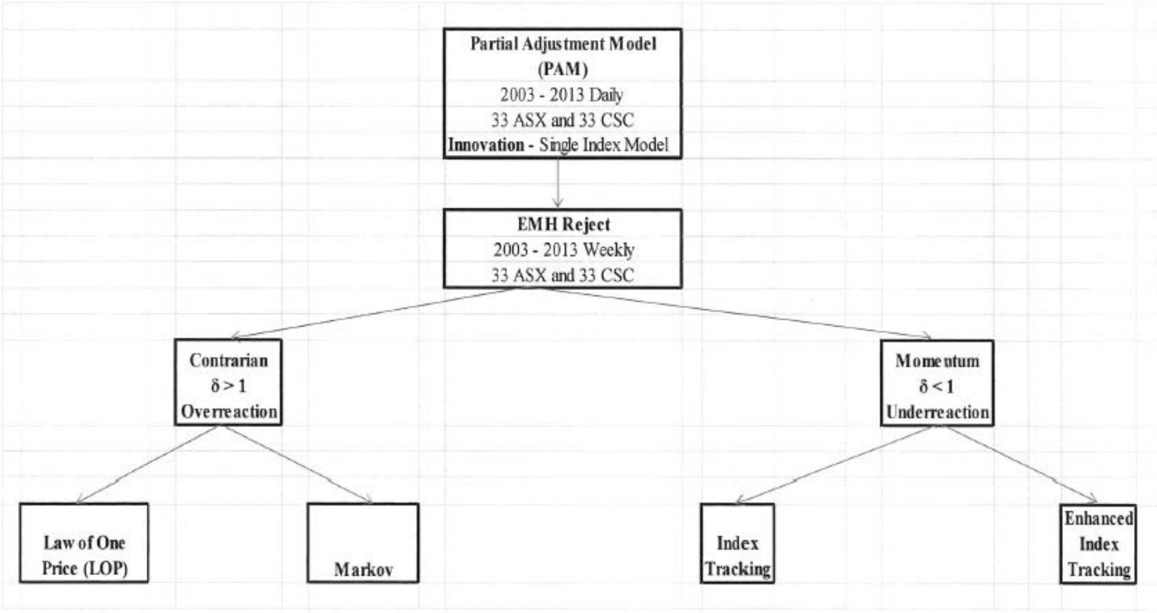
Having constructed a simple tracking strategy, this study will replicate ‘plus’ and ‘minus’ benchmarks, constructed by adding to and subtracting from, the benchmark returns an annual excess return of x%, uniformly distributed to daily returns.

$$Log(CSC_t Plus_t) = a_0 + \sum_{k=1}^{n} a_k . LogP_{kt} + e_t \tag{4.6}$$

$$Log(CSC_t Minus_t) = a_0 + \sum_{k=1}^{n} a_k . LogP_{kt} + e_t \tag{4.8}$$

Gitman et al. (2001) define a hedge as “a combination of two or more securities into a single investment position for the purpose of reducing or eliminating risk” (p.375). It may involve buying an underlying asset and simultaneously buying a derivative security, for example, a put or a future. In the case of futures, hedgers are commodity producers or processors who use futures to protect their underlying investment in the commodity. A fundamental characteristic of a hedge is that the two assets chosen must have opposite pay-offs. Their combination, allows the hedger to hedge exchange rate risk. This is important, as commodity prices are volatile; it brings certainty in an uncertain transaction. The other clear benefit of a long-short investment hedge, such as the index tracking or enhanced indexing strategies mentioned above, lie in risk reduction. By going long in a replicated index and going short in a replicated index, simultaneously, the strategy eliminates systematic risk. However, there is still risk. In this study, cointegration is used to implement the index tracking and enhanced indexing strategies. As long as the cointegrating relationship is maintained, the strategies should perform well. If the relationship breaks down, however, then the strategy will fail.

**Figure 4-1 Overview of Methodology**




The Figure 4-1 shows the schematic of the methodology. This analysis begins with the PAM using daily data from 2003-2013 comprising 33 A&P/ASX 300 MAM and 33 CSC constituent stocks. The main innovation is the PAM which incorporates the single index model. The tests of speed of adjustment produced by the PAM reject the EMH in the short-run. This implies that there are arbitrage opportunities which can be exploited. Two contrarian strategies and two momentum strategies were implemented. The two contrarian strategies were the LOP and Markov and the two momentum strategies were the index tracking and enhanced indexing strategies.

### 4.3.6 Summary

This chapter described the hypotheses to be answered in this study and outlined the models to be tested to answer the hypotheses. The previous Chapter described the theory and related literature, and concluded that the assumptions of the EMH are questioned by Behaviourists. Investors have psychological biases and often use heuristics, such as representativeness and conservatism; further they are thought to have loss aversion and perform mental accounting. These biases cause stocks to be mis-priced and informationally inefficient in the short-run.

Furthermore, the trading behaviour of noise traders causes stocks to over-react and under-react to economic news. This leads to contrarian and momentum effects.

According to behavioural finance, there are limits to arbitrage, so mis-pricing continues unchecked. That is not the case in this study. The use of cointegration and Markovian methodologies ensures that there will be mean reversion. Therefore, the mis-pricing will always be corrected by arbitrageurs in these scenarios. In this chapter the development of the PAM, LOP, Markovian, the index tracking and enhanced indexing models, and the development of the hypotheses was presented.

The variable of interest in the LOP, Markov, index tracking and enhanced indexing strategies was the returns of each strategy. The motivation is to examine international arbitrage opportunities between Australia and China. A case is made that the two countries are linked through trade in metals, minerals and coal and that this has resulted in MAM constituent stocks and CSC constituent stocks being economically linked and thus traded using statistical arbitrage strategies.

There are no hypotheses for noise traders and informed traders. However, these concepts were introduced in the literature review and subsequently, to the analysis, to demonstrate that markets are not always efficient and that there is a difference in returns from small cap stocks traded by noise traders, and large cap stocks traded by informed traders. This phenomenon is what is mentioned in the analysis. The stocks with high betas tended to have faster and slower speed of adjustment, which implies that stocks which under-react and over-react are risky.

# CHAPTER FIVE

# METHOD AND DATA

## 5.1 Introduction

This study investigates international arbitrage opportunities between the China and Australian resource sectors. The growing economic and trading relationship between China and Australia has seen the two countries become increasingly financially integrated. This study consists of three parts; a PAM was developed in Part One to assess relative efficiency of the Chinese and Australian markets. In Part Two of this study two contrarian strategies, a LOP strategy and a Markovian strategy were developed. These strategies formed stock pairs in one instance, by grouping stocks which had similar speed of adjustments as determined by the PAM; another method for forming stock pairs was also used, namely, grouping stocks according to their market capitalisations. In Part Three, two momentum strategies were developed; an index tracking strategy, and an enhanced indexing strategy. This chapter presents the data used in this study, and methodologies for the different analyses.

## 5.2 Method

The method used in this study can be divided into three parts. The first part is concerned with the process of selecting the trading pairs, along with a discussion of the PAM. In the second part, the speed of adjustment coefficient is used to identify pairs in conjunction with cointegration and Markov switching. In the third part, the speed of adjustment coefficient and cointegration is used to select stocks for index tracking and enhanced indexing strategies. The second component of this study is concerned with the estimation of the LOP strategy, using the Engle-Granger's (1987) methodology, and the Markovian strategy using the Hamiltonian's (1989, 1990) two-state regime Markov switching methodology. The third part uses Alexander's (1999) methodology to implement index tracking and enhanced indexing methodologies.

### 5.2.1 Partial Adjustments Model

There is no autocorrelation or auto-covariance structure in this formulation of the PAM. It therefore avoids the problem of nonsynchronous or infrequent trading that effect many of the other models which estimate the speed of adjustment. In an efficient market, observed price should include new information to reflect changes to its fundamental value. Such an adjustment should be immediate if the market is strongly efficient (Fama, 1991). Thus the adjustment speed of stock price to the changed fundamental value due to economic news determines the degree of efficiency in the stock market (Marisetty, 2003). The PAM assumes the long-run equilibrium equation is given by the single-index model:

$$R_t = a + \beta R_m + e \qquad (5.1)$$

Where $R_t$ is the target return; a is the excess return; B is the sensitivity of the stock to the market, $R_m$ is the market return; and e is the residual.

Similar to the model of Amihud and Mendelson's (1987) model, the impact from noise trading is the difference between the fundamental return and the observed return.

The following hypothesis, known as the PAM, is postulated:

$$R_t - R_{t-1} = \delta(R_t - R_{t-1}) \qquad (5.2)$$

$$R_t - R_{t-1} = \delta\big((a + \beta R_m + e) - R_{t-1}\big) \qquad (5.3)$$

$$R_t = \delta a + \delta\beta R_m + (1 - \delta)R_{t-1} + \delta e \qquad (5.4)$$

$$R_t = \delta a + \delta\beta R_m + (1 - \delta)\beta R_{m_{t-1}} + \delta e \qquad (5.5)$$

Where $R_t$ is the return in time period t, $R_{t-1}$ is the return in time period t-1, δ is the speed of adjustment coefficient, and e is the error term E[e]=0 and E~ N(0, $\sigma^2$). When δ equals 0 there is no adjustment, when δ equals 1 there is full adjustment and the market is efficient, when δ is greater than 1 there is an over-reaction to economic information, and when δ lies between 0 and 1 there is partial adjustment or under-reaction to economic information. There will be no opportunity to use information gathered in period t-1 to provide a correct assessment of the expected return. The information available at t-1, the time series of past returns, cannot be used to correctly determine the expected return. Using past information in this way enables this approach to be a test of weak-form market efficiency. If the variance of e is high then that would be evidence against weak-form market efficiency, along with the value of the speed of adjustment.

The first step is to calculate the alpha (excess return) and beta (systematic risk) by regressing the stock's return against the market return. The beta is multiplied by the market return and added to alpha. The proxy used for the lagged return is $\beta R_{m(t-1)}$. The stochastic explanatory variable $R_{t-1}$ may be correlated with the error term, which in turn makes the OLS estimator biased and inconsistent so that the estimates do not approximate their true population values. This correlation can be removed by finding a suitable proxy for $R_{t-1}$. Such a proxy is $\beta R_{m(t-1).}$

The single-index model is used in the PAM, instead of a multi-factor model. The reason for doing so is that the object of the PAM is to calculate the speed of adjustment coefficient. A multi-factor model will introduce too many terms into the PAM and would lead to difficulties in finding an appropriate proxy for $R_{t-1}$.There is no autocorrelation or auto-covariance structure in this formulation of the PAM. The PAM, therefore, avoids the problem of non-synchronous or infrequent trading that effects many other models which estimate the speed of adjustment. The change in actual return is then regressed on to the change in abnormal return using the instrumental variables method, and determining the speed of adjustment coefficient. The proxy used for the lagged return is $\beta R_{m(t-1)}$. The stochastic explanatory variable $R_{t-1}$ may be correlated with the error term, which in turn makes the OLS estimator biased and inconsistent so that the estimates would not approximate their true population values. This correlation can be removed by finding a suitable proxy for $R_{t-1}$.

The basic procedure developed by Theobald and Yallup (2004) to adjust the covariance ratios estimators to nonsynchronous trading consists in lagging thecovariances for *q* periods. Although, this removes the nonsynchronous trading effect, it is quite an *adhoc* procedure because it implies that there is prior knowledge on which lags to include in the calculation. Thereportingof lags depends on the time needed to gather information for all the constituent stocks and to resolve the computation algorithm. On the other hand, the PAM is a straightforward calculation and achieves the same result (Helder and Sebastiao, 2009).

In Part Two of this study two contrarian strategies, a LOP strategy and a Markovian strategy were developed. These strategies formed stock pairs in one instance, by grouping stocks which had similar speed of adjustments as determined by the PAM; another method for forming stock pairs was also used, namely, grouping stocks according to their market capitalisations.

### 5.2.2 LOP strategy

The adapted stage three trivariate co integration test of PPP starts with the following model:

$$S_t = \alpha + \beta_0 P_t - \beta_1 P_t^* + \mu_t \quad (5.6)$$

$S_t$ is the nominal exchange rate; $P_t$ is the Australian stock; and $P_t^*$ is the CSC stock; and $\mu_t$ stands for the regression errors. The Engle-Granger cointegration method was implemented. Engle and Granger (1987) contended that a linear combination of two or more non-stationary series may be stationary if such a stationary linear combination exists, and the non-stationary time series are said to be cointegrated. The cointegrating equation may be interpreted as a long-run equilibrium relationship among the variables (Dunis and Ho, 2005). Cointegration of stock markets means there is a long-run relationship between them; if Y and X are I(1) time series and are cointegrated so that $u = Y - \alpha - \beta x$ is I(0), then, in the long-run, Y and X do not drift apart, since u has a constant mean, which is zero. $Y = \alpha + \beta X$ can be interpreted as an equilibrium or long-run relationship between these markets and u is referred to as the error correction term and the deviation from equilibrium which, in the long-run, is zero (Dunis and Ho, 2005).

The series were transformed into logarithms. The Australian-Chinese exchange rate was obtained from the Reserve Bank of Australia. The time series {lnPt} and {lnPt*} are non-stationary. The first step is to use unit root tests to determine whether they are integrated of the same order. If this is so, the next step involves the estimation of the regression equation

$S_t = \alpha + \beta_0 P_t - \beta_1 P_t^* + \mu$tand to take the unit root of the residual series {ut}. They are cointegrated if the test is successful. The residual equation is $\mu_t = S_t - \alpha - \beta_0 P_t + \beta_1 P_t^*$, which is the log spread of the two series {lnPt} and {lnPt*}. This study used the following Signal Index to determine when to enter and exit a trade.

$$RESID=E[\mu_t])+/-\delta\sigma_{\mu t} \quad (5.7)$$

The SI is based on the 95% confidence interval, where $E[\mu_t]=0$ $\delta=1.96$. Enter the trade if the RESID (the residual) value is greater than $\delta\sigma_{\mu t}$, or less than - $\delta\sigma_{\mu t}$, standard deviations from the mean and exit the trade by reversing positions if the $+/-\delta\sigma_{\mu t}$ standard deviation is less than RESID.

If RESID ≥ $+\delta\sigma_{\mu t}$, the trading rule is to go long in Pt and short Pt*. If RESID ≤ $-\delta\sigma_{\mu t}$, the trading rule is to short Pt and go long in Pt*

### 5.2.3 Markov Switching strategy

In this study the researcher conducted a pair trading statistical arbitrage between 33 pairs of stocks from the CSC Index and the Australian resource stocks. The pairs of stocks were selected using market capitalisation information. The pairs were transformed into a relative price ratio and Markov switching models were employed. The price ratio of two assets, Australian and Chinese are assumed to follow a mean reverting process, which implies that short-term deviations from the equilibrium ratio are balanced after a period of adjustment (Bock and Mestel, 2009). The ratio exhibits a switching mean. The regime shifts are governed by a Markov chain. The current regime $s_t$ is determined by an unobservable variable. The inference of regimes is based on state probabilities. The applied model has two-states, and is a first-order Markov-switching process with a switching mean, and a switching variance.

The data was transformed into logarithms. The Chinese data was converted into Australian dollars. Thereafter a price ratio of Australian stocks to Chinese stocks was undertaken. This ratio converged to a long-run equilibrium, but in the short-run there are arbitrage opportunities. Using the Markov switching program supplied by Brooks (2008) in RATS, which is based on Hamilton's (1990) regime switching EM algorithm[9] and solved using maximum likelihood techniques, the means, standard deviations and probabilities of the ratio being in state one (a high mean regime) or state two (a low mean regime) were calculated. The daily probabilities of the ratio being in the high or low mean regime were also calculated. The trading rule was that if the ratio was likely to be in the high mean regime then a trader would sell Australian stock and buy the Chinese stock. If the ratio was likely to be in the low mean regime, then a trader would buy Australian stock and sell Chinese stock.

### 5.2.4 Index Tracking Model

The portfolio holdings in each of the stocks selected are estimated, based on ordinary least squares coefficients of the cointegration equation that regresses the index log price on the portfolio stocks' log prices over a given calibration period prior to the portfolio's construction moment. The log transformation is applied to produce a more homogenous series.

[9] EM algorithm represents 'expectation-maximisation algorithm', and it is a maximum likelihood estimate obtained by separating a sample into subgroups and estimating a model for each group using maximum likelihood (Greene, 2008).

$$Log(CSC_t) = a_0 + \sum_{k=1}^{n} a_k . LogP_{kt} + e_t \tag{5.8}$$

The index is the CSC Index, $P_{K,t}$ is the price of the Australian stock $P_K$ at time t. If the series CSC Index is co integrated with $P_{K,t}$, the residual series (the tracking error) will be stationary. The data are transformed in to logarithms and standardised according to the following formula:

$$Standardised\ Price = \frac{Price - Mean\ Price}{Standard\ Deviation\ of\ Price} \tag{5.9}$$

**5.2.5 Enhanced Indexing Model**

Having constructed a simple tracking strategy, this study will replicate 'plus' and 'minus' benchmarks which are constructed by adding to and subtracting from the benchmark returns an annual excess return of x%, uniformly distributed to daily returns.

$$Log(CSC_t Plus_t) = a_0 + \sum_{k=1}^{n} a_k . LogP_{kt} + e_t \tag{5.10}$$

The CSC Plus index is devised as a benchmark for the long portfolio.

$$Log(CSC_t Minus_t) = a_0 + \sum_{k=1}^{n} a_k . LogP_{kt} + e_t \tag{5.11}$$

The CSC Minus index is devised as a benchmark for the short portfolio.

The tracking error and the Sharpe ratio were calculated for the index tracking and enhanced indexing portfolios. The tracking error was a measure of how closely a portfolio follows the index to which it is benchmarked.

$$\omega = \sqrt{Var(r_p - r_b)} \tag{5.12}$$

The Sharpe Ratio measured the performance of the portfolio.

$$SR = \frac{Return - Risk\ FreeRate}{Standard\ Deviation} \tag{5.13}$$

## 5.3 Data

The data used for this study comprised of stock prices of 33 financial stocks listed on the Australian Stock Exchange (ASX) and the Shanghai Stock Exchange (SSE). All of the Australian 33 stocks were listed on the S&P/ASX300 Metals and Mining Index, they were chosen according to their market capitalisation, which means that they were amongst the largest and most actively traded stocks in that industry. This is important for pairs trading since illiquidity on both the long and short side of the market is a fundamental risk when implementing this trading strategy. The Chinese stocks were the top 33 (by market capitalisation) stocks on the Chinese Shanghai Composite Index (CSC). The choice of 33 pairs of stocks was dictated by the Australian MAM index. The constituents of that index have very small capitalisations after the top 33 stocks are chosen, whereas the CSC constituents have larger capitalisations. The reason why these stocks were chosen was to allow meaningful comparison of stocks. For instance, the CSC has far more constituent stocks than the MAM. In order to find CSC/MAM pairs that were cointegrated or had regime switching characteristics, in the time period for all constituents would be time consuming. Also, it is thought that stocks with similar market capitalisation rankings in their respective indices may share other common characteristics.

For Part One of this study, the data was made up of daily data from 1 January 2003 to 1 March 2013. For Parts Two and Three of the study the data was made up of weekly data from 1 January 2007 to 1 March 2013. Missing values were replaced with the previous day's values. If data for the stock were not available in the given time period, the stock was discarded from the sample. The data was accessed from Yahoo Finance. There were 2353 daily price observations and 532 weekly observations.

The Table below lists the financial stocks used in this study.

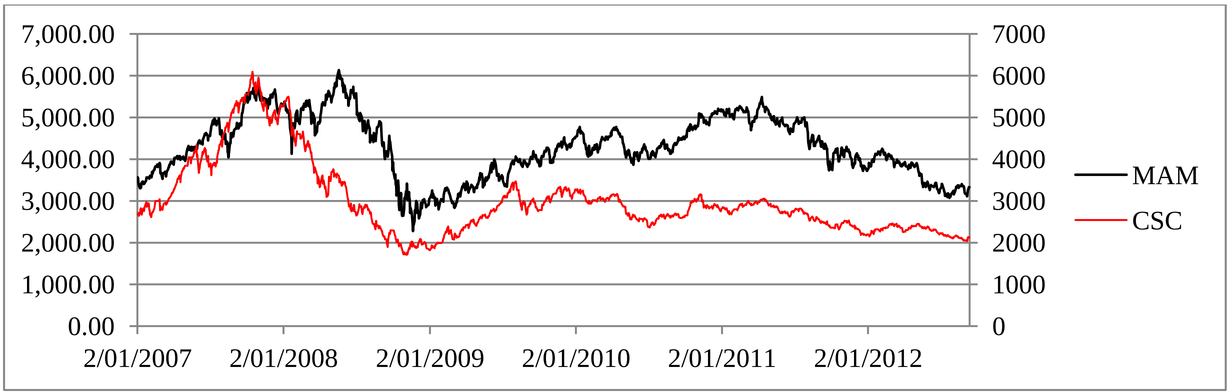
**Table 5-1 List of CSC and MAM stocks**

| STOCK | NAME | STOCK | NAME |
|---|---|---|---|
| 600879.ss | **Aerospace Times Electronic Technology Co., Ltd.** | AAI.AX | **Alcoa Inc.** |
| 601600.ss | **Aluminium Corporation of China Limited** | AGG.AX | **Anglogold Ashanti Limited** |
| 600019.SS | **Baoshan Iron And Steel Co., Ltd.** | AQP.AX | **Aquarius Platinum Ltd** |
| 600037.ss | **Beijing Gehua Catv Network Co., Ltd.** | ARI.AX | **ARRIUM FPO** |
| 600036.SS | **China Merchants Bank Co., Ltd.** | BHP.AX | **BHP Billiton Ltd** |
| 600016.SS | **China Minsheng Banking Corp Ltd.** | BSL.AX | **BlueScope Steel Limited** |
| 600028.SS | **China Petroleum and Chemical Corporation** | CDU.AX | **CuDeco Limited** |
| 600026.SS | **China Shipping Development Co., Ltd.** | EVN.AX | **EVOLUTION FPO** |
| 600050.ss | **China Unicom (Hong Kong) Ltd** | GBG.AX | **Gindalbie Metals Ltd.** |
| 600601.ss | **Finder Technology Group Corp.** | GDO.AX | **Gold One International Limited** |
| 600795.ss | **GD Power Development Co., Ltd.** | GRR.AX | **Grange Resources Limited** |
| 600011.SS | **Huaneng Power International Inc.** | IMD.AX | **Imdex Limited** |
| 600111.ss | **Inner Mongolia Baotou Steel Rare-earth Hi-tech Co., Ltd.** | IGO.AX | **Independence Group NL** |
| 600887.ss | **Inner Mongolia Yili Industrial Group Co., Ltd.** | IRN.AX | **Indophil Resources NL** |
| 600362.ss | **Jiangxi Copper Company Limited** | IGR.AX | **Integra Mining Limited** |
| 600269.ss | **Jiangxi Ganyue Expressway Co., Ltd.** | KCN.AX | **Kingsgate Consolidated Limited** |
| 600519.ss | **Kweichow Moutai Co., Ltd.** | LYC.AX | **Lynas Corporation Ltd.** |
| 600583.ss | **Offshore Oil Engineering Co., Ltd.** | MDL.AX | **Mineral Deposits Limited** |
| 600811.ss | **Orient Group, Inc.** | MGX.AX | **Mount Gibson Iron Limited** |
| 600104.ss | **Saic Motor Corporation Limited** | NCM.AX | **Newcrest Mining Limited** |
| 600009.SS | **Shanghai International Airport Co., Ltd.** | OGC.AX | **OceanaGold Corporation** |
| 600018.SS | **Shanghai International Port Group Co., Ltd.** | OZL.AX | **Oz Minerals Limited** |
| 600832.ss | **Shanghai Oriental Pearl Group** | PNA.AX | **PanAust Limited** |
| 600000.SS | **Shanghai Pudong Development Bank Co., Ltd** | RRL.AX | **Regis Resources Limited** |
| 600320.ss | **Shanghai Zhenhua Heavy Industries Co Ltd** | RSG.AX | **Resolute Mining Ltd.** |
| 600642.ss | **Shenergy Company Limited** | RIO.AX | **Rio Tinto Ltd** |
| 600331.ss | **Sichuan Hongda Co., Ltd.** | SGM.AX | **Sims Metal Management Ltd.** |
| 600688.ss | **Sinopec Shanghai Petrochemical Company Limited** | SIR.AX | **Sirius Resources NL** |
| 600717.ss | **Tianjin Port Group** | SPH.AX | **Sphere Minerals Ltd** |
| 600100.ss | **Tsinghua Tongfang Co., Ltd.** | SBM.AX | **St Barbara Ltd.** |
| 600005.SS | **Wuhan Iron And Steel Company Limited** | SDL.AX | **Sundance Resources Limited** |
| 600309.ss | **Yantai Wanhua Polyurethane Co., Ltd.** | TRY.AX | **Troy Resources Ltd** |
| 600177.ss | **Youngor Group Co., Ltd.** | WSA.AX | **Western Areas NL** |

The data were transformed into logs. For Part Three of the study, the index tracking and enhanced indexing portions of the Chinese and Australian data were standardised and a tracking error calculated.

Figure 5-1 compares the China Shanghai Composite Index (CSC) and the S&P/ASX 300 Metals and Mining Index (MAM). As can be seen, the two indices closely track each other, indicating that a close relationship exists between China and Australia.

**Figure 5-1The comparison of the Chinese and Australian indices**




*Note:* the daily data of the CSC is measured in Yuan and the daily data of the MAM is measured in Australian dollars. The data on the CSC is sourced from Yahoo Finance whilst the data on the MAM is sourced from Standard and Poor's. The latter source contains the full price history of the MAM.

Figure 5-1 shows that there is a structural break in about 2009. This is a graph in levels, depicting non-stationary and therefore, time-dependent volatility and short-term inefficiencies. The data were formally examined for a structural break using a Quandt-Andrews (Quandt, 1960) and (Andrews and Fair, 1988) test. A structural break was identified for 13 July 2009. The time series data was examined to identify if the Chinese and Australian variables were cointegrated. It was found that the series were cointegrated before and after the break. Whilst the study has conducted a test for structural breaks (see Appendix B), structural breaks are not relevant because this study employs a statistical arbitrage strategy which profits from the relative mis-pricing of stocks which takes advantage of 'down' as well as 'up' markets. The whole purpose of this study is to examine arbitrage opportunities, which do not take into account structural breaks. By selling stocks that are relatively over-priced and going long in stocks that are relatively under-priced, the strategy makes a profit when the stock pairs return to their equilibrium value. This does not bias the LOP strategy because it is the relative values of the stock pairs that are of interest. Also, if the pairs are cointegrated, then there must be a long-term equilibrium state to which the stock pairs revert towards.The aim of the dissertation is to study international arbitrage opportunities between Australia and China and not a single economic event between both countries. A common 'event study' does not prove economic interconnectedness between Australia and China over a period of time. A time series analysis over a period of time provides evidence of sustained interconnectedness over the time period. This dissertation studies international arbitrage. In a perfectly efficient market there would be no opportunities for arbitrage. The fact that there are arbitrage opportunities between Australian stocks and Chinese stocks (matched into pairs) show that both markets are inefficient and economically linked.

The study did not consider structural breaks, so a significant event such as the global financial crisis is already included in the analysis. The motivation of the study is not to consider specific economic events common to both countries, but to consider opportunities for statistical arbitrage. Whilst it has been proposed that such opportunities arise because of trade linkages between the countries, which result in a log-run equilibrium relationship between Australian and Chinese stocks, these economic links are not the focus of the study.

The Single Index model is more suitable for solving the PAM than multi-factor models. This is because a multi-factor model introduces too many terms in the PAM, whilst the single index model transforms to a first order autoregressive model which can be solved simply. Thus far, there have been no multi-factor models included in any PAM that the author is aware of. It is agreed that the single index model as well as the multi-factor problem suffer from the joint hypothesis problem (as does every asset pricing model). In this instance the problem is corrected with the use of the single index model used to calculate the speed of adjustment characteristics of Australian and Chinese stocks and not as a mechanism for asset pricing.

The following tables are mainly for descriptive statistics. Returns are provided in detail in the tables reported in Chapter Six.

Tables 5.2, 5.3, 5.4, and 5.5, below, show the descriptive statistics for the Chinese and Australian stocks.

The Jarque-Bera test statistic reveals that the data in all tables are not normally distributed.

**Table 5-2The descriptive statistics for the top 33 CSC index constituent stocks in levels**

## Panel A

| | Mean | Median | Maximum | Minimum | Std. Dev. | Skewness | Kurtosis | JB[1] |
|---|---|---|---|---|---|---|---|---|
| **_000001_SS** | 7.6761 | 7.719 | 8.7147 | 6.9192 | 0.4123 | 0.2066 | 2.3391 | 65.3597 |
| **_600000_SS** | 1.3863 | 1.7093 | 2.7305 | 0.0198 | 0.8463 | -0.2495 | 1.4082 | 299.3891 |
| **_600005_SS** | 1.2662 | 1.1969 | 3.0106 | -0.5108 | 0.8184 | -0.1446 | 2.6035 | 25.9146 |
| **_600009_SS** | 2.6102 | 2.5603 | 3.6881 | 1.6134 | 0.419 | 0.2541 | 4.0602 | 148.6338 |
| **_600011_SS** | 1.8255 | 1.7867 | 2.81 | 1.3137 | 0.2789 | 0.9775 | 4.0884 | 538.4704 |
| **_600016_SS** | 1.0278 | 1.5665 | 2.2586 | -0.9163 | 0.9616 | -0.5364 | 1.5867 | 338.6007 |
| **_600018_SS** | 1.8281 | 1.7716 | 2.7738 | 0.8671 | 0.5647 | -0.0257 | 1.6141 | 206.8282 |
| **_600019_SS** | 1.6876 | 1.5953 | 2.8976 | 1.075 | 0.3924 | 0.9723 | 3.5868 | 443.722 |
| **_600026_SS** | 2.1849 | 2.0869 | 3.6803 | 1.4061 | 0.5288 | 0.918 | 3.2452 | 368.9852 |
| **_600028_SS** | 1.8618 | 1.9359 | 3.2328 | 0.9933 | 0.4953 | 0.1266 | 2.371 | 49.4562 |
| **_600036_SS** | 1.9118 | 2.2951 | 3.228 | 0.3784 | 0.8472 | -0.4892 | 1.7241 | 278.105 |
| **_600037_SS** | 1.9921 | 2.1494 | 3.5788 | 0.6098 | 0.7675 | -0.1049 | 2.0027 | 111.7453 |
| **_600050_SS** | 1.4608 | 1.5369 | 2.5297 | 0.7372 | 0.4109 | 0.1889 | 2.2685 | 72.9215 |

## Panel B

| | Mean | Median | Maximum | Minimum | Std. Dev. | Skewness | Kurtosis | JB |
|---|---|---|---|---|---|---|---|---|
| **_600100_SS** | 1.2059 | 1.2369 | 2.5855 | 0.0488 | 0.6743 | 0.0787 | 1.7267 | 177.0904 |
| **_600104_SS** | 1.8421 | 1.9293 | 3.0606 | 0.4318 | 0.7698 | -0.1059 | 1.4914 | 249.6796 |
| **_600111_SS** | 0.1315 | 0.0296 | 3.8282 | -2.4079 | 1.8214 | 0.4031 | 1.8829 | 204.1856 |
| **_600177_SS** | 1.5487 | 2.0669 | 3.3354 | -0.6733 | 1.1276 | -0.55 | 1.9404 | 250.9588 |
| **_600269_SS** | 0.5987 | 0.8502 | 2.2235 | -1.1394 | 0.9823 | -0.3426 | 1.7572 | 216.6866 |
| **_600309_SS** | 1.4923 | 2.2006 | 3.1064 | -1.4697 | 1.3675 | -0.8261 | 2.2918 | 347.6396 |
| **_600320_SS** | 1.0317 | 1.6563 | 2.9156 | -2.0402 | 1.4139 | -0.8904 | 2.4464 | 374.1044 |
| **_600331_SS** | 1.3216 | 1.8856 | 3.1876 | -1.8971 | 1.5649 | -0.8096 | 2.2645 | 340.0121 |
| **_600362_SS** | 2.6998 | 3.0342 | 4.267 | 1.3191 | 0.8273 | -0.2252 | 1.5621 | 244.2693 |
| **_600519_SS** | 3.6602 | 4.5433 | 5.571 | 0.3577 | 1.7078 | -0.737 | 1.9467 | 353.0821 |
| **_600583_SS** | 0.4005 | 1.3284 | 2.2752 | -2.6593 | 1.7082 | -0.6344 | 1.7553 | 339.8636 |
| **_600601_SS** | 1.0562 | 1.0473 | 2.2513 | 0.0392 | 0.5453 | 0.0507 | 2.0785 | 92.4688 |
| **_600642_SS** | 1.1571 | 1.203 | 2.1066 | 0.3075 | 0.4183 | 0.0708 | 2.0211 | 105.2547 |

**Panel C**

| | Mean | Median | Maximum | Minimum | Std. Dev. | Skewness | Kurtosis | JB |
|---|---|---|---|---|---|---|---|---|
| **_600688_SS** | 1.8484 | 1.7884 | 3.0502 | 1.1019 | 0.4167 | 0.3772 | 2.5739 | 80.7495 |
| **_600717_SS** | 2.017 | 2.0242 | 3.4532 | 0.6678 | 0.6264 | -0.0471 | 2.7342 | 8.5581 |
| **_600795_SS** | -0.163 | 0.0296 | 1.3191 | -2.1203 | 0.9895 | -0.1751 | 1.5365 | 243.6076 |
| **_600811_SS** | 1.1599 | 1.4219 | 2.7421 | -0.1165 | 0.8012 | -0.1416 | 1.4719 | 259.8514 |
| **_600832_SS** | 1.3149 | 1.678 | 2.6355 | -0.462 | 0.8985 | -0.5298 | 1.6971 | 303.4281 |
| **_600879_SS** | 1.895 | 1.8547 | 2.8202 | 0.7885 | 0.5055 | -0.0856 | 1.7547 | 169.9907 |
| **_600887_SS** | 1.475 | 1.3661 | 3.1897 | -0.4155 | 0.9004 | 0.2935 | 2.3394 | 84.0147 |
| **_601600_SS** | 2.5026 | 2.4345 | 4.0358 | 1.5195 | 0.476 | 0.6882 | 3.6446 | 248.5236 |

Amongst the CSC constituent stocks, 600362.ss has the highest mean (2.6998) and the highest maximum value (4.2670); 600111.ss has the highest standard deviation (1.8213). The Jarque-Bera statistics reveal the data are not normally distributed.

**Table 5-3The descriptive statistics for the top 33 Australian resource stocks in levels**

## Panel A

| | Mean | Median | Maximum | Minimum | Std. Dev. | Skewness | Kurtosis | JB |
|---|---|---|---|---|---|---|---|---|
| **AAI** | 2.9098 | 3.1199 | 3.7558 | 1.6094 | 0.4944 | -0.3847 | 1.7766 | 224.7168 |
| **AGG** | 2.184 | 2.1939 | 2.735 | 1.4183 | 0.1964 | -0.3259 | 3.6404 | 89.8079 |
| **AQP** | 0.6257 | 0.8879 | 2.7991 | -1.273 | 1.1679 | -0.0927 | 1.6747 | 192.516 |
| **ARI** | 0.6526 | 0.7324 | 1.7174 | -0.7134 | 0.5425 | -0.1535 | 2.1175 | 93.932 |
| **BHP** | 3.1594 | 3.3937 | 3.858 | 1.884 | 0.5399 | -0.8663 | 2.433 | 357.5573 |
| **BSL** | 4.5531 | 4.7313 | 5.6247 | 1.1787 | 0.8899 | -1.3421 | 4.3368 | 967.4249 |
| **CDU** | 1.0204 | 1.2698 | 1.9615 | -1.9661 | 0.8383 | -2.3633 | 7.7236 | 4803.897 |
| **EVN** | 1.7151 | 1.7884 | 3.5035 | 0.174 | 0.9591 | -0.0674 | 1.6257 | 205.0593 |
| **GBG** | -0.8632 | -0.5621 | 0.5988 | -2.8134 | 0.9439 | -0.6008 | 2.074 | 247.5834 |
| **GDO** | 2.1485 | 2.5802 | 6.6438 | -1.5141 | 2.6947 | -0.1097 | 1.332 | 304.509 |
| **GRR** | -0.8349 | -0.755 | 0.3646 | -2.2073 | 0.6295 | -0.3092 | 2.2194 | 106.6907 |
| **IGO** | 0.9482 | 1.3097 | 2.1702 | -1.3863 | 0.8842 | -0.8399 | 2.8619 | 305.63 |
| **IGR** | -1.569 | -1.6094 | -0.3011 | -2.9957 | 0.7358 | -0.0399 | 1.6882 | 185.8112 |

## Panel B

| | Mean | Median | Maximum | Minimum | Std. Dev. | Skewness | Kurtosis | JB |
|---|---|---|---|---|---|---|---|---|
| **IMD** | -0.5923 | -0.4155 | 1.1282 | -2.8134 | 1.047 | -0.2875 | 1.7201 | 211.8145 |
| **IRN** | -0.6377 | -0.6733 | 0.3507 | -1.8971 | 0.5369 | -0.1295 | 2.0091 | 112.8485 |
| **KCN** | 1.4971 | 1.4816 | 2.4458 | 0.5766 | 0.4458 | 0.1597 | 2.0747 | 103.0825 |
| **LYC** | -1.0041 | -0.9676 | 0.9555 | -2.8134 | 0.9757 | 0.0153 | 2.0088 | 105.7945 |
| **MDL** | 3.6621 | 4.1431 | 5.2497 | 1.1817 | 1.2187 | -0.6632 | 1.9694 | 303.5375 |
| **MGX** | -0.3572 | -0.2485 | 1.1878 | -2.5257 | 0.9371 | -0.667 | 2.5065 | 217.6489 |
| **NCM** | 3.1107 | 3.2013 | 3.7448 | 1.0919 | 0.4596 | -1.0309 | 3.5938 | 495.2306 |
| **OGC** | 1.6561 | 1.2398 | 3.2741 | -1.8326 | 1.2903 | -0.3236 | 2.0581 | 140.5303 |
| **OZL** | 1.8232 | 1.7405 | 3.3036 | -0.2614 | 0.8186 | -0.1428 | 2.4267 | 44.1393 |
| **PNA** | 4.0906 | 4.1696 | 5.0034 | 3.291 | 0.3969 | -0.0681 | 2.3548 | 46.7778 |
| **RIO** | 1.1065 | 1.6094 | 2.8904 | -2.6593 | 1.4145 | -0.8604 | 2.626 | 333.2651 |
| **RRL** | 0.1925 | 0.27 | 0.9203 | -0.9943 | 0.3752 | -0.7893 | 3.0977 | 269.11 |
| **RSG** | 1.6385 | 1.9257 | 3.285 | 0.01 | 0.9788 | -0.0186 | 1.3638 | 288.1708 |

**Panel C**

| | Mean | Median | Maximum | Minimum | Std. Dev. | Skewness | Kurtosis | JB |
|---|---|---|---|---|---|---|---|---|
| **SBM** | -2.3382 | -2.0402 | -0.1625 | -4.6052 | 1.3272 | -0.3833 | 1.7694 | 226.1625 |
| **SDL** | 2.6639 | 2.7279 | 3.6447 | 1.6696 | 0.438 | -0.3496 | 2.5125 | 78.1467 |
| **SGM** | 4.1222 | 7.4775 | 8.6614 | -2.9957 | 4.0033 | -0.3561 | 1.5578 | 278.3379 |
| **SIR** | -0.0095 | 0.1613 | 1.4351 | -2.3026 | 1.0619 | -0.6078 | 2.1309 | 240.2393 |
| **SPH** | 0.7837 | 0.7747 | 1.6094 | -0.5276 | 0.4281 | -0.1929 | 2.683 | 26.8215 |
| **WSA** | 2.0107 | 2.2252 | 2.9601 | 0.6931 | 0.5615 | -0.4427 | 1.7667 | 247.949 |
| **TRY** | 1.0535 | 1.3674 | 2.3915 | -1.3093 | 0.7927 | -0.9929 | 3.2912 | 433.336 |

BSL has the highest mean (4.5531) and the highest maximum value (5.6247); SBM has the highest standard deviation (1.3271). The Jarque-Bera statistics reveal the data are not normally distributed.

**Table 5-4The descriptive statistics for the top 33 CSC index constituent stocks in first differences**

## Panel A

| | Mean | Median | Maximum | Minimum | Std. Dev. | Skewness | Kurtosis | JB |
|---|---|---|---|---|---|---|---|---|
| **_600000_SS** | 1.3863 | 1.7093 | 2.7305 | 0.0198 | 0.8463 | -0.2495 | 1.4082 | 299.3891 |
| **_600005_SS** | 1.2662 | 1.1969 | 3.0106 | -0.5108 | 0.8184 | -0.1446 | 2.6035 | 25.9146 |
| **_600009_SS** | 2.6102 | 2.5603 | 3.6881 | 1.6134 | 0.419 | 0.2541 | 4.0602 | 148.6338 |
| **_600011_SS** | 1.8255 | 1.7867 | 2.81 | 1.3137 | 0.2789 | 0.9775 | 4.0884 | 538.4704 |
| **_600016_SS** | 1.0278 | 1.5665 | 2.2586 | -0.9163 | 0.9616 | -0.5364 | 1.5867 | 338.6007 |
| **_600018_SS** | 1.8281 | 1.7716 | 2.7738 | 0.8671 | 0.5647 | -0.0257 | 1.6141 | 206.8282 |
| **_600019_SS** | 1.6876 | 1.5953 | 2.8976 | 1.075 | 0.3924 | 0.9723 | 3.5868 | 443.722 |
| **_600026_SS** | 2.1849 | 2.0869 | 3.6803 | 1.4061 | 0.5288 | 0.918 | 3.2452 | 368.9852 |
| **_600028_SS** | 1.8618 | 1.9359 | 3.2328 | 0.9933 | 0.4953 | 0.1266 | 2.371 | 49.4562 |
| **_600036_SS** | 1.9118 | 2.2951 | 3.228 | 0.3784 | 0.8472 | -0.4892 | 1.7241 | 278.105 |
| **_600037_SS** | 1.9921 | 2.1494 | 3.5788 | 0.6098 | 0.7675 | -0.1049 | 2.0027 | 111.7453 |
| **_600050_SS** | 1.4608 | 1.5369 | 2.5297 | 0.7372 | 0.4109 | 0.1889 | 2.2685 | 72.9215 |
| **_600100_SS** | 1.2059 | 1.2369 | 2.5855 | 0.0488 | 0.6743 | 0.0787 | 1.7267 | 177.0904 |

## Panel B

| | Mean | Median | Maximum | Minimum | Std. Dev. | Skewness | Kurtosis | JB |
|---|---|---|---|---|---|---|---|---|
| **_600104_SS** | 1.8421 | 1.9293 | 3.0606 | 0.4318 | 0.7698 | -0.1059 | 1.4914 | 249.6796 |
| **_600111_SS** | 0.1315 | 0.0296 | 3.8282 | -2.4079 | 1.8214 | 0.4031 | 1.8829 | 204.1856 |
| **_600177_SS** | 1.5487 | 2.0669 | 3.3354 | -0.6733 | 1.1276 | -0.55 | 1.9404 | 250.9588 |
| **_600269_SS** | 0.5987 | 0.8502 | 2.2235 | -1.1394 | 0.9823 | -0.3426 | 1.7572 | 216.6866 |
| **_600309_SS** | 1.4923 | 2.2006 | 3.1064 | -1.4697 | 1.3675 | -0.8261 | 2.2918 | 347.6396 |
| **_600320_SS** | 1.0317 | 1.6563 | 2.9156 | -2.0402 | 1.4139 | -0.8904 | 2.4464 | 374.1044 |
| **_600331_SS** | 1.3216 | 1.8856 | 3.1876 | -1.8971 | 1.5649 | -0.8096 | 2.2645 | 340.0121 |
| **_600362_SS** | 2.6998 | 3.0342 | 4.267 | 1.3191 | 0.8273 | -0.2252 | 1.5621 | 244.2693 |
| **_600519_SS** | 3.6602 | 4.5433 | 5.571 | 0.3577 | 1.7078 | -0.737 | 1.9467 | 353.0821 |
| **_600583_SS** | 0.4005 | 1.3284 | 2.2752 | -2.6593 | 1.7082 | -0.6344 | 1.7553 | 339.8636 |
| **_600601_SS** | 1.0562 | 1.0473 | 2.2513 | 0.0392 | 0.5453 | 0.0507 | 2.0785 | 92.4688 |
| **_600642_SS** | 1.1571 | 1.203 | 2.1066 | 0.3075 | 0.4183 | 0.0708 | 2.0211 | 105.2547 |
| **_600688_SS** | 1.8484 | 1.7884 | 3.0502 | 1.1019 | 0.4167 | 0.3772 | 2.5739 | 80.7495 |

**Panel C**

| | Mean | Median | Maximum | Minimum | Std. Dev. | Skewness | Kurtosis | JB |
|---|---|---|---|---|---|---|---|---|
| **_600717_SS** | 2.017 | 2.0242 | 3.4532 | 0.6678 | 0.6264 | -0.0471 | 2.7342 | 8.5581 |
| **_600795_SS** | -0.163 | 0.0296 | 1.3191 | -2.1203 | 0.9895 | -0.1751 | 1.5365 | 243.6076 |
| **_600811_SS** | 1.1599 | 1.4219 | 2.7421 | -0.1165 | 0.8012 | -0.1416 | 1.4719 | 259.8514 |
| **_600832_SS** | 1.3149 | 1.678 | 2.6355 | -0.462 | 0.8985 | -0.5298 | 1.6971 | 303.4281 |
| **_600879_SS** | 1.895 | 1.8547 | 2.8202 | 0.7885 | 0.5055 | -0.0856 | 1.7547 | 169.9907 |
| **_600887_SS** | 1.475 | 1.3661 | 3.1897 | -0.4155 | 0.9004 | 0.2935 | 2.3394 | 84.0147 |
| **_601600_SS** | 2.5026 | 2.4345 | 4.0358 | 1.5195 | 0.476 | 0.6882 | 3.6446 | 248.5236 |

600009.sshave the highest mean (2.6102) and the highest maximum value (3.6881); 600111.ss has the highest standard deviation (1.8213). The Jarque-Bera statistics reveal the data are not normally distributed.

**Table 5-5The descriptive statistics for the top 33 Australian resource stocks in first differences**

## Panel A

| | Mean | Median | Maximum | Minimum | Std. Dev. | Skewness | Kurtosis | JB |
|---|---|---|---|---|---|---|---|---|
| **AAI** | 2.9098 | 3.1199 | 3.7558 | 1.6094 | 0.4944 | -0.3847 | 1.7766 | 224.7168 |
| **AGG** | 2.184 | 2.1939 | 2.735 | 1.4183 | 0.1964 | -0.3259 | 3.6404 | 89.8079 |
| **AQP** | 0.6257 | 0.8879 | 2.7991 | -1.273 | 1.1679 | -0.0927 | 1.6747 | 192.516 |
| **ARI** | 0.6526 | 0.7324 | 1.7174 | -0.7134 | 0.5425 | -0.1535 | 2.1175 | 93.932 |
| **BHP** | 3.1594 | 3.3937 | 3.858 | 1.884 | 0.5399 | -0.8663 | 2.433 | 357.5573 |
| **BSL** | 4.5531 | 4.7313 | 5.6247 | 1.1787 | 0.8899 | -1.3421 | 4.3368 | 967.4249 |
| **CDU** | 1.0204 | 1.2698 | 1.9615 | -1.9661 | 0.8383 | -2.3633 | 7.7236 | 4803.897 |
| **EVN** | 1.7151 | 1.7884 | 3.5035 | 0.174 | 0.9591 | -0.0674 | 1.6257 | 205.0593 |
| **GBG** | -0.8632 | -0.5621 | 0.5988 | -2.8134 | 0.9439 | -0.6008 | 2.074 | 247.5834 |
| **GDO** | 2.1485 | 2.5802 | 6.6438 | -1.5141 | 2.6947 | -0.1097 | 1.332 | 304.509 |
| **GRR** | -0.8349 | -0.755 | 0.3646 | -2.2073 | 0.6295 | -0.3092 | 2.2194 | 106.6907 |
| **IGO** | 0.9482 | 1.3097 | 2.1702 | -1.3863 | 0.8842 | -0.8399 | 2.8619 | 305.63 |
| **IGR** | -1.569 | -1.6094 | -0.3011 | -2.9957 | 0.7358 | -0.0399 | 1.6882 | 185.8112 |

## Panel B

| | Mean | Median | Maximum | Minimum | Std. Dev. | Skewness | Kurtosis | JB |
|---|---|---|---|---|---|---|---|---|
| **IMD** | -0.5923 | -0.4155 | 1.1282 | -2.8134 | 1.047 | -0.2875 | 1.7201 | 211.8145 |
| **IRN** | -0.6377 | -0.6733 | 0.3507 | -1.8971 | 0.5369 | -0.1295 | 2.0091 | 112.8485 |
| **KCN** | 1.4971 | 1.4816 | 2.4458 | 0.5766 | 0.4458 | 0.1597 | 2.0747 | 103.0825 |
| **LYC** | -1.0041 | -0.9676 | 0.9555 | -2.8134 | 0.9757 | 0.0153 | 2.0088 | 105.7945 |
| **MDL** | 3.6621 | 4.1431 | 5.2497 | 1.1817 | 1.2187 | -0.6632 | 1.9694 | 303.5375 |
| **MGX** | -0.3572 | -0.2485 | 1.1878 | -2.5257 | 0.9371 | -0.667 | 2.5065 | 217.6489 |
| **NCM** | 3.1107 | 3.2013 | 3.7448 | 1.0919 | 0.4596 | -1.0309 | 3.5938 | 495.2306 |
| **OGC** | 1.6561 | 1.2398 | 3.2741 | -1.8326 | 1.2903 | -0.3236 | 2.0581 | 140.5303 |
| **OZL** | 1.8232 | 1.7405 | 3.3036 | -0.2614 | 0.8186 | -0.1428 | 2.4267 | 44.1393 |
| **PNA** | 4.0906 | 4.1696 | 5.0034 | 3.291 | 0.3969 | -0.0681 | 2.3548 | 46.7778 |
| **RIO** | 1.1065 | 1.6094 | 2.8904 | -2.6593 | 1.4145 | -0.8604 | 2.626 | 333.2651 |
| **RRL** | 0.1925 | 0.27 | 0.9203 | -0.9943 | 0.3752 | -0.7893 | 3.0977 | 269.11 |
| **RSG** | 1.6385 | 1.9257 | 3.285 | 0.01 | 0.9788 | -0.0186 | 1.3638 | 288.1708 |

**Panel C**

| | Mean | Median | Maximum | Minimum | Std. Dev. | Skewness | Kurtosis | JB |
|---|---|---|---|---|---|---|---|---|
| **SBM** | -2.3382 | -2.0402 | -0.1625 | -4.6052 | 1.3272 | -0.3833 | 1.7694 | 226.1625 |
| **SDL** | 2.6639 | 2.7279 | 3.6447 | 1.6696 | 0.438 | -0.3496 | 2.5125 | 78.1467 |
| **SGM** | 4.1222 | 7.4775 | 8.6614 | -2.9957 | 4.0033 | -0.3561 | 1.5578 | 278.3379 |
| **SIR** | -0.0095 | 0.1613 | 1.4351 | -2.3026 | 1.0619 | -0.6078 | 2.1309 | 240.2393 |
| **SPH** | 0.7837 | 0.7747 | 1.6094 | -0.5276 | 0.4281 | -0.1929 | 2.683 | 26.8215 |
| **TRY** | 1.0535 | 1.3674 | 2.3915 | -1.3093 | 0.7927 | -0.9929 | 3.2912 | 433.336 |
| **WSA** | 2.0107 | 2.2252 | 2.9601 | 0.6931 | 0.5615 | -0.4427 | 1.7667 | 247.949 |

BSL has the highest mean value (4.5531) and the highest maximum value (5.6247); SBM has the highest standard deviation (1.3271). The Jarque-Bera statistics reveal the data are not normally distributed.

According to Brooks (2008) it may be possible to employ an estimation method that does not assume normality, but that such a method is difficult to implement. Brooks (2008) recommends continuing using OLS, as its behaviour is well researched and for sufficiently large sample sizes violation of the normality assumption is inconsequential.

Tables 5-6 and 5-7 that follow demonstrate the results of preliminary analysis to ascertain whether the CSC and MAM indices are correlated. If they are correlated, then they may be economically linked and may also be cointegrated.

**Table 5 6Results of CSC index regressed on to MAM index**

The Table 5-6 shows the result of the hypotheses test. $H_0$:$\beta = 1$.

| | |
|---|---|
| Coefficient of Constant | -262.26** |
| Coefficient of MAM | 0.7603* |
| Standard Error of Constant | 109.16 |
| Standard Error of MAM | 0.025 |
| t-Statistic of Constant | -2.4024 |
| t-Statistic of MAM | 30.3694 |
| Adjusted R-squared | 0.3936 |
| Durbin-Watson | 0.0122 |

$CSC_t = \alpha + \beta\ MAM_t + \varepsilon$

**Note:** * significant at 1%; ** significance at 5%.

The test results suggest that the null hypothesis should be clearly rejected. The p-value for the test is zero to four decimal places. The results reveal that the slope parameter is not one. This implies that the CSC and MAM indices are not perfectly correlated, that the sensitivity of CSC to MAM is 0.7603, so there is a lag in the adjustment of CSC to MAM. The Durbin-Watson test statistic shows evidence of significant serial correlation; implying that the coefficients in this table cannot be relied upon.

**Table 5-7 Results of CSC index returns regressed on to MAM index returns**

The Table 5-8 shows the result of the hypotheses test. $H_0: \beta = 1$.

| | |
|---|---|
| Coefficient of Constant | -0.1139 |
| Coefficient of MAM | 0.1870* |
| Standard Error of Constant | 15.68 |
| Standard Error of MAM | 0.018 |
| t-Statistic of Constant | -0.0726 |
| t-Statistic of MAM | 10.3408 |
| Adjusted R-squared | 0.071 |
| Durbin-Watson | 0.071 |

**Notes:** * significant at 1%; ** significance at 5%.

$CSC_{RET} = \alpha + \beta\ MAM_{RET} + \varepsilon$

The Durbin-Watson test statistic shows that there is no evidence of serial correlation. The slope parameter is 0.1870. The coefficients reveal that there is a relationship, but that there is a lag in the adjustment of CSC to MAM. This is confirmed by the Wald test in Table 5-8. As the CSC and MAM indices are linked, they may be used to implement an international arbitrage strategy based on this preliminary analysis.

**Table 5-8 Results of Wald Test for MAM in returns**

| Test Statistic | Value |
|---|---|
| t-statistic | -44.9493* |
| F-statistic | 2020.441* |
| Chi-square | 2020.441* |

**Notes:** * significant at 1%; ** significance at 5%.

The Table 5-8 shows the result of the hypotheses test. $H_0: \beta = 1$. The test results suggest that the null hypothesis should be clearly rejected. The p-value for the test is zero to four decimal places. The results of the Wald test reveal that there is a relationship between the CSC and MAM indices, but that they are not perfectly correlated. The reason for the Wald test is that part of our analysis examines non-linear relationships by way of a Markov switching strategy. This preliminary result demonstrates that there is a non-linear relationship between the variables.

Using a separate t-tests of the means of CSC and MAM indices, it is shown that the means of the returns of CSC (-0.1541) and MAM (-0.2145) are significantly different with t-values of -2.03E-07 and -7.61E-08 respectively. The CSC index has a higher return to that of the MAM index.

### 5.4 Summary

In this Chapter, the LOP, Markov, index tracking and enhanced indexing models were presented. The sample consisted of the 2353 daily observations and 532 weekly observations of the largest 33 (by market capitalisation) Australian resource stocks and CSC constituent stocks. The descriptive statistics reveal that the data were not normally distributed. They showed evidence of fat tails and peaks around their mean values; characteristic of leptokurtic distributions, typical of financial data. The lack of normally distributed distributions is a potential limitation of this study, however, it is inconsequential in this instance because the sample size is large, which, according to the Central Limit Theorem, suggests that the results may not be biased despite non-normality. Preliminary data analysis reveals that the Australian and CSC samples are significantly different; the CSC index has a higher return to that of the MAM index.

# CHAPTER SIX

# RESULTS

## 6.1 Introduction

The Results section report the findings with the analysis left to chapter 7 'Discussion of Results'. It is there that the results are explained in terms of the analysis. Chapter Six reports results. In depth analysis is left to Chapter 7, which discusses the results in view of the detailed Theory and Literature section. The objective of this study is to investigate international arbitrage strategies between China and Australia. The study is comprised of Three Parts. Part One deals with market efficiency and the PAM. Part Two examines two contrarian strategies (LOP and Markov switching strategy) and Part Three deals with two momentum strategies (index tracking and enhanced indexing).

The crux of investing lies in information, and the main issue is how this information is processed. If information is processed rationally and quickly, then markets are efficient; otherwise they are categorised as being inefficient. Investors are not a homogenous group. They consist of noise traders and informed traders. Noise traders are uninformed investors who behave irrationally. Their behaviour leads to information processing errors caused by behavioural biases and psychological heuristics. The subsequent mis-pricing of stocks is a short-term phenomenon in this study, due to the cointegrating relationship and Markovian relationship between the CSC index, its constituent stocks, and Australian resource stocks. The mis-pricing represents a short-run inefficiency, in the long-run there is equilibrium and markets are efficient. In this formulation there are no limits to arbitrage.

In this section of the study the results are presented, with particular attention paid to those relating to the testing of hypotheses. The findings related to market efficiency, contrarian strategies (LOP and Markov switching), combined strategies, momentum strategies (index tracking, enhanced indexing and combined strategies) are presented in turn.

The first step in the study is to present the results of the PAM's speed of adjustment coefficient for the CSC constituent stocks and the Australian resource stocks. The next step is to analyse the results for the LOP and Markov strategies. The LOP is based on the Engle-

Granger (1987) methodology, and the study must ascertain whether or not the variables are stationary. If they are non-stationary in levels and stationary in first differences they are said to be integrated of order one, and can be combined to form a long-run equilibrium relationship. If there is a long-run equilibrium between stocks, then they are efficient, and rational expectations are implied. The tests for determining whether the series contain a unit root are applied, including the Augmented Dickey-Fuller (ADF), the Phillips-Perron (PP) and the KPSS tests. The reason for three lots of unit root tests, is because it is important that the variables are integrated even where there are structural breaks in the data. The PP test controls for structural breaks in the data. The three tests verify the robustness of the unit roots. In light of the limitations of the data a significance level of 10% is accepted.

For the contrarian strategy, the study has chosen the stock pairs by way of the PAM's speed of adjustment coefficient for one lot of tests, and then by market capitalisation for another lot of tests.

After the results of the contrarian (LOP and Markov switching) strategies are presented, the unit root tests of residuals for the Index tracking strategies are presented. There were 13 stocks that were found to be cointegrated using the Engle-Granger (1987) methodology. Following this, the results of the index tracking and enhanced indexing strategies are presented. If there is cointegration, then in the short-term there is over-estimation or under-estimation of the exogenous variable; in the long-term there is market efficiency. Cointegration means that there is evidence of rational expectations. Refer to Table 5-1 for company codes.

Finally the LOP and Markov switching strategies are combined into a global portfolio; and the index tracking and enhanced indexing strategies are also combined into a global portfolio; and the efficient portfolio for each of these a global portfolios is determined.

**Figure 6-1 Overview of Results**

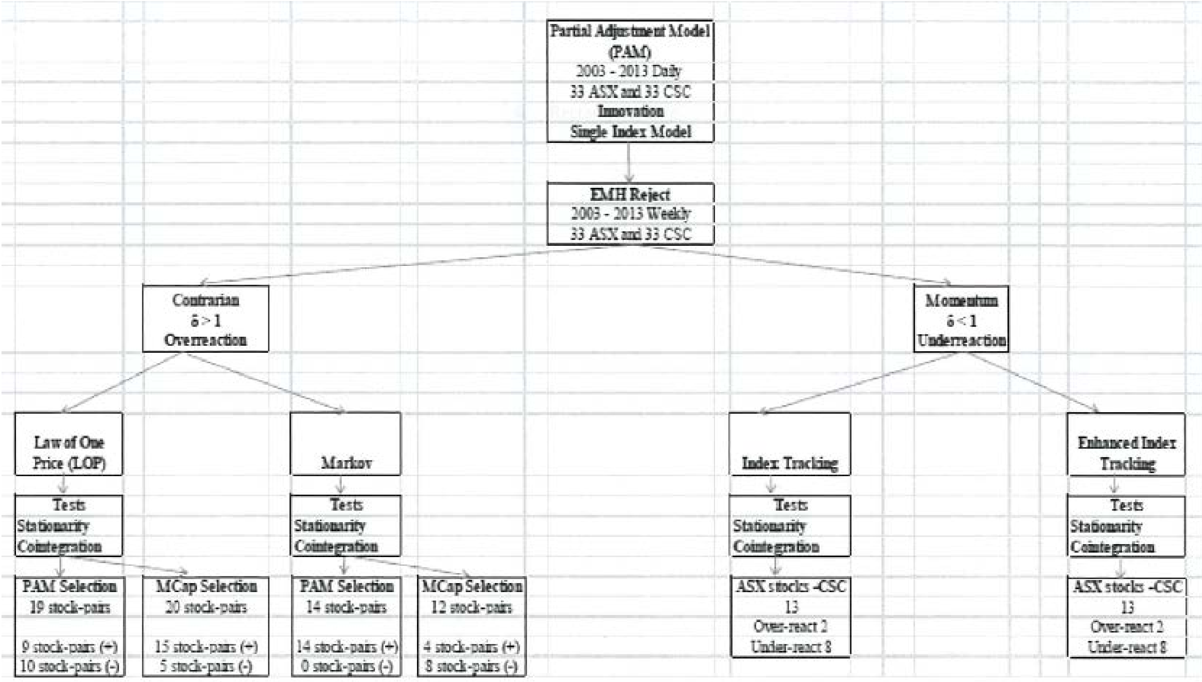



Figure 6-1 shows that under the LOP strategy the variable are tested for stationarity and then cointegration is employed to ascertain whether the stock pairs have a long-run relationship. There are two methods used for the selection of stocks, the PAM and market capitalisations. In the Markov model stocks are also selected using PAM and market capitalisations. With momentum strategies all variables are tested for stationarity and then cointegration is employed. The two momentum strategies are index tracking and enhanced indexing.

Table 6-1presents the speed of adjustment coefficients derived from the PAM for Chinese CSC constituent stocks and Australian resources stock's.

**Table 6-1The speed of adjustment coefficients for Chinese and Australian stocks**

| **'STOCK'** | **SPEED** | **BETA** | **MCAP(mil)** | **'STOCK'** | **SPEED** | **BETA** | **MCAP(mil)** |
|---|---|---|---|---|---|---|---|
| **600519.ss** | 1.0664 | 1.0694 | 26386.0800 | **NCM.AX** | 1.5637 | 1.1534 | 14399.0500 |
| **600583.ss** | 1.0308 | 1.0696 | 3867.2400 | **OGC.AX** | 1.0751 | 1.1948 | 1362.9100 |
| **600050.ss** | 1.0127 | 0.8299 | 12033.8100 | **MDL.AX** | 1.0456 | 1.0662 | 275.6800 |
| **600018.SS** | 1.0078 | 1.1250 | 9494.8500 | **GDO.AX** | 1.0417 | 0.8104 | 339.9700 |
| **600016.SS** | 1.0071 | 0.5820 | 40444.8400 | **KCN.AX** | 1.0306 | 0.9918 | 531.4000 |
| **600879.ss** | 1.0057 | 1.2637 | 1123.4400 | **AGG.AX** | 1.0114 | 1.4252 | 1831.0000 |
| **600036.SS** | 1.0030 | 1.2908 | 42476.3300 | **AAI.AX** | 1.0077 | 0.1332 | 8500.0000 |
| **600000.SS** | 1.0000 | 1.0624 | 29108.0700 | **SBM.AX** | 1.0073 | 1.4554 | 514.9200 |
| **600642.ss** | 0.9969 | 1.1110 | 3293.4500 | **CDU.AX** | 1.0032 | 0.2997 | 663.5900 |
| **600037.ss** | 0.9963 | 0.8170 | 1051.0300 | **RRL.AX** | 1.0017 | 0.2689 | 1878.6800 |
| **600795.ss** | 0.9937 | 1.1549 | 7910.9400 | **IGO.AX** | 0.9988 | 0.8381 | 859.3400 |
| **601600.ss** | 0.9926 | 1.3598 | 7473.8000 | **SPH.AX** | 0.9920 | 1.7944 | 676.6300 |
| **600331.ss** | 0.9914 | 1.0290 | 872.4300 | **BHP.AX** | 0.9911 | 0.6385 | 161632.0000 |
| **600688.ss** | 0.9864 | 1.1146 | 5543.3900 | **MGX.AX** | 0.9898 | 1.0831 | 512.5700 |
| **600832.ss** | 0.9795 | 0.8298 | 2698.6100 | **RSG.AX** | 0.9898 | 1.4357 | 729.9100 |
| **600028.SS** | 0.9791 | 1.0624 | 104374.2400 | **IGR.AX** | 0.9895 | 0.8761 | 485.9000 |
| **600104.ss** | 0.9788 | 0.8398 | 25140.5000 | **LYC.AX** | 0.9887 | 0.9966 | 1009.8100 |
| **600887.ss** | 0.9783 | 0.8853 | 8758.2200 | **SDL.AX** | 0.9855 | 1.5307 | 645.1400 |
| **600811.ss** | 0.9779 | 1.1585 | 1484.0600 | **PNA.AX** | 0.9853 | 1.3347 | 1406.9900 |
| **600100.ss** | 0.9732 | 0.8378 | 2139.7700 | **ARI.AX** | 0.9849 | 0.5668 | 1020.4000 |
| **600009.SS** | 0.9705 | 0.9965 | 3945.5000 | **AQP.AX** | 0.9801 | 0.5560 | 316.0000 |
| **600011.SS** | 0.9700 | 1.2696 | 14692.2400 | **BSL.AX** | 0.9780 | 0.7667 | 2651.6600 |
| **600269.ss** | 0.9665 | 0.8928 | 1231.6800 | **GBG.AX** | 0.9766 | 0.7884 | 283.5100 |
| **600005.SS** | 0.9654 | 1.0961 | 4305.6800 | **TRY.AX** | 0.9693 | 1.8089 | 173.9600 |
| **600026.SS** | 0.9641 | 0.9780 | 1969.2000 | **OZL.AX** | 0.9560 | 1.3319 | 1440.0000 |
| **600111.ss** | 0.9598 | 0.8418 | 10891.4600 | **SGM.AX** | 0.9554 | 1.6807 | 1936.8500 |
| **600717.ss** | 0.9586 | 1.1286 | 1563.8900 | **IMD.AX** | 0.9391 | 0.9426 | 271.5100 |
| **600177.ss** | 0.9543 | 1.1485 | 2676.7100 | **IRN.AX** | 0.9301 | 0.9802 | 409.0700 |
| **600309.ss** | 0.9492 | 1.0354 | 6034.0600 | **EVN.AX** | 0.9160 | 0.7868 | 902.8200 |
| **600362.ss** | 0.9434 | 1.0321 | 10341.6700 | **GRR.AX** | 0.8977 | 0.8190 | 219.7300 |
| **600019.SS** | 0.9425 | 1.0911 | 12881.1100 | **RIO.AX** | 0.8967 | 1.3359 | 85933.6700 |
| **600320.ss** | 0.9399 | 1.0102 | 1965.1800 | **SIR.AX** | 0.8958 | 1.6822 | 788.4200 |
| **600601.ss** | 0.9253 | 0.9234 | 796.6800 | **WSA.AX** | 0.8956 | 1.7422 | 574.7800 |

**Note:** The word 'stock' is the Chinese and Australian stock, BETA is systematic risk, 'MCAP' is market capitalisation, and 'speed' is the speed of adjustment coefficient from the PAM. Refer to Table 5-1 for company codes.$R_t = \delta a + \delta\beta R_m + (1-\delta)\beta R_{m_{t-1}} + \delta e$

Table 6-1 show the 33 Australian and Chinese financial stocks, ranked in order from the fastest speed of adjustment to the slowest speed of adjustment. The fastest Chinese and Australian stocks are 600519.ss and NCM.AX, with speed of 1.07 and 1.56, which is followed by 600583.ss and OGC.AX with speed of 1.03 and 1.08. The slowest speed of adjustment are 600601.ss and WSA.AX with speed of 0.92 and 0.90. The second slowest and third slowest are 600320.ss (0.94) and SIR.AX (0.90) and 600019.ss (0.94) and RIO.AX (0.90) respectively.

It may be recalled that a speed of adjustment of 1 means the stocks fully adjust to new information and that they are efficient. A speed greater than 1 means the stocks over-react and a speed of $0 < \delta < 1$ means the 'stock' under-react. It is contended that over-reaction leads to contrarian strategies, and that under-reaction leads to momentum strategies. Thus, both contrarian and momentum strategies should be profitable in this sample.

Both faster speed of adjustment and slower speed of adjustment stocks had higher betas. This implies that stocks which over-react and under-react are more risky. The small cap stocks tended to over-react and the large cap stocks tended to under-react.

MacKinnon (1983) critical values are used in all unit root tests.

Table 6-2 presents the augmented Dickey-Fuller (ADF) results of all variables in levels and first differences.

**Table 6-2 The Augmented Dickey-Fuller unit root tests of Chinese and Australian stocks in levels and first differences**

| 'STOCK' | LEVELS | FIRST DIFFERENCES | 'STOCK' | LEVELS | FIRST DIFFERENCES |
|---|---|---|---|---|---|
| **600028.SS** | -1.9969 | -18.2075* | **BHP.AX** | -1.9215 | -16.7865* |
| **600036.SS** | -1.7525 | -19.7431* | **RIO.AX** | -0.5653 | -20.9347* |
| **600016.SS** | -1.6756 | -20.4917* | **NCM.AX** | -0.6318 | -22.7843* |
| **600000.SS** | -0.9464 | -10.9864* | **AAI.AX** | -1.0142 | -18.5239* |
| **600519.ss** | -2.1004 | -18.9818* | **BSL.AX** | 0.6956 | -19.5256* |
| **600104.ss** | -1.3261 | -17.5771* | **SGM.AX** | -1.2004 | -17.6744* |
| **600011.SS** | -2.5579 | -19.9081* | **RRL.AX** | -2.3269 | -20.0371* |
| **600019.SS** | -2.0323 | -18.6066* | **AGG.AX** | -1.9257 | -19.8033* |
| **600050.ss** | -1.6792 | -18.6832* | **OZL.AX** | -2.5137 | -18.6538* |
| **600111.ss** | 0.317282 | -17.2249* | **PNA.AX** | -0.3939 | -21.8424* |
| **600362.ss** | -1.6417 | -18.1293* | **OGC.AX** | -1.2440 | -20.3579* |
| **600018.SS** | -1.8221 | -17.2039* | **ARI.AX** | -1.5561 | -18.9231* |
| **600887.ss** | -1.1257 | -18.5267* | **LYC.AX** | -1.1211 | -22.5899* |
| **600795.ss** | -1.4865 | -20.0937* | **EVN.AX** | -1.3073 | -21.0473* |
| **601600.ss** | -1.5556 | -17.0557* | **IGO.AX** | -1.6723 | -21.7838* |
| **600309.ss** | -2.1530 | -19.8242* | **SIR.AX** | -1.9967 | -18.2977* |
| **600688.ss** | -2.1771 | -17.9420* | **RSG.AX** | -0.9780 | -20.6035* |
| **600005.SS** | -2.1856 | -19.8832* | **SPH.AX** | -1.6511 | -19.6499* |
| **600009.SS** | -2.5351 | -16.5346* | **CDU.AX** | -2.5713 | -19.3073* |
| **600583.ss** | -1.8006 | -20.0999* | **SDL.AX** | 0.4466 | -22.6581* |
| **600642.ss** | -2.2030 | -20.0552* | **WSA.AX** | -2.2643*** | -19.6016* |
| **600832.ss** | -1.8976 | -16.6918* | **KCN.AX** | -1.1721 | -22.4598* |
| **600177.ss** | -1.8881 | -17.3036* | **SBM.AX** | -0.6099 | -21.6654* |
| **600100.ss** | -1.1502 | -18.4461* | **MGX.AX** | -1.6937 | -18.3990* |
| **600026.SS** | -1.5655 | -17.7047* | **IGR.AX** | 0.247615 | -22.0842* |
| **600320.ss** | -2.3784 | -19.3928* | **IRN.AX** | -2.1345 | -20.7689* |
| **600717.ss** | -2.1209 | -18.5014* | **GDO.AX** | -0.8083 | -20.9787* |
| **600811.ss** | -1.3883 | -17.0888* | **AQP.AX** | -1.3441 | -10.6064* |
| **600269.ss** | -1.6909 | -20.1924* | **GBG.AX** | -1.1974 | -20.8002* |
| **600879.ss** | -2.4282 | -18.2815* | **MDL.AX** | -0.1303 | -19.9141* |
| **600037.ss** | -1.6577 | -17.9749* | **IMD.AX** | -1.1396 | -19.5771* |
| **600331.ss** | -1.9296 | -16.8448* | **GRR.AX** | -2.5485 | -17.5864* |
| **600601.ss** | -1.9212 | -18.5517* | **TRY.AX** | -3.0922** | -16.1333* |

**Note:** The critical values are -3.442483 (1%)*; -2.866784 (5%)**; -2.569624 (10%)*. 'stock' refers to the Chinese CSC constituent stocks and the Australian resources stocks; 'levels' refers to the results of the ADF test in levels; 'first difference' refers to the results of the ADF test in first differences. * signifies 1% significance level; ** signifies 5% significance level; and *** signifies 10% significance level. Refer to Table 5-1 for company codes. The regression of this *augmented Dickey Fuller Test* (ADF) is as follows:

$$\Delta X_t = c + (\alpha - 1)X_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta X_{t-i} + \varepsilon_t$$

whereas with the simple Dickey-Fuller Test the null hypothesis of a unit root is rejected when the test statistic is smaller than the critical value (which have been summarized in a table).

The results of the ADF unit root tests show that the variables, except WSA.AX and TRY.AX, are non-stationary in levels and stationary after first differences.

Table 6-3presents the Phillips-Perron (PP) unit root results for all variables in levels and first differences.

**Table 6-3 The Phillips-Perron unit root tests of Chinese and Australian stocks in levels and first differences**

| ‘STOCK’ | LEVELS | FIRST DIFFERENCES | ‘STOCK’ | LEVELS | FIRST DIFFERENCES |
|---|---|---|---|---|---|
| **600028.SS** | -2.0305 | -18.1853* | **BHP.AX** | -1.7899 | -19.4243* |
| **600036.SS** | -1.7838 | -20.0786* | **RIO.AX** | -0.7283 | -20.9343* |
| **600016.SS** | -1.6972 | -20.7515* | **NCM.AX** | -0.6694 | -22.7836* |
| **600000.SS** | -1.0157 | -18.9336* | **AAI.AX** | -1.0521 | -18.5807* |
| **600519.ss** | -2.0929 | -19.1172* | **BSL.AX** | 1.2239 | -19.4238* |
| **600104.ss** | -1.4090 | -17.8077* | **SGM.AX** | -1.1696 | -17.6320* |
| **600011.SS** | -2.4731 | -19.9074* | **RRL.AX** | -2.1732 | -19.8861* |
| **600019.SS** | -2.1121 | -18.6912* | **AGG.AX** | -1.6756 | -19.5830* |
| **600050.ss** | -1.7210 | -18.6570* | **OZL.AX** | -2.4990 | -18.6707* |
| **600111.ss** | 0.591360 | -16.9920* | **PNA.AX** | -0.6076 | -21.8406* |
| **600362.ss** | -1.6526 | -18.1664* | **OGC.AX** | -1.2928 | -20.5779* |
| **600018.SS** | -1.6301 | -16.7368* | **ARI.AX** | -1.5160 | -18.9147* |
| **600887.ss** | -1.1000 | -18.5426* | **LYC.AX** | -1.2372 | -22.6130* |
| **600795.ss** | -1.4779 | -19.9788* | **EVN.AX** | -1.4255 | -21.0473* |
| **601600.ss** | -1.4293 | -17.0266* | **IGO.AX** | -1.8205 | -21.8036* |
| **600309.ss** | -2.1630 | -19.8456* | **SIR.AX** | -1.9915 | -18.2380* |
| **600688.ss** | -2.2874 | -18.0818* | **RSG.AX** | -1.2365 | -20.7085* |
| **600005.SS** | -2.1848 | -20.0575* | **SPH.AX** | -1.7682 | -19.8223* |
| **600009.SS** | -2.5543 | -16.4983* | **CDU.AX** | -2.5145 | -19.2616* |
| **600583.ss** | -1.8367 | -20.1144* | **SDL.AX** | 0.4035 | -22.6629* |
| **600642.ss** | -2.1977 | -19.9694* | **WSA.AX** | -2.3657 | -19.5577* |
| **600832.ss** | -1.9473 | -16.3328* | **KCN.AX** | -1.2021 | -22.4708* |
| **600177.ss** | -1.9429 | -17.3415* | **SBM.AX** | -0.6625 | -21.6667* |
| **600100.ss** | -0.9805 | -18.1559* | **MGX.AX** | -1.6692 | -18.6080* |
| **600026.SS** | -1.5726 | -17.6332* | **IGR.AX** | 0.1323 | -22.0838* |
| **600320.ss** | -2.5451 | -19.2850* | **IRN.AX** | -2.4943 | -20.8021* |
| **600717.ss** | -2.1650 | -18.5014* | **GDO.AX** | -0.8542 | -20.9887* |
| **600811.ss** | -1.3539 | -17.0400* | **AQP.AX** | -1.2764 | -17.6017* |
| **600269.ss** | -1.7618 | -20.1472* | **GBG.AX** | -1.4539 | -20.9123* |
| **600879.ss** | -2.4128 | -18.1326* | **MDL.AX** | 0.044004 | -19.8149* |
| **600037.ss** | -1.6278 | -17.9074* | **IMD.AX** | -1.2314 | -20.0948* |
| **600331.ss** | -1.9887 | -16.4594* | **GRR.AX** | -2.4683 | -17.5864* |
| **600601.ss** | -1.9658 | -18.6004* | **TRY.AX** | -3.3142** | -15.6319* |

**Note:** The critical values are -3.442460 (1%); -2.866774 (5%); -2.569618 (10%). ‘stock’ refers to the Chinese CSC constituent stocks and the Australian resources stocks; ‘levels’ refers to the results of the PP test in levels; ‘first difference’ refers to the results of the PP test in first differences. * signifies 1% significance level; ** signifies 5% significance level; ***signifies 10% significance level. Refer to Table 5-1 for company codes.

Phillips-Perron tests assess the null hypothesis of a unit root in a univariate time series *y*. All tests use the model:

$y_t = c + \delta t + ay_{t-1} + e(t)$.

The null hypothesis restricts $a = 1$. Variants of the test, appropriate for series with different growth characteristics, restrict the drift and deterministic trend coefficients, $c$ and $\delta$, respectively, to be 0. The tests use modified Dickey-Fuller statistics (see adftest) to account for serial correlations in the innovations process $e(t)$.

The results of the PP unit root tests show that the variables, except TRY.AX, are non-stationary in levels and stationary after first differences.

Table 6-4presents the KPSS unit root results for all variables in levels and first differences.

**Table 6-4 The KPSS unit root tests of Chinese and Australian stocks in levels and first differences**

| 'STOCK' | LEVELS | FIRST DIFFERENCES | 'STOCK' | LEVELS | FIRST DIFFERENCES |
|---|---|---|---|---|---|
| **600028.SS** | 1.5208 | 0.2580*** | **BHP.AX** | 2.3995 | 0.2524*** |
| **600036.SS** | 2.1953 | 0.2466*** | **RIO.AX** | 0.9462 | 0.3748** |
| **600016.SS** | 2.3362 | 0.1931*** | **NCM.AX** | 1.5972 | 0.4953* |
| **600000.SS** | 2.4053 | 0.0834*** | **AAI.AX** | 1.8096 | 0.1246*** |
| **600519.ss** | 2.5254 | 0.58348 | **BSL.AX** | 1.7061 | 0.6607* |
| **600104.ss** | 2.2614 | 0.0707*** | **SGM.AX** | 2.5773 | 0.1657*** |
| **600011.SS** | 0.2875*** | 0.1283*** | **RRL.AX** | 0.2833*** | 0.1015*** |
| **600019.SS** | 0.6043* | 0.1750*** | **AGG.AX** | 0.9736 | 0.1074*** |
| **600050.ss** | 1.1561 | 0.2207*** | **OZL.AX** | 0.7876 | 0.1809*** |
| **600111.ss** | 2.6952 | 0.3783** | **PNA.AX** | 0.8273 | 0.4150** |
| **600362.ss** | 2.1182 | 0.1579*** | **OGC.AX** | 1.8921 | 0.1316*** |
| **600018.SS** | 2.3747 | 0.2450*** | **ARI.AX** | 0.6326* | 0.3124*** |
| **600887.ss** | 2.6251 | 0.0701*** | **LYC.AX** | 2.1006 | 0.0594*** |
| **600795.ss** | 2.7720 | 0.1150*** | **EVN.AX** | 2.3964 | 0.0323*** |
| **601600.ss** | 0.7025* | 0.2275*** | **IGO.AX** | 1.8624 | 0.5290* |
| **600309.ss** | 2.3150 | 0.4366** | **SIR.AX** | 1.9024 | 0.1197*** |
| **600688.ss** | 1.0369 | 0.1814*** | **RSG.AX** | 0.6496* | 0.2156*** |
| **600005.SS** | 1.1799 | 0.5293* | **SPH.AX** | 1.2870 | 0.0629*** |
| **600009.SS** | 0.6408* | 0.3513** | **CDU.AX** | 0.2637*** | 0.0656*** |
| **600583.ss** | 2.5705 | 0.4396** | **SDL.AX** | 0.7845 | 0.5627* |
| **600642.ss** | 1.6926 | 0.1265*** | **WSA.AX** | 1.6854 | 0.4878* |
| **600832.ss** | 2.2602 | 0.2910*** | **KCN.AX** | 1.4579 | 0.3450*** |
| **600177.ss** | 2.1092 | 0.4559** | **SBM.AX** | 2.4221 | 0.0828*** |
| **600100.ss** | 2.2474 | 0.0747*** | **MGX.AX** | 1.8585 | 0.0617*** |
| **600026.SS** | 0.5327* | 0.3951** | **IGR.AX** | 2.5532 | 0.1863*** |
| **600320.ss** | 1.9114 | 0.8843 | **IRN.AX** | 0.7093* | 0.0569*** |
| **600717.ss** | 1.1427 | 0.4744* | **GDO.AX** | 2.6931 | 0.0710*** |
| **600811.ss** | 2.1528 | 0.0933*** | **AQP.AX** | 1.4823 | 0.3855** |
| **600269.ss** | 2.4511 | 0.3134*** | **GBG.AX** | 1.8216 | 0.0597*** |
| **600879.ss** | 1.7767 | 0.1255*** | **MDL.AX** | 1.0671 | 0.5206* |
| **600037.ss** | 1.5614 | 0.3403** | **IMD.AX** | 2.1506 | 0.0720*** |
| **600331.ss** | 2.2467 | 0.4983* | **GRR.AX** | 0.5020* | 0.2427*** |
| **600601.ss** | 1.3387 | 0.2992*** | **TRY.AX** | 2.2770 | 0.4600** |

Note: The critical values are 0.739000 (1%); 0.463000 (5%); 0.347000 (10%). 'stock' refers to the Chinese CSC constituent stocks and the Australian resources stock's; 'levels' refers to the results of the KPSS test in levels; 'first difference' refers to the results of the KPSS test in first differences. *signifies 1% significance level; ** signifies 5% significance level; *** signifies 10% significance level. Refer to Table 5-1 for company codes. The regression model with a time trend has the form

$$X_t = c + \mu t + k \sum_{i=1}^{t} \xi_i + \eta_t,$$

All Chinese stocks, except for 600011.ss, 600009.ss and 600026.ss, are non-stationary in levels and stationary in first differences.

All Australian stocks, except for RRL.AX, ARI.AX, CDU.AX, IRN.AX, and GRR.AX, are non-stationary in levels and stationary in first differences. The stocks in Tables 6-2, 6-3 and 6-4 which are stationary can undergo further testing to see whether these variables can achieve cointegration in the longer-term.

Table 6-5presents the ADF unit root results for the residuals of the OLS regressions of the Chinese and Australian 'stock' pairs.

**Table 6-5 The ADF test for Chinese-Australian OLS residuals**

| 'STOCK' | 'STOCK' | CONSTANT | LINEAR TREND | NONE |
|---|---|---|---|---|
| **OGC** | **600583.ss** | -1.9348 | -1.9303 | -1.8626*** |
| **GDO** | **600018.0000** | -4.2223* | -4.9150* | -4.2017* |
| **AGG** | **600879.ss** | -2.3779 | -2.4952 | -2.3434** |
| **SBM** | **600000.ss** | -2.1536 | -2.1553 | -2.0887** |
| **CDU** | **600642.ss** | -1.7328 | -1.8836 | -1.9138*** |
| **RRL** | **600037.ss** | -1.6371 | -1.4206 | -1.7947*** |
| **SPH** | **601600.ss** | -2.1928 | -2.1999 | -2.1416** |
| **BHP** | **600331.ss** | -3.7090* | -3.9093* | -3.7100* |
| **MGX** | **600688.ss** | -1.9148 | -1.9400 | -1.8448*** |
| **LYC** | **600104.ss** | -2.7899*** | -2.7859 | -2.7218* |
| **ARI** | **600100.ss** | -1.6418 | -1.8691 | -1.7500*** |
| **AQP** | **600009.ss** | -2.4017 | -2.5348 | -2.4359** |
| **GBG** | **600269.ss** | -3.2029** | -3.1200 | -3.0279* |
| **TRY** | **600005.ss** | -2.1809 | -0.9608 | -2.4581** |
| **SGM** | **600111.ss** | -1.7713 | -1.5958 | -1.7847*** |
| **IMD** | **600717.ss** | -1.4565 | -1.7777 | -1.4180 |
| **IRN** | **600177.ss** | -2.5795*** | -2.7386 | -2.3495** |
| **EVN** | **600309.ss** | -2.1696 | -2.2172 | -2.1213** |
| **RIO** | **600019.ss** | -2.0067 | -2.0011 | -2.0534** |
| **WSA** | **600601.ss** | -2.3153 | -1.7850 | -2.2723** |

**Note:** the critical values are: (constant) -3.442483 (1%); -2.866784 (5%); -2.569624 (10%); (linear trend) -3.975466 (1%); -3.418322 (5%); -3.131651 (10%); (none) -2.569332 (1%); -1.9414222 (5%); -1.616298 (10%). The word 'stock' refers to the Chinese and Australian stocks; 'constant' refers to the ADF test for constant; 'linear trend' refers to the ADF test for constant and linear trend; NONE refers to the ADF test for none. *signifies 1% significance level; ** signifies 5% significance level; *** signifies 10% significance level. Refer to Table 5-1 for company codes. The regression of this *augmented Dickey Fuller Test* (ADF) is as follows:

$$\Delta X_t = c + (\alpha - 1)X_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta X_{t-i} + \varepsilon_t$$

whereas with the simple Dickey-Fuller Test the null hypothesis of a unit root is rejected when the test statistic is smaller than the critical value (which have been summarized in a table).

The ADF test reveals that all variables are cointegrated. That is because the variables were I(1) and were linearly combined together using the Engle-Granger (1987) cointegration method; the residuals were captured of the OLS regression between the Chinese-Australian stock pairs, and were determined to be stationary.

Table 6-6presents the PP unit root results for the residuals of the OLS regressions of the Chinese and Australian 'stock' pairs.

**Table 6-6 The PP test for Chinese-Australian OLS residuals**

| 'STOCK' | 'STOCK' | CONSTANT | LINEAR TREND | NONE |
|---|---|---|---|---|
| **OGC** | **600583.ss** | -2.1425 | -2.1399 | -2.0496** |
| **GDO** | **600018.ss** | -3.6559* | -4.4542* | -3.6554* |
| **AGG** | **600879.ss** | -2.2257 | -2.3348 | -2.1884** |
| **SBM** | **600000.ss** | -2.3205 | -2.3211 | -2.2576** |
| **CDU** | **600642.ss** | -1.7858 | -2.0165 | -1.9515** |
| **RRL** | **600037.ss** | -1.5294 | -1.2504 | -1.7118*** |
| **SPH** | **601600.ss** | -2.1117 | -2.1125 | -2.0580** |
| **BHP** | **600331.ss** | -3.8190* | -4.0157* | -3.8199* |
| **MGX** | **600688.ss** | -1.8486 | -1.8708 | -1.7802*** |
| **LYC** | **600104.ss** | -3.1801** | -3.1918*** | -3.1139* |
| **ARI** | **600100.ss** | -1.5340 | -1.7365 | -1.6636*** |
| **AQP** | **600009.ss** | -2.2730 | -2.3816 | -2.3073** |
| **GBG** | **600269.ss** | -3.3756** | -3.3210*** | -3.1806* |
| **TRY** | **600005.ss** | -2.1273 | -1.0244 | -2.3462** |
| **SGM** | **600111.ss** | -1.8745 | -1.6385 | -1.8755*** |
| **IMD** | **600717.ss** | -1.4564 | -1.7510 | -1.4147 |
| **IRN** | **600177.ss** | -2.7219 | -2.9603 | -2.4749** |
| **EVN** | **600309.ss** | -2.2628 | -2.3079 | -2.2110** |
| **RIO** | **600019.ss** | -2.1891 | -2.1895 | -2.2448** |
| **WSA** | **600601.ss** | -2.2160 | -1.6252 | -2.1830** |

**Note:** the critical values are: (constant) -3.442460 (1%); -2.866774 (5%); -2.569618 (10%); (linear trend) -3.975466 (1%); -3.418322 (5%); -3.131651 (10%); (none) -2.569332 (1%); -1.9414222 (5%); -1.616298 (10%). The word 'stock' refers to the Chinese and Australian stocks; 'constant' refers to the PP test for constant; 'linear trend' refers to the PP test for constant and linear trend; NONE refers to the PP test for none. *signifies 1% significance level; ** signifies 5% significance level; *** signifies 10% significance level. Refer to Table 5-1 for company codes. Phillips-Perron tests assess the null hypothesis of a unit root in a univariate time series *y*. All tests use the model:

$$y_t = c + \delta t + a y_{t-1} + e(t).$$

The null hypothesis restricts $a = 1$. Variants of the test, appropriate for series with different growth characteristics, restrict the drift and deterministic trend coefficients, $c$ and $\delta$, respectively, to be 0. The tests use modified Dickey-Fuller statistics (see ad test) to account for serial correlations in the innovations process $e(t)$.

The PP test reveals that all variables are cointegrated. That is because the variables were I(1) and were linearly combined together using the Engle-Granger (1987) cointegration method; the residuals were captured of the OLS regression between the Chinese-Australian stock pairs, and were determined to be stationary.

Table 6-7presents the KPSS unit root results for the residuals of the OLS regressions of the Chinese and Australian 'stock' pairs.

**Table 6-7 The KPSS test for Chinese-Australian OLS residuals**

| 'STOCK' | 'STOCK' | CONSTANT | LINEAR TREND |
|---|---|---|---|
| **OGC** | **600583.ss** | 0.172002*** | 0.1683** |
| **GDO** | **600018.ss** | 0.639276** | 0.2082* |
| **AGG** | **600879.ss** | 0.285977*** | 0.2457 |
| **SBM** | **600000.ss** | 0.2485*** | 0.2533 |
| **CDU** | **600642.ss** | 1.5865* | 0.2493 |
| **RRL** | **600037.ss** | 1.5001* | 0.5485 |
| **SPH** | **601600.ss** | 0.2378*** | 0.2366 |
| **BHP** | **600331.ss** | 0.2120*** | 0.0697*** |
| **MGX** | **600688.ss** | 0.2318*** | 0.2404 |
| **LYC** | **600104.ss** | 0.3276*** | 0.1436** |
| **ARI** | **600100.ss** | 1.7956* | 0.3611 |
| **AQP** | **600009.ss** | 0.5218* | 0.4065 |
| **GBG** | **600269.ss** | 0.5241* | 0.1994* |
| **TRY** | **600005.ss** | 1.2658 | 0.636385 |
| **SGM** | **600111.ss** | 0.195839*** | 0.125976** |
| **IMD** | **600717.ss** | 0.7093* | 0.616146 |
| **IRN** | **600177.ss** | 1.1582 | 0.0820*** |
| **EVN** | **600309.ss** | 0.4492** | 0.4378 |
| **RIO** | **600019.ss** | 0.2055*** | 0.2008* |
| **WSA** | **600601.ss** | 1.3925 | 0.2778 |

**Note:** The critical values are: (constant) 0.739000(1%); 0.463000 (5%); 0.347000 (10%); (linear trend) 0.216000 (1%); 0.146000 (5%); 0.119000 (10%). 'constant' refers to the KPSS test for constant; 'linear trend' refers to the KPSS test for constant and linear trend.*signifies 1% significance level; ** signifies 5% significance level; *** signifies 10% significance level. Refer to Table 5-1 for company codes. The regression model with a time trend has the form

$$X_t = c + \mu t + k \sum_{i=1}^{t} \xi_i + \eta_t,$$

The KPSS test reveals that all variables except WSA.AX are cointegrated. That is because the variables were I(1) and were linearly combined together using the Engle-Granger (1987) cointegration method; the residuals were captured of the OLS regression between the Chinese-Australian stock pairs, and were determined to be stationary. After demonstrating cointegration, and thus providing evidence of market efficiency and rational expectations in the longer-term. The next stage of the analysis is to apply the various arbitrage strategies on the basis of that the markets are not efficient in the short-term.

Table 6-8presents the results of the ADF unit root results for Chinese-Australian OLS regression's residuals where the stocks were paired according to their market capitalisations.

**Table 6-8 The ADF test for Chinese-Australian OLS residuals (MCAP)**

| 'STOCK' | 'STOCK' | CONSTANT | LINEAR TREND | NONE |
|---|---|---|---|---|
| **SGM.AX** | **600104.ss** | -1.8943 | -1.8919 | -1.9382*** |
| **RRL.AX** | **600011.SS** | -2.4296 | -2.4221 | -2.4739** |
| **AGG.AX** | **600019.SS** | -1.8298 | -2.3571 | -1.7842*** |
| **OGC.AX** | **600362.ss** | -2.4509 | -2.4627 | -2.4210** |
| **ARI.AX** | **600018.SS** | -1.5282 | -4.7362* | -1.4161 |
| **LYC.AX** | **600887.ss** | -2.7211*** | -2.8262 | -2.6771* |
| **EVN.AX** | **600795.ss** | -3.1260** | -3.2159*** | -2.9493* |
| **SIR.AX** | **600309.ss** | -2.6576*** | -2.8901 | -2.5287** |
| **RSG.AX** | **600688.ss** | -2.1691 | -2.0311 | -2.2145** |
| **SPH.AX** | **600005.SS** | -1.9848 | -2.0625 | -2.1331** |
| **CDU.AX** | **600009.SS** | -2.1352 | -2.0057 | -2.1705** |
| **WSA.AX** | **600642.ss** | -2.0072 | -0.6855 | -2.0517** |
| **MGX.AX** | **600100.ss** | -1.9558 | -2.3666 | -1.7170*** |
| **IRN.AX** | **600320.ss** | -2.8200*** | -2.8142 | -2.4553** |
| **AQP.AX** | **600811.ss** | -1.6587 | -2.8494 | -1.7576*** |
| **GBG.AX** | **600269.ss** | -3.2029** | -3.1200 | -3.0279* |
| **MDL.AX** | **600879.ss** | -2.1759 | -1.7485 | -2.1811** |
| **IMD.AX** | **600037.ss** | -1.7740 | -1.8738 | -1.6972*** |
| **GRR.AX** | **600331.ss** | -2.0162 | -2.7782 | -1.8481*** |
| **TRY.AX** | **600601.ss** | -1.7146 | -1.4571 | -1.6303*** |

**Note:** the critical values are: (constant) -3.442483 (1%); -2.866784 (5%); -2.569624 (10%); (linear trend) -3.975466 (1%); -3.418322 (5%); -3.131651 (10%); (none) -2.569332 (1%); -1.9414222 (5%); -1.616298 (10%). The word 'stock' refers to the Chinese and Australian stocks; 'constant' refers to the ADF test for constant; 'linear trend' refers to the ADF test for constant and linear trend; NONE refers to the ADF test for none. *signifies 1% significance level; ** signifies 5% significance level; *** signifies 10% significance level. Refer to Table 5-1 for company codes. The regression of this *augmented Dickey Fuller Test* (ADF) is as follows:

$$\Delta X_t = c + (\alpha - 1)X_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta X_{t-i} + \varepsilon_t$$

whereas with the simple Dickey-Fuller Test the null hypothesis of a unit root is rejected when the test statistic is smaller than the critical value (which have been summarized in a table).

The ADF test reveals that all variables are cointegrated. That is because the variables were I(1) and were linearly combined together using the Engle-Granger (1987) cointegration method; the residuals were captured of the OLS regression between the Chinese-Australian stock pairs, and were determined to be stationary.

In tables 6-5 and 6-8 the ADF test reveals that all variables are cointegrated. Most of the stationarity is categorised as having no intercept and no trend.

Table 6-9presents the results of the PP unit root results for Chinese-Australian OLS regression's residuals where the stocks were paired according to their market capitalisations.

**Table 6-9 The PP test for Chinese-Australian OLS residuals (MCAP)**

| **'STOCK'** | **'STOCK'** | **CONSTANT** | **LINEAR TREND** | **NONE** |
|---|---|---|---|---|
| **SGM.AX** | **600104.ss** | -2.2075 | -2.2044 | -2.2347** |
| **RRL.AX** | **600011.SS** | -2.2805 | -2.2723 | -2.3298** |
| **AGG.AX** | **600019.SS** | -1.5109 | -2.0009 | -1.4557 |
| **OGC.AX** | **600362.ss** | -2.3719 | -2.3853 | -2.3416** |
| **ARI.AX** | **600018.SS** | -1.2964 | -4.2628* | -1.1772 |
| **LYC.AX** | **600887.ss** | -2.7593*** | -2.8725 | -2.7127* |
| **EVN.AX** | **600795.ss** | -2.9990** | -3.0990 | -2.8375* |
| **SIR.AX** | **600309.ss** | -2.4665 | -2.6959 | -2.3551** |
| **RSG.AX** | **600688.ss** | -2.1563 | -2.0221 | -2.2002** |
| **SPH.AX** | **600005.SS** | -2.0605 | -2.2317 | -2.1907** |
| **CDU.AX** | **600009.SS** | -1.9947 | -1.8640 | -2.0304** |
| **WSA.AX** | **600642.ss** | -2.0471 | -0.6855 | -2.0827** |
| **MGX.AX** | **600100.ss** | -1.8787 | -2.2611 | -1.6528*** |
| **IRN.AX** | **600320.ss** | -3.0394** | -3.0926 | -2.6480* |
| **AQP.AX** | **600811.ss** | -1.0733 | -2.4258 | -1.5139 |
| **GBG.AX** | **600269.ss** | -3.3756** | -3.3210*** | -3.1806** |
| **MDL.AX** | **600879.ss** | -2.0006 | -1.4508 | -2.0090** |
| **IMD.AX** | **600037.ss** | -1.7221 | -1.8157 | -1.6400*** |
| **GRR.AX** | **600331.ss** | -1.8661 | -2.6235 | -1.7087*** |
| **TRY.AX** | **600601.ss** | -1.6318 | -1.3387 | -1.5642 |

**Note:** the critical values are: (constant) -3.442460 (1%); -2.866774 (5%); -2.569618 (10%); (linear trend) -3.975466 (1%); -3.418322 (5%); -3.131651 (10%); (none) -2.569332 (1%); -1.9414222 (5%); -1.616298 (10%). The word 'stock' refers to the Chinese and Australian stocks; 'constant' refers to the PP test for constant; 'linear trend' refers to the PP test for constant and linear trend; NONE refers to the PP test for none. *signifies 1% significance level; ** signifies 5% significance level; *** signifies 10% significance level. Refer to Table 5-1 for company codes. Phillips-Perron tests assess the null hypothesis of a unit root in a univariate time series *y*. All tests use the model:

$$y_t = c + \delta t + a y_{t-1} + e(t).$$

The null hypothesis restricts $a = 1$. Variants of the test, appropriate for series with different growth characteristics, restrict the drift and deterministic trend coefficients, $c$ and $\delta$, respectively, to be 0. The tests use modified Dickey-Fuller statistics (see adf test) to account for serial correlations in the innovations process $e(t)$.

The results in Table 6-9present the outcome of stage two of the Engle-Granger (1987) methodology. It shows that the residuals of all Australian and stocks in the sample except AGG.AX, and TRY.AX stationary, and are therefore cointegrated. That is because the variables were I(1) and were linearly combined together using the Engle-Granger (1987) cointegration method; the residuals were captured of the OLS regression between the Chinese-Australian stock pairs, and were determined to be stationary.

Table 6-10presents the results of the KPSS unit root results for Chinese-Australian OLS regression's residuals where the stocks were paired according to their market capitalisations.

**Table 6-10 The KPSS test for Chinese-Australian OLS residuals (MCAP)**

| 'STOCK' | 'STOCK' | CONSTANT | LINEAR TREND |
|---|---|---|---|
| SGM.AX | 600104.ss | 0.0977*** | 0.0973*** |
| RRL.AX | 600011.SS | 0.2852*** | 0.2829 |
| AGG.AX | 600019.SS | 0.8767 | 0.4080 |
| OGC.AX | 600362.ss | 0.1804*** | 0.0976*** |
| ARI.AX | 600018.SS | 2.3982 | 0.4566 |
| LYC.AX | 600887.ss | 0.4304** | 0.1240** |
| EVN.AX | 600795.ss | 0.2255*** | 0.1801* |
| SIR.AX | 600309.ss | 0.8540 | 0.2920 |
| RSG.AX | 600688.ss | 0.9950 | 0.2765 |
| SPH.AX | 600005.SS | 1.8496 | 0.2131* |
| CDU.AX | 600009.SS | 0.5964* | 0.5083 |
| WSA.AX | 600642.ss | 1.7455 | 0.4689 |
| MGX.AX | 600100.ss | 1.0211 | 0.4311 |
| IRN.AX | 600320.ss | 0.7842 | 0.0546*** |
| AQP.AX | 600811.ss | 1.7713 | 0.1279** |
| GBG.AX | 600269.ss | 0.5240* | 0.1994* |
| MDL.AX | 600879.ss | 0.9080 | 0.5243 |
| IMD.AX | 600037.ss | 0.4887* | 0.4861 |
| GRR.AX | 600331.ss | 1.1692 | 0.2441 |
| TRY.AX | 600601.ss | 1.0033 | 0.4379 |

**Note:** The critical values are: (constant) 0.739000(1%); 0.463000 (5%); 0.347000 (10%); (linear trend) 0.216000 (1%); 0.146000 (5%); 0.119000 (10%). 'constant' refers to the KPSS test for constant; 'linear trend' refers to the KPSS test for constant and linear trend. *signifies 1% significance level; ** signifies 5% significance level; *** signifies 10% significance level. Refer to Table 5-1 for company codes. The regression model with a time trend has the form

$$X_t = c + \mu t + k \sum_{i=1}^{t} \xi_i + \eta_t,$$

The KPSS test reveals that all variables except AGG.AX, ARI.AX, SIR.AX, RSG.AX, WSA.AX, MGX.AX, MDL.AX, GRR.AX, TRY.AX are stationary, and therefore cointegrated. That is because the variables were I(1) and were linearly combined together using the Engle-Granger (1987) cointegration method; the residuals were captured of the OLS regression between the Chinese-Australian stock pairs, and were determined to be stationary. After demonstrating cointegration, and thus providing evidence of market efficiency and rational expectations in the longer-term. The next stage of the analysis is to apply the various arbitrage strategies on the basis of that the markets are not efficient in the short-term.

Table 6-11 shows the diagnostics of the Markov switching strategy where the ‘stock’ pairs were chosen using the PAM. The Markov strategy is captures changes in regimes. It tests whether stock pairs’ relative valuations changes from a high mean regime to a low mean regime and vice-versa. In this manner it accounts for structural breaks in the data.

**Table 6-11The diagnostics of the Markov switching strategy (PAM)**

| ‘STOCK’ PAIR | MEAN 1 | MEAN 2 | SD 1 | SD 2 | THE TERM ‘P12’ | THE TERM ‘P21’ |
|---|---|---|---|---|---|---|
| **MDL/600050** | 6.8104 | 3.2869 | 0.9718 | 0.7955 | 0.0089 | 0.0024 |
| **AGG/600879** | 2.8585 | 1.7147 | 0.6019 | 0.1389 | 0.0075 | 0.0038 |
| **SPH/601600** | 1.4271 | 0.8499 | 0.3120 | 0.1040 | 0.0046 | 0.0064 |
| **MGX/600688** | 1.0033 | 0.3258 | 0.1409 | 0.6545 | 0.0093 | 0.0148 |
| **IGR/600028** | 0.4680 | -0.3603 | 0.2815 | 0.3253 | 0.0076 | 0.0114 |
| **LYC/600104** | 0.6641 | -0.2754 | 0.1946 | 0.5587 | 0.0069 | 0.0127 |
| **SDL/600887** | 2.7066 | 3.8102 | 0.9498 | 7.1176 | 0.0057 | 0.0109 |
| **ARI/600100** | 1.0616 | 0.6408 | 0.1663 | 0.1519 | 0.0075 | 0.0077 |
| **BSL/600011** | 3.9316 | 2.8975 | 0.4407 | 0.4342 | 0.0128 | 0.0146 |
| **OZL/600026** | 1.8439 | 1.5731 | 0.4006 | 0.1195 | 0.0192 | 0.0136 |
| **IMD/600717** | 1.1343 | 0.1846 | 0.2458 | 0.4724 | 0.0057 | 0.0057 |
| **IRN/600177** | 1.3645 | 0.5484 | 2.3491 | 0.2308 | 0.0102 | 0.0049 |
| **GRR/600362** | 0.6587 | 0.1740 | 0.1458 | 0.2183 | 0.0051 | 0.0030 |
| **RIO/600019** | 2.2409 | 1.8093 | 0.1647 | 1.2888 | 0.0230 | 0.0076 |

**Note:** ‘stock pair’ is the Chinese and Australian ‘stock’ pair. Mean 1 is the mean value of regime state 1. Mean 2 is the mean value of regime state 2. ‘SD1’ is the standard deviation of regime 1. ‘SD 2’ is the standard deviation of regime 2. ‘THE TERM ‘P12’’ is the probability of being in regime 1 given that in the last state the value was in regime 2. ‘THE TERM ‘P21’’ is the probability of being in regime 2 given that previously the value was in state 1.Refer to Table 5-1 for company codes.

The results in Table 6-11 shows that it is clear that the regime switching model has split the data into two distinct samples; one with a high mean and one with a lower mean. Also apparent is the fact that the MDL/600050; AGG/600879; SPH/600879; ARI/600100; OZL/600026; IRN/600177 ratios are more variable at times when it is in the high mean regime, evidenced by their higher standard deviation. The low values of the term‘P12’ and the term ‘P21’ parameters indicate that the regimes are highly stable.

Table 6-12 shows the diagnostics of the Markov switching strategy where the 'stock' pairs were chosen using market capitalisations

**Table 6-12The diagnostics of the Markov switching strategy (MCAP)**

| 'STOCK' PAIR | MEAN 1 | MEAN 2 | SD 1 | SD 2 | THE TERM 'P12' | THE TERM 'P21' |
|---|---|---|---|---|---|---|
| **BHP/600028** | 3.0973 | 2.2457 | 0.3799 | 0.1983 | 0.0029 | 0.0055 |
| **RRL/600011** | 1.3113 | 0.8284 | 0.1861 | 0.1886 | 0.0094 | 0.0193 |
| **AGG/600019** | 2.7201 | 2.3043 | 0.7595 | 0.2128 | 0.0132 | 0.0069 |
| **OZL/600050** | 3.1506 | 2.2585 | 0.9187 | 0.2626 | 0.0252 | 0.0157 |
| **IGO/601600** | 1.3279 | 0.9970 | 0.6261 | 0.2135 | 0.0053 | 0.0030 |
| **SDL/600583** | 18.2998 | 0.8756 | 13.6802 | 2.6005 | 0.0179 | 0.0021 |
| **WSA/600642** | 4.6579 | 2.7963 | 1.0610 | 0.3189 | 0.0161 | 0.0109 |
| **MGX/600100** | 0.6333 | 0.2088 | 0.0921 | 0.3636 | 0.0065 | 0.0106 |
| **IGR/600026** | 0.4806 | -0.2392 | 0.3435 | 0.2203 | 0.0077 | 0.0110 |
| **IRN/600320** | 1.5532 | 0.1884 | 1.5949 | 0.0681 | 0.0109 | 0.0058 |
| **MDL/600879** | 3.9401 | 2.1187 | 0.6128 | 0.5853 | 0.0070 | 0.0041 |
| **IMD/600037** | 0.6515 | 0.3657 | 0.1182 | 0.6841 | 0.0100 | 0.0063 |
| **GRR/600331** | 1.6817 | 0.3640 | 7.6847 | 0.3390 | 0.0081 | 0.0025 |
| **RIO/600019** | 2.2409 | 1.8093 | 0.1647 | 1.2888 | 0.0230 | 0.0076 |

**Note:** 'stock pair' is the Chinese and Australian 'stock' pair. Mean 1 is the mean value of regime state 1. Mean 2 is the mean value of regime state 2. 'SD1' is the standard deviation of regime 1. 'SD 2' is the standard deviation of regime 2. 'THE TERM 'P12'' is the probability of being in regime 1 given that in the last state the value was in regime 2. 'THE TERM 'P21'' is the probability of being in regime 2 given that previously the value was in state 1.Refer to Table 5-1 for company codes.

As can be seen in Table 6-12, it is clear that the regime switching model has split the data into two distinct samples; one with a high mean (BHP/600028 (3.09); RRL/600011 (1.31); AGG/600019 (2.72); OZL/600050 (3.15); IGO/601600 (1.32); SDL/600583 (18.30); WSA/600642 (4.65); MGX/600100 (0.633); IGR/600026 (0.48); IRN/600320 (1.55); MDL/600879 (3.94); IMD/600037 (0.65); and GRR/600331 (1.68)) and one with a lower mean (2.24; 0.82; 2,30; 2.25; 0.99; 0.87; 2.79; 0.21; -0.24; 0.19; 2.12; 0.37; 0.36).

Also apparent in this analysis, is that the BHP/600028, AGG/600019, OZL/600050, IGO/601600, SDL/600583, WSA/600642, IRN/600320, GRR/600331 ratios are more variable at times when it is in the high mean regime, evidenced by their higher standard deviation. The low values of the TERM ‘P12’ and THE TERM ‘P21’ parameters indicate that the regimes are highly stable.

Table 6-13 compares the average speed of adjustment from the error correction term to the speed of adjustment coefficient from the PAM. The error correction term the average speed of adjustment of the cointegrated variables towards a long-term equilibrium. The PAM's speed of adjustment coefficient shows the adjustment of stock returns towards a long-term fundamental value. Therefore the error correction term (ECT)and the PAM should be correlated.

**Table 6-13 The Error Correction Term for the LOP residuals**

| 'STOCK' | SPEED | BETA | MCAP(mil) | 'STOCK' | SPEED | BETA | MCAP(mil) | AVGSPD | ABS |
|---|---|---|---|---|---|---|---|---|---|
| **600583.ss** | 1.0308 | 1.0696 | 3867.2400 | **OGC.AX** | 1.0751 | 1.1948 | 1362.9100 | -0.0026** | **0.0026** |
| **600018.SS** | 1.0078 | 1.1250 | 9494.8500 | **GDO.AX** | 1.0417 | 0.8104 | 339.9700 | -0.0024** | **0.0024** |
| **600879.ss** | 1.0057 | 1.2637 | 1123.4400 | **AGG.AX** | 1.0114 | 1.4252 | 1831.0000 | -0.0208 | **0.0208** |
| **600000.SS** | 1.0000 | 1.0624 | 29108.0700 | **SBM.AX** | 1.0073 | 1.4554 | 514.9200 | -0.0067* | **0.0067** |
| **600642.ss** | 0.9969 | 1.1110 | 3293.4500 | **CDU.AX** | 1.0032 | 0.2997 | 663.5900 | -0.0004** | **0.0004** |
| **601600.ss** | 0.9926 | 1.3598 | 7473.8000 | **SPH.AX** | 0.9920 | 1.7944 | 676.6300 | -0.0034 | **0.0034** |
| **600331.ss** | 0.9914 | 1.0290 | 872.4300 | **BHP.AX** | 0.9911 | 0.6385 | 161632.0000 | -0.0147* | **0.0147** |
| **600688.ss** | 0.9864 | 1.1146 | 5543.3900 | **MGX.AX** | 0.9898 | 1.0831 | 512.5700 | -0.0067* | **0.0067** |
| **600104.ss** | 0.9788 | 0.8398 | 25140.5000 | **LYC.AX** | 0.9887 | 0.9966 | 1009.8100 | -0.0090* | **0.0090** |
| **600100.ss** | 0.9732 | 0.8378 | 2139.7700 | **ARI.AX** | 0.9849 | 0.5668 | 1020.4000 | 0.0004*** | **0.0004** |
| **600009.SS** | 0.9705 | 0.9965 | 3945.5000 | **AQP.AX** | 0.9801 | 0.5560 | 316.0000 | 0.0021*** | **0.0021** |
| **600269.ss** | 0.9665 | 0.8928 | 1231.6800 | **GBG.AX** | 0.9766 | 0.7884 | 283.5100 | -0.0005 | **0.0005** |
| **600005.SS** | 0.9654 | 1.0961 | 4305.6800 | **TRY.AX** | 0.9693 | 1.8089 | 173.9600 | 0.0002* | **0.0002** |
| **600111.ss** | 0.9598 | 0.8418 | 10891.4600 | **SGM.AX** | 0.9554 | 1.6807 | 1936.8500 | -0.0024** | **0.0024** |
| **600717.ss** | 0.9586 | 1.1286 | 1563.8900 | **IMD.AX** | 0.9391 | 0.9426 | 271.5100 | -0.0013** | **0.0013** |
| **600177.ss** | 0.9543 | 1.1485 | 2676.7100 | **IRN.AX** | 0.9301 | 0.9802 | 409.0700 | -0.0014** | **0.0014** |
| **600309.ss** | 0.9492 | 1.0354 | 6034.0600 | **EVN.AX** | 0.9160 | 0.7868 | 902.8200 | -0.0031** | **0.0031** |
| **600019.SS** | 0.9425 | 1.0911 | 12881.1100 | **RIO.AX** | 0.8967 | 1.3359 | 85933.6700 | -0.0033** | **0.0033** |
| **600601.ss** | 0.9253 | 0.9234 | 796.6800 | **WSA.AX** | 0.8956 | 1.7422 | 574.7800 | 0.0019** | **0.0019** |

**Note:** The 'stock' is the Chinese and Australian stocks, 'speed' is the speed of adjustment coefficient from the PAM, 'beta' is systematic risk, and 'mcap' is market capitalisation in millions of Australian dollars. 'avg speed' is the average speed of adjustment coefficient from the Engle-Granger (1987) methodology and 'abs' is the absolute value of this coefficient. Refer to Table 5-1 for company codes. *signifies 1% significance level; ** signifies 5% significance level; *** signifies 10% significance level. $S_t = \alpha + \beta_0 P_t - \beta_1 P_t^* + \mu_t$

The absolute value of the average speed of adjustment from the cointegrating relationship is in the general direction of the speed of adjustments determined by the PAM, and thus are a check for robustness of the PAM.

Table 6-14 shows the results of the LOP and Markov switching strategies where 'stock' pairs were chosen by the PAM. This is the first step in the analysis of the contrarian strategy. The next step involves choosing stock pairs through their market capitalisations.

**Table 6-14The results of the LOP and Markov switching strategies (PAM)**

| 'STOCK' | SPEED | BETA | MCAP(mil) | 'STOCK' | SPEED | BETA | MCAP(mil) | Markov | LOP |
|---|---|---|---|---|---|---|---|---|---|
| **600519.ss** | 1.0664 | 1.0694 | 26386.0800 | **NCM.AX** | 1.5637 | 1.1534 | 14399.0500 | | |
| **600583.ss** | 1.0308 | 1.0696 | 3867.2400 | **OGC.AX** | 1.0751 | 1.1948 | 1362.9100 | | **0.0507** |
| **600050.ss** | 1.0127 | 0.8299 | 12033.8100 | **MDL.AX** | 1.0456 | 1.0662 | 275.6800 | **0.1893** | |
| **600018.SS** | 1.0078 | 1.1250 | 9494.8500 | **GDO.AX** | 1.0417 | 0.8104 | 339.9700 | | **-0.0652** |
| **600016.SS** | 1.0071 | 0.5820 | 40444.8400 | **KCN.AX** | 1.0306 | 0.9918 | 531.4000 | | |
| **600879.ss** | 1.0057 | 1.2637 | 1123.4400 | **AGG.AX** | 1.0114 | 1.4252 | 1831.0000 | **0.0495** | **-0.0173** |
| **600036.SS** | 1.0030 | 1.2908 | 42476.3300 | **AAI.AX** | 1.0077 | 0.1332 | 8500.0000 | | |
| **600000.SS** | 1.0000 | 1.0624 | 29108.0700 | **SBM.AX** | 1.0073 | 1.4554 | 514.9200 | | **0.0272** |
| **600642.ss** | 0.9969 | 1.1110 | 3293.4500 | **CDU.AX** | 1.0032 | 0.2997 | 663.5900 | | **0.0258** |
| **600037.ss** | 0.9963 | 0.8170 | 1051.0300 | **RRL.AX** | 1.0017 | 0.2689 | 1878.6800 | | |
| **600795.ss** | 0.9937 | 1.1549 | 7910.9400 | **IGO.AX** | 0.9988 | 0.8381 | 859.3400 | | |
| **601600.ss** | 0.9926 | 1.3598 | 7473.8000 | **SPH.AX** | 0.9920 | 1.7944 | 676.6300 | **0.0217** | **-0.0014** |
| **600331.ss** | 0.9914 | 1.0290 | 872.4300 | **BHP.AX** | 0.9911 | 0.6385 | 161632.0000 | | **0.0597** |
| **600688.ss** | 0.9864 | 1.1146 | 5543.3900 | **MGX.AX** | 0.9898 | 1.0831 | 512.5700 | **0.0243** | **-0.0600** |
| **600832.ss** | 0.9795 | 0.8298 | 2698.6100 | **RSG.AX** | 0.9898 | 1.4357 | 729.9100 | | |
| **600028.SS** | 0.9791 | 1.0624 | 104374.2400 | **IGR.AX** | 0.9895 | 0.8761 | 485.9000 | **0.1168** | |
| **600104.ss** | 0.9788 | 0.8398 | 25140.5000 | **LYC.AX** | 0.9887 | 0.9966 | 1009.8100 | **0.0132** | **-0.0393** |
| **600887.ss** | 0.9783 | 0.8853 | 8758.2200 | **SDL.AX** | 0.9855 | 1.5307 | 645.1400 | **0.1564** | |
| **600811.ss** | 0.9779 | 1.1585 | 1484.0600 | **PNA.AX** | 0.9853 | 1.3347 | 1406.9900 | | |
| **600100.ss** | 0.9732 | 0.8378 | 2139.7700 | **ARI.AX** | 0.9849 | 0.5668 | 1020.4000 | **0.0462** | **0.0100** |
| **600009.SS** | 0.9705 | 0.9965 | 3945.5000 | **AQP.AX** | 0.9801 | 0.5560 | 316.0000 | | **-0.0121** |
| **600011.SS** | 0.9700 | 1.2696 | 14692.2400 | **BSL.AX** | 0.9780 | 0.7667 | 2651.6600 | **0.0797** | |
| **600269.ss** | 0.9665 | 0.8928 | 1231.6800 | **GBG.AX** | 0.9766 | 0.7884 | 283.5100 | | **-0.0488** |
| **600005.SS** | 0.9654 | 1.0961 | 4305.6800 | **TRY.AX** | 0.9693 | 1.8089 | 173.9600 | | **0.0745** |
| **600026.SS** | 0.9641 | 0.9780 | 1969.2000 | **OZL.AX** | 0.9560 | 1.3319 | 1440.0000 | **0.0076** | |
| **600111.ss** | 0.9598 | 0.8418 | 10891.4600 | **SGM.AX** | 0.9554 | 1.6807 | 1936.8500 | | **-0.1189** |
| **600717.ss** | 0.9586 | 1.1286 | 1563.8900 | **IMD.AX** | 0.9391 | 0.9426 | 271.5100 | **0.1056** | **0.0232** |
| **600177.ss** | 0.9543 | 1.1485 | 2676.7100 | **IRN.AX** | 0.9301 | 0.9802 | 409.0700 | **0.0979** | **-0.0132** |
| **600309.ss** | 0.9492 | 1.0354 | 6034.0600 | **EVN.AX** | 0.9160 | 0.7868 | 902.8200 | | **-0.0163** |
| **600362.ss** | 0.9434 | 1.0321 | 10341.6700 | **GRR.AX** | 0.8977 | 0.8190 | 219.7300 | **0.1364** | |
| **600019.SS** | 0.9425 | 1.0911 | 12881.1100 | **RIO.AX** | 0.8967 | 1.3359 | 85933.6700 | **0.0566** | **0.0734** |
| **600320.ss** | 0.9399 | 1.0102 | 1965.1800 | **SIR.AX** | 0.8958 | 1.6822 | 788.4200 | | |
| **600601.ss** | 0.9253 | 0.9234 | 796.6800 | **WSA.AX** | 0.8956 | 1.7422 | 574.7800 | | **0.0507** |

**Note:** The 'stock' is the Chinese and Australian stocks, 'speed' is the speed of adjustment coefficient from the PAM, 'beta' is systematic risk, and 'mcap' is market capitalisation in millions of Australian dollars. There were 33 Chinese and Australian stocks. The stocks were ranked in order from fastest speed of adjustments to slowest speed of adjustments. LOP is the outcome of the LOP strategy and Markov is the outcome of the Markov switching strategy. Refer to Table 5-1 for company codes. The missing values in the Markov results are omitted because they show no regime changing characteristics. The missing values in the LOP results are omitted because they are either not cointegrated or they do not match the trading rule.

The results in Table 6-14indicate that the LOP strategy largest returns were 5.1% (OGC/600583), 6% (BHP/600331), 7.5% (TRY/600005) and 7.3% (RIO/600019) annually. This strategy captured temporary divergences from the mean only later to return to their long-run equilibrium value. This strategy captured the influence of noise traders. Noise traders are supposed to be retail investors who trade in small-caps.

The Table 6-14 shows that the Markov strategy had the largest returns of 19% (MDL/600050), 12% (IGR/600028), 16% (SDL/600887) and 14% (GRR/600362) annually.

The Markov strategy captures permanent changes in pairs trading. It is believed that informed traders are more likely to make permanent changes than noise traders (who make transitory changes).

The largest cap pairs were not cointegrated under the LOP strategy nor did they have regime-switching characteristics. It is surmised that very large-cap stocks are followed by many analysts, and therefore trade close to their fundamentals and so offer few arbitrage opportunities. Small-cap 'stock' pairs are generally more profitable than large-cap 'stock' pairs, perhaps reflecting the fact that they are riskier and thus require a higher rate of return. Generally, informed traders are more profitable than noise traders. The CSC constituent stocks and the Australian resources stocks are cointegrated and two successful pairs trading strategies were implemented. The Markov switching strategy was more profitable, demonstrating that informed traders are more profitable in their trades than noise traders.

Table 6-15 shows the results of the LOP and Markov switching strategies where 'stock' pairs were chosen by market capitalisation.

**Table 6-15The results of the LOP and Markov switching strategies (MCAP)**

| 'STOCK' | MCAP(mil) | 'STOCK' | MCAP(mil) | Markov | LOP |
|---|---|---|---|---|---|
| **600028.SS** | 104374.2400 | **BHP.AX** | 161632.0000 | **-0.0233** | |
| **600036.SS** | 42476.3300 | **RIO.AX** | 85933.6700 | | |
| **600016.SS** | 40444.8400 | **NCM.AX** | 14399.0500 | | |
| **600000.SS** | 29108.0700 | **AAI.AX** | 8500.0000 | | |
| **600519.ss** | 26386.0800 | **BSL.AX** | 2651.6600 | | |
| **600104.ss** | 25140.5000 | **SGM.AX** | 1936.8500 | | **-0.0017** |
| **600011.SS** | 14692.2400 | **RRL.AX** | 1878.6800 | **-0.0557** | **0.0455** |
| **600019.SS** | 12881.1100 | **AGG.AX** | 1831.0000 | **0.0127** | **0.0449** |
| **600050.ss** | 12033.8100 | **OZL.AX** | 1440.0000 | **-0.1682** | |
| **600111.ss** | 10891.4600 | **PNA.AX** | 1406.9900 | | |
| **600362.ss** | 10341.6700 | **OGC.AX** | 1362.9100 | | **-0.1008** |
| **600018.SS** | 9494.8500 | **ARI.AX** | 1020.4000 | | **0.0059** |
| **600887.ss** | 8758.2200 | **LYC.AX** | 1009.8100 | | **0.1254** |
| **600795.ss** | 7910.9400 | **EVN.AX** | 902.8200 | | **-0.1167** |
| **601600.ss** | 7473.8000 | **IGO.AX** | 859.3400 | **-0.1465** | |
| **600309.ss** | 6034.0600 | **SIR.AX** | 788.4200 | | **0.0219** |
| **600688.ss** | 5543.3900 | **RSG.AX** | 729.9100 | | **0.0385** |
| **600005.SS** | 4305.6800 | **SPH.AX** | 676.6300 | | **0.0351** |
| **600009.SS** | 3945.5000 | **CDU.AX** | 663.5900 | | **-0.0157** |
| **600583.ss** | 3867.2400 | **SDL.AX** | 645.1400 | **0.2001** | |
| **600642.ss** | 3293.4500 | **WSA.AX** | 574.7800 | **-0.0472** | **-0.0246** |
| **600832.ss** | 2698.6100 | **KCN.AX** | 531.4000 | | |
| **600177.ss** | 2676.7100 | **SBM.AX** | 514.9200 | | |
| **600100.ss** | 2139.7700 | **MGX.AX** | 512.5700 | **-0.1407** | **0.0897** |
| **600026.SS** | 1969.2000 | **IGR.AX** | 485.9000 | **0.1634** | |
| **600320.ss** | 1965.1800 | **IRN.AX** | 409.0700 | **-0.2545** | **0.0321** |
| **600717.ss** | 1563.8900 | **GDO.AX** | 339.9700 | | |
| **600811.ss** | 1484.0600 | **AQP.AX** | 316.0000 | | **0.0453** |
| **600269.ss** | 1231.6800 | **GBG.AX** | 283.5100 | | **0.0382** |
| **600879.ss** | 1123.4400 | **MDL.AX** | 275.6800 | **0.1914** | **0.0501** |
| **600037.ss** | 1051.0300 | **IMD.AX** | 271.5100 | **0.1297** | **0.0208** |
| **600331.ss** | 872.4300 | **GRR.AX** | 219.7300 | **-0.0539** | **0.0283** |
| **600601.ss** | 796.6800 | **TRY.AX** | 173.9600 | | **0.0328** |

**Note:** The 'stock' is the Chinese and Australian stocks, 'speed' is the speed of adjustment coefficient from the PAM, 'beta' is systematic risk, and 'mcap' is market capitalisation in millions of Australian dollars. There were 33 Chinese and Australian stocks. The stocks were ranked in order from fastest speed of adjustments to slowest speed of adjustments. LOP is the outcome of the LOP strategy and Markov is the outcome of the Markov switching strategy. Refer to Table 5-1 for company codes. The missing values in the LOP results are omitted because they are either not cointegrated or they do not match the trading rule.$S_t = \alpha + \beta_0 P_t - \beta_1 P_t^* + \mu_t$

Table 6-15 above shows that the LOP strategy was generally more profitable for small-cap stocks than for large-cap stocks. This strategy captured temporary divergences from the mean only later to return to their long-run equilibrium value. This strategy captured the influence of noise traders. Noise traders are supposed to be retail investors who trade in small-caps. Small-cap pairs were more profitable under this strategy than medium cap to large-cap pairs.

The results in Table 6-16 reflect that the Markov strategy was more profitable in relatively small-cap pairs, capturing permanent changes in pairs trading. It is believed that informed traders are more likely to make permanent changes than noise traders (who make transitory changes). Therefore, informed traders may trade profitably in small-cap pairs.

The largest cap pairs were not cointegrated under the LOP strategy, nor did they have regime-switching characteristics. It is surmised that very large-cap stocks are followed by many analysts and trade close to their fundamentals and so offer few international arbitrage opportunities. Small-cap 'stock' pairs are generally more profitable than large-cap 'stock' pairs, perhaps reflecting the fact that they are riskier and thus require a higher rate of return. Generally, informed traders are more profitable than noise traders. The CSC constituent stocks and the Australian resources stocks are cointegrated and two successful pairs trading strategies were implemented. The Markov switching strategy was more profitable, demonstrating that informed traders are more profitable in their trades than noise traders.

The similarities between the PAM and market capitalisation models, is that in both instances small cap stocks were generally more profitable than large cap stocks. The Markov strategy was more profitable for the PAM than for market capitalisation. In the PAM the Markov strategy was generally more profitable for stock pairs that over-reacted and under-reacted. In the market capitalisation model the LOP was generally more profitable than the Markov strategy.

Table 6-16 shows the results of the LOP strategy which was tested for lead-lag effects. Lo and MacKinlay (1990) stated that lead-lag effects were the main reason for the profitability of contrarian strategies, rather than the over-reaction of stocks to economic information as suggested by De Bondt and Thaler (1985).

**Table 6-16 Lead-lag effects for the LOP strategy**

| 'STOCK' | SPEED | BETA | MCAP(mil) | 'STOCK' | SPEED | BETA | MCAP(mil) | LOP |
|---|---|---|---|---|---|---|---|---|
| **600601.ss** | 0.9253 | 0.9234 | 796.6800 | **NCM.AX** | 1.5637 | 1.1534 | 14399.0500 | **-0.0325** |
| **600320.ss** | 0.9399 | 1.0102 | 1965.1800 | **OGC.AX** | 1.0751 | 1.1948 | 1362.9100 | **0.0521** |
| **600019.SS** | 0.9425 | 1.0911 | 12881.1100 | **MDL.AX** | 1.0456 | 1.0662 | 275.6800 | **-0.0241** |
| **600362.ss** | 0.9434 | 1.0321 | 10341.6700 | **GDO.AX** | 1.0417 | 0.8104 | 339.9700 | **-0.1548** |
| **600177.ss** | 0.9543 | 1.1485 | 2676.7100 | **AGG.AX** | 1.0114 | 1.4252 | 1831.0000 | **0.0284** |
| **600717.ss** | 0.9586 | 1.1286 | 1563.8900 | **AAI.AX** | 1.0077 | 0.1332 | 8500.0000 | **-0.0322** |
| **600111.ss** | 0.9598 | 0.8418 | 10891.4600 | **SBM.AX** | 1.0073 | 1.4554 | 514.9200 | **-0.0835** |
| **600026.SS** | 0.9641 | 0.9780 | 1969.2000 | **CDU.AX** | 1.0032 | 0.2997 | 663.5900 | **-0.0072** |
| **600005.SS** | 0.9654 | 1.0961 | 4305.6800 | **RRL.AX** | 1.0017 | 0.2689 | 1878.6800 | **-0.0509** |
| **600269.ss** | 0.9665 | 0.8928 | 1231.6800 | **IGO.AX** | 0.9988 | 0.8381 | 859.3400 | **0.0559** |
| **600011.SS** | 0.9700 | 1.2696 | 14692.2400 | **SPH.AX** | 0.9920 | 1.7944 | 676.6300 | **-0.0238** |
| **600009.SS** | 0.9705 | 0.9965 | 3945.5000 | **BHP.AX** | 0.9911 | 0.6385 | 161632.0000 | **0.0245** |
| **600100.ss** | 0.9732 | 0.8378 | 2139.7700 | **MGX.AX** | 0.9898 | 1.0831 | 512.5700 | **-0.1062** |
| **600811.ss** | 0.9779 | 1.1585 | 1484.0600 | **RSG.AX** | 0.9898 | 1.4357 | 729.9100 | **-0.0650** |
| **600887.ss** | 0.9783 | 0.8853 | 8758.2200 | **IGR.AX** | 0.9895 | 0.8761 | 485.9000 | **-0.0099** |
| **600104.ss** | 0.9788 | 0.8398 | 25140.5000 | **LYC.AX** | 0.9887 | 0.9966 | 1009.8100 | **-0.0881** |
| **600028.SS** | 0.9791 | 1.0624 | 104374.2400 | **SDL.AX** | 0.9855 | 1.5307 | 645.1400 | **-0.0152** |
| **600832.ss** | 0.9795 | 0.8298 | 2698.6100 | **PNA.AX** | 0.9853 | 1.3347 | 1406.9900 | **-0.0550** |
| **600688.ss** | 0.9864 | 1.1146 | 5543.3900 | **ARI.AX** | 0.9849 | 0.5668 | 1020.4000 | **-0.0701** |
| **600331.ss** | 0.9914 | 1.0290 | 872.4300 | **AQP.AX** | 0.9801 | 0.5560 | 316.0000 | **-0.0467** |
| **601600.ss** | 0.9926 | 1.3598 | 7473.8000 | **BSL.AX** | 0.9780 | 0.7667 | 2651.6600 | **-0.0893** |
| **600795.ss** | 0.9937 | 1.1549 | 7910.9400 | **GBG.AX** | 0.9766 | 0.7884 | 283.5100 | **0.0261** |
| **600037.ss** | 0.9963 | 0.8170 | 1051.0300 | **TRY.AX** | 0.9693 | 1.8089 | 173.9600 | **0.0024** |
| **600642.ss** | 0.9969 | 1.1110 | 3293.4500 | **OZL.AX** | 0.9560 | 1.3319 | 1440.0000 | **-0.0231** |
| **600000.SS** | 1.0000 | 1.0624 | 29108.0700 | **SGM.AX** | 0.9554 | 1.6807 | 1936.8500 | **-0.0675** |
| **600036.SS** | 1.0030 | 1.2908 | 42476.3300 | **IMD.AX** | 0.9391 | 0.9426 | 271.5100 | **0.0464** |
| **600879.ss** | 1.0057 | 1.2637 | 1123.4400 | **IRN.AX** | 0.9301 | 0.9802 | 409.0700 | **-0.0707** |
| **600016.SS** | 1.0071 | 0.5820 | 40444.8400 | **EVN.AX** | 0.9160 | 0.7868 | 902.8200 | **0.0589** |
| **600018.SS** | 1.0078 | 1.1250 | 9494.8500 | **GRR.AX** | 0.8977 | 0.8190 | 219.7300 | **-0.0040** |
| **600050.ss** | 1.0127 | 0.8299 | 12033.8100 | **RIO.AX** | 0.8967 | 1.3359 | 85933.6700 | **0.1004** |
| **600583.ss** | 1.0308 | 1.0696 | 3867.2400 | **SIR.AX** | 0.8958 | 1.6822 | 788.4200 | **-0.1051** |
| **600519.ss** | 1.0664 | 1.0694 | 26386.0800 | **WSA.AX** | 0.8956 | 1.7422 | 574.7800 | **-0.0499** |

**Note:** The 'stock' is the Chinese and Australian stocks, 'speed' is the speed of adjustment coefficient from the PAM, 'beta' is systematic risk, and 'mcap' is market capitalisation in millions of Australian dollars. There were 33 Chinese and Australian stocks. The stocks were ranked in order from fastest speed of adjustments to slowest speed of adjustments. LOP is the outcome of the LOP strategy. Refer to Table 5-1 for company codes.

$S_t = \alpha + \beta_0 P_t - \beta_1 P_t^* + \mu_t$

Lead-lag effects are constructed by combining Chinese and Australian stocks with faster speed of adjustments to stocks with those with slower speed of adjustments. The results of Table 6-16 show that most of the portfolios are not profitable using lead-lag effects. There are only small profits to be made from the other 'stock' pairs.

Table 6-17 shows the ADF unit root tests for the index tracking OLS residuals. The index tracking strategy uses the Engle-Granger cointegration methodology; an OLS regression is run combining the I(1) variables and the residuals of the regression are captured and tested to ascertain whether or not they are stationary. If the residuals are stationary, the variables are said to be cointegrated. The unit root tests are important for constructing the two momentum strategies; index tracking and enhanced indexing. These strategies employ the Engle-Granger (1987) cointegration methodology.

**Table 6-17 ADF test results of Index Tracking OLS residuals**

| 'STOCK' | CONSTANT | LINEAR TREND | NONE |
|---|---|---|---|
| AAI | -1.4320 | -1.2035 | -1.4324 |
| AGG | -1.5339 | -1.2737 | -1.5348 |
| AQP | -2.0429 | -2.1151 | -2.0458** |
| ARI | -1.3996 | -2.0831 | -1.4015 |
| BHP | -1.6092 | -1.6214 | -1.6111*** |
| BSL | -1.3988 | -1.1795 | -1.3990 |
| CDU | -1.9502 | -1.7822 | -1.9505*** |
| EVN | -1.5873 | -1.4872 | -1.5887 |
| GBG | -2.4832 | -2.4865 | -2.4862** |
| GDO | -1.4182 | -1.3803 | -1.4197 |
| GRR | -1.3716 | -1.7349 | -1.3731 |
| IGO | -1.6648 | -1.7065 | -1.6706*** |
| IGR | -0.5881 | -0.5231 | -0.5918 |
| IMD | -1.7675 | -1.8440 | -1.7696*** |
| IRN | -1.8800 | -1.8196 | -1.8824*** |
| KCN | -0.9121 | -1.2885 | -0.9176 |
| LYC | -1.2291 | -1.2291 | -1.2018 |
| MDL | -1.3068 | -1.3639 | -1.3075 |
| MGX | -1.5027 | -1.4638 | -1.5061 |
| NCM | -0.3849 | -0.8930 | -0.3917 |
| OGC | -1.6782 | -1.6365 | -1.6796*** |
| OZL | -1.8771 | -2.2889 | -1.8788*** |
| PNA | -0.8464 | -1.6006 | -0.8614 |
| RIO | -1.5074 | -1.7097 | -1.5100 |
| RRL | -1.2152 | -0.8238 | -1.2160 |
| RSG | -1.3740 | -1.6411 | -1.3758 |
| SBM | -1.6978 | -1.9391 | -1.7023*** |
| SDL | 0.1048 | -0.8612 | 0.0962 |
| SGM | -1.4403 | -1.3812 | -1.4414 |
| SIR | -1.7673 | -1.7658 | -1.7691*** |
| SPH | -1.3216 | -1.1637 | -1.3224 |
| TRY | -2.2859 | 2.2519 | -2.2867** |
| WSA | -2.6844 | -2.6778 | -2.6874* |

**Note:** the critical values are: (constant) -3.442483 (1%); -2.866784 (5%); -2.569624 (10%); (linear trend) -3.975466 (1%); -3.418322 (5%); -3.131651 (10%); (none) -2.569332 (1%); -1.9414222 (5%); -1.616298 (10%). The word 'stock' refers to the Chinese and Australian stocks; 'constant' refers to the ADF test for constant; 'linear trend' refers to the ADF test for constant and linear trend; NONE refers to the ADF test for none.*signifies significance level of 5%; ** signifies significance level of 5%; ***signifies significance level of 10%.Refer to Table 5-1 for company codes. The regression of this *augmented Dickey Fuller Test* (ADF) is as follows:

$$\Delta X_t = c + (\alpha - 1)X_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta X_{t-i} + \varepsilon_t$$

whereas with the simple Dickey-Fuller Test the null hypothesis of a unit root is rejected when the test statistic is smaller than the critical value (which have been summarized in a table).

AQP, BHP, CDU, GBG, IGO, IMD, IRN, OGC, OZL, SBM, SIR, TRY, WSA all show evidence of being cointegrated with the CSC index. Technically, BHPis not stationary. However, it is close to being stationary, and is included in the analysis because otherwise the index and enhanced indexing strategies would be skewed towards small cap stocks. This is because the study wishes to examine the different behaviours of large cap and small cap stocks in the context of index tracking.

Table 6-18 shows the PP unit root tests for the index tracking OLS residuals. The index tracking strategy uses the Engle-Granger cointegration methodology; an OLS regression is run combining the I(1) variables and the residuals of the regression are captured and tested to ascertain whether or not they are stationary. If the residuals are stationary, the variables are said to be cointegrated.

**Table 6-18 PP test results of Index Tracking OLS residuals**

| 'STOCK' | CONSTANT | LINEAR TREND | NONE |
|---|---|---|---|
| AAI | -1.5458 | -1.3337 | -1.5482 |
| AGG | -1.5285 | -1.2167 | -1.5296 |
| AQP | -1.7357 | -1.8024 | -1.7380*** |
| ARI | -1.2957 | -1.9460 | -1.3488 |
| BHP | -1.5630 | -1.5907 | -1.5652 |
| BSL | -1.5072 | -1.2674 | -1.5098 |
| CDU | -2.0009 | -1.8025 | -2.0038** |
| EVN | -1.6509 | -1.5285 | -1.6519 |
| GBG | -2.5658 | -2.5645 | -2.5680** |
| GDO | -1.3939 | -1.3489 | -1.3949 |
| GRR | -1.2792 | -1.5877 | -1.2805 |
| IGO | -1.7858 | -1.7984 | -1.7916*** |
| IGR | -0.7563 | -0.5231 | -0.7619 |
| IMD | -1.7119 | -1.7701 | -1.7133*** |
| IRN | -1.9640 | -1.9084 | -1.9659** |
| KCN | -1.1306 | -1.4966 | -1.1723 |
| LYC | -1.2291 | -1.3052 | -1.2317 |
| MDL | -1.4140 | -1.4771 | -1.4184 |
| MGX | -1.5066 | -1.4504 | -1.5122 |
| NCM | -0.8898 | -1.3508 | -0.9543 |
| OGC | -1.8528 | -1.8104 | -1.8538*** |
| OZL | -1.6827 | -1.9127 | -1.6840*** |
| PNA | -0.7838 | -1.5877 | -0.8568 |
| RIO | -1.6801 | -1.8806 | -1.6878*** |
| RRL | -1.2550 | -0.8390 | -1.2558 |
| RSG | -1.5880 | -1.9114 | -1.5942 |
| SBM | -1.4898 | -1.7731 | -1.5055 |
| SDL | 1.1645 | -1.2828 | -0.3575 |
| SGM | -1.6567 | -1.6006 | -1.6580*** |
| SIR | -1.6201 | -1.6155 | -1.6218*** |
| SPH | -1.3453 | -1.1750 | -1.3467 |
| TRY | -2.2104 | -2.1679 | -2.2122** |
| WSA | -2.5388 | -2.4506 | -2.5409** |

**Note:** the critical values are: (constant) -3.442460 (1%); -2.866774 (5%); -2.569618 (10%); (linear trend) -3.975466 (1%); -3.418322 (5%); -3.131651 (10%); (none) -2.569332 (1%); -1.9414222 (5%); -1.616298 (10%). The word 'stock' refers to the Chinese and Australian stocks; 'constant' refers to the PP test for constant; 'linear trend 'refers to the PP test for constant and linear trend; NONE refers to the PP test for none. *signifies significance level of 5%; ** signifies significance level of 5%; ***signifies significance level of 10%.Refer to Table 5-1 for company codes. Phillips-Perron tests assess the null hypothesis of a unit root in a univariate time series *y*. All tests use the model:

$y_t = c + \delta t + a y_{t-1} + e(t)$.

The null hypothesis restricts $a = 1$. Variants of the test, appropriate for series with different growth characteristics, restrict the drift and deterministic trend coefficients, $c$ and $\delta$, respectively, to be 0. The tests use modified Dickey-Fuller statistics (see adf test) to account for serial correlations in the innovations process $e(t)$.

AQP, CDU, GBG, IGO, IMD, IRN, OGC, OZL, SGM, SIR, TRY, WSA all show evidence of being cointegrated with the CSC index.

Table 6-19 shows the KPSS unit root tests for the index tracking OLS residuals. The index tracking strategy uses the Engle-Granger cointegration methodology; an OLS regression is run combining the I(1) variables and the residuals of the regression are captured and tested to ascertain whether or not they are stationary. If the residuals are stationary, the variables are said to be cointegrated.

**Table 6-19 KPSS test results of Index Tracking OLS residuals**

| 'STOCK' | CONSTANT | LINEAR TREND |
|---|---|---|
| **AAI** | 1.0438 | 0.3246 |
| **AGG** | 1.0089 | 0.3446 |
| **AQP** | 0.1691*** | 0.1095*** |
| **ARI** | 1.6107 | 0.1555* |
| **BHP** | 0.2063*** | 0.1983* |
| **BSL** | 1.1934 | 0.3294 |
| **CDU** | 1.3081 | 0.4480 |
| **EVN** | 0.5053* | 0.3347 |
| **GBG** | 0.1055*** | 0.1063*** |
| **GDO** | 0.3354*** | 0.3174 |
| **GRR** | 1.1048 | 0.2656 |
| **IGO** | 0.2219** | 0.2014* |
| **IGR** | 0.3736** | 0.3637 |
| **IMD** | 0.3172*** | 0.3138 |
| **IRN** | 0.9377 | 0.1675** |
| **KCN** | 0.6682* | 0.2848 |
| **LYC** | 0.4722* | 0.4658 |
| **MDL** | 1.3511 | 0.2717 |
| **MGX** | 0.2467** | 0.2048* |
| **NCM** | 0.6042 | 0.2053* |
| **OGC** | 0.2717*** | 0.1775* |
| **OZL** | 0.8801 | 0.1582* |
| **PNA** | 1.0344 | 0.1723* |
| **RIO** | 0.7527 | 0.1780* |
| **RRL** | 1.1883 | 0.3799 |
| **RSG** | 1.3648 | 0.1419** |
| **SBM** | 0.3828** | 0.3074 |
| **SDL** | 1.1645 | 0.1540** |
| **SGM** | 0.4399** | 0.3256 |
| **SIR** | 0.3357** | 0.3040 |
| **SPH** | 0.8829 | 0.4008 |
| **TRY** | 0.1720*** | 0.1802** |
| **WSA** | 0.1686*** | 0.1685** |

**Note:** The critical values are: (constant) 0.739000(1%); 0.463000 (5%); 0.347000 (10%); (linear trend) 0.216000 (1%); 0.146000 (5%); 0.119000 (10%). 'constant' refers to the KPSS test for constant; 'linear trend' refers to the KPSS test for constant and linear trend. *signifies significance level of 5%; ** signifies significance level of 5%; ***signifies significance level of 10%.Refer to Table 5-1 for company codes. The regression model with a time trend has the form

$$X_t = c + \mu t + k \sum_{i=1}^{t} \xi_i + \eta_t,$$

AQP, ARI, BHP, EVN, GBG, IGO, IGR, IMD, IRN, KCN, LYC, MGX, NCM, OGC, OZL, PNA, RIO, RSG, SDL, TRY, WSA were all found to be stationary.

Combining the results of Tables 6.17, 6.18 and 6.19, and choosing stocks which overlap, reveals that there were 13 Australian resource stocks which were cointegrated with the CSC index; AQP, BHP, CDU, GBG, IGO.IMD, IRN, OGC, OZL, SBM, SIR, TRY and WSA.

Table 6-20 shows the speed of adjustment coefficients for variables involved in the index tracking strategy. This is important as the analysis will examine these stocks to ascertain whether they over-react or under-react to economic information.

**Table 6-20 Speed of adjustment coefficients for Index Tracking**

| 'STOCK' | SPEED | BETA | MCAP(mil) |
|---|---|---|---|
| AAI.AX | 1.0077 | 0.1332 | 8500.0000 |
| AGG.AX | 1.0114 | 1.4252 | 1831.0000 |
| AQP.AX | 0.9801 | 0.5560 | 316.0000 |
| ARI.AX | 0.9849 | 0.5668 | 1020.4000 |
| BHP.AX | 0.9911 | 0.6385 | 161632.0000 |
| BSL.AX | 0.9780 | 0.7667 | 2651.6600 |
| CDU.AX | 1.0032 | 0.2997 | 663.5900 |
| EVN.AX | 0.9160 | 0.7868 | 902.8200 |
| GBG.AX | 0.9766 | 0.7884 | 283.5100 |
| GDO.AX | 1.0417 | 0.8104 | 339.9700 |
| GRR.AX | 0.8977 | 0.8190 | 219.7300 |
| IGO.AX | 0.9988 | 0.8381 | 859.3400 |
| IGR.AX | 0.9895 | 0.8761 | 485.9000 |
| IMD.AX | 0.9391 | 0.9426 | 271.5100 |
| IRN.AX | 0.9301 | 0.9802 | 409.0700 |
| KCN.AX | 1.0306 | 0.9918 | 531.4000 |
| LYC.AX | 0.9887 | 0.9966 | 1009.8100 |
| MDL.AX | 1.0456 | 1.0662 | 275.6800 |
| MGX.AX | 0.9898 | 1.0831 | 512.5700 |
| NCM.AX | 1.5637 | 1.1534 | 14399.0500 |
| OGC.AX | 1.0751 | 1.1948 | 1362.9100 |
| OZL.AX | 0.9560 | 1.3319 | 1440.0000 |
| PNA.AX | 0.9853 | 1.3347 | 1406.9900 |
| RIO.AX | 0.8967 | 1.3359 | 85933.6700 |
| RRL.AX | 1.0017 | 0.2689 | 1878.6800 |
| RSG.AX | 0.9898 | 1.4357 | 729.9100 |
| SBM.AX | 1.0073 | 1.4554 | 514.9200 |
| SDL.AX | 0.9855 | 1.5307 | 645.1400 |
| SGM.AX | 0.9554 | 1.6807 | 1936.8500 |
| SIR.AX | 0.8958 | 1.6822 | 788.4200 |
| SPH.AX | 0.9920 | 1.7944 | 676.6300 |
| TRY.AX | 0.9693 | 1.8089 | 173.9600 |
| WSA.AX | 0.8956 | 1.7422 | 574.7800 |

**Notes:** Refer to Table 5-1 for company codes..$R_t = \delta a + \delta\beta R_m$+$(1-\delta)\beta R_{m_{t-1}} + \delta e$

There were 13 Australian resource stocks which were cointegrated with the CSC index; AQP, BHP, CDU, GBG, IGO. IMD, IRN, OGC, OZL, SBM, SIR, TRY and WSA. Of these 8 stocks under-reacted to economic information, three stocks BHP, CDU and IGO fully adjusted and were efficient and two stocks, OGC and SBM over-reacted to economic information. The results support the under-reaction hypothesis. All stocks were small-cap stocks except for OGC and OZL which were mid-cap stocks, and BHP which was a large-cap 'stock'.

Table 6-21 shows the results of the index tracking strategy and the enhanced indexing strategies. The index tracking and enhanced indexing strategies are momentum strategies. The index tracking strategy is a passive investment, whilst the enhanced indexing is an active strategy.

**Table 6-21The results of Index Tracking and Enhanced Indexing strategies**

| | Index | 5 Per cent | 10 Per cent | 15 Per cent |
|---|---|---|---|---|
| **Annual Return** | 0.1035 | 0.1357 | 0.1377 | 0.1397 |
| **TE** | 0.0040 | 0.0069 | 0.0070 | 0.0072 |
| **RF** | 0.0499 | 0.0499 | 0.0499 | 0.0499 |
| **SD** | 0.6100 | 1.3300 | 1.3600 | 1.3900 |
| **SR** | 0.0883 | 0.0646 | 0.0645 | 0.0644 |

**Note:** A/Return is the annual return, TE is the tracking error, RF is the average risk-free rate, SD is the standard deviation and SR is the Sharpe ratio.

$$Log(CSC_t) = a_0 + \sum_{k=1}^{n} a_k.LogP_{kt} + e_t$$

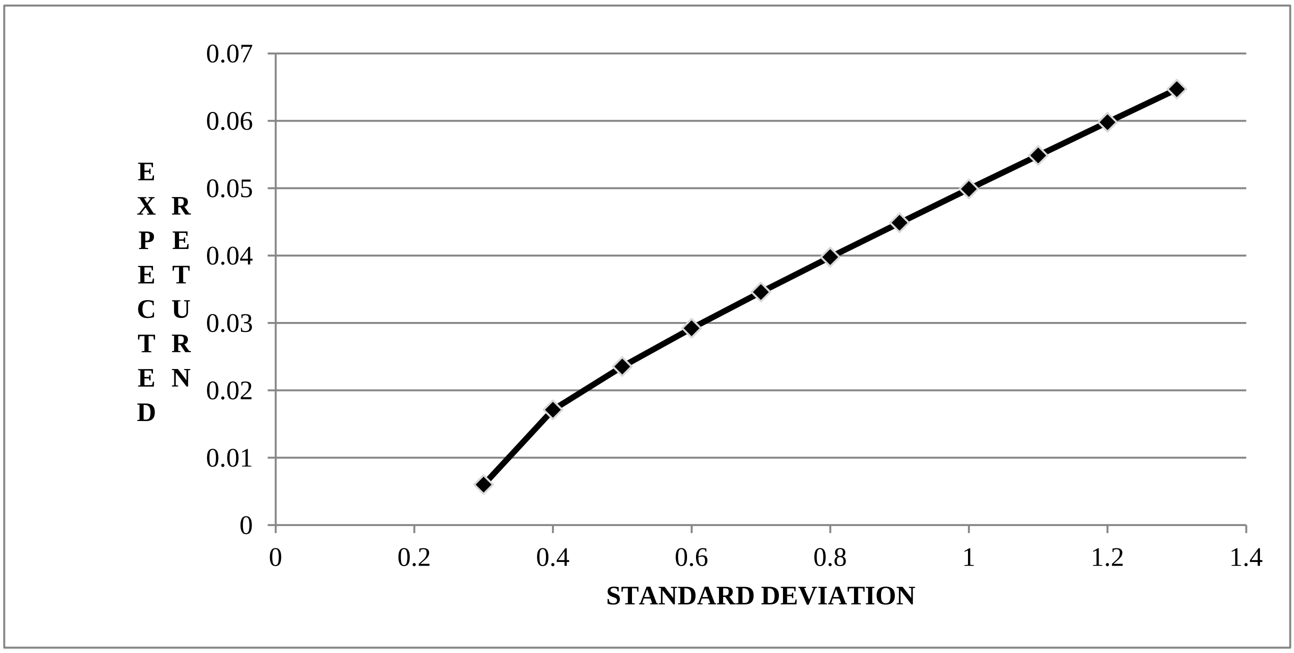
$$Log(CSC_t Plus_t) = a_0 + \sum_{k=1}^{n} a_k.LogP_{kt} + e_t$$

$$Log(CSC_t Minus_t) = a_0 + \sum_{k=1}^{n} a_k.LogP_{kt} + e_t$$

The Index is the CSC benchmark. 5 per cent is the Plus 5% and Minus5% portfolio, 10 per cent is the Plus 10% and Minus 10% portfolio and 15 per cent is the Plus 15% and Minus 15% portfolio. Table 21 shows that the index tracking strategy has an annual return of 10.35% and a tracking error (TE) of 0.4%. Plus Minus 5% portfolio has an annual return of 13.57% and a TE of 0.69%. Plus Minus 10% portfolio has an annual return of 13.77% and a TE of 0.70%. Plus Minus 15% portfolio has an annual return of 13.97% and a TE of 0.72%. However, the index tracking portfolio has the highest Sharpe ratio of 8.83%.

Figure 6-2 shows the efficient frontier for the LOP and Markov switching portfolios. The portfolios are combined into a global portfolio, the efficient frontier is determined and the market portfolio is found. The figure is constructed using experimental data developed in this study.

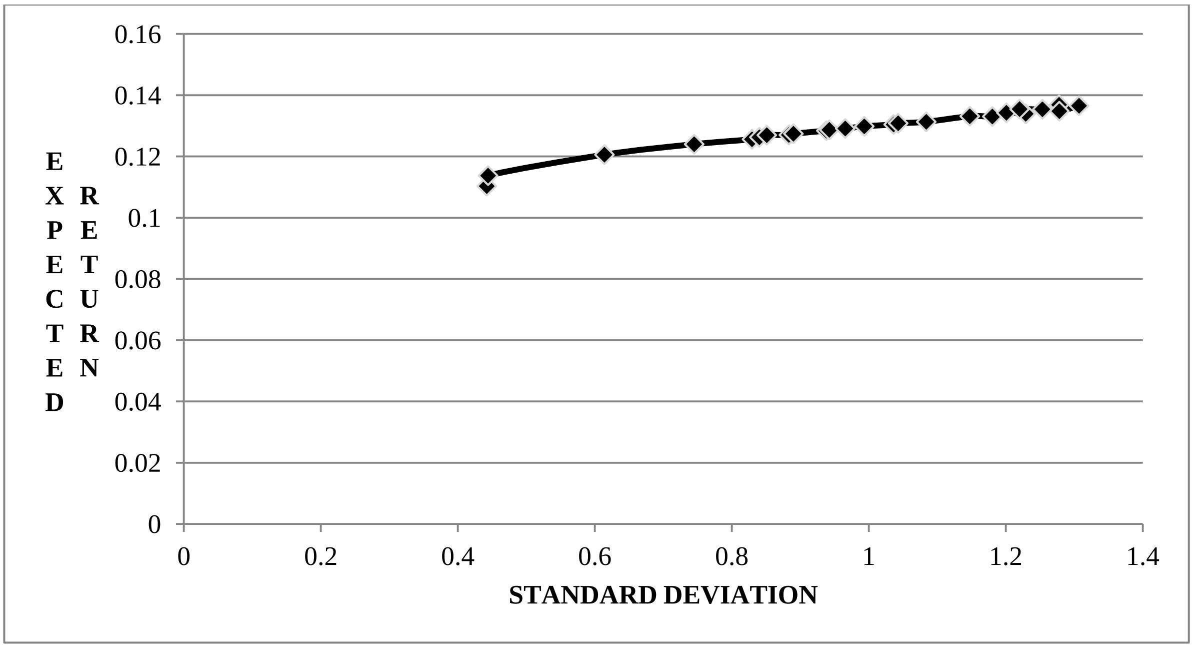
**Figure 6-2The efficient frontier for LOP and Markov switching strategies**




The Sharpe ratio was maximised (20%) to find the optimal portfolio. It was determined that the portfolio consisted of going long in the LOP portfolio (91.7%) and the Markov portfolio (8.3%) for a return of 0.4%.

Figure 6-3 shows the efficient frontier for the index tracking portfolio and the three enhanced indexing portfolios. The portfolios are combined into a global portfolio, the efficient frontier is determined and the market portfolio is found. The figure is constructed using experimental data developed in this study.

**Figure 6-3The efficient frontier for Index Tracking and Enhanced Indexing portfolios**




The Sharpe ratio was maximised to find the optimal portfolio which had a return of 10.39%. It was determined that the portfolio consisted of going long in the index tracking portfolio (64.46%) and the Plus-Minus 5% portfolio (210%) and going long in the Plus-Minus 10% portfolio (202%) and going short in the Plus-Minus 15% portfolio (376%).

## 6.2 Summary

The results show that Chinese and Australian stocks co-vary and have a long-run equilibrium relationship. The series showed regime switching characteristics. Small-cap stocks tend to over-react and under-react to new information whilst large-cap stocks tend to fully adjust and are thus more efficient than small-cap stocks. Lead and lag effects did not seem to be the reason for this profitability. The Markov and LOP strategies were both profitable; the Markov strategy was more profitable. The “index” and “enhanced indexing” strategies were both profitable.

Behavioural biases and psychological heuristics create inefficiencies which run counter to the EMH and makes statistical arbitrage possible. There are two ways to exploit these inefficiencies; through contrarian and momentum strategies. It is assumed that noise traders (who are uniformed traders) trade small cap stocks utilising contrarian approaches, whilst informed traders trade in large cap stocks through momentum strategies. The analysis tests the profitability of contrarian and momentum strategies and in this way the impact of noise (uninformed) traders and informed traders are also tested.

The methodology involved pairs trading and index tracking and the tests employed were appropriate to answer the hypothesis. The thesis now notes that similar robustness tests have been provided in the literature (Vidyamurthy, 2004 and Alexander et al., 2002).

# CHAPTER SEVEN

# DISCUSSION OF RESULTS

## 7.1 Introduction

In order to test the hypotheses, the first step was to distinguish between the three parts of the study. Part One deals with market efficiency and the PAM. Part Two deals with contrarian strategies, and Part Three deals with momentum strategies. This study investigates international arbitrage strategies between China and Australia. In contrast to other studies on international arbitrage, it examines joint strategies, whether they be pairs trading or indexing strategies, between the CSC index and its constituent stocks on the one hand, and Australian resource stocks on the other. As previously mentioned, issues were developed for study and these issues were converted into hypotheses. A discussion of the results in relation to the hypotheses is presented below.

The variable of interest in the LOP, Markov, index tracking and enhanced indexing strategies was the returns of each strategy. The motivation is to examine international arbitrage opportunities between Australia and China. A case is made that the two countries are linked through trade in metals, minerals and coal and that this has resulted in MAM constituent stocks and CSC constituent stocks being economically linked and thus traded using statistical arbitrage strategies.

## 7.2 Discussion

**H1**: **There is weak-form inefficiency in the top 33 CSC constituent stocks.**

**H2**:**There is weak-form inefficiency in the top 33 Australian resources stocks.**

The hypotheses are grouped together because of similar and overlapping evidence. Neither hypothesis is rejected. Tables 6-2, 6-3 and 6-4 show that the results of 3 different categories of unit root tests (ADF, PP, and KPSS) provide evidence against the existence of random walks in Chinese and Australian stocks. There is no evidence of a unit root in the return series and, therefore, this is evidence against market efficiency. This supports Hypotheses 1 and 2. The evidence in support of the hypotheses are as follows

Table 6-1 shows that the 33 Australian and Chinese financial stocks are ranked in order from the fastest speed of adjustment to the slowest speed of adjustment. The fastest Chinese and Australian stocks are 600519.ss and NCM.AX, with speed of 1.07 and 1.56 respectively, followed by 600583.ss and OGC.AX with speed of 1.03 and 1.08. The slowest speed of adjustment are 600601.ss and WSA.AX, with speed of 0.92 and 0.90. The second slowest and third slowest are 600320.ss (0.94) and SIR.AX (0.90), and 600019.ss (0.94) and RIO.AX (0.90) respectively. This supports hypothesis 1 and 2.It may be recalled that a speed of adjustment of 1 means the stocks fully adjust to new information and are efficient. A speed greater than 1 means the stocks over-react, and a speed of $0 < \delta < 1$ means the stock under-react. Over-reaction leads to contrarian strategies, and under-reaction leads to momentum strategies. The speed of adjustments in Table 6-10 suggest that some stocks under-react, others over-react, and a few fully adjust to new price information. Therefore, there should be opportunities for contrarian strategies and momentum strategies.

In the absence of transaction costs, the price reflects all past, present and future information (Fama, 1970). Investors form expectations rationally, based on all the information at their disposal (Blanchard and Sheen, 2009). Behaviourists question this proposition. They state that people do not want to realise their losses (Odean, 1998) and trade too much (Odean, 1999). They make decisions using psychological heuristics and behavioural biases (Osler, 1998). De Bondt and Thaler (1985) state that investors over-react to good or bad news which leads to over-reaction. Black (1986) introduced the concept of noise traders, whose behaviours lead to mis-pricing and over-reaction to economic information. Chen et al. (2005) find evidence that Chinese investors tend to over-react.

The speed of adjustments suggest that neither the Chinese stocks nor the Australian stocks are efficient. As the PAM used lagged returns (by one period), this suggests that the Chinese and Australian stocks were not weak-form efficient. The empirical results give some support to hypotheses 1 and 2. They also lend some support to Chen et al.(2005) and Worthington and Higgs (2006).

This study proposes that stocks are informationally efficient in the long-run; however, in the short-run they are inefficient, leading to arbitrage opportunities. It was previously discussed in Chapter Three that Behaviourists have criticised the basic assumptions of the EMH;

namely, that investors are rational utility-maximisers and homogenous. Biases and heuristics (Kahneman and Tversky, 1979) and the existence of noise traders (Black, 1986) suggest that stocks both over-react and under-react to new information. This leads to mis-pricing in the short-run. This study departs from the Behaviourists' critique in that the former states that there are limits to arbitrage. If stocks are cointegrated, then mean-reversion is guaranteed; there will be no limits to arbitrage, and there will be equilibrium in the long-run.

Chen et al. (2005) shows that Chinese investors have a tendency to over-react to good (bad) news and under-react to bad (good) news in a bullish (bearish) market. Lee and Rui (2000) also find that foreign investors may lack the knowledge of the Chinese market, proposed that asset prices in China may not be trading at their fundamental values. Worthington and Higgs (2006) research examined the weak-form market efficiency of the Australian stock market. Serial correlation tests conclusively rejected the presence of a random walk in weekly returns. The unit root tests concluded that unit roots were absent in the differences of the series. Worthington and Higgs (2006) concluded that weekly Chinese and Australian returns from 2003 to 2013 did not follow a random walk. Therefore the hypotheses are supported.

**H3:Cointegration and PAM can identify contrarian strategies.**
**H4:Markov switching and PAM can identify contrarian strategies.**
**H5:Cointegration and PAM can identify momentum strategies.**

The hypotheses are grouped together because of similar and overlapping evidence. H3 is supported using cointegration and the PAM. H4 is supported using Markov switching and PAM. H5 is supported using cointegration and the PAM.The evidence in support of the hypotheses are as followsTables 6-5, 6-6 and 6-7present the results of three types of unit root tests (ADF, PP, and KPSS) for Chinese-Australian OLS residuals. The ADF and PP shows that all variables are stationary, confirming a cointegrating relationship. For the KPSS, there were five stock pairs which did not show a cointegrating relationship. It was decided to rely on the ADF and PP results, however the robustness of the results are questioned. This supports H3.

Tables 6-8, 6-9 and 6-10present similar results for the stock pairs chose using market capitalisations. It is concluded that all variables in the sample show a cointegrating relationship. This supports H3.

The results in Table 6-11 indicate that the regime switching model has split the data into two distinct samples; one with a high mean, and one with a lower mean. Also apparent is the fact that the MDL/600050; AGG/600879; SPH/600879; ARI/600100; OZL/600026; IRN/600177 ratios are more variable at the times when it is in the high mean regime, evidenced by their higher standard deviation. The low values of the term ‘P12’ and the term ‘P21’ parameters indicate that the regimes are highly stable. This supports H4.

Data in Table 6-12 also indicate that it is clear that the regime switching model has split the data into two distinct samples; one with a high mean and one with a lower mean, for Markov switching strategies where the stock pairs were chosen on the basis of their market capitalisations. Also apparent is that most ratios are more variable at times when it is in the high mean regime, evidenced by their higher standard deviation (except for MGX/600100 and IMD/600037). The low values of the term‘P12’ and the term ‘P21’ parameters indicate that the regimes are highly stable. The results are supportive of the hypothesis four. They show that there are short-run inefficiencies which can be exploited by LOP and Markov switching strategies and that the PAM can be used to identify stock pairs for these strategies. This lends support to Wilson and Marashdeh’s (2007) conclusion that financial series which are cointegrated, may be inefficient in the short-term, resulting in arbitrage opportunities, though in the long-run they are efficient. The speed of adjustment of the observed price to the changed fundamental value, due to new information, is a measure of stock efficiency. As stated above, speed of adjustment may be instantaneous in an efficient market. However, the speed of adjustment derived from the PAM show that some stocks under-react, some over-react, and others fully adjust. This is evidence of short-term inefficiencies in the stocks. This supports H4.

The literature in relation to over-reactions (cf., De Bondt and Thaler, 1985, 1987), under-reactions (cf., Michaely et al., 1995; Bernard and Thomas, 1989) and further anomalies (cf., Jegadeesh and Titman, 1993, 2001) led to a search for alternative theoretical models to describe the price adjustment process. Behavioural models have subsequently been developed to justify the under (over) reaction hypotheses (cf., Barberis et al. 1998). Damodaran (1993) and Brisley and Theobald (1996) estimated the speed of price adjustment using the partial adjustment model. Theobald and Yallup (2004) compared the speed of price adjustments between large and small companies (Jang, 2009).

The purpose of this study is to estimate speed of adjustment within a new partial adjustment model (PAM), in order to investigate the efficiency of the Chinese Shanghai Composite index constituent stocks and the Australian resources stocks. The results have many implications for both researchers and practitioners. First, the price adjustment process in Chinese and Australian markets is mixed. Some stocks over-react, some under-react, and some fully adjust to new economic information. Secondly, price over-reaction and under-reaction indicates inefficiencies in the information dissemination process in these markets. Thirdly, the PAM demonstrates that these inefficiencies are short-term, and that in the long-term there is equilibrium and markets are efficient.

In this study a new PAM was developed which is not affected by the problem of non-synchronous trading because it does not make use of auto-correlation structures in its formulation. The new measure reports that for both Chinese and Australian markets, there are short-term inefficiencies. These occur mainly in small-cap stocks which under-react and over-react to new economic information. Due to the nature of the PAM, there is a long-term equilibrium. Therefore markets are efficient in the long-term.

Out of 66 stocks in Table 6-1, seven Chinese and ten Australian stocks have (*g)* greater than one. This does not, however, represent an overwhelming indication of over-reaction of the prices for the arrival of new information. Twenty-five (25) Chinese and 23 Australian stocks have (g) less than one, suggesting under-reaction or slow adjustment process. The results indicate that speed of adjustment is quite slow in China and Australia. The traders tend to under-react to the arrival of information. The results are not wholly consistent with De Bondt and Thaler (1985) investor over-reaction theory but they provide some support.

Chinese and Australian stocks exhibit variation in their speed of adjustments, indicating the dominant role of firm-specific factors in the price adjustment process. This could be the result of inefficiency in the information dissemination process. Traders are comprised of informed and uninformed traders. Informed traders have superior or private information, apart from the market information. Uninformed investors have only market information. The market information is commonly shared by both the informed and uninformed. Thus, price adjustment due to market information will be faster than firm-specific information. Uninformed traders can observe the moves of informed traders as part of the process towards their investments decisions (Marisetty, 2003).

The results imply the speed of adjustment process in Chinese and Australian markets is very slow. This indicates inefficiencies in the information dissemination process. The lack of private information means uninformed investors exhibit herd behaviour resulting in momentum effects, followed by long-term reversals. The speed of the adjustment coefficient derived from the PAM reveals heterogeneity amongst investors, evidenced in the different coefficient values for small-cap stocks as opposed to large-cap stocks for both Chinese and Australian markets. Heterogeneity amongst investors, as evidenced by the PAM, is a critical blow to the EMH's assumption of investors as a homogenous group. This study assumes that there are two categories of investors, namely, noise traders and informed investors. The characteristics of noise traders and informed investors are discussed below.

As previously mentioned, the PAM reveals short-term inefficiencies amongst Chinese and Australian stocks. This study proposes that these inefficiencies are due to the behavioural biases and psychological heuristics of investors. A brief review of behavioural finance ensues. This thesis departs from the Behaviourists in one crucial respect; that is, in formulation there is no limit to arbitrage. This is the direct result of a cointegrating relationship in the LOP, index tracking and enhanced indexing strategies, and a Markovian relationship in the Markov switching strategy. Both cointegration and Markov switching hold that there is a long-run equilibrium relationship between stocks, which implies market efficiency in the long-run.

In the following discussion, the development of the new PAM is outlined. This is important because it is the PAM which identifies stock pairs for the LOP and Markov switching strategies. As a comparison, the LOP and Markov switching strategies were also implemented where the stock pairs were chosen on the basis of their market capitalisations. In an efficient market, prices incorporate economic news quickly. There are, however, many approaches to measuring the speed of adjustment. Previous studies such as Damodaran (1993) have contributed to a theory which measures the speed of the adjustment. Black (1986) developed the concept of 'noise' as the factor which makes observations imperfect and inhibits accurate measurement of expected return on a stock or portfolio.

Amihud and Mendelson's (1987) Partial Adjustment Model incorporated the noise factor. This study calculates the speed of adjustment of large and small-cap Australian resource stocks and the China Shanghai Composite Index. The researcher draws from the work of Amihud and Mendelson (1987) but transforms the partial adjustment model by incorporating the firm-specific return from the single index model. Estimation of the speed of adjustment means that stocks can be compared using the speed at which they move to their fundamental value. This study estimates the speed of adjustment to the arrival of all information, using continuous time series information. The fact that the results of the PAM show different speedof adjustments for small-cap and large-cap stocks reveals that there is heterogeneity amongst traders. If investors are homogeneous, rational, and fully informed, there would be no noise traders. Black (1986) defines noise traders as non-fundamental traders who trade on noisy information. As noise traders' trade on information that does not reflect any fundamental value, they add additional volatility to the market (Black, 1986). Chakravarty (2001), and Kurov and Sancetta (2008) stated that noise traders are retail investors. Noise traders introduce liquidity into the financial markets (Black, 1986). Mitchell et al. (2002) stated that since small-cap stocks are not covered as comprehensively by analysts as large-cap stocks, they introduce costs of information gathering. This places limits on arbitrage, which leads small-caps to be more volatile than large-cap stocks.

Many financial economists have been reluctant to assign any role to noise traders in studying the behaviour of asset prices. Even if many investors do trade irrationally, sophisticated arbitrageurs will trade against them and drive prices close to fundamental values (Fama 1970). Those whose judgments of stock's fundamentals are wrong, will lose money to rational investors and be driven out of the market.

The following discussion points to the existence of two types of investors, namely, noise traders and informed investors. The characteristics of noise traders are such that they may be suited to contrarian (pairs trading) strategies through their trades in small-cap stocks. It is assumed that informed investors trade in large-cap stocks and, therefore, trade stocks close to their fundamental values. In contrast, informed traders may not be profitable under contrarian strategies.

Noise traders push stock values away from fundamentals. If it were not for noise traders, market making would not be possible. Noise traders provide market makers with profit which in turn compensates them for subsequent losses with informed traders. Milgrom and Stokey (1982) find that if there was an absence of noise trading in the stock market, trade would not happen, even though traders received different signals in the stocks' fundamental value. The 'market selection hypothesis' stated that traders who do not behave rationally are eventually are driven out of the market (Alchian, 1950). De Long, Shleifer, Summers and Waldman (1990) state that arbitrageurs have a constrained time horizon, which results in limited arbitrage and allows noise traders to survive. Retail investors are noise traders or individual investors who invest in a manner that is inconsistent with the rational construct. These investors are undiversified (Benartzi and Thaler, 2001), loss averse (Odean, 1998a) and over-confident (Odean, 1999). Investor over-confidence leads to excessive trading (Benos, 1998; Odean 1998b).

De Long et al. (1990) noted that when information arrives, investors do not all respond the same way. Some investors are informed and respond only to fundamental shocks. Informed traders have rational expectations from fundamental shocks, purchasing stocks when their gathered information indicates stocks are undervalued, and selling when information reveals stocks are overvalued. They push prices towards their fundamental values. Noise traders incorrectly believe that fundamental and non-fundamental shocks carry true information. They buy and sell stocks based on their incorrect beliefs.

In the debate over market efficiency, the question remains as to whether noise traders distort stock prices. If they do, then, noisy traders must misinterpret available information or trade for irrational reasons. Further, noise trades must be correlated; that is, they are mainly buyers or sellers of the same stocks. However, if they buy and sell randomly, they will cancel each other out. If these statements hold, noise trades distort stock prices. If, in the long-run, stock prices return to their mean value, then noise trader actions will predict future asset returns. The ability of rational, well-informed investors to correct mis-pricing through arbitrage may be limited.

The notion of formulation of prices through interaction of the forces of supply and demand is fundamental in economics. There is a tremendous amount of information contained and synthesised in market prices. For large institutional investors, the stock market is not perfectly competitive in the short-run. These investors have private information about prices, their trading strategies, and other factors. Private information may cause the prices of the pairs of stocks to be in disequilibrium in the short-run; but in the long-run, as private information becomes publicly known, market forces, through the buying and selling activities of arbitrageurs, will drive the pairs of stocks towards a long-run equilibrium. On the other hand, noise traders may cause temporary divergences of stock pairs, which nonetheless return to their fundamental values.

As stated above, this study employs two contrarian strategies namely, a LOP strategy and a Markov switching strategy. Both strategies use stock pairs which are formed through the use of the PAM, having similar speed of adjustments coefficients. The LOP strategy involves the establishment of a cointegrating relationship. The Markov switching strategy establishes a regime switching relationship between the stock pairs. Both of these approaches state that, in the short-term, there are inefficiencies due to behavioural biases and psychological heuristics which manifest themselves as divergences from the long-run equilibrium. Therefore, in the short-run stocks may be inefficient, but in the long-run they are efficient.

Cointegration is stated to mean that there will be a long-run equilibrium relationship between two stocks. In the short-run these stocks may diverge, but in the long-run they will revert to their mean value. The PAM can be used to measure the speed of adjustment of stocks toward a long-run equilibrium. Contrarian strategies are characterised by over-reaction of stock prices to new information. Momentum strategies are characterised by under-reaction of stock prices to new information. Markov switching also purports that the pairs of -stocks will move towards a long-run equilibrium; however, means reversion may be to the original mean, or to a new mean regime.

Wilson and Marashdeh’s (2007) research demonstrates that the correction to long-run equilibrium allows systematic profits to be obtained in the short-run. Whilst this disequilibrium behaviour describes short-run market inefficiency, the consequent arbitrage activity moves the foreign exchange and stock markets to long-run equilibrium (in levels) consistent with market efficiency in the long-run. Market inefficiency in the short-run ensures market efficiency in the long-run.

The evidence on Table 6-20 show that most of the Australian stocks in the momentum/index tracking strategy under-reacted to economic information, based on the speed of adjustment coefficient as determined by the PAM. This supports H5. Tables 6-17, 6-18, 6-19 found 13 Australian stocks were cointegrated. This supports H5.

In summary, cointegration and PAM and Markov switching can identify contrarian and momentum strategies. The PAM reveals that stocks are informationally inefficient in the short-run. It also reveals that investors are heterogeneous, made up of informed and uninformed (noise traders) investors. The behaviour of these classes of investors explains why some stocks are efficient, and others are inefficient. In the long-run, however, all stocks are efficient as arbitrageurs exploit price discrepancies and trade away inefficiencies. Amihud and Mendelson (1987) developed a PAM which may be used to measure the degree of market efficiency. They find that stock prices tend towards their fundamental values. Damodaran (1993) constructed a measure of the speed of adjustment towards a stocks fundamental value after an information ‘shock’ is applied. Brisley and Theobald (1996) corrected an error in Damodaran’s (1993) original formulation. Theobald and Yallup (2004) construct two speed of adjustment estimators based on a new formulation than that of Damodaran (1993). The problem with the above estimators is that they suffer from nonsynchronous trading. This study uses a new formulation of the PAM which avoids this problem.

**H6:There are arbitrage profits to be made from the LOP strategy.**

**H7:There are arbitrage profits to be made from the Markov switching strategy.**

The hypotheses are grouped together because of similar and overlapping evidence. H6 is supported using the LOP strategy. H7 is supported using the Markov switching strategy. The evidence in support of the hypotheses are as follows. The data in Table 6-13 show that the absolute value of the average speed of adjustment from the Engle-Granger cointegration coincides with the speed of adjustment rankings from the PAM. This provides a check on the speed of adjustments coefficient of the PAM, and shows them to be robust.

Table 6-14 presents results that indicate that for the LOP strategy with stock pairs selected by the speed of adjustment derived from the PAM, the largest returns were 5.1% (OGC/600583), 6% (BHP/600331), 7.5% (TRY/600005) and 7.3% (RIO/600019) annually. This strategy captured temporary divergences from the mean only later to return to their long-run equilibrium value. This strategy captured the influence of noise traders. Noise traders, are supposed to be retail investors who trade in small-caps. This supports H6.

Table 6-14also shows that the Markov strategy had the largest returns of 19% (MDL/600050), 12% (IGR/600028), 16% (SDL/600887) and 14% (GRR/600362) annually. The Markov strategy captures permanent changes in pairs trading. It is believed that informed traders are more likely to make permanent changes than noise traders, who are thought to make transitory changes. This supports H7.

The largest cap pairs were not cointegrated under the LOP strategy; nor did they have regime-switching characteristics. It is surmised that very large-cap stocks are followed by many analysts and trade close to their fundamentals, offering few arbitrage opportunities. Small-cap stock pairs are generally more profitable than large-cap stock pairs, perhaps reflecting the fact that they are riskier and thus require a higher rate of return. Generally, informed traders are more profitable than noise traders. The CSC constituent stocks and the Australian resources stocks were cointegrated and two successful pairs trading strategies were implemented. The Markov switching strategy was more profitable, demonstrating that informed traders are more profitable in their trades than noise traders.

A contrarian strategy is comprised of buying stocks which have performed poorly in the past, and selling stocks which have performed well in the past. De Bondt and Thaler (1985, 1987) find that in the past three to five years, the losers outperformed the previous winners by nearly 25% in the following three to five years. There are alternatives which have been proposed to explain this outcome. The first is that losers are generally stocks with small-capitalisations and over-reaction is a characteristic for small firms. Zarowin (1989) and Chopra et al. (1992) investigated the size effect and find that when size is taken into account, the returns of the losers are diminished. However, they also stated that larger firms are efficient. The second is that time-varying risk has been neglected (Chan, 1988; and Ball and Kothari, 1985).

In this study, the profitability of the international contrarian strategy is examined through a pairs trading approach in the Chinese and Australian stock markets. There are a limited number of studies of investment strategies in the Chinese market and fewer studies investigating international arbitrage between China and Australia, even though China is one of the fastest growing economies in the world and an emerging super-power. The work is motivated by the desire to scrutinise the Chinese-Australian economic relationship and to exploit any opportunities for profit. There has been a growing economic and trading relationship between the two nations. China's demand for metals, minerals and energy products has witnessed growing and favourable terms of trade for Australia. China, too, has benefitted as it has used Australian iron ore and coal to urbanise, industrialise and manufacture goods for export.

DeBondt and Thaler (1985, 1987) contend that an interpretation of return predictability is that the stock market consistently over-reacts to new information. The over-reaction in stocks means that stock prices take temporary swings away from their fundamental values, due to bouts of optimism and pessimism. Chopra et al. (1992) find that long-term price reversals lead to investor over-reaction. Jegadeesh (1990) and Lehmann (1990) provided evidence of short-term return reversals at monthly and weekly intervals. Profitability of these short-term contrarian strategies indicated diminished liquidity in the market rather than over-reaction. Jegadeesh and Titman (1991) demonstrate the relationship between short-term contrarian effects and bid-ask spreads. Lo and MacKinlay (1990) argued that the abnormal return reported by Jegadeesh and Titman (1993) was due to lead-lag effects in stock prices, as a consequence of common factors rather than over-reaction.

Profits generated by contrarian strategies have been documented in stock markets across continents. For example, Chang et al.(1995) find evidence of short-term abnormal returns of the contrarian investment strategy in the Japanese stock market. Campbell and Limmack (1997) also find that from 1979-1990 in the United Kingdom, loser's generated positive abnormal returns in the 12 months following portfolio formation. The smallest loser companies experienced a reversal in their abnormal returns over the following 12 months; however, no such reversal was demonstrated for the smallest winner companies. Baytas and Cakici (1999) find that arbitrage portfolios based on price are greater than those based on size, and outperform the winner-loser arbitrage portfolios. Zamri and Simon (2001) investigated long-run over-reaction and seasonal effects for stocks in Kuala Lumpur Stock Exchange from 1986-1996. Stocks that exhibited extreme returns relative to the market over a three-year period experienced a reversal of fortunes during the following three years. A contrarian trading strategy may therefore yield excess returns.

De Bondt and Thaler's (1987) research focuses on over-reaction, and found the winner-loser effect cannot be attributed to changes in risk and size effect; and that the earnings of winning and losing firms exhibit reversal patterns that are consistent with over-reaction.

In addition, Chopra et al. (1992) examined over-reaction in portfolios formed on the basis of prior 5-year returns, and find that extreme prior losers outperform extreme prior winners by 5-10% per year during the following five years. Over-reaction was significantly more prominent amongst small firms. Jegadeesh and Titman (2001) find strong evidence of contrarian effects for small firms, and weak evidence for large firms.

In light of this evidence, this study proposes that the contrarian strategy is a result of short-run inefficiencies, which are eliminated by arbitrage. The use of cointegration and Markov switching indicates that short-run inefficiencies are eliminated as Chinese and Australian markets reach a long-run equilibrium value, which is efficient. Wilson and Marashdeh (2007) argued that cointegrating relationships between stock prices imply market efficiency in long-run equilibrium. The inefficient error correction adjustment therefore, continues until all arbitrage opportunities are eliminated. Short-run stock market inefficiency leads to efficient markets in the long-run.

The study shows that international contrarian strategies are profitable between China and Australia, with Markov switching strategies being more profitable than LOP strategies. Chinese and Australian resource stocks were cointegrated and showed regime switching characteristics. The study lends qualified support to DeBondt and Thaler (1985; 1987), Jegadeesh and Titman (1991; 1993) and others who advocate the over-reaction hypothesis. It is qualified because stocks which under-react were also profitable under the contrarian strategy. It is surmised that the reason for this puzzle is that the contrarian strategy used in this study is a pairs trading strategy using cointegration and Markov switching. Further, the stocks which under-react and over-react represent divergences from equilibrium, and provide profitable trading opportunities by shorting the over-priced stock and going long in the under-priced stock, and closing the position once the stock pairs converge on their long-run equilibrium value. Support is also provided to Wilson and Marasdeh(2007) in that the cointegrating relationship represents a long-run equilibrium in which the stocks are efficient. It is again claimed that in the short-run there is inefficiency, which results in arbitrage opportunities. Small-cap stocks were generally more profitable than large-cap stocks. Therefore, the size-effect hypothesis is also supported. The size-effect is distinct from the over-reaction effect. Lead-lag effects do not seem to explain contrarian effects in this study.

Table 6-16 shows the results of the LOP and Markov switching strategies with the stock pairs selected by market capitalisations. The 33 stocks are ranked in order from fastest speed of adjustment to slowest speed of adjustment. The LOP strategy had five profitable stock pairs; the RRL/600011.ss (4.5%); AGG/600019 (4.5%); SBM.AX/600832.SS (4.25%); LYC/600887 (13%); and MGX/600100 (9%). It is believed that stocks which over-react are better suited to contrarian strategies, however, this research shows that stocks which under-react, and over-react are profitable under contrarian strategies. There are profit opportunities to be made from market inefficiencies in the short-run. This supports H6 and H7.

The Markov switching strategy shows the largest returns; SDL/ 600583 (20%); IGR/600026 (16%); MDL/600879 (19%); and IMD/600037 (13%). These results indicate that informed investors are more profitable than noise traders. This supports H7.

The main objective of this study is to demonstrate international arbitrage opportunities in short-term inefficient markets, using strategies based on contrarian effects. The secondary objective demonstrates international investment opportunities in a growing economic and financial relationship between the Chinese economy and the Australian mining industry. Thecointegration study included aims to demonstrate that the Chinese Shanghai Composite Index (CSC) and the Australian resources stocks have a long-run relationship which is mean reverting and can be used for contrarian (pairs trading).If the profitability of strategies constitutes evidence against the efficient markets hypothesis (EMH) and because it does not use an underlying equilibrium asset pricing model, and so avoids the joint-hypothesis problem. This is considered to be valuable information for traders, investment firms, and hedge funds.

Behaviourists propose that participants over-react and under-react. However, if these deviations are normally distributed, they cancel each other out and stock prices cannot be used to make abnormal profits. Noise traders explain the transitory part of stock prices. Noise traders effect temporary changes in stock prices, whilst informed traders effect more permanent changes.

Contrarian strategies sell past winners and simultaneously buy past losers. This study developed two contrarian strategies. The law of one price (LOP) strategy accounts for temporary price changes caused by noise traders. The Markov switching strategy accounts for more permanent changes caused by informed traders. The EMH proposes that rational investors will undo any disturbances caused by irrational investors, but correcting mis-pricing can be risky and costly (cf., Barberis and Thaler, 2003). Pairstrading takes advantage of mis-pricing and mean reversion to produce profits. Pairs trading is contrarian strategy (buying past losers and selling past winners) on the basis that herd behaviour from other traders can lead to mis-pricing (c.f., Lakonishok et al 1994).The profitability of the LOP strategy and the Markov strategy was mixed. In light of these findings, preliminary results indicate a strong contrarian effect amongst some Australian and Chinese pairs. This study investigates international arbitrage opportunities between China and Australia, a topic which has not been previously addressed in the literature. The LOP strategy is adapted from the tests of purchasing price parity. Further, this methodology has not been extensively used in past empirical studies.

The EMH asserts that financial markets are informationally efficient. The EMH is based on a number of underlying assumptions. One assumption is that agents are utility maximisers with rational expectations. The concept of rational expectations' is based on the premise that all the participants have full and correct information about all the particulars of a given situation, and they reach the correct and most efficient conclusions in a given scenario. These participants are often seen as rational agents, who always choose to act in a way that the expected utility is optimised from the given information. The prices in markets are established by economic agents who act according to Bayes Theorem and therefore, have rational preferences.

However, in reality noise trading explains the transitory component in stock prices (cf., Poterba and Summers, 1988). Lo and MacKinlay (1990) find that contrarian profits could also be driven by lead-lag effects between winner and loser stocks. If stock *j* reacts in the same direction as stock *i* but with a delay, then buying (selling) *j* subsequent to an increase (decrease) in *i* will generate profits, even if neither stocks over-react. Lo and MacKinlay (1990) also find that around 50% of contrarian profits was generated by such lead-lag effects (as cited in Bolgun et al., 2009).

Jegadeesh and Titman (1995) extended Lo and MacKinlay's (1990) research by studying the relationship between lead-lag effects and the price reaction to common factors. Their analyses concluded that contrarian effects were the result of over-reaction to idiosyncratic news.

Pairs trading exploits short-term mis-pricing, present in a pair of securities. It is possible for one group of stocks to out-perform another group. This has caused frustration for proponents of the rational paradigm, because rational models are unable to explain this tendency. For many years, researchers have argued that this strategy can out-perform the market in the long-run. Contrarian investment strategies work, because investors do not know their limitations as forecasters. As long as traders think they can forecast favoured and unfavoured stocks, returns are possible using contrarian strategies (cf., Dreman, 1997).

Two cointegrated stocks which have a long-run equilibrium relationship and movements away from this equilibrium will be temporary and stocks will return to their fundamental value in the future. The study uses the Engle-Granger two-step cointegration methodology to test the LOP strategy. Hamilton's (1989) two state regime switching model is used to test the Markov switching strategy. As mentioned previously, the study investigates the Australian-Chinese economic and financial relationship to uncover opportunities for statistical international arbitrage and hedging. The research compares two contrarian strategies (LOP and Markov switching). The profitability of both approaches was skewed towards small-cap stock pairs. This is evidence that markets are not weak-form efficient in the short-term; thus, contrarian strategies produce abnormal returns which can be identified and compared. Markov switching strategies were generally more profitable than LOP strategies. Noise traders are retail investors who trade in small-cap stocks, whereas informed traders trade mainly in large-cap stocks. Small-caps were more profitable than large-caps. This may imply that noise traders trade profitably and exert their influence in both the LOP strategy and the Markov switching strategy. The Markov switching strategy captures the influence of informed traders who make permanent changes as opposed to the LOP strategy which captures the transitory changes of noise traders. However, even amongst informed traders, small-caps were more profitable than large-caps. Therefore, informed traders may also trade profitably in small-cap stocks.

This research is important because it uses a new data set, develops a new model of pairs trading, as well as a new theoretical approach to pairs trading. This allows the researcher to test for market efficiency, and develop strategies than can be used for investment or hedging. This is particularly useful for hedge funds and Australian mining companies who can hedge the sale of resources to China. While this is a general methodology, it can be applied to international arbitrage amongst strongly economically related countries.

The results of this study lend support to both the hypotheses. Arbitrage profits are indeed available from both the LOP and Markov switching strategies.

A discussion of contrarian and pairs trading strategies and their intersection follows. This study takes the view that pairs trading is a particular instance of contrarian strategy. The profitability of contrarian approaches is a blow to the EMH and rational choice theories. As stated previously, this study finds that investors are heterogeneous, comprised of noise traders and informed investors. The impact of noise traders can be captured by the LOP strategy, which accounts for transitory changes. The impact of informed traders can also be captured by the Markov switching strategy which accounts for permanent changes in stock prices. The first step in considering the hypotheses entails a discussion of contrarian and pairs trading strategies and their intersection.

Contrarian investment strategies are achieved when investors buy under-priced stocks and short over-priced stocks. The under-priced stocks may be value stocks, while the overpriced stocks may be growth stocks. Lakonishok et al. (1994), and Chan and Lakonishok (2004) provided evidence of successful contrarian strategies in the US stock markets. Chan et al. (1992) find better performance of investment strategies based on contrarian strategies in the Japanese stock market, while Fama and French (1998) find a value premium in international stock markets. Fama and French state that markets are efficient and that the superior performance of the contrarian strategies through value investing is the result of value stocks being riskier. However, Lakonishok et al. (1994)find no evidence that value stocks are riskier. They stated that the value premium is best explained by preference of investors for growth stocks over value stocks, because investors suffer from cognitive biases resulting in the extrapolation of past growth rates of glamour stocks and their subsequent purchase at the going price.

The results of this study show that small-cap stocks generally tend to over-react and under-react to new information. The following section, the over-reaction and under-reaction hypotheses are discussed. Ultimately, pairs trading is a particular type of contrarian strategy. Any divergence, whether it be over-reaction or under-reaction, may be profitable once trade is closed out.

Individual rationality is assumed, which means that market participants update their beliefs correctly when new information is received according to Bayes' Theorem. Probabilities are interpreted as a subjective measure of belief. Bayesian thinking allows agents to assign probabilities to unique events. It is assumed that these agents revise their probabilities in accordance with new information.

Consistent beliefs entails that market participants use new information in a correct manner and that they can accurately allocate resources using their precise economic information. This enables participants to make correct decisions and forecast future unknown variables (Barberis and Thaler, 2003).

Poterba and Summers (1988) contended that noise trading explained the transitory component in stock prices. They stated that constructing and testing theories of noise trading could account for stock returns being autocorrelated. Nicolas (1997) fined that historic returns have predictive power in Australian market.

Behavioural finance is the study of psychology on the behaviour of market participants and its effect on the market and asset prices. This area focused attention on the human behaviour of financial practitioners. Prospect theory identifies a strong preference for outcomes that are certain, rather than outcomes that are probable, and so called the 'certainty effect'. Agents tend to give zero weight to extremely small probabilities and the weight of one to very high probabilities, even though this might not be the most optimal and rational weighting (Tversky and Kahneman, 1979; Barberis and Thaler, 2003).

Depending on how a problem is framed, as the choice is affected by whether it is described from a positive or negative perspective. An outcome is viewed as a gain, and then the decision makers will tend to be risk averse. If the outcome is viewed as a loss, then the decision-makers will be risk seeking. The framing of the problem is determined by its formulation, as well as the norms, habits and personal characteristics of the decision-maker (Tversky and Kahneman, 1981).

Another element inherent in the way agents characterise the problem is called ‘mental accounting’. Framing is the way an investor characterises a transaction in their mind and will subsequently determine the wellbeing they expect to receive. This means that when information is perceived, agents form different decisions due to dispersed perception and evaluation of the received input and will also perceive the outcome differently from one another. So apart from the above-mentioned framing problem, agents also tend to form the phenomenon differently within their minds.

Relying on available heuristics in the decision-making process may lead to irrational decisions, due to incorrect probability conclusions. It is easier to recall recent information than older information (Barberis and Thaler, 2003) and assets with a high level of coverage and published research might be easier recalled by an agent, than assets with less coverage. Consequently, assets that have performed well, or positively spoken about in the past, may be more available in investors’ minds and give more investment. The third, and final, heuristics treated here is the anchoring and adjustment heuristics, where agents tend to make an estimate by starting from an initial position that is constantly adjusted until the final estimate is reached when new information is received.

Over-trading will result in over-confident investors earning lower returns due to transaction costs. Over-confidence may be the result of hindsight bias that is a tendency to not remember things accurately (Barberis and Thaler, 2003). An agent tends to think that they would know actual events would occur before they actually happened, if there had been a reason to pay attention to these events, simply because the agent believes in their own abilities to such a great extent. This means that those with hindsight bias sees the world as being more predictable than it is. This can be related to the previously mentioned availability heuristics, where the event that did occur is more salient in the mind of the agent than the one that did not.

Dispersed investment styles and strategies are applied to the market by investors with various ideas about in the market and the tendencies which may apply to it. Some investors believe in very active and dynamic strategies, such as constant mix strategies or constant proposition strategies where the portfolio is constantly adjusted to the currently market conditions. Others make use of passive strategies, where a simple 'buy and hold' principle is followed. Which strategy is the best for the investor depends on the risk tolerance of the investors and the wanted exposure. When investors choose an investment strategy, the choice of what stocks to invest in remains unsolved. Investors can choose to invest in small-caps, large-caps, value or growth stocks, or a combination of these categories.

Despite individual preferences, which need to be taken into account in the decision process, many studies (Barberis and Thaler, 2003)find that 'buy and hold' investment strategy with a long horizon, by simultaneously going long in value stocks and a short in growth stocks, has yielded superior returns. This strategy is called a contrarian investment strategy. The strategy tries to utilize the fact that investors act irrationally and force prices away from the fundamental value. This is accomplished by investing in loser stocks and shorting winner stocks. In the following section, the principles of such an investment strategy will be elaborated upon.

The market-neutral investing strategy is designed in such a way that there is almost no exposure to systematic risk, while producing active returns from the long and short positions respectively. Pairs trading takes advantage of such short-term mis-pricing through an equity trading strategy that identifies the relative mis-pricing of two stocks. Technically, it is debateable as to whether or not pairs trading is a market-neutral strategy (Do et al., 2006).

The over-reaction hypothesis states that investors are subject to runs of optimism and pessimism and, therefore, create a kind of momentum that causes prices to temporarily move away from their fundamental values (cf., DeBondt and Thaler, 1985, 1987). A consequence of over-reaction is the profitability of a contrarian portfolio strategy; a strategy that exploits negative serial dependence in asset returns in particular (Lo and Mackinlay, 1990).

The fact that some contrarian strategies have positive expected profits need not imply stock market over-reaction. Lo and MacKinlay (1990) find that large-cap stocks tend to lead small-cap stocks and that the profitability of contrarian strategies lies in non-synchronous or 'thin' trading.

De Bondt and Thaler (1985) findings have been re-examined frequently and have been challenged. To date the studies on over-reaction Effect are mainly from three perspectives; (1) on the existence of long-term over-reaction; (2) the existence of short-term over-reaction; and (3) the reasons and sources of contrarian profits (Maheshwari, 2013).

The results in this study show that pairs trading profits can be made when the stocks under-react or over-react. Both under-reaction and over-reaction cause divergences from the mean, which later converge towards their equilibrium value, because they are cointegrated. A test was implemented to ascertain the effects of lead-lag relationships by pairing the stocks with the quickest speed of adjustments with those that had the slowest speed of adjustments. The results show that there was no discernible trend, thus providing evidence against lead-lag relationships.

In summary, contrarian strategies are profitable. For strategies where the stocks were paired according to the PAM or by market capitalisations, Markov switching strategies were more profitable than LOP strategies. Small-cap stocks were more profitable than large-cap stocks. Small-caps tended to under-react and over-react to economic information, whilst large-cap stocks tended to be more efficient and fully adjust. This may be because large-caps are followed by more analysts and thus tend to trade close to their fundamental values.

Pairs trading takes advantage of short-term mis-pricing with long-term mean reversion in order to produce profits. The different approaches to pairs trading include the distance method (Gatev et al., 1999; Nath, 2003); the stochastic approach (Elliott et al., 2005); the stochastic residual approach (Do et al., 2006); the cointegration approach (Vidyamurthy, 2004); and the Markov switching approach (Bock and Mestel, 2009). In this study, two new variations of existing methodologies have been used. In the first instance, a cointegration approach was applied to a pairs trading strategy based on the Law of One Price; and in the second, a Markov switching approach was used with a new trading strategy. The stock pairs were chosen in two ways; firstly by pairing stocks with similar speed of adjustment; and secondly, by pairing large cap stocks together and small cap stocks together. The selection of Chinese-Australian stock pairs makes this an international statistical arbitrage strategy.

The results show that over-reaction and under-reaction are both profitable in these contrarian strategies. The reason for this is that these contrarian strategies are pairs trading approaches. Thus any divergence, whether it be over-reaction or under-reaction, will be potentially profitable when it converges towards its fundamental value. The reasons given for over-reaction and under-reaction are behavioural biases and psychological heuristics which lead to short-term inefficiencies. In the long-run stocks approach their fundamental values as arbitrageurs trade away short-term inefficiencies. Therefore the hypotheses are not rejected.

**H8:There are profits to be made from the index tracking strategy.**

**H9:The index tracking strategy closely tracks the CSC index.**

**H10:There are profits to be made from the enhanced indexing strategy.**

**H11:The indexing strategy closely tracks the CSC index.**

**H12:The enhanced indexing strategy closely tracks the CSC index.**

**H13:The combined momentum strategy is more profitable than the combined contrarian strategy.**

The hypotheses are grouped together because of similar and overlapping evidence. H8 is supported. H9 is supported. H10 is supported. H11 is supported. H12 is supported. H13 is supported. The evidence in support of the hypotheses are as follows.

The index tracking methodology utilised cointegration to replicate the S&P/ASX 300 MAM and CSC indices using a bundle of constituent stocks within each index. The enhanced strategy uses the respective index to construct minus (short) and plus (long) portfolios which are subsequently combined in a global portfolio. Table 6-21 shows that the index tracking strategy has an annual return of 10.35% and a tracking error (TE) of 0.4%. Plus Minus 5% portfolio has an annual return of 13.57% and a TE of 0.69%. Plus Minus 10% portfolio has an annual return of 13.77% and a TE of 0.70%. Plus Minus 15% portfolio has an annual return of 13.97% and a TE of 0.72%. However, the index tracking portfolio has the highest Sharpe ratio of 8.83%.The uses of indices in the above strategies mean that the unsystematic risk is diversified away. Also, the use of a long-short equity hedge mean that systematic risk is also emanated and that the return is 'locked in' irrespective of subsequent movement in stock prices. This is evidence that H8, H9, H10, H11, H12 and H13 are supported.

Long-short hedging strategies buy an undervalued stock and sellan overvalued stock. The short portfolio is a hedge against falls in the stock price, giving investors the opportunity to gain by selecting stocks that decline in value relative to the market. Thus, the position may still be profitable if both long and short stocks decline as long as the long position declines less that the short position. In this study, by taking long-short positions by way of index tracking or enhanced indexing, the fund hedges its exchange rate exposure, while at the same time trading on the relative valuation across two countries; China and Australia. When the price spreads of the index and its 'Australian constituent' stocks reverts back to their fundamental values, the strategy will result in a profit. It is therefore market-neutral and hedged in reference to exchange rate risk.

Figures 1 and 2 in Chapter Six compare the efficient portfolios for the momentum and contrarian strategies respectively. The optimal momentum portfolio had a return of 10.39% compared with 0.4% for the contrarian strategy. Therefore the hypothesis thirteen is supported.

In order to provide evidence which supports the hypotheses, a discussion of the EMH and the Behaviourists' critique of it will be outlined. This is followed by a discussion of the momentum effect, which has roots in behavioural biases and psychological heuristics. A brief review of statistical arbitrage also follows. Then the index tracking and enhanced indexing strategies are specifically discussed.

The deviation from the EMH by the profitability of the momentum strategies is discussed. The reasons for momentum effects are also discussed. Prospect theory and under-reaction play a major role in this explanation.

Efficient market hypothesis has been violated by the performances of stock returns in some studies. Equilibrium model are commonly employed to examine these contradictions. These models are subject to the joint hypotheses problem (Fama, 1998). Abnormal returns may indicate the equilibrium model used is wrong instead of showing market inefficiency. Fama (1998) also argues that the determination of long-term inefficiency is sensitive to statistical methodology. The prospect theory of Kahneman and Tversky (1979), and Jegadeesh and Titman (1993) proposed a model of momentum to examine market efficiency. It finds that stock prices are predictable under the momentum model. The extension of prospect theory by Daniel and Titman (2000), on over-confidence, also indicates that certain stocks can generate greater over-confidence among investors, resulting in a stronger momentum effect.

This study intends to examine momentum related effects through an alternative model based on the theory of statistical arbitrage. The statistical arbitrage approach in this study explores the disposition and over-confidence effects for possible causes of tested results. A negative disposition effect results in mixed and insignificant momentum effect in a down market. The significant momentum returns find in this study can be considered as driven mainly by the follow on trading pattern of institutional investor, which dominates the moderate disposition effect.

The significant bullish market momentum phenomenon is a result of similar behaviour of the two major investor groups, while the absence of bearish market momentum is due to the difference between them in trading pattern there. Findings of this study contribute to the understanding of long-term market anomalies and their major driving factors. The model-free statistical arbitrage analysis adds to those based on equilibrium asset prices in providing conclusions free of the joint-hypothesis problem.

Wang (1994) concluded that momentum in consecutive returns is likely if the primary motive for the informed investors' trading and a reversal is likely if the primary motive for the informed investors' trading in the former period is changes in their outside investment opportunities (Chan, Hameed and Tong, 1999).

The momentum strategies are profitable in an up market, but behave inconclusively in a down market. The disposition effect and the over-confidence effect are the major driving factors for the momentum effect. This thesis examines the profitability of momentum strategies formed based on past returns of Australian/Chinese indices. Our results indicate that the momentum profits cannot be completely explained by non-synchronous trading and are not confined to emerging markets.

The results support Jegadeesh and Titman (1993) and Jegadeesh and Titman (2001) by finding evidence of momentum in Chinese and Australian markets, and confirm Rouwenhorst (1998) and Griffin, Ji, and Martin (2003) who find momentum in international markets. Fama and French (1998) stated market, value, and size factors cannot account for momentum returns and Grundy and Martin (2001) contended that firm-specific factors are responsible for momentum. The findings of this study are that size does indeed matter as most of the small-cap stocks showed evidence of momentum effects.

Lending support for the hypothesis of asymmetric information, this study finds that information about small firms gets out more slowly which may be the result of responses to firm-specific information. Chan et al. (1996) demonstrate momentum may reflect the adjustment of stock prices to information that is not publicly available to all investors at once

(Hong et al.,1998). This study confirms Rouwenhorst (1998) who demonstrated that momentum strategies are profitable in emerging markets.

According to Markowitz (1952) it is optimal and rational, to hold a well-diversified portfolio. This reduces unsystematic risk. However, diversification does not eliminate systematic risk, because all stocks are related to each other in some manner. The enhanced indexing strategy; by combining a long portfolio based on replicating the CSC index with a portfolio of Australian resource stocks; and a short portfolio, also based on replicating the CSC index; into a global portfolio, which eliminates systematic risk. The fact that this method also utilises international diversification, means that the entire efficient frontier is pushed up; making higher rewards available for accepting a given amount of risk.

The findings of this study were that both index tracking and enhanced indexing strategies were profitable. Enhanced indexing was more profitable than index tracking; however, index tracking had a higher Sharpe ratio, a lower tracking error and significantly lower volatility. Of these momentum strategies, most Australian resource stocks which replicated the CSC index were small-cap stocks and under-reacted to economic information. This supports the theories of Chan et al (1996). Small-cap stocks seemed to gradually diffuse economic information. It is surmised that this is because small-cap stocks do not have high levels of analyst coverage and are therefore inefficient. The results confirm that momentum stocks are profitable in an emerging country such as China and lend support to Rouwenhorst (1998).

In summary, enhanced indexing is more profitable than index tracking. However, index tracking has a smaller tracking error, standard deviation and a greater Sharpe ratio, that is, it has a better risk-adjusted return. Behavioural biases are proposed as being responsible for the momentum strategies. However, in this thesis there is no evidence of arbitrage reaching its limits. The index tracking and enhanced indexing strategies are implemented with a cointegration methodology. This means that the benchmark and the stocks may diverge in terms of their prices in the short-run, but in the long-run they are combined.

Jegadeesh and Titman (1993), Conrad and Kaul (1998) and Rouwenhorst (1998) developed trading strategies based on momentum effects. Ryan and Obermeyer (2004) find evidence of momentum effects, confirming the results of Jegadeesh and Titman (1993). In this study an index tracking and enhanced indexing model proposed by Alexander (1999, 2001) is used. However, this study differs from that of Alexander (1999, 2001) through the replication of the CSC index by a portfolio of Australian resource stocks. It is essentially a test of international momentum effects.

There is tentative support for the proposition that momentum effects may be due to the under-reaction of stocks to economic information, due in part to the private information of informed investors, which is revealed slowly and becomes publicly available to uninformed investors, who copy the trading behaviours of the informed traders (Wang, 1994), leading to herding behaviours (Barber, Odean and Zhu, 2009).

## 7.3 Summary

The financial economics literature typically distinguishes between two classes of investors; namely, ‘informed’ and ‘uninformed’ traders. This thesis is one of the first attempts to empirically examine, analyse and compare the performance of informed traders against the market.

Chan, Jegadeesh and Lakonishok (1996; 1999) demonstrate that under-reaction to economic news on earnings explain momentum profits. Further, Jegadeesh and Titman (1993) stated the nexus between earnings announcements and momentum profits within event study method. They find evidence in favour of momentum effects. Chan et al. (1996) studied the ability of past returns and public earnings surprises and were able to predict subsequent returns at a six-monthly horizon. They find that these strategies yielded significant profits. They also find that there is only a marginal difference between returns of these strategies. The momentum variables studied take advantage of under-reaction to different pieces of information (Chan et al. 1996).

Momentum and contrarian strategies are opposing trading methods which try to make excess returns through investigating historical prices and/or returns in order to determine future returns. Momentum strategy buys stocks which have strong historical performance and sells stocks which have done poorly. Contrarian strategy advocates buying losers and selling winners based on historical data. There is ample empirical evidence of success of both strategies. The evidence that both momentum and contrarian strategies can earn abnormal returns is strong (Hamalainen, 2007).

Lakonishok et al. (1994) stated that past losers are not riskier than past winners, when risk is measured by beta or standard deviation. The explanation for the profitability of contrarian strategies lies in the tendency of investors to make judgmental errors. There is also a tendency of institutional investors to prefer prior winner stocks, allowing previous loser stocks to become under-priced relative to their risks and returns. However, Lo and MacKinlay (1990) show that under-reaction of some stocks to new information, or how returns of some stock lead the returns of others, can result in evidence supporting the contrarian effect (Hamalainen, 2007).

The profitability of contrarian strategy has as its foundations lie in behavioural theory which states that people do not behave rationally when making decisions because they tend to over-react to unexpected information. Based on this belief, contrarian strategy is believed to earn abnormal returns. De Bondt and Thaler (1985) developed the over-reaction hypothesis, and investigated what impact such behaviour has on stock prices. Jegadeesh and Titman (1993) demonstrated that the momentum effect is able to generate significant abnormal returns.

The findings of this study were that the Chinese and Australian markets were not weak-form efficient and that LOP and Markov switching strategies were both profitable, although Markov switching strategies were more profitable than LOP strategies. Index tracking and enhanced indexing strategies were both profitable. Stocks under-react and over-react to financial information as identified by the PAM. In light of the support for the hypothesis, the study also provides support for past theory and evidence.

## 7.4 Limitations

The limitations of this study are that the sample for the LOP, Markov switching, index tracking and enhanced indexing strategies used weekly data with only 532 observations. Also this was a limited study, focusing on China and Australia, and examining only 33 Chinese and 33 Australian stocks.

There could be several reasons for the relatively few empirical studies using stock returns data from China. First of all, the stock markets in China started to operate more than 16 years ago and the sample chosen was from 2003 to 2013. That creates a limitation in the statistical sense, the number of observations is simply too small to make a valid statistical inference. Secondly, there are potential difficulties in obtaining reliable stock price data.

Regardless of the cause, the lack of empirical research provides a great opportunity for contribution. It is the main purpose of this study to test whether internationally recognised contrarian and momentum strategies will work on the joint Chinese-Australian stock markets. Such empirical testing has several implications. Firstly, it would constitute another out-of-sample test of efficient market hypothesis, which has lately received a lot of academic criticism. Secondly, it would, from the potential outside investor's point of view, be interesting to know whether portfolio diversification to the Chinese stock market can add some value to the existing holdings.

Because of the lack of ability of Australians to affect trades in the Chinese Shanghai Stock Exchange, this study is by necessity a hypothetical study which demonstrates an universal arbitrage trading strategy between any two countries stocks, where the countries have an economic and financial connection, and where there are open financial markets.

## 7.5 New and unique

This study contributes to the literature because it shows the feasibility of a new universal approach to international arbitrage strategies between countries where there is a strong and growing economic and financial relationship. The study applies a new contrarian/pairs trading strategy in the Chinese and Australian markets, but also applies a strategy originally designed for the domestic market (index tracking and enhanced indexing) to an international setting. It brings a fresh perspective to understanding international arbitrage mechanisms by considering the trading of risky asset returns. This allows for the creation of a strategy based on pairs trading and index tracking/enhanced indexing. Up to now, trading strategies have been employed in one market, while the other market has not been implemented. This means arbitrage is not profitable in the joint market due to differences between the two markets, for instance, transaction costs and financial regulations.

The stock pairs for the contrarian strategy in one instance, is chosen on the basis of the speed of adjustment coefficient derived from the new PAM. This PAM is a new formulation, used because it avoids the problems of non-synchronous trading, which plague other methods. Also, this PAM is easier to calculate.

## 7.6 Policy Implications

Whilst the feasibility of a new international approach to arbitrage is demonstrated, this is a hypothetical study; in reality foreigners are as yet prohibited from buying most stocks in China. However, Chinese traders are generally free to implement the trading strategies outlined in this study as for them there are little or no restrictions. Institutions, unlike individual investors, are able to reduce their per unit transactions costs by pooling transactions, negotiating commissions, and, on occasion, by dealing directly with issuers of securities. They may follow market developments closely throughout the world, to investigate investment opportunities, and they tend to execute decisions promptly. Institutions also feel the pressure to earn risk-adjusted returns. They are diversifying internationally as a means of boosting their returns and reducing the volatility of their portfolios(Herring and Litan, 1995).

Prudential regulations have acted as a constraint for institutional investors' investments. These constraints are being removed, with regulators viewing international diversification as being a way to increase safety and soundness of investments(Herring and Litan, 1995).With markets becoming more integrated, asset prices become more responsive to international flows of capital. One day, perfectly integrated markets may remove the need for capital to move from one market to another. Such a situation may be one in which investors adjust equilibrium prices instantaneously in response to new information, rather than face losses by transacting at prevailing prices. If there is no divergence from equilibrium, arbitrage cannot take place(Herring and Litan, 1995).

The different international legal systems and regulations, such as company insolvency rules, may disadvantage foreign investors. Tax laws, language barriers, business customs, and disclosure laws, political and macroeconomic policies, may interfere with international capital flows(Herring and Litan, 1995).

Cross-border flows of money have tightened the connections between leading financial markets. These forces of innovation and technological advance are responsible for such integration. Large institutions are already integrated; more so than was conceivable in the 1940s and 1950s. This is due to the wave of liberalism that took place in advanced economies in the 1970s(Herring and Litan, 1995).It is possible to retreat from further integration; however, the costs of isolation are prohibitive. Technological advances such as the Internet, computers, smart-phones, and such, constrain the capacity of governments to block integration (Reserve Bank of India, 2005).

The financial crises in the 1990s and 2000s have shown that financial integration comes with risk. However, the benefits of further harmonisation outweigh the costs, in terms of increased productivity, competition, savings, investment, and economic growth (Reserve Bank of India, 2005). The risk of contagion; the transmission of ‘financial viruses’ from host to population, may seem arbitrary and cruel, however, despite the risks, the benefits of globalisation are great.

## 7.7 Future directions

Future lines of investigation may examine the integration of other developed and developing markets, such as the USA and China, Australia and India, USA and India, Australian and Indonesia. Future directions may study whether stocks with higher information flows and more prominent status in the market adjust to information faster. In the Chinese market A-shares, stocks with higher earnings adjust to information faster, while the speed of adjustment for B-shares is correlated with firm size (Chiang et al., 2004). It would add to the body of knowledge on informational efficiency to ascertain the robustness of this result using statistical arbitrage.

# CHAPTER EIGHT

# CONCLUSION

This study provides improved models and methodology to effectively analyse international arbitrage opportunities utilising the evidence in stock market data from China and Australia. The two countries selected for study are most topical in light of their strongly growing economic and trade relationships. The theoretical basis of the thesis is that in the long-term rational expectations may be proven, indicating long-term equilibrium relationships and market efficiency. However, in the short-term, arbitrage opportunities exist where differing stochastic trends are identified indicating a lack of short-term efficiency and therefore the opportunity to generate abnormal returns. The study examines and compares share price and sectoral share price indices and in doing do the study is effectively investigating hypothetical, yet fully diversified share portfolios in its analysis of investor arbitrage opportunities.

The thesis consists of three parts. Part One presents the partial adjustments model which tests for market efficiency using the speed of adjustment. Part Two presents two contrarian strategies; a LOP strategy, and a Markov switching strategy. Part Three presents two momentum strategies; an index tracking strategy and an enhanced indexing strategy. This is a hypothetical study; in reality foreigners are still prohibited from buying most stocks in China. However, Chinese traders are generally free to implement the trading strategies outlined in this study as there are little or no restrictions on them. Australia is important to China. Australia's metals, minerals and energy exports have allowed China to industrialise, urbanise and manufacture goods for export. The benefits flow both ways. China is important to Australia, as its demand for Australian goods has led to a resources boom and a growing Australian economy.

This is a three part study to examine and test forms of international arbitrage opportunities with particular reference to Chinese and Australian data and the growing economic relationship between China and Australia. Part one of the study discussed a new test for market efficiency using a partial adjustments model (PAM). This is important in the study as the PAM was used to select stock pairs in order to test contrarian strategies in the international context of China and Australia. The contrarian strategies that were tested were the LOP (Law of One Price) strategy and the Markov switching strategy. The momentum strategies that were tested were in part three were the index tracking strategy and the enhanced indexing strategy. The PAM measured the speed of adjustment towards long-run equilibrium for momentum stocks to ascertain whether they under-react to economic information. Each of these strategies was considered in the light of past literature identifying gaps in the literature and methodologies.

This study applied the re-formulated PAM to test for market efficiency and select stocks for the contrarian and momentum strategies. Using the theory of behavioural finance, and focusing on the behaviour of noise traders and informed traders, the study formulated twelve hypotheses linking market inefficiency, psychological biases and heuristics, and noise traders with short-run inefficiencies and arbitrage opportunities which were exploited through contrarian and momentum strategies.

The objective of this study is to investigate international arbitrage opportunities between Chinese and Australian stocks. The findings suggest that international arbitrage opportunities are possible between the CSC index, its constituent stocks and Australian resource stocks. On the other hand, the profitable contrarian portfolios; both LOP and Markov switching, were small. Momentum strategies (index tracking and enhanced indexing) were much more profitable. Furthermore, the speed of adjustments coefficients derived from the PAM showed that some of the stocks examined under-react to economic news, some over-react, and some fully adjust. To the best of our knowledge, this is the first time this formulation of the PAM has been utilised and it is the first time the LOP strategy has been used for pairs trading. It is also the first time the index tracking and enhanced indexing strategies have been employed to investigate international arbitrage opportunities.

As stated above a number of models were tested in an empirical analysis over two different samples; one comprising daily data from 2003 to 2013 (the PAM), and the other consisting of weekly data from 2003 to 2013 (the contrarian and momentum strategies).This study attempted to do two things; first, incorporate the PAM with contrarian and momentum strategies and in so doing include mental accounting, loss aversion, asymmetric risk-taking behaviour, and psychological heuristics to account for the mis-pricing of stocks by individual investors; and, second, to demonstrate through the uses of cointegration and Markov switching that, while there are inefficiencies in stocks in the short-run, in the long-run there is equilibrium and markets are efficient.

For Part One of the study, the data comprised daily data from 1 January 2003 to 1 March 2013. For Parts Two and Three of the study, the data comprised weekly data from 1 January

2003 to 1 March 2013. Missing values were replaced with the previous day's values. If data for the stock were not available in the given time period, the stock was discarded from the sample. The data was accessed from Yahoo Finance. There were 2563 daily price observations, and 532 weekly observations.

Considering the results for Part One; the speed of adjustments coefficients derived from the PAM reveal that all 33 Chinese and 33 Australian stocks under-react, over-react or fully adjust to economic news. This suggests that the behaviour of noise traders is evident and that there are inefficiencies in the Chinese and Australian market that can be exploited for financial gain. The results also indicate that the Chinese and Australian markets are not weak-form efficient. The robustness of the speed of adjustment coefficients derived from the PAM was confirmed by using the average speed of adjustment coefficient derived from the Engle-Granger (1987) cointegration methodology.

Part Two of the study investigated two contrarian approaches; a LOP strategy, and a Markov switching strategy. Both of these strategies are based on the divergence of stock pairs and their subsequent convergence to the mean. A theory based on the behaviour of noise traders and informed traders was proposed. This study tests how efficiently stocks reflect economic news to develop a new approach to explain contrarian trading. If economic agents are rational, homogenous and fully informed, there will be no noise traders. Noise traders cause temporary disequilibrium in the pairs of stocks as they quickly over-react or under-react to news. After a period of time, the pairs of stocks return to their fundamental values. Informed traders, on the other hand, act on private information gleaned through superior information gathering and sophisticated analysis. As they act on this private information, the pairs of stocks diverge and then slowly converge to their mean value after the private information is revealed publicly, which may revert to the original regime or to a new mean regime. Noise traders affect temporary changes in the stock pairs while informed traders affect more permanent changes. The LOP and Markov switching strategies had five portfolios each that were profitable. In general, for the LOP and Markov switching strategies, slow speed of adjustment stocks were more profitable than faster stocks (although all stocks were relatively slow). Small-cap stocks were more profitable than large-cap stocks, perhaps reflecting the view that they are riskier and therefore require a higher return.

Part Three of the study concerned two momentum strategies; index tracking and enhanced indexing. According to Wang (1994), once the private information of informed traders is revealed publicly, uninformed traders imitate the informed traders trading behaviour and this leads to momentum strategies. The PAM shows that the speed of adjustments coefficients of most Chinese and Australian stocks in the sample under-reacted to economic news. Therefore, these stocks are best suited to momentum strategies. This proposition has been borne out by the results. Both the index tracking and enhanced indexing strategies are highly profitable, with the index tracking having a superior Sharpe ratio.

This study investigates international arbitrage in cointegrated markets. Markets are proposed to have a long-run equilibrium and so are efficient in the long-run. In the short-run, however, markets are inefficient and provide arbitrage opportunities that may be exploited by investors. Individual investors are noise traders. They are motivated by psychological heuristics and biases. Mental accounting and risk seeking in the domain of losses may result in investors holding onto losing investments and selling winners. The representativeness heuristic may result in investors buying securities with strong recent returns. Over-confidence may lead investors to trade too aggressively, which, could contribute to momentum in stock returns (Barber, Odean and Zhu, 2009).

A new approach to pairs trading has been developed based on the behaviour of noise traders and informed traders. Noise traders are irrational and over-confident. They trade on misinformation as if it was economic news. Their over-reaction and under-reaction to information causes the stock pairs to temporarily diverge, only to return to their long-run equilibrium value later. Informed traders have private information based on sophisticated methodologies and analysis. As they act on this private information, the stock pairs diverge, only to return to the mean value of the original regime or to a new mean regime. Where noise traders affect temporary changes captured by the LOP strategy, informed traders who are informed traders, affect more permanent changes captured by the Markov switching strategy.

This study proposes that stocks be examined through use of the PAM for under-reaction and over-reaction. It is expected that index tracking and enhanced indexing strategies consist of stocks which exhibit under-reaction. This is because index tracking and enhanced indexing are momentum strategies. This may be explained using the theory proposed by Wang (1994) which states that as the private information of informed investors is revealed and becomes public and available to uninformed investors these investors replicate the strategies of informed investors leading to herding behaviour.

The methodology for the index tracking and enhanced indexing strategies was developed by Alexander (1999), but was applied internationally through the use of the CSC index as the benchmark and a portfolio of Australian resource stocks. These strategies would not be profitable if markets were internationally and domestically efficient, therefore, this study tests for efficiency using the PAM whose speed of adjustment coefficient is used for matching stock pairs.

Extending the prospect theory of Kahneman and Tversky (1979), Jegadeesh and Titman (1993) proposes a model of momentum to examine market efficiency and find that stock prices are predictable under the momentum model. In addition, the extension of Prospect theory by Daniel and Titman (2000) on over-confidence also indicates that certain stocks could generate greater over-confidence among investors, resulting in stronger momentum effect. Other studies argue that momentum returns only appear in up-market rather than in down-market.

Momentum and contrarian strategies are opposing trading methods which try to make excess returns through investigating historical prices and/or returns in order to determine future returns. Momentum strategy buys stocks which have a good historical performance and sells stocks which have done poorly. Contrarian strategy advocates buying losers and selling winners based on historical data. There is ample empirical evidence of success of both strategies. The evidence that both, momentum and contrarian, strategies can earn abnormal returns is strong. The main source of observed contrarian profits is the tendency of stock prices to over-react to firm-specific news.

Based on this belief, contrarian strategy is believed to earn abnormal returns. De Bondt and Thaler (1985) were the first investigate the contrarian strategy. They developed the over-reaction hypothesis, and investigated what impact such behaviour has on stock prices. Levy (1967) examined momentum, but the results are controversial. Jegadeesh and Titman (1993) were the first to demonstrate clear evidence that momentum effect is able to generate significant abnormal returns.

The findings were that the Chinese and Australian markets were not weak-form efficient and That LOP and Markov switching strategies were both profitable, though Markov switching strategies were more profitable than LOP strategies. The findings also revealed that index tracking and enhanced indexing strategies were both profitable and that index tracking was more profitable than enhanced indexing. Index tracking and enhanced indexing were more profitable than LOP and Markov switching strategies, perhaps reflecting that the stocks under-react to financial information as identified by the PAM.

The limitations of this study are that the sample for the LOP, Markov switching, index tracking and enhanced indexing strategies used weekly data with only 532 observations. Also this was a limited study focusing on China and Australia examining only 33 Chinese and 33 Australian stocks.

There could be several reasons behind the relatively few empirical studies using stock returns data from China. First of all, the stock markets in most of these countries have started to operate more than 16 years ago and the sample chosen was from 2003 to 2013. That creates a limitation in the statistical sense, the number of observations is simply too small to make a valid statistical inference. Secondly, there are potential difficulties in obtaining the reliable stock price data.

Regardless of the cause, the lack of empirical research provides a great opportunity for contribution. It is the main purpose of this study to test whether internationally recognised contrarian and momentum strategies will work on the joint Chinese-Australian stock markets. Such empirical testing will have several implications. Firstly, it will constitute another out-of-sample test of Efficient market hypothesis, which has lately received a lot of academic criticism. Secondly, it will be interesting from potential outside investor's point of view it would be interesting to know whether portfolio diversification to the Chinese stock market can add some value to the existing holdings.

This study contributes to the literature not only by applying a new contrarian/pairs trading strategy in the Chinese and Australian markets, but also by applying one originally designed for the domestic market (index tracking and enhanced indexing) to an international setting. The results also show that there are benefits from international diversification and active management. The CSC index was replicated by a bundle of Australian resource stocks. That being the case, the subsequent portfolio has diversified away its' idiosyncratic risk, leaving only systematic risk. In addition the results also show that hedge funds, Chinese and Australian investors and mining companies could use the long-short market neutral index tracking and enhanced indexing strategies to hedge exchange rate risk.

The study brings a fresh perspective to understanding international arbitrage mechanisms by considering the trading of risky asset returns in China and Australia. This allows for the creation of a strategy based on pairs trading and index tracking/enhanced indexing. Up to now trading strategies employed in one market and the other market has not been implemented in the joint market likely due to differences between the two markets for instance, transaction costs and financial regulations. Future lines of investigation may examine the integration of other developed and developing markets, such as the USA and China, Australia and India, USA and India, Australian and Indonesia. As further extensions of the present research, it is suggested the inclusion of a larger sample looking at more countries financial data be conducted. Once this change is introduced the uncertainty surrounding the general applicability of these results to other countries will be diminished.

The cointegration result reveals that the Australian and Chinese markets are internationally efficient in the long-run, but inefficient in the short-run, leading to arbitrage opportunities. What is good for arbitragers is bad for policy makers and regulators who hope for efficient markets, especially if the mis-pricing comes from misinformation or market manipulation, or if markets are too volatile. It is often thought that if stocks are followed by analysts their prices will be close to fundamentals. This may be true of large-cap stocks but it is not the case for small-cap stocks. There needs to be better dissemination of economic firm-specific news in small-cap stocks, as well as more financial education for noise traders, so that they may behave more rationally.

The results reveal that the impact of noise traders is greatest in small-cap stocks; therefore, policy makers should look at policies that will reduce the negative effect on the market of noise traders. Future lines of investigation may examine how markets can be unified to enable the convergence of risk and return on similar assets in both the Chinese and Australian markets, the harmonization of prudential regulations and further integration of financial markets in China to promote savings, investment and economic growth. This may give a fresh impetus for the continued opening up, transparency and democratization of Chinese institutions. Future directions may study whether stocks with higher information flows and more prominent status in the market adjust to information faster. In the Chinese market A-shares, stocks with higher earnings adjust to information faster, while the speed of adjustment for B-shares is correlated with firm size (Chiang et al., 2004). It would add to the body of knowledge on informational efficiency to ascertain the robustness of this result using statistical arbitrage.

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## Appendix A

The following discussion is an excerpt fromMizrach, B., and Watkins, J.1998. “A Markov Switching Cookbook”. Departmental Working Papers, 199817.Rutgers University, Department of Economics, Pages 34 to 41.

The following follows Hamilton (1993).

“Consider a first order auto-regression where the mean value around which this series clusters may take on one of two values, $\mu^1$ and $\mu^2$ such that:

$$y_t - \mu_t = \varphi(y_{t-1} - \mu_{t-1}) + \varepsilon_t \tag{1}$$

Suppose that $\varepsilon_t \sim iid\ N(0, \sigma^2)$ . A change in the value of μ alone is a change in regime. The state variable $s_t$ is associated with the indices for the constant terms in equation 1. Since the state variable is unobservable, there is a need to form probabilistic inferences of its value, and in so doing form equivalent inferences regarding parameter values in 1. It is assumed that the state variable is governed by the Markov chain[10]:

$$p(s_t = 1 | s_{t-1} = 1) = p^{11} \tag{2}$$

$$p(s_t = 2 | s_{t-1} = 1) = p^{12} \tag{3}$$

$$p(s_t = 1 | s_{t-1} = 2) = p^{21} \tag{4}$$

$$p(s_t = 2 | s_{t-1} = 2) = p^{22} \tag{5}$$

These transition probabilities are restricted so that $p^{11} + p^{12} = p^{21} + p^{22} = 1$.

**DFP**(*Davidson, Fletcher Powell)*

Recall the assumption that the state variable $s_t$ is generally unobservable. In order to estimate the parameters of a MS model with this uncertainty, the probabilities associated with each possible regime must be computed. Further, in the case of a MS model where the conditional density depends on both current and past regimes:

$$p(y_t | s_t, Y_{t-1}) \neq p(y_t | s_t, s_{t-1}, s_{t-2}, \dots, Y_{t-1}) \tag{7}$$

[10] A Markov chain is a mathematical system that describes a situation where a current state, and all previous states, of a process are known, the probabilities of all future states depend only on the current state, and not on earlier states (De Groot & Schervish, 2002).

these inferences need to extend over several periods

$$p(s_t, s_{t-1}, \dots, s_{t-r} | Y_{t-1}) \quad (8)$$

Such probabilities are estimated using Hamilton's recursive filter: This procedure will compute r and r+1 period inferences and the conditional likelihood function. It is the conditional likelihood function that techniques such as Davidson-Fletcher-Powell (DFP) are employed, since the burdensome exact-likelihood method provides only a marginal improvement. In the case where there are two states, and the initialization of the filter is reserved to the end of the discussion.

An arbitrary iteration of the filter begins by advancing an r-period inference, available to us from the prior iteration,

$$p(s_{t+1}, s_t, \dots, s_{t-r+1} | Y_t) = p(s_{t+1} | s_t).p(s_t, s_{t-1}, \dots, s_{t-r+1} | Y_t) \quad (9)$$

The appropriate density is used to find the joint probability inference of the current observation and the r+1 most recent states, conditional on last period's datum,

$$p(y_{t+1}, s_{t+1}, s_t, \dots, s_{t-r+1} | Y_t) =$$

$$p(y_{t+1} | s_{t+1}, s_t, \dots, s_{t-r+1}, Y_t).p(s_{t+1}, s_t, \dots, s_{t-r+1} | Y_t)(3.24) \quad (10)$$

Integrating over states, it is determined that a density conditional only on prior data,

$$p(y_{t+1} | Y_t) = \sum_{s(t+1)=1}^{2} \sum_{s(t)=1}^{2} \sum_{s(t-r+1)=1}^{2} (y_{t+1}, s_{t+1}, s_t, \dots, s_{t-r+1} | Y_t) \quad (11)$$

This leads to an r+1 period inference conditional on current data:

$$p(s_{t+1}, s_t, \dots, s_{t-r+1} | Y_t) = \frac{p(y_{t+1}, s_{t+1}, s_t, \dots, s_{t-r+1} | Y_t)}{p(y_{t+1} | Y_t)} \quad (12)$$

and by integration, an updated r period inference

$$p(s_{t+1}, s_t, \dots, s_{t-r+2} | Y_{t+1}) = p(s_{t+1}, s_t, \dots, s_{t-r+1} = 1 | Y_t) + p(s_{t+1}, s_t, \dots, s_{t-r+1} = 2 | Y_{t+1}$$

$$(13)$$

The updated inference is then used as input for the next iteration. The filter is initialised with r-period unconditional probabilities,

$$p(s_r, s_{r-1}, \dots, s_1) = p(s_t, s_{t-1}, \dots, s_{t-r+1}) \quad (14)$$

To find these, the ergodic[11] probabilities are computed, which are simply the unconditional estimates that the process will fall into each regime at an arbitrary date

$\pi^j \equiv p(s_t = j)$for j = 1, 2 (15)

These are finding by solving the following set of equations:

$p^{1j}.\pi^1 + p^{2j}.\pi^2 = \pi^j$for j= 1, 2 (16)

$\pi^1 + \pi^2 = 1$ (17)

Employing the appropriate transition probabilities, the necessary r-period unconditional probabilities are computed, as follows:

$$p(s_t = 1, s_{t-1} = 2, s_{t-2} = 1) = (1 - p(s_t = 2|s_{t-1} = 2).(1 - p(s_{t-1} = 1|s_{t-2} = 1).\pi^1 \quad (18)$$

After the entire sample has been passed through the filter, the computed observation densities can be used to form the conditional likelihood function:

$p(yT, yT - 1, \dots, y_{r+1}) = \prod_{t=r+1}^{T} p(y_t\, |Y_{t-1})$ (19)

**The EM Algorithm**

The EM algorithm (hereafter EMA), as outlined by Hamilton (1990), deals with the dual uncertainty problem in a different way. One begins with an initial guess for the vector of parameters, say $\theta^{[0]}$. The filter and smoother, both parameterised by the extent of regime dependence, are executed to obtain inferences conditional on the entire sample of observations. The smoothed inferences are used as weights for coefficient updating, via minimization of the sum of weighted squared residuals. Improved estimates of the transition probabilities are simple functions of the smoothed probabilities. The set of updated values constitutes $\theta^{[1]}$; the process is repeated until some convergence criterion is satisfied.

To outline the procedure in greater detail, consider a two-state MS(2) model:

$(y_t - \mu^{(1)} = \varphi^{(11)}(y_{t-1} - \mu_{t-1}) + \varphi^{(12)}(y_{t-2} - \mu_{t-2}) + \varepsilon_t^{(1)}$ (28)

$(y_t - \mu^{(2)} = \varphi^{(21)}(y_{t-1} - \mu_{t-1}) + \varphi^{(22)}(y_{t-2} - \mu_{t-2}) + \varepsilon_t^{(2)}$ (29)

[11] A state is said to be ergodic if it is recurrent in a period of one and it has a finite mean recurrence time.

$\varepsilon_{i,t} \sim N(0, (\sigma^{(i)})^2), i = 1,2.$ Constructed this way, 10 parameters need to be estimated:

$\mu^{(1)}, \mu^{(2)}, \varphi^{(11)}, \varphi^{(12)}, \varphi^{(21)}, \varphi^{(22)}, \sigma^{(1)}, \sigma^{(2)}, p^{(11)}, p^{(22)}$.

A single iteration of the EM algorithm starts by executing the filter. Upon completion, the filter yields regime inferences for two periods:

$p(s_t . s_{t-1} | Y_t)$

and for three periods

$$p(s_t^* | Y_t) = p(s_t, s_{t-1}, s_{t-2}, Y_{t-1}) \qquad (30)$$

The * is used to redefine the state in terms of the permutations of the three lags, that is

$s_t^* = 1$ Implies $s_t = 1, s_{t-1} = 1, s_{t-2} = 1$. Also obtained are observational densities, both conditioned on states:

$$p(y_t | s_t^*, Y_{t-1}) = p(y_t | s_t . s_{t-1}, s_{t-2}, Y_{t-1}) \qquad (31)$$

and unconditional with regard to states

$p(y_t | Y_{t-1})$

A typical observation density is written

$$p(y_t | s_t^* = 3, Y_{t-1}) = \frac{1}{\sigma^{(1)}\sqrt{2\pi}} \exp\{[(y_t - \mu^{(1)}) - \varphi^{(11)}(y_{t-1} - \mu^{(2)}) - \varphi^{(12)}(y_{t-2} - \mu^{(1)})]^2 / 2(\sigma^{(1)})^2\}$$

The smoother is used to find a probability series that is less volatile than that provided by the filter:

$$p(s_t^* | Y_T) = p(s_t, s_{t-1}, s_{t-2} | Y_T) \qquad (32)$$

while integration yields

$$p(s_t, s_{t-1} | Y_T) \text{and} p(s_t | Y_T) \qquad (33)$$

With smoothed inferences available, coefficients are updated numerically by minimizing the sum of weighted squared residuals:

$$[\mu^{(1)}, \mu^{(2)}, \varphi] = \arg\min\{\textstyle\sum_{t=3}^{T} \sum_{k=1}^{8} (v_t^{(k)})^2 . p(s_t^* = k | Y_T)\} \qquad (34)$$

where$\varphi = [\varphi^{(11)}, \varphi^{(12)}, \varphi^{(21)}, \varphi^{(22)}]$ and

$$v_t^{(k)} = y_t - E(y_t | s_t^* = k, Y_{t-1}) \tag{35}$$

An example of an error series element would be

$$v_t^{(2)} = \left(y_t - \mu^{(2)}\right) - \varphi^{(21)}\left(y_{t-1} - \mu^{(1)}\right) - \varphi^{(22)}(y_{t-2} - \mu^{(2)})$$

Estimation of the regimes' variances requires similar weighting

$$\left(\sigma^{(j)}\right)^2 = \frac{p(s_t = j.s_{t-1}, s_{t-2}|Y_T)}{\sum_{t=3}^{T} p(s_t = j)} \times \sum_{T=3}^{T} \sum_{s(t-1)=1}^{2} \sum_{s(t-2)=1}^{2} [(y_t - \mu^{(j)}\big) - \varphi^{(j1)}\big(y_{t-1} - \mu^{(s_{t-1})}\big) - \varphi^{(j2)}\big(y_{t-2} - \mu^{(s_{t-2})}\big)]^2$$

for $j$=1,2. Updated transition probabilities also utilize smoothed inferences

$$p_{ij} = p(s_t = j | s_{t-1} = i) = \frac{\sum_{t=r+1}^{T} p(s_t = j | s_{t-1} = i | Y_T)}{\sum_{t=r+1}^{T} p(s_{t-1} = i | Y_T)} \text{for} i, j = 1, 2. \tag{36}$$

A single iteration of the algorithm is thus completed which is repeated until convergence.

**Relative Merits of Different Algorithms**

The DFP routine described earlier is the same method used by Hamilton (1989) for his analysis of the business cycle. Hamilton (1990) proposed the above EMA as an alternative, to handle systems of greater complexity. Problems may arise during gradient computation due to the shape of the likelihood surface associated with a MS model. Mixture distributions may have as many local maxima as regimes, and likelihood functions derived from these densities may be plagued by the same features. The EMA however, does not involve the examination of likelihood surfaces, and as such, may avoid both local maxima and singularities. Another positive attribute of the EMA noted in other applications is its ability to arrive in the neighbourhood of the mode of the likelihood function in a few early steps, which can prove advantageous if one is performing a rough grid search to determine optimal starting values. Hamilton also argues that an EMA may not be as demanding numerically. If the EMA is indeed more robust than a DFP algorithm and computationally more efficient, one would clearly prefer the former. In their investigation of exchange rates, Engel and Hamilton (1990) successfully employed the EMA in the presence of numerous local maxima. The case for the EMA is also strengthened by the possibility of using the approximate smoother, as it is only marginally more demanding than the filter". In this thesis the variables were estimated using a RATS program supplied by Brooks (2008), which was based on a GAUSS program initially supplied by Hamilton.

# Appendix B

The following is the results of the Quandt-Andrews Test. It is recalled that the test was used to test for structural breaks, however, the structural break is not applied because the purpose of the study is to apply a statistical arbitrage strategy which takes advantage of ‘down’ as well as ‘up’ markets.

Quandt-Andrews unknown breakpoint test
Null Hypothesis: No breakpoints within 15% trimmed data
Varying regressors: All equation variables
Equation Sample: 1/10/2003 3/01/2013
Test Sample: 7/19/2004 8/30/2011
Number of breaks compared: 1839

| Statistic | Value | Probability. |
|---|---|---|
| Maximum LR F-statistic (7/13/2009) | 1.311232 | 0.6684 |
| Maximum Wald F-statistic (7/13/2009) | 44.58188 | 0.6684 |
| Expected LR F-statistic | 0.487711 | 0.8782 |
| Expected Wald F-statistic | 18.78601 | 0.6647 |
| Average LR F-statistic | 0.969542 | 0.5442 |
| Average Wald F-statistic | 32.96444 | 0.5442 |

Note: probabilities calculated using Hansen's (1997) method; LR stands for ‘Likelihood Ratio’

## Appendix C

The following is the RATS program for the Markov switching strategy. The first two lines "read in the data, and the following one defines the dependent variable used in the program. The next line tells RATS that a non-linear estimation will be conducted and the parameters to be estimated are listed: P12 P21 A01 A02 SIGMA1 SIGMA2 (P12 is the probability of being in state 2 given that the value was previously in state 1; A01 is the mean of the value in state 1; A02 is the mean of the value in state 2; SIGMA 1 is the variance of state 1; and SIGMA 2 is the variance of state 2).FRML then defines the formulae for the residuals for each regime, then some initial starting value guesses are offered for the probabilities. The linear regression and the four COMPUTE instructions that follow it also generate initial guesses, for the means and variances in each regime. The vector PSTAR will contain the probabilities of being in state 1 at each point in time for the sample and this must be initialised. The next FRMLconstructs a formula, called MARKOV, that defines the log-likelihood as afunction of the parameters, and finally the MAXIMIZE command does the Estimation" (Brooks, 2009).

```
OPEN DATA 'G:\MAR2.DAT'

DATA(FORMAT=FREE,ORG=OBS) mr

SET Y = mr

NONLIN P12 P21 A01 A02 SIGMA1 SIGMA2

FRML REG1 = Y-A01

FRML REG2 = Y-A02

*

COMPUTE P12=0.7

COMPUTE P21=0.3

LINREG(NOPRINT) Y

# CONSTANT

COMPUTE A01=%BETA(1)+0.5

COMPUTE A02=%BETA(1)

COMPUTE SIGMA1=SQRT(%SEESQ)

COMPUTE SIGMA2=SQRT(%SEESQ)
```

```
*
SET PSTAR 1 531 = 0.5
FRML MARKOV = $
F1=%DENSITY(REG1{0}/SIGMA1)/SIGMA1 , $
F2=%DENSITY(REG2{0}/SIGMA2)/SIGMA2 , $
RP1=F1*(P21*(1-PSTAR{1})+(1-P12)*PSTAR{1}) , $
RP2=F2*((1-P21)*(1-PSTAR{1})+P12*PSTAR{1}) , $
PSTAR=RP1/(RP1+RP2) , $
LOG(RP1+RP2)
MAXIMIZE(ROBUST) MARKOV 2 531
PRINT 1 531 PSTAR
```