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Macroeconomic Risk Factors of Australian Mining Companies

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Dedication

I dedicate this thesis to my wife, Mansura Rahman, for nurturing me with affections & love, and for her constant support and encouragement during the challenges of my life.

Also dedicated to my late parents, who taught me to trust in Almighty, believe in hard work, and encouraged me to believe in myself.

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My journey to completing this MRES thesis was supported by a number of people. I would like to express my gratitude to my principal supervisor, Dr. Zahid Hasan, for his sincere support and encouragement throughout my candidature. He always kept an eye on the progress of my work and was available for help whenever I needed it. I am also especially thankful to my co-supervisor Professor Helene de Burgh-Woodman, who provided me with guidance and direction throughout my candidature. Appreciation is also due to the members of research office at UNDS.

As always, my family has proved to be the ultimate place of refuge, enabling me to keep the stress of research at bay. I remain heavily indebted to my family members, especially my wife, who looked after me tremendously and encouraged me throughout my candidature. Finally, I would like to thank all my friends and relatives who were with me in this sometimes excruciating, but always thrilling, journey.

Statement of Authentication

I hereby declare that the work presented in this thesis is, to the best of my knowledge and belief, original except as acknowledged in the text. I also declare that I have not submitted this material, either in full or in part, for a degree at the University of Notre Dame Sydney or any other institution.

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(Mohammed Kamruzzaman)

10 January 2018

Contents

List of Tables

List of Figures

ABSTRACT

This thesis identifies the priced macroeconomic risk factors for the Australian mining industry from January, 2004 to December, 2013, and the macroeconomic variables that have had an impact on stock returns. A rapid growth in the stock returns of the mining industry in Australia occurred during this period. This phenomenon is studied using a multifactor model and arbitrage pricing theory. The method involves analysis of two samples: the top ten mining firms and the aggregate mining industry. Firstly, unbalanced panel data containing 1550 yearly observations of 155 mining companies is selected for the aggregate industrial analysis. Secondly, data from the top ten mining firms (based on market capitalization) is selected for the firm-based analyses. The thesis provides new evidence regarding the drivers of stock returns. Results reveal that market return, the foreign exchange rate, and the rate of changes in sales are significantly associated with stock market returns.

CHAPTER ONE: INTRODUCTION

Macroeconomic factors are inherently volatile and can have has significant effects on the financial world and global economy. Sudden and severe movements of these factors can puzzle consumers as well as policy analysts and observers. For example, throughout the first half of 2008, energy prices regularly reached record levels. On July 11, 2008, the world observed the highest crude oil price in its history, reaching $156.34 per barrel. Crude oil prices then slumped significantly from $146 to below $60 by end of the same year due to the world-wide financial crisis, which abruptly lowered the future demand for crude oil. Recently, the crude oil price of $106.30 in May 2014 plummeted to $29.38 in January 2016. Such energy price shocks have significant effects on global stock markets. Similarly, fluctuations in exchange rates can affect both the economy and stock markets. For example, during the Global Financial Crisis (GFC) of 2008, the Australian dollar dropped to USD 0.63, yet managed to make a significant adjustment in just two years to USD 1.08 in 2011. At the end of 2016, the Australian dollar traded at USD 0.70.

The Australian stock market (ASX) is one of the fastest growing stock markets and it ranks eighth in the world in terms of market capitalisation. Mining companies constitute the biggest portion of this stock market and mining resource companies represent 24% of total market capitalization. The Australian stock market is the home of some renowned multinational mining companies, e.g. BHP Billiton, Newcrest, Rio Tinto, Alcoa, Alcon, and Xstrata. Approximately one-third of the listed companies in ASX deals with mining and mining related operations.

According to the Australian Bureau of Statistics (ABS), the mining industry comprises the companies dealing with mainly extracting naturally occurring mineral solids, liquid minerals, and gases. This classification is also in accordance with the mining industry classification provided by Australian and New Zealand Standard Industrial Classification (ANZSIC). This classification also includes industries which offer mining related activities and services to reflect the broader view of the industry. The mining industry has great importance in Australian economy. It contributes significantly to GDP and employment in Australian economy. For example, in 2014–15, Industry Value Added (IVA) for the Australian Mining industry was $133 billion of which 40.2% was contributed by iron ore mining. A significant increase in the demand for minerals and commodities from China and other parts of Asia in 2015 resulted in a phenomenal 15% increase in Australia's energy and mineral commodity exports at $190 billion in 2014–15. IVA for the Australian mining industry registered -14.3% declines in 2012–13 registering $114 billion but the industry IVA picked up by 12.3% in 2013–14. This increase in the IVA for mining was due to the mining investment boom in the recent years, which is now slowing down. The mining industries value added decreased by 7.4% in 2014–15 from the previous year, with the largest decrease in the metal ore mining subdivision, which is related to falling commodity prices. These decreases also led to a decrease in Gross Capital Formation (-11.7%) as well as total employment by the mining industry by -6.9%. (Table 2, Australian Industry Report, 2015).

Stock prices tend to respond to economic fluctuations, and shocks to them are attributed to both macroeconomic variables and firm-specific factors (Beaudry & Portier, 2006;

Kurmann & Mertens, 2014). Existing literature suggests that fluctuations in stock prices reflect market expectations about future economic developments (Beaudry & Portier, 2006). Literature in macroeconomics traditionally confirms that economic fluctuations are associated with stock market fluctuations (Pigou, 1926; Keynes, 1936; Benhabib & Farmer, 1999). Macroeconomic price shocks and their volatility have a profound impact on economic activities. Generally, efficient asset pricing accommodates expected macroeconomic risk factors in determining the price of any asset. Any unexpected change in the risk factors can create uncertainty, which leads to movement in asset prices. For example, an increase in energy prices leads to a rise in production costs and frequent jumps in prices increase uncertainty, which creates an adverse environment for productive investment. Investors and market participants delay investment because of this higher uncertainty (Bernanke, 1983; Pindyck, 1991). In a breakthrough paper, Hamilton (1983) contends that energy price shock has been one of the most important factors contributing to economic recessions in the United States. Studies on the relationship between energy price shock and performance of macro economy have isolated other factors. In another example, borrowing cost or interest rate is one of the important macroeconomic risk factors for the stock markets. As companies require capital for investment, changes in interest rate can affect the same dividend cash flow by increasing the financing cost or asset risk premium.

In this thesis, we will investigate the intertemporal relationship between the return of mining companies in Australia and macroeconomic risk factors. Foreign exchange rates are also considered as one of the determining factors of stock return. Finance literature identifies that foreign exchange rates are a priced risk factor. In an early paper, Jorion (1991) establishes links between exchanges rates and stock markets. In a recent empirical study Kansas *et al*. (2017) confirm that companies engaged in international trading are exposed to changes in exchange rates. In this thesis, we study the macroeconomic risk factors in determining the stock returns in Australian mining companies. To understand the plausible risk factors for the mining companies, this study will use the risk factors that have been identified in the study of mining, oil, and gas companies. For example, risk factors used by the studies of Boyer and Filion (2007), Kang *et al*. (2017), Sadorsky (2001), Ramos and Veiga (2011) we will apprise .

Macroeconomic shocks have a direct effect on a firm's level of performance. Higson *et al*. (2004) and Kang *et al*. (2017) state that firms are exposed to industry specific and economic-wide events, along with idiosyncratic shocks. Empirical evidence validates that macroeconomic variables, such as interest rate, exchange rate, GDP growth rate, inflation, gas, or oil prices, have explanatory power when analysing variations in stock returns. Economic theories such as Efficient Market Hypothesis (EMH), Arbitrage Pricing Theory (APT) and Capital Asset Pricing Model (CAPM) provide theoretical linkage of the association between macroeconomic variables and stock returns. The CAPM model was developed by William Sharpe (1964) and John Lintner (1965). A basic single factor CAPM model is based on one independent variable, i.e. risk premium and mean variance framework. This model provides an approach in estimating risk premium after quantifying risk. This risk premium is translated into estimation of expected returns. CAPM is used in calculating expected returns by researchers as it has several advantages over other models. For example, this model is easy to implement and it considers systematic risk, which investors find only relevant factor to be compensated. Moreover this model enables correct calculation of the stock prices or cost of equity by accounting for a company's level of systematic risk relative to the stock market as a whole.

The APT theory by Ross (1976) is an extension of the CAPM model. APT is the most quoted theory with reference to macroeconomic variables and it employs a multi-factor framework. APT is based on the idea that stock returns are affected by other factors, along with market factors. According to Ross (1976), factors affecting the stock return will be priced according to whether investor is willing to pay a premium. These factors have a significant effect on the behaviour of stock and a company's overall economic performance. To study econometric evidence provided by the U.S market, Campbell, Lo and MacKinlay (1997) and Cochrane (2001) employ various methodologies to estimate and test APT and multi-factor modelling. APT assumes that returns of an asset are determined by various macroeconomic, security-specific, and market-specific variables. It involves a mechanism used by many investors for identifying an incorrectly priced asset, such as a share of common stock. Investors can subsequently bring the price of the security back into alignment with its actual value.

This thesis looks at how macroeconomic factors affect the stock prices of mining companies in Australia. We consider market returns, interest rates, energy prices of oil and coal, and exchange rates as macroeconomic factors. For exchange rates, we will use the three main currencies of the U.S. dollar, the euro, and the Japanese yen for a better understanding of the exposures of Australian mining companies to the exchange rate factors. To identify the mining companies, the study will consider the mining companies listed in the Australian Stock Exchange (ASX). A panel will be formed from the listed companies to conduct our study. Our intention is to create an understanding of the significant factors that determine the risk premium for the expected returns for the investors. As the investors are taking risks when investing into risky assets, it is important to identify the priced risk factors. All risk factors are not equally important for every company. For example, financial companies have relatively higher exposure to interest rates whereas resource companies are more exposed to energy price risk. This thesis will also analyse the priced risk factors for the top ten mining companies. This analysis will facilitate in checking the robustness of the study.

Generally speaking, energy prices are assumed to play a significant role in determining stock returns. The energy price returns and their volatility are believed to affect energy intensive sectors such as mining. Jones and Kaul (1996) investigate the influence of oil price shocks on stock returns in four developed markets of Canada, Japan, U.K. and U.S., and observe a link between these two variables. In another study, Sadorsky (1999) finds the evidence of negative effect of oil price shocks on aggregate stock returns in the U.S. Again, Ciner (2001) observes a negative association between stock returns and oil price returns. Considering the imminent effects of changes in energy prices on mining companies, we use coal and oil prices as risk factors to identify their effect on these companies. We use oil and coal price returns and their volatility in our model. Since coal is a source of revenue for many mining companies in Australia, it is hypothesized that higher coal prices will lead to higher stock returns and vice versa. Similarly, oil and gas companies and sectors experience the same effect when oil prices move up[1].

Furthermore, the effect of oil prices on mining companies in Australia might be positive or negative. In one study, Ratti and Hasan (2103) find that oil price return has a positive effect on the Australian energy and material sectors. Energy and material sectors are generally comprised of mining companies. The effect would be positive when oil and coal prices are co-integrated and oil prices lead to coal prices. Generally, the oil is used as input in production. Therefore, the effect of higher oil prices would be negative if the mining companies use oil in their production and processing purposes. It is also valid for other types of companies in the stock market. On the other hand, if a change in oil price affect's other energy prices, the effect would be positive on the mining companies. Therefore, it would be interesting to find out the effect of changes in oil prices.

Higher interest rates leave a negative impact on the stock market. Chen et al (1986) was the first to use oil price returns as a plausible risk factor for stock returns in their study. Their findings suggest an insignificant relationship between oil price shocks and stock market trends. Chen *et al*. (1986), Jones and Kaul (1996) study differs as they carry out a detailed and deep investigation of oil price shocks in association with the stock market. Both Jones & Kaul (1996) and Huang *et al*. (1996) analyse U.S. stock market reactions in response to oil price shocks. Findings from their study suggest that stock prices affect

[1] See Faff and Brailsford (1999), El-Sharif *et al*. (2005), Boyer and Filion (2007), and Park and Ratti (2008).

present and future real cash flows as induced by the news. Their results affirm that the Canadian and U.S. stock markets respond to oil price shocks. Few empirical studies have confirmed strong relationships between the performance of stock market and energy price shocks.

Since most previous studies on energy resources only analyse oil and natural gas, this study contributes to the existing literature by investigating coal energy prices in addition to oil prices. The thesis uses coal price as an important factor to develop the conceptual framework. Coal price volatility is used as a variable for analysing its volatility transmission with reference to the Australian stock market. Although coal is a major energy resource in Australia, there are few studies research on the relationship between coal prices and stock returns. Only the study of Hasan and Ratti (2015) use coal price in their study; but their study is related to only coal companies from international perspective. There is no comprehensive and appropriate research study or analysis investigating the effect of coal price return on Australian mining companies.

There is also a dearth of studies on the impact of energy price fluctuations on stock market returns for the mining industry in Australia. No recent study has focused on energy price fluctuations and its association with the stocks of Australian mining companies. Thus, this research aims to present new empirical evidence with reference to the association between mining companies in Australian stock market and macroeconomic risk factors and make a significant contribution by examining the volatility of dominant energy resources. Since stock market and energy sectors are highly significant in financial markets, the findings of this study would also highlight the process of portfolio creation by investors.

The literature also considers asymmetry of the effect of energy price changes on the macro economy and the stock market. Generally, higher energy prices have a negative impact on the economy and the stock market, whereas lower prices have a positive impact. However, the extent of the effect is not similar in higher and lower energy prices. Mork (1989) and Mork *et al*. (1994) argue that higher energy prices have a negative effect on economic output, but drops in the price of the same do not necessarily have a positive effect on output, and certainly effect is not to the same extent. Similar results are also observed in stock market. Basher and Sadorsky (2006), Cong *et al*. (2008) and Park and Ratti (2008) also study the asymmetry effect of energy prices on the stock market and observe mixed results. In this thesis, we also study the asymmetry aspect of oil and coal price on mining company returns. We calculate two types of asymmetry of oil and coal price return and consider them in our estimation.

In addition to energy price returns, foreign exchange returns, and interest rates, we also consider market return. Market return is used to capture the impact of other important factors appropriately. An econometric analysis is carried out by creating a panel from stock return data extracted from mining companies, as listed on the ASX. The stock return data of top 155 listed mining companies (on the basis of market capitalization) is pooled for the purpose of analysis. Monthly data is collected for the period from January 2004 to December 2015.

Mining companies have a strong dominance in stock markets around the world. Results of this study would have direct implications for mining companies in Australia. Understanding the priced risk factors that affect the behaviour of stock prices of mining companies is of great importance to investors and other market participants. The findings will also be useful for developing efficient hedging policies to deal energy price shocks. Since significant factors for sector returns are identified, findings would facilitate international investors to control risks.

The estimated results of number of econometric models of our study suggest that interest rate difference, foreign exchange return, and coal price return are statistically significant. The coefficients of market returns are relatively high when compared to the coefficients of other variables, which implies that benchmark market return explains most of the variability in the returns of the mining companies. For interest rates, our results suggest that a change in interest rate is not a priced risk factor for Australian mining companies. The coefficients of interest rate difference are negative, implying that when the interest rate increases from the previous month the lower returns in mining stock returns. In terms of the foreign exchange rate, the coefficient of the Australian dollar/USD exchange rate is found to be significant but negative. The thesis also identifies the impact of energy price returns and their volatility on Australian mining companies and the results suggests that oil price returns have greater impact on the mining companies compared to the effect of coal price returns.

The remainder of this thesis is organized as follows: Chapter 1 provides an overview of the mining industry in Australia and the Australian stock market, highlighting their significance in the economy. Chapter 2 establishes the theoretical basis of the study and discusses relevant studies. This chapter also demonstrates the gap in the literature and how this research will fill it. Chapter 3 discusses the research methodology; Chapter 4 identifies the models that are estimated to ascertain the research findings. Chapter 5 defines the data of the study and provides descriptive statistics of the data. Chapter 6 provides the empirical findings based on the estimated models and finally Chapter 7 concludes the study.

CHAPTER TWO: OVERVIEW OF THE AUSTRALIAN MINING INDUSTRY AND STOCK MARKET

The mining and resource sector has made a substantial contribution to Australia's prosperity since 1800. As a key Australian resource sector, it is highly competitive within the global minerals and energy products supplier market. According to Division B of the 2006 edition of the ANZSIC (cat. no. 1292.0), mining means mineral extraction of what occurs naturally as solids, such as coal, iron ores, crude petroleum, and natural gas. Also other mining activities such as preparing, including crushing, screening, washing, and flotation, which are generally carried out in near or at a mining field, are also an integral part of the mining industry. The sector also includes petroleum and mineral exploration, mining support services and development of mining sites.

Minerals production started in Australia with early European settlement. Coal was first discovered in 1788 near Newcastle in New South Wales and then to the south and west of this settlement. In South Australia, lead was discovered in around 1841. When gold was discovered near Bathurst in 1851, it was a major driver for resource development for the Australian mining industry. By 1871, the Australian population had trebled due to the large number of immigrants who emigrated to search for gold. After the discovery of metal at Mt. Bischoff in Tasmania in the 1870s, Australia became one of the important producers and exporters of tin in the world. Several mines operated in the 19th century: Silver, lead, and zinc were mined at Broken Hill in New South Wales; copper and gold at Mt. Morgan near Rockhampton in Queensland; and copper and gold at Mt.

Morgan near Rockhampton in Queensland. These are known as the first great mines of the Australian mining sector.

Despite the increased value of mineral resources in the world, Australian mining activity began to decline in the early years of the 20th century. In that period, lead, zinc, and copper deposits at Mt Lisa were the only the major discoveries in the Australian mining industry. However, it was not until the 1950s that their full potential was released. Key events in the development of the Australian mining industry from 1900 to 2000 are depicted in Appendix 1. According to data extracted from the Mineral Council of Australia, Australia is known as one of the leading nations in mineral resources in the world. Australia is the largest producer of industrial diamonds and gems, tantalum, and lead, along with mineral sands including ilmenite, zircon, and rutile. Australia is also the largest refiner of bauxite. Australia is the leader in coal export, even though as a coal producer they are fifth in the world. Australia is also the fourth largest producer of primary aluminium, second largest for zinc, third largest for gold, iron ore, and manganese, and fourth and fifth largest for nickel and copper and silver respectively. The nation has the largest resources for low-cost uranium. As new mining deposits are discovered and developed in Australia, Australia is becoming a leading mineral nation in the world. As Australia acts as major mining trading nation in the world, Australians enjoy a high living standard. In the Australian export trade, mining industries are one of the largest contributors.

Currently, the demand for mineral resources is increasing, due to high demand from Asia particularly India and China. This increase in demand is a key factor for the increase in mineral price and in the levels of Australia's resource investment, exports, and production especially for iron ore and coal. The mining sector is critical for Australian economy, which is demonstrated by data from the Australian Bureau of Statistics and The Bureau of Resources and Energy Economics. Gross Domestic Product (GDP) is one of the most key macroeconomic indicators of a country. GDP is the contribution of an industry's goods and services production to the overall economy. It is measured by the industry gross value added (GVA). According to Table 1, the total volume of production of the Mining and energy industry increased from 2007–08 at 124.3 MT to 143.6 MT by 2013–14. According to the report 'Resources and Energy Quarterly, December 2015' published by industry.gov.au, the Mining industry's contribution to GDP was 6% in 2004–05 but in 2014–15 it was 9% of total GDP. In 2014–15, the mining and resources industry was the second largest contributor to Australia's GDP with 9% of the total amount of $145.73 trillion.

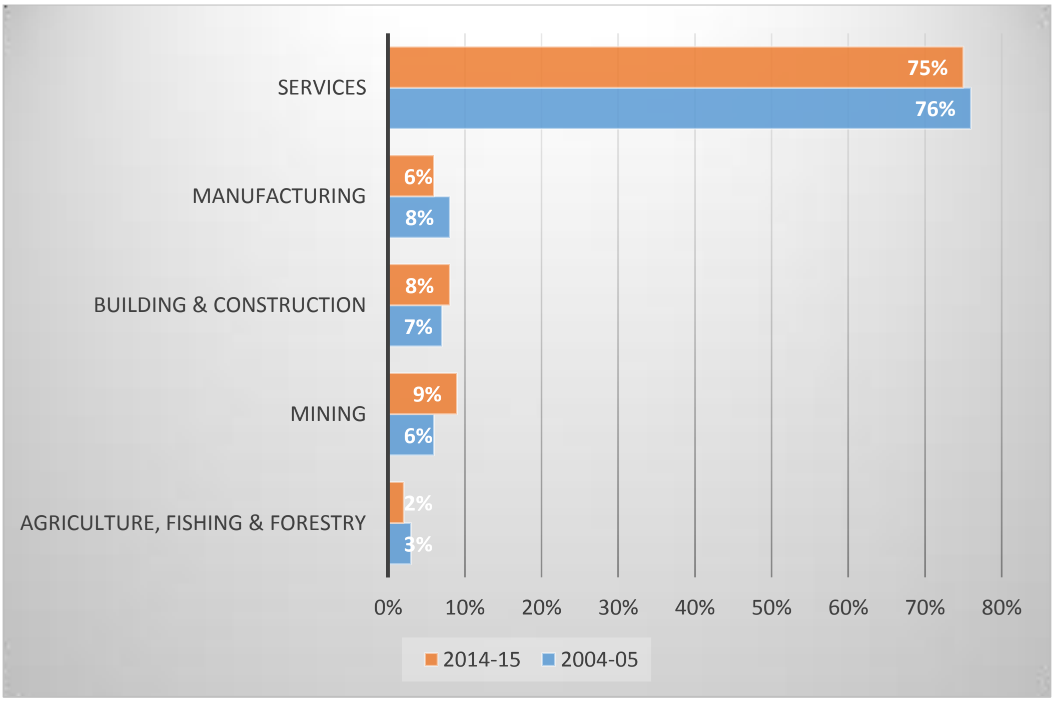
Table 1: Annual volume of mine production indexes (MT), Australia.

Index	2008	2009	2010	2011	2012	2013	2014
Energy	118.5	113.7	127.1	118.7	120.9	126.7	134.6
Metals and other minerals	124.3	124.1	119.6	123.2	138.9	141	143.6

Source: Australian Bureau of Statistics

The mining industry is a major contributor to the Australian economy and adds 6% in terms of GVA (Table 1) when compared to other industries, such as the service industry (75%), manufacturing (6%), building and construction (8%) and agriculture, forestry and fishing with 2%. Significantly, the mining industry's contribution to the GDP increased by 3% from 2004-05 to 2014-15, whereas the contribution by the manufacturing industry decreased by 2%. The coal and petroleum industries contributed around $37.5 billion to industry gross value added during 2014–15, representing 2.4% of the aggregate Australian industry. The electricity and gas supply industries together contributed another $28.3 billion to industry GVA. Furthermore, these industries provide significant employment and infrastructure to the national economy. Present research focuses on examining the shocks faced by the Australian mining industry and determining the return of the mining companies with reference to economic and fundamental determinants. Interest rates, energy prices of oil and coal, gold price, exchange rates are considered as macroeconomic variables.

Figure 1: Sector wise contribution to GDP in Australian Economy



Source: *Resources & Energy Quarterly December Quarter* 2015 (www.bree.gov.com.au)

During 2012–13, Industry value added (IVA) for the mining industry was $149.2 billion, which is $15 billion more than in 2011–12 and consists of mining (excluding services) $138.3 billion and exploration and mining service of $10.8 billion followed by construction services ($115.4 billion) and manufacturing ($103.7 billion). Surprisingly IVA for the mining industry fell by 7.4% from 2013–14 to 2014–15 because of the decrease in metal ore mining production as well as the pricing. These figures represent the significance of the sector to the Australian economy in terms of its contribution to exports and its role in local economies where the mining and/or other operational industries is located. Australia is a major exporter of mineral commodities and goods and services in the world market. According to Table 2, in 2013-14 mineral resources contributed nearly 58.5% ($175.9 billion) of total goods and services exports worth $300.6 billion. Similarly 70.6% in proportion of total merchandise exports valued at $249.2 billion. Australia's largest export markets are China (27% of total exports), Japan (17%), South Korea (7%), India (6%) and the European Union countries.

Table 2: Contribution to Australian exports

Year	Resources and energy sectors ($M)	Resources and energy sectors (%)
2002	57833	37.1
2003	57118	36.7
2004	56861	37.5
2005	53402	36.5
2006	68362	41
2007	91260	46.6
2008	106220	49

2009	115904	49.6
2010	160251	56.4
2011	138183	54.6
2012	177729	59.8
2013	190934	60.4
2014	175888	58.5

Sources: BREE; ABARES; ABS, Balance of Payments, Australia, cat. No. 5302.0 and 5303.0, Canberra.

Mining is one of the most investment-oriented industries, and initial and operating investment costs are higher than any other industry. Also high demand for mining resources from the emerging Asian economy has intensified a investment in mining. Table 3 reports the contribution of the mining sector to capital formation in recent years. It reveals that the investment in mining sector has experienced an increasing trend since 2001. Only 2015 experienced a decline in investment because of the decline in global demand of mining products. In terms of investment formation, the mining sector plays a very important role as it contributes nearly 40% of total investment in Australia.

Table 3: Gross Capital formation

Year	Mining ($m)	% of Total Investment
2001	5,729	12.1
2002	7,596	15.5
2003	9,215	16.3
2004	9,795	17.1
2005	10,843	16.9
2006	19,659	24.4
2007	24,230	16.58

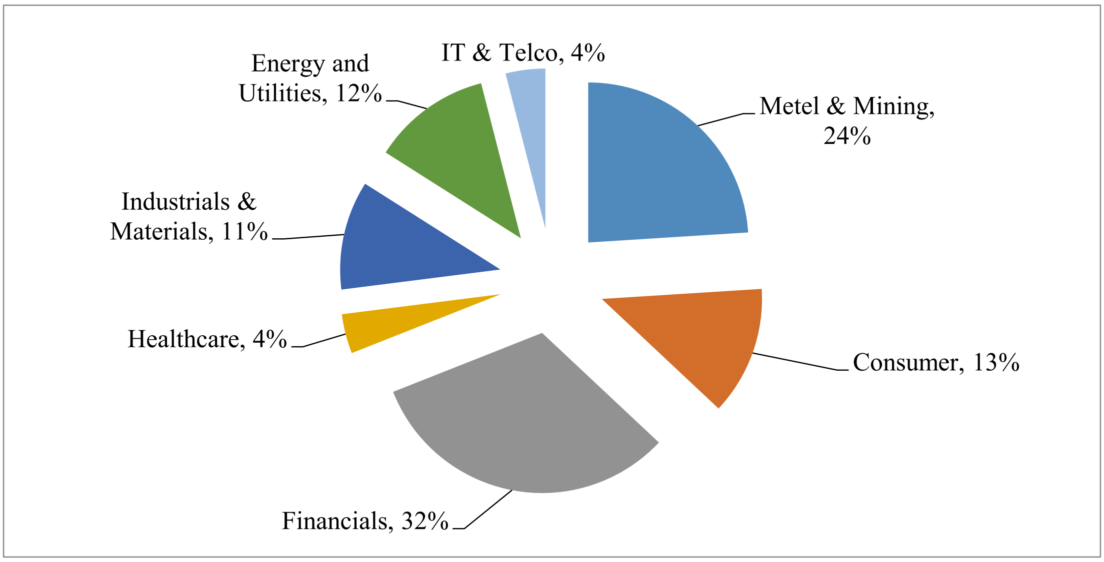
2008	25,886	14.98
2009	34,997	18.48
2010	34,403	24.07
2011	48,549	30.43
2012	82,574	38.19
2013	93,686	44.13
2014	91,875	43.00
2015	81,086	37.59

Source: Australian Bureau of Statistics. 8155.0 - Australian Industry, 2014-15, Issue released on 17th June 2016.

The Australian Bureau of Statistics, Labour force Catalogue (2016) records that, in 2014-2015, the annual labour force in the Australian mining industry was 173388, with metal ore mining industries employing the most at 65,035 followed by the coal mining industry with 39,128 employees. In the world of economic resources, Australia ranks in the top six countries for black and brown coal, bauxite, copper, cobalt, gold, iron ore, manganese ore, and nickel reserve. It also has the world's largest demonstrated resources of lead, mineral sands, uranium, silver, and zinc. Currently, more than 400 medium-sized to large mines in Australia have deposits of most of the major mineral commodities.

The stock exchange in Australia was established in mid-1800s and since then the mining sector has been playing a significant role in Australian equity market. The first stock market in Australia was opened in Ballarat, Melbourne in 1858. From the beginning, industrial and resources sectors were main sectors in the Australian stock market. The resources sector is comprised of mining and energy sectors. The All-Resources Index was used to be the benchmark for investors in resource sector. Now, The Global Industry Classification Standard (GICS) classifies components of the resources sector into the materials sector (metals and mining) and the energy sector. In the ASX, the metals and mining sector is the largest industry sector by the number of listed companies, which include the more than 700 companies that are involved with mineral exploration, development and production across the country. The sector comprises several of the world's largest diversified and renowned resource companies, including global giants BHP Billiton and Rio Tinto. According to Figure 2, mining resources represent 24% of the market capitalisation, which is the second largest sector after the financial sector (32%). However, if the energy and utilities sector is added to mining, the sector would top the rank with 36% capitalisation.

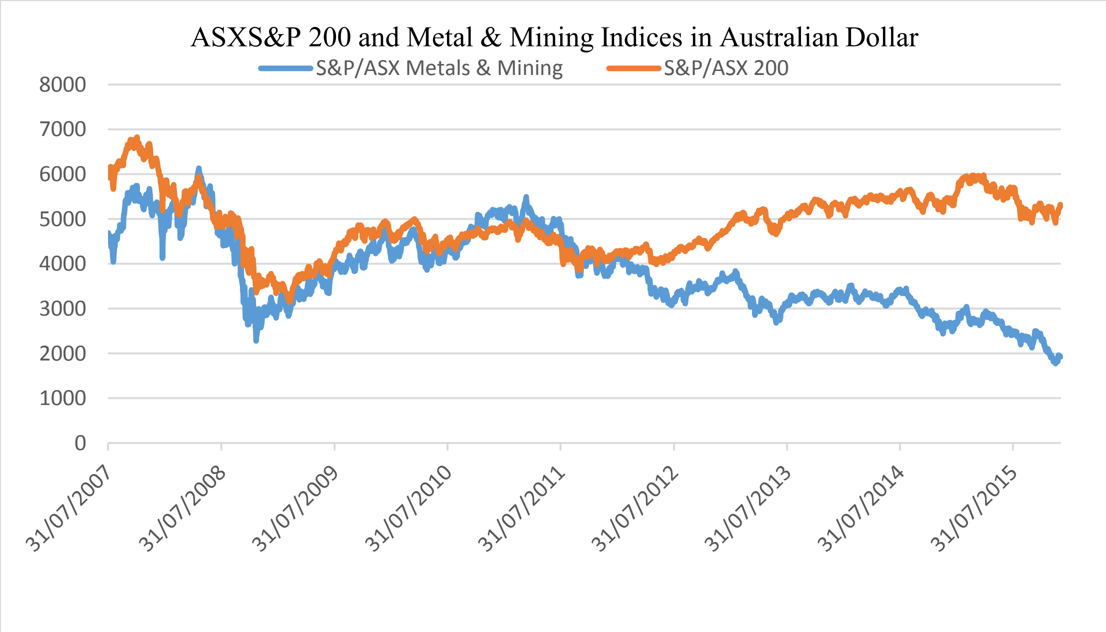
Figure 2: Market Capitalizations by Industry



Source: Metals and Mining Sector fact sheet Profile June 2011, Published by Australian Securities Exchange (ASX).

Indices launched for the industrial and resources sector to identify or compare are S&P/ASX 100, S&P/ASX 200, S&P/ASX 300, S&P/ASX Midcap 50 and S&P/ASX Small Ordinaries. These indices are constructed and identified on the basis of criteria relating to GICS. Resources are outlined as companies categorised in the energy sector (GICS Tier 1) and the metals and mining industry (GICS Tier 3). However, industrial indices are combined of everything and out of the scope of the GICS industrial sector. Analysis of these indices reveals that the mining sector is one of the most important sectors in the Australian equity market. It has also enhanced the profile of gold and metals and mining industry in both Australian and international market. The S&P/ASX 200 metals and mining index is based on the S&P/ASX 200, and includes companies that are categorised in the metals and mining industry (GICS Tier 3). Figure 3 displays the movement of S&P/ASX 200 and S&P/ASX metal and mining indices. Earlier these two indices were used to track one another and thus moved together. It is also evident that the average Australian market has recovered from the GFC; however, the mining stock prices are still in a slump. Therefore, the gap between these two indices has increased.

Figure 3: Australian Benchmark Market (ASX/S&P 200) and Mining (S&P/ASX Metals and Mining) Indices



CHAPTER THREE: THEORETICAL LINKS AND EMPIRICAL EVIDENCE

In an asset pricing model, macroeconomic factors are crucial and they contribute to the asset risk premium. A dividend discount model serves as a theoretical framework to establish a connection between asset prices and macroeconomic variables. This model establishes a channel of transmission between macroeconomic shocks and asset prices. The news or changes in prices of macroeconomic variables affects future cash flows, discounts rates or both, and thereby affects the price of stocks. Moreover, CAPM or APT theoretical models identify the relationship between risk or volatility and stock returns.

According to basic finance theory, the price of a stock is determined by expected dividend cash flows. Earlier studies by Fisher (1930) and Williams (1938) postulate that the expected future income of a stock and the required or expected rate of return[2] of that stock are determining factors of its price. Therefore, any macroeconomic factor affecting either expected income, expected rate of return, or both have a significant effect on stock prices. Since we concentrate on the stock price in this thesis, the price of stock can be determined by the following dividend discount model[3]:

[2] In finance theory, required or expected rate of return is the summation of risk-free rate and risk premium of the asset. Changes in oil prices could affect the risk premium, and therefore the required rate of return could be altered.

[3] Chen *et al*. (1986) mention dividend discount model to provide theoretical linkage between stock prices and macroeconomic risk factors.

$$\text{Value of stock} = \sum_{t=1}^{t=\infty} \frac{E(DPS_t)}{(1+k_e)^t} \quad (1)$$

where $E(DPS_t)$ is the expected dividend per share at time t and k_e is the required rate of return of the investors. The value of stock is calculated by discounting all expected future dividends. Therefore, any factor affecting a future dividend or required rate of return of a stock should have a significant effect on the price of that stock. It is expected that changes in any macroeconomic factors could affect both future dividends and the required rate of return. For example, any oil price increase would lower the price of stock, since higher oil prices increase cost of production, lower profitability, and therefore, an expected dividend would be lowered. Since return is a function of inflation, the changes in oil prices can affect the required returns by changing expected inflation. Driesprong *et al*. (2008) also find that changes in oil prices affect expected cash flows of the companies and alter the expected return of the investors.

Widespread evidence in the finance literature supports a relationship between stock market returns and a range of macroeconomic and financial variables. Historically, it has been observed that stock prices vary in response to news of economic fluctuations. Empirical evidence has confirmed that economic factors can be used to explain stock returns. However, few studies have examined the factors of returns of mineral companies and have focused instead on the energy and other mining sectors. Thus, it is important to review the literature on energy companies and mining companies. An early paper by Chen *et al*. (1986) evaluates the effect of macroeconomic factors on U.S stock return. They identify that few macroeconomic variables have a systematic influence on market return. They further examine the effect of macroeconomic variables on asset pricing. Their findings validate the argument that industrial production, fluctuations in risk premiums, and the term structure are positively related to expected market returns. Following the study of Cox *et al*. (1985), Chen *et al*. (1986) postulate that from the perspective of efficient market theory and the rational expectations of intertemporal asset pricing theory state variables can determine asset prices as these variables can explain economy. Their conclusion is consistent with the asset-pricing theories of Merton (1973) or the APT by Ross (1976). Fama (1981, 1990), Schwert (1990). Ferson & Harvey (1991) find that returns and their aggregate real activity are dependent on each other in the U.S. stock market. Studies by Asprem (1989), Beckers *et al*. (1992) also exhibit consistent results for other markets.

In general, these studies identify the short-term relationship for market returns with changes in economic factors such as inflation rate, interest rates, industrial production, yield curve, and risk premium. Using a stock valuation model with Engle-Granger's (1987) co-integration test between stock market price and dividends, Campbell and Shiller (1988) find a significant long-term relationship between the stock market and macroeconomic factors. Researchers conclude that prediction of dividends and the ratio of the earning variables depend on the long-term earnings of the stocks. These are also a powerful tool for predicting future stock returns.

Rostamy *et al*. (2013) examine studied the correlation between market return and exchange rate with stock returns in nine Indonesian industrial sectors by using monthly data for the period from 1996 to 2008. Results indicate a significant relationship between market return and stock return in nine Indonesian industries. A significant relationship is also found between exchange rate and stock return of the financial, infrastructure, miscellaneous, mining, property, and business industries. Using daily data, Najaf and Najaf (2016) investigate the relationship among stock market return and exchange rate and oil price in sixteen industrial sectors in Turkey, using daily data for the period from 2000 to 2008. Their results show a significant relationship between stock return and market returns and a non-significant relationship between exchange rates and stock returns in the specified Turkish industries.

A few studies have been conducted internationally at the market level and industry level, i.e. Chen *et al*. (1986), Hamao (1988), Poon and Taylor (1991), Dinenis and Stailouras (1998), Cheung and Ng (1998), Canova and Nicolo (2000), Sadorsky (2001), Apergis and Eleftherious (2002), Patro *et al*. (2002), Erdem *et al*. (2005) and Elyasiani and Mansur (1998) (2013), Rostamy *et al*. (2013). Humpe and Macmillan (2009) apply a co-integration vector analysis to investigate the relationship between U.S. and Japanese stock prices with industrial production, the consumer pricing index, money supply and long-term interest rate. Their research demonstrates that stock prices are positively linked to industrial production and negatively linked to consumer price index and long-term interest rate. A positive yet insignificant relationship of stock returns is found with money supply. Their analysis of the Japanese market suggests two co-integrating vectors, where one vector indicates positive relationship between stock prices and industrial production and negative association with money supply while the second vector indicates negative relationship between industrial production and interest rate and consumer price index.

Boyer and Filion (2007) focus on oil and gas companies in Canada, and explore determinants and risk factors. Sadorsky (2001) explains the multi-factor model by examining Canadian market return, crude oil price, exchange rate between the U.S. and Canada as well as the short-term interest rate. He concludes by stating that these four factors affect Canadian energy stocks, and that the market return and crude oil price have much more impact than the exchange rate factor and the short-term interest rate factor. He uses two equation models: in model one, he uses oil return and market return as parameters; and model two, he includes interest rate and exchange rate. Both models are estimated using an ordinary least squares method. Results from model one indicate that market beta and the oil beta are positive and statistically significant. It is also determined that adjusted R^2 value explains the deviation of the stock price by market and oil price returns. The findings from model suggest that multifactor model has significantly higher explanatory power than the single factor market model. The general findings from Sadorsky's (2001) model two indicate the statistical significance of each factor on the stock return of Canadian oil and gas sectors. The coefficient of market return beta used in model two is also similar to model one, which signifies the robustness of the findings. However, with regard to the oil price risk factor it is evident that, if oil price changes significantly, the stock price will also be changed. Term premium and exchange rate factor are found to be negative and statistically significant, which means the stock return will be lower if the borrowing cost of a company is higher.

Exchange rate variable has a negative coefficient in the model, which implies that an increased exchange rate will decrease the oil and gas stock return for Canada. This researcher concludes that oil and stock price has a positive effect whereas the deflated Canadian dollar and increased interest rate factor has a negative effect on the stock prices.

According to Ferson and Harvey (1991), interest rate and market return are the most important determinant factors in the U.S. petroleum stock market. Boyer and Filion (2007) explore the fact that macroeconomic factors and firm-specific factors are common to all firms and should explain total returns. These researchers have also investigated how macroeconomic factors affect oil intensive and natural gas intensive firms. Using economic factors of interest rates, exchange rates, shocks in oil and gas prices, they assess the impact on the stock returns of Canadian oil and gas companies. Their findings suggest that the average systematic risks of the Canadian energy firms are below average when compared with other corporations in Canada. These results are true for both integrated energy firms as well as oil or gas producers. They also find one surprising result: that firms producing more crude oil or natural gas receive less returns for their stock from the market, whereas, in normal circumstances, increased production increases the cash flow of the firm's. In another study, O'Neil *et al*. (2008) also observe similar result for oil and gas companies in U.S. Dayanandan and Donker (2011) extend their study to North American oil and gas companies and observe positive impact on the stock returns implying higher oil prices lead to higher return and vice versa.

While working on several industrial sectors within the G-7 nations of Canada, France, Germany, Italy, Japan, UK, and the U.S.; Lee (2012) establishes the fact that oil price doesn't have any impact on the composite indices on their economies when the Granger causality method is employed, whilst it has significantly influenced the individual sector indices of some countries. For example, in this thesis 50% of the German, French, and U.S. industry sectors are affected by an oil price change; whereas the other four economies are not significantly impacted. These researchers also establish the fact that in the industrial sector, the IT sub-sector is ranked first followed by consumer staples, and these sectors are impacted more frequently by changes in oil price. They also find that the transportation sector in the U.S. and the utility and financial sector in Germany are affected by the oil price shocks. Health care, energy materials, and telecommunication sectors are not significantly influenced by the oil price shocks for the G7 economies. Besides that, the findings indicate that higher stock prices reflect the growth rate of the economy, which will result in an increase in oil demand and prices.

Bert, S. and Yurtsever, C. (2012) also use the vector auto regression (VAR) model to analyse the relationship between oil price and the value of 38 European industries. They conclude that oil price shocks have a positive relationship with those industries that have oil and energy as an output (oil, gas, mining, electricity) but, with those that have oil and energy as an input, the pattern is quite different. Ramos and Veiga (2011) study the exposure of the oil and gas industry stock returns of 34 countries to several macroeconomic variables. They find that the returns of oil and gas industry predominantly depend on the market portfolio and oil price returns. They also detect the asymmetric effect of oil price changes on the returns of this sector. Their research makes it evident that market portfolio, currency rates, interest rates, and oil price can have a significant impact on the equity returns of oil and gas industry companies and markets. They also remark that an oil and gas industry, when operating as a multinational, is strongly affected by local market return. These findings are supported by Elyasiani and Mansur (2013), who use the GARCH (1,1) methodology to study the risk and return patterns of thirteen U.S. industrial sector under the four major types of industries of utilities., resources, oil-user, and financial. They find strong evidence that fluctuations in oil price is an important macroeconomic factor. It is also statistically significant as nine of the thirteen sectors studied where systematic asset price risk is incorporated. In contrast, both changes in oil futures return and the volatility of oil price return influence the financial sectors return. Huang *et al*. (1996) opine that if oil plays an important role in an economy, then changes in oil price and changes in the stock market will be correlated.

There is no company level study to identify the effect of oil prices on mining companies in Australia. However, for Australian mining companies, there is a study by Ball and Brown (1980), who use accounting variables on evaluating risk and return patterns. Faff and Brailsford (1999) work on various industrial sectors of the Australian stock market to determine the effect of oil price shocks. They use an augmented market model of APT to investigate the sensitivity of industry equity returns to an oil price factor over the period 1983–1996. They find that oil and gas as well as diversified resources industries are positively affected by energy prices to a significant degree, whereas. And the paper and packaging, and transport industries are negatively affected. Their research also indicates that energy price is likely to have a direct and indirect influence on the operational cost of many companies. Consequently, management in these industries needs to be aware of the risks resulting from these changes. Using time series analysis on monthly data, McSweeney and Worthington (2008) also examine the impact of the market, oil price, exchange rate, and interest rate to stock returns in nine industrial sectors in Australia. Results confirm the statistically significant correlation between market return and stock returns in each of the nine industrial sectors. The energy sector shows the evidence of a strong positive exposure to oil price changes, while the transportation and the banking sector exhibit negative association with the changes in oil prices.

Researchers have also indicated that other macroeconomic factors influence industry returns. Empirical evidence has shown, while market portfolio plays an important role in all industry's excess return, the energy, materials, and media industries are more volatile than finance, retail, and transport. Similarly, exchanges rates and term premiums are also identified as a dominant factor for excess returns in the energy, insurance, and retail industries with diversified financial instruments. The Australian stock market currently finances a large proportion of exploration companies, many of which are gold mine companies. Faff and Chan (1998) evaluate the performance of Australian gold industry stocks using a multi-factor model in the Australian equity market for the period 1979–1992. In another study, using the multi-factor model, Hasan & Ratti (2014) examine the panel stock data for Australian coal companies from the Australian stock exchange for the period 1999–2010 and conclude that macroeconomic factors such as market rate, interest rate, and foreign exchange rate, are the significant determining factors in the Australian coal industry returns. They also find the significance of oil price volatility with the Australian energy sector in another study by Ratti and Hasan (2013).

In summary, there is no study has focused on examining the priced risk factors of the stock returns at a company level in the mining sectors in Australia. We will analyse the stock data from 155 listed mining companies over eleven years, using the panel data method. In this thesis we will develop and estimate a model that is capable of explaining movements in the conditional volatility of Australian mining stocks. In the view of the increased global demand for mining resources, notably from emerging Asia, that underpins significant changes in the contemporary mining sector in Australia, we aim with this study to broaden understanding of the macroeconomic risk factors affecting the stock returns of the Australian total mining industry.

Literature Review Summary Table

Name and Year of the Author/s	Market data	Summary of the literature
Ball, R., & Brown, P. (1980).	Shares in mining companies and shares in industrial and commercial companies.	The results of this research indicated that there are less rewards in the mining industry than in the industrial and commercial business shares. The industrial and commercial companies proved to offer higher prices in their shares hence attracting investors to the industry.
Fama, E. F. (1981).	Stock return and inflation	Total return variation is explained by cash flows expected shocks and expected return shocks to judge the rationality of stock prices.
Chen, N., Roll, R., & Ross, S. A. (1986).	The stock market and the select macroeconomic variables at log-levels, in India (1991:01 to 2008:04).	These research findings showed that there is a positive relation between the long run stock market behaviour to output and exchange rate. With long-term interests, money supply, and inflation, the relation is negative.

Engle, R. F., & Granger, C. W. (1987).	Co-integration and error correction models.	This article provides empirical examples, procedures, and estimations. Co-integration tests are suggested and examined by Monte Carlo simulation. Error correlation representations, autoregressive, and the moving average are connected by a representation theorem.
Campbell, J. Y., & Shiller, R. J. (1988).	US stock market data.	The estimates for aggregate data from the US stock market indicated that the real wages for the historical period 1871 to 1986 was a good predictor of future and the current value. The weighted average of moving average earnings and current real price is the optimal forecast of the present value and future real dividends.
Faff, R., & Chan, H. (1998).	Gold prices, interest rates, and exchange rates in Australian equity.	This paper examines the empirical performance of a specification that puts in place multi-factor model and the three variables. Gold prices factors, the paper identifies, are only from variables with significant power.
Elyasiani, E., & Mansur, I. (1998). (2013)	Stock return distribution of 10 major US sectors.	The investigation uses the FIGARCH model to capture the GARCH, IGARCH, and Fama-French as the study cases and proceeds to test their validity. The investigation concluded that oil return is a significant variable of every sector's return and return volatility.

Sadorsky, P. (1999).	Oil prices and oil price volatility on real stock returns.	Through vector regression indicated a large fraction of forecast error variance in real stock returns as compared to interest rates and that volatility of oil prices has asymmetrical impacts on the economy.
Faff, R. W., & Brailsford, T. J. (1999).	Equity returns and the oil price factor in Australia 1983-1996.	Through an augmented market model the paper findings indicate that, despite the presence of persistent long-term effects of equity returns on oil prices, most firms have passed the burden to the customer to reduce risks.
Sadorsky, P. (2001).	Exchange rates, crude oil prices, and interest rates and their impact on the stock price returns.	This paper presents results from an investigation of variables that indicate that stock price returns in Canada are greatly impacted on by crude oil prices, exchange rates and interest rates.
Sadorsky, P. (2004).	Oil prices and stock market returns	This paper uses an international multi-factor model to incorporate both unconditional and conditional risk factors in examining the relationship of the variables. The findings are that oil price risk impacts stock price returns in upcoming markets.
Boyer, M. M., & Filion, D. (2007).	Natural gas prices, internal cash flows, interest rates, and stock market return.	This paper, based on Canadian energy stock, finds that the market is positively impacted by appreciations of crude oil and prices of natural gas. However, the weakening of the Canadian dollar against the U.S. dollar has a negative impact.

Park, J., & Ratti, R. A. (2008).	Oil stock returns impact on the real stock returns in the US and Europe.	This article looks into the impact of oil price increases/ shocks in the period 1986–2005. The results indicate that, in European countries, increased volatility of oil prices has a significant depression on real stock returns. This is not the case in the U.S.
Ramos, S. B., & Veiga, H. (2011).	Risk factors in investing in oil and gas industry.	This article explains the recent boom of investments in oil and gas industry and the risk factors to investors globally. Results from this investigation indicated that the oil and gas industry stands out as result of pass through effect. While there is an asymmetrical response to oil prices in the oil and gas industry, oil price rise has no parallel proportion in the commodity industry.
Rostamy, A. A. A., Hosseini, G., & Bakhshitakanlou, F. (2013).	The impact of market return, oil price, exchange rate and interest rate changes on stock returns.	This study covers 36 sectors of industry in the Tehran Stock Exchange for the monthly data in the period November 2003 to November 2008. The study uses the multivariate regression model to examine the variables. The findings indicate that, market returns, oil prices, and interest rate changes as well as exchange rates do significantly impact on industry returns.

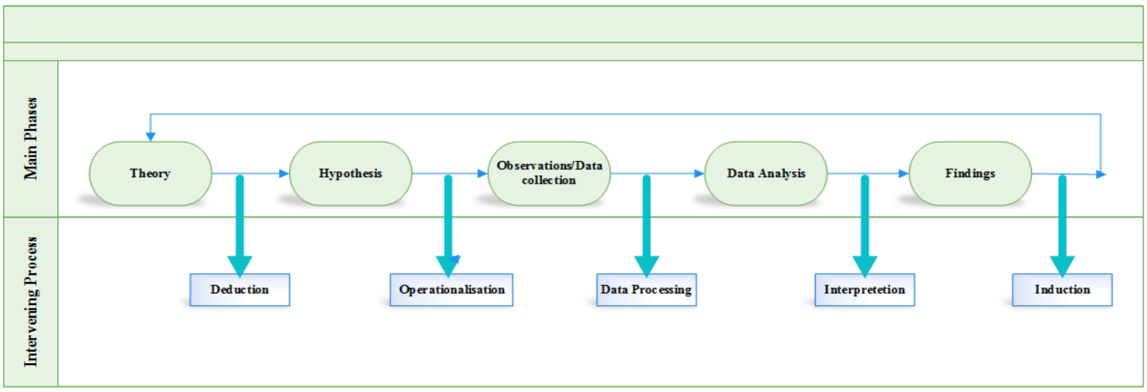
Ratti, R. A., & Hasan, M. Z. (2013).	Oil shocks and return volatility in Australian stock market.	This paper looks into sector returns, rather than the general index of stock returns, since they may differ in their response to fluctuating oil prices or price shocks. The results indicate that a rise in prices increases returns in material sectors and the energy sector. The returns to financial sector get lower with increases in oil prices.

CHAPTER FOUR: METHODOLOGY

To define research Slesinger D. and Stephenson M. (1930) define research as "the manipulation of things, concepts, or symbols for the purpose of generalizing to extend, correct, or verify knowledge, whether that knowledge aids in construction of theory or in the practice of an art." Also Creswell (2008) states that research is a process that involves collecting and analysing data to understand a topic or issue. Three steps are recognised by him: Pose a question, collect data to answer the question, and present an answer to the question. Research follows an impartial and systematic method to gain knowledge and clarify a problem or issue. A research methodology has various steps that include defining a clear purpose and objective, outlining the research problem, and developing approaches to find a solution to it. Mills (1959) has defined research methods as a procedure to understand or explain problems. According to Emory (1980), a research methodology consists of four major stages: exploration of the situation, development of the research design, data collection and analysis, and interpretation of the results. Kothari (2004) states that the objective of a research method is to understand the problems by using scientific techniques. Though every research study has its own specific objectives, a clear research methodology is important if the research is to be systematic and logical in its process and the result has a sound foundation.

There are two types of methodology can be used for the research thesis, which are quantitative and qualitative, which are also known as deductive and inductive methods, respectively (Bryman, 1988). A quantitative method involves structuring the information gleaned from primary and/or secondary data sources and solves the research problem by employing different statistical tests and working with measurable units. According to Gill and Johnson (2002) a quantitative method is used for the development of a conceptual and theoretical structure before testing it through empirical observation. However, Creswell, J.W. (1994) argue that the quantitative study of theories and hypotheses involves testing them according to cause and effect, which is characterized by the use of rational arguments and logic. Concepts, variables and hypotheses are selected before the start of the study and remain fixed during the study (see Figure 4). Qualitative methods deal with theoretical issues and concerns and subjective accounts of the research, and observations are not measurable. Creswell, J. W. (2013) also argue a research can adopt a 'mixed method' approach, which involves the study of human and social problems by combining both statistical trends and stories. An emerging approach, mixed methods can provide a more comprehensive understanding of the problem and its solution.

Figure 4: The Logical Structure of the Quantitative Research Process adapted from Creswell. J.W (1994)



Source: Creswell, J. W. (2008).

The objective of this research is to study the effect of macroeconomic variables on Australian mining stock returns. We employ quantitative approach as it would enable us to estimate the extent and direction of the effect of the macroeconomic factors on the mining stock returns. A fundamental relationship can be established using the estimated coefficient. After estimation of the model, hypothesis testing will be performed to conclude whether the estimated findings are statistically significant or not. We use both time-series and panel data models. For panel data, we employ the fixed effect with ordinary least square (OLS) methodology and random effect with generalized least squares (GLS) technique. To effectively control data heteroscedasticity and autocorrelation, the GLS technique is used. Baltagi (2001) argues that data that is collected using the panel data method is more reliable and informative, has less co-linearity among the variables, and more degrees of freedom. A method that employs panel data is also an effective way of dealing with heterogeneity and examining the fixed and/or random effects in the time-series data.

4.1 Literature review for methodology

Elyasiani, E. *et al*. (2013) use the GARCH technique to identify the risk and return patterns of thirteen industrial sectors in the U.S. Ramos and Veiga (2011) use the multi-factor model to study oil and gas indices from 34 countries using monthly data from May 1998 to Dec 2009. This factor model is also used by Ferson and Harvey (1994), Tufano (1998), Karolyi and Stulz (2003) and Jin and Jorion (2006). However, Faff and Brailsford (1999) use a two factor / augmented market model to examine the sensitivity of Australian industry equity returns to an oil price factor. Al-Mudhaf and Goodwin (1993) also use two factors APT model to investigate a sample of 29 New-York stock exchange listed oil companies return covering the period 1970–1978, by using market and oil price change factor.

Since the work by Darby (1982) and Hamilton (1983), the VAR model has been frequently used to analyse the impact of oil price shocks on economic activity. Huang et al (1996) use this model to reveal the relationship between daily U.S oil futures returns and stock returns. Similarly, Sadorsky (1999) and Papapetrou (2001) use this model to discuss the relationships between economic variables in regard to U.S. stock returns and Greek stock returns respectively. Bjørnland (2008) also uses the structural VAR model to find out the oil price-motivating effect within the Norwegian economy. Recently Scholtens, Bert, S. and Yurtsever, C. (2012) uses an unrestricted VAR model to establish the dynamic relationship between the variables without making many assumptions for the 38 industries in European economy and twelve industry indices for G7 countries.

Other popular techniques in use are the Johansen or Engle-Granger co-integration technique and Granger causality test. Co-integration analysis is fundamentally multivariate, as two or more time series are co-integrated. In this theory, data maintain an equilibrium relationship and also both the time-series data that are integrated are of the same order. The Granger causality test was introduced by Clive Granger (1969) and is another way to determine the forecasting efficiency of a time-series data in relation to another. It can be used when data are non-stationary. Other researchers have used this technique to find out the long-term relationship between a macroeconomic variable and the stock prices. For example, Chaudhuri and Smiles (2004) use this model when working with the Australian stock market and economic factors. Similarly, Nasseh and Strauss (2000) find a significant relationship between stock market and the economic activity within several European countries using this model. Also Cheung and Ng (1998) use the similar approach in his research.

Though theoretically appealing and practically simple, the ECM cannot be used in complex situations involving a number of stationary variables. In such situations one can choose vector error correction models (VECM), which are multivariate specification of the ECM. Mukherjee and Naka (1995) use the Johansen co-integration test in a VECM model to find the relationship between the Japanese stock market and another six macroeconomic variables. Mayasmai and Koh (2000) use a similar model to determine these relationships within the Singapore stock market. Again Kwon and Shin (1999) find that the stock market is not the leading indicator for the set of economic variables.

4.2 Panel data

Panel data consists of both time-series and cross-sectional components of the data. It is a method that studies multiple sites that are periodically observed over a defined timeframe. In panel data, observations have at least two extents; a) a cross-sectional dimension indicated by subscript i, and b) a time-series dimension indicated by subscript t. However, panel data can also consist of a more complicated structure or clustering. For example, the panel analysis equation of the personal expenditures might be expressed as follow:

$$y_{it} = a_i + \mu_1 x_{1it} + \cdots\cdots\cdots + e_{it} \quad (2)$$

Where y_{it} is the dependent variable for i at time of t, a is the intercept of the equation, x_{it} is the independent variable of i, μ is the vector of coefficient, and e is the error term.

Using panel data gives the researcher flexibility when working with a large number of facts. It improves the efficiency of the model by reducing the collinearity among explanatory variables and increasing the degrees of freedom. Researchers can use panel data to investigate a number of economic questions, which might not be addressed by using cross-sectional or time-series data. Panel data is more adaptable and variable, and superior when identifying and measuring effects those are simply not detectable in other data types.

In general, panel data has two types of model: a fixed effect model and a random effect model. In the fixed effect model, random variables are allowed to be correlated with the explanatory variables. This model represents the observed quantities as explanatory variables where the quantities were non-random in nature. A random effects model is known as a variance component model. It is a kind of linear model where individual specific effect of random variables are uncorrelated with the explanatory variables. Random effects models are also used analysis assume or accept that there are no fixed effects. This random effect model assumes that the residual term is not correlated with predictors. Therefore, it allows time invariant variables to play a role as explanatory variables. Whilst there is time invariant variable in our model, we use a random effect model because the variation across the entities is assumed to be random and uncorrelated with the regressors considered in the model. The variable specific effects are to be orthogonal to the other covariate in the random effects model.

To understand the preferred model for research, a Hausman test is used in the literature. The null hypothesis of the test is that the preferred model is random effects whereas the alternative hypothesis is that fixed effects are at least consistent and thus preferred. The Hausman test is as follows:

$$H_0: \alpha_i \perp X_{it}, Z_i$$

$$H_a: \alpha_i \nmid X_{it}, Z_i$$

If H_0 is true, both $\hat{\beta}_{RE}$ and $\hat{\beta}_{FE}$ are consistent, but only $\hat{\beta}_{RE}$ is efficient. If $H_a$is true, $\hat{\beta}_{FE}$ is consistent and $\hat{\beta}_{RE}$ is not.

The organization of the panel data is a painstaking process; however, it allows us to investigate more issues than either cross-sectional or time-series data. As Baltagi (2001) mentions, for research, panel data is more informative and efficient, it also has more variety with less co-linearity among the considered variables. In this research we will employ both fixed effect and random effect model to inform the study. This study will also use the Hausman test to understand the suitable model for the research.

CHAPTER FIVE: THE MULTI-FACTOR MODEL

5.1 Macroeconomic Risk Factors

In theories of financial economics, stock prices of a firm are affected by the macroeconomic variables. Effect incurs through the impact on firm's future cash flows and required returns or discount rates. It suggests that the movement of macroeconomic variable directly affect either expected cash flows or discount rate. In this research, the macroeconomic variables are assumed to be key state variables in asset pricing as the variables affect future investment opportunities and consumption. In our research, we consider market returns, various foreign exchange risks, interest rate risks, oil and coal price shocks as important determinants of the returns of mining companies in Australia.

There is a close association between a company's stock return and average market return. From a theoretical perspective, the asset pricing theory by Merton (1973) and Sharpe (1964) establishes connections between company stock return and average market return. The empirical literature also identifies that market return has a strong effect on a company's stock returns. For example, Basher and Sadorsky (2006), Faff and Brailsford (1999), Sadorsky (1999) and others use market return as the explanatory variable for their research. Therefore, this study also considers market return as an explanatory variable of the mining companies' return. We expect that market return would be the most contributing factor.

One of the important characteristics of mining companies is that they are heavily involved with international trade of import and export. The exchange rate of the domestic currency has direct effect on the revenue of these companies, and in turn their profitability and cash flows are affected. Thus, mining companies are exposed to foreign exchange risk. In a breakthrough paper, Jorion (1991) contends that the performance of the multinational resource companies are directly linked to foreign exchange fluctuations. From Australian perspective, Faff and Brailsford (1999) augment their study by including foreign exchange risk factor to research on the effect of the various industries' equity return to the oil price shocks. Khoo (1994) estimates the foreign exchange risk exposure to stock return and finds that the foreign exchange risk factor has a significant effect on the return of the mining companies.

Interest rate also plays a crucial role for mining companies. The finance literature finds the evidence of statistical significance of interest rates on stock return of resource companies. For example, Boyer and Filion (2007), and Chan and Faff (1998) include interest rate factor into their regression model in identifying the determinants of stock returns of mining related companies. Interest rate plays a role in two ways: firstly, since investment is a function of interest rate, a higher interest rate jeopardises the investment possibility of the companies, and a lower interest rate facilitate it. Mining companies are capital incentive, and the success of the company depends on investment. Investment is required to purchase capital equipment, and to explore coal mining. Sadorsky (2001) mention that oil and gas companies demand a large amount of capital for maintaining their extensive operations in existing mines and for the investment in finding new reserves. As mining companies require the same high amount of capital and interest rates are the cost of these capitals, interest rate is expected to affect the stock return of the mining companies. Most mining companies are heavily leveraged because of the high requirement of the investment. So, when the interest rate fluctuates, profitability and cash flows are affected. Secondly, random fluctuations in interest rate create uncertainty and therefore, affect the future profitability of the company. In this case, the investors might be cautious to invest and it would lead to slow investment. All these, in turn, affect the return of the mining companies.

When the economy perceives higher energy prices as shocks, mining companies embrace higher coal prices if they are involved in coal trading. The higher coal prices lead to more cash flows and as a result more profit to the coal mining companies, and the opposite occurs when coal prices decline. However, the effect can be inverse if the mining companies use coal as a cost of production. Mining companies respond to information about higher or lower coal prices by changing their stock prices. When coal price increases, the future expected profit and cash flows of the mining companies will increase and the stock price will go up. The opposite will happen when coal prices decline. Sadorsky (2004) describes the importance of energy prices for energy companies like oil, gas, and coal. He mentions that energy price increases are suitable to companies engaged in energy industry, although they are not welcome to the economy as a whole. Consequently, coal price risk is a concern for coal companies. El-Sharif *et al*. (2005) and Boyer and Filion (2007) observe a positive association between changes in oil prices and oil companies' stock returns. Park and Ratti (2008) also find that rises in the price of oil lead to higher stock returns of oil and gas industries for thirteen European countries.

Oil price is perceived as one of the important macroeconomic variables and its effect on stock return is well established. At first, Chen *et al*. (1986) considers oil prices as a risk factor for stock prices; they do not find any significant oil prices changes on stock return. Jones and Kaul (1996) observe that oil prices, through changes in the cash flows of the companies, have influenced stock prices in the U.S. and Canada. Sadorsky (1999) reports a significant relationship between oil price changes and stock returns in the U.S. Park and Ratti (2008) show that oil prices have a negative impact on stock returns in the U.S. and in twelve European countries. In the Australian context, Faff and Brailsford (1999) study the effect of oil prices on various industries of Australian stock market. They find significant and positive oil price sensitivity to the oil and gas, and diversified resource industries, and negative oil price sensitivity to the paper and packaging, and transport industries. Thus we also consider oil risk factor in our study.

5.2 The Regression Functions

We employ a multi-factor APT model to panel data to identify the priced risk factors for Australian mining companies' returns. We follow the models used in Hasan and Ratti (2015). In their study, they identify the impact of oil price returns on coal sector returns in various countries. As explained in the previous section, in our model, the stock returns of the mining companies in Australia are expected to be affected by the energy price shocks, foreign exchange fluctuations, changes in interest rates and market returns. The regression model is as follows:

$$r_{i,t} = \vartheta + \delta_m r_{m,t} + \delta_i r_{i,t} + \delta_{fx} fx_{i,t} + \delta_o r_{o,t} + \delta_c r_{c,t} + \mu_{i,t} \qquad (3)$$

where $r_{i,t}$ represents the excess return of the mining companies i at time t, r_m is the excess market return, $i_{i,t}$ is the changes in interest rates, $fx_{i,t}$ is the foreign exchange returns of the U.S. dollar, the euro or the Japanese yen t, $r_{0,t}$ is the oil price return, $r_{c,t}$ is the coal price return, ϑ is a constant, and $\mu_{i,t}$ is an error term. We calculate excess returns subtracting the risk free rate of return from respective returns. We estimate our regression model using both fixed effect and random effect models. The fixed effect model follows the ordinary least square (OLS) methodology and the random effect model follows generalized least squares (GLS) technique. The GLS methodology has the advantages in controlling heteroskedasticity and autocorrelation evident in the data.

Since oil prices and coal prices are closely associated, we would have a problem of multicollinearity if we use them in the same regression equation. To avoid this problem, we calculate orthogonalised oil price returns. Following Hasan and Ratti (2015), we regress oil price returns on coal price returns and estimate residuals. These residuals will be incorporated into the model (3) to understand the impact of oil price shocks on the stock returns of the mining companies[4]. The regression of orthogonalised oil price returns is as follows:

$$r_{o,t} = \phi + \varphi r_{c,t} + \varepsilon_t \quad (4)$$

[4] Our calculation shows the correlation between coal price and oil price is 0.78 for the data period between 2004 to 2015.

Here, $r_{c,t}$ is the coal price return at time t, $r_{o,t}$ oil price return at time t and ε_t is an error term encapsulating the information of oil price returns not that are not available in coal price return. The estimated error forms orthogonal oil return variable. This estimated variable using equation (4) will be augmented into equation (5) to capture the effect of oil price shocks. This orthogonalised oil price return is termed as $r_{o,t}^{orth}$. The model incorporating orthogonal oil price return forms the following equation:

$$r_{i,t} = \vartheta + \delta_m r_{m,t} + \delta_i r_{i,t} + \delta_{fx} fx_{usd,t} + \delta_c r_{c,t} + \delta_o r_{o,t}^{orth} + \mu_{i,t} \qquad (5)$$

If we find the coefficient δ_o in equation (5) is statistically significant, then we can contend that oil price returns are priced risk for mining companies outside the impact of coal price return. For foreign currency risk factor, equation (5) only considers U.S. dollar against Australian dollar.

We expect the volatility of energy price returns can also affect the stock returns of the mining companies. Literature identifies the inclusion of volatility measure of energy prices in studying the determining factors of stock returns. For example, the study by Sadorsky (1999) incorporates both oil price shocks and oil price volatility into regression equation and finds the evidence of role in explaining U.S. stock returns in various sectors. In another study, Hasan and Ratti (2015) also use volatility of oil and coal prices in identifying prices risk factors of coal companies. The justification of using volatility term is that higher volatility in energy prices leads to uncertainty of the demand for the mining products. It can also affect expected return on investment of mining companies as the successes of the mining companies are linked to energy prices. A model that captures the effects of energy price volatility is given by:

$$r_{i,t} = \vartheta + \delta_m r_{m,t} + \delta_i r_{i,t} + \delta_{fx} fx_{usd,t} + \delta_c r_{c,t} + \delta_o r_{o,t}^{orth} + \delta_{coalvol} \sigma_{c,t}^2 + \delta_{oilvol} \sigma_{c,t}^2 + \mu_{i,t} \quad (6)$$

In equation (6), the volatility in oil price is denoted by $\sigma_{o,t}^2$ and volatility in coal price is denoted by $\sigma_{c,t}^2$. Oil and coal price volatilities are estimated by the error terms that are not assumed in the oil and coal prices changes in the last period.

We evaluate the effect of oil and coal return volatility on the return of Australian mining companies. Volatility creates uncertainty, deteriorates investment possibility and affects the firm value (Ramos and Veiga, 2011). Lee *et al*. (1995) suggest using volatility when studying the effect of energy price changes, since energy price fluctuations are likely to have a greater impact on environments where energy prices have been stable. Following the methodology provided in Ramos and Veiga (2011), we measure oil and coal price volatility by employing moving average technique of the following equation:

$$\sigma_t^2 = \left[(m+1)^{-1} \sum_{j=0}^{m} \varepsilon_{t-j}^2 \right]^{0.5} \quad (7)$$

with t = 0...n-m-1 and m=4, obtaining by fitting an AR (1) model to oil and coal returns,

$$r_{o,t} = c + \phi r_{0,t-1} + \varepsilon_t \quad (8\ a)$$

$$r_{c,t} = c + \phi r_{c,t-1} + \varepsilon_t \quad (8\ b)$$

Volatility is estimated from the residuals or error terms which are not accounted for by the previous changes in oil and coal prices. Oil and coal price returns are regressed on their previous monthly returns and then residuals are estimated. Researchers, for example, Doran and Ronn (2008) prefer to use this methodology when both return and volatility are evaluated in the same model.

We also study the asymmetry effect of energy prices on mining companies. Positive changes in oil prices do not have equal effect of negative changes in oil prices. In general, the rise in oil price has greater effect on stock returns than equal decline in oil prices. Finance literature also documents the evidence of asymmetric effect of energy prices in empirical studies. The studies by Balke *et al*. (2002), Davis and Haltiwanger (2001) and Mork (1989), amongst others for the U.S., by Lee *et al*. (2001) for Japan, by Huang *et al*. (2005) for Canada, Japan, and the U.S., and by Cunado and Perez de Garcia (2003) for most European countries.

To test the asymmetric effect of oil and coal price changes on the mining companies return, we need to estimate non-linear measures of these two variables. In general, nonlinearity is measured by differentiating positive changes in prices from negative changes. For example, Nandha and Faff (2008) and Sadorsky (2008) have measured nonlinearity of oil price changes in their studies using the same methodology. This can be measured by using following equations:

$$op_t = \max\{0, ln(oil_t) - ln(oil_{t-1})\} \quad (9a)$$

$$cp_t = \max\{0, ln(coal_t) - ln(coal_{t-1})\} \quad (9b)$$

$$on_t = \min\{0, ln(oil_t) - ln(oil_{t-1})\} \quad (9c)$$

$$cn_t = \min\{0, ln(coal_t) - ln(coal_{t-1})\} \quad (9d)$$

Where op_t (on_t) is the positive (negative) changes in oil prices and cp_t (cn_t) is the positive (negative) changes in coal prices. We have positive value of oil or coal price changes when the returns are positive and zero otherwise. We augment our model by incorporating these asymmetric measures of oil and coal returns into the following equations:

$$r_{i,t} = \vartheta + \delta_m r_{m,t} + \delta_i r_{i,t} + \delta_{fx} fx_{usd,t} + \delta_c^p cp_t + \delta_c^n cn_t + \delta_{coalvol}\sigma_{c,t}^2 + \mu_{i,t} \quad (10a)$$

$$r_{i,t} = \vartheta + \delta_m r_{m,t} + \beta_i r_{i,t} + \delta_{fx} fx_{usd,t} + \delta_c^p op_t + \delta_c^n on_t + \delta_{oilvol}\sigma_{o,t}^2 + \mu_{i,t} \quad (10b)$$

We follow another measure of asymmetry of energy price return proposed by Hamilton (1996). Net oil price increase ($nopi$) will capture unsustainable large increase in the price of oil. Net coal price increase ($ncpi$) will do the same for coal prices. Although an unusually large increase in oil and coal prices might have negative effect on aggregate stock market, the effect of the same might be positive in case of mining companies of our study.

Following Hamilton (1996), the net oil and coal price return measures used in this chapter are the net coal and oil price increases and decreases over the previous 12-months given by:

$$ncpi_t = \max\{0, \ln(coal_t) - \ln(\max(coal_{t-1}, \ldots\ldots, coal_{t-12}))\} \quad (11a)$$

$$nopi_t = \max\{0, \ln(oil_t) - \ln(\max(oil_{t-1}, \ldots\ldots, oil_{t-12}))\} \quad (11b)$$

$$ncpd_t = \min\{0, \ln(coal_t) - \ln(\min(coal_{t-1}, \ldots\ldots, coal_{t-12}))\} \quad (11c)$$

$$nopd_t = \min\{0, \ln(oil_t) - \ln(\max(oil_{t-1}, \ldots\ldots, oil_{t-12}))\} \quad (11d)$$

where $ncpi_t$, $ncpd_t$, $nopi_t$, and $nopd_t$ are net coal price increase, net coal price decrease, net oil price increase, and net oil price decrease respectively at time t. By net price increase (decrease), we measure when the log price of coal and oil price exceeds its maximum (minimum) over the last twelve months. These non-linear transformations filter out relatively small increases and decrease in the price changes of coal and oil and identify large price changes relative to those over the last twelve months. Bernanke et al. (1997) and Lee and Ni (2002) apply this transformation in understanding the macroeconomic effect of oil price shocks. Net oil price increases and net coal price increases are displayed in Figure 5 and Figure 6. The figures identify that oil prices have more frequent positive changes than coal prices.

The following model incorporates the effects of energy price asymmetry of Hamilton (2008):

$$r_{i,t} = \vartheta + \delta_m r_{m,t} + \delta_i r_{i,t} + \delta_{fx} fx_{usd,t} + \delta_{ncpi} ncpi_t + \delta_{ncpd} ncpd_t + \delta_{coalvol} \sigma^2_{c,t} + \mu_{i,t} \quad (12a)$$

$$r_{i,t} = \alpha + \delta_m r_{m,t} + \delta_i r_{i,t} + \delta_{fx} fx_{usd,t} + \delta_{nopi} nopi_t + \delta_{nopd} nopd_t + \delta_{oilvol} \sigma^2_{o,t} + \mu_{i,t} \quad (12b)$$

Figure 5: Net Oil Price Increase (NOPI)

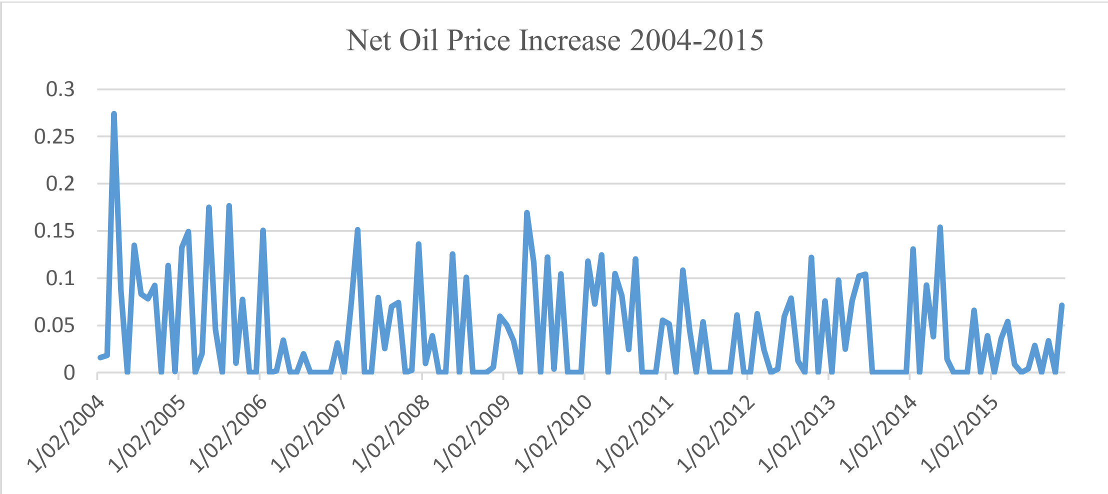
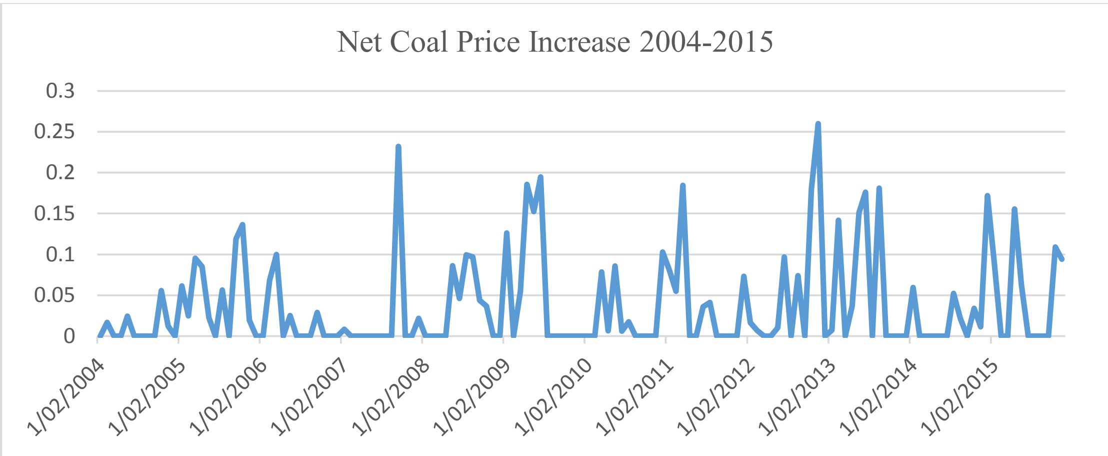


Figure 6: Net Coal Price Increase (NCPI)



CHAPTER SIX: DATA DESCRIPTION AND DESCRIPTIVE STATISTICS

The main focus of the research is to study mining companies in Australia. In this regard, we consider all the listed mining companies in ASX, of which there are over 700. To create balanced panel data, we only consider the 155 companies with available data from 2004 to 2015. Our study period is from January 2004 to December 2015. Data are monthly and we have 144 monthly observations for each variable. We calculate the excess return series for the mining companies is by subtracting the short run government bill rate from stock return of the mining companies. Stock returns of the mining companies are calculated by the log difference of consecutive two month's stock prices.

For benchmark market return data, we have the options of using ASX all ordinaries, ASX/S&P 200 or ASX/S&P 300 indices. All these indices are closely related. Our calculation indicates that the average correlation among these indices is 0.85. Therefore, the result will be consistent with any of the indices taken for the study. We use ASX/S&P 200 for this study. Hasan (2017) and Koller e*t al*. (2010) suggest using market index to measure market exposure of company returns. For stock market risk factor, we use their excess return data. In this regard, short-term interest rate is deducted from the market returns. For short-term interest rate, we use three-month government bill rate. Benchmark market return data are taken from DataStream.

The variables in the paper are: $r_{i,t}$ - the excess return of the mining company i at time t, r_m is the stock market excess return, r_i - is the short-term interest rate, $fx_{i,t}$ - the foreign exchange return of currency i (U.S. dollar, euro or yen) against Australian dollar, $r_{c,t}$ - coal price return, $r_{o,t}$ - oil price return, $r_{o,t}^{orth}$ - orthogonalised oil price return, $\sigma_{c,t}^2$ - volatility of coal price, $\sigma_{o,t}^2$ - volatility of oil price, op - change in oil price return (positive), on - change oil price return (negative), cp - change in coal price return (positive), cn - change in coal price return (negative), $nopi$ - increase in net oil price, $nopd$ - decrease in net oil price, $ncpi$ - increase in net coal price, and $ncpd$ - decrease in net coal price. Table 4 lists all the variables with their definition and symbol. We winsorize[5] 1st percentile and 99th percentile of mining company returns, market index return to deal with the outliers. Here, we do not trim the extreme observations.

For foreign exchange risk factor, we use monthly logarithmic difference of foreign exchange rates of the U.S. dollar, the euro, and the Japanese yen against the Australian dollar. We incorporate changes in interest rate for interest rate risk. The interest rate difference is three-month government bill. The price of coal is ICE Global Newcastle coal in Australian dollar per metric tonne. The price of oil is three–month future price of West Texas Intermediaries (WTI) in Australian dollar. Both oil and coal price data are from DataStream. Following Sadorsky (2003), we prefer forward prices over spot prices as spot prices are more susceptible to random movement because of the short-run changes in economic variables. Generally, the estimation results do not vary

[5] Winsorizing is technique to transform the extreme values in the data to reduce the effect of the outliers. STATA has a routine function to perform this task.

significantly because of the choices of spot or future prices as these two prices are strongly correlated[6].

Table 4: List of Variables

Variable	Symbol	Measures
Market return	r_m	Monthly logarithmic changes in the stock market index in excess of a 3 month Treasury bill
Foreign exchange rate	fx	Monthly logarithmic changes in foreign exchange rates against U.S. dollar.
Interest rate	i	Monthly difference in 3-month government bill rate
Orthogonalised oil price return	r_o^{orth}	Monthly disturbance term of 1–month forward WTI return after regressing oil price return against coal price return
Coal price return	r_c	Monthly logarithmic changes of ICE Global Newcastle coal prices
Oil return volatility	σ_o^2	Monthly volatility measures of 1-month future WTI price returns
Coal Return volatility	σ_c^2	Monthly volatility measure of ICE Global New Castle coal price returns
Oil price change (positive)	op	Monthly positive logarithmic changes in 3-month forward WTI prices
Oil price change (negative)	on	Monthly negative logarithmic changes in 3-month forward WTI prices
Coal price change (Positive)	cp	Monthly positive logarithmic changes in ICE Global New Castle coal prices
Coal price change (negative)	cn	Monthly negative logarithmic changes in ICE Global New Castle coal prices
Oil price increase (net)	$nopi$	Oil price exceeds its maximum value over last 12 months
Oil price decrease (Net)	$nopd$	Oil price recedes its minimum value over last 12 months
Coal price increase (net)	$ncpi$	Coal price exceeds its maximum value over last 12 months
Coal price decrease (net)	$ncpd$	Coal price recedes its minimum value over last 12 months

6 Kilian (2009) states that the correlations between oil spot and future prices are statistically significant. Our calculation of correlation between WTI spot price and WTI three-month forward price is 97.7%.

All data are analysed in term of mean, median, standard deviation, skewness, kurtosis and Jarque-Bera and the results reported in Table 5. We calculate a continuously compounded return, which is the difference between the natural logarithm of the month ending price and that of the month beginning price. The continuously compounded return equation takes the following form:

$$r_t = ln\left(\frac{p_t}{p_{t-1}}\right) \tag{13}$$

where r_t is the monthly continuously compounded price return, p_t is the monthly ending stock price and p_{t-1} is the monthly beginning stock price. The average of the monthly stock return is 0.317% whereas average monthly market return is 0.002%. It appears that mining company stock returns are higher than average market returns since the sample 155 companies are the top companies in the mining industry. For foreign currencies, the US dollar, the euro, and the yen have appreciated against the Australian dollar as evident by the negative currency return.

By skewness we can measure the balance or the lack of balance of a given data. On the one hand, a data set can be symmetric if it looks the same to the left and right of the centre point. On the other hand, kurtosis also provides a visual estimation of variance in a sample. It is a measure of whether the details are peaked or flat relative to normal distribution. Kurtosis means zero, so when kurtosis is greater than 3 it is called leptokurtic. It is sharper then a normal distribution with values concentrated around the mean and has a thicker tail, which means half probability for extreme values and little variance. If the kurtosis value is negative, more than -1, it is called Platykurtic distribution. Visually it is flatter than the normal distribution and has a wider peak. The probability for extreme value is less than for normal distribution and values are spread out wider. We have a greater variance standard deviation around the mean. Kurtosis equal to zero or close is a measure of normal distribution.

Our study shows that the kurtoses of all data series of the macroeconomic variables are greater than 3, which is evidence of leptokurtosis. The oil price return has skewness of 0 and kurtosis of 5.01. In terms of skewness, the oil return variable is normal; however, the kurtosis measure indicates otherwise. In this the Jarque-Bera test indicates that the oil return variable is not normal as the null hypothesis is reject at 1% level of significance. On the other hand, both the measures of skewness and kurtosis specify the coal return variable is also not normal. It is also supported by Jarque-Bera test. Kurtosis is more than three for market returns and the returns are negatively skewed. The kurtosis for both market return and mining companies return are higher than three. In case of skewness, market returns are negatively skewed and market returns are positively skewed. Considering skewness and kurtosis, none of the variables of this study are normally distributed. The fat tails of excess skewness can be modeled by assuming a conditional normal distribution for returns. The general skewness equation as follows:

$$g_1 = \frac{\sum_{i=1}^{N}(Y_i - \bar{Y})^3/\mathrm{N}}{s^3} \qquad (14)$$

where $\bar{Y}$ is the mean, s is the standard deviation, and N is the number of data points. Note that in computing the skewness, the s is computed with N in the denominator rather than N - 1.

$$kurtosis = \frac{\sum_{i=1}^{N}(Y_i - \bar{Y})^4/\text{N}}{s^4} - 3 \quad (15)$$

where $\bar{Y}$ is the mean, s is the standard deviation, and N is the number of data points. Note that in computing the kurtosis, the standard deviation is computed using N in the denominator rather than N - 1. The kurtosis for a standard normal distribution is three.

The Jarque-Bera (JB) test statistics allows a joint test of skewness and kurtosis characteristics. The probability values of the JB test indicate that the null hypothesis is rejected, which implies the variables are not normally distributed. This test suggests that mining companies stock returns are normally distributed whereas market returns are not normally distributed. This is also true for interest rates, foreign exchange rates, and both energy prices of coal and oil price returns.

The correlation matrix in Table 6 shows that the market values of the companies are highly positively correlated with the market return. The other macroeconomic variables are not significantly correlated with market returns. Stock price is also correlated with those variables but relatively less positively. Among the exchange rates the correlation is relatively higher between the U.S. dollar and the Japanese yen, and between the U.S. dollar and the euro. However, this will not create a multi-collinearity problem as the variables will not be used in the model simultaneously. As we use orthogonalised oil price returns, the correlation is not high between coal price return and oil price return. In general, oil prices and coal prices have higher correlation. Empirical study suggests that oil price affects coal prices and therefore, they have higher correlation. For example, Zamani (2016) postulates that coal prices are affected by the supply and demand fluctuations in the oil market and, therefore, a high level of interaction persists between these two prices.

Table 5: Summary Statistics of Macroeconomic Variables

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	P-value
Stock return	0.0317	0.0059	-0.0452	0.0389	0.0118	2.26	0.1430	1.07	0.5851
3-month bill	-0.0002	0.00000	0.06155	-0.13069	0.00870	-2.62	34.83	124.10	0.0000
EUR/AUD	-0.0001	0.00000	0.14224	-0.14266	0.00754	0.36	94.99	101.00	0.0000
JPY/AUD	-0.0001	0.00000	0.09382	-0.09038	0.01124	0.45	12.16	122.46	0.0000
USD/AUD	-0.0001	0.00000	0.07739	-0.07155	0.00858	0.35	11.37	87.63	0.0000
Oil	0.0003	0.00024	0.09728	-0.08501	0.01698	0.00	5.01	481.87	0.0000
Coal	0.0002	-0.00026	0.37814	-0.23405	0.01900	3.07	109.12	135.00	0.0000
ASX200	0.0002	0.00026	0.05628	-0.08704	0.01068	-0.47	8.91	420.87	0.0000

Table 6: Correlation matrix of the variables

	Market	JPY	USD	EUR	Coal	Oil	Coal vol.	Oil vol.
Market	1							
JPY	-0.004	1						
USD	0.010	0.803	1					
EUR	0.006	0.576	0.523	1				
Coal	-0.159	0.019	-0.044	0.020	1			
Oil	0.168	0.044	0.094	0.193	0.202	1		
Coalvol	-0.102	0.021	-0.058	-0.084	0.171	-0.053	1	
Oilvol	-0.062	-0.026	-0.040	-0.031	-0.175	0.026	-0.328	1

CHAPTER SEVEN: EMPIRICAL ANALYSIS

In this chapter, we present our findings estimated from the models discussed in the previous chapter. Considering the panel data in this chapter, our challenge is to capture company-specific effects of the macroeconomic risk factors. To obtain the results we estimate using both a fixed effect model and random effect model. Fixed effect models follow ordinary least squares estimation method and a random effect models follow generalized least squares (GLS) estimation method. The random effects method is preferred to fixed effects methods since the company effects may be correlated with the regressors. We employ the Hausman test to obtain the best specification in the results. The Hausman test confirms that random effects specification is better than fixed effect specification. In Hausman tests, the null hypothesis is the absence of correlation. The test results indicate the null hypothesis is rejected. Therefore, the random effects specifications are appropriate than the fixed effects models and random effect specification model can capture individual-level company effects. Only random effect results are presented[7].

7.1 Macroeconomic Factors with Control Variable

The main objective of the research is to identify the priced risk factors for Australian mining companies. Since we assume that investors should be rewarded for the market-specific risk factors for their investment, only macroeconomic factors are

[7] The fixed effect results and Hausman test results are available upon request.

considered in this thesis. A control variable of company sales is used. Table 7 displays the results using the basic equation (3). The main results indicate that energy price returns and exchange rate returns are important for the Australian mining companies that were selected for study. Although we expect changes in interest rate will be statistically significant in determining mining company returns, the estimated results for interest rates inform otherwise. Importantly, all the exchange rates considered for this study are found to be statistically significant except for the Japanese yen. The Wald test statistic for panel data indicates the models are statistically significant.

Table 7: Risk factors in mining companies

This table reports estimation results of equation (3):
$r_{i,t} = \vartheta + \delta_m r_{m,t} + \delta_i r_{i,t} + \delta_{fx} fx_{i,t} + \delta_o r_{o,t} + \delta_c r_{c,t} + \mu_{i,t}$. Sample size: 155 Companies
*Significant at 10%, **significant at 5%, and ***significant at 1% level of significance.

Coefficients	1	2	3	4	5
ϑ	0.1983*** (0.0695)	0.0987** (0.0449)	0.1593*** (0.0325)	0.1352*** (0.0347)	0.1325*** (0.0347)
r_m	1.0162*** (0.1137)	0.8534*** (0.1356)	1.0610*** (0.1132)	1.1154*** (0.1169)	1.1249*** (0.1313)
i_i	-0.0334 (0.1608)	-0.0937 (0.2045)	-0.0773 (0.1690)	-0.1524 (0.1959)	-0.1239 (0.1354)
r_o	0.2970** (0.1521)		0.1784*** (0.0288)	0.1021*** (0.0271)	0.1285*** (0.0374)
r_c		0.0891* (0.0557)			0.1036 (0.1154)
fx_{usd}	-0.2116*** (0.0432)	-0.3495*** (.0366)			-0.6871* (0.3751)
fx_{euro}			-0.0608** (0.0315)		
fx_{jpy}				-0.0555 (0.0874)	
Wald χ^2	226.72	223.26	205.36	181.79	235.37
Prob>χ^2	0.0000	0.0000	0.0000	0.0000	0.0000
R^2	0.1521	0.1501	0.1396	0.1254	0.1822

The market return coefficient in all models except model 2 was greater than one which implies that the equity of these Australian mining companies is more risky than market return. Consequently, the results for Australian mining companies is in line with the findings of O'Callaghan and Graetz (2017) who noted that beta coefficients was greater than 1 for the firms that they studied. The value of the coefficients is relatively high compared to the coefficients of other variables. This implies that the average market return explains most of the variability in the returns of these mining companies. The coefficient of long-term bond interest rate and rate of change in profit were not significant statistically in the five models. Hence, changes in the value of the long-term bond interest rate and the rate of change in profit do not have an effect on the stock returns of these Australian mining companies. This result was in line with those of Dayanandan and Donker (2011) and Yoon and Ratti (2011). For our control variable, the rate of change in sales is statistically significant. The coefficients are positive in all models presented in Table 7. This suggests that a higher sale leads to high stock returns. The results are in line with the reports of Narayan and Narayan (2007).

The estimated results show that oil price returns and coal price returns have a profound significance in determining the return of Australian mining companies. We use orthogonalised oil price return to capture the effect of changes in oil prices that are not reflected in the coal price change. In all five models presented in Table 7, the coefficients of the energy price returns are statistically significant. Both coefficients of oil price return and coal price return have a positive effect in determining the stock returns of the mining companies chosen for study. This result is validated by the findings of the studies by Ratti and Hasan (2013) and Ramos and Veiga (2011). They argue that energy prices are more important in generating revenue for the mining companies. When the literature identifies that higher energy prices are depressing for stock returns for most companies because of the higher cost of production and negative sentiment in the market, mining companies consider the same price hike in positive terms because of higher revenue. In our results, the coefficients of oil price returns are higher than the coefficients of coal price return implying the oil price returns are more important than the coal price returns in determining returns of these mining companies.

In terms of the foreign exchange rate, model 1 reveals that the coefficient of Australian dollar/USD exchange rate is found to be significant but negative. This means that when the Australian dollar depreciates against the USD then the stock returns of Australian mining companies is negatively affected. This result conforms those of Warell (2006) and Mohanty and Nandha (2011) who noted that depreciation of the domestic currency affects stock returns of firms negatively. Similarly, the relationship between the Australian dollar/USD exchange rate and stock returns of Australian mining companies was found to be negative and significant in model 2 and 5 as in the case of model 1.

Based on the fact that Australian mining companies export more heavily to Europe and Japan, the Australian dollar/Euro exchange rate and Australian dollar/Japanese yen exchange rate are also included in our model following DiIorio and Faff (2000). The findings are displayed in column 3 and 4 in Table 10. The results suggest that foreign exchange return of euro is statistically significant whereas Japanese yen is not statistically significant for Australian mining companies. The coefficient of euro/Australian exchange rate is negative which means that appreciation of Australian dollar against the Euro reduces the stock returns of the Australian mining companies. Again the coefficient of Australian Japanese yen/Australian dollar exchange rate is negative but not significant. This result confirms the findings of Nandha and Faff (2008) and Park and Ratti (2008).

Our results suggest that a change in interest rate is not a priced risk factor for Australian mining companies. The coefficients of interest rate difference are negative implying that when the interest increases from the previous month the lower returns in mining stock returns. Although we have expected signs in the coefficients; they are not statistically significant from column 1-5, in Table 7. Although the mining companies are capital intensive, which is considered as an important risk factor, we do not find the coefficient of interest rates is statistically significant in this thesis. A plausible reason would be the lower interest rate environment in recent periods. Since the GFC, the interest rate has been relatively low and the general perception among market participants has been that the interest rate would not increase abruptly in the near future; and they have not considered changes in the interest rate to be risky. Therefore the coefficient for interest rate might not be statistically significant.

7.2 Oil and Coal Return Volatility

In this thesis, we assume that changes in energy prices and the volatility of energy prices may have different impacts on the stock returns of Australian mining companies. As the volatilities are not directly observable, we construct measures of oil price volatility and coal price volatility by using equation (8). This measure of energy price volatility is considered in equation (6). Results from estimating equation (6) are reported in Table 8. For exchange risk, we only consider the Australian dollar return against the U.S. dollar. The overall results are consistent with the findings outlined in the previous section and presented in Table 7. The coefficient of market return is statistically significant at 1% in column 1 to 6. The size of the coefficient indicates that mining companies are more risky compared to the average market. Both interest rate and foreign exchange coefficients have negative sign; however, the interest rate is not statistically significant except in column 5.

Table 8: Risk factors in coal industries

This table reports estimation results of equation (6):

$$r_{i,t} = \vartheta + \delta_m r_{m,t} + \delta_i r_{i,t} + \delta_{fx} fx_{usd,t} + \delta_c r_{c,t} + \delta_o r_{o,t}^{orth} + \delta_{coalvol}\sigma_{c,t}^2 + \delta_{oilvol}\sigma_{c,t}^2 + \mu_{i,t}.$$

Sample size: 155 Companies.

*Significant at 10%, **significant at 5%, and ***significant at 1% level of significance.

	1	2	3	4	5	6
ϑ	0.1751***	0.1390***	0.1786**	0.1856***	0.2780***	0.3214***
	(0.0741)	(0.0625)	(0.0989)	(0.0410)	(0.0962)	(0.0942)
r_m	1.1104***	1.0868***	1.0903***	1.0636***	1.1061***	1.0015***
	(0.1747)	(0.1547)	(0.1341)	(0.1412)	(0.1014)	(0.1457)
fx	-0.3174***	-0.2474***	-0.3396***	-0.2859***	-0.3004***	-0.292***
	(0.1047)	(0.1474)	(0.1985)	(0.2000)	(0.1558)	(0.2041)
i	-0.0785	-0.0425	-0.1046	-0.1568	-0.0613*	-0.0923
	(0.1873)	(0.1900)	(0.2023)	(0.2254)	(0.0385)	(0.1134)
r_c	0.1787***	0.1766***		0.1698***		0.1684***
	(0.0410)	(0.0587)		(0.0425)		(0.0776)
r_o			0.2220***	0.2950***	0.2355***	0.2472***
			(0.0901)	(0.0947)	(0.1074)	(0.0621)
σ_c^2		0.2204*				0.3253
		(0.1191)				(0.4125)
σ_o^2					-0.0996***	-0.0608**
					(0.0241)	(0.0387)
Wald χ^2	108.02	154.74	110.32	101.88	110.25	112.21
Prob>χ^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R^2	0.1729	0.1921	0.1741	0.1847	0.1874	0.2235

The estimated results in Table 8 also suggest that the coefficients of coal and oil price returns are statistically significant in explaining that mining company returns. Both coefficients of oil price return and coal price return are strongly significant at 1%. This result signifies the robustness of oil and coal price returns when volatility measures are incorporated into the regression equation (6). The estimated results also indicate that oil price returns have a greater influence on Australian mining companies than coal price return. Volatility measures of oil and coal have different impact on mining companies. Oil return volatility has negative impact whereas coal return volatility has a positive effect on mining company returns. The coefficient of coal return volatility, $\beta_{coalvol}$, is statistically significant at 10% level and the coefficient of oil return, β_{oilvol}, volatility is statistically significant in column 5 and 6 at 1% level.

7.3 Asymmetry effects of coal and oil price changes

To evaluate the asymmetric effect of oil and coal price returns on the returns in the mining companies, we measure non-linear changes in oil and coal price returns. We consider positive and negative coal and oil price changes ($cp, cn, op, and\ on$) in one group and net coal and oil changes using Hamilton (1996) measure ($ncpi, ncpd, nopi\ and\ nopd$) in another group. We use equation (9) and (11) to obtain asymmetric measures of oil and coal price return. These asymmetric measures of oil and coal price returns are incorporated into equation (10) and (12). The estimated results are presented in Table 9.

The coefficients of market returns and foreign exchange return are statistically significant, but the coefficients of interest rates are not statistically significant. And their signs are also consistent with the previous estimation results. Columns 1-2 show that non-linear measures of coal price returns are statistically significant except the coefficient of cn when it is used with coal return volatility. However, positive and negative oil changes have an effect on the returns of the mining companies. This result implies that company returns follow both positive and negative oil price changes. The notable thing is the coefficients of op are higher than the coefficients of on, which implies that mining company returns are more exposed to negative oil price changes than to positive oil price changes. Both oil and coal return volatility is statistically significant with non-linear measures of coal and oil price changes.

Columns 5-8 report the asymmetry results of estimation of equation 12(a) and 12(b). The results indicate that the coefficient of $ncpi$ is statistically significant; however, the coefficient of $ncpd$ is not statistically significant. The results state that mining company returns react to positive coal price changes but do not react to negative coal price changes. The estimation results also indicate that positive and negative changes in oil prices do not have similar effect on mining company returns suggesting the presence of asymmetry effect of oil price change. These results are reported in column 7-8 of Table 9. An increase in oil price changes that is larger than other increases over the past twelve months may indicate that the market believes that oil prices (and other energy prices) will now be trading at higher levels than thought likely up to that point. Note that net oil price return (if non-zero) is the excess of the current oil price return over the highest most recent oil price return. The coefficient of oil return volatility is statistically significant with the asymmetric measure of oil price changes.

Table 9: Asymmetric effects of energy prices on mining company stock returns

This table reports estimation results of equation 10 (a, b) and 12 (a, b).

$$r_{i,t} = \vartheta + \delta_m r_{m,t} + \delta_i r_{i,t} + \delta_{fx} fx_{usd,t} + \delta_c^p cp_t + \delta_c^n cn_t + \delta_{coalvol}\sigma_{c,t}^2 + \mu_{i,t}$$

$$r_{i,t} = \vartheta + \delta_m r_{m,t} + \beta_i r_{i,t} + \delta_{fx} fx_{usd,t} + \delta_c^p op_t + \delta_c^n on_t + \delta_{oilvol}\sigma_{o,t}^2 + \mu_{i,t}$$

$$r_{i,t} = \vartheta + \delta_m r_{m,t} + \delta_i r_{i,t} + \delta_{fx} fx_{usd,t} + \delta_{ncpi} ncpi_t + \delta_{ncpd} ncpd_t + \delta_{coalvol}\sigma_{c,t}^2 + \mu_{i,t}$$

$$r_{i,t} = \alpha + \delta_m r_{m,t} + \delta_i r_{i,t} + \delta_{fx} fx_{usd,t} + \delta_{nopi} nopi_t + \delta_{nopd} nopd_t + \delta_{oilvol}\sigma_{o,t}^2 + \mu_{i,t}$$

Sample size: 155 Companies, *Significant at 10%, **significant at 5%, and ***significant at 1% level of significance.

All sample								
Variables	1	2	3	4	5	6	7	8
ϑ	0.0567***	0.0453**	0.1044***	0.0965***	0.0730***	0.0761***	0.1000**	0.0516***
	(0.0123)	(0.0199)	(0.0334)	(0.0345)	(0.0227)	(0.0262)	(0.0481)	(0.0123)
r_m	1.0898***	1.0891***	1.1261***	0.9948***	1.0872***	1.1608***	1.0769***	1.0491***
	(0.1532)	(0.1456)	(0.2086)	(0.1935)	(0.1025)	(0.1932)	(0.1887)	(0.0540)
fx	-0.3385**	-0.2607*	-0.2100***	-0.2908***	-0.2359**	-0.2936**	-0.2482**	-0.3966**
	(0.1648)	(0.1358)	(0.0673)	(0.0923)	(0.1321)	(0.1239)	(0.1114)	(0.1159)
i	-0.0495***	-0.0388**	-0.0492***	-0.0435**	-0.0496**	-0.0501**	-0.0372*	-0.0234*
	(0.0135)	(0.0197)	(0.0122)	(0.0224)	(0.0225)	(0.0202)	(0.0215)	(0.0134)
cp	0.1104**	0.1321**						
	(0.0516)	(0.0658)						
cn	-0.0861***	-0.0984						
	(0.0253)	(0.7452)						
op			0.3169***	0.2443***				
			(0.09641)	(0.0807)				
on			0.2230*	0.1937**				
			(0.1312)	(0.0933)				

ncpi					0.1122***	0.1059***		
					(0.0397)	(0.0259)		
ncpd					-0.2015	-0.0875		
					(0.2000)	(0.1333)		
nopi							0.2111*	0.3287**
							(0.1199)	(0.1635)
nopd							0.2249***	0.2451**
							(0.0771)	(0.1023)
σ_c^2		0.0123				0.0237*		
		(0.0565)				(0.0132)		
σ_o^2				-0.1637***				-0.2174***
				(0.0415)				(0.0787)
$Wald\,\chi^2$	155.51	173.32	200.26	125.31	200.82	206.89	203.21	214.35
$Prob>\chi^2$	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R^2	0.1771	0.2112	0.2162	0.1988	0.2018	0.1882	0.1917	0.1871

7.4 Risk Factors for an Individual Company

In the previous chapter we considered 155 companies in panel form and identified the risk factors for Australian mining companies. In this section, we extend our analysis to understand the risk factors at an individual company level. Therefore, we take the top ten mining companies by market capitalisation. This analysis will serve two purposes: first, to check the robustness of the findings observed for the panel data and, second, to enable us to evaluate whether risk factors have different implications at an individual company level. The top ten company's names are listed below in Table 10:

Table 10: Market capitalization of top 10 Australian mining firms

Code	Company	Market Cap	Weight
BHP	BHP Billiton Limited	60,508,300,000	4.02
WPL	Woodside Petroleum Limited	22,383,800,000	1.49
RIO	RIO Tinto Limited	19,022,900,000	1.26
AMC	Amcor Limited	16,868,300,000	1.12
NCM	Newcrest Mining Limited	16,246,200,000	1.08
FMG	Fortescue Metals Group LTD	10,291,100,000	0.68
OSH	Oil Search Limited 10T	10,148,700,000	0.67
STO	Santos Limited	8,800,450,000	0.59
CTX	Caltex Australia Limited	8,312,030,000	0.55
IPL	Incitec Pivot Limited	5,567,660,000	0.37

To identify the relationship between the dependent and the independent variables for the Australian top ten mining companies. For this we use following equation:

$$r_{i,t} = \alpha_0 + \beta_1 r_{m,t} + \beta_2 i_{i,t} + \beta_3 r_{o,t} + \beta_4 r_{c,t} + \beta_5 fx_t + \varepsilon_t \quad (16)$$

Where, $r_{i,t}$ is the stock returns of the mining industry at a time t; α is constant; β_1 to β_5 are coefficients; r_m is market return at a time t; i is short-term interest rate at a time t; r_o is return on oil price at a time t; r_c is return on coal price at a time t; fx_t is foreign exchange return of Australian dollar against US dollar; and ε_t error term.

Table 11 displays the estimated results from equation (16). The results of each company are presented in columns and it displays the regression results of the top ten companies. The results confirm that energy prices of oil and coal price return, the foreign exchange return, and interest rates are priced risk factors at the level of an individual company. The most interesting finding is that the coefficients of interest rates are statistically significant for most the companies. The plausible reason would be the interest rate is important for top mining companies in Australia but it is not equally important for all mining companies.

Table 11: Risk factors for the top mining companies

This table reports estimation results of equation (16):

$$r_{i,t} = \alpha_0 + \beta_1 r_{m,t} + \beta_2 i_{i,t} + \beta_3 r_{o,t} + \beta_4 r_{c,t} + \beta_5 fx_t + \varepsilon_t$$

Sample size: Top 10 Australian mining firms
*Significant at 10%, **significant at 5%, and ***significant at 1% level of significance.

Coefficients	BHP	WPL	RIO	AMC	NCM	FMG	OSH	STO	CTX	IPL
Constant	0.0515***	0.0884	0.0451	0.1123**	0.0870*	0.1275	0.0409***	0.2743***	0.1001**	0.0409***
	(0.0132)	(0.0822)	(0.0834)	(0.0667)	(0.0511)	(0.0934)	(0.0011)	(0.0987)	(0.0513)	(0.0011)
r_m	1.1811***	1.1078***	1.1646***	1.2710***	0.1.2300***	1.2003***	1.2710***	1.0123***	1.0656***	1.002***
	(0.1617)	(0.2909)	(0.2151)	(0.1517)	(0.2553)	(0.3100)	(0.1517)	(0.1594)	(0.2865)	(0.1808)
i_i	-0.1025***	-0.1654***	-0.0356*	-0.2625**	-0.1118***	-0.0876**	-0.1557	-0.3011**	-0.0994**	-0.2099**
	(0.0395)	(0.0962)	(0.0209)	(0.1319)	(0.0355)	(0.0427)	(0.1087)	(0.1500)	(0.0473)	(0.0988)
r_o	0.3329***	0.2375**	0.1897***	0.1787***	0.1375**	0.3598*	0.1980***	0.2287***	0.1123***	0.1790**
	(0.1096)	(0.1136)	(0.0601)	(0.0439)	(0.0667)	(0.2116)	(0.0613)	(0.0718)	(0.0457)	(0.0865)
r_c	0.0156	0.0157**	0.0122**	0.0276	0.0556	0.01278	0.0076*	0.1234	0.1232	0.0345
	(0.0234)	(0.0070)	(0.0056)	(0.0323)	(0.0435)	(0.0114)	(0.0042)	(0.1008)	(0.0876)	(0.0222)
fx	-0.1593**	-0.1982**	-0.3235**	-0.3593**	-0.1876	-0.1254***	-0.2544**	-0.1982***	-0.3006***	-0.0987**
	(0.0645)	(0.0989)	(0.1612)	(0.1645)	(0.2239)	(0.0478)	(0.1225)	(0.0462)	(0.1124)	(0.0500)
Log-likelihood	113.54	110.87	198.08	132.63	128.51	143.34	139.00	139.16	122.83	145.07
Durbin-Watson	1.93	2.28	1.96	2.02	1.92	1.79	2.01	2.22	2.14	1.98
Adjusted R^2	0.39	0.45	0.54	0.33	0.34	0.40	0.44	0.31	0.32	0.41

In regression results, if the correlation coefficient is negative, it provides statistical evidence of a negative relationship between the variables. The results of this study identify that the return of the individual company's stock returns varies on the basis of changes of a coefficient.

Market return is an important factor to determine a company's stock return. Equation results indicate the beta coefficient of the market return is more than 1 and highly significant with the all the ten individual companies at 1%. The result implies that the market risk of the mining companies is more than the market average. Oil Search Limited (OSH) has the highest market beta of 1.2710 indicating the greatest reaction to market movement compared to other nine companies. On the other hand, Incitec Pivot Limited (IPL) has the lowest market beta of 1.0020. As IPL is not directly involved in mining operation, their market beta is relatively low compared to other top mining companies.

Regarding the interest rate, the stock returns of nine out of ten of these companies are affected by changes in interest rates. The coefficients of interest rates are statistically significant at 1% for BHP, WPL and NCM whereas the same coefficient is statistically significant at 5% for AMC, FMG, STO, CTX, and IPL. The negative coefficient implies that, if the interest rate increases, the stock return of the company declines and vice versa. As mining companies are capital intensive, these findings are consistent with theoretical understanding.

Our findings also indicate that the mining companies' stock returns have a negative significant relationship with the foreign exchange rate. It is established that the exchange rate affects the mining companies, as all of these companies are export oriented, so that their costs, profitability, and revenues are directly affected by such changes. Excluding NCM, the coefficients of foreign exchange returns are statistically significant for all other companies. The negative coefficients suggest that appreciation of the Australian dollar has a negative effect on the stock return. Among the top mining companies, AMC, RIO, and CTX have the highest coefficient values, whereas FMG and BHP have relatively low coefficient value. This implies that AMC, RIO, and CTX are more affected by the changes in foreign currency fluctuations compared to FMG and BHP.

The estimated results shows that oil price shocks have a profound significance in determining the returns of the top mining stocks in Australia. The coefficients of oil price return are statistically significant for all ten mining companies under study at various level of significance. The coefficient of oil price return is positive, which is consistent with the previous findings. Among the top ten mining companies in Australia, BHP, FMG, and WPL are most affected by the changes in the oil price. Compared to oil price changes, the coefficients of coal price returns are not statistically significant for all companies. We find that three out of ten of the top mining companies are affected by changes in the coal price returns. This finding is somewhat different from the findings from previous estimation results. The plausible reason would be that coal is not important for all mining companies.

7.5 Robustness Check

This section describes the overall validity of our estimated models. For the panel data model, we use Wald statistics to check the overall robustness of the estimated results. The null hypothesis of the Wald test is that all the coefficients of the regressors are zero i.e. altogether none of the coefficients has any impact on the stock returns of the Australian mining companies. The Wald test statistics are presented at the end of Table 7, 8, and 9. Overall, the p-values of Wald test suggest that the null hypotheses are rejected; implying at least one of the coefficients has significant impact on the dependent variable of stock returns of these mining companies. Therefore, we can conclude that our estimated models are statistically robust.

R-square explains the variations in the dependent variable by the estimated model. The higher the value of R-square, the greater the performance of the models. R-square values are presented in the last row of the Tables 7, 8, 9, and 11. For the panel data models, we have a moderate R-square value, which suggests that our models capture moderate variation in the stock returns of Australian mining companies. The remaining variations of the stock returns are captured by the residuals. For our ordinary least square models in Table 11, the average R-square value is 40%. This conveys that our models are able to explain 40% of variations in the stock returns of the Australian mining companies.

The Durbin-Watson test is a well-known formal method of testing if serial correlation is a problem in our model. It is used to investigate if there is autocorrelation between the variables, for example, assessing the confidence in the predicted value of a dependent variable. The test statistic of the Durbin-Watson (DW) procedure is calculated as follows:

$$d = \frac{\sum_{t=2}^{n}(e_t - e_{t-1})^2}{\sum_{t=1}^{n} e_t^2} \quad (17)$$

The DW statistic can take any value between 0 and 4. If the DW statistic is greater than 2, the error term has positive autocorrelation whereas if the DW value is less than 2, the residual has negative autocorrelation. In our study, multiple regressions were done, as there were more than two variables that were being studied. The DW is measured between 0 and 4. According to our results, the DW values are close to 2 in most of companies of our study. AMC, OSH, RIO, and IPL have DW values close to 2. The strongest positive autocorrelation is found for FMG Company, while the strongest negative autocorrelation is found for WPL Company. The company with the weakest autocorrelation is OSH with a value of 2.01. Therefore, our DW results suggest that the estimated results do not have an autocorrelation problem.

CHAPTER EIGHT: CONCLUSION

The main purpose of this thesis is to understand the priced risk factors of Australian mining companies. As macroeconomic risk factors determine the risk premium of stock returns, this research has aimed to unveil those that are most important. Mining companies dominate Australian stock market as one third of the listed companies are mining companies. Therefore, the findings of this research have paramount importance as they can assist participants in the market to manage their portfolio. The thesis has focused on the impact of energy price volatility of coal and oil price return on the mining companies. The research has been augmented by the study of the asymmetry effect of energy price change since it is assumed that positive and negative changes in energy price do not have the same effect on the stock returns. Finally, this thesis has focused on the regression results for top ten mining companies. It has presented the necessary analysis to answer whether fluctuations in the identified macroeconomic variables impact the stock market returns of Australian mining companies. The thesis fills some gaps in the literature of financial economics, which are specifically identified after a rigorous review and mentioned in each chapter. The topic of this thesis is timely, and the findings provide significant information to various groups of people such as risk managers, policy makers, and market participants who wish to understand the impact of major macroeconomic variables on mining stock returns.

For studying risk factors, we considered benchmark market returns, interest rate premium, foreign exchange risks, oil, and coal price returns and their volatility. To create balanced panel data, we only considered the companies with data available from

2004 to 2015, which were 155 companies. Data was taken monthly and ranged from January 2004 to December 2015, comprising 144 monthly observations. We employed both fixed and random effect to capture effects on an individual company. The Hausman test has preferred a random effect since null hypothesis of absence of correlation cannot be rejected. The Wald test has confirmed the robustness of this study. We reported our results based on random effect. Random effect is done with GLS methodology, which is an efficient method for controlling heteroskedasticity and autocorrelation present in the data.

8.1 Overview of the Thesis

After introduction in chapter 2, chapter 3 has provided an overview of the Australian mining industry and stock market. The chapter establishes that the mining sector has critical importance in the Australian economy as approximately 9% of GDP comes from this sector and gross value addition to the economy is 6%. In terms of industry value addition, the mining sector contributes 150 billion Australian dollars. Australia has been enjoying higher terms of trade (ToT) in recent years because of the higher export prices of mining products. In terms of investment formation, the mining sector plays a very important role as it contributes nearly 40% of total investment in Australia. In the Australian stock market, the mining sector ranks top by the number of listed companies and ranks second in terms of market capitalisation.

Chapter 4 has established theoretical linkages between macroeconomic factors with stock returns and discusses the main research in the literature. IT has also identified the research gap, and provided a concise review of literature along with empirical evidence discussing the relationship between stock returns and macroeconomic variables. Global studies conducted at the market and industry levels are reviewed including: work on these relationships in the context of the U.S. and Japan (Humpe and Macmillan, 2009); Canadian oil and gas companies (Sadorsky, 2001 and Boyer and Filion, 2007); the U.S. petroleum stock market (Ferson and Harvey, 1991); North American oil and gas companies (Dayanandan and Donker, 2011); European economies Bert, S. and Yurtsever, C. (2012); and Australian industries (Ball and Brown, 1980; Brailsford, 1999; McSweeney and Worthington, 2008).

The review of the literature indicates that there is a dearth of studies on the impact of energy price fluctuations on stock market returns for the mining industry in Australia. No recent study has focused on energy price fluctuations and its association with the stocks of the Australian mining companies. This thesis presents new empirical evidence with reference to the association between Australian mining companies and macroeconomic risk factors. It also makes a significant contribution to scholarship by examining the volatility of the dominant energy resources of crude oil and coal. Although coal is a major energy resource in Australia, there are few studies on the relationship between coal prices and stock returns. Only the study of Hasan and Ratti (2015) uses coal price; however, only on coal companies from an international perspective. There is no comprehensive and appropriate research study or analysis investigating the effect of coal price return on Australian mining companies.

Chapter 5 has discussed the research methodology that was applied to understand the relationship between macroeconomic variables and stock returns. It presented a review of studies that have used such methodologies. The chapter has also described the panel data models and identified the rationale for using panel data model for this study. Panel data is more informative and efficient; it also has more variety with less co-linearity among the considered variables. Panel data improves the efficiency of the model by reducing the collinearity among explanatory variables and increasing the degrees of freedom. In this research we have employed both fixed effect and random effect models to inform the study. This study has also used Hausman test to understand the suitable model for the research.

Chapter 6 has isolated the regression equations employed to conduct the study of this thesis. This chapter has also described the justification of the variables considered in the study. Interest rate, oil, and coal prices, exchange rates of the U.S. dollar, the euro, and the Japanese yen, and market stock returns are used as regressors and included in the model. This chapter has also provided the calculation of oil and coal returns volatility estimation and asymmetry measures. The equation also incorporates these volatility and asymmetry measures into regression models.

In chapter 7, data sources, nature of data, sample size, and time period were discussed in detail. Balanced panel data containing 144 monthly observations of 155 mining companies was selected. Time period chosen was January, 2004 to December, 2015. Measure of historic volatility was used as to measure the variance of returns. Descriptive statistics such as values of mean, median, standard deviation, skewness, kurtosis, and Jarque-Bera test coefficients and correlation matrix were reported in the tabular form.

In chapter 8, empirical analysis was presented. The first equation estimated the impact of independent variables of interest rates, returns on coal and oil prices, foreign exchange returns, and market returns on the dependent variable stock returns of the mining industry are provided. This chapter reported the estimated results of equations (3), (6), (10) and (12). Equation (3) deals with basic model where market returns, exchange returns of the U.S. dollar, the euro, and the Japanese yen, oil and coal price return and market returns are considered as independent variables. Estimation of Equation (6) provided the results of coal and oil price return volatility in addition to other variables considered in equation (3). Estimation of equations (10) and (12) identified the asymmetry impact of coal and oil price return. Finally, this chapter provided the findings of the impact of macroeconomic variables on the top ten mining companies. The result is based on individual company. The robustness of the study was determined in the final section of this chapter.

8.2 Major Findings and Implications

In all regressions, benchmark market return, interest rate difference, foreign exchange return, and coal price return are statistically significant. The coefficients of market returns are relatively high when compared to the coefficients of other variables, which implies that benchmark market return explains most of the variability in the returns of the mining companies. The estimated coefficients of market returns in all regression equations are greater than one, implying that mining companies are more responsive than average market returns. For interest rates, our results suggest that a change in interest rate is not a priced risk factor for Australian mining companies. The coefficients of interest rate difference are negative, implying that when the interest rate increases from the previous month the lower returns in mining stock returns. In terms of the foreign exchange rate, model 1 revealed that the coefficient of the Australian dollar/USD exchange rate is found to be significant but negative. This means that when the Australian dollar depreciates against the USD, then the stock returns of Australian mining companies is negatively affected.

To consider the effect of energy price shocks, we take orthogonalised oil price return and coal price return. The regression results state that the coefficient of coal price return is statistically significant and it has a positive effect in all equations. Similarly, the oil price return plays an important role in determining the return of Australian mining companies and the sign of the coefficients of oil return is also positive. In the case of coal and oil return volatility, coal return volatility has a positive effect on coal companies' return; however, oil return volatility has a negative effect.

To understand the asymmetric effect of oil and coal price return on coal sectors, we use two measures of asymmetry. In the first measure, we separate positive and negative changes in oil and coal prices, and in the second measure, we use the technique followed in Hamilton (1996). The first non-linear measure of oil and coal price return is statistically significant in our estimation when it is full panel. For Hamilton's (1996) measure of asymmetry, net coal price increase is statistically significant; however, net coal price decrease is not significant. Net oil price increase and decrease have an effect on coal sector returns.

The thesis also estimates the impact of these macroeconomic variables on the top ten mining companies. The results are very much similar to the findings of the previous panel study. Of interest is that the coefficients of interest rates are statistically significant for most the companies. The plausible reason would be that the interest rate is important for the top mining companies in Australia, but it is not equally important for all mining companies. The coefficients of interest rates are not statistically significant in earlier regression equations.

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