An analysis of the co-movement between South African and global mining indices

JA van der Linde
0000-0002-8074-5015

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Supervisor: Dr AM Pretorius

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DECLARATION

I declare that dissertation is my own work, except where otherwise specified in the text. This dissertation has not been submitted to any other university for the purposes of the conferral of a degree.

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ABSTRACT

After the 2008 global financial crisis the need to understand the level of financial market integration has risen dramatically. Consideration has especially been given to investigating the link between commodities and stocks, since the former are now more frequently incorporated into portfolio allocations. Recent international events such as the British Referendum aimed at a decision to leave the European Union and the United States Presidential Election have emphasised the significance of understanding the degree of financial market integration. This argument becomes particularly relevant for South Africa when considering the dualistic nature of its market in terms of the country's fiscal environment and sophisticated financial sector.

The Johannesburg Stock Exchange is the second oldest bourse on the African continent and owes its existence to South Africa's first gold rush at Witwatersrand during the late 1880s. Moreover, mining has been the country's mainstay over the past 100 years. Furthering the argument, this study focuses specifically on examining the co-movement of South African mining indices with global mining indices. Although a vast body of literature exists on financial market integration, to the author's knowledge no studies have examined the co-movement of mining indices in particular.

The first objective of this study has been to establish the degree of integration for South African mining stocks and then to further identify possible idiosyncratic factors that may be able to explain the variation in returns for the country's mining indices. An attempt is also made to link the common global factor with macro-economic variables that serve as prominent drivers for the various sectors during different stages in time. Three global samples are investigated, viz. Iron & Steel, Mining and Gold. Factor analysis is employed to empirically examine co-movement. This study addresses the dynamic nature of financial market integration by considering a rolling window approach.

Empirical findings show that the South African Mining and Gold indices are more integrated with global markets, less so for Iron & Steel. Evidence of increasing market integration is observed for South African indices. It is apparent that idiosyncratic events are particularly influential in driving South African mining stocks at times. The Marikana events are an appropriate example of how local events can affect stock markets. It is also evident that different macro-economic variables become more substantial in describing the variation of global mining indices during various stages in time. Findings also show that significant economic events like the global financial crisis have a more profound impact on global indices that fall under the non-ferrous category. This is also observed for the South African indices.

Keywords: co-movement, mining indices, South Africa, factor analysis

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CHAPTER 1: INTRODUCTION

1.1 Introduction and background

Bekaert and Harvey (1995) pose the question which lies at the heart of international finance. Why do different countries' market indices exhibit different expected returns? The most forthright answer would probably be that this is due to different risk exposures. On an international scale it is challenging to quantify these risks due to the effects of country-specific factors. Moreover, the complexity increases if a country is not fully integrated with global capital markets. It is common knowledge that developed countries tend to be more integrated with global markets compared to developing countries. Pukthuanthong and Roll (2009) maintain that global markets seem to exhibit an increasing degree of integration. However, this process is time-varying which allows the degree of integration to change as time progresses.

The relevance of this study is probably best encapsulated in present-day conditions. With a greater integrated global economy, spill-over effects associated with significant political/ economical events fulfil a prominent role in global markets[1]. This is apparent in the British Referendum to leave the European Union which created tremendous volatility in financial markets, as the DAX fell by 6.8%, the DJIA by 3.4% and the FTSE 100 by 3.2% (Schiereck, Kiesel & Kolaric, 2016:291). Events such as these are not confined to the country of origin and the impact will differ given the transmitted country's level of integration into global markets, thus illustrating how foreign factors may impact on capital markets in other countries. This does not differ for the South African context, and literature documents the significant effect that foreign stock market volatility has on South African equity market volatility. Alternatively, literature also shows that local factors may influence a country's capital market.

This study focuses specifically on the mining segment of South Africa's equity market, namely mining indices. For the last 100 years mining has remained the economy's mainstay, contributing substantially to the country's industrial development. Traditionally, gold has been the largest contributor to the country's mining sector; however, since the early 1990s titanium, steel, aluminium and ferro-alloy industries have become more prominent, coupled with an expansion in coal exports and a surge in platinum group metal prices (Coakley, 2000:1). The mining sector occupies nearly one-third of the Johannesburg Stock Exchange's (JSE) market capitalisation. Moreover, the sector serves as a stimulant for foreign investment and fulfils a significant role in global mineral reserves and production. Given the significance of South Africa's mining sector, the FTSE/JSE Mining Index (J177) (comprising major mining companies

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[1] At the time of this dissertation's composition, uncertainty looms over the United States Presidential Election and the impact it might have on global financial markets.

in South Africa) was constructed with the aim to provide analysts/investors with appropriate information that reflected performance of the country's mining sector (Chinhamu, Huang, Huang & Hammujuddy, 2015:41). Additionally the performance of mining stocks in South Africa has drawn attention as a result of recent local calamities which include mining strikes, electricity constraints and a rapid decline in production and output (Chinhamun *et al.,* 2015:41).

Given the country's historic and on-going dominant role in mining, South Africa is considered a leading global contender. As Robinson (2016:775) rather facetiously notes, commentators and politicians are enthusiastic to quote the April 2010 Citi report which suggests that South Africa is the world's wealthiest country when considering the in situ value of its mineral reserves[2]. Logic then dictates that South Africa should be an inviting environment for foreign investment, given the country's endowed mineral wealth. Yet this is not necessarily the case. In 1990 the mining industry was largely owned by domestic mining houses listed on the JSE and based in Johannesburg. This soon changed due to pressure from both domestic and global economic/political events. For example, during the late 1990s and early 2000s, South Africa was subject to radical and controversial mining legislation. As a result significant disinvestment occurred in the form of Anglo-American and BHP Billiton (incorporating Gencor) moved their primary listings and headquarters to London. Moreover, other idiosyncratic factors such as energy constraints and political unrest and unstable labour conditions ultimately led to the decline of South Africa's mining industry. In this regard refer to Antin (2013:17) and Robinson (2016:775). It has to be noted, though, that there have been instances of foreign investment in the country's mining industry (for example, Glencore Xtrata's listing on the JSE), but not at the level one would expect. From a global perspective, the commodity boom in 2000 to 2007 and the recent slump in the commodities – due to global decline in demand and slower economic growth – are testament to the influence that global events may exert on the South Africa's mining sector.

A general assessment of the South African mining industry (from 1990/01/01 to 2013/08/19) shows an increase in prices between 1998 and 2000[3]. This is unexpected when considering the significant disinvestment of BHP Billiton and Anglo-American during 1997 and 1999 respectively. Robinson (2016:769) maintains that this has damaged the country's financial capacity and inhibited the development of South Africa's mining industry, yet the Mining Index exhibits a definite increase. Figure 1.1.1 shows the standardised prices (the first observation is set to a value of 100 in order to simplify comparisons) for the country's overall mining sector.

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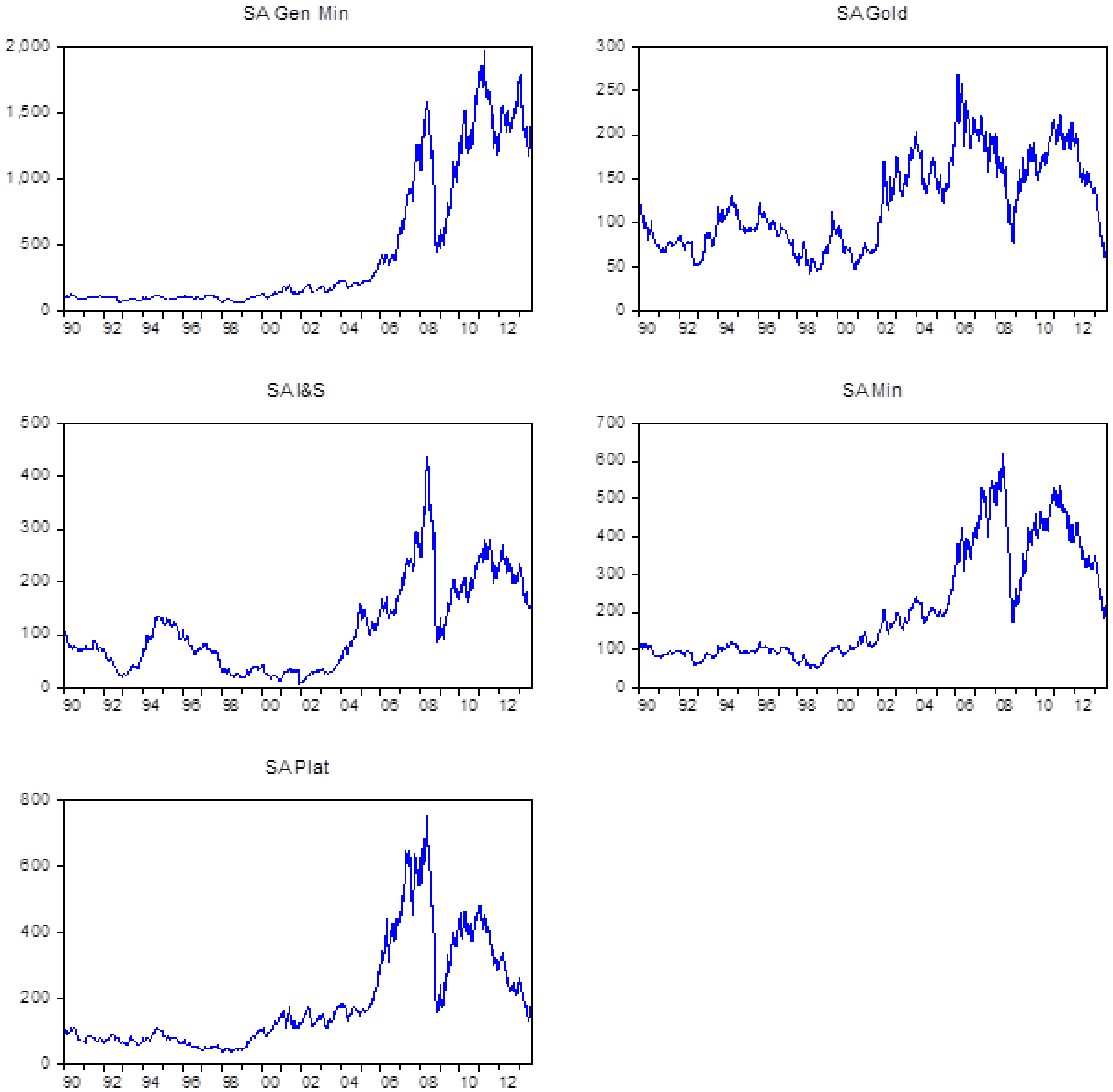
[2] Note that this is not consistent with the world's largest mining companies. According to PWC's annual review of the global mining industry, South Africa's largest mining company is AngloGold Ashanti Ltd, placed at number 30 (PricewaterhouseCoopers, 2016:25). Companies are allocated based on the country's primary listing according to market capitalisation on 31 December 2015.

[3] The graphs also exhibit an increase during 1994; however, this has been short-lived.

Additional South African indices are included (general mining, platinum and precious metals) in an attempt to produce a more representative picture. In general, all of the indices underwent an upsurge during the late 1990s and throughout the early 2000s. Moreover, the five South African indices all appear to share the impact of the global financial crisis. Also note the declining trend apparent for each index from 2011 to 2013.

Figure 1.1.1: Standardised indices for the South African aggregate mining sector



Source: Author's own calculations using data from Datastream

Note: SA Gen Min - South Africa General Mining; SA Gold - South Africa Gold; SA I&S - South Africa Iron & Steel; SA Min - South Africa Mining; SA Plat - South Africa Platinum and Precious Metals

Considering that this study focuses specifically on the Iron & Steel, Mining and Gold sectors[4], the section proceeds by examining the price data (the first observation of each index is set to begin at a 100) for each sector in an attempt to identify any possible signs of co-movement. Figures 1.1.2 to 1.1.4 compare the performance of the Iron & Steel, Mining and Gold sectors, representing the share prices of all companies listed on the country's exchange for the respective index associated with each individual country. In addition, the South African index is displayed individually to provide a clearer representation. Moreover, the returns for each sector are calculated in order to examine the correlation coefficients for the South African indices (Appendix A). This may offer additional insight into possible relationships that may exist between South Africa and other countries.

Figure 1.1.2 shows that all the countries appear to co-move up to 2005. Greece is the only noteworthy outlier, experiencing a substantial surge during 1999 to 2000 (refer to A). A possible reason might be attributed to idiosyncratic factors. This behaviour is not indicative of the global sample and is a clear demonstration of how other factors may be able to explain the variation in a country's share prices. As such not much attention is needed to elucidate this behaviour. Further investigation also hints at a growing trend in prices that is consistent with the global commodity boom, the effects of which are perhaps more clearly demonstrated by the South African index during 2001 to 2008. Collectively all the countries for this sector built up to 2008 with Germany and Greece achieving unusually high peak levels. Notable peaks are also documented for Brazil, Italy and Morocco. Subsequently, all countries experienced a significant price decline during 2008 (refer to B in Figure 1.1.2). Note that price levels fail to reach the peak levels prior to the global financial crisis. The most noteworthy recoveries (post-financial crisis) are documented for Brazil, Germany, India and Italy (refer to C in Figure 1.1.2). The South African index plummeted during the global finical crisis and failed to reach the initial peak levels again, in fact prices declined during 2012 and this trend persisted in 2013, whereas global indices seemed to increase or consolidate in a horizontal trend. Correlation analysis is also performed for Iron & Steel sector as a supplementary attempt to identify signs of possible relationships among indices. The results primarily show that the South African index correlates with developed markets across the entire sample period (refer to Appendix A).

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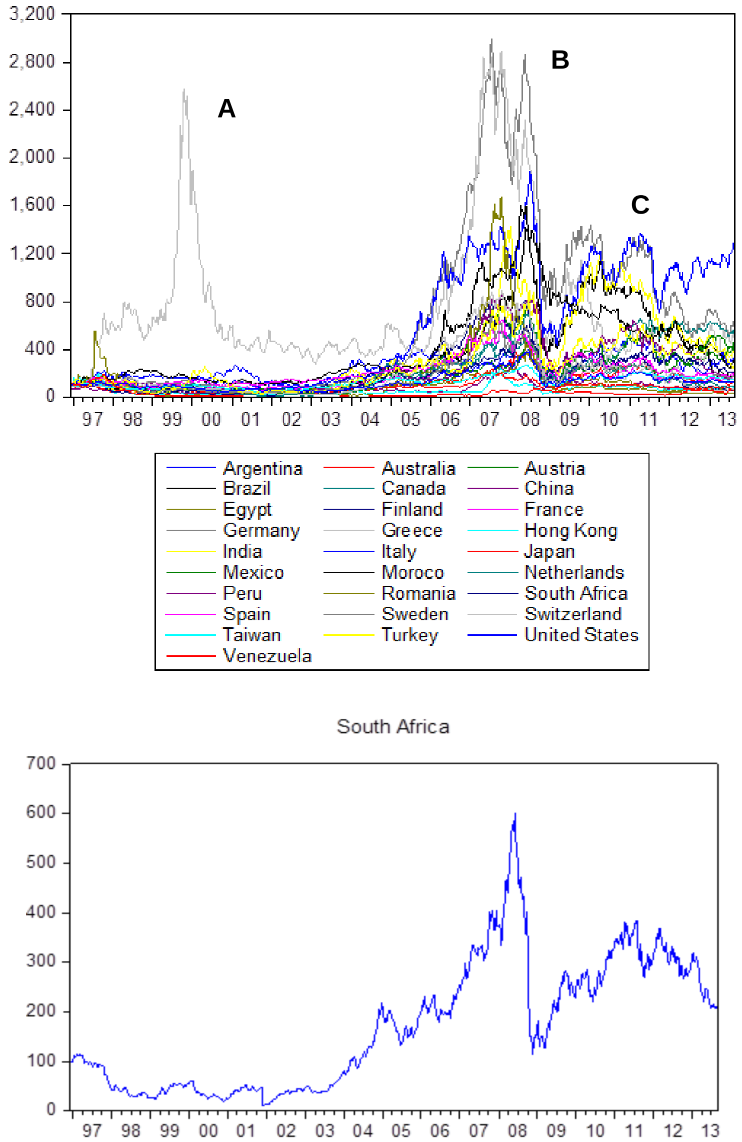
[4] Note that Section 1.2 provides a motivation on the specific sectors that are chosen. Moreover, to avoid future confusion, when referred to *Iron & Steel*, *Mining* and *Gold* are represented in capital letters

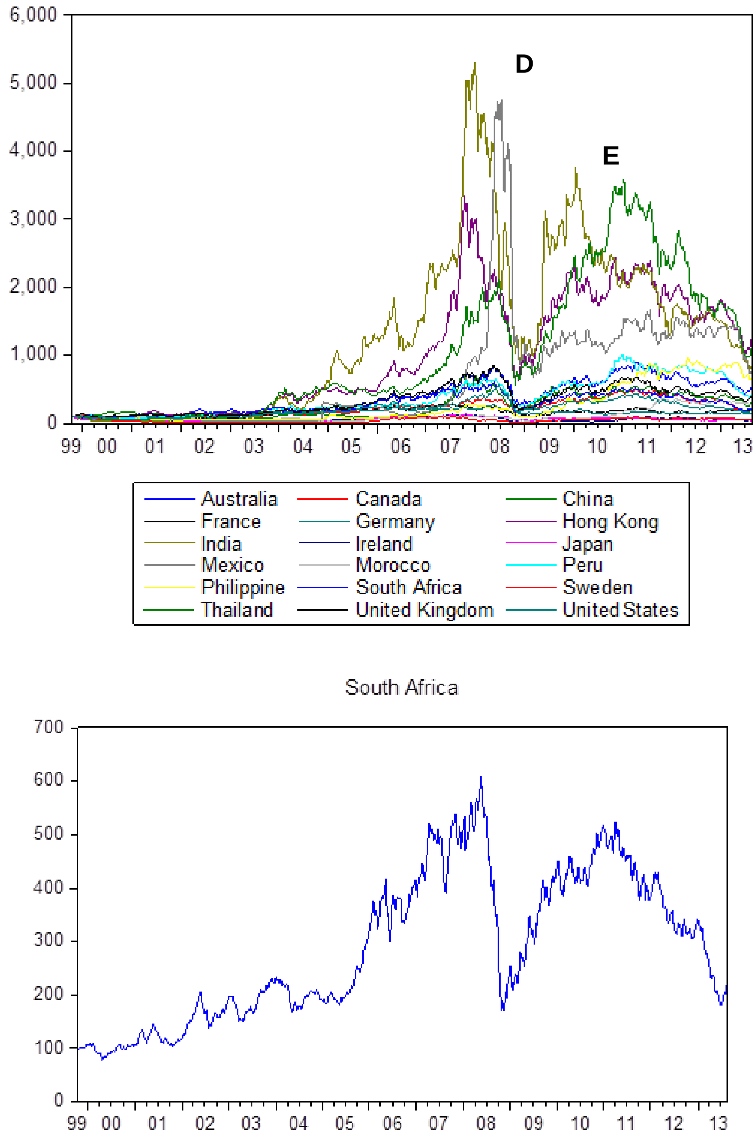
Figure 1.1.2: Standardised indices for Iron & Steel



Source: Author's own calculations using data from Datastream

An increasing trend is clearly identified for Mining during 2003 to 2008. Moreover, emerging market indices seem to dominate the Mining sector with China, India and Mexico displaying high peak levels during 2007 to 2008 (refer to E in Figure 1.1.3). However, subsequent reversals are apparent for global Mining prices during the global financial crisis. Price recovery attempts for this sector (refer to D in Figure 1.1.3) post-global financial crisis seem to be more successful compared to the performance for Iron & Steel. This might be due to the manner in which this sector is structured. In fact, prices increased substantially from 2009 to 2010 (China, India and Thailand); however, a reversal saw prices declining once again in 2011. The South African index seems to conform to global indices, suggesting a higher level of integration for this sector. The correlation coefficients for the South African Mining index also confirm a strong prominent relationship with other developed countries.

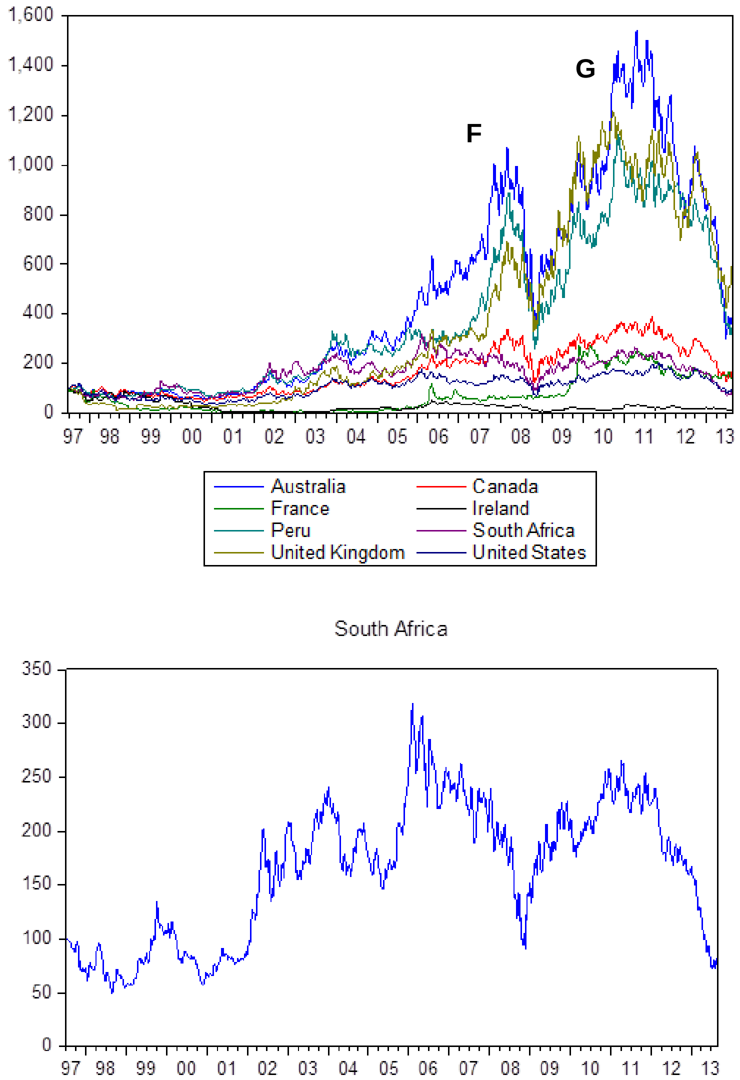
Figure 1.1.3: Standardised indices for Mining



Source: Author's own calculations using data from Datastream

The Gold sector appears to have experienced a definite increase from 2000 to 2008. In addition, Gold exhibits two apparent cohorts which move together: i) The United Kingdom, Australia and Peru, ii) South Africa, Canada, France and the United States. Note that recovery for Gold is more substantial compared to the other sectors. In general, price levels post-financial crisis (refer to G in Figure 1.1.4) are also higher compared to peak levels prior to the global financial crisis (refer to F in Figure 1.1.4). Intuitively this makes sense considering Gold is a safe haven for investors during periods of increased volatility. Not surprisingly, developed countries reached the highest price levels throughout the entire sample period. Individually the South African Gold index exhibits a significant amount of volatility overall; however, when compared to the other countries South Africa appears to co-move with developed countries. The correlation coefficients also confirm this trend (Appendix A).

Figure 1.1.4: Standardised indices for Gold



Source: Author's own calculations using data from Datastream

Literature shows that the assumption that mining companies co-move in a similar manner to commodities does not hold and different countries' mining companies do in fact display varying prices. Nangolo and Musingwini (2011:460) add to the discussion by stating that commodity prices fluctuate over time while simultaneously following cyclical patterns that tend to be disproportionate. The authors also show that the spot prices of mineral commodities are prominent in explaining the variation in the share price for mining companies (Nangolo & Musingwini, 2011:468). Moreover Byrne, Fazio, and Fiess (2013:16) document the co-movement of primary commodity prices, yet this does not explain the argument pertaining to the co-movement of mining stocks.

1.2 Problem statement

This then leads to the purpose of this study, which is to examine how South African mining indices co-move with the rest of the world's mining indices. Logic dictates that if the prices of commodities are homogenous across countries, then it is not entirely incorrect to assume the same for share prices of mining companies. When one considers the stock prices of mining companies, the expectation is that they should be driven by commodity prices and that global mining indices should co-move. However, the mining sector in South Africa has recently been faced by a few unique challenges; raising the question as to what extent stock prices of South African mining companies are co-moving with those of mining companies globally and to what extent idiosyncratic/ country specific factors are driving South African mining shares. Literature documents the notion of increased market integration over time. Moreover evidence shows that in time, different factors become more prominent in explaining the variation in market returns. In this regard see - Brooks and Del Negro (2002) and Carrieri, Errunza and Hogan (2007).

1.3 Research question and objectives

This then poses the question as to what drives mining stocks in different countries? More importantly, do the share prices of South African mining companies co-move with the rest of the world?

General objective

The general objective of this study is to determine whether the share prices of South African mining companies co-move with global mining share prices.

This is achieved by addressing specific objectives.

- Determine to what extent share prices of South African mining indices co-move with global mining share prices.
- Assess whether there are specific periods/instances of non-co-movement and whether it can be ascribed to specific economic events. Consideration is given to both local and global events/factors.
- Identify macro-economic variables as possible drivers for global mining shares.

1.4 Overview and layout

The study focuses particularly on South Africa in relation to world markets since it attempts to capture country-specific factors by examining the unique South African mining environment. It is expected that country specific factors could have aggravated volatility in the country's mining indices in recent years. Examples of such events include the loss of production due to electricity shortages, strikes and the Marikana events. Moreover, thought is given to the various indices/sectors of South African mining companies, in order to see whether global or idiosyncratic factors are more dominant in explaining price movements. The sectors employed in this study form part of South Africa's aggregate mining sector, as portrayed by the Minerals Bureau, Department of Mineral Resources for South Africa (Chamber of Mines of South Africa, 2014:5). Consideration is also given to the structure of the Industry Classification Benchmark (ICB), since this coincides with Datastream's classification. After much deliberation it was decided to select the sectors for Iron & Steel, Mining and Gold due to the nature of the data composition[5].This allows one to compare different types of mining companies which might offer insight into the impact of local/global factors have on ferrous and non-ferrous mining companies. This is especially noteworthy from a South African perspective and allows for examining the impact of industry-specific factors.

Metals are considered an important raw material involved in the process of industrial production. As such metals occupy a prominent role in many economies, and if metal prices were to increase, so would the revenue of mining companies (Qiao, 2014:11). This gives rise to the argument of co-movement among mining prices. Mining stocks are unique since they deal with an actual underlay which needs to be physically extracted, rendering companies more vulnerable due to increased exposure. More simply put, mining companies may have to contend with global as well as idiosyncratic factors. This decision also extends consideration toward investigating the influence that sub-indices have on the index it comprises. For example, is Gold a prominent factor that explains the variation in the returns for Mining?

Factor analysis is used to inspect the degree of integration and co-movement for South African mining companies, with Pukthuanthong and Roll's (2009) measure of integration serving as the foundation for examining this phenomenon. Economic analysis often consists of examining different variables that exhibit comparable relationships which give rise to modelling these co-movements. Prominent examples of studying co-movement in large multivariate data sets are the effect of macro-economic indicators on business cycles. Economists and researchers are typically concerned with common factors in order to explain the underlying co-movement. Pukthuanthong and Roll (2009) maintain that no single worthy measure for integration exists and go on to state that simple correlation may be an ineffective measure for integration. The authors employ a multifactor model with the contention that global factors are able to explain a country's returns. Moreover, if the proportion explained by these factors is small, then the country is governed by idiosyncratic factors. However, if a group of markets are greatly exposed to similar global influences, it would suggest increased integration (Pukthuanthong & Roll,

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5 Refer to the data description segment in Chapter three for a detailed discussion on the selection process regarding the relevant countries and sectors.

2009:215). Previously, single-asset pricing models have been suggested; however, the model proposed by the authors does not address the asset pricing subject, instead it focuses on a broader aspect of integration that relies on a high frequency return generating process.

This study differs from previous work since it employs global mining index data whereas other studies predominately used all-shares data. Collectively the global sample consists of 14 emerging and 18 developed economies. The findings of this study indicate that South African mining indices are more integrated with the world, evolving as time progresses. The time varying nature of integration is also identified for each sector, indicating that at certain times idiosyncratic factors are prominent in driving South African share prices. The effects associated with significant global economic events are also apparent during certain instances. After 2008 global factors have become more significant in explaining South African mining indices. Additionally, definitive inferences can be drawn for macro-economic variables driving the common global factor. Different macro-economic variables become prominent during certain stages in time. Collectively the impact associated with local and global factors differs with respect to each sector, confirming that integration is not a static process.

The remainder of the dissertation is structured to consider co-movement literature in Chapter two. Chapter three proceeds with discussing the empirical methodology used, namely factor analysis and further provides a data-description segment which considers the entire data-selection process and describes the primary and macro-economic data used for this study. An empirical analysis is conducted in Chapter four which examines and discusses the results obtained. Attention is given to the implications this may hold and possible recommendations are suggested which will allow for a more comprehensive appreciation of the results. The study ends with a summary and conclusion provided in Chapter five.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter is divided into four sections structured to provide background and examine integration literature in accordance with this study's specific objectives. The first section centres on inspecting the degree of stock market integration and the co-movement of global capital markets. Subsequently literature pertaining to South Africa's level of integration is reviewed in order to provide evidence of the country's level of co-movement with global capital markets. Consideration is also given to integration literature on commodity markets and commodity stocks. This is necessary since this study examines mining indices or, alternatively put, stocks that deal in mining commodities. Commodity stocks are different in the sense that they are subject to the systematic risk involved in stock exchanges and the prices of the commodity itself. It has to be noted, though, that literature pertaining to the co-movement of global mining stocks appears to be non-existent. Finally the chapter concludes by considering the relationship between macro-economic factors and equity prices by discussing different macro-economic variables prominent in finance literature.

2.2 Stock market integration and co-movement

In order to avoid possible ambiguities the section starts with some standard definitions of market integration and co-movement that will be used throughout the remainder of the dissertation. Capital market integration is described as a state where assets in various currencies or countries exhibit the same risk-adjusted expected returns. In contrast, segmentation signifies that the risk-return relationship in each national market is principally influenced by country-specific factors (Hamao & Jorion, 1992:454). In essence market integration can be defined as a situation involving no arbitrage opportunities across international markets (Lence & Falk, 2005:876). This study interprets market integration as a static measure which does not necessarily elucidate the dynamic behaviour that accompanies co-movement. Regarding co-movement, modern business cycle theory concludes that business fluctuations exhibit irregular patterns across time. Lucas (1977) is credited with directing emphases on co-relations between different time series sets (Danthine, 1992:409). Moreover, Qiao (2014:6) proposes co-movement as an interaction between earnings and fluctuations, coupled with the dynamic features pertaining to correlation. Baur (2003) maintains that literature fails to produce an explicit definition for "co-movement" and also notes the oscillating and inaccurate manner in which the term is often used. The author defines co-movement as the movement of assets, shared by all assets at a specific time (Baur, 2003:5)[6]. Given the vagueness that accompanies this term, certain starkness is required. As such this study interprets co-movement simply as the dynamic price behaviour envisaged between two or more assets at time t.

It is commonly agreed that global economies and financial structures have become progressively integrated and as a result precipitated equity markets to exhibit greater levels of co-movement. The reasons for this are twofold; involving firstly the swift growth associated with the global trade in commodities, services and secondly the growth pertaining to financial assets (Kearny & Lucey, 2004:571). The initial linkage emanates from growing domestic exports while simultaneously compelling countries to import commodities and services due to increasing scopes of domestic consumption and investment. The associated implications suggest the manifestation of global integration - parallel to this there is the increasing level and speed of global financial integration. The financial assets linkage occurs due to the progressive investment opportunities that are at the disposal of the various market participants. Kearny and Lucey (2004) quote Watson *et al.* (1988) who attribute the development in financial markets to internationalisation, liberalisation and securitisation. Concerning internationalisation, financial markets in industrial countries have outpaced real output accompanied by growing activity in offshore financial markets. Liberalisation has seen local financial markets enjoy greater foreign involvement, an increase in cross-country capital flows (by removing price and quantity restrictions). Finally, securitisation has seen the desertion of indirect finance and the adoption of direct finance. Fadhlaoui, Bellalah, Dherry and Zouaouii (2009:164) also support the notion of increased market integration as a result of liberalisation.

Liu (2013:2) acknowledges that King, Sentana and Wadhwani (1994) provide an essential contribution to the dynamics of co-movements among international stock markets. The authors estimate a multivariate factor model for 16 national stock markets (for the period 1970 to 1988) they also induce the return volatility by altering the orthogonal factors' volatility (King *et al.,* (1994:901). Ultimately their findings show that the inter-market correlation has risen since the stock market crash in 1987, albeit not necessarily trend altering[7]. Although the idea of increased market integration is well-known, numerous studies have shown this phenomenon to be time varying, with the reason for this being quite elusive in nature. Bekaert and Harvey (1995) propose a conditional regime-switching model as a measure for integration and find evidence of time varying integration across countries (sample period from as early as 1969 up to 1992). The authors show that despite the perception of markets becoming more integrated, country-specific results suggest that this is not always the case, since the degree of integration varies over time

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6 Baur (2003:4) provides a definition in mathematical terms to distinguish between bivariate and multivariate co-movement.

7 Additionally King *et al.* (1994:901) find that unobservable economic variables - compared to the observable variables - have been more significant in explaining stock market returns during periods of market distress.

(Bekaert & Harvey, 1995:437). Bracker, Docking and Koch (1999) conducted a study on why national equity markets exhibit differing degrees of co-movement over time. The authors examine national stock indices from nine developed markets spanning from 1972 to 1993, and the results show a high degree of market integration. Moreover, they note that this trend strengthens over time. The authors maintain that these market co-movements can be explained by various macro-economic factors. For example, it is argued that countries that are closely situated in proximate geographical areas will exhibit greater market co-movement compared to countries that are located further apart. Another factor responsible for increased co-movement can be attributed to national stock indices that share greater similarities with regards to industrial composition, which in turn relates to bilateral import dependency and market size differentials (Bracker *et al.,* 1999:25).

Brooks and Del Negro (2002:5) employ monthly stock returns from 1985 to 2002 for 9679 companies. The authors find that the degree of co-movement across national equity markets has increased dramatically since the mid-1990s (Brooks & Del Negro, 2002:13). A possible reason for this is due to the rise in industry effects compared to country effects. The results show that this increase is linked to a cyclical pattern which sees industry effects becoming temporarily more important during periods of market distress which include October 1987 and March 2000[8]. Additionally Baca, Garbe and Weiss (2000:34) find that industry effects have become more prominent in explaining international return variation during the late 1990’s. Cavaglia, Brightman and Aked (2000:41) support the increased importance of industry factors, and suggest that diversification across industries compared to countries is more desirable in terms of risk reduction. In contrast Yang (2003:1) finds that global common shocks explain a significant amount of world economic fluctuations. The author employs a dynamic factor model to study the co-movement of 103 developed and developing countries. Moreover, Yang (2003) documents that developed economies are less sensitive to global shocks compared to developing countries.

Brooks and Del Negro (2005) estimate a latent factor model that decomposes stock returns into global, country and industry components (for 42 countries, from 1985 to 2002). First the authors find that the dispersion of the shocks is economically and statistically significant. Furthermore they report that shock exposures are linked to observed firm level characteristics such as size and the degree to which a company operates internationally. Lastly the findings show that portfolios comprising stocks with low correlation to country shocks produce substantial variance reduction relative to a global market portfolio (Brooks & Del Negro, 2005:3). The authors also address the argument pertaining to whether country/industry-specific shocks are more important

8 These periods of distress refer to Black Monday (1987) and the Internet Bubble (2000); in this regard see Carlson (2006) and Ofek and Richardson (2003).

in explaining the behaviour of national stock markets. The results show that country shocks are more significant compared to industry shocks. Heston and Rouwenhorst (1994:3) and Griffin and Karolyi (1998:371) support these notions.

Carrieri *et al.* (2007) assess the evolution of market integration for eight emerging markets by using equity indices spanning from January 1977 to December 2000. Their findings support an increase in financial market integration specifically towards the late 1990s; however, reversals are apparent at times (Carrieri *et al.,* 2007:917). The authors note that the potential impact significant economic events such as the Mexican crisis of 1994, the Asian crisis of 1997 to 1998 and the Russian default of 1998 can have on a on a country's level of market integration. Findings also suggest that local risk is still an important factor in explaining the level of integration for emerging markets. Their results are in line with theoretical literature on the impropriety of using market-wide correlation as a measure of integration since it does not account for country-specific fundamentals, and this is also supported by Dumas, Harvey and Ruiz (2003:806 & Carrieri *et al.,* 2007:933). Lastly the authors report evidence that links financial market integration with macro-economic development, financial market development and financial liberalisation policies (Carrieri *et al.,* 2007:917).

In order to distinguish among different types of markets, Fadhlaoui *et al.* (2009:167) examine the short and long-run relationships among the G7 equity markets and three central European emerging markets. The authors maintain that despite the substantial body of literature pertaining to capital market integration between emerging and developed equity markets, little attention has been devoted to Central European markets. The study employs Johansen cointegration techniques to carry out the long-run relationships. The results indicate that the central European markets are segmented as a group this is also true when compared to the G7 markets, suggesting substantial diversification benefits (Fadhlaoui *et al.,* 2009:172).

In this vein Gilmore, Lucey, and McManus (2008:606) argue that banking currency and economic crises have led investors to search for alternative markets, more specifically Central European markets. These countries strive to be part of the European Union mainly because of the attractive growing political economic stability associated with this area. This reinforces Bracker *et al*.'s (1999) argument pertaining to the linkage associated with geographics and market similarities. Gilmore *et al.* (2008:606) maintain that co-movements between markets can sprout from the increase of capital mobility, international trade, and relaxation of capital controls and lastly the alignment of economic policies. Relevant to this are the cases of the Hungarian, Czech Republic and Polish equity markets that have exhibited successful market transformation since 1989. In their study the authors test for short and long-term co-movement between developed and central European countries in the Europe Union. They employ both static and dynamic methods of analysis, covering the period from July 1995 to February 2005 (daily closing prices for stock market indices are used). The static analyses show low levels of short-run correlation, the study also fails to produce statistically significant results for cointegration. The dynamic analyses which utilise rolling-window periods deliver a more complex picture indicative of sporadic short-run correlations and long-run cointegration. Moreover, dynamic principal component analysis is able to produce a single stable factor that significantly explains the behaviour of the sample group. Put more simply. Central European markets do not show a long-run equilibrium relationship with developed European Union markets (Gilmore *et al.,* 2008:619).

Unique work conducted by Pukthuanthong and Roll (2009) suggests that global markets seem to show an increased level of integration; noting, however that no single worthy measure for integration exists. The authors go further and show that simple correlation between global markets is a poor measure for integration (Pukthuanthong & Roll, 2009:231). They argue that when a number of global factors are present, simple correlation between the index returns of two countries is a deficient measure for economic integration. Unless the countries share similar exposure to these global factors, they will show imperfect correlation even when the global factors explain 100% of the index returns of the countries. The countries therefore do not share the same sensitivities to the different return volatilities. This is supported by Bekaert and Harvey (1995:436). The results provide evidence for an increasing degree of integration between global markets (Pukthuanthong & Roll, 2009:231). In their data sample of stock returns from 81 countries spanning the period from 1973-2006 the authors show that troubled countries (Bangladesh, Nigeria, Pakistan, Sri Lanka, and Zimbabwe) primarily exhibit signs of less integration. In contrast, though, certain countries experience more significant levels of integration (for example, the Western European countries and South Korea).

The argument of country specific idiosyncrasy is carried on by Bekaert, Hodrick and Zhang (2009:2624) who estimate a simple linear factor model with time-varying abilities for 23 developed markets from 1980 to 2005. Their main findings suggest the on-going importance of country-specific factors. Kose, Otrok and Prassad (2012:511) employ dynamic factor analysis to analyse the degree of global cyclical interdependence from 1960 to 2008. Their findings suggest that the importance of the global factor has weakened with regards to its explanatory ability of business cycles between emerging markets and industrial economies.

Finally, Chen (2013), Harper (2011) and Liu (2013) all test for market co-movement. Chen (2013:7) employs a Bayesian dynamic latent factor model that aims to estimate common factors in global stock markets. The author finds support for increasing international co-movement and also documents the significance of the common world factor (2013:28). Additionally the author finds significance for the regional factor, especially with regards to emerging markets. Harper (2011:89) examines the co-movement between India and its trading partners, and the results indicate that a linear relationship exists. The author also finds support for the regional factor associated with India’s Asian trading partners. Liu (2013:11) estimates a dynamic factor model that decomposes stock returns into global, region and country specific components, where it is assumed that these orthogonal factors include all possible variations among the return volatilities. The author documents greater financial integration among global stock markets, the author also finds significant results of the world factor in the Latin and North American markets, while the regional factor is dominant in the Asian and European markets Liu (2013:44). See Pretorius (2015:180) for a comprehensive and further assessment of previous literature pertaining to global stock market integration.

Summary

The general consensus is that global markets have become more integrated and as a result cause national equity markets to co-move. Also literature suggests that market integration is time-varying which is particularly evident during instances of market distress. Although the trend is that of increased global integration, there is not always uniformity with regards to the dominant factors responsible for market integration. Literature often suggests that idiosyncratic factors are more significant in describing market co-movement, whereas in other instances studies identify regional and global factors as dominant drivers for co-movement. Global factors tend to become increasingly important during the periods subject to market turmoil. Ultimately these factors will vary across countries given their level of integration relative to global markets. Yang (2003:1) supports this and describes investment sensitivity exposure to global common shocks as a function of a country’s size and its accessibility to other global markets.

2.3 South African market integration and co-movements

The Johannesburg Stock Exchange (JSE) was established in 1887 making it the second oldest stock exchange in Africa (pre dated only by the Egyptian stock exchange, established in 1883) (Smith, Jefferies & Ryoo, 2002:475). This gives rise to the argument that South Africa should be significantly financially integrated with its African peers. One of the main motivations for the bourse’s existence is attributed to the proclamation of the Witwatersrand gold fields, 14 years after the JSE was founded (Moolman & Du Toit, 2005:87). The exchange enabled new mines to raise capital and also assisted in developing the country’s mining industry. However due to the JSE’s rapid growth, the composition of listed companies these days has changed with regards to size and industry. Moolman and Du Toit (2003:79) maintain that the South African market has undergone a process of reintegration since 1994; and an example of this is the introduction of a 24-hour share trading platform which has rendered the JSE more susceptible to global trends and events[9]. The JSE is considered the dominant stock market in Africa with regards to size and sophistication and it is currently the 19th largest stock exchange in the world (Johannesburg Stock Exchange, 2014:4). The exchange also boasts impressive listings that include Anglo-American Plc, AngloGold Ashanti Ltd, BHP Billiton Plc, Glencore Plc and Gold Fields Ltd[10]. This suggests increased global integration of South Africa's equity market (especially with developed markets) and validates the argument that the country's equity market occupies a significant capacity when viewed from a global perspective and more importantly a regional perspective. However, literature does not necessarily produce comparable findings.

From a South African perspective Jefferies and Okeahalam (1999) observe the linkage associated with South African and world stock markets, comprising both developing and developed markets. They employ weekly data spanning from mid-1989 to end-1996 and test for short-run and long-run relationships. The results indicate that South Africa is closely related to Asia and the United Kingdom in the short run. Moreover, South Africa and Botswana exhibit significant co-movement mainly as a result of the close economic links these markets share. However, the similar conclusions cannot be reached for other African markets. According to the authors, the lack of co-movement may be attributable to the difference in the sectoral composition pertaining to different countries' indices (Jefferies & Okeahalam, 1999:47). In order to illustrate this, consider the Zimbabwean market, as the majority of its firms have local owners, which suggest minimal linkage to other international and regional groups. Zimbabwe is also very dependent on its agriculture sector, which in turn renders it more exposed to geographical and idiosyncratic factors.

Additionally Lamba and Otchere (2001:201) investigate South Africa's relationship with other major world equity markets and document findings of long-run relationships. For the complete subset, the Japanese market displays the least influence on South Africa while Australia, Canada and the United States exert the most. However, the analysis for the sub-period shows no long-run relationship relating to the Apartheid era. This changes in the long run though, where the relationship becomes significant post-Apartheid, concluding that the South African equity market is financially more integrated with developed stock markets. However, a recent analysis conducted by Pretorius (2015:148) indicates that South African stocks and bonds are more integrated with emerging markets, whereas developed markets explain a larger share of South Africa's currency market. In similar vein, Kabundi and Mouchili (2009:51) examine the level of integration between South African and global stock indices by employing a dynamic factor model[11]. The authors conclude that the South African equity market co-moves with

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9 In this regard also refer to Van Zyl, Botha and Skerritt (2003).

10 Note that these companies are dual-listed on foreign stock exchanges.

11 The authors' model sprouts from the dynamic factor model put forward by Forni, Hallin, Lippi. and Reichlin (2005a).

emerging markets. However they document a less significant relationship with developed stock markets.

Summary

Literature suggests that South Africa displays high levels of market integration with global financial markets mainly due to market liberalisation and increased globalisation. For example the JSE is considered among the most sophisticated in Africa and has companies that are listed both locally and abroad. Logic dictates that for this reason South African stocks should co-move with global equity markets. Greater financial integration also suggests that the country would be more vulnerable to global shocks, which means local markets are less affected by idiosyncratic factors in relation to global factors.

2.4 The role of commodities in stock market integration and co-movement

Since this study is concerned with co-movements between global mining indices the topic to follow becomes relevant. When considering integration in commodity markets the unavoidable argument of homogeneity associated with these markets arises. Parallel to this is the law of one price, that contends that if two or more markets are integrated and deal in similar goods, these markets should in theory produce equal prices (Jain, 1981:65). However this law has strict assumptions and therefore invokes controversy since it fails to consider certain dissimilarities between the goods and services traded in these markets (Kenen, 1976:8). This especially applies to commodity markets due to possible differences in grades of commodities that are traded, trade barriers and transport costs. In spite of this reasoning, the common assumption persists that primary commodities prices appear to be perfectly arbitraged (this is considered true for the long run). However Ardeni (1989:661) maintains that this is counterfactual and attributes this to econometric shortcomings found in previous empirical studies.

Usually the commodity market is made up of a commodity element and a financial element. The former consists of the dynamics involved in the changes associated with supply/demand of the commodity itself and the subsequent influence exerted on commodity prices. The financial element concerns speculation by using financial leverage to break the supply/demand relationship associated with commodity prices. There are a number of explanations for this but collectively the main reason is that commodities have come to function as a substitute for financial assets by providing similar investment functions (Qiao, 2014:16). This is especially true for oil and metal, for example; these commodities serve as a hedge against inflation and devaluation of the United States dollar. Additionally aluminium, copper and oil are important raw inputs for the construction industry, not to mention the role they play in the futures market.

Creti, Joëts and Mignon (2013:16) maintain that commodity prices have undergone extraordinary volatility over the last decade. The global financial crisis has triggered a dramatic drop in commodity prices; however, commodity shares seem to have stabilised since the financial turmoil. As a result the various market participants have become more interested in this relationship, and moreover Choi and Hammoudeh (2010:4388) contend that this is especially true for commodity exporters such as South Africa, since it would assist in understanding the possible implications this volatility holds for the economy. According to Creti *et al.* (2013:16) commodity and stock markets share a number of characteristics but up to now literature has only investigated this relationship by mostly examining the co-movement between oil and stock markets. As a result the literature pertaining to the relationship equity markets and the commodity market is concomitantly vast.

In this vein, Pindyck and Rotemberg (1990:1173) examine the co-movement amongst commodity returns and find that commodity returns exhibit a persistent tendency to move together. The authors also show that returns exhibit co-movement after accounting for macro-economic factors. To demonstrate this, consider the following: An increase in interest rates should cause commodity prices to decrease, higher interest rates would lower future aggregate demand (hence higher commodity demands) and also increase commodity carrying costs. From the example provided it's clear that changes in macro-economic variables affect demand/supply which in turn directly impacts on price. As noted by the authors, commodities serve as inputs to production for other commodities, also it is storable which means expectations about future market conditions influence the demand for storage and hence the prevail of current prices (Pindyck & Rotemberg, 1990:1776). Lastly the authors also find that the macro-economic factors' ability to explain co-movement is more sufficient for longer holding periods because it prevents the exclusion of relevant macro-economic variables.

More recent studies include Choi and Hammoudeh (2009:4388) who test for dynamic correlations between commodities (copper, gold, silver, Brent/West Texas Intermediate oil) and the stock market. The results show that since 2003 correlations between the commodities have increased but suggest a negative relationship with the stock market. Additionally, Creti *et al.* (2013:21) point out the increased level of volatility between commodities and stock markets during the financial crisis, highlighting the financial evolution of commodity markets. In addition Qiao (2014:69) also examines dynamic correlation and concludes that commodity (aluminium, copper and oil) prices and stock markets show a positive relationship after the global financial crisis, suggesting global integration.

Filis, Degiannakis and Floros (2011:23) examine the time-varying relationship between stock markets and oil prices for both oil-importing/exporting countries from 1987 to 2009. Their findings indicate a correlation between stock markets and oil prices do not differ for countries importing/exporting oil. Moreover, the authors also document a negative relationship. Creti *et al.* (2013:18) maintain that literature provides ample evidence of a negative relationship between stock and oil markets. In addition to this, Filis *et al.* (2011) suggest that demand shocks originating form economic crises have a more profound effect on stock markets compared to supply shocks or non-economic crises.

Similar to the purpose of this study Byrne *et al*. (2013:16) employ factor analysis to inspect the extent/nature of co-movement. However, the authors examine primary commodity prices for 24 different commodities including certain precious metals. Their findings support evidence of co-movement between commodities. The results are not necessarily consistent with the purpose of this study but it adds to the methodology employed for this study. Moreover, it enhances the argument of this section, which is to highlight the void that exists in finance literature pertaining to the co-movement of global mining indices.

Summary

In conclusion, literature suggests that the link between commodity and stock prices has increased, especially after the financial turmoil from 2007 to 2008. As a result the commodity market has undergone a state of financialisation, prompting an increased interest in investigating the relationship between the commodity and stock markets. A substantial literature has developed that examines the co-movement between commodity and stock markets; however, this focus has primarily been on the oil and stock markets. Empirical studies pertaining to the co-movement between global commodity (specifically mining) indices are sparse or non-existent. This study aims to fill this gap. Relevant to this section is the influence that macro-economic variables exert on commodity/equity prices (see for example, Pindyck & Rotemberg, 1990 and Ai, Chatrath & Song, 2006). The section to follow examines this relationship.

2.5 Macro-economic factors and equity prices

From the foregoing discussions it is clear that macro-economic factors play an important role when it comes to equity prices, and it is therefore fitting to discuss this relationship. Due to an increase in market liberalisation and globalisation over the past couple of decades, a rapid surge in cross-country financial flows and global trade in goods/services have come to be. Consequently, nowadays economies’ financial markets and macro-economic performance are not immune to economic events that occur in other parts of the world anymore. These financial and trade linkages have engendered a substantial literature on global co-movements (Chen, 2013:52). The rationale is that macro-economic factors influence equity returns, which in turn affect co-movements and equity market integration. This relationship has been examined comprehensively (see for example Fisher, 1930, Ross, 1976 & Harper, 2013:45). It is noted that past studies have primarily focused on developed economies and failed to include developing economies. Chen (2013:52) duly captures the relevance of this relationship by contending that global integration can fundamentally change risk for an investor, thus altering stock market dynamics. For example, consider an isolated economy where the market risk associated (identified systematic risk) refers to risk that has already been priced. Yet with an integrated economy the priced risk in this instance would be the level of exposure to international stock markets. Likewise the effect for equity markets that are driven by macro-economic fundamentals will also be different in the two states. The macro-economic fundamentals of an isolated economy would probably be the dominant force in driving the equity market. Conversely stock markets in a globally integrated economy would perhaps have a better response to global business cycles shocks compare to idiosyncratic macro-economic fluctuations (Chen, 2013:52). Essentially this is a review that focuses on the relationship that key macro-economic variables have with equity markets in order to uncover the subsequent linkage associated with co-movements and market integration which include inflation, interest rates, money supply, exchange rates and industrial production.

2.5.1 Inflation

Inflation is an essential macro-economic variable that affects equity returns. Logic suggests this is achieved through using the discount rates channel, where higher inflation would cause the discount rate to increase, resulting in lower equity returns (Chen, 2013:61). Fisher (1930) fulfils a primary role in studying the relationship between inflation and stock returns. The author maintains that equity shares function as a hedge against inflation, driven by the general notion that equity market increases are correlated with price levels, thus inflation would not affect returns. Fama (1981) examines the negative relationship between inflation and equity returns and the findings suggest that returns are based on real variables additionally, so that the author interprets these findings in the framework of money demand theory/quantity theory of money (Fama, 1981:563).

Alternatively Geske and Roll (1983:1) argue that equity returns have a negative relationship to the concurrent changes in expected inflation since it signals a sequence of procedures that will result in a greater rate of monetary expansion. Similar to this strand of research, Lee (1992) examines the relationship between equity returns, inflation, interest rates and real activity for the post-war period in the United States. The author’s findings seem to be similar to Fama’s (1981) conclusions concerning the negative relationship between inflation and equity returns, as oppose to Geske and Roll (1983) and Ram and Spencer’s (1983) findings (Lee, 1992:1591). In response to his 1981 paper, Fama (1983) offers a few remarks on the suggestions made by Ram and Spencer (1983), where the author states that the Ram-Spencer model is internally inconsistent due to certain assumptions made and the authors provide misleading impressions regarding Fama (1981)'s real activity variables (Fama, 1983: 471).

2.5.2 Interest rates

Similarly, interest rates can also influence equity returns, recall the "Fisher effect" where the expected nominal interest rates of financial assets is considered to move in tandem with expected inflation (Lee, 1992:1596). Moreover short/long-term interest rate changes are considered likely to affect the discount rate by means of the nominal risk-free rate channel (Chen 2013:61). Chen (2013) continues by stating that interest rates may also implicate the stock market through the discount factor or inflationary effects. Harper (2013:52) notes the implications of macro-economic factors and maintains that monetary officials need to recognise the effects that monetary policy has on equity markets, especially emerging stock markets.

2.5.3 Money supply

Another factor that can affect equity returns is money supply. It is argued that an increase in a country's money supply will give rise to inflation, which would create negative implications for stock market returns (Fama, 1981:563). Alternatively an increase in money supply could also cause interest rates to decline resulting in additional investment opportunities for firms and reductions in discount rates (Chen, 2013:61). Prior to Fama (1981), Cooper (1974:887) suggests that a change in money supply gives way to changes in the equilibrium position of money which in turn alters the investor's' asset and price structure. Additionally Rogalski and Vinso (1977:1017) show that changes in money supply can influence real economic variables which create a lagged effect on equity returns.

In essence the previous two mechanisms that have been mentioned all propose that the relationship between money supply and equity returns is positive. An example of this is the Federal Reserve's large-scale unconventional monetary policy scheme, also referred to as Quantitative Easing (QE). This term is generally defined as policy aimed at affecting the economy's reserves and money supply and by expanding the central bank's balance sheets (Bernanke & Reinhart, 2004:87). A desired effect of QE is to increase liquidity in the private sector by injecting money into the economy, which in turn would push up stock prices. This measure is not exclusive to the United States (US) and has been implemented by Japan, the United Kingdom and the European Union (Joyce, Miles, Scott & Vayanos, 2012:274). This measure remains very controversial. For example, Fratzscher, Lo Duca and Straub (2013:26) find that QE in the US was effective in decreasing yields and elevating the US stock markets and equities across the world, specifically during the first two stages of QE. However, the counter-argument is that given the sluggish recovery associated with Western economies, unconventional monetary policy was not successful and that is why additional stages of QE were required (Joyce *et al.,* 2012:274). Literature also shows that the effects of QE policies have led to the aggravation of increased global volatility, precipitating sharp rebalancing in emerging markets (Sahay, Arora, Arvanitis, Faruqee, N'Diaye & Mancini-Griffoli, 2014:5).

2.5.4 Exchange rates

Harper (2013:47) states the importance of knowing how exchange rates impact on stock returns. Ajayi and Mougue (1996:193) show that aggregate domestic equity increases and domestic currency value share a negative short-run relationship; however, this relationship becomes positive in the long run. Conversely, depreciation in currency negatively affects stock markets in both the short/long-run. Ajayi, Friedman and Mehdian (1998) employ daily stock indices and exchange rates for developed and emerging countries. The results suggest a unidirectional relationship between equity and currency markets associated with developed countries, while failing to find significant causal evidence for emerging countries. Additionally equity and currency markets in developed countries are more integrated compared to emerging countries. This in turn renders the former's currency market more efficient in responding to newly-priced market information. Finally the authors speculate about the contradictions between the developed and emerging markets and attribute the differences in results to dissimilarities relating to financial market structures and characteristics (Ajayi *et al.,* 1998:248).

2.5.5 Industrial production

It is generally concluded that equity returns exhibit a positive relationship with industrial production (Lee, 1992:1596). This is supported by Fama (1981:563) who maintains that a significant positive correlation exists between industrial production and equity returns. Fama (1981) maintains that stock prices are the primary leading indicator for real economic activity and show that stock returns are never led by any real economic variables. Moreover industrial production is the only variable found to exhibit a robust contemporaneous relationship with stock returns (Fama, 1981:555). Additionally Schwert (1990) replicated Fama's (1990) results (for the period 1953 to 1987), while extending the study by including an additional 65 years of data, and the author also included the Miron-Romer (1989) index as an alternative measure of industrial production (Schwert, 1990:1237). However, according to Harper (2013:53) the relationship between industrial production and stock markets has been well researched in developed markets but the same cannot be said for developing markets. The author maintains that empirical studies for the latter have produced mixed results, and attributes this to different sampling periods and the particular set of countries used.

2.5.6 Global macro-economic fundamentals

Chen (2013:54) maintains that there is an extensive variety of studies that examined co-movements attributed to macro-economic activity by means of the common factor. Since the global factor is a prominent measure applied to examine macro-economic shocks it can also be employed to examine global stock markets' underlying risk. Kose, Otrok and Whiteman (2003:1216) and Stock and Waston (2003:200, 2005:968) examine macro-economic fluctuations in G7 economies. The general findings show that common shocks are important in driving country output fluctuations. In this vein, recent studies have concentrated on examining the global inflation movements. For example, Neely and Rapach (2008:2) employ a dynamic latent factor model using data from emerging and industrialised countries. The authors document co-movements of global inflation across various countries. In conclusion, different macro-economic shocks are capable of producing co-movements within countries.

2.5.7 South African macro-economic factors on equity prices

When contextualising these factors in the South African sense, empirical results suggest that macro-economic uncertainty inflicts a substantial amount of volatility onto the country's equity market. For example Chinzara (2011) examines the transmission of systematic risk originating from macro-economic events and finds that volatility related to short-run interest and exchange rates are most influential in driving South African stock market volatility (Chinzara, 2011:27). Additionally, Coetzee (2002:8) finds that the country's equity market has a prominent relationship with exchange rates, international equity indices and monetary variables; however, the relationship is less substantial for industrial production. Moolman and Du Toit (2005:87) find support for a short-run relationship between the South African stock market and interest rates, exchange rates and global equity indices. Finally, Samouilhan (2006:249) and Chinzara and Aziakpono (2009:69) document the significant effect that foreign stock market volatility exerts on South African equity market volatility. The latter contends that volatility in developed and emerging markets describes the JSE's volatility. Heymans and Ricardo (2013:432) examine the volatility transmission during global financial crises and find that South African's equity market seems to be affected though contagion from a country of origin.

Summary

Literature offers convincing support for increased levels of global integration, thus leading to greater co-movement between capital markets. Various explanations exist as to whether it is due to increased interconnectivity as a result of global trade, geographic factors, industry/country effects or increased financial linkage due to internationalisation, liberalisation and securitisation. Literature extends its argument by expressing integration as a dynamic/sporadic process as opposed to a static phenomenon. This means the level of co-movement between two or more capital markets is most likely to fluctuate over time. Literature suggests that the South African equity market conforms to global integration trends. This is particularly true with regards to the relationship that exists between the JSE and developed equity markets, including that of emerging markets. Intuitively this makes sense considering South Africa's advance financial institutions and its membership of BRICS.

A topic more germane to this study is that of commodity and stock prices, particularly the co-movement of global mining indices. Literature maintains that the relationship between commodity and stock markets has become more relevant after the global financial crisis, with the lion share focusing on the co-movement between the oil and stock market. However, hardly any or no attention has gone into examining the co-movement between global commodity indices, especially true in the case of global mining indices. This chapter concludes by examining the relationship that exists between macro-economic variables and the behaviour of stock prices. Literature is clear on the influential nature that different macro-economic variables have on stock markets and South Africa is not different in this regard. Literature maintains that macro-economic uncertainty inflicts a substantial amount of volatility onto the JSE.

CHAPTER 3: EMPIRICAL METHODOLOGY AND DATA DESCRIPTION

3.1 Introduction to empirical methodology

Chapter three consists of two main parts. The first part deals with the empirical methodology and the second part provides a data description. Since the aim of this study is to examine the co-movement between the South African and global mining indices, the first part of this chapter is devoted to discussing various methods of measuring integration and co-movement. Section 3.2 provides a review of the most prominent methods used in previous literature. Sections 3.3 and 3.4 introduce and discuss factor analysis which will be used to conduct the empirical studies. Section 3.5 continues by discussing the importance of retaining and extracting the correct number of factors, and various methods are listed which may offer insight into obtaining this objective. Finally, Section 3.6 concludes the first part by discussing the specific measure of integration used for the empirical analysis. The second main part of the chapter, Section 3.7-3.9, addresses the data selection process and provides a data description of the primary data while also including an analysis of the descriptive statistics for each of the three sectors.

3.2 Different measures of co-movement

As noted by Kearney and Lucey (2004: 575) a significant amount of literature exists (accompanied by a voluminous range of methodologies) that have examined international market integration and co-movement from the perspective of increasing correlations in equity returns over time. With the general reasoning suggesting that the correlation structure exhibits instability over time, coupled with the assumption of increasing correlation, this ultimately reveals a greater degree of integration. However, these tests fail to provide an interpretation on the evolution of cross-market linkage or co-movement since studies usually divide sample periods according to different phases of regime changes. This suggests a subjective approach that fails to capture the evolution of co-movement for financial markets over time (Wang & Moore, 2008:117).

Additionally Kearny and Lucey (2004:574) maintain that there are three focal threads apparent to the literature: First, examining stock market segmentation by means of the international capital asset pricing model (CAPM), secondly, literature that examines the extent of market fluctuations pertaining to correlation and cointegration structures and thirdly, recent literature that employs time-varying measures of integration. The purpose of this study is not to perform a review of integration methods but to estimate integration. Still it is worth mentioning the most prominent methodologies found in finance literature and to present the common limitations associated with some of these methods before proceeding to the empirical analysis.

3.2.1 Correlation analysis

Among the methods for measuring integration there are simple studies of correlation. Longin and Solnik (1995:3)[12] document that the correlation matrices of international returns form an integral part of finance literature. The main driver behind this is the abundant research done in the early 1970s on international diversification benefits encouraged by low correlation between national stock markets, particularly between developed and emerging markets[13]. To motivate this argument, consider the following: if the correlation coefficients between markets are high it would lead to lower gains associated with international diversification and vice versa, illustrating the importance of possible excess returns (Fadhlaoui *et al.,* 2009:164). Additionally, in contrast to cointegration techniques, correlation techniques are primarily employed to measure short-run relationships and may sometimes yield different results for integration compared to the former. For example, Fadhlaoui *et al.* (2009:163) document low levels of correlation between developed and emerging markets in the short run, but fail to find evidence of a long-run relationship. In essence market correlation reveals market interdependence. Chen (2013:35) acknowledges the on-going use of correlation analysis to investigate market linkage during periods associated with elevated volatility. The author employs four different correlation models (including two time-varying models and two constant models) to examine correlation among stock markets.

3.2.2 GARCH models

In this vein it is worth measuring GARCH techniques as a measure of market co-movement. Return variance tends to display signs of heteroskedasticity, and a successful alternative to model the conditional variance of returns is the univariate GARCH model (Longin & Solnik, 1995:6). Engle (1982) introduced the autoregressive conditional heteroskedastic model, which was generalised by Bollerslev (1986) - accounting for numerous refinements. In short the typical GARCH[14] model calculates the variance for the period $t+1$ by squaring the volatility of period $t+0$. In literature, methods are sometimes combined to provide more robust results. For example, Longin and Solnik (1995) find that correlation and co-variance matrices exhibit unstable behaviour over time and GARCH models may assist in capturing this fluctuation volatility. However, the authors note that the models are limited in explaining complete market evolution. Other studies that employed GARCH models to estimate market integration include Carrieri *et al.* (2007), Choi and Hammoudeh (2010) and Creti *et al.* (2013).

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12 The authors examined the returns for seven developed countries from 1960 to 1990 and document an increase in cross-country correlation during periods of instability.

13 In this regard refer to Fadhlaoui *et al*. (2009).

14 Hentschel (1995) develops a family of all the popular GARCH models.

3.2.3 Cointegration methods

Definition of cointegration

Consider the case where X_t, and Y_t are $[I(1)]$ with the possibility that a linear combination $Z_t = m + aX_t + bY_t$ exists with a mean of zero and is $[I(0)]$, then it is considered that X_t, and Y_t are cointegrated (Engle & Granger, 1991:6). In other words cointegration requires variables to be integrated of the same order or share common stochastic trends (Watson, 2008:871).

Equivalent to studies of correlation is the literature that employs cointegration methods to measure the degree of market integration. Kearney and Lucey (2004) recognise the intuitive properties associated with cointegration, which researchers find appealing[15]. To exemplify various methods of cointegration, consider the following difference in results obtained from previous studies that employed the Engle-Granger methodology and the Johansen Multivariate approach. Kearney and Lucey (2004:576) compiled a collection of previous cointegration studies employing either the Engle-Granger or the Johansen Multivariate approach. The authors document that the studies using the Engle-Granger approach fail to produce significant evidence of integration. However, the studies that used the more sophisticated Johansen method found more conclusive evidence for integration. An alternative explanation may be attributed to the sample data employed. Studies from the era included 1980s data, a period recognised for its instability (Longin & Solnik, 1995:6).

In order to better understand cointegration, consider spurious regressions, where the error of two non-stationary variables can be presented as a series of stochastic trends. It is expected that the latter would merge and create another non-stationary process. However, if two variables X and Y are in fact related, it is expected that they would move together and that the possibility then exists to produce a combination of stochastic trends that would eliminate non-stationarity. In this case the variables are considered to be cointegrated. Cointegration becomes a necessity for any economic model that employs non-stationary time series data (Asteriou & Hall, 2011:356).

Since this concept was first introduced by Engle and Granger (1987), time series literature has seen the behaviour of cointegration being studied and tested in an array of settings (Lence & Falk (2005, 874). According to the authors the widespread interest seems to sprout from a blending of forces. Firstly it would seem that numerous univariate economic time series behave similar to difference-stationary or integrated of order one $[I(1)]$ series. This is considered a precondition for cointegration. Furthermore cointegration tends to display long-run equilibrium

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[15] The popularity of cointegration is noted however these methods rely on a strict unit-root assumption which is not always easily justified in theoretical or economical terms (Hjalmarsson & Österholm, 2007:1).

relations (Implied by economic theory) in an appealing manner. Lastly a sizeable and particular econometric literature has emerged to facilitate estimation and inference of the data when cointegration is found to be present.

3.2.4 Engle-Granger technique

The Engle-Granger approach tests whether or not long run equilibrium relationships exist. Consider two series X_t and Y_t; if $Y_t \sim I(0)$ and $X_t \sim I(1)$ then generally the linear combinations obtained from these two series will produce a series that is $[I(1)]$ (i.e. non-stationary). The reason for this is due to the dominant nature of $[I(1)]$ over $[I(0)]$. However, there are exceptions to this, where in rare cases a combination might realise that is $[I(0)]$. When this unique combination occurs, it is believed that X_t and Y_t are cointegrated $(1,1)$ (Asteriou & Hall, 2011:364). Engle and Granger (1987) proposed a simplistic four-step method of estimating the parameters of the long-run equilibrium relationships.

The simplicity of implementing and understanding the Engle–Granger approach is probably its most attractive feature; however, there are shortcomings associated with this methodology. For example it fails to identify which variable should adopt the role as the dependent variable or the regressor. This problem intensifies when the regression includes more than two variables thus rendering the approach unable to specify the correct number of cointegrating variables. The first concern involves the order of the variables, more specifically when the long-run relationship is estimated. One variable has to serve as the dependent variable and the other as the regressor. The Engle–Granger approach fails to specify which variable should adopt which role (Asteriou & Hall, 2011:366).

3.2.5 The Johansen multivariate approach

Following the discussion of the shortcomings of the Engle-Granger approach, if a model consists of more than two variables the possibility exists of having more than one cointegrating vector. In general, if there are n number of variables there can only be $n - 1$ cointegrating vectors. Considering a simpler case with $n = 2$ the cointegrating vector would be unique in this instance[16]. However, with $n > 2$ variables the possibility exists that there are more than one cointegrating vector which creates serious problems that the Engle-Granger single-equation approach cannot resolve. An appropriate alternative is the Johansen Multivariate approach which supplies estimates for all cointegrating vectors. Similar to the Dickey-Fuller test if unit roots exists it can be assumed that asymptotic distributions do not appertain. In essence the Johansen Multivariate approach can be seen as a generalisation of the augmented Dickey-

[16] Assume there are n variables and n cointegrating vectors, the variables would not have unit roots, since the vectors can be expressed as scalar multiples for each individual variable, suggesting that the variables do not contain unit roots.

Fuller test (Asteriou & Hall, 2011:368). Finally the Johansen approach consists of two tests; the maximum eigenvalue and the trace test (in this regard see Hjalmarsson & Österholm, 2007:5).

It is apparent that caution needs to be applied concerning the method/ criteria used for examining the dynamic of financial market integration. Gilmore, Lucey and McManus (2008) employ a blend of dynamic and static methods of cointegration. The results are inconsistent for the two measures. Moreover, the authors maintain that static studies generally assume stable long-run relationships. However, this assumption is false, since the linkage between markets may be sporadic and time-varying (Gilmore *et al.,* (2008:607). A possible remedy is Gregory and Hansen's (1996) method that is able to detect structural breaks while allowing for long-run relationships to be exposed, which evidently static cointegration tests fail to identify.

3.3 Background and research method

The empirical study employs factor analysis. This method has provoked controversy throughout its history. The main reason is attributed to the lack of powerful computing facilities in the early 20th century; however, the advent of high speed computers has sparked an interest in the computational and theoretical characteristics of factor analysis. In this light recent developments have seen controversies resolved, for example, most of the original techniques have been abandoned. It has to be noted, though, that application of each technique should be examined on its own merits (Johnson & Wichern, 1992:481).

Factor analysis serves as an attractive dimension reduction technique. It accounts for prevalent cross-correlations which makes it suitable in numerous disciplines, for example chemometrics, econometrics, psychometrics, signal processing and statistics, among others (Alessi, Barigozzi & Capasso, 2010:1). A further motivation for the use of factor analysis is suggested by Pukthuanthong and Roll (2009:231), who mention that previous integration studies employed correlation analysis as a measure for broad cross-market integration. Consequently this measure is found to poorly mimic additional measures of actual integration. The authors derive a new measure for integration grounded on the explanatory ability of a multi-factor model. In addition, compared to cointegration techniques, factor analysis is better suited and designed for handling large cross-section time series data panels (in excess of a hundred variables), without suffering from the loss of degrees of freedom - a problem encountered by cointegration techniques. Thus, the empirical power of cointegration and VAR analysis is limited when dealing with large datasets - in this regard refer to Bellman (1961), Donoho (2000) and Lam and Yao (2011).

3.3.1 Specifying the correct model

Exploratory factor analysis can be quite confusing at times due to the latent nature surrounding the extracted factors and it is therefore necessary to set out clear and definitive goals. When conducting exploratory factor analysis there are a couple of important decisions to consider. Firstly the correct model should be specified; for example, common factor analysis or principal component analysis. The second consideration is the number of factors to retain and thirdly the rotation method to be employed[17]. As noted by Preacher and MacCallum (2003:14) valid implications for theory and application can be gained from good decision-making, consequently poor decisions could lead to invalid and confusing implications, which unfortunately have come to be true for a number of studies. The importance of a decided approach cannot be stressed enough. Much of modern applied factor analysis literature has fallen victim to the confusion between exploratory factor analysis and principal component analysis. These two terms have become incorrectly interchangeable. Although the methods bear striking similarities, they are in fact quite different. To account for any possible ambiguities, a discussion will now follow to clarify the two concepts at hand.

3.3.2 Factor analysis

Factor analysis aims to identify latent variables (common factors) that account for the covariance and common variance associated with measured variables, with the number of unobserved variables exceeding the number of observed variables (EViews, 2015:990). Considering the common factor model, variance can be separated into idiosyncratic and common variance[18]. From here idiosyncratic variance is sub-divided further into *specific components* (representing systematic variance of specific individual variables) and *error components* (representing systematic variance of random error measures). In factor analysis common and unique variance are computed separately while at the same time acknowledging the possibility of error (Preacher & MacCallum, 2003:20).

The following argument motivates the factor model: Assume that variables can be grouped according to their correlations – all the variables within a certain group exhibit high correlation among themselves but show relatively small correlations within a different group of variables. Then it is considered that each group of variables represents a single underlying factor which is the reason for the observed correlation (Johnson & Wichern, 1992:481). In conclusion, common factor models attribute co-movement to common factors. These models offer parsimony and

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17 Note that no further consideration is provided toward rotation methods since it does not align with the purpose of this particular study.

18 Idiosyncratic variance is not accounted for by common factors whereas common variance is accounted for.

make the estimation process simpler by reducing the number of parameters. These features make the common factor model appealing in an empirical setting (Anderson, 2008:17).

3.3.3 Principal component analysis

In contrast principal component analysis aims to achieve data reduction. This is achieved by producing observable components that explain a variance or covariance structure for a number of variables by means of linear compositions associated with the variables (Johnson & Wichern, 1992:430). Note that principal component analysis does not distinguish between variance nor does it attempt to separate the two from the extracted factors. More simply put, the principal components replace the original variables, but maintain effective interpretation properties. While both factor analysis and principal component analysis approximate covariance $\sum$, the factor analysis approximation is more elaborate and for this reason can be interpreted as an extension of principal component analysis (Johnson & Wichern, 1992:482).

At first glance these two methods might seem superficially similar, but in fact they are conceptually and mathematically different in nature. This reinforces the argument that serious problems can arise when attempts are made to substitute components between the two methods, rendering the statement made earlier (the importance of making correct initial decisions) a valid one. Preacher and MacCallum (2003:39) suggest that principal component analysis be avoided unless the aim is to achieve data reduction and to conduct factor analysis when attempting to identify factors that explain correlations among variables. Secondly a combination of criteria may prove more successful in determining the correct number of factors to retain. Lastly the authors note that a factor's success is measured by its ability to identify and display common variation of the underlying observed data.

3.4 The common factor model

The common factor model to be put forward runs parallel with the discussions in Johnson and Wichern (1992). The basic factor model assumes that for i the observable random vector p – vector X_i has a mean μ and covariance matrix $\sum$. X is linearly dependent on common factors which in essence are a couple of unobservable random variables F_1, F_2,... F_m in addition X also depends on p sources of variation ε_1 $\varepsilon_{2,}$... ε_p referred to as errors or alternatively specific factors (Johnson & Wichern, 1992:482). Essentially the factor model is

$$\begin{aligned} X_1 - \mu_1 &= \ell_{11} F_1 + \ell_{12} F_2 + ... + \ell_{1m} F_m + \varepsilon_1 \\ X_2 - \mu_2 &= \ell_{21} F_1 + \ell_{22} F_2 + ... + \ell_{2m} F_m + \varepsilon_2 \qquad (1.1) \\ X_p - \mu_p &= \ell_{p1} F_1 + \ell_{p2} F_2 + ... + \ell_{pm} F_m + \varepsilon_p \end{aligned}$$

in matrix notation (similarly presented by Brooks and Del Negro (2005) and Bai and Ng (2002),

$$X_i - \mu = LF_i + \varepsilon_i \qquad (1.2)$$

where:

- μ represents a $(p \times 1)$ vector of variable means.
- L represents a $(p \times m)$ coefficient matrix.
- F_i represents a $(m \times 1)$ vector for standardised unobserved variables, also referred to as common factors.
- ε_i represents a $(p \times 1)$ vector of errors also termed unique/ idiosyncratic factors.

The model denotes p observable variables $X_i - \mu$ as m unobservable common factors F_i and p unobservable idiosyncratic factors ε_i.. As pointed out by Johnson and Wichern (1992:482), the number of unobserved variables is greater than the observable variables, making a direct verification of the factor model hopeless[19].

In order to proceed, the model has to undergo assumptions. Covariance and moment restrictions are imposed to achieve; $E(F_i) = 0$ and $E(\varepsilon_i) = 0$, $E(F_i\varepsilon_i) = 0$, $E(F_iF_i') = \Phi$, and $E(\varepsilon_i\varepsilon_i) = \Psi$ with Ψ representing a diagonal matrix for the idiosyncratic variance (EViews, 2015:990). Assume also that the factors are orthogonal for the purpose, $\Phi = I$ (Bai & Ng (2002:195). From here the variance relationship can be derived.

The variance matrix of the observable variables takes the following form:

$$\begin{aligned} \mathrm{var}(X) &= E[(X_i - \mu)(X_i - \mu)'] \\ &= E[(LF_i + \varepsilon_i)(LF_i + \varepsilon_i)'] \\ &= L\Phi L' + \Psi \end{aligned} \qquad (1.3)$$

decomposing the variance of each variable into:

$$\sigma_{jj} = h^2_j + \psi_j \qquad (1.4)$$

For every j, h^2_j (representing the communality for the j^{th} variable) are obtained from $L\Phi L'$ and ψ_j (the idiosyncratic variance for the j^{th} variable) is the diagonal analogous for Ψ (EViews, 2015:990).

[19] The matrix L ties the unobservable common factors with the observable data, since L's j^{th} row denotes the loadings for the j^{th} variable of the common factors. It is therefore allowed to observe the row as the common factors' coefficients for the j^{th} variable (Widaman, 1993:267).

To obtain a factor structure matrix that includes the correlation between the factors and the variables, consider the following:

$$\begin{aligned} \text{var}(X, F) &= E[(X_i - \mu)F_i'] \\ &= E[(LF_i + \varepsilon_i)F_i'] \\ &= L\Phi \end{aligned} \tag{1.5}$$

continuing with the assumption of orthogonal factors:

$$\begin{aligned} \text{var}(X) &= LL' + \Psi \\ \text{var}(X, F) &= L \end{aligned} \tag{1.6}$$

From equation (1.6) it can be observed that the communalities h^2_j associated with the orthogonal factors are represented by the diagonal elements of LL' (EViews, 2015:990).

Factor analysis primarily aims to model $p(p + 1)/2$ observable variance and covariance associated with X as functions of p specific variance in Ψ, and pm factor loadings in L. From $\hat{L}$ and $\hat{\Psi}$ newly estimates may be derived for; the fitted total variance matrix or $\hat{\sum} = \hat{L}\hat{L}' + \hat{\Psi}$, and the fitted common variance matrix or $\hat{\sum}c = \hat{L}\hat{L}'$. Assume S is the observable dispersion matrix then the estimates may be used to represent the total variance matrix, $\hat{E} = S - \hat{\sum}$ and also the common variance residual $\hat{E}c = S - \hat{\sum}c$ (EViews, 2015:991). Once the specific variance and loadings are obtained, the factors can then be identified and the factor scores can be constructed (Johnson & Wichern, 1992:487)[20].

Summary

The common factor model is but one way to identify factors. Anderson (2008:17) notes that there are many ways to identify factors. In this regard, prominent standard techniques include factor analysis and principal component analysis (discussed previously). However, more recently researchers have shifted their focus toward the time series properties associated with multivariate sectors and the implication of this has led to variations of the common factor model. A popular example is the Dynamic factor model. Classic factor models (quite similar to principal component models) are generally not the most appropriate alternative for time series multivariate analyses since these models fail to assume serial correlation in ε_i, moreover if F_i contain any dynamics it would mean the models are modelled implicitly and not explicitly. Dynamic factor models account for this by considering ε_i and F_i as autoregressive moving

20 For a more compressive discussion on the covariance structure of the orthogonal factor model see Johnson and Wichern (1992:481).

average (ARMA) processes. As a result, these types of factor models have been popular in business cycle studies. Additionally for more summative discussions on other factor model specifications, which include principal component models, classic factor models canonical correlation-based models and common feature models, see Anderson (2008).

3.5 Number of factors to retain

Retaining the appropriate number of factors is considered probably the most important step in factor analysis and this is evident in the large and varied literature that exists on this topic, describing different criteria for determining the appropriate number of factors (EViews, 2015:991). An introductory stride toward deciding how many factors to retain will depend on the technique employed. Firstly there is a non-iterative principal factor technique, where communalities are gauged in a single step by employing the squared multiple correlation coefficients[21]. The second is an iterative technique that requires a number of factors that should be specified a priori, while initially estimating communalities and then entering an iterative procedure. Watson (2010:19) also notes that a combination of a priori knowledge would yield positive results in determining the correct number of retainable factors. New communality estimates are obtained (for each iteration) from a factor loading matrix, which in turn is derived from a sample correlation matrix. The communalities are then inserted diagonally into the correlation matrix where a new factor loading matrix is derived, and this will continue up to a point where the differences between two consecutive communality sets are below a predetermined level (Preacher & MacCallum (2003:21). Lastly maximum likelihood factor analysis is another common technique, where factor loadings and unique variances are determined in order to maximise the multivariate likelihood function. The three techniques mentioned here represent opposing ways of fitting the common factor model.

3.5.1 Information criteria

Bai and Ng (2002) propose a method (consisting of six criteria) for selecting latent factors in large dimensional panels by means of asymptotic principal components. These panels constitute two segments where (p) represent cross-section dimensions/ indices and (t) time. The appealing factor is encapsulated by the assumption that $p, t \rightarrow \infty$, thus rendering the criteria appropriate for numerous datasets which is indicative of macro-economic analysis (Bai & Ng, 2002:209). Stock and Watson (2010:19) maintain that this criterion substitutes the advantage of including an additional factor/parameter with an increased sampling variability associated with estimating additional parameters. This is achieved by minimising the penalised sum of squares.

[21] The coefficients are obtained from $h_{jj} = 1 - (P^{-1}{}_{jj})^{-1}$ where $P^{-1}{}_{jj}$ denotes diagonal elements of an inverse matrix (Preacher & MacCallum, 2003:21).

Fittingly the first three criteria are referred to as PC_p since it generalises Mallows' (1973) C_p criterion which appoints panel data models associated with strict time-series or cross-section settings. The subsequent three criteria, known as IC_p are based on the Akaike and Bayesian information creation (Bai & Ng, 2002:201). The authors note that their models contain idiosyncratic errors, uncorrelated across time and units. They therefore recommend PC_{p1}, PC_{p2}, and IC_1, IC_2 be used for strict factor models and PC_{p1}, and IC_1, when dealing with cross-section correlation models (Bai & Ng, 2002:204). However, Alessi *et al*. (2010) maintain the double-asymptotic framework proposed by Bai and Ng (2002) often yield non-robust results due to the over or under–estimation for the number of factors. The authors propose an alternative model. In contrast their results are more appealing since it builds on a theoretically proven and well-known criterion, the finite sample of the original criterion sees improved performance and finally the implementation process is easier. To conclude, Alessi *et al*.'s (2010:9) model provides more robust results in improving dataset analysis where co-movement among variables is concealed by large idiosyncratic factors.

In general, the criteria to determine the number of retainable factors fall into two broad categories - depending on the exploratory factor analysis technique employed. When iterative or non-iterative techniques are chosen, a decision will typically follow based on the eigenvalues of the reduced sample correlation matrix (Preacher & MacCallum, 2003:22). The authors note that there is no single superior method that can assist with this decision, and generally researchers depend on various rules of thumb or econometric criteria. The criteria put forward by Bai and Ng (2002) will be used to extract the factors in the empirical studies to follow. However, the following methods are also predominant in factor analysis literature and are therefore worth mentioning.

3.5.2 Kaiser-Guttman/Minimum Eigenvalue test

The Kaiser-Guttman rule is considered a popular criterion. This approach aims to retain as many factors as possible, in accordance with the eigenvalues of the unreduced dispersion matrix greater than one. The measured variables are usually standardised to contain a unit variance, therefore components with eigenvalues exceeding one, are considered to account for the same variability compared to the explanatory ability of a measured variable[22]. However, Preacher and MacCallum (2003:22) note that there are several practical shortcomings, more specifically the application of Guttman's (1954) weaker lower band. Firstly, the rule applies to the correlation matrix and assumes that the model will hold perfectly in a population with m factors. This is concerning since the population correlation matrix is absent and will therefore

[22] Consequently, components with eigenvalues less than one will have little interest for researchers (Floyd & Widaman, 1995:291).

not hold perfectly. The second shortcoming is that the criterion fails to appropriately apply eigenvalues to the reduced correlation matrix - this misapplication is often the case in practical scenarios. Finally Preacher and MacCallum (2003:23) quote Gorsuch (1983) who observes that a number of researchers misinterpret the Kaiser criterion as the number of retainable factors as oppose to the lower bound for the factors. In addition, findings also suggest that the criterion tends to under and overestimate the number of retainable factors. This concludes that there is not a substantial justification to utilise the Kaiser criterion in the factor identification process.

3.5.3 Scree test

This test aims to retain as many factors in relation to eigenvalues as possible that rank before the last significant drop in a scree plot. It is achieved by means of visual inspection of a scatter plot containing eigenvalues plotted in accordance with their respective magnitude (Stock & Watson, 2010:19). However the scree test has a subjective nature that accompanies the process of determining cut-off points along the scree curve. A more objective version is the Cattell-Nelson-Gorsuch scree test which provides a formal statistical test that compares regression slopes for eigenvalue clusters. Several studies have found positive results for the scree test's[23] ability to accurately determine the number of retainable factors (Floyd & Widaman, 1995:292).

3.5.4 Parallel analysis test

This criterion compares eigenvalues of the dispersion matrix (reduced or unreduced) to simulations that are obtained from employing uncorrelated data. To elaborate, this analysis is done by generating a number of random data sets for random variables with similar variance as the original data. From here a correlation/covariance matrix is constructed for the simulated data and the eigenvalues are decomposed for each data set. In order to get the number of retainable factors, the eigenvalues that exceed their simulated counterpart are examined. As noted by Preacher and MacCallum (2003:23) the logic behind this lies with the expectation that useful factors should account for variance that does not exceed that of one measured variable (as is the case with the Kaiser rule). However, it should be able to account for additional variance that can be expected to occur. Previous literature finds this method to produce fairly accurate results.

3.5.5 Fraction of total variance test

Other criteria include the fraction of total values, which involves retaining an unspecified number of factors that sum up to the first m eigenvalues that exceed some predetermined threshold.

[23] Alessi, *et al*. (2010:2) recognise the scree test's simplicity.

However, this method is often employed in principal component analysis, and researchers will typically include components that represent 95% of the total variance (EViews, 2015:991). Jackson (1993:2207) notes that while some statisticians support this method[24], Jackson (1991) advises against its application due to unreliable and unsupported conclusions.

3.5.6 Broken stick test

Based on Frontier (1976)'s model of eigenvalues for random data, this criterion compares the variance obtained from the j^{th} largest eigenvalue (of the unreduced matrix) to the analogous expected value which is derived from a broken stick distribution (EViews, 2015:992). More simply put, if the sum of the eigenvalues/total variance is randomly divided among the various components, then it is assumed that the eigenvalues' expected distribution will follow a broken stick distribution (Jackson, 1993:2207).

3.5.7 Minimum average partial test

Velicer's (1976) criterion calculates the mean of the squared partial correlations following the process undergone for out of partial m components (where $m = 0, \ldots, p - 1$). The number of retainable factors is in fact an average minimising equivalent. Evidence shows that under certain conditions this method is able to outperform other methods (Zwick & Velicer, 1986:432 and EViews, 2015:992).

3.6 Measure of integration

This study employs a measure of integration comparable to that of Carrieri *et al.* (2007) and Pukthuanthong and Roll (2009). Unlike the former, Pukthuanthong and Roll's (2009) formulation is not based on an asset pricing theory[25]. Instead the measure consists of an R-square (hereafter referred to as R^2) from a regression of an index. The standardised data for a specific index/country (in this case South Africa) is regressed against the extracted common global factors in order to obtain the R^2, which is used to examine the level of co-movement for the three South African indices. Furthermore the number of global factors included in the regression depends on the results obtained from the various factor analysis criteria. This measure of integration is also used by Kabundi and Mouchili (2009) and Pretorius (2015).

A basic regression is represented here in equation two

$$R(j,t) = c(j) + \beta_0(j,i) + \beta_1(j,i)\,F_1(i,t) + \ldots \beta_n(j,i)\,F_n(i,t) \qquad (2)$$

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[24] See for example, Jolliffe (1972:171).

[25] In this case, Carrieri *et al.*'s (2007) formulation is centred on Errunza and Losq's (1985) international asset pricing theory.

where:

- $R(j, t)$ represents the standardised return for country j in time t.
- $c(j)$ is a constant.
- $\beta(j, i)$ are the sensitivity coefficients for country j and index i.
- $F(i, t)$ is the common global factor for index i in time t.

Finally this equation is adjusted for each sector according to the relevant requirements.

Summary

This chapter introduces factor analysis as the primary method for examining co-movement between South African and global mining indices, by debating the theoretical basis and estimation techniques concerning this specific methodology. Moreover, attention is given to various methods for measuring co-movement common in integration literature, as Kearny and Lucey (2004) duly point out. Subsequently a discussion follows that depicts the properties of the two standard techniques i.e. factor analysis and principal component analysis. Additionally consideration is given to the common factor model, since variant models sprout from these standard factor models. Appropriately, Section 3.3.1 emphasises the importance of extracting the correct number factors by stating various criteria used for this purpose. Bai and Ng (2002)'s criteria are employed as the principal method for determining the number of retainable factors. Section 3.6 discusses the measure of integration used for the empirical tests, a simple regression is used to obtain the R^2's for South Africa. The initial segment of Chapter three therefore offers adequate background surrounding this brand of factor analysis criteria. Against the information provided here and in Chapter two, Section 3.7 proceeds by emphasising the importance of selecting the correct data - followed by detailed data description.

3.7 Data description

This section sets out to discuss the data used for this study. Three sectors are chosen, Iron & Steel, Mining and Gold. The author acknowledges the importance of selecting the appropriate data since this directly relates to the discussions in the foregoing segment of chapter three. Preacher and MacCallum (2003) note the importance of specifying the correct model in order to extract the correct number of factors. This is especially relevant when considering the latent nature that accompanies factor analysis. A well thought-through *a priori* will assist in achieving an accurate result. For this reason a discussion follows that introduces several criteria to offer guidance in the data selection process. Subsequently an analysis is provided of the descriptive statistics for each chosen sector. A brief encapsulation also discusses the macro-economic data used to address one of the objectives set out for the empirical analysis.

As primary data for the share prices of the three chosen sectors, the study uses weekly data sourced from Datastream.

The decision concerning the frequency is based on the length of the sample period and the superiority of weekly data above daily data. Converting daily data to weekly data, by means of a five-day average, avoids the issue of unsynchronised international trading and eliminates the noise and volatility associated with daily data. It is worth mentioning that Datastream data contain the properties associated with the Hodrick-Prescott (HP) filter (Thomson Reuters, 2013:1). This is considered a standard tool in macro-economics that entails decomposing a time series into trends and cycles. Simply put the estimation accounts for property trade-offs among trends, smoothness and the restriction of cyclical components. This process enables the trend's slope to gradually change over time.

In order to determine the co-movement between South African and global mining indices, the empirical study should be based on a global sample. Datastream assists in this regard by providing uniform sectors that produce an equally weighted index for each country. The data sample consists of global weekly mining index return data (in US dollars) for 32 countries that comprises 14 emerging and 18 developed economies (see Table 3.7.1). The empirical analysis focuses on three specific sectors, viz. Iron & Steel, Mining and Gold. Considerable thought has gone into the decision process while also bearing in mind the availability of the data. For example, South Africa needs to be included in the Datastream dataset for the specific sectors before the sector could be considered. As an example, Datastream does not provide a South African share price index for platinum. So while the author definitely wanted to include the platinum sector as well, the lack of data did not allow it. A further consideration is the time period for which the data is available. For example, an index of mining share prices for two countries, Brazil and Turkey, is only available since 2010. Including Brazil and Turkey in the sample would therefore considerably shorten the sample period of the study – and these two countries are thus excluded from the study.

Table 3.7.3 displays Datastream's global equity index structure which illustrates the different levels of the sectors that are chosen (Iron & Steel, Mining and Gold, indicated in bold). Firstly, Mining is chosen as representative of the mining sector as a whole. Gold is chosen since this sector contains enough countries that cover a sample period which dates appropriately. Coal is not chosen since the sector does not contain data for South Africa. Diamonds and Gemstones fail to provide enough data to produce a truly representative sample and are therefore not included. Furthermore, General Mining is excluded since this sub-sector does not fulfil a specific description within the Mining sector - see Industry Classification Benchmark (2012:1). It has to be noted that considerable attention has been given to Platinum and Precious Metals since South Africa assumes such a prominent role in this sector both on a local and global scale.

However, this sector fails to provide a sufficient number of countries which is able to cover a representative time period.

Finally Iron & Steel was chosen since this sector assists in achieving the second criterion of examining possible industry factors. According to the metals classification, Iron & Steel falls under the ferrous metals industry whereas Gold falls under a non-ferrous/precious metals industry classification[26]. Note that although Iron & Steel and Gold form part of different sub-sectors they run on a parallel level. Fittingly, Mining assumes a higher level on the global equity index structure (Table 3.7.3), thus meeting both criteria and reaffirming that the decision ensures the largest and most representative global sample. Moreover, all three sectors conform to South Africa's aggregate mining sector and the classification of the Minerals Bureau, Department of Mineral Resources for South Africa's classification for mining sectors (Chamber of Mines of South Africa, 2014:5).

Table 3.7.1: List of countries for each sector

Iron & Steel	***Mining***	***Gold***
*Argentina***	*Australia**	*Australia**
*Australia**	*Canada**	*Canada**
*Austria**	*China***	*France**
*Brazil***	*Hong Kong**	*Ireland**
*Canada**	*France**	*Peru***
*China***	*Germany**	*South Africa***
*Egypt***	*India***	*United Kingdom**
*Finland**	*Ireland**	*United States**
*France**	*Japan**	
*Germany**	*Mexico***	
*Greece**	*Morocco***	
*Hong Kong**	*Peru***	
*India***	*Philippine***	
*Italy**	*South Africa***	
*Japan**	*Sweden**	
*Mexico***	*Thailand***	
*Morocco***	*United Kingdom**	
*Netherlands**	*United States**	
*Peru ***		
*Romania***		
*South Africa***		
*Spain**		
*Sweden**		
*Switzerland**		
*Taiwan**		
*Turkey***		
*United States**		
*Venezuela***		
Economy Classification		
Developed *		
Emerging **		

[26] For a more elaborate discussion of the classification of metals refer to Kernot (2006) and Reichl, Schatz and Zsak (2016).

The number of countries and sample period for each sector are displayed in Table 3.7.2. Different initial dates are chosen for each sector due to availability of data for certain countries. Note that there are more countries included in the sample for Iron & Steel compared to the sectors for Mining and Gold. Intuitively it would make sense considering that the Gold sector falls under precious metals and the underlying may be less abundant than the underlying for Iron & Steel. Moreover, the latter also contains more emerging markets whereas Gold mainly comprises developed economies.

Table 3.7.2: Sample period for each sector

Sector	***Number of Countries***	***Sample Period***
Iron & Steel	28	09/12/1996 to 19/08/2013
Mining	18	18/10/1999 to 19/08/2013
Gold Mining	8	07/07/1997 to 19/08/2013

As mentioned in the foregoing discussion, Table 3.7.3 illustrates how Datastream allocates its global equity indices based on the Industry Classification Benchmark (ICB). The broad breakdown consists of different levels that include the ICB industry level, ICB super-sector level, ICB sector level, ICB sub-sector, and the Datastream subsector level. According to the Industry Classification Benchmark (2012:1), Iron & Steel comprises companies/manufacturers and equity-holders of primary iron and steel products. Mining comprises companies dealing in the exploration/mining of coal, diamonds/gemstones, platinum group metals and the extraction and refining of other minerals not defined elsewhere. Included in Mining is gold which comprises extractors, prospectors and refineries of gold-bearing ores.

Table 3.7.3: Datastream Global Equity Index Structure

ICB Industry DS Level			ICB Super-sector DS Level			ICB Sector DS Level			ICB Subsector DS Level			DS Sector		
ICB Code	Name	INDC Mnem	ICB Code	Name	INDC Mnem	ICB Code	Name	INDC Mnem	ICB Code	Name	INDC Mnem	Name	INDC Mnem	INDG
1000	Basic Materials	BMATR												
			1700	Basic Resources	BRESR									
						1750	Industrial Metals & Mining	INDMT						
									1757	**Iron & Steel**	**STEEL**	**Iron & Steel**	**STEEL**	**56**
						1770	**Mining**	**MNING**						
									1771	Coal	COALM	Coal	COALM	49
									1773	Diamonds & Gemstones	DIAMD	Diamonds & Gemstones	DIAMD	89
									1775	General Mining	MINES	General Mining	MINES	122
									1777	**Gold Mining**	**GOLDS**	**Gold Mining**	**GOLDS**	**119**
									1779	Platinum & Precious Metals	PLTNM	Platinum & Precious Metals	PLTNM	78

Source: Thomson Reuters (2012)[27]

27 Note this is a selective representation of Datastream's Global Equity Index structure.

3.8 Descriptive statistics

Iron & Steel

The relevant descriptive statistics are reported for each sector (South Africa indicated in bold). In general, the mean returns and standard deviations for emerging markets are higher when compared to developed markets (Table 3.8.1). Moreover, logic dictates that this is often the case. However, upon closer inspection it becomes clear that high standard deviations are not exclusive to emerging markets, and Greece, Hong Kong and the Netherlands fall under the list of top 25% countries with the highest standard deviations - this list also includes South Africa. When assessing distributional asymmetry, the data exhibits both negative and positive skewness and all the data follows a leptokurtic distribution. The null hypothesis for the Jarque-Bera statistic is rejected for all the countries under the conditions of a normal distribution.

Mining

Overall the descriptive statistics for Mining indicate that mean returns and standard deviations for the emerging markets are higher when compared to developed markets; however, exceptions are apparent (Table 3.8.2). South Africa exhibits a standard deviation similar to Canada and the United States. Moreover, South Africa falls under the bottom third of countries exhibiting the lowest standard deviations. The majority of countries in this sector exhibit positive skewness and all the data appear to be leptokurtic. The null hypothesis for the Jarque-Bera statistic is rejected for the entire dataset.

Gold

This sector mainly consists of developed countries with only two being emerging markets (Table 3.8.3). Therefore any attempts to compare the countries' means and standard deviations would be a floccinaucinihilipilification. However, from a South African perspective, the country's standard deviation can be compared to Australia and Canada. South Africa also appears to fall in the bottom half of economies with the lowest standard deviations. Moreover, all the countries in this sample are positively skewed and the countries exhibit a leptokurtic distribution. Finally the null hypothesis for the Jarque-Bera statistic is rejected for the entire dataset.

Collectively the South African index seems to exhibit attributes indicative of developed economies. A similar interpretation can be made from the correlation coefficients provided in Appendix A. This becomes more apparent for the Mining and Gold sectors. This may also add to the discussion pertaining to industry factors. For example, a closer relationship exists between developed economies and the Gold sector - similarly for the Iron & Steel sector and emerging economies. However, these suggestions are merely based on observation and require a more thorough empirical investigation.

Table 3.8.1: Descriptive statistics for Iron & Steel

Iron & Steel

Statistic	*Country*													
	Argentina	*Australia*	*Austria*	*Brazil*	*Canada*	*China*	*Egypt*	*Finland*	*France*	*Germany*	*Greece*	*Hong Kong*	*India*	*Italy*
Mean	0.00276	0.001579	0.002747	0.002774	0.002851	0.0000842	0.000837	0.000507	0.001925	0.00311	0.004346	0.00244	0.002803	0.003895
Median	0.002104	0.005335	0.003833	0.003967	0.002701	-0.001256	-0.000701	0.002507	0.002362	0.002981	-0.00147	-0.001243	0	0.002433
Maximum	0.34312	0.187019	0.18505	0.207574	0.212638	0.16	0.303214	0.209076	0.260045	0.163467	0.881606	0.472269	0.332485	0.197049
Minimum	-0.206585	-0.300868	-0.194097	-0.293912	-0.241302	-0.247176	-0.18333	-0.169832	-0.209363	-0.226304	-0.279094	-0.373482	-0.195349	-0.21569
Std. Dev.	0.053956	0.050039	0.043906	0.053361	0.042062	0.039296	0.049342	0.045611	0.049091	0.042794	0.074195	0.073406	0.058877	0.043827
Skewness	0.681313	-0.493188	-0.548091	-0.321337	-0.390247	-0.103709	0.409309	0.023031	-0.039347	-0.221352	2.238313	0.782664	0.385456	-0.358064
Kurtosis	7.765551	6.114921	6.145003	5.487352	7.839796	6.403818	6.289695	4.355372	5.449157	5.243835	25.79256	8.106004	5.193184	5.685753
Jarque-Bera	892.6093	387.8826	403.0331	239.7982	873.1915	422.5202	417.5509	66.82264	218.1658	190.0518	19603.32	1036.282	196.3585	280.7153
Probability	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum	2.40715	1.376579	2.395316	2.418621	2.485924	0.073444	0.729987	0.442197	1.678658	2.711932	3.790139	2.127704	2.444368	3.396012
Sum Sq. Dev.	2.535699	2.180871	1.679093	2.48007	1.541008	1.344973	2.120604	1.811987	2.099009	1.59511	4.794747	4.69337	3.019323	1.673019
Observations	872	872	872	872	872	872	872	872	872	872	872	872	872	872

Statistic	*Japan*	*Mexico*	*Moroco*	*Netherlands*	*Peru*	*Romania*	***South Africa***	*Spain*	*Sweden*	*Switzerland*	*Taiwan*	*Turkey*	*United States*	*Venezuela*
Mean	0.000633	0.002541	0.001368	0.002093	0.001675	0.001485	**0.003565**	0.001456	0.001762	0.00139	0.001006	0.003783	0.001278	0.003171
Median	0	0.004148	0	0.000801	-0.001038	-0.002744	**0.003658**	0.001579	0.001867	-0.000792	0	0.00297	0.003167	-0.000748
Maximum	0.217391	0.220055	0.226179	0.457447	0.275154	1.099938	**0.305405**	0.139	0.202667	0.238489	0.137795	0.349866	0.294392	0.518486
Minimum	-0.17284	-0.364864	-0.202327	-0.267964	-0.347961	-0.301721	**-0.810496**	-0.162077	-0.194815	-0.253003	-0.165644	-0.296028	-0.241811	-0.382516
Std. Dev.	0.038134	0.044774	0.037008	0.065231	0.048009	0.077774	**0.065207**	0.034999	0.04701	0.058707	0.032698	0.068663	0.044244	0.088997
Skewness	0.22494	-0.543845	0.164774	0.752982	0.058482	3.893301	**-2.197009**	0.046355	-0.196162	0.085337	-0.051623	-0.002417	-0.209205	1.477035
Kurtosis	5.202995	9.693742	7.668421	8.253542	13.38982	52.68666	**32.28513**	4.489878	4.920497	5.558947	5.684786	5.188687	7.578257	10.70922
Jarque-Bera	183.6861	1670.943	795.8001	1085.191	3922.62	91901.36	**31861.65**	80.96269	139.6008	238.9767	262.2808	174.0502	767.9234	2476.427
Probability	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0
Sum	0.552397	2.215695	1.193191	1.824932	1.460691	1.2952	**3.108562**	1.269412	1.53636	1.212228	0.876939	3.29863	1.11444	2.765504
Sum Sq. Dev.	1.26659	1.746142	1.192912	3.706192	2.007548	5.268451	**3.703431**	1.066912	1.924832	3.001941	0.931255	4.106441	1.704979	6.89869
Observations	872	872	872	872	872	872	**872**	872	872	872	872	872	872	872

Table 3.8.2: Descriptive statistics for Mining

Mining

Statistic	*Country*																	
	Australia	*Canada*	*Hong Kong*	*China*	*France*	*Germany*	*India*	*Ireland*	*Japan*	*Mexico*	*Morocco*	*Peru*	*Philippine*	***South Africa***	*Sweden*	*Thailand*	*United Kingdom*	*United States*
Mean	0.002932	0.001995	0.004938	0.002327	0.001566	0.000956	0.005197	0.000825	0.000211	0.010895	0.002271	0.002773	0.003769	**0.001887**	0.001647	0.004642	0.00281	0.001632
Median	0.004676	0.003957	0.005781	0	0.003535	-0.000197	0	-0.000655	0	0	0	0.001244	0	**0.004408**	0.000632	0.002253	0.006556	0.003672
Maximum	0.1804	0.276722	0.258158	0.22207	0.195446	0.23257	0.377504	0.397944	0.20000	6.673469	0.238095	0.247123	0.299492	**0.203757**	0.42471	0.374641	0.162887	0.244553
Minimum	-0.220036	-0.192022	-0.194631	-0.168902	-0.165694	-0.156227	-0.231065	-0.313377	-0.26087	-0.404609	-0.19007	-0.186527	-0.186508	**-0.230731**	-0.269113	-0.284648	-0.203032	-0.203255
Std. Dev.	0.039088	0.043205	0.053835	0.043738	0.037334	0.032095	0.070061	0.061854	0.052787	0.254386	0.03966	0.039744	0.049567	**0.041328**	0.067681	0.052085	0.044704	0.042382
Skewness	-0.443984	0.019594	0.148829	0.435633	-0.270324	0.761716	0.82308	0.361466	-0.190091	24.89572	0.195396	-0.096749	0.878235	**-0.398907**	0.400278	0.513559	-0.553978	-0.178304
Kurtosis	5.709924	6.626127	5.189393	5.307903	5.365759	10.27357	5.99416	8.559676	5.995564	652.6537	6.962182	7.030018	7.987025	**5.676845**	6.721245	8.480437	5.144961	5.810979
Jarque-Bera	244.9819	396.1538	147.0715	183.3264	177.4096	1663.673	351.7045	946.9078	274.678	12788940	477.5297	490.3895	842.1626	**235.0355**	436.4676	936.5909	175.5814	241.8668
Probability	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0	0
Sum	2.119837	1.442721	3.570003	1.682652	1.132393	0.690855	3.757353	0.596176	0.152302	7.876881	1.641654	2.004848	2.725291	**1.364056**	1.190789	3.356263	2.031597	1.179884
Sum Sq. Dev.	1.103135	1.347712	2.092488	1.381221	1.006357	0.743715	3.543995	2.762298	2.011827	46.72218	1.135662	1.140441	1.773906	**1.233192**	3.307242	1.958654	1.442887	1.296897
Observations	723	723	723	723	723	723	723	723	723	723	723	723	723	**723**	723	723	723	723

Table 3.8.3: Descriptive statistics for Gold

Gold								
Statistic	*Country*							
	Australia	*Canada*	*France*	*Ireland*	*Peru*	***South Africa***	*United Kingdom*	*United States*
Mean	0.002752	0.001719	0.003081	0.002433	0.002514	**0.001**	0.003789	0.000952
Median	0.00292	0.001472	-0.003368	-0.002072	0.000498	**-0.0000259**	0	-0.000482
Maximum	0.282193	0.287374	0.808806	0.674479	0.302542	**0.351016**	0.410357	0.35595
Minimum	-0.220637	-0.205129	-0.253403	-0.498311	-0.200958	**-0.189874**	-0.439255	-0.164955
Std. Dev.	0.051232	0.047834	0.079819	0.100097	0.047353	**0.050444**	0.059754	0.045084
Skewness	0.227637	0.264272	2.631899	1.190851	0.320993	**0.691496**	0.358691	0.768724
Kurtosis	6.084124	6.110749	23.12689	12.71732	6.566723	**7.190816**	10.72027	8.555829
Jarque-Bera	340.9784	349.2938	15184.04	3511.8	460.7725	**683.2692**	2109.114	1165.854
Probability	0	0	0	0	0	**0**	0	0
Sum	2.316897	1.447675	2.594403	2.048814	2.116791	**0.842236**	3.190527	0.801209
Sum Sq. Dev.	2.20743	1.924252	5.358126	8.426334	1.885815	**2.139965**	3.002856	1.709353
Observations	842	842	842	842	842	**842**	842	842

3.9 Macro-economic data

This section expands on the secondary data that represents the global macro-economic indicators employed in an attempt to link common global factors with macro-economic variables. Due to cost and practical limitations, data was gathered from various sources. For uniformity purposes, data was selected spanning from 01/01/1999 to 31/12/2013 and subsequently converted into weekly and monthly frequencies. Consequently the macro-economic variables used in this study are chosen to correspond with finance literature. Consideration is also given to availability of the data. Exchange rates (daily am weighted average rates) for the US Dollar and Euro are obtained from the South African Reserve Bank. Daily gold prices (gold spot US dollar per troy ounce, London pm fixed rate)[28] are Datastream data obtained from the World Gold Council. Daily (ending Friday) Brent crude oil prices in US Dollar are obtained from the US Energy Information Administration. The S&P 500's volatility index (weekly closing prices in US Dollar) is obtained from Yahoo! Finance. Monthly US Dollar prices for Chinese Industrial Production are obtained from the World Bank. Monthly long-term interest rates (total % for ten year Government bonds) for the US and Euro Area (EA) 19 are obtained from the Organisation for Economic Co-operation and Development OECD)[29]. This is the closest and most relevant representation for global interest rates.

28 Compared to forward and long term prices, spot prices tend to be more effective in driving mining stocks in general (Nangolo & Musingwini, 2011:459).

29 This list includes: Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia and Spain (European Union, 2015:1).

Summary

The second part of this chapter is devoted to describing the data used for this study. The data description addresses the entire process that went into selecting the three sectors which will be used to conduct the empirical analysis. As mentioned initially when conducting factor analysis it is important to consider the data, since this will assist in deciding how many factors to extract. The latent nature that accompanies this form of analysis requires a very inclusive approach throughout the entire research process. Subsequently a descriptive analysis is provided for the primary data in an attempt to provide additional information of the data itself, which might complement the empirical findings to follow. Lastly a brief account of the macro-economic data is provided since it is used to investigate the driving forces for the common global factor.

CHAPTER 4: EMPIRICAL RESULTS

4.1 Introduction

Following the data description at the end of Chapter three, Chapter four presents the results of the empirical analysis. Considering the importance of ensuring that the entire research process is conducted in a conjoint manner the following discussion becomes relevant. First the data is processed by transforming it into log differences in order to calculate the returns and render it stationary. Using the three panels of global mining returns data, common factors driving mining share prices are extracted by means of MATLAB and EViews. The reported variance share of the extracted common factors for South Africa is an indication of co-movement/integration for South African mining share prices when compared to their global counterparts. This assists in achieving the first objective[30] set out in Chapter one. In order to address the second objective, rolling regressions for the extracted common factors are run on the standardised returns of the South African sectors. The R-squares obtained from the rolling regressions provide insight into the dynamic nature associated with market co-movement/integration while at the same time enabling the study to link specific time periods with possible idiosyncratic/country-specific events. Finally an attempt is made to link the extracted common global factors to macro-economic indicators, also considering potential variation in their importance over the sample period - thus addressing the final objective of the study.

This chapter begins by listing the results obtained from the various tests for determining the number of factors as deliberated in Chapter three, followed by a discussion of the number of common factors that are retained for each of the three sectors. Subsequently attention is given to the level of integration that exists between countries, specifically how the South African indices co-move with the global market for each respective sector. The argument of time varying co-movement is further addressed by considering rolling window periods. The envisaged varying levels of co-movement during specific periods are then linked to idiosyncratic factors that can explain why South African indices deviate from global indices. Finally the section also attempts to link the common factors to macro-economic indicators, which may serve as influential drivers of co-movement for the various sectors with the extracted common factors indicative of movements in the global market.

4.2 Identification of the number of common factors

Section 3.3.1 considers the various tests available for identifying the appropriate number of common factors. This study employs Bai and Ng's (2002) Information Criteria as the primary

[30] Determine to what extent share prices of South African mining companies co-move with global mining share prices.

criteria to determine the number of common factors to extract, coupled with supplementary criteria/tests in order to obtain a more comprehensive judgement. Literature considers this approach to be highly effective. The initial analysis is performed in MATLAB while further factor analysis tests available in EViews are used as supplements. Three sectors are investigated, viz. Iron & Steel, Mining and Gold[31]. In order to avoid any possible ambiguities the following recapitulation becomes relevant. When considering the different sectors, there are a couple of factors that could potentially drive the price of Iron & Steel companies in South Africa similarly for Mining and Gold. However, as mentioned previously, the latter forms part of a subsector for Mining, suggesting that Gold itself may be a driving factor for Mining. It is therefore necessary to develop a well thought through *a priori* that can assist with the factor selection process. Moreover, from the foregoing discussion, literature is not clear on a superior method for retaining a specific number of factors. These key points are duly noted and are considered during this chapter.

Iron & Steel

The tests for the Information Criteria are arbitrarily set to consider a maximum of ten common factors (unless specified otherwise), serving as a benchmark from which a more accurate process for identifying the correct number of factors can follow. Table 4.2.1 displays the critical values for the indicated number of factors according to the six Information criteria. The optimum number of factors is either five factors, according to the PC values, or one factor, according to the IC values - as indicated by the lowest value in each column.

Table 4.2.1: Critical values for Iron & Steel

	PC_{P1}	PC_{P2}	PC_{P3}	IC_{P1}	IC_{P2}	IC_{P3}	*Variance Explained*
1	0.68514670	0.68552030	0.68429483	**-0.31509075**	**-0.31392574**	**-0.31774708**	0.35312807
2	0.67940630	0.68015351	0.67770257	-0.26521244	-0.26288242	-0.27052509	0.04480838
3	0.67400531	0.67512614	0.67144972	-0.22027896	-0.21678394	-0.22824794	0.04446857
4	0.67203669	0.67353112	0.66862923	-0.17505148	-0.17039145	-0.18567680	0.04103227
5	**0.67044769**	**0.67231573**	**0.66618836**	-0.13535474	-0.12952971	-0.14863638	**0.04065221**
6	0.67603066	0.67827231	0.67091947	-0.08661946	-0.07962942	-0.10255743	0.03347201
7	0.68236483	0.68498009	0.67640178	-0.04178682	-0.03363177	-0.06038112	0.03271994
8	0.69034931	0.69333818	0.68353439	0.00102078	0.01034083	-0.02022984	0.03106774
9	0.69958656	0.70294903	0.69191978	0.04067554	0.05116060	0.01676858	0.02981353
10	0.71085821	0.71459430	0.70233957	0.07936316	0.09101323	0.05279988	0.02777679

[31] **Note:** Iron & Steel is a sub-sector of Industrial Metals while Gold serves as a sub-sector of Mining (refer to section 3.8 in this regard).

Due to the inconclusive nature of the results various alternative criteria are also employed in order to obtain a more exact result. Table 4.2.2 is a summary of the results for the various factor analysis methods performed in EViews[32].

Table 4.2.2: Summary of alternative criteria for Iron & Steel

No.	***Factor Analysis Tests***	***Number of Factors Retained***	***Proportion Variance Explained***
I	*Kaiser-Guttman*	5	2
ii	*Standard-Error Scree*	5	2
iii	*Parallel Analysis*	1	1
Iv	*Fraction of Total Variance*	5	2
V	*Broken Stick*	14	6
vi	*Minimum Average Partial*	1	1

As discussed in Chapter three each test focuses on a different objective, suggesting the likelihood of contradictory results. The summary indicates how many factors each test retains based on the criteria that the proportion of variance explained for each factor 5% or above. Although no single criterion suggests retaining five factors (accounting for 5% or more, up to the fifth factor), method i, ii and iv retain five factors. Moreover, as expected the variation in results is attributed to the dissimilar dynamics associated with each criterion. Considering all the results an informed decision is made to retain five factors for Iron & Steel. The validity of this decision is reaffirmed by the information provided in the last column of Table 4.2.1, where the proportion of the variance explained (by each additional factor) for five factors is close to 5% (4.06%)[33]. More simply put, each of the five factors that have been extracted on its own, explains 5% or more of the variance in the panel of Iron & Steel sector. Consequently, note the large proportion of variance explained for the first factor. Intuitively this makes sense since a single global factor is most likely to explain a large portion of the variation in Iron & Steel share price movements. However considering this specific sector, logic would dictate that there may be various additional factors that might influence this sector, thus concluding that five factors are an appropriate choice.

Mining

The critical values for Mining (Table 4.2.3) largely suggest divergence by retaining ten factors (according the PC values) and one factor (according the IC values) for this sector. The results obtained from the alternative factor analysis methods also provide mixed results. A possible reason for this may be attributed to the fact that Mining subsumes a number of specific sectors

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[32] **Note:** For the regression outputs refer to Appendix B. The estimation options for each alternative criterion employed are set according to the programme's default settings.

[33] The proportion variance explained is subject to a 5% level.

including; Gold, Coal, Diamonds and Gemstones, General Mining and Platinum and Precious Metals. Each of these sectors can be a potential driving force behind Mining prices in general. Consider the argument made in chapter three, viz. that no single method exists which is superior in identifying the correct number of factors to extract. An informed decision is made to retain five factors for Mining. Intuitively this makes sense, considering the manner in which this sector is structured would make it seem that one factor should be retained for Mining. However, logic would dictate that a number of influential factors may exist that might influence this sector. Moreover, the variance explained for South Africa's Mining sector indicates that five factors are consistent at a 5% level, thus providing support for the choice of factors.

Table 4.2.3: Critical values for Mining

	PC_{P1}	PC_{P2}	PC_{P3}	IC_{P1}	IC_{P2}	IC_{P3}	*Variance Explained*
1	0.65858576	0.65884366	0.65809405	**-0.30507782**	**-0.30367667**	**-0.30774920**	0.36955893
2	0.62540496	0.62592077	0.62442153	-0.25145705	-0.24865476	-0.25679982	0.06228361
3	0.59719779	0.59797150	0.59572265	-0.20012924	-0.19592582	-0.20814340	0.05730310
4	0.57313677	0.57416839	0.57116992	-0.15235108	-0.14674651	-0.16303662	0.05315120
5	0.55060024	0.55188977	0.54814167	-0.11438343	-0.10737772	-0.12774037	**0.05162460**
6	0.53005156	0.53159898	0.52710127	-0.08710951	-0.07870265	-0.10313783	0.04963400
7	0.51098775	0.51279308	0.50754575	-0.07458117	-0.06477317	-0.09328088	0.04814707
8	0.49534062	0.49740386	0.49140691	-0.07367857	-0.06246943	-0.09504967	0.04472566
9	0.48152900	0.48385014	0.47710357	-0.09362984	-0.08101956	-0.11767233	0.04288761
10	**0.47423372**	**0.47681276**	**0.46931658**	-0.11603670	-0.10202527	-0.14275057	0.03636224

Table 4.2.4: Summary of alternative criteria for Mining

No.	***Factor Analysis Tests***	***Number of Factors Retained***	***Proportion Variance Explained***
i	*Kaiser-Guttman*	4	4
ii	*Standard-Error Scree*	1	1
iii	*Parallel Analysis*	1	1
iv	*Fraction of Total Variance*	3	3
v	*Broken Stick*	8	4
vi	*Minimum Average Partial*	1	1

Gold

Only eight common factors are considered for Gold, due to the smaller number of countries (only eight countries) which are represented in the panel for this sector. The results shown in Table 4.2.5 suggest retaining eight factors for the Gold sector. However, the alternative factor analysis methods indicate unanimous support for retaining one factor. Furthermore the variance explained for one factor is more significant when compared to eight factors, thus one factor is retained for the Gold sector. Following logic this makes sense since it is most likely that fewer factors would influence the share prices in the Gold sector. A possible reason for the dissimilar results between the information Criteria and alternative factor analysis methods may be attributed to the size of the data panel for Gold itself and the various dynamics associated with the criteria employed. As mentioned in the foregoing methodology and data chapter, it is particularly important to consider the data when deciding how many factors to retain and extract. In this case the unique structure associated with each sector is important to consider as well as the specific characteristics of the sector itself, since this would yield a more logic conclusion.

Table 4.2.5: Critical values for Gold

	PC_{P1}	PC_{P2}	PC_{P3}	IC_{P1}	IC_{P2}	IC_{P3}	***Variance Explained***
1	0.45073653	0.45073653	0.45073653	-0.53566573	-0.53447245	-0.53694210	0.54872752
2	0.32670422	0.32670422	0.32670422	-0.59628690	-0.59390036	-0.59883965	0.12417979
3	0.21790047	0.21790047	0.21790047	-0.74009715	-0.73651733	-0.74392627	0.10893312
4	0.14409530	0.14409530	0.14409530	-0.89245408	-0.88768099	-0.89755957	0.07389293
5	0.08832260	0.08832260	0.08832260	-1.12072633	-1.11475997	-1.12710819	**0.05583901**
6	0.04986582	0.04986582	0.04986582	-1.43118007	-1.42402043	-1.43883831	0.03850252
7	0.01399416	0.01399416	0.01399416	-2.44066872	-2.43231582	-2.44960333	0.03591431
8	**0.00000000**	**0.00000000**	**0.00000000**	**-68.1198138**	**-68.1102676**	**-68.1300247**	0.01401081

Table 4.2.6: Summary of alternative criteria for Gold

No.	***Factor Analysis Tests***	***Number of Factors Retained***	***Proportion Variance Explained***
i	*Kaiser-Guttman*	1	1
ii	*Standard-Error Scree*	1	1
iii	*Parallel Analysis*	1	1
iv	*Fraction of Total Variance*	1	1
v	*Broken Stick**	N/A	N/A
vi	*Minimum Average Partial*	1	1

* The Broken stick test cannot be performed for Gold since the factor model is under-identified, no unique maximum can be reached.

4.3 Variance share

Essentially the variance share obtained from the MATLAB output indicates to what extent a country is integrated with the global market or how it co-moves with other global indices. The purpose is to identify how much of the variation in each country's index is driven or explained by the global factors. The variance share for each country included in the three panels is ranked from high to low as displayed in Table 4.3.1. Consequently a higher level of integration would translate into a greater level of co-movement. Common knowledge dictates that developed countries are more prone to greater global co-movement, suggesting that these countries will have a higher variance share.

When examining Iron & Steel for South Africa, the variance share is conspicuously low. This suggests the country's Iron & Steel index is not particularly integrated with global indices. Note the bottom 25% seems to be predominately made up of emerging economies whereas the top 25% largely consist of developed economies[34]. This observation indicates less convergence for Iron & Steel which means there are more idiosyncratic factors active in determining the share prices for Iron & Steel as such logic dictates a lower degree of co-movement for the South African index.

South Africa has a high variance share for Mining, indicating that 75.78% of the variation in the country's Mining share index can be explained by the common global factors, extracted from the panel of global indices. This percentage is similar to that of the United Kingdom and United States, aligning with Lamba and Otchere's (2001) findings that South Africa is particularly integrated with developed countries. This is expected when considering the dual-listed mining companies that South Africa share with these countries. Ultimately it is recognised that the South African Mining index co-moves with global indices.

Finally the results for Gold show a high variance share for South Africa, similar to that of Australia and the United States. South Africa's Gold index is positioned in the top half of all countries included in this sector, indicating a high degree of co-movement which is represented by the 73.5% variation in the country's Mining share index that can be explained by the common global factor. Additionally, note how certain countries exhibit a higher overall level of integration (visible across all three sectors) which is largely the case for developed economies for example; Australia, Canada and the United States. This is not surprising and is in accordance with integration literature (Kearny & Lucey, 2004:571).

Additionally, Mining and Gold appear to have higher variance shares compared to Iron & Steel, suggesting that countries in the former two sectors are more integrated globally and perhaps may be more profoundly affected during periods of economic crisis, thus highlighting the dynamics associated with industry-related factors. This topic will be discussed in the forthcoming section in order to put forward a more comprehensive argument.

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[34] Kabundi and Mouchili (2009) maintain that the South African equity market has a tendency to co-move with emerging markets.

Table 4.3.1: Variance share for the three sectors

Rank	Iron & Steel		Mining		Gold	
1	Sweden	0.70823712	Mexico	0.92837547	Canada	0.85606158
2	Romania	0.70027991	Australia	0.81041663	United States	0.76847092
3	United States	0.68911549	Canada	0.78138160	Australia	0.75925448
4	Austria	0.68485666	United Kingdom	0.77801684	**South Africa**	**0.73506971**
5	Finland	0.67368635	United States	0.76146651	Peru	0.61453502
6	Germany	0.66091419	**South Africa**	**0.75778200**	United Kingdom	0.47781610
7	Canada	0.63220564	China	0.70804515	France	0.16315047
8	Spain	0.63183665	Hong Kong	0.65941314	Ireland	0.01546184
9	China	0.58148217	Peru	0.58429347		
10	Brazil	0.55103697	Germany	0.56318650		
11	Mexico	0.52976684	Sweden	0.55526007		
12	Netherlands	0.52359845	Japan	0.48930740		
13	Greece	0.51842780	France	0.48436076		
14	Australia	0.51505661	Thailand	0.48190458		
15	Venezuela	0.51292958	Ireland	0.43497849		
16	Taiwan	0.49998191	India	0.37068709		
17	Egypt	0.48885213	Morocco	0.35540196		
18	France	0.47801360	Philippine	0.25996630		
19	Italy	0.46724258				
20	Switzerland	0.46361491				
21	Argentina	0.43794171				
22	Hong Kong	0.43760300				
23	Peru	0.43027339				
24	Morocco	0.38860158				
25	India	0.38007296				
26	**South Africa**	**0.37970440**				
27	Japan	0.36398420				
28	Turkey	0.34518913				

4.4 Global factors

Although the various criteria do not agree on the exact number of factors to extract, it is comforting to observe that the first global factor to be extracted remains exactly the same regardless of the number of factors that are extracted. In the subsequent analysis (Section 4.8) where the global factors are linked to macro-economic variables, the focus will be directed to the first factor that contributes most to the overall variance explained. In addition, a varying degree of influence for the common global factors is visible in each of the three sectors.

Furthermore the common global factors for Iron & Steel, Mining and Gold are displayed in Figure 4.4.1[35]. Corresponding volatility is apparent during 2002, 2006, 2008 and 2011 for the three sectors. Pindyck and Rotemberg (1990) argue that commodity returns have a persistent tendency to move together. At first glance the figures appear to be quite similar, however note the difference in spikes for Iron & Steel and Gold during 2008. The latter displays a prominent

35 **Note:** The data for each sector is set to begin on 18/10/1999 since this is the earliest available date for Mining.

positive spike and the same is visible for Mining to lesser extent. This “flight to safety” phenomenon resembles investors who flock to gold investments as this is perceived to be a “safe haven” during periods of instability. For example, Baur and Lucey (2010:217) investigate whether gold acts a hedge or a safe haven by examining German, UK and US stocks (1995 to 2005). Their findings suggest gold is a general hedge against stocks and becomes a safe haven during instances of considerable market instability. Conversely Iron & Steel display a negative spike for the same period. This accentuates the impact of the global financial crisis, more importantly it illustrates the difference between ferrous/non-ferrous mining industries.

Brooks and Del Negro (2002) maintain that during periods of economic crises, certain industries may be affected more than others depending on the type of economic crisis itself. Moreover the global factors show companies that have dealings in the precious metals industry tend to be more strongly affected by the global financial crisis. A similar phenomenon is identified during 2013 where the Iron & Steel experience subdued spikes compared to Gold and Mining during 2013, suggesting the impact of global events is received differently according to the specific index.

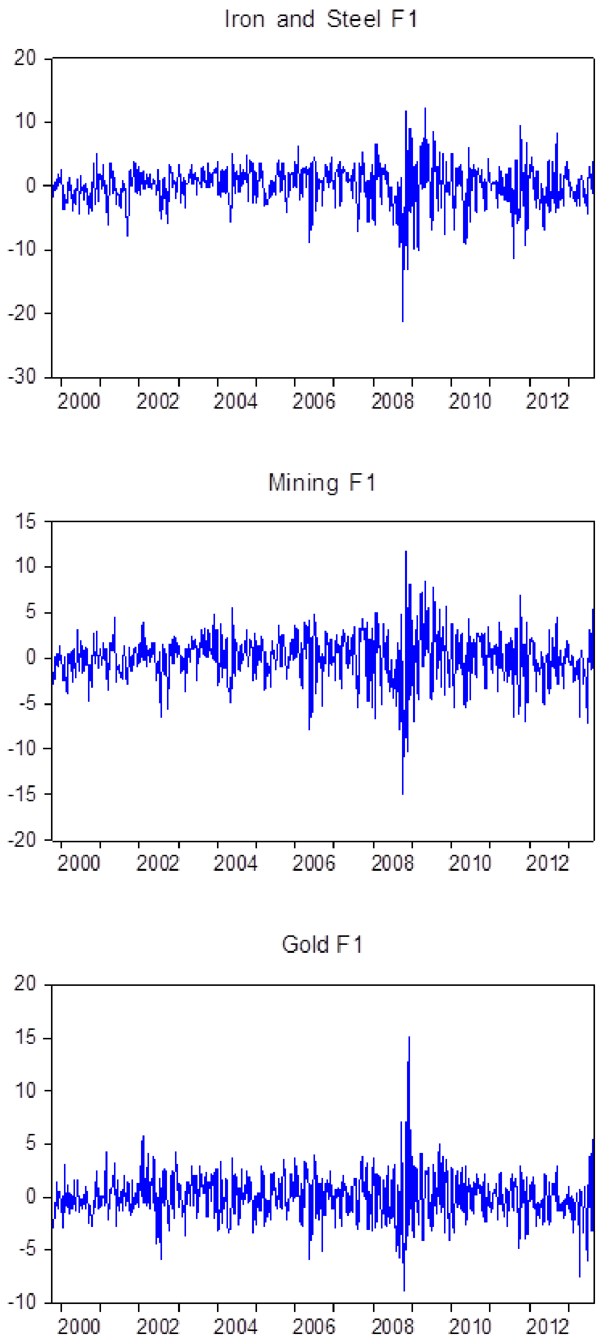
This argument is supported by the correlation coefficients for the global factor, displayed in Table 4.4.1. Note that Iron & Steel and Mining exhibit a strong relationship, however this may be explained by the various indices that Mining comprises. Additionally the relationship between Iron & Steel and Mining is the weakest which is consistent with the argument of non-ferrous/ferrous metal structures. The global factors that drive Iron & Steel and Gold are not necessarily similar. Fittingly the relationship between Mining and Gold is noteworthy, since Gold is most probably one of the global factors that drive the movement identified for Mining.

Table 4.4.1: Correlation coefficients for factor one

Factor 1

	Iron & Steel F1	*Mining F1*	*Gold F1*
Iron & Steel F1	1		
Mining F1	0.88722456	1	
Gold F1	0.54117768	0.76591115	1

Figure 4.4.1: Factor one for Iron & Steel, Mining and Gold



4.5 Dynamic co-movement

The initial discussion in this chapter concluded that five global factors are retained for Iron & Steel/Mining and one factor for Gold. Although the various factor analysis methods provide dissimilar results, the decision pertaining to the chosen number of factors is conducted in accordance with factor analysis literature (refer to Appendix C for a supplementary discussion/explanation on this topic).

Now that the number of factors and South Africa's level of co-movement for the three different sectors have been established, this section continues by considering the argument raised in

Chapter two that co-movement is episodic and time-varying. This notion is well documented in literature and fundamentally supported by Bekaert and Harvey (1995). This study addresses the matter by implementing a rolling window approach that allows for inspection of possible varying levels of co-movement throughout the entire sample period. It is thus expected that there will be periods where idiosyncratic factors are driving the South African indices and other periods where global factors are predominantly driving the South African indices.

It is necessary since the economic/industry/political environments are constantly changing and implicate the co-movement of the South African mining companies. Given the frequency and time span of the data employed in this study, 161 day rolling-windows are considered for South Africa's standardised data. Suitably, Gilmore *et al*. (2008:619) employ a static approach (for the entire sample period) and fail to produce evidence of linkages between countries but succeed with a dynamic rolling-window approach. Ultimately the authors maintain that the markets employed in their study, exhibit an intermittent relationship where short-run idiosyncratic factors that include periods of instability/economic prosperity are substantial in determining long-run relationships.

As mentioned earlier a measure of integration similar to that of Pukthuanthong and Roll's (2009) measure is used to examine the co-movement of each South African index. Coupled with the rolling-window approach, regressions are run for South Africa's standardised return data which represents the dependent variable and the common factors representing the independent variable. Based on equation two (chapter three), the regression for each sector is as follows:

- Iron & Steel: $\text{SAreturns}_{\text{I\&S}} = \beta_0 + \beta_1\, F_{1\,\text{I\&S}} + \beta_2\, F_{2\,\text{I\&S}} + \beta_3\, F_{3\,\text{I\&S}} + \beta_4\, F_{4\,\text{I\&S}} + \beta_5\, F_{5\,\text{I\&S}}$
- Mining: $\text{SAreturns}_{\text{MIN}} = \beta_0 + \beta_1\, F_{1\,\text{MIN}} + \beta_2\, F_{2\,\text{MIN}} + \beta_3\, F_{3\,\text{MIN}} + \beta_4\, F_{4\,\text{MIN}} + \beta_5\, F_{5\,\text{MIN}}$
- Gold: $\text{SAreturns}_{\text{GOLD}} = \beta_0 + \beta_1\, F_{1\,\text{GOLD}}$

This process produces the R^2's for each South African index, as represented in Figures 4.5.1 to 4.5.3. Note that the variance shares reported earlier in Table 4.3.1 are actually the R^2's for the three regressions (as indicated in the aforementioned equations) ran over the whole sample period. A low R^2 indicates that the South African index is deviating from global indices[36]. In other words a lack of co-movement which motivates the argument, that a blend of idiosyncratic factors drives these deviating movements. Conversely a higher R^2 indicates that global factors do explain returns of South African mining companies, and confirm co-movement.

Considering the discussion pertaining to the variance share for the South Africa, an attempt is made to illustrate how the dynamics of co-movement may affect each of three South African indices. The figure for Iron & Steel indicates an overall upward trend with instances where the

[36] It has to be noted that lower R^2's may also be instances where South African indices increase relative to global indices.

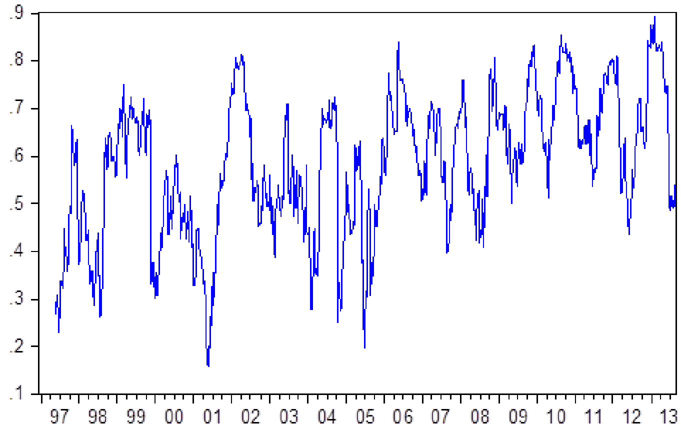
South African index does not co-move with global indices. For example, in 2001 the index has R^2 as low as 0.15, but during the end of 2012 the index almost completely co-moves with an R^2 of almost 0.9. Ultimately this demonstrates that different factors drive South African Iron & Steel returns during specific periods in time. A more focussed investigation of Figure 4.5.1 shows Iron & Steel exhibits significant low R^2 levels or dispersions - in relation to the primary trend during; 1998, 1999, 2001, 2004, 2005, 2007, 2008, 2010[37], 2011, 2012 and 2013. However, there are also instances of significant high R^2 movements during 2002, 2006 and briefly in 2013.

Mining seems to demonstrate more consistent periods of higher R^2 levels. Moreover there are fewer instances where the South African index does not co-move with global indices - with the lowest R^2 visible during end-2001. The upward trend suggests progression in global integration, especially noticeable from 2007 to 2013. Low R^2 movements for Mining (Figure 4.5.2) include 1999, 2001, 2002, 2004, 2005 (modest in 2007 and 2008), 2011, 2012 and 2013. Instances of significant high R^2 movements are during 2002, 2006 and briefly in 2013.

The Gold index does not hint at a specific trend, however it does show various instances of co-movement and periods where the index does not co-move with global markets. Low R^2 movements for Gold (Figure 4.5.3) include; 1999, 2000, 2001, 2004, 2005 (modest in 2007 and 2008), 2009, 2010, 2012 and 2013. High R^2's are apparent during 1999, 2002 and 2008. Overall Gold shows high levels of R^2 with instances of significant deviation. The visual inspection allows assessing certain periods where the degree of co-movement for South African mining indices varies over time. Collectively the South Africa's Iron & Steel, Mining and Gold index seems to be integrated with global indices; however, idiosyncrasies cause noteworthy deviations at specific periods. Docking and Koch (1999) maintain that global integration is an increasing phenomenon, and fittingly the figures for each sector show an increase in integration over time (less visible for Gold).

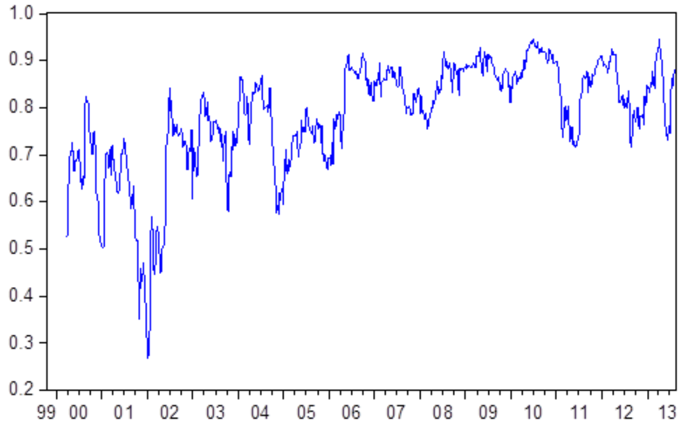
[37] Note the movements for 2007, 2008 and 2010 are not as considerable when compared to other periods, yet remain noteworthy.

Figure 4.5.1: R^2 of Rolling regressions for South African Iron & Steel returns



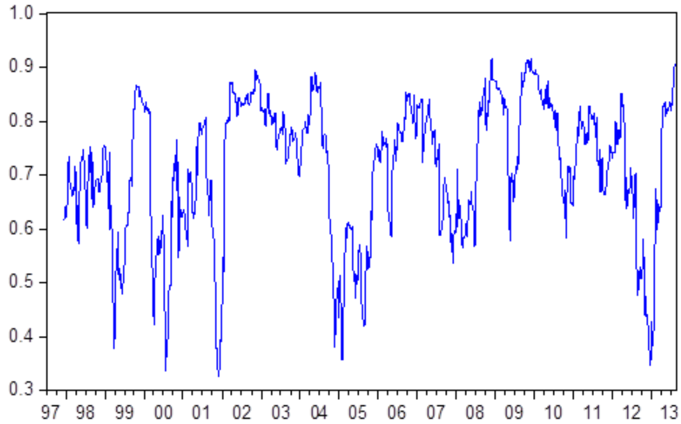
Note: Five factors are extracted for Iron & Steel

Figure 4.5.2: R^2 of Rolling regressions for South African Mining returns



Note: Five factors are extracted for Mining

Figure 4.5.3: R^2 of Rolling regressions for South African Gold returns



Note: One factor is extracted for Gold

Ultimately it is expected that the South African mining indices will exhibit varying levels of co-movement at different points in time. From a broader perspective this becomes particularly relevant, since it provides insight into how local mining companies co-move with global mining companies, which inevitably leads to the topic of portfolio diversification. An investor would typically be interested to know the influence that idiosyncratic factors exert on South African mining companies is greater compared to global factors at times. To exemplify this, consider the three figures above, during the financial crisis period of 2007 to 2008, in comparison to previous periods the graphs appear unassertive, suggesting global factors are prominent yet the decline in R^2 cannot go unnoticed.

Another important point gleaned from examining the extracted R^2's shows that, although Iron & Steel, Mining and Gold exhibit comparable activity around the periods of 1999 to 2000, 2001 to 2002, 2004 to 2005 and 2012 to 2013, periods are apparent where each index experiences varying levels of activity in terms of the movements' magnitude particularly from 2002 to 2004 and 2007 to 2010. The reasons for this may be attributed to the underlying products that are associated with each specific index, for example, how ferrous/non-ferrous metal industries are affected by events, and this is especially true for Iron & Steel and Gold. With this in mind, the next step is to identify the factors that drive these movements by linking them with specific local events. However, note the factors which have been identified are latent and for this reason require merging the factors with relevant global and idiosyncratic events that have occurred at the corresponding time periods which may be able to explain the behaviour exhibited.

4.6 Periods of idiosyncratic behaviour

This section attempts to link local events with periods where South African mining indices significantly deviate from global indices. A low R^2 suggests that idiosyncratic factors are more prominent in describing the variation in the South African share prices. Moreover, significant descending deviations are also inspected because it shows the influences of local factors. The discussion to follow examines and documents important events associated with the country's mining industry and other relevant events that may affect each of the three South African indices between 1997 and 2013.

1997-1999

During 1999 South Africa was en route to its second democratic election. With the country's democracy still in its infancy, it faced numerous restructuring obstacles which caused uncertainty and inevitably led to increased market volatility. These restructurings were especially evident in the country's mining sector. The period of 1998 to 1999 sees the lowest levels of employment in twenty years. The mining industry was one of the most severely affected sectors, with one out of seven workers becoming unemployed during this period. In addition to this adversity were the increased levels of strikes for higher wages and workdays lost due to other work-related stoppages. These actions precipitated an adverse deterioration of general business conditions (South African Reserve Bank, 1999:1).

During 1999 the mining industry was also faced with corporate unbundling and a series of mergers and acquisitions that continued to restructure the South African mineral industry, which lasted until early 2000 (Coakley, 1999:1). In this vein it is necessary to mention the listing (including the relocation of headquarters) of BHP Billiton plc (including former South African mining giant Gencor Ltd) and Anglo-American plc on the London Stock Exchange (LSE) in 1997 and 1999 respectively. Robinson (2016:774) notes this would inhibit the country's ability to undertake highly complex mining projects in the future. In a sense, it can be argued that this flight of capital added to the deterioration of investor confidence and would continue to do so in the years to come. This spate of events can possibly be linked to the low R^2's exhibited in Figure 4.5.1 for Iron & Steel during 1997, 1998 and 1999, similarly for Gold (Figure 4.5.3) during 1999. Due to data constraints the same cannot be concluded for Mining (Figure 4.5.2) around this period. However, note the graph sprouts from a relative low base, suggesting that Mining was similarly impacted on during the late 1990s.

2000-2001

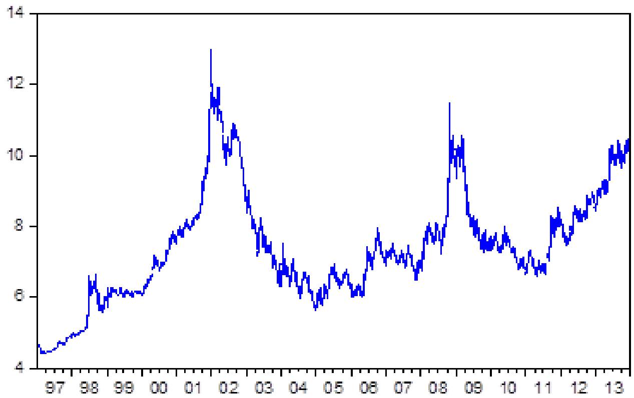
Since 1995 Government has debated the Minerals Development Bill, drafted by the Ministry of Mines and Energy's Department of Minerals and Energy (DME). The Bill was published in the Government Gazette (18 December, 2000) and remained open to public comments until 31 March, 2001[38] (Coakley, 2000:1). Essentially the Bill sees the state as sole custodians of all mineral rights within the country. Moreover the Bill focuses on freeing up unexploited mineral rights which were traditionally held by the major mining houses, in order to create new opportunities for black local entrepreneurs. Additionally Government intervened to counter the persisting "capital flight" phenomenon, by blocking the merger of Gold Fields Ltd. with Franco-Nevada Mining Corp. of Canada in September 2000 worth US $3 billion (Coakley, 2000:3). In 2001 Arcelor Mittal (based in London) gained control over Iscor, a former state-owned steel producer.

Additionally Anglo-American sought to dismantle its crossholding with De Beers. This led to De Beers delisting from the JSE and becoming a private company. These events highlight significant structural changes in South Africa's major mining companies during the early 2000s. Fittingly the Rand depreciated during this time period (Figure 4.6.1). Global commodities are

[38] The responses of this bill will give rise to the Mineral and Petroleum Resources Development Act 28 of 2002 which is seen as an agreement between senior state officials and industry executives (Cawood, 2004:56).

denominated in US Dollar which means the stronger Dollar relative to the Rand made South African mining exports more attractive globally. This draws a positive inference for South African mining stocks. Gold displayed a very low R^2 during 2000, suggesting that the foregoing events had a significant impact on South African companies. Additionally in 2000, Mining experienced its second lowest level for the entire sample period. This is supported by the South African Reserve Bank that reported that South Africa had progressed correspondingly with the global economy; however, this synchronisation concluded in 2000. The reasons for this could be attributed to local factors, more specifically South Africa's lethargic reaction to demand stimuli (South African Reserve Bank, 2000:1). During 2001 Iron & Steel, Mining and Gold experienced the lowest R^2's thus highlighting the substantial influence local factors exerted on South African companies for this period.

Figure 4.6.1: ZAR per US Dollar exchange rate



2002-2003

In 2002 several black economic empowerment firms were established with the aim to form a more representative mining industry that would see these new firms play a more prominent role during the next decade. Government attempted to see this through by realising the "Proposed Broad-Based Socio-Economic Empowerment Charter" for the country's mining industry, in October 2002. However, in the same month Soweto was hit by bomb explosions and blasts were recorded near Pretoria, suggested to be the work of right-wing extremists. Police also charged 17 political extremists with conspiring against the state in a separate incident (British Broadcasting Corporation, 2015). Chen and Siems (2004:349) maintain that terrorist related acts create panic that can easily lead to chaos, resulting in adverse implications for stock prices. These events highlight the political instability the country was faced with at the time. Additionally in 2002, 199,300 people were working in the gold industry and one out of three of the workforce was infected with HIV (Coakley, 2002:4). This resulted in higher labour costs (both direct and indirect) and forced mining companies to provide employees with antiretroviral treatment, prompting investor concern. The concerns surrounding the labour costs associated with HIV-infected employees continued throughout 2003 (USGS, 2003:4).

Government submitted the first draft of the Minerals and Petroleum Resources Royalty Bill, which would enforce royalties to be paid on mining revenues. Van der Zwan and Nel (2010:89) note the possible adverse effects that this may have on employment and foreign investment. Moreover the controversy surrounding legislation pertaining to mineral royalties was documented globally (Otto, Andrews, Cawood, Doggett, Guj, Stermole, Stermole & Tilton, 2006:1). Iron & Steel and Mining have high R^2's in 2002, but this declined toward 2003. It is evident that a significant event caused the indices to rise, however idiosyncratic factors might have precipitated the subsequent drop in R^2. Additionally Mining exhibited slight deviations; however, it seems Gold for the most part, was not affected by idiosyncratic factors between 2002 and 2003.

2004-2005

In 2004 the African National Congress was re-elected during the national election. A significant event identified for the country's mining industry was the Mineral and Petroleum Resources Development Act 28 of 2002 that came into effect on 1 May 2004. This legislation dramatically transformed the country's mining industry in the sense that the state now owned all the mineral rights. Cawood (2004:64) noted the severity of the implications that restructurings such as these could hold for stakeholders and the economy in general. During 2005 the Government continued with the implementation of its Black Economic Empowerment programme[39] that required the mining industry to be more representative in terms of black ownership. Noteworthy deals included mining giants, AngloGold Ashanti Ltd transferring its mining operations to a black-owned company and Gold Fields Ltd entering into an agreement to sell 20% of its shares by 2009 to a black-empowered mining firm (Yager, 2005:1).

In June 2005, President Thabo Mbeki suspended his deputy, Mr Jacob Zuma due to the outcome of a corruption case. However, these charges were dismissed in September 2006 - improving Mr Zuma's bid to become South African president. Added pressure was put on the country's mining sector when 100 000 gold miners brought the industry to a standstill during a major strike for higher wages (British Broadcasting Corporation, 2015). During 2004 Iron & Steel experienced a very low R^2, this was repeated in 2005 when Iron & Steel dropped dramatically. Mining also exhibited a low R^2 for 2004 – however, this was not repeated in 2005. Similarly, Gold experienced a substantial drop in 2004 which continued in 2005, indicating the low R^2 for

[39] Government requires the mining industry represent black ownership of 15% by 2009 and 26% by 2014 (Yager, 2005:1).

this period. With the information provided, a clear link can be drawn between the country specific events that occurred during 2004 and 2005 and the patterns relating to each sector.

2006-2007

No significant events affecting the mining industry were recorded for 2006. However, in June 2007 the country was faced with the largest strike since the apartheid era, with a couple 100 000 public sector workers striking for an entire month. This caused widespread disruption in various sectors of the economy and raised investor concern (British Broadcasting Corporation, 2015). This spilled over into the mining sector which was hit with concerns over inadequate energy supply due to instability, rapid growth in the demand for electricity and the fact that Eskom has failed to build any new power-plants over the last two decades (Yager, 2007:9). During 2006 the three indices experienced high R^{2}'s (especially true for Iron & Steel and Mining), but this diminished somewhat during 2007, suggesting that local factors were not particularly prominent in this period.

2008-2009

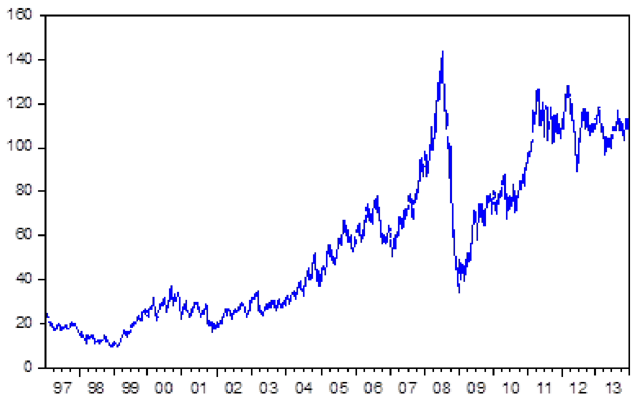
In 2008 the unrest continued and turned into violence. Dozens of people were killed in waves of xenophobic attacks forcing thousands of foreigners across the country to flee their homes (British Broadcasting Corporation, 2015). Fear of electricity constraints were realised in the summer of 2007 to 2008. Eskom struggled to build capacity for the coming winter and as a result the country was flung into a state of load-shedding. In an attempt to alleviate the situation several large mines and industrial firms reduced their energy consumption, but to no avail since blackouts returned in April 2008 (National Energy Regulator of South Africa, 2009:14). Moreover the economy suffered, with thousands of jobs put at risk and major commercial activities were almost forced to a halt. It is estimated that these series of blackouts/load shedding cost the economy around R50 billion (Papapetrou, 2014:5).

Consequently these events damaged investor confidence and the JSE experienced a decline in January 2008, accompanied by the depreciation of the Rand during the third quarter of 2008 (Figure 4.6.1) (Radobank, 2008:2). As mentioned previously, a weaker local currency is perceived to be favourable for the exports of South African mining companies. Closely linked to the exchange rate were the volatile oil prices (Figure 4.6.2) during the period for 2008 and 2009. South Africa is an importer of oil which means the exchange rates has a definite impact from a local perspective. The effect of the events mentioned here may possibly be attributed to the high R^2 levels for the sectors particularly during 2008 and 2009.

Lastly, in September 2008 President Thabo Mbeki resigned and was replaced by African National Congress (ANC) deputy leader Mr Motlanthe (British Broadcasting Corporation, 2015).

In April 2009 the ANC won the general election and soon after elected Mr Zuma as President of South Africa. Subsequently the economy fell into recession for the first time in 17 years (British Broadcasting Corporation, 2015). It is necessary to state that a causal relationship is not at all suggested, since this event occurs around the same period as the global finical crisis. The intention is to observe relevant geo-economic events that may have had an impact on South African stock markets. Moreover this observation perhaps becomes even more relevant when considering the recent tumultuous United States presidential election. The month of July saw violent protests due to poor living conditions, adding pressure on investor confidence. Finally in the second half of 2009, African National Congress Youth League (ANCYL) President Mr Malema raised the issue of nationalising mines and continued to drive this idea in the years to come (Antin, 2013:13). Iron & Steel exhibited unstable fluctuations during 2008 to 2009, however these movements were not substantial and the R^2 was not as low compared to previous periods. This was also the case for Gold, moreover during 2008 the index reached its highest level for the entire time period and was repeated in 2009. The R^2 for Mining proved inconsequential between 2008 and 2009.

Figure 4.6.2: Oil Price in US Dollar



2010-2011

In August 2010 more than one million civil servants united in a nationwide strike, threatening to bring the South African economy to a halt (Herskovitz, 2010). Significant mining events included the introduction of Government's new Mining Charter that obligated mining companies to make specified acquisitions from Black Economic Empowerment firms which include 70% for services, 50% for consumable goods and 40% for capital goods (Yager, 2010:1). Additionally gold mines in the Witwatersrand Mining Basin produced acid drainage, contaminating nearby rivers, resulting in concerns over environmental risks.

In October 2011 Mr Malema rallied his supporters (about 5000) and embarked on a protest march to the Chamber of Mines and the JSE, carrying placards that read "Expropriation of Land without Compensation” and “We Demand Nationalization” (Antin, 2013:13). During this protest Mr Malema called for drastic expropriation of land without compensation, and moreover he requested the immediate nationalisation of mines and threatened bloodshed if demands were not met. In November 2011 Mr Malema was suspended by the ANC for disgracing the party. However, these series of events had a considerable negative impact on the country’s economy and investor confidence (Antin, 2013:14). The unstable yet trifling behaviour for Iron & Steel identified in 2008 to 2009 persisted in 2010 to 2011. Gold experienced a decline in its R^2 from the previous elevated levels associated with 2009 and 2010. Mining exhibited the lowest drop in R^2 levels since 2006. Results showed a relatively high degree of integration; however, it was clear that the local factors did affect the indices, and evidence to support this was reflected in protest marches during 2011.

2012-2013

In August 2012 negotiations over a substantial wage increase between striking mine workers and Lonmin plc failed, resulting in violence where 34 mine workers were killed at the company’s Marikana mine (Antin, 2013:2). During the period of August to October more than 75 mine workers were injured and more than 200 arrested, additionally prosecutors dropped more than 270 murder charges and Government was forced to intervene by setting up a judicial commission of inquiry (British Broadcasting Corporation, 2015). In October Amplats fired 12 000 mine workers due to prolonged hostility. The damage of these series of events was reported to have cost R15 billion in sales and production losses, the market capitalisation of the top 39 mining companies dropping by 5% (from June to September 2012) and the Rand depreciated several percentage points during this period. Moreover, among the top ten mining companies, six of them lost R40 billion in market value (PricewaterhouseCoopers, 2012:4).

Tension and disputes in the mining sector continued in 2013 due to unrealistic wage demands that were not reflective of the economic outlook and prevailing commodity prices (International Monetary Fund, 2013:5). In 2012 mining companies were concerned about possible energy tariff increases. In March 2012 the National Energy Regulator of South Africa approved the 2012/2013 tariff increase of 16%, effective on the first of April 2012 (Eskom, 2013:6). Due to capacity constraints during 2012/2013 Eskom was also forced to enter into energy buy-back agreements with power-intensive ferrochrome and alloy producers, suppressing the Iron & Steel industry (Yager, 2013:12). In November 2013 Glencore Xtrata listed on the JSE, which was an inviting development given the company’s diverse country portfolio and mining interests (Robinson, 2016:774)[40].

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[40] **Note:** The data for this study concludes on 19 August 2013, which means the effect of the event cannot be interpreted. However, given the significance, this event is included to achieve inclusivity.

A substantial decline in Iron & Steel's R^2 was visible during 2012 and subsequently in 2013. This was also true for Mining. Additionally Gold experienced a large drop in 2012 resulting in a very low R^2. The recent controversial events are a good example of how idiosyncratic factors affect South Africa's mining industry. Moreover the difference in impact that these factors had on each index was clearly visible in Iron & Steel and Gold. Although both groups form part of South Africa's mining industry, mine worker strikes mainly occurred at mines that were owned by companies dealing in precious metals which form part of non-ferrous metals, whereas Iron & Steel fall under ferrous metals and consequently were not as severely affected.

Summary

From the foregoing series of events dating from 1997 to 2013, a general picture is derived of the South African mining sector. Despite the rapid rise in global commodity prices in 2000 to 2007, the South African mining sector failed to take advantage of the commodity boom (Antin, 2013:5). Given the fact that during this period South Africa was still a fairly young democracy, Government aimed to restructure the country's mining industry by applying controversial legislation during the late 1990s and early 2000s. This resulted in significant disinvestments such as Anglo-American and BHP Billiton. South Africa also experienced an increase of political discontent especially in the mining sector where impractical wage demands were often the topic of discussion. Moreover, with an ever-increasing HIV-infected workforce, concerns over productivity and additional labour costs prohibited the sector from growing efficiently. Coupled with electricity constraints and increased input costs, mining companies in South Africa struggled to stay profitable.

Radical claims of expropriation and violence in the mining sector caused irreparable damage to the economy and investor confidence. Moreover, all three indices experienced low R^2's during the country's national election years in 1999, 2004 and 2009 with Mining being the exception during the latter period. Given the evidence provided it is clear that idiosyncratic factors explained a significant proportion of South African mining indices throughout different stages in time. This corresponds with the findings of Brooks and Del Negro (2005) and Bekaert *et al*. (2009) who highlight the on-going importance of country-specific factors.

4.7 Global events

This chapter would be incomplete without a brief discussion of the significant global events during 1997 to 2013. The purpose is to identify relevant events that may have aggravated volatility in global mining indices, which may be visible in the common global factor. However, it would be an onerous task to identify all possible global events. For this reason only the most appropriate events are identified for the prescribed time window. With this in mind emphasis now shifts toward the common global factor which is indicative of the global returns for each of the three sectors. This section continues by attempting to link significant global events with the common global factors for each sector, as presented earlier in Figure 4.4.1. The figure for the global factor clearly demonstrates the varying nature of the returns for each of the three sectors during different stages throughout the sample period. In addition to this, evidence also suggests that global events are apparent during periods where South African mining indices exhibit a high R^2 (as discussed in Section 4.5). Finally, for simplicity global events are arranged chronologically across five sample periods.

1997-1999

It is largely agreed that the East Asian crisis of 1997 to 1998 started on July 1997 when the Thai baht unpegged from the US Dollar, leading to large capital withdrawals. This triggered havoc and spill-over effects soon emerged in other Asian currencies. Coupled with the recession in Japan a decline in global economic growth was realised during the latter part of 1997 and in 1998 (Pretorius & de Beer, 2014:432). The Russian crisis occurred in August 1998 when the Russian Government unexpectedly announced unilateral restructuring of external debt and the devaluation of its currency. This triggered a "flight for quality" phenomenon, where investors pursued developed economies as alternative opportunities for investment. The repercussions of these events were felt in South Africa where the JSE plummeted by more than 36% (US Dollar terms) during the peak of the crisis (Pretorius & de Beer, 2014:432). The impact of this on South African indices cannot go unnoticed, and may possibly be linked with the country's index for Iron & Steel in 1997 and the general higher R^2 for Gold in 1997 and 1998.

Additionally the Euro currency (comprising eleven member states) was introduced on the first of January 1999. The significance of this lies in the fact that the currency depreciated since its introduction up to February 2002 (Shams, 2005:1). This had direct implications for South Africa when considering the prominent position the European Union occupied between 1997 and 2012 as a trading partner (Heymans & da Camara, 2013:421). During 1999 there were signs of higher R^2's for the South African indices, suggesting that the country co-moved more with global mining indices. Note that this specific sample period was not linked with the common global factors, since they were set to begin on 18/10/1999.

2000-2002

March 2000 is associated with the DotCom mania when the so-called Internet bubble burst due to huge level sell-offs driven by institutional investors (Ofek & Richardson, 2003:1113). Heymans and da Camara (2013:431) note the volatility transmission from, for example, the DJIA and CAC onto the JSE are prominent in this instance. A possible reason may be attributed to a blend of financial and political crises associated with the United States at the time. On 11 September, 2001 the US fell victim to unprecedented terrorist attacks. Chen and Siems (2004:358) note that as a result 31 out of 33 global capital markets (including the JSE) experienced significant negative average returns at a 1% level. Fittingly the common global factors for each of the three sectors experienced noteworthy downward spikes between 2000 and 2002. Moreover, significantly high R^2's were recorded for the South African Iron & Steel, Mining and Gold indices during the latter stages of 2001 and early 2002.

2003-2006

On March 20, 2003 Iraq was invaded by the United States, signalling the start of the Iraq War (Jackson, 2008:19). The significance of this may be linked to the temporarily higher R^2's for the three South African indices. In November 2004 President G.W. Bush was elected president of the US for the second time. These events came at a particularly volatile time and the effects of this may be visible in the movements for the common global factor. The 2016 US election was a reminder of how an event of this magnitude can affect global markets (Ahmed, 2016). The common global factors for Iron & Steel, Mining and Gold showed negative spikes during 2006, however, no significant economic events were identified for this period. A possible explanation might be gleaned from examining various macro-economic variables[41].

Although no significant economic events are identified for 2006, the period is associated with remarkable economic prosperity which is consistent with the global economic boom from 2000 to 2007 and as a result global mining industry experienced an extraordinary period (International Monetary Fund, 2006:3). Rising commodity prices and increasing Asian demand drove global mining growth, and at the forefront of this was takeover activity. Mining "giants" continued to grow with mergers and acquisitions, noteworthy deals in 2006 included Companhia Vale do Rio Doce's (CVRD) purchase of Inco Limited (PricewaterhouseCoopers, 2007:5). The global mining industry's total market capitalisation increased by an additional 22% in 2006 over the 72% in 2005 to $962 billion (PricewaterhouseCoopers, 2007:10). Among the top ten global mining companies (according to market capitalisation in US$ billion) are BHP Billiton, Anglo-American and Anglo-Platinum which all have ties with the South African mining industry. The relevance of this may perhaps be visible in the high R^2's identified for the three South African indices during this period. The expansion of the global mining industry was also reflected in South Africa's mining industry (Chamber of Mines of South Africa, 2006:4).

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[41] Since no obvious global events can explain the movement in the global common factor for each of the three sectors (during 2006), an alternative approach needs to be followed. Therefore this phenomenon may add to the validation of this particular study's objective; of linking common global factors with macro-economic variables (refer to Section 4.8) rather than specific events.

2007-2009

The global financial crisis was prompted by the sub-prime crisis in the third quarter of 2007 when the United States sub-prime mortgage market suffered devastating losses, unsettling global financial markets (Pretorius & de Beer, 2014:432). The pending meltdown was aggravated by the deterioration of Bear Stearns' financial health in March 2008, but intervention from the Federal Reserve aided the situation when JP Morgan Chase acquired Bear Stearns (Kaplan, Idzorek, Gambera, Yamaguchi, Xiong & Blanchett, 2009:136). However, this was to no avail when Lehman Brothers filed for bankruptcy in September 2008, marking the beginning of the global financial crisis (Fratzscher, Lo Duca & Straub, 2013:4).

Subsequent ramifications were transmitted through global financial linkages to advanced markets in the European region. During the global financial period the common global factor for each sector exhibited significant volatile behaviour. Initially the movements were negative and particularly evident for Iron & Steel and Mining. However, subsequent increases were visible for Gold, which makes sense since logic dictates that investors perceive gold as a safe investment during periods of increased volatility. It is generally agreed that the evolution of regulatory controls may have shielded the South African market against the effects of the global financial crisis (Heymans & da Camara, 2013:431). Overall this period showed a high R^2 for all three South African indices which continued to increase throughout 2008 and 2009.

2010-2013

It would be partial not to briefly address Quantitative Easing implemented in the United States. As mentioned in the foregoing discussion, the financial crisis created adverse financial implications that spilled over into the global economy. Quantitative Easing in the US consisted of three rounds; QE1 implemented on November 2008; QE2 November 2010 and QE3 September 2012 (Nellis, 2013:108). Finally in May 2013 US Federal Reserve Chairman Ben Bernanke announced that the Federal Reserve would potentially be unwinding its QE policy. This resulted in the "taper tantrum" and created significant levels of volatility in emerging markets (Sahay *et al*., 2014:5). The high R^2 for South Africa's Iron & Steel, Mining and Gold during 2010 may be linked to the implementation of QE2, since this had a profound effect on emerging market equity markets (prompting huge rebalancing from global bond markets to emerging equity markets) (Fratzscher, Lo Duca & Straub, 2013:6). The common global factors for Iron & Steel and Mining also exhibited increased volatility between 2010 and 2012.

Also worth mentioning is the Euro sovereign debt crisis and the effects associated with 2010 to 2013. Stracca (2013:3) maintains that this crisis caused renewed global financial turmoil. Fittingly the common global factors for the Mining and Gold sector experienced increased volatility for this period. In addition, during mid-2013 the three South African indices exhibited a surge in R^2 which might possibly have been ascribed to the Federal Reserve's announcement of potential tapering, resulting in substantial capital outflows from emerging markets. In terms value the United States and European region consistently remained among the most prominent South African trading partners. It is therefore logical to assume that volatile events associated in these countries would spill over to the South African market. This argument becomes even more valid when one considers the various dual listed mining companies listed on the JSE and LSE/NYSE.

Tests for robustness

Keeping in mind that this section is committed to investigating the common global factor, additional regressions are run for the United States indices to further examine and compare the influence of the global factor. The United States is selected since it often serves as a suitable proxy for measuring/comparative purposes in finance literature. Moreover, analysis thus far has shown the South African and US markets bear a close relationship - see Appendix A. These two markets also share multiple dual listed mining companies on their respective stock exchanges (mentioned in the forthcoming discussion). Literature shows that developed countries are more integrated globally, which suggests that the US markets should be greatly affected by the common global factor. This analysis may assist in depicting the different impacts the major common global factor has on a developed versus an emerging market. Finally the US (like South Africa) remains one of the few countries that are represented in each of the three sectors. Consequently the explanatory power of the first global factor for South Africa and the United States is considered in order to see how each country's index is influenced by the major common global factor. A rolling-window approach (similar to the foregoing analysis) is conducted for the United States' standardised data. The regressions take the following form:

- Iron & Steel: $\text{SAreturns}_{\text{I\&S}} = \beta_0 + \beta_1\, F_{1\,\text{I\&S}}$ & $\text{USAreturns}_{\text{I\&S}} = \beta_0 + \beta_1\, F_{1\,\text{I\&S}}$
- Mining: $\text{SAreturns}_{\text{MIN}} = \beta_0 + \beta_1\, F_{1\,\text{MIN}}$ & $\text{USAreturns}_{\text{MIN}} = \beta_0 + \beta_1\, F_{1\,\text{MIN}}$
- Gold: $\text{SAreturns}_{\text{GOLD}} = \beta_0 + \beta_1\, F_{1\,\text{GOLD}}$ & $\text{USAreturns}_{\text{GOLD}} = \beta_0 + \beta_1\, F_{1\,\text{GOLD}}$

Iron & Steel

Note (Figure 4.7.1) that the R^2s for South Africa's Iron & Steel index (during 1998 to 2004) were lower compared to the United States' index, however the South African index has progressively increased since then. Additionally in 2008 South Africa exhibited a lower R^2 compared to the United States, suggesting the global financial crisis had a lesser impact on the South African index. These findings are consistent with the results obtained from the variance shares (Table 4.3.1) for the two respective countries, which show the United States index for Iron & Steel was more integrated globally compared to the South African index. Finally the correlation coefficients for the different R^2's for each country's Iron & Steel index are displayed in Table 4.7.1 which suggests that a noteworthy relationship existed between the explanatory power of the first/common global factor. This result coincides with the relationship presented in Appendix A which indicates that the US and South African index (returns) for Iron & Steel are the most correlated (note that these coefficients are not particularly high).

Figure 4.7.1: R^2 of rolling regressions for South African/United States Iron & Steel returns

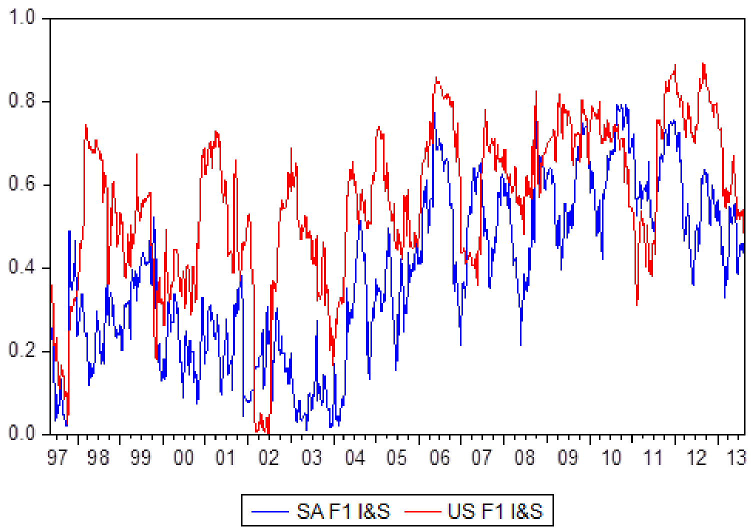


Table 4.7.1: Correlation coefficients of R^2's for Iron & Steel returns

	US F1 I&S	*US F3 I&S*	*US F5 I&S*	*SA F1 I&S*	*SA F3 I&S*	*SA F5 I&S*
US F1 I&S	1					
US F3 I&S	0.94411907	1				
US F5 I&S	0.89487865	0.93941570	1			
SA F1 I&S	**0.61805043**	0.60704415	0.62285008	1		
SA F3 I&S	0.52262321	0.51686153	0.55485062	0.91447437	1	
SA F5 I&S	0.27386732	0.25288271	0.28004178	0.66888007	0.76019643	1

Mining

The variance share for the Mining sector shows that the United States index is slightly more integrated with global markets compared to the South African index. However, the global financial crisis appears to have had a more profound effect on the South African Mining index. This is apparent in the higher R^2 observed for the South African index during 2008. According to logic this is somewhat contradictory. Further investigation indicates a more stable and increased degree of integration visible for the South African index from mid-2006 to 2013. The US index appears to have experienced a larger degree of variation during this time - although it remains reasonably integrated globally. In addition, Table 4.7.2 shows that a noteworthy relationship exists between the common global factor for South Africa and the United States respectively.

Figure 4.7.2: R^2 of rolling regressions for South African/ United States Mining returns

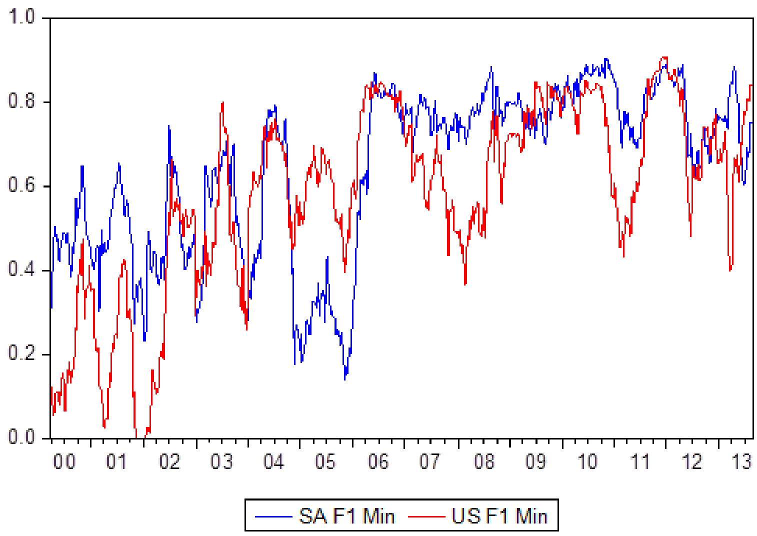


Table 4.7.2: Correlation coefficients of R^2's for Mining returns

	US F1 Min	*US F3 Min*	*US F5 Min*	*SA F1 Min*	*SA F3 Min*	*SA F5 Min*
US F1 Min	1					
US F3 Min	0.79316593	1				
US F5 Min	0.73256726	0.94697444	1			
SA F1 Min	**0.63898155**	0.52178662	0.42943045	1		
SA F3 Min	0.70627432	0.65368175	0.54247302	0.89790806	1	
SA F5 Min	0.77976941	0.75738428	0.63566725	0.76473045	0.86048641	1

Gold

According to its variance share (displayed in Table 4.3.1) the United States Gold index is more integrated with global markets compared to South Africa. This trend is also apparent throughout Figure 4.7.3. Furthermore the impact of idiosyncratic events appears to be more relevant for the South African index (visible in the low R^2's) which accentuates how the country, at times, does not co-move with global markets. This phenomenon may perhaps be visible in the low coefficients presented in Table 4.7.3. In general these observations are in line with expectations of an emerging market; however, note that the South African index (ignoring the substantial low R^2's) seems to follow a trend akin to the US index. The correlation coefficients in Appendix A support this notion. Moreover, during 2008 South Africa briefly displayed a higher R^2 than the US. This is rather noteworthy when considering the number of dual listed companies (AngloGold Ashanti Ltd and Gold Fields Ltd) that exist between these two countries. Provided that Gold is considered a safe haven and supposedly, primarily driven by the gold price itself while also considering the relationship that exist between South Africa and United States Gold mining indices, it would not be incorrect to expect a robust relationship. However, this does not seem to be the case. Finally this adds to the discussion surrounding the ambiguity of South African markets. The country has sophisticated financial institutions but is faced with various fiscal challenges. Collectively the relationship for the common global factors for Iron & Steel is stronger compared to Gold (this is also true for Mining). This then further reaffirms the impact of industry factors where the effects of global economic events differ with respect to diffident mining sectors. Moreover, it also shows that a country's level of integration is not necessarily indicative of the influence that global events may exert on the country's equity market.

Figure 4.7.3: R^2 of rolling regressions for South African/United States Gold returns

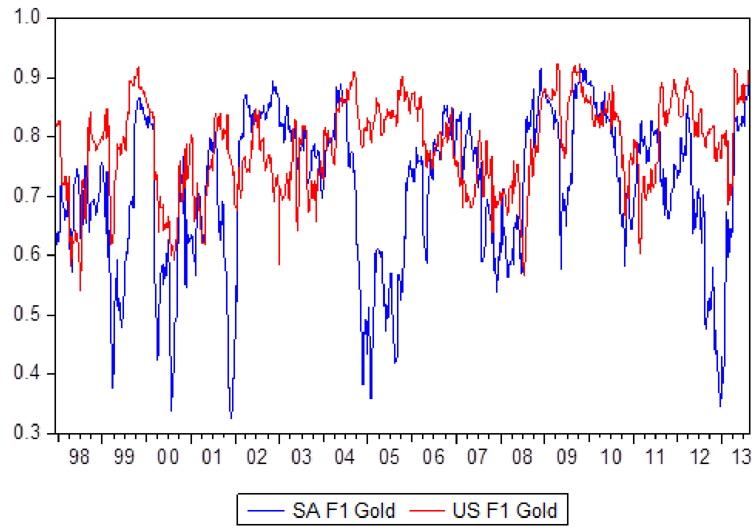


Table 4.7.3: Correlation coefficients of R^2s for Gold returns

	US F1 Gold	*US F3 Gold*	*US F5 Gold*	*SA F1 Gold*	*SA F3 Gold*	*SA F5 Gold*
US F1 Gold	1					
US F3 Gold	0.90215108	1				
US F5 Gold	0.66911091	0.74159775	1			
SA F1 Gold	**0.28846563**	0.30473077	0.32652999	1		
SA F3 Gold	0.31387727	0.33659632	0.32953023	0.96192306	1	
SA F5 Gold	0.35623635	0.38683722	0.36267895	0.89841668	0.91761327	1

4.8 The common global factor and macro-economic variables

It is evident that any attempt to link specific movements for the South African indices with global economic events is particularly challenging. Therefore this study furthers its analysis by attempting to link the first common factor extracted from each global sample to macro-economic variables, in order to identify possible economic forces that may stimulate co-movement. As mentioned previously the first factor/global factor remains exactly the same, regardless of the number of factors extracted from each panel. The first factor also explains the largest share of total variation in each panel. It therefore makes sense to try and link movements in the macro economy to this first factor (common global factor).

Since this section is concerned with the global factor, all macro-economic variables were set to commence on 18/10/1999. Although financial variables are available on a daily basis, most real economic variables are either quoted in a monthly or quarterly frequency. The weekly price data for Iron & Steel, Mining and Gold is converted to monthly returns and the factors are extracted/regressed, exactly similar to the process conducted for the weekly data. Correlation analysis initially assists in identifying a relationship between the global factors and macro-economic variables. Subsequently linear regressions are performed to further examine the relationship between the respective common global factors for Iron & Steel, Mining and Gold and the different macro-economic variables. Finally rolling correlation analysis is conducted. The estimated t-statistic and coefficient help to identify whether certain macro-economic variables are more prominent in describing the variation of the common global factor during certain periods.

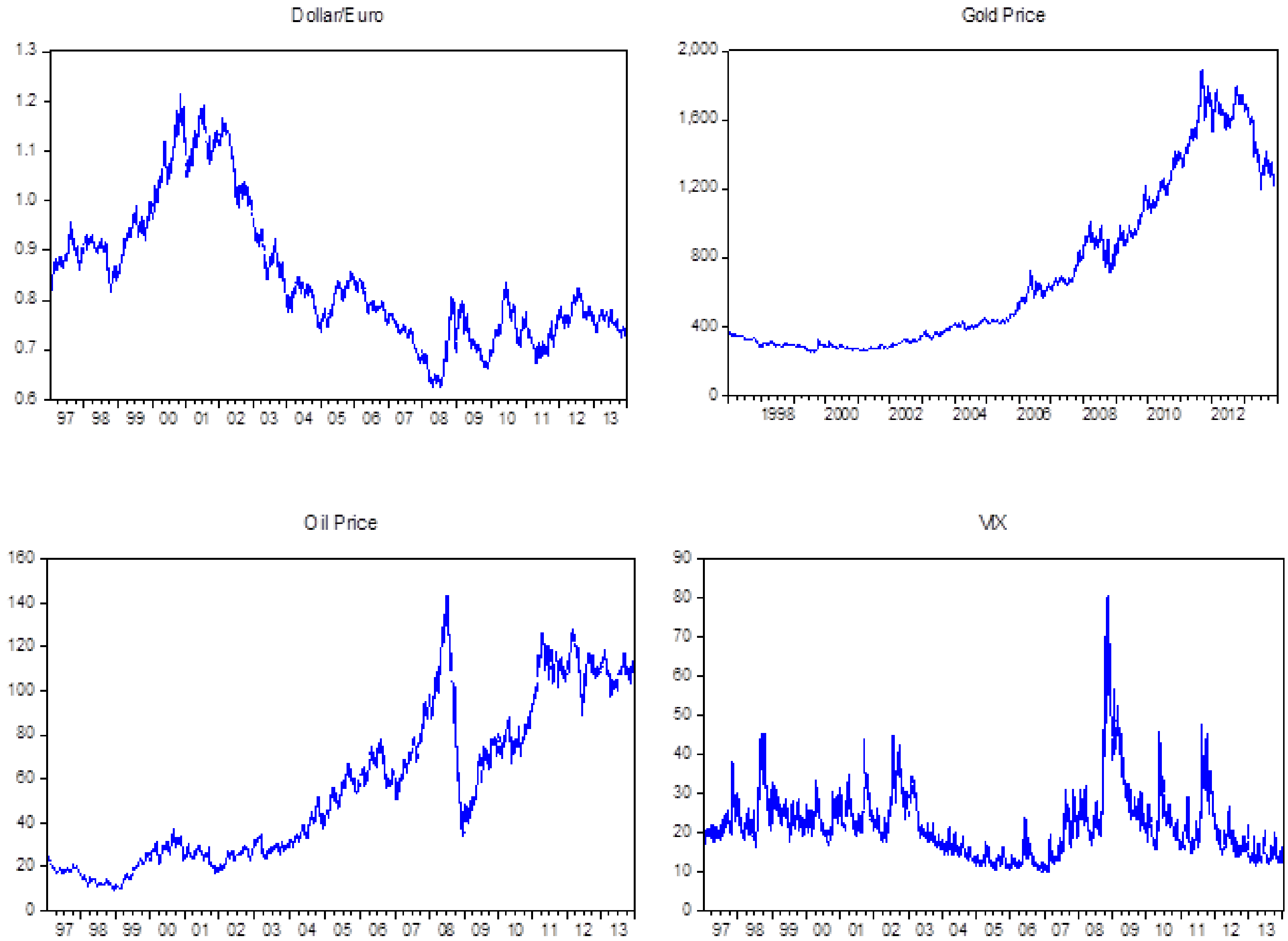
(a) Weekly variables

Simple correlation

Figure 4.8.1 shows the four weekly macro-economic variables used for this section, dating from 18/10/1999 to 19/08/2013: The variables include: US Dollar/ Euro exchange rate, oil prices, Gold prices and the S&P 500's volatility index (VIX)[42]. The data for all of these variables is available on a daily frequency similar to the three sectors. They are likewise transformed into weekly averages and the returns are calculated to conduct relevant comparisons.

[42] Refer to Section 3.10 for a detailed macro-economic data description.

Figure 4.8.1: Weekly macro-economic variables



Note: All figures are in US dollar

Table 4.8.1 displays the correlation coefficients between the common global factors (factor one (F1) for each of the three sectors) and macro-economic variables across the entire time[43]. The macro-economic variables do not exhibit significant correlations among one another, apart from perhaps the negative correlation between the Dollar/Euro exchange rate and the gold price. Considering all three global factors, the Dollar/Euro rate has a negative relationship with each individual sector. This corresponds with Ajayi *et al*. (1998) who investigate daily stock indices and exchange rates for both developed and emerging countries.

Intuitively this makes sense since a stronger US dollar would mean vital inputs such as that oil will become more expensive for mining companies. Oil prices are positively correlated with the global factor for all three sectors, most significantly for Mining and Iron & Steel. This contradicts Filis *et al*. (2011) and literature in general, since the relationship between oil prices and stock markets is considered to be negative (Creti *et al.,* 2013:18). The argument here is that a higher oil price indicates greater demand and seeing that mining companies are large oil consumers it

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43 Refer to Appendix D for the complete table of weekly correlation coefficients.

would suggest prosperity in the mining industry in general. However, according to Park and Ratti (2007:2587) the effect that oil prices have in stock prices varies across countries. The authors investigate the relationship between oil prices and stock returns for thirteen European countries and the US (1986 to 2005) and found that volatility in oil prices has a negative impact on nine out of fourteen stock markets. Moreover Park and Ratti (2007) show that oil prices contribute more to the variability in stock returns (for 12 out of 14 stock markets) compared to short-term interest rates. As expected the Gold F1 and gold prices are highly correlated, suggesting the latter is prominent in driving the Gold index[44]. Fittingly the effect of gold prices on Gold F1 is also reflected in Mining F1, due to the manner in which the sector is structured. Finally VIX is negatively correlated with all the global factors which make sense. For example, a decrease in volatility would most probably lead to an increase in mining indices. Also note the smaller correlation coefficient for Gold F1 which is surprising, considering that gold is regarded as a safe haven for investors.

Table 4.8.1: Correlation coefficients for weekly variables

	Iron & Steel F1	*Mining F1*	*Gold F1*
Dollar/Euro Rate	-0.450530881	-0.483262504	-0.462039994
Oil Price	0.373705897	0.409999222	0.290701239
Gold Price	0.294713475	0.531196410	0.785645659
VIX	-0.300661367	-0.225197439	-0.128030598

Linear regression

Since the foregoing correlation coefficients do not serve as an indication of causality, linear regressions are also performed for the common global factor (factor one) for Iron & Steel, Mining and Gold as the dependent variable and the macro-economic variables as the independent variable, for the entire sample period, as displayed in Table 4.8.2. It is important to keep in mind that the common factor is a dynamic blend of economic influences, making it impossible to attribute a specific factor to a single real economic variable. As such this study includes a novel approach where multi-variable regressions are run to investigate how changes in the common global factor are influenced by changes in economic variables. This analysis expands on empirical analysis done by Ludvigson and Ng (2009) in which single variable regressions were run - with only one macro-economic indicator as explanatory variable per regression.

The independent variables for all three regressions are statistically significant at a 1% level. The adjusted R-squares for each of the three sectors appear to be low for Iron & Steel (35.5%), however, increases for Mining (46.9%) and Gold (66.3%). Finally, according to the Durbin-

[44] Baur and Lucey (2010) identify notable linkages between gold and equity markets.

Watson (DW) test there is no clear indication of autocorrelation present for the regressions. In general the regression results for Iron & Steel, Mining and Gold are in accordance with the correlation coefficients, where the exchange rate and gold prices are the dominant drivers. Note the substantial influence (negative) the dollar/euro rate exerts on the global factor for Iron & Steel and Mining. Additionally gold prices have a noteworthy effect (positive) on the Mining and Gold sectors. Oil prices also have a positive relationship with all three sectors, most notably for Iron & Steel[45]. VIX bears a negative relationship with each of the three sectors however this is not as substantial when compared to the negative relationship between dollar/ euro rate in relation to each of the three sectors.

Table 4.8.2: Summary of regressions (F1) for all three sectors

Iron & Steel F1

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
Dollar/ Euro Rate	-90.04593	9.001843	-10.00305	0.0000
Gold Price	15.24644	5.201951	2.930909	0.0035
Oil Price	20.82542	2.408361	8.647136	0.0000
VIX	-6.727712	0.777171	-8.656671	0.0000
Adjusted R-squared			0.358608	
Durbin Watson stat			1.648841	

Mining F1

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
Dollar/ Euro Rate	-56.11286	6.581546	-8.525786	0.0000
Gold Price	45.68111	3.803319	12.01085	0.0000
Oil Price	16.20395	1.760832	9.202439	0.0000
VIX	-4.239590	0.568215	-7.461237	0.0000
Adjusted R-squared			0.469439	
Durbin Watson stat			1.688364	

Gold F1

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
Dollar/ Euro Rate	-21.25643	4.063063	-5.231627	0.0000
Gold Price	69.08902	2.347947	29.42528	0.0000
Oil Price	4.167868	1.087035	3.834162	0.0001
VIX	-2.315011	0.350783	-6.599554	0.0000
Adjusted R-squared			0.663476	
Durbin Watson stat			1.710875	

Table 4.8.2 represents a summary of the results from the weekly regression outputs for the Iron & Steel, Mining and Gold sectors

45 The relationship between oil prices and stock returns envisaged for this study is consistent with Ono's (2011:43) findings. The author investigates the relationship between oil prices and the stock returns for the BRICS economies (1999 to 2010) and observes (statistically significant) positive responses for China, India and Russia.

Rolling correlations, t-statistic and coefficients

Recall the results from the correlation coefficients and linear regressions, which show that certain macro-economic variables have a more notable relationship with the most important common factor from each of the three sectors. Although these criteria offer insight into different possible drivers for the global factor, the former relationships remain an analysis based on correlation. The foregoing literature section identifies this form of analysis as an insufficient measure of integration, since correlation does not imply causality. While the linear regression expands on the relationship between the global factors and macro-economic variable it fails to address the dynamic aspect of co-movement.

With this in mind, rolling correlations with a period of 24 weeks are conducted. Instead of extracting the R^2's, the t-statistic and coefficients for each macro-economic variable are extracted, similar to the procedure applied for Section 4.5. This process is repeated for the Iron & Steel, Mining and Gold sector. Moreover, absolute values are obtained for the rolling correlations in order to create a more concrete representation, since a blend of negative and positive values fail to produce an accurate illustration. This approach assists in addressing the dynamic aspect of co-movement by identifying whether specific macro-economic variable are more prominent during specific periods in time. Emphasis is placed on the t-statistic and to a lesser extent, the coefficient for each macro-economic variable in relation to the first factors for Iron & steel Mining and Gold.

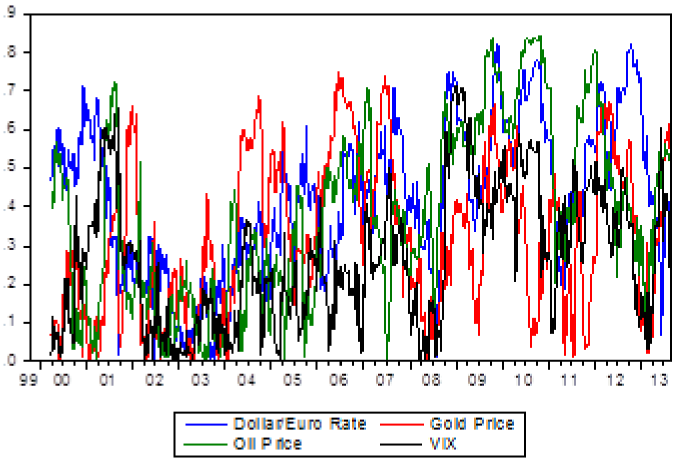
(i) Iron & Steel

This section continues by identifying whether certain macro-economic variables are more significant in explaining the variation in each of the three sectors. Figure 4.8.2 groups the rolling correlation (in absolute terms), t-statistic and coefficient for Iron & Steel together in a single figure, and this form of representation aims to simplify the visual comparison. Furthermore the t-statistics for Iron & Steel exhibit significant spikes for the exchange rate in 2000, 2001, 2008, 2011 and 2012, oil prices in 2008, 2009 and VIX in 2004, 2007. During early 2000 the Dollar appreciated (Figure 4.8.1) and correspondingly the effect of this was visible in the downward movement for the exchange coefficient, confirming that the exchange rate was the prominent global factor that drove Iron & Steel in 2000 and 2001. Moreover the Iron & Steel coefficients for the exchange rate also demonstrate the negative relationship observed earlier for the correlation analysis/ linear regressions.

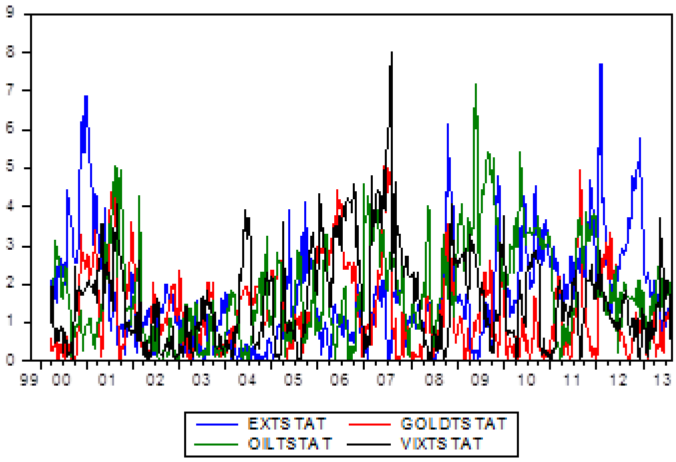
It has to be noted though that the macro-economic variables for the rolling correlation/t-statistics converge during the latter stages of 2001 which may be attributed to the 9/11 terrorist attacks (Chen & Siems, 2004 note the impact of such an event) – and this is confirmed by the increase in VIX (Figure 4.8.1). During 2004 a spike in the t-statistic is visible for VIX, however the rolling correlation exhibits elevated levels for the gold price, and a possible reason for this may be attributed to investors' tendency of flocking towards safe havens such as gold during times of increased volatility. VIX's t-statistic also increased significantly during 2007 and this was supported with an instantaneous spike for VIX and may be linked to the early stages of the sub-prime crisis in the US. However, rolling correlations for the gold price and exchange rate appear dominant in 2007, this is also supported by the coefficients. In 2008 the exchange rate emerged as the dominant factor which is consistent with the strengthening US dollar. Oil prices were significant in 2008 and 2009, which may be linked to the substantial drop in oil prices during late 2008. In 2011 and 2012 the exchange rate emerged as the dominant factor which may be attributed to the impact of QE/Eurozone crisis, leading to the appreciation of the dollar and depreciation of the euro respectively. Note the co-movement between the exchange rate and oil prices and the relationship formed between gold prices and VIX.

Figure 4.8.2: Weekly indicators for Iron & Steel

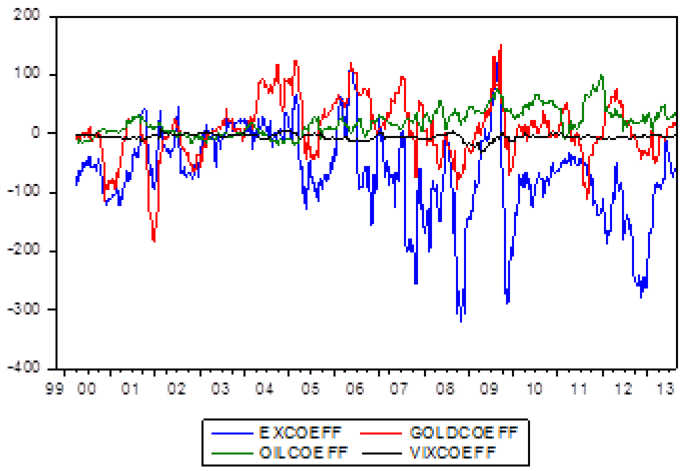
I&S Rolling correlation



I&S t-Statistics



I&S Coefficients

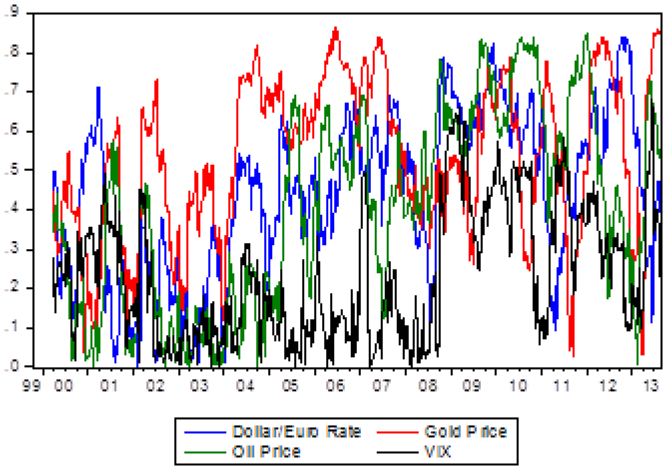


(ii) Mining

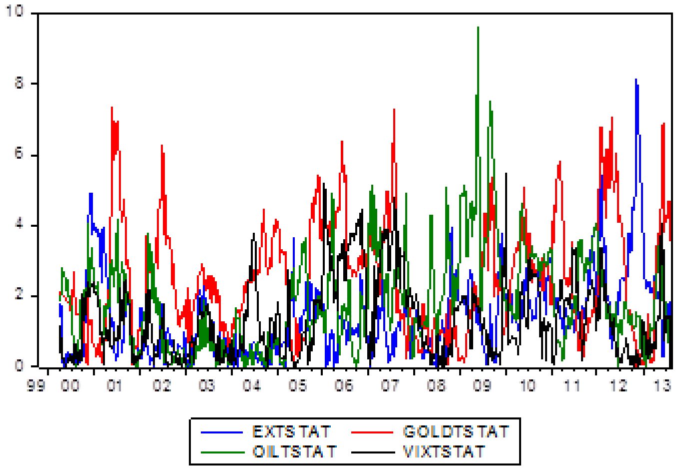
Similar to Iron & Steel, the influence of the exchange rate during 2000 and 2001 can be identified for Mining visible in the rolling correlations, t-statistics and coefficients (Figure 4.8.3). From mid-2001 to 2007 gold prices appeared to be the dominant factor and this might be attributed to the increase in gold prices associated with the specified period (Figure 4.8.1). The sharp decrease associated with oil prices is evident in the figures for Mining during 2008 and 2009. However, the rolling correlations show that oil prices appeared to become a prominent factor once again during late 2009 to 2011 (this is also consistent with the substantial increase in oil prices). Gold prices continued to be the dominant factor between 2010 mid-2012; however, in 2012 the exchange rate temporarily developed as the dominant factor, which is visible in the rolling correlations and t-statistics figures for Mining. Finally during 2013 gold prices became the dominant factor once again and this was confirmed by each of the three indicators for Mining.

Figure 4.8.3: Weekly indicators for Mining

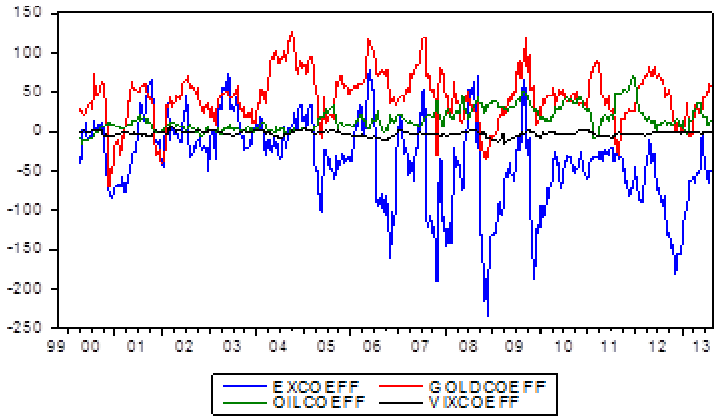
Mining rolling correlations



Mining t-statistics



Mining coefficients

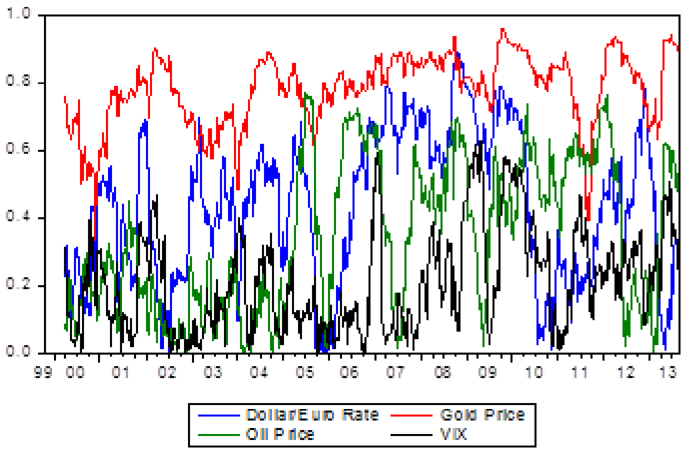


(iii) Gold

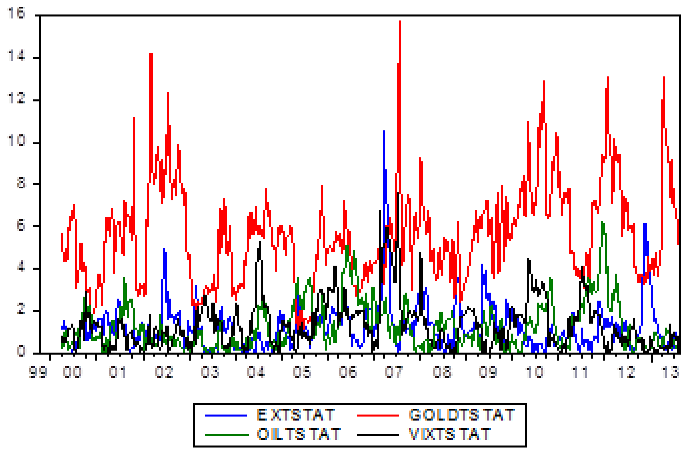
Not surprisingly gold prices appeared to be the dominant factor for the global factor from the Gold sector throughout the entire sample period (Figure 4.8.4). However, the exchange rate became a prominent factor during 2003, 2007 and 2008 and the effects of this may be linked to the depreciation of the Dollar. Tully and Lucey (2007:316) conclude that the US dollar remained the foremost macro-economic variable to affect gold. A similar relationship was identified for this empirical analysis suggesting that this influence perhaps existed in gold equities as well. Subsequently exchange rates became significant in 2012 – however, this occurrence may largely be due to the weakening impact of gold prices. Alternatively the rolling correlations showed oil prices were prominent factors during 2005 and 2011. These movements were linked to periods where the significance of gold prices appeared to decline (visible for rolling correlations and t-statistics). Finally VIX does not appear to be a prominent factor for the Gold sector, despite the former increasing dramatically during 2007 and 2008/ 2009.

Figure 4.8.4: Weekly indicators for Gold

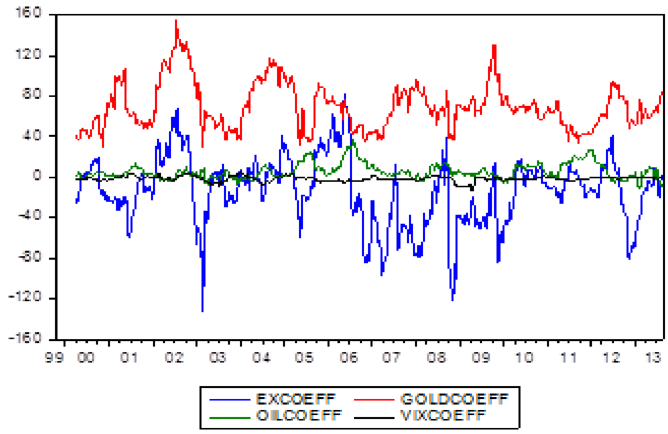
Gold rolling correlations



Gold t-statistics



Gold coefficients



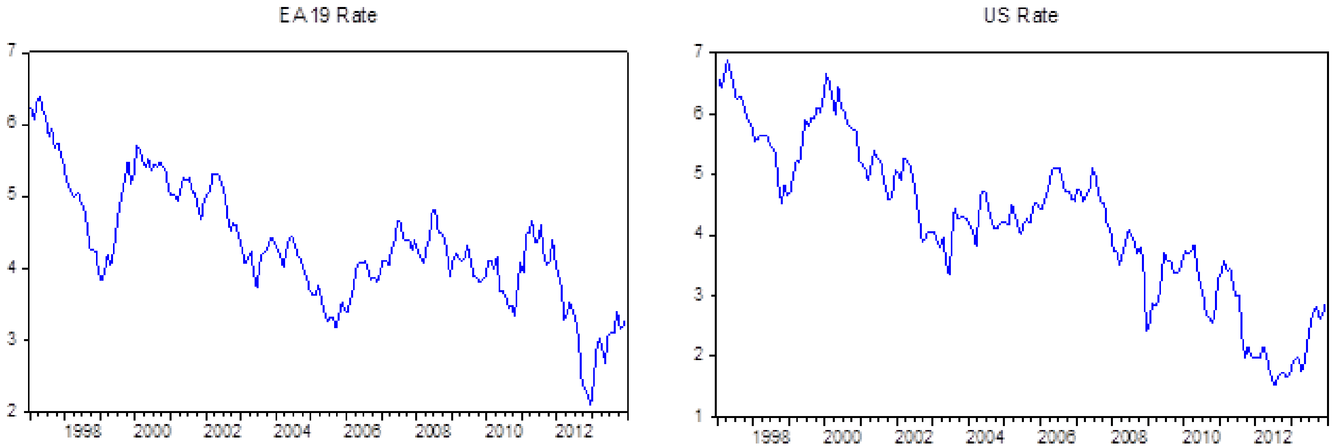
Caution has to be practised with regard to the interpretation of results. For example, a particular macro-economic variable may appear to be the dominant factor for a specific index – however, this behaviour might be as a result of the comparatively subdued performance in relation to the other economic variables. This phenomenon might explain the varying nature exhibited by certain variables for the different figures. Kurihara (2006:376) maintains the influence that macro-economic factors exert on stock prices change as time progresses. The empirical analysis conducted for this study also documents a similar dynamic relationship over time.

(b) Monthly variables

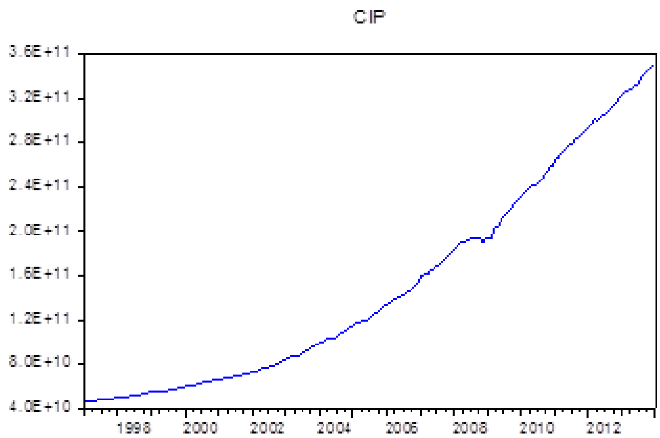
Correlation analysis

Due to the fact that certain real economic variables are only available in a monthly frequency a process similar to the foregoing weekly variables is performed for the monthly set of macro-economic variables. Iron & Steel, Mining and Gold price data is converted to monthly returns where the first factor is extracted for each sector. Figure 4.8.5 shows the three-monthly macro-economic variables used in this section: Euro Area (EA) 19 and United States interest rates and Chinese Industrial Production (CIP).

Figure 4.8.5: Monthly macro-economic variables



Note: Interest rates in %



Note: CIP in US dollar

Table 4.8.3 shows that only one (CIP) of the macro-economic variables exhibits a noteworthy relationship with the global factors over the entire period[46]. CIP is negatively correlated with EA 19 interest rate but positively correlated with US interest rates. Additionally a noteworthy positive relationship exists between EA 19 and US interest rates. CIP is positively correlated with each of the global factors and also appears to be the most prominent among the three variables. Fama (1981) maintains that a significant positive correlation exists between industrial production and equity returns. Both EA 19 and US interest rates have positive relationships with the global factors for Iron & Steel and Mining; however, they are negatively correlated with Gold, thus supporting Fisher (1930). Moreover Alam and Uddin (2009:43) also document a negative relationship between interest rates and stocks, and the authors investigate monthly data from 1988 to 2003 for developed and developing countries.

Table 4.8.3: Correlation coefficients for monthly variables

	Iron & Steel F1	*Mining F1*	*Gold F1*
CIP	0.266836548	0.347958891	0.301745076
EA 19 Rate	0.109880788	0.093881443	-0.034065002
US Rate	0.288714513	0.175530009	-0.123692910

Linear regressions

Similar to the process for the weekly variables, regressions are also performed for monthly variables. EA 19 Rate indicates a negative relationship with the common factor for Iron & Steel but displays a positive relationship with Mining and Gold. Also worth mentioning is the positive relationship between US interest rates and Iron & Steel. Note that US Rate bears a positive relationship with the common factor for Mining and a negative relationship with Gold. Results also present the substantial (positive) influence CIP has on the global factors for Iron & Steel, Mining and Gold. Apart from CIP, the independent variables are statistically insignificant (at a 5% level) for the remaining regressions. The adjusted R-squares for each of the three sectors are also very low. The Durbin Watson test indicates positive autocorrelation for Iron & Steel, however, no clear evidence of autocorrelation is documented for Mining and Gold. Considering that these sets of variables are monthly returns a possible explanation for autocorrelation points to misspecification. This indicates there may be other variables that are better suited to explain the variation in the global factors for Iron & Steel. It has to be remembered though that the aim of this study is not to identify macro-economic variables that completely explain the global factors. Additionally, to the author's knowledge this specific approach has not been performed in previous literature, therefore providing opportunities for future research.

[46] Refer to Appendix D for the complete table of monthly correlation coefficients.

Table 4.8.4: Summary of regressions (F1) for all three sectors

Iron & Steel F1

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
EA 19 Rate	-3.758053	6.026466	-0.623592	0.5338
US Rate	16.25320	4.484239	3.624516	0.0004
CIP	123.1380	34.47844	3.571449	0.0005
Adjusted R-squared			0.137318	
Durbin Watson stat			1.536094	

Mining F1

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
EA 19 Rate	0.768184	4.872672	0.157651	0.8749
US Rate	6.736111	3.625712	1.857873	0.0650
CIP	132.3510	27.87739	4.747611	0.0000
Adjusted R-squared			0.133433	
Durbin Watson stat			1.592194	

Gold F1

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
EA 19 Rate	2.445803	3.645461	0.670917	0.5032
US Rate	-5.017162	2.712555	-1.849608	0.0662
CIP	86.23908	20.85630	4.134917	0.0001
Adjusted R-squared			0.094193	
Durbin Watson stat			1.757246	

Table 4.8.4 represents a summary of the results from the monthly regression outputs for the Iron & Steel, Mining and Gold sectors

Table 4.8.4 includes a lead of one period for the industrial production variable (CIP). This is motivated by the notion that share prices are supposedly forward looking in nature, thus reflecting expected/future events in the sector. It can therefore be expected that returns should reflect expected production and not so much current production. In order to test for this, the regression in Table 4.8.5 also includes CIP in the following month - as indicated by CIP (1). The results confirm the previously reported relationship among the three first factors and the two interest rate variables. More important, however, are the statistically significant estimates for CIP (1), CIP in the following month and for all three regressions. Another striking observation is that the estimated coefficients of CIP (1) are larger than the estimated coefficient of CIP in all three regressions. The relationship between current returns and future production is therefore stronger than the relationship between current returns and current production levels.

Table 4.8.5: Summary of Regressions (F1) for all three sectors including a lead

Iron & Steel F1

Variable	***Coefficient***	***Std. Error***	***t-Statistic***	***Prob.***
EA 19 Rate	-3.889695	5.619077	-0.692230	0.4898
US Rate	14.03024	4.211907	3.331091	0.0011
CIP	109.5063	32.24134	3.396457	0.0009
CIP(1)	167.2469	32.42484	5.157985	0.0000
Adjusted R-squared			0.253571	
Durbin Watson stat			1.569671	

Mining F1

Variable	***Coefficient***	***Std. Error***	***t-Statistic***	***Prob.***
EA 19 Rate	0.653223	4.444784	0.146964	0.8833
US Rate	4.715589	3.331689	1.415375	0.1589
CIP	119.9764	25.50344	4.704321	0.0000
CIP(1)	151.5530	25.64859	5.908823	0.0000
Adjusted R-squared			0.282620	
Durbin Watson stat			1.628942	

Gold F1

Variable	***Coefficient***	***Std. Error***	***t-Statistic***	***Prob.***
EA 19 Rate	2.445395	3.488859	0.700915	0.4844
US Rate	-6.204432	2.615154	-2.372492	0.0189
CIP	79.19202	20.01850	3.955942	0.0001
CIP(1)	82.41918	20.13244	4.093850	0.0001
Adjusted R-squared			0.175021	
Durbin Watson stat			1.793053	

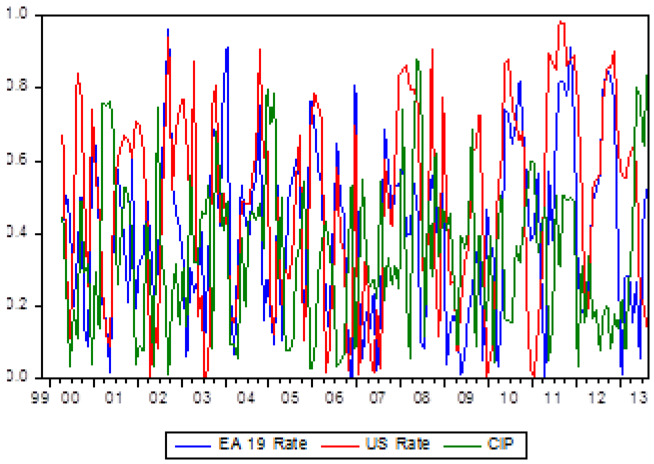
Rolling correlations, t-statistic and coefficients

(i) Iron & Steel

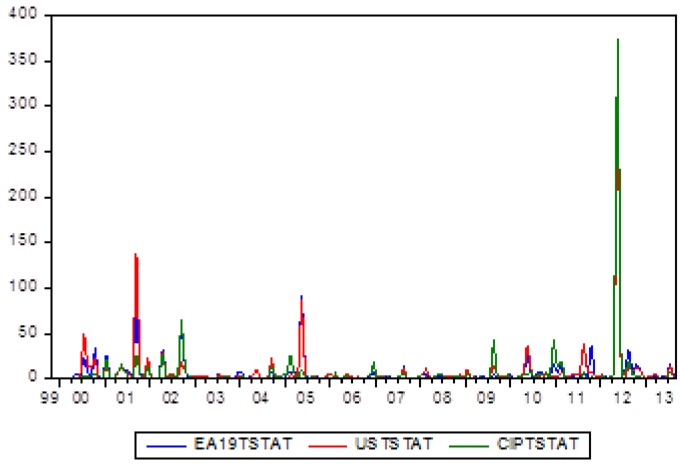
Figures 4.8.6 displays the rolling correlations (in absolute terms), t-statistics and coefficients of the global factors for the monthly Iron and Steel sector. Rolling correlations show that US interest rates are the most dominant factor in explaining Iron & Steel. The two interest rate variables tend to co-move over the entire sample period (also evident in Figure 4.8.5), with EA 19 interest rates overriding US rates in 2002, 2004 2006 and 2007. CIP becomes the dominant factor in 2001, 2008 and 2013. The t-statistics seem to provide an unclear representation for each of the three sectors. A possible reason might be the frequency of the data. In 2001 US and EA 19 rates spike and again in 2005. CIP increases in 2002 and again in 2012 accompanied by US/EA 19 rates. These movements can be linked to the rolling correlations however CIP is very low in 2012. The coefficients suggest that CIP is the dominant factor for describing the variation in Iron & Steel.

Figure 4.8.6: Monthly indicators for Iron & Steel

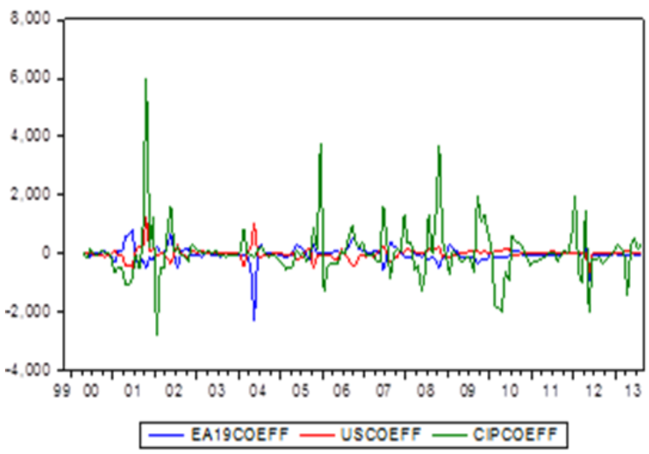
I&S rolling correlation



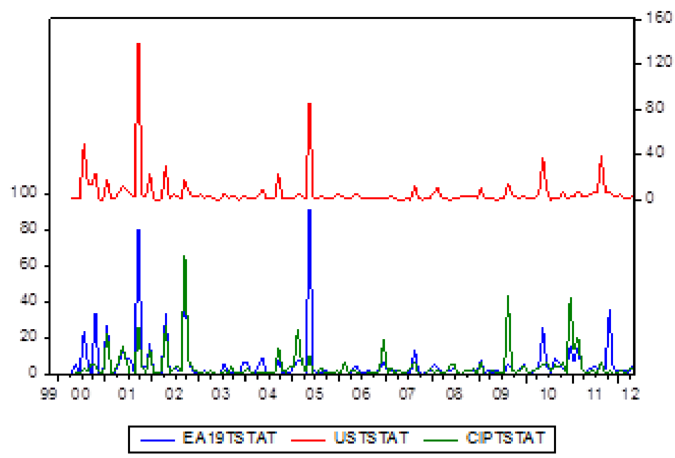
I&S t-statistics



I&S coefficients



I&S t-statistics*

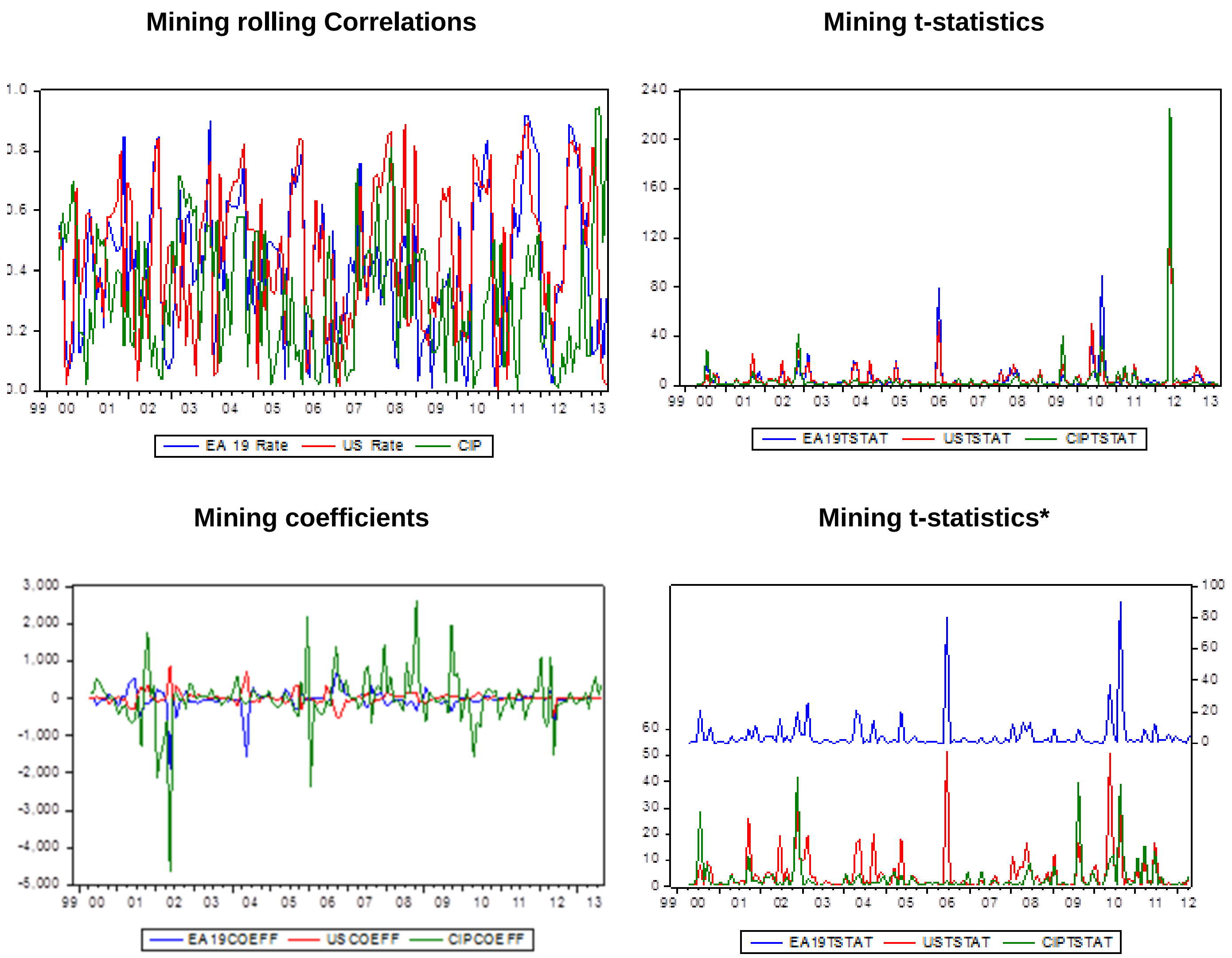


*Given the extremely high t-statistic in the top right graph, the period for the t-statistics has been adjusted to provide a more comparable illustration in the bottom right-hand graph

(ii) Mining

Figure 4.8.7 shows that US interest rates appear to be the prominent factor for the Mining sector; however, EA 19 rate exceeds the former during late-2001, 2004 and 2010 to 2012. CIP is dominant during 2000, 2003, 2008 and 2013. The t-statistics for mining show CIP increasing in 2002, 2009 and significantly in 2012. US/EA 19 rates increased in 2006, 2010 and 2012. The coefficients for Mining show that CIP was the dominant factor throughout the entire sample period. In addition, the regression for Mining suggests a positive relationship, yet the coefficients displayed significantly negative spikes during 2002, 2006, 2010 and 2012.

Figure 4.8.7: Monthly indicators for Mining

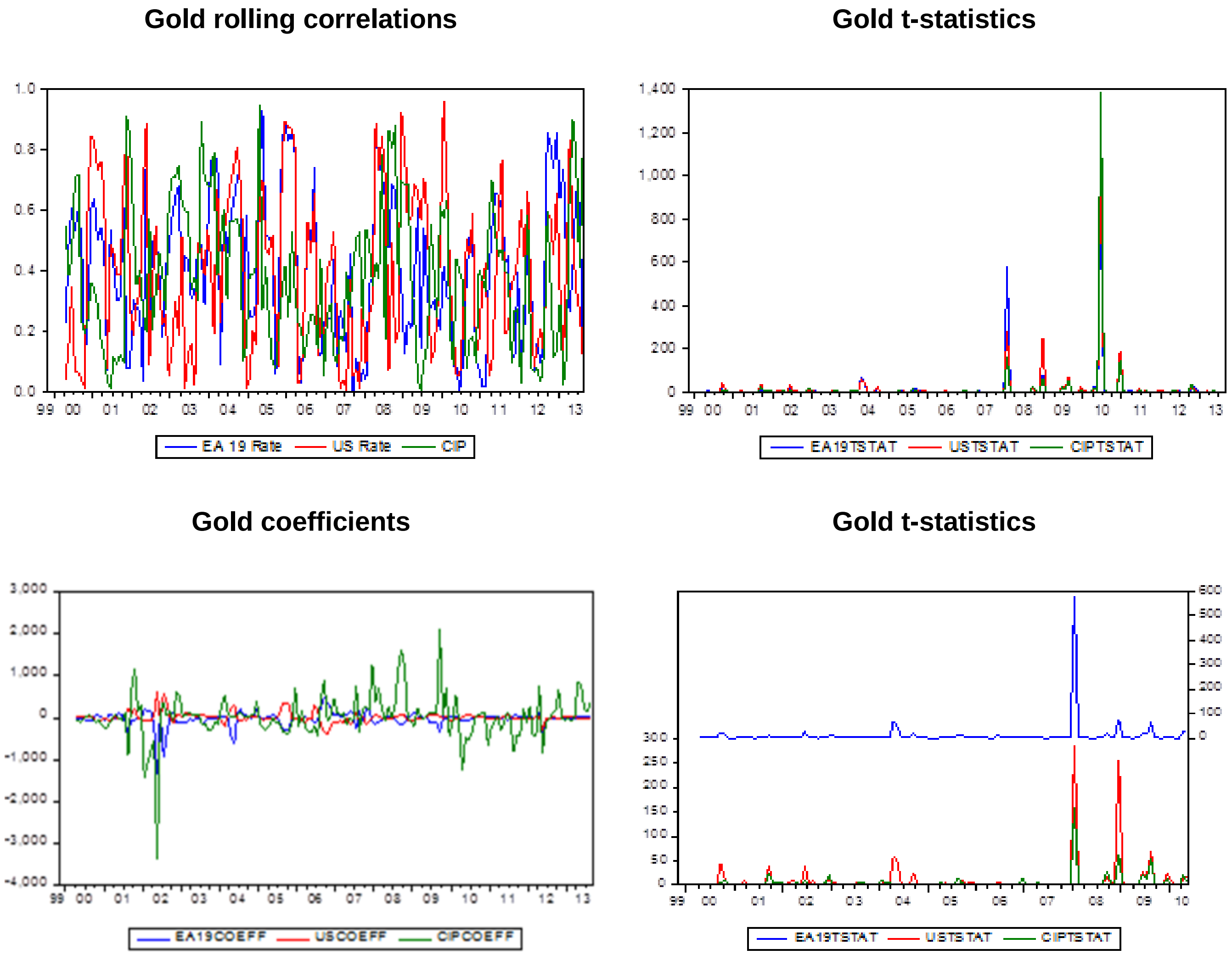


*The sample period for the graph on the bottom right has again been adjusted to provide a more comparable illustration

(iii) Gold

Finally US rates were prominent for Gold (Figure 4.8.8); however, this was less significant compared to Iron & Steel and Mining. EA 19 rate was the main driver for Gold's global common factor during 2005, 2006 and 2012. The co-movement between the interest rates appears less significant for Gold, and moreover instances emerge where the relationship with CIP strengthened. Overall the influence of CIP was more substantial for Gold, particularity evident in 2000, late-2001, 2003, 2005, 2008 and 2013. The t-statistic for Mining increases in 2008 and significantly in 2010. Gold's t-statistics for US interest rates during 2008 to 2011 coincided with the rolling correlations for the same period. No prominent links could be drawn from the remaining variables for Gold. The regression for Mining indicates positive relationships with CIP, yet the coefficients show substantial negative movement.

Figure 4.8.8: Monthly indicators for Gold



*The sample period for the graph on the bottom right has again been adjusted to provide a more comparable illustration

Summary

A few noteworthy aspects can be gleaned from the empirical analyses for the weekly/monthly common global factors. Weekly correlation analysis and linear regions show that a static relationship (negative) exists between Iron & Steel and the Dollar/Euro exchange rate. The dynamic measures also demonstrate a noteworthy relationship for the exchange rate but it shows the prominence of this relationship varies over time. For example, oil prices become prominent during 2001, and gold prices are noteworthy during 2002, 2003, 2004, 2005 and 2006. VIX briefly becomes the important factor during 2009. Oil prices are noteworthy during 2009 to 2011. The static measures for Mining suggest a positive relationship with the gold price and a negative relationship with exchange rates. In general the dynamic measures support this, with gold prices dominating from 2001 to 2007; however, oil prices and the exchange rate appear to be noteworthy during 2008 to 2011. Finally the static and dynamic measures show that a substantial relationship existed between gold prices and Gold. Yet the exchange rate displayed prominence during 2003, 2008 and 2012 and oil prices during 2005 and 2011.

A similar phenomenon is observed for the monthly variables. The static measures show that US interest rates and CIP both share a positive relationship with Iron & Steel. The dynamic analysis supports this but is able to show that this relationship varies across time, and moreover EA (19) rates become more prominent during 2002, 2004, 2006, 2010 and 2011. The static analysis conducted for Mining also suggests that a relationship exists with US interest rates and CIP. Although the dynamic measures largely support this, EA (19) rates exhibit noteworthy behaviour during 2002, 2004, 2007, 2010, 2011 and 2012. Finally the static analysis for Gold shows that a negative relationship exists with US rates and a positive relationship with CIP. Note that CIP is less substantial for Iron & Steel[47] and more noteworthy in describing the variation in Gold returns. Collectively the results show that the influence of macro-economic factors vary across time, with the respective state of prominence changing relative to prevailing global economic conditions.

[47] This is rather thought-provoking since China accounts for nearly 70% of global Iron ore demand (PricewaterhouseCoopers, 2016:9).

CHAPTER 5: SUMMARY AND CONCLUSION

5.1 Summary of findings

The main purpose of this study was to analyse the co-movement between South African and global mining indices by determining to what extent the country's financial markets are integrated with global markets, and to identify the factors that drive this co-movement. Three samples were chosen that represent the global sectors for Iron & Steel, Mining and Gold from which the suitable number of latent common factors was extracted for each sector. These common factors serve as global drivers for the world's financial markets. This study contributes by identifying the level of integration for global mining indices and describing South African co-movement to a blend of both idiosyncratic and global factors. The latter is achieved by linking common global factors to macro-economic variables. Evidence also supports the effect of industry factors which clearly envisage the varying impact of idiosyncratic/global factors on each of the three sectors.

The variance share for South Africa shows that the Iron & Steel index is less integrated with global indices; however, the country's Mining and Gold indices indicate a higher degree of global integration. Although the South African markets appear to be more integrated globally, it does not necessarily imply that they are more integrated with developed markets. Literature shows that South African stocks and bonds are more integrated with emerging markets, whereas developed markets explain a larger share of South Africa's currency market. The study also documents the impact of a sub-index onto the index it comprises. Results suggest that Gold (a sub-sector for Mining) at times appears to be a dominant factor for the Mining index, particularly visible during the global financial crisis.

Subsequently, the dynamic nature of co-movement is clearly captured for each South African index. Moreover, results exhibit an increasing trend for global integration over time. It is also apparent that at times idiosyncratic factors become more prominent in explaining the variation for South African indices. This study also documents the extent of the influence that certain idiosyncratic events has on the various South African indices. For example, recall the degree to which idiosyncratic events drive South African mining companies. The empirical analysis observes low R^2's for Iron & Steel, Mining and Gold during late 2012. The events that took place at Marikana during this time clearly had a definitive impact on the country's mining industry. More specifically mining companies were disrupted due to the chaos inflicted by mineworkers. Important to note is that the impact of this event differs for each South African index. Gold indices are more severely implicated compared to Iron & Steel indices. The reason for this may be due to the nature of the strikes, resulting in non-ferrous industries being affected more profoundly by the Marikana events, thus accentuating dynamics of industry factors.

Finally the analysis for the common global factor clearly shows the influence of macro-economic variables. Results show that the weekly variables for Iron & Steel indicate that the US Dollar/Euro exchange rate explains the largest share of the variation for this sector. Gold prices appear to be the dominant factor for the Mining and Gold sector. The results for the monthly variables suggest that United States interest rates are important in describing variation in returns for the Iron & Steel sector. Chinese Industrial Production emerges as a prominent driver for all three sectors. It is important to note that although certain macro-economic variables are more substantial in explaining the variation in returns for specific sectors these relationships are sporadic and change in relation to the prevailing economic conditions present at the time. This in turn can be linked to significant global economic events and the impact it exerts on different macro-economic variables at diffident stages in time. For example, compared to Iron & Steel, the South African Gold and Mining indices became more integrated with global markets during the global financial crisis. South African indices experienced unusually high R^{2}'s during the global financial crisis. This is reaffirmed by the increase in VIX during 2008 to 2009 for all three sectors. Thus the varying nature of co-movement as presented in literature is also observed for the weekly and monthly real economic variables included in this analysis. The implications identified for this study's findings probably best relate to the dualistic nature of South Africa's markets. It is noted that the country holds fundamentals of both sophisticated developed markets and emerging markets, as such confirming that South African financial markets will react differently to local policies and to global shocks.

5.2 Policy implications

The empirical finings of this study may hold noteworthy policy implications for the South African mining industry. Considering the results, it is suggested that the South African Government do more to provide stability in the country's mining industry. More specifically consideration should be given towards legislation and the adverse effects it may have on mining companies, as literature documents the controversy surrounding this topic (Otto *et al*., 2006). In addition, evidence suggests that Government should act on providing a more stable labour environment. Costs related to working days lost due to strikes and labour costs associated with assisting a largely HIV infected workforce adversely affect company revenue. Social unrest in the past has led to violence and drastic requests of expropriation, prompting serious investor concern. For example, recall the disinvestment of Anglo-American and BHP Billiton during the late 1990s, the implications of which may have led to South African mining shares not benefiting (in relation to other global mining shares) from the global commodity boom in the early 2000s.

Uncertainty surrounding the country's energy supply has cost the economy billions of Rands over the last couple of years. The empirical section shows that idiosyncratic events do affect local factors for South African mining companies. Monetary authorities should continue pursuing a stable local currency. The International Monetary Fund (2013:4) reports that domestic vulnerabilities render South Africa's economy more exposed to the effects of external shocks. However, the country has progressed in shielding the country's stock market against global financial crises. Evidence of this is Government's proposition of the Single Financial market bill, aimed at increasing stability in banks/insures and under-regulated products that include derivatives and hedge funds (Heymans & da Camara, 2013:432).

South Africa offers a unique case given its advanced financial institutions combined with its large unskilled workforce and the country's fiscal shortcomings (World Economic Forum, 2015:326). Literature argues that South Africa has failed to benefit from the global economic boom during the early 2000s, and future global commodity outlooks remain bleak. Testament to this is weaker global demand. China has been the leading consumer of commodities and represents nearly 40% of global demand. However, a weaker Chinese growth has precipitated lower demand and this is likely to persist. This holds serious implications for mining companies which have been declining in market capitalisation since 2011 (PricewaterhouseCoopers, 2016:7).

South Africa boasts an impressive arsenal of natural mineral resources and produces around 25% of all raw materials used in production in global jewellery; however, this represents less than 1% of the global manufactured jewellery market[48] (Parsons, 2013:73). Considering the foregoing discussion, it becomes imperative for the South African Government to address these issues in order to keep the country's mining companies competitive and to prevent any future disinvestment. Recall the substantial disinvestment the country suffered in the form of Anglo-American and BHP Billiton during the late 1990s. More relevant to this study, a stable local mining industry would most likely cause fewer shocks to the country's mining stocks. It is important to stress that this study did not set out to examine the recommendations that have been mentioned here. These suggestions are purely based on observations obtained from previous literature and the empirical results that clearly show that South African mining indices are affected by idiosyncratic factors, in some instances more than other countries.

5.3 Conclusion and suggestions for future research

Co-movement in South African mining indices is not an either/or condition. Instead the degree of co-movement changes over time. Moreover, different factors drive South African stock

48 This relates to precious metal companies in South Africa.

markets during different periods. For example, at times global factors (compared to idiosyncratic factors) are able to better explain the variation in returns for South African mining stocks and vice versa. However, it is important to note that no set of factors is superior. Consequently different factors become more prominent in describing the degree of co-movement observed for different sectors which, in turn, is subject to the prevailing economic conditions at the time - whether these be global or idiosyncratic. Finally the effect of this varies across industries, suggesting that some factors may have a more profound impact on a specific sector. South Africa encapsulates these observations rather seamlessly, considering the country's unique composition of advanced financial institutions and fiscal shortcomings.

It is important to be mindful of the findings presented for South African mining indices in order to attempt future research, as such areas for future research may include investigating alternative mining sectors. Considering the prominent position that South Africa occupies in global mining, interesting findings may be gleaned from examining other mining sectors, for example; Diamonds and Gemstones Aluminium, Coal and Platinum and Precious Metals. Questions also remain unanswered surrounding the topic of which real economic variables are most suited for explaining the variation for certain mining sectors. Another topic worth investigating involves using different frequencies for real economic variables. This study uses weekly and monthly macro-economic variables. As such interesting findings may be found from examining economic variables that are quoted in a quarterly frequency.

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APPENDICES

Appendix A

The table below ranks the returns for South Africa's correlation coefficient from highest to lowest for the Iron & Steel, Mining and Gold sectors.

A 1: South African correlation coefficients

	Iron & Steel		***Mining***		***Gold***	
Rank	***Country***	*r*	***Country***	*r*	***Country***	*r*
1	*United States*	0.40192260	*United Kingdom*	0.74503755	*Canada*	0.75876743
2	*Finland*	0.39758814	*Canada*	0.71881699	*United States*	0.72952440
3	*Sweden*	0.39337309	*Australia*	0.70997951	*Australia*	0.70946589
4	*Canada*	0.39313948	*United States*	0.65945616	*Peru*	0.59978104
5	*Germany*	0.38590811	*Peru*	0.61024597	*United Kingdom*	0.50954385
6	*Brazil*	0.38336377	*Sweden*	0.54879326	*France*	0.28430583
7	*Spain*	0.38009225	*France*	0.51941138	*Ireland*	0.07490138
8	*Australia*	0.37492837	*Hong Kong*	0.46745442		
9	*Taiwan*	0.36977131	*Thailand*	0.41739589		
10	*Netherlands*	0.36791375	*Japan*	0.36464065		
11	*Austria*	0.36613927	*Philippine*	0.33796901		
12	*Mexico*	0.35935835	*India*	0.33283722		
13	*Italy*	0.34189132	*Ireland*	0.30904257		
14	*France*	0.31192443	*China*	0.25756597		
15	*Turkey*	0.29345606	*Germany*	0.17569135		
16	*Japan*	0.27840483	*Morocco*	0.12950705		
17	*India*	0.26292806	*Mexico*	0.04158437		
18	*Hong Kong*	0.25364472				
19	*Switzerland*	0.23587720				
20	*Greece*	0.22498753				
21	*Argentina*	0.21725045				
22	*Egypt*	0.15413343				
23	*China*	0.14450597				
24	*Peru*	0.12414615				
25	*Romania*	0.10024815				
26	*Morocco*	0.08706522				
27	*Venezuela*	-0.04057510				

Appendix B

B 1.1: Factor analysis outputs for Iron & Steel

Kaiser-Guttman Test

Factor Method: Maximum Likelihood
Date: 10/06/16 Time: 11:34
Covariance Analysis: Ordinary Correlation
Sample: 12/09/1996 8/19/2013
Included observations: 872
Number of factors: Kaiser-Guttman
Prior communalities: Squared multiple correlation
Convergence achieved after 31 iterations

	Unrotated Loadings						
	F1	F2	F3	F4	F5	Communality	Uniqueness
ARGENTINA__STE...	0.395241	0.304337	-0.000843	-0.312901	-0.024754	0.347357	0.652643
AUSTRALIA__STEE...	0.676359	0.119844	-0.024915	0.149050	0.008279	0.494729	0.505271
AUSTRIA__STEEL...	0.790080	-0.086441	0.202005	-0.071129	0.070430	0.682524	0.317476
BRAZIL__STEELBR...	0.688094	0.194856	-0.081331	-0.018499	-0.039663	0.519973	0.480027
CANADA__STEELC...	0.778910	-0.029021	-0.281695	0.014687	0.135663	0.705516	0.294484
CHINA_A__STEEL...	0.212246	0.189956	-0.019026	0.324954	0.015258	0.187322	0.812678
EGYPT__STEELEY...	0.224365	0.209851	0.122436	-0.078777	-0.084033	0.122635	0.877365
FINLAND__STEELF...	0.777575	-0.118717	0.221796	0.028228	-0.047952	0.671006	0.328994
FRANCE__STEELF...	0.619162	-0.113553	0.134263	-0.027817	-0.215998	0.461711	0.538289
GERMANY__STEEL...	0.771732	-0.082676	0.176266	0.040478	0.143658	0.655751	0.344249
GREECE__STEEL...	0.458192	0.041459	0.128064	0.036231	0.156783	0.253953	0.746048
HONG_KONG__ST...	0.411650	0.264693	-1.61E-05	0.117750	-0.069682	0.258238	0.741762
INDIA_STEELIN_	0.547679	0.129002	0.029718	0.177514	0.051725	0.351664	0.648336
ITALY_STEELIT_	0.650048	0.101910	0.053991	0.009674	0.049008	0.438359	0.561641
JAPAN_STEELJP_	0.510839	0.099170	0.031238	0.123318	-0.160306	0.312672	0.687328
MEXICO_STEELMX...	0.633946	0.191595	-0.144184	-0.252616	0.017764	0.523516	0.476484
MOROCO__STEEL...	0.156489	0.012545	0.151723	0.066133	0.054695	0.055031	0.944969
NETHERLANDS_S...	0.682202	0.001152	-0.078534	-0.081376	0.085197	0.485449	0.514551
PERU__STEELPE_	0.297036	0.150455	0.093444	0.020303	0.043387	0.121893	0.878107
ROMANIA_STEELR...	0.208829	0.125138	0.089008	0.060517	0.282867	0.150867	0.849135
SOUTH_AFRICA__...	0.512250	0.149639	-0.021442	0.049930	-0.090234	0.295887	0.704113
SPAIN__STEELES_	0.764928	-0.077703	0.153982	-0.119541	-0.156420	0.653621	0.346379
SWEDEN__STEEL...	0.816196	-0.111205	0.145924	0.022338	-0.021701	0.700806	0.299194
SWITZERLAND__S...	0.536685	-0.003986	0.215480	0.018448	0.113316	0.347660	0.652340
TAIWAN__STEELTA...	0.505176	0.365697	0.013210	0.149384	-0.133590	0.429273	0.570727
TURKEY__STEELT...	0.486571	0.113704	-0.035997	-0.130915	0.078010	0.274200	0.725800
US__STEELUS_	0.818458	-0.153736	-0.347023	0.034738	-0.055137	0.818180	0.181820
VENEZUELA__STE...	0.065690	0.132915	-0.066263	-0.196623	0.089127	0.072977	0.927023

Factor	Variance	Cumulative	Difference	Proportion	Cumulative
F1	9.351367	9.351367	8.671574	0.820816	0.820816
F2	0.679793	10.03116	0.132770	0.059669	0.880485
F3	0.547023	10.57818	0.068454	0.048015	0.928500
F4	0.478569	11.05675	0.142553	0.042006	0.970506
F5	0.336016	11.39277	---	0.029494	1.000000
Total	11.39277	11.39277		1.000000	

	Model	Independenc...	Saturated
Discrepancy	0.453996	11.18988	0.000000
Chi-square statistic	395.4304	9746.381	---
Chi-square prob.	0.0000	0.0000	---
Bartlett chi-square	389.3015	9632.618	---
Bartlett probability	0.0000	0.0000	---
Parameters	158	28	406
Degrees-of-freedo...	248	378	---

Standard-Error Scree Test

Factor Method: Maximum Likelihood
Date: 10/06/16 Time: 11:35
Covariance Analysis: Ordinary Correlation
Sample: 12/09/1996 8/19/2013
Included observations: 872
Number of factors: Standard-error scree
Prior communalities: Squared multiple correlation
Convergence achieved after 31 iterations

	Unrotated Loadings						
	F1	F2	F3	F4	F5	Communality	Uniqueness
ARGENTINA__STE...	0.395241	0.304337	-0.000843	-0.312901	-0.024754	0.347357	0.652643
AUSTRALIA__STEE...	0.676359	0.119844	-0.024915	0.149050	0.008279	0.494729	0.505271
AUSTRIA__STEEL...	0.790080	-0.086441	0.202005	-0.071129	0.070430	0.682524	0.317476
BRAZIL__STEELBR...	0.688094	0.194856	-0.081331	-0.018499	-0.039663	0.519973	0.480027
CANADA__STEELC...	0.778910	-0.029021	-0.281695	0.014687	0.135663	0.705516	0.294484
CHINA_A__STEEL...	0.212246	0.189956	-0.019026	0.324954	0.015258	0.187322	0.812678
EGYPT__STEELEY...	0.224365	0.209851	0.122436	-0.078777	-0.084033	0.122635	0.877365
FINLAND__STEELF...	0.777575	-0.118717	0.221796	0.028228	-0.047952	0.671006	0.328994
FRANCE__STEELF...	0.619162	-0.113553	0.134263	-0.027817	-0.215998	0.461711	0.538289
GERMANY__STEEL...	0.771732	-0.082676	0.176266	0.040478	0.143658	0.655751	0.344249
GREECE__STEEL...	0.458192	0.041459	0.128064	0.036231	0.156783	0.253953	0.746048
HONG_KONG__ST...	0.411650	0.264693	-1.61E-05	0.117750	-0.069682	0.258238	0.741762
INDIA_STEELIN_	0.547679	0.129002	0.029718	0.177514	0.051725	0.351664	0.648336
ITALY_STEELIT_	0.650048	0.101910	0.053991	0.009674	0.049008	0.438359	0.561641
JAPAN_STEELJP_	0.510839	0.099170	0.031238	0.123318	-0.160306	0.312672	0.687328
MEXICO_STEELMX...	0.633946	0.191595	-0.144184	-0.252616	0.017764	0.523516	0.476484
MOROCO__STEEL...	0.156489	0.012545	0.151723	0.066133	0.054695	0.055031	0.944969
NETHERLANDS_S...	0.682202	0.001152	-0.078534	-0.081376	0.085197	0.485449	0.514551
PERU__STEELPE_	0.297036	0.150455	0.093444	0.020303	0.043387	0.121893	0.878107
ROMANIA_STEELR...	0.208829	0.125138	0.089008	0.060517	0.282867	0.150867	0.849135
SOUTH_AFRICA__...	0.512250	0.149639	-0.021442	0.049930	-0.090234	0.295887	0.704113
SPAIN__STEELES_	0.764928	-0.077703	0.153982	-0.119541	-0.156420	0.653621	0.346379
SWEDEN__STEEL...	0.816196	-0.111205	0.145924	0.022338	-0.021701	0.700806	0.299194
SWITZERLAND__S...	0.536685	-0.003986	0.215480	0.018448	0.113316	0.347660	0.652340
TAIWAN__STEELTA...	0.505176	0.365697	0.013210	0.149384	-0.133590	0.429273	0.570727
TURKEY__STEELT...	0.486571	0.113704	-0.035997	-0.130915	0.078010	0.274200	0.725800
US__STEELUS_	0.818458	-0.153736	-0.347023	0.034738	-0.055137	0.818180	0.181820
VENEZUELA__STE...	0.065690	0.132915	-0.066263	-0.196623	0.089127	0.072977	0.927023

Factor	Variance	Cumulative	Difference	Proportion	Cumulative
F1	9.351367	9.351367	8.671574	0.820816	0.820816
F2	0.679793	10.03116	0.132770	0.059669	0.880485
F3	0.547023	10.57818	0.068454	0.048015	0.928500
F4	0.478569	11.05675	0.142553	0.042006	0.970506
F5	0.336016	11.39277	---	0.029494	1.000000
Total	11.39277	11.39277		1.000000	

	Model	Independenc...	Saturated
Discrepancy	0.453996	11.18988	0.000000
Chi-square statistic	395.4304	9746.381	---
Chi-square prob.	0.0000	0.0000	---
Bartlett chi-square	389.3015	9632.618	---
Bartlett probability	0.0000	0.0000	---
Parameters	158	28	406
Degrees-of-freedo...	248	378	---

Parallel Analysis Test

Factor Method: Maximum Likelihood
Date: 10/06/16 Time: 11:35
Covariance Analysis: Ordinary Correlation
Sample: 12/09/1996 8/19/2013
Included observations: 872
Number of factors: Parallel analysis (nreps=100, rng=kn, seed=105612840)
Prior communalities: Squared multiple correlation
Convergence achieved after 3 iterations

	Loadings F1	Communality	Uniqueness
ARGENTINA__STE...	0.396930	0.157554	0.842446
AUSTRALIA__STEE...	0.677063	0.458414	0.541586
AUSTRIA__STEEL...	0.794344	0.630983	0.369017
BRAZIL__STEELBR...	0.686782	0.471670	0.528330
CANADA__STEELC...	0.756392	0.572129	0.427871
CHINA_A__STEEL...	0.213200	0.045454	0.954546
EGYPT__STEELEY...	0.234048	0.054779	0.945221
FINLAND__STEELF...	0.782521	0.612340	0.387660
FRANCE__STEELF...	0.620237	0.384693	0.615307
GERMANY__STEEL...	0.775653	0.601637	0.398363
GREECE__STEEL...	0.463903	0.215206	0.784794
HONG_KONG__ST...	0.413863	0.171282	0.828718
INDIA_STEELIN_	0.551825	0.304511	0.695489
ITALY_STEELIT_	0.655006	0.429033	0.570967
JAPAN_STEELJP_	0.512175	0.262323	0.737677
MEXICO_STEELMX...	0.624717	0.390271	0.609729
MOROCO__STEEL...	0.163014	0.026573	0.973427
NETHERLANDS_S...	0.679734	0.462038	0.537962
PERU__STEELPE_	0.303625	0.092188	0.907812
ROMANIA_STEELR...	0.215840	0.046587	0.953413
SOUTH_AFRICA__...	0.514173	0.264374	0.735626
SPAIN__STEELES_	0.765188	0.585513	0.414487
SWEDEN__STEEL...	0.819218	0.671118	0.328882
SWITZERLAND__S...	0.547349	0.299591	0.700409
TAIWAN__STEELTA...	0.506911	0.256959	0.743041
TURKEY__STEELT...	0.488623	0.238753	0.761247
US__STEELUS_	0.780506	0.609189	0.390811
VENEZUELA__STE...	0.065991	0.004355	0.995645

Factor	Variance	Cumulative	Difference	Proportion	Cumulative
F1	9.319517	9.319517	---	1.000000	1.000000
Total	9.319517	9.319517		1.000000	

	Model	Independenc...	Saturated
Discrepancy	1.344801	11.18988	0.000000
Chi-square statistic	1171.322	9746.381	---
Chi-square prob.	0.0000	0.0000	---
Bartlett chi-square	1156.753	9632.618	---
Bartlett probability	0.0000	0.0000	---
Parameters	56	28	406
Degrees-of-freedo...	350	378	---

Fraction of Total Variance Test

Factor Method: Maximum Likelihood
Date: 10/06/16 Time: 11:35
Covariance Analysis: Ordinary Correlation
Sample: 12/09/1996 8/19/2013
Included observations: 872
Number of factors: Fraction of total variance = .5
Prior communalities: Squared multiple correlation
Convergence achieved after 31 iterations

	Unrotated Loadings						
	F1	F2	F3	F4	F5	Communality	Uniqueness
ARGENTINA__STE...	0.395241	0.304337	-0.000843	-0.312901	-0.024754	0.347357	0.652643
AUSTRALIA__STEE...	0.676359	0.119844	-0.024915	0.149050	0.008279	0.494729	0.505271
AUSTRIA__STEEL...	0.790080	-0.086441	0.202005	-0.071129	0.070430	0.682524	0.317476
BRAZIL__STEELBR...	0.688094	0.194856	-0.081331	-0.018499	-0.039663	0.519973	0.480027
CANADA__STEELC...	0.778910	-0.029021	-0.281695	0.014687	0.135663	0.705516	0.294484
CHINA_A__STEEL...	0.212246	0.189956	-0.019026	0.324954	0.015258	0.187322	0.812678
EGYPT__STEELEY...	0.224365	0.209851	0.122436	-0.078777	-0.084033	0.122635	0.877365
FINLAND__STEELF...	0.777575	-0.118717	0.221796	0.028228	-0.047952	0.671006	0.328994
FRANCE__STEELF...	0.619162	-0.113553	0.134263	-0.027817	-0.215998	0.461711	0.538289
GERMANY__STEEL...	0.771732	-0.082676	0.176266	0.040478	0.143658	0.655751	0.344249
GREECE__STEEL...	0.458192	0.041459	0.128064	0.036231	0.156783	0.253953	0.746048
HONG_KONG__ST...	0.411650	0.264693	-1.61E-05	0.117750	-0.069682	0.258238	0.741762
INDIA_STEELIN_	0.547679	0.129002	0.029718	0.177514	0.051725	0.351664	0.648336
ITALY_STEELIT_	0.650048	0.101910	0.053991	0.009674	0.049008	0.438359	0.561641
JAPAN_STEELJP_	0.510839	0.099170	0.031238	0.123318	-0.160306	0.312672	0.687328
MEXICO_STEELMX...	0.633946	0.191595	-0.144184	-0.252616	0.017764	0.523516	0.476484
MOROCO__STEEL...	0.156489	0.012545	0.151723	0.066133	0.054695	0.055031	0.944969
NETHERLANDS_S...	0.682202	0.001152	-0.078534	-0.081376	0.085197	0.485449	0.514551
PERU__STEELPE_	0.297036	0.150455	0.093444	0.020303	0.043387	0.121893	0.878107
ROMANIA_STEELR...	0.208829	0.125138	0.089008	0.060517	0.282867	0.150867	0.849135
SOUTH_AFRICA__...	0.512250	0.149639	-0.021442	0.049930	-0.090234	0.295887	0.704113
SPAIN__STEELES_	0.764928	-0.077703	0.153982	-0.119541	-0.156420	0.653621	0.346379
SWEDEN__STEEL...	0.816196	-0.111205	0.145924	0.022338	-0.021701	0.700806	0.299194
SWITZERLAND__S...	0.536685	-0.003986	0.215480	0.018448	0.113316	0.347660	0.652340
TAIWAN__STEELTA...	0.505176	0.365697	0.013210	0.149384	-0.133590	0.429273	0.570727
TURKEY__STEELT...	0.486571	0.113704	-0.035997	-0.130915	0.078010	0.274200	0.725800
US__STEELUS_	0.818458	-0.153736	-0.347023	0.034738	-0.055137	0.818180	0.181820
VENEZUELA__STE...	0.065690	0.132915	-0.066263	-0.196623	0.089127	0.072977	0.927023

Factor	Variance	Cumulative	Difference	Proportion	Cumulative
F1	9.351367	9.351367	8.671574	0.820816	0.820816
F2	0.679793	10.03116	0.132770	0.059669	0.880485
F3	0.547023	10.57818	0.068454	0.048015	0.928500
F4	0.478569	11.05675	0.142553	0.042006	0.970506
F5	0.336016	11.39277	---	0.029494	1.000000
Total	11.39277	11.39277		1.000000	

	Model	Independenc...	Saturated
Discrepancy	0.453996	11.18988	0.000000
Chi-square statistic	395.4304	9746.381	---
Chi-square prob.	0.0000	0.0000	---
Bartlett chi-square	389.3015	9632.618	---
Bartlett probability	0.0000	0.0000	---
Parameters	158	28	406
Degrees-of-freedo...	248	378	---

Broken Stick Test

Factor Method: Maximum Likelihood
Date: 10/06/16 Time: 11:35
Covariance Analysis: Ordinary Correlation
Sample: 12/09/1996 8/19/2013
Included observations: 872
Number of factors: Broken stick
Prior communalities: Squared multiple correlation
Convergence achieved after 58 iterations

								Unrotated Loadings						
	F1	F2	F3	F4		F14	Communality	Uniqueness	F8	F9	F10	F11	F12	F13
ARGENTINA__STE...	0.346547	0.080126	0.163775	0.109120	0	0.077658	0.347523	0.652484	.034872	-0.113210	0.003065	0.120942	-0.121923	0.054552
AUSTRALIA__STEE...	0.431690	0.337499	0.305128	0.202065	0	0.059211	0.502019	0.497982	.019370	0.170437	0.077946	-0.030580	-0.022555	0.021414
AUSTRIA STEEL...	0.496755	0.389223	0.371079	0.183508	0	-0.018720	0.686912	0.313093	.152740	-0.044322	-0.089739	-0.008457	0.092500	-0.095904
BRAZIL__STEELBR...	0.925456	0.044796	-7.30E-17	0.351848	-0	4.27E-18	1.000000	0.000000	.30E-17	-1.11E-16	-1.51E-16	-4.87E-17	8.18E-17	6.27E-17
CANADA STEELC...	0.516572	0.288542	0.420172	0.212247	0	0.004261	0.724765	0.275235	.295770	0.109926	-0.039905	0.050147	0.011617	-0.054944
CHINA_A__STEEL...	0.044489	0.651691	3.66E-16	0.085808	-0	-4.03E-17	1.000000	0.000000	.11E-17	-1.38E-16	-2.33E-17	7.08E-17	2.98E-17	1.10E-16
EGYPT STEELEY...	0.160635	0.020124	0.117089	0.128374	0	-0.009688	0.161290	0.838713	.130879	0.111046	0.055999	0.085067	0.063684	-0.014663
FINLAND__STEELF...	0.481815	0.375149	0.355438	0.254791	0	0.023452	0.755810	0.244192	.258797	0.003455	-0.200332	-0.073210	-0.113655	-0.056689
FRANCE__STEELF...	0.415972	0.216562	0.328518	0.217256	0	0.048893	0.623061	0.376941	.247654	-0.169604	0.321627	0.001244	0.086499	0.000340
GERMANY__STEEL...	0.476358	0.713130	2.03E-16	0.212210	0	-1.71E-18	1.000000	0.000000	.72E-16	0.000000	-3.91E-17	1.15E-16	6.27E-18	2.97E-17
GREECE__STEEL...	0.329242	0.271896	0.194385	-0.068493	0	-0.036564	0.298306	0.701701	.064870	-0.038754	0.052459	-0.089425	0.109942	0.002765
HONG KONG ST...	0.264907	0.233000	0.177184	0.125798	-0	-0.032637	0.285861	0.714141	.002997	0.111591	0.116613	-0.077524	-0.121553	0.120035
INDIA_STEELIN_	0.409024	0.238009	0.256520	0.122576	0	0.029521	0.497859	0.502141	.051118	0.271952	-0.006855	-0.246938	0.174950	0.122936
ITALY STEELIT	0.452353	0.299041	0.269980	0.157972	0	-0.115727	0.527736	0.472265	.027502	0.119180	-0.004953	0.215968	-0.088066	0.116011
JAPAN_STEELJP_	0.337633	0.199094	0.265768	0.181772	0	0.052909	0.412474	0.587526	.089024	0.156870	0.175378	-0.083028	-0.137146	-0.227746
MEXICO STEELMX...	0.462512	0.171570	0.327058	0.221523	0	-0.082761	0.672910	0.327102	.228065	-0.195947	-0.027678	-0.116604	0.040231	-0.079945
MOROCO__STEEL...	0.086536	0.148437	0.012161	0.056856	0	-0.080934	0.073820	0.926190	.111209	0.039271	-0.022548	0.047338	0.088210	-0.085416
NETHERLANDS_S...	0.451633	0.267431	0.335979	0.214728	0	0.208322	0.550640	0.449356	.095976	0.030694	-0.128476	0.085973	0.071372	-0.008146
PERU__STEELPE_	0.227619	0.130325	0.121283	0.055776	0	-0.067632	0.190079	0.809922	.074949	0.157100	0.091926	0.146340	0.044784	-0.104888
ROMANIA_STEELR...	0.442713	0.167360	3.15E-17	-0.763915	0	6.74E-18	1.000000	0.000000	.25E-17	-2.04E-17	-1.30E-17	1.83E-17	2.96E-17	1.44E-17
SOUTH AFRICA ...	0.248904	0.111398	2.77E-17	0.503997	0	7.40E-18	1.000000	0.000000	.67E-17	3.38E-17	5.83E-17	-2.61E-17	-3.91E-17	4.20E-17
SPAIN__STEELES_	0.429567	0.327450	0.461450	0.211823	0	0.063668	0.677430	0.322570	.176902	-0.134115	0.035738	0.043726	-0.078334	0.049621
SWEDEN STEEL...	0.497779	0.383900	0.431263	0.211387	0	-0.102845	0.737557	0.262444	.162114	-0.021740	-0.061213	0.006374	0.031109	0.118320
SWITZERLAND__S...	0.335986	0.301498	0.213702	0.133435	0	-0.041693	0.440300	0.559706	.171439	0.155360	0.004491	0.208575	0.157488	-0.108198
TAIWAN STEELTA...	0.348737	0.208723	0.181781	0.212557	0	-0.005049	0.416485	0.583515	.024715	0.204781	0.127836	-0.102968	-0.132721	0.037129
TURKEY__STEELT...	0.358606	0.191582	0.172723	0.167722	0	0.082821	0.317556	0.682447	.077571	-0.066150	-0.100034	-0.000502	0.093064	0.152553
US__STEELUS_	0.503713	0.308578	0.485637	0.282382	0	-0.029916	0.807881	0.192120	.275789	-0.035214	0.058428	0.001361	-0.026309	0.008527
VENEZUELA STE...	0.105536	-0.046011	0.069266	-0.048300	0	0.227483	0.131214	0.868785	.097409	0.002145	0.019661	0.069925	0.057350	0.067306

Factor	Variance	Cumulative	Difference	Proportion	Cu
F1	4.796326	4.796326	2.300515	0.302808	0
F2	2.495811	7.292137	0.552350	0.157569	0
F3	1.943461	9.235598	0.211826	0.122697	0
F4	1.731635	10.96723	0.450542	0.109324	0
F5	1.281093	12.24833	0.264040	0.080880	0
F6	1.017054	13.26538	0.467020	0.064210	0
F7	0.550034	13.81541	0.018331	0.034725	0
F8	0.531702	14.34712	0.152244	0.033568	0
F9	0.379459	14.72657	0.108411	0.023956	0
F10	0.271047	14.99762	0.006186	0.017112	0
F11	0.264862	15.26248	0.053645	0.016722	0
F12	0.211217	15.47370	0.015104	0.013335	0
F13	0.196113	15.66981	0.026439	0.012381	0
F14	0.169674	15.83949	---	0.010712	1
Total	15.83949	15.83949		1.000000	

	Model	Independenc...	Saturated
Discrepancy	0.070531	11.18988	0.000000
Chi-square statistic	61.43286	9746.381	---
Chi-square prob.	0.9025	0.0000	---
Bartlett chi-square	60.05750	9632.618	---
Bartlett probability	0.9230	0.0000	---
Parameters	329	28	406
Degrees-of-freedo...	77	378	---

Warning: Heywood solution (uniqueness estimates are non-positive).
Results should be interpreted with caution.

Minimum Average Partial Test

Factor Method: Maximum Likelihood
Date: 10/06/16 Time: 11:36
Covariance Analysis: Ordinary Correlation
Sample: 12/09/1996 8/19/2013
Included observations: 872
Number of factors: Minimum average partial
Prior communalities: Squared multiple correlation
Convergence achieved after 3 iterations

	Loadings		
	F1	Communality	Uniqueness
ARGENTINA__STE...	0.396930	0.157554	0.842446
AUSTRALIA__STEE...	0.677063	0.458414	0.541586
AUSTRIA STEEL...	0.794344	0.630983	0.369017
BRAZIL STEELBR...	0.686782	0.471670	0.528330
CANADA__STEELC...	0.756392	0.572129	0.427871
CHINA_A__STEEL...	0.213200	0.045454	0.954546
EGYPT STEELEY...	0.234048	0.054779	0.945221
FINLAND STEELF...	0.782521	0.612340	0.387660
FRANCE STEELF...	0.620237	0.384693	0.615307
GERMANY__STEEL...	0.775653	0.601637	0.398363
GREECE__STEEL...	0.463903	0.215206	0.784794
HONG KONG ST...	0.413863	0.171282	0.828718
INDIA STEELIN	0.551825	0.304511	0.695489
ITALY_STEELIT_	0.655006	0.429033	0.570967
JAPAN_STEELJP_	0.512175	0.262323	0.737677
MEXICO_STEELMX...	0.624717	0.390271	0.609729
MOROCO STEEL...	0.163014	0.026573	0.973427
NETHERLANDS S...	0.679734	0.462038	0.537962
PERU__STEELPE_	0.303625	0.092188	0.907812
ROMANIA_STEELR...	0.215840	0.046587	0.953413
SOUTH_AFRICA__...	0.514173	0.264374	0.735626
SPAIN STEELES	0.765188	0.585513	0.414487
SWEDEN STEEL...	0.819218	0.671118	0.328882
SWITZERLAND__S...	0.547349	0.299591	0.700409
TAIWAN__STEELTA...	0.506911	0.256959	0.743041
TURKEY STEELT...	0.488623	0.238753	0.761247
US STEELUS	0.780506	0.609189	0.390811
VENEZUELA STE...	0.065991	0.004355	0.995645

Factor	Variance	Cumulative	Difference	Proportion	Cumulative
F1	9.319517	9.319517	---	1.000000	1.000000
Total	9.319517	9.319517		1.000000	

	Model	Independenc...	Saturated
Discrepancy	1.344801	11.18988	0.000000
Chi-square statistic	1171.322	9746.381	---
Chi-square prob.	0.0000	0.0000	---
Bartlett chi-square	1156.753	9632.618	---
Bartlett probability	0.0000	0.0000	---
Parameters	56	28	406
Degrees-of-freedo...	350	378	---

B 1.2: Factor analysis outputs for mining

Kaiser-Guttman Test

Factor Method: Maximum Likelihood
Date: 10/06/16 Time: 11:37
Covariance Analysis: Ordinary Correlation
Sample: 10/18/1999 8/19/2013
Included observations: 723
Number of factors: Kaiser-Guttman
Prior communalities: Squared multiple correlation
Convergence achieved after 7 iterations

	Unrotated Loadings					
	F1	F2	F3	F4	Communality	Uniqueness
AUSTRALIA__MNIN...	0.885432	0.167875	0.155162	0.095089	0.845288	0.154712
CANADA__MNINGC...	0.610062	0.742978	-0.106364	-0.042141	0.937281	0.062719
CHINA__MNINGCH...	0.561815	0.212427	0.656171	-0.172404	0.821045	0.178956
CHINA_A__MNING...	0.282712	0.158464	0.364029	-0.024814	0.238170	0.761833
FRANCE__MNINGF...	0.633112	0.110979	0.111191	0.089322	0.433489	0.566511
GERMANY__MNIN...	0.177323	0.133342	0.013121	0.135987	0.067888	0.932111
INDIA__MNINGIN_	0.396761	0.076657	0.169571	0.173542	0.222167	0.777833
IRELAND__MNINGI...	0.356955	0.065586	0.138941	0.318554	0.252500	0.747500
JAPAN__MNINGJP...	0.389835	0.104853	0.131997	0.408504	0.347264	0.652737
MEXICO__MNINGM...	0.093396	0.029578	0.021494	0.007220	0.010112	0.989888
MOROCCO__MNIN...	0.124097	0.097858	0.080068	0.188447	0.066900	0.933100
PERU__MNINGPE_	0.506957	0.480905	0.136365	0.181276	0.539732	0.460269
PHILIPPINE__MNIN...	0.322342	0.186355	0.183664	0.206674	0.215079	0.784921
SOUTH_AFRICA__...	0.745038	0.359190	-0.016838	0.106599	0.695745	0.304255
SWEDEN__MNING...	0.624304	0.104743	0.138065	0.275051	0.495441	0.504560
THAILAND__MNIN...	0.480548	0.171687	0.373965	0.134741	0.418407	0.581595
UK__MNINGUK_	1.000000	4.45E-16	-1.48E-16	9.35E-17	1.000000	0.000000
US__MNINGUS	0.650374	0.525773	-0.084264	-0.012811	0.706688	0.293312

Factor	Variance	Cumulative	Difference	Proportion	Cumulative
F1	5.404591	5.404591	3.980537	0.650122	0.650122
F2	1.424054	6.828645	0.522073	0.171300	0.821422
F3	0.901980	7.730625	0.319409	0.108500	0.929922
F4	0.582572	8.313197	---	0.070078	1.000000
Total	8.313197	8.313197		1.000000	

	Model	Independenc...	Saturated
Discrepancy	0.218514	8.452544	0.000000
Chi-square statistic	157.7673	6102.737	---
Chi-square prob.	0.0000	0.0000	---
Bartlett chi-square	155.6914	6044.978	---
Bartlett probability	0.0000	0.0000	---
Parameters	84	18	171
Degrees-of-freedo...	87	153	---

Warning: Heywood solution (uniqueness estimates are non-positive).
Results should be interpreted with caution.

Standard-Error Scree Test

Factor Method: Maximum Likelihood
Date: 10/06/16 Time: 11:37
Covariance Analysis: Ordinary Correlation
Sample: 10/18/1999 8/19/2013
Included observations: 723
Number of factors: Standard-error scree
Prior communalities: Squared multiple correlation
Convergence achieved after 4 iterations

	Loadings		
	F1	Communality	Uniqueness
AUSTRALIA__MNIN...	0.924663	0.855001	0.144995
CANADA__MNINGC...	0.741085	0.549207	0.450799
CHINA__MNINGCH...	0.643081	0.413554	0.586438
CHINA_A__MNING...	0.357808	0.128026	0.871971
FRANCE__MNINGF...	0.663826	0.440665	0.559329
GERMANY__MNIN...	0.227086	0.051568	0.948431
INDIA__MNINGIN_	0.436303	0.190360	0.809636
IRELAND__MNINGI...	0.404202	0.163379	0.836618
JAPAN__MNINGJP...	0.456308	0.208217	0.791779
MEXICO__MNINGM...	0.107950	0.011653	0.988347
MOROCCO__MNIN...	0.172570	0.029780	0.970219
PERU__MNINGPE	0.653306	0.426809	0.573192
PHILIPPINE__MNIN...	0.409536	0.167719	0.832278
SOUTH_AFRICA__...	0.811989	0.659326	0.340675
SWEDEN__MNING...	0.669364	0.448048	0.551945
THAILAND__MNIN...	0.564984	0.319206	0.680787
UK__MNINGUK	0.907827	0.824150	0.175848
US__MNINGUS	0.744686	0.554557	0.445445

Factor	Variance	Cumulative	Difference	Proportion	Cumulative
F1	6.441226	6.441226	---	1.000000	1.000000
Total	6.441226	6.441226		1.000000	

	Model	Independenc...	Saturated
Discrepancy	1.439803	8.452544	0.000000
Chi-square statistic	1039.538	6102.737	---
Chi-square prob.	0.0000	0.0000	---
Bartlett chi-square	1028.739	6044.978	---
Bartlett probability	0.0000	0.0000	---
Parameters	36	18	171
Degrees-of-freedo...	135	153	---

Parallel Analysis Test

Factor Method: Maximum Likelihood
Date: 10/06/16 Time: 11:37
Covariance Analysis: Ordinary Correlation
Sample: 10/18/1999 8/19/2013
Included observations: 723
Number of factors: Parallel analysis (nreps=100, rng=kn, seed=313059856)
Prior communalities: Squared multiple correlation
Convergence achieved after 4 iterations

	Loadings F1	Communality	Uniqueness
AUSTRALIA__MNIN...	0.924663	0.855001	0.144995
CANADA MNINGC...	0.741085	0.549207	0.450799
CHINA__MNINGCH...	0.643081	0.413554	0.586438
CHINA_A__MNING...	0.357808	0.128026	0.871971
FRANCE MNINGF...	0.663826	0.440665	0.559329
GERMANY__MNIN...	0.227086	0.051568	0.948431
INDIA__MNINGIN_	0.436303	0.190360	0.809636
IRELAND MNINGI...	0.404202	0.163379	0.836618
JAPAN__MNINGJP...	0.456308	0.208217	0.791779
MEXICO__MNINGM...	0.107950	0.011653	0.988347
MOROCCO__MNIN...	0.172570	0.029780	0.970219
PERU__MNINGPE_	0.653306	0.426809	0.573192
PHILIPPINE MNIN...	0.409536	0.167719	0.832278
SOUTH_AFRICA__...	0.811989	0.659326	0.340675
SWEDEN__MNING...	0.669364	0.448048	0.551945
THAILAND MNIN...	0.564984	0.319206	0.680787
UK__MNINGUK_	0.907827	0.824150	0.175848
US MNINGUS	0.744686	0.554557	0.445445

Factor	Variance	Cumulative	Difference	Proportion	Cumulative
F1	6.441226	6.441226	---	1.000000	1.000000
Total	6.441226	6.441226		1.000000	

	Model	Independenc...	Saturated
Discrepancy	1.439803	8.452544	0.000000
Chi-square statistic	1039.538	6102.737	---
Chi-square prob.	0.0000	0.0000	---
Bartlett chi-square	1028.739	6044.978	---
Bartlett probability	0.0000	0.0000	---
Parameters	36	18	171
Degrees-of-freedo...	135	153	---

Fraction of Total Variance Test

Factor Method: Maximum Likelihood
Date: 10/06/16 Time: 11:38
Covariance Analysis: Ordinary Correlation
Sample: 10/18/1999 8/19/2013
Included observations: 723
Number of factors: Fraction of total variance = .5
Prior communalities: Squared multiple correlation
Convergence achieved after 9 iterations

	Unrotated Loadings F1	F2	F3	Communality	Uniqueness
AUSTRALIA__MNIN...	0.898948	0.097589	0.187272	0.852702	0.147301
CANADA MNINGC...	0.656689	0.702670	-0.081258	0.931589	0.068411
CHINA MNINGCH...	0.578336	0.121964	0.397412	0.507284	0.492718
CHINA_A__MNING...	0.295995	0.114925	0.322269	0.204678	0.795325
FRANCE MNINGF...	0.642665	0.059235	0.121737	0.431347	0.568656
GERMANY MNIN...	0.187872	0.120197	0.089450	0.057745	0.942255
INDIA__MNINGIN_	0.404693	0.038291	0.233944	0.219972	0.780027
IRELAND MNINGI...	0.364865	0.032988	0.251465	0.197449	0.802550
JAPAN MNINGJP...	0.401227	0.069389	0.272499	0.240054	0.759945
MEXICO__MNINGM...	0.096321	0.021492	0.029497	0.010610	0.989390
MOROCCO MNIN...	0.132705	0.083931	0.163798	0.051485	0.948515
PERU MNINGPE	0.541368	0.439986	0.245976	0.547171	0.452831
PHILIPPINE__MNIN...	0.338330	0.153826	0.275749	0.214167	0.785833
SOUTH AFRICA ...	0.768659	0.309114	0.034073	0.687549	0.312452
SWEDEN MNING...	0.634628	0.052395	0.214226	0.451390	0.548611
THAILAND__MNIN...	0.496284	0.115872	0.420499	0.436544	0.563459
UK MNINGUK	0.994835	-0.063275	-0.015073	0.993927	0.006073
US MNINGUS	0.683905	0.487176	-0.066188	0.709447	0.290553

Factor	Variance	Cumulative	Difference	Proportion	Cumulative
F1	5.699376	5.699376	4.564876	0.735868	0.735868
F2	1.134500	6.833877	0.223269	0.146480	0.882348
F3	0.911231	7.745108	---	0.117652	1.000000
Total	7.745108	7.745108		1.000000	

	Model	Independenc...	Saturated
Discrepancy	0.375731	8.452544	0.000000
Chi-square statistic	271.2780	6102.737	---
Chi-square prob.	0.0000	0.0000	---
Bartlett chi-square	267.9591	6044.978	---
Bartlett probability	0.0000	0.0000	---
Parameters	69	18	171
Degrees-of-freedo...	102	153	---

Broken Stick Test

Factor Method: Maximum Likelihood
Date: 10/06/16 Time: 11:38
Covariance Analysis: Ordinary Correlation
Sample: 10/18/1999 8/19/2013
Included observations: 723
Number of factors: Broken stick
Prior communalities: Squared multiple correlation
Convergence achieved after 9 iterations

	Unrotated Loadings									
	F1	F2	F3	F4	F5	F6	F7	F8	Communality	Uniqueness
AUSTRALIA__MNIN...	0.652627	0.375229	0.573471	-0.010027	0.099984	-0.138410	0.026317	-0.031035	0.926498	0.073502
CANADA__MNINGC...	0.798393	0.111739	0.148025	0.352140	-0.133319	-0.080492	0.087829	0.001982	0.827803	0.172197
CHINA__MNINGCH...	0.422997	0.906131	1.43E-15	-2.43E-17	-7.07E-17	1.97E-16	3.32E-17	3.40E-17	1.000000	0.000000
CHINA_A__MNING...	0.229266	0.379285	0.054953	0.103920	0.076924	-0.028161	0.033384	-0.042370	0.219859	0.780141
FRANCE__MNINGF...	0.494123	0.260338	0.358882	-0.070772	0.006283	0.157569	0.212754	0.053664	0.518750	0.481250
GERMANY__MNIN...	0.154680	0.040898	0.154078	0.124033	0.094696	-0.043491	0.187887	-0.007221	0.110935	0.889065
INDIA__MNINGIN_	0.253092	0.232724	0.277845	0.065230	0.129824	0.167201	0.166948	0.278325	0.349816	0.650184
IRELAND__MNINGI...	0.263325	0.155615	0.254713	0.065614	0.236130	0.179164	-0.039744	-0.031421	0.253164	0.746836
JAPAN__MNINGJP...	0.298934	0.147803	0.300899	0.111793	0.285042	0.210405	-0.049995	-0.086386	0.349727	0.650273
MEXICO__MNINGM...	0.096594	0.029621	0.046426	-0.052223	0.083332	-0.106895	0.054370	-0.023118	0.036952	0.963048
MOROCCO__MNIN...	0.079268	0.080822	0.125695	0.140804	0.134091	0.097403	0.206171	0.064439	0.122567	0.877433
PERU__MNINGPE_	0.563363	0.215845	0.213166	0.440697	0.078674	-0.033710	-0.133591	-0.015726	0.629040	0.370960
PHILIPPINE__MNIN...	0.305313	0.191354	0.162179	0.160145	0.173642	0.063731	-0.003914	0.087738	0.223707	0.776293
SOUTH_AFRICA__...	0.659456	0.208035	0.419893	0.268696	-0.190385	0.118153	-0.051028	-0.003887	0.779494	0.220506
SWEDEN__MNING...	0.454644	0.257982	0.418411	0.042168	0.117918	0.299075	0.032798	-0.187343	0.589626	0.410374
THAILAND__MNIN...	0.371468	0.412460	0.219870	0.131339	0.244056	-0.008046	-0.200820	0.201874	0.514414	0.485586
UK__MNINGUK_	0.650374	0.316410	0.621048	-0.125531	-0.095905	0.029009	-0.031765	0.023236	0.936149	0.063851
US__MNINGUS	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	1.000000	0.000000

Factor	Variance	Cumulative	Difference	Proportion	Cumulative
F1	4.414449	4.414449	2.655878	0.470198	0.470198
F2	1.758572	6.173021	0.144501	0.187311	0.657509
F3	1.614070	7.787091	1.088320	0.171920	0.829429
F4	0.525751	8.312842	0.149017	0.055999	0.885428
F5	0.376734	8.689576	0.088835	0.040127	0.925555
F6	0.287899	8.977475	0.057520	0.030665	0.956220
F7	0.230379	9.207854	0.049732	0.024538	0.980759
F8	0.180647	9.388500	---	0.019241	1.000000
Total	9.388500	9.388500		1.000000	

	Model	Independenc...	Saturated
Discrepancy	0.050250	8.452544	0.000000
Chi-square statistic	36.28019	6102.737	---
Chi-square prob.	0.5026	0.0000	---
Bartlett chi-square	35.66882	6044.978	---
Bartlett probability	0.5314	0.0000	---
Parameters	134	18	171
Degrees-of-freedo...	37	153	---

Warning: Heywood solution (uniqueness estimates are non-positive).
Results should be interpreted with caution.

Minimum Average Partial Test

Factor Method: Maximum Likelihood
Date: 10/06/16 Time: 11:38
Covariance Analysis: Ordinary Correlation
Sample: 10/18/1999 8/19/2013
Included observations: 723
Number of factors: Minimum average partial
Prior communalities: Squared multiple correlation
Convergence achieved after 4 iterations

	Loadings		
	F1	Communality	Uniqueness
AUSTRALIA__MNIN...	0.924663	0.855001	0.144995
CANADA__MNINGC...	0.741085	0.549207	0.450799
CHINA__MNINGCH...	0.643081	0.413554	0.586438
CHINA_A__MNING...	0.357808	0.128026	0.871971
FRANCE__MNINGF...	0.663826	0.440665	0.559329
GERMANY__MNIN...	0.227086	0.051568	0.948431
INDIA__MNINGIN_	0.436303	0.190360	0.809636
IRELAND__MNINGI...	0.404202	0.163379	0.836618
JAPAN__MNINGJP...	0.456308	0.208217	0.791779
MEXICO__MNINGM...	0.107950	0.011653	0.988347
MOROCCO__MNIN...	0.172570	0.029780	0.970219
PERU__MNINGPE_	0.653306	0.426809	0.573192
PHILIPPINE__MNIN...	0.409536	0.167719	0.832278
SOUTH_AFRICA__...	0.811989	0.659326	0.340675
SWEDEN__MNING...	0.669364	0.448048	0.551945
THAILAND__MNIN...	0.564984	0.319206	0.680787
UK__MNINGUK_	0.907827	0.824150	0.175848
US__MNINGUS	0.744686	0.554557	0.445445

Factor	Variance	Cumulative	Difference	Proportion	Cumulative
F1	6.441226	6.441226	---	1.000000	1.000000
Total	6.441226	6.441226		1.000000	

	Model	Independenc...	Saturated
Discrepancy	1.439803	8.452544	0.000000
Chi-square statistic	1039.538	6102.737	---
Chi-square prob.	0.0000	0.0000	---
Bartlett chi-square	1028.739	6044.978	---
Bartlett probability	0.0000	0.0000	---
Parameters	36	18	171
Degrees-of-freedo...	135	153	---

B 1.3: Factor analysis outputs for Gold

Kaiser-Guttman Test

Factor Method: Maximum Likelihood
Date: 10/06/16 Time: 11:27
Covariance Analysis: Ordinary Correlation
Sample: 7/07/1997 8/19/2013
Included observations: 842
Number of factors: Kaiser-Guttman
Prior communalities: Squared multiple correlation
Convergence achieved after 4 iterations

	Loadings F1	Communality	Uniqueness
AUSTRALIA__GOL...	0.826729	0.683480	0.316521
CANADA__GOLDS...	0.953763	0.909664	0.090337
FRANCE__GOLDS...	0.319655	0.102179	0.897821
IRELAND__GOLDS...	0.092550	0.008566	0.991434
PERU__GOLDSPE...	0.709721	0.503704	0.496296
SOUTH_AFRICA__...	0.812923	0.660843	0.339158
UK__GOLDSUK_	0.600186	0.360223	0.639777
US__GOLDSUS	0.893054	0.797546	0.202448

Factor	Variance	Cumulative	Difference	Proportion	Cumulative
F1	4.026206	4.026206	---	1.000000	1.000000
Total	4.026206	4.026206		1.000000	

	Model	Independenc...	Saturated
Discrepancy	0.148727	4.609665	0.000000
Chi-square statistic	125.0793	3876.728	---
Chi-square prob.	0.0000	0.0000	---
Bartlett chi-square	124.4596	3860.595	---
Bartlett probability	0.0000	0.0000	---
Parameters	16	8	36
Degrees-of-freedo...	20	28	---

Standard-Error Scree Test

Factor Method: Maximum Likelihood
Date: 10/06/16 Time: 11:27
Covariance Analysis: Ordinary Correlation
Sample: 7/07/1997 8/19/2013
Included observations: 842
Number of factors: Standard-error scree
Prior communalities: Squared multiple correlation
Convergence achieved after 4 iterations

	Loadings F1	Communality	Uniqueness
AUSTRALIA__GOL...	0.826729	0.683480	0.316521
CANADA__GOLDS...	0.953763	0.909664	0.090337
FRANCE__GOLDS...	0.319655	0.102179	0.897821
IRELAND__GOLDS...	0.092550	0.008566	0.991434
PERU__GOLDSPE...	0.709721	0.503704	0.496296
SOUTH_AFRICA__...	0.812923	0.660843	0.339158
UK__GOLDSUK_	0.600186	0.360223	0.639777
US__GOLDSUS	0.893054	0.797546	0.202448

Factor	Variance	Cumulative	Difference	Proportion	Cumulative
F1	4.026206	4.026206	---	1.000000	1.000000
Total	4.026206	4.026206		1.000000	

	Model	Independenc...	Saturated
Discrepancy	0.148727	4.609665	0.000000
Chi-square statistic	125.0793	3876.728	---
Chi-square prob.	0.0000	0.0000	---
Bartlett chi-square	124.4596	3860.595	---
Bartlett probability	0.0000	0.0000	---
Parameters	16	8	36
Degrees-of-freedo...	20	28	---

Parallel analysis test

Factor Method: Maximum Likelihood
Date: 10/06/16 Time: 11:28
Covariance Analysis: Ordinary Correlation
Sample: 7/07/1997 8/19/2013
Included observations: 842
Number of factors: Parallel analysis (nreps=100, rng=kn, seed=850645995)
Prior communalities: Squared multiple correlation
Convergence achieved after 4 iterations

	Loadings		
	F1	Communality	Uniqueness
AUSTRALIA__GOL...	0.826729	0.683480	0.316521
CANADA__GOLDS...	0.953763	0.909664	0.090337
FRANCE__GOLDS...	0.319655	0.102179	0.897821
IRELAND__GOLDS...	0.092550	0.008566	0.991434
PERU__GOLDSPE...	0.709721	0.503704	0.496296
SOUTH_AFRICA__...	0.812923	0.660843	0.339158
UK__GOLDSUK_	0.600186	0.360223	0.639777
US__GOLDSUS	0.893054	0.797546	0.202448

Factor	Variance	Cumulative	Difference	Proportion	Cumulative
F1	4.026206	4.026206	---	1.000000	1.000000
Total	4.026206	4.026206		1.000000	

	Model	Independenc...	Saturated
Discrepancy	0.148727	4.609665	0.000000
Chi-square statistic	125.0793	3876.728	---
Chi-square prob.	0.0000	0.0000	---
Bartlett chi-square	124.4596	3860.595	---
Bartlett probability	0.0000	0.0000	---
Parameters	16	8	36
Degrees-of-freedo...	20	28	---

Fraction of total variance test

Factor Method: Maximum Likelihood
Date: 10/06/16 Time: 11:28
Covariance Analysis: Ordinary Correlation
Sample: 7/07/1997 8/19/2013
Included observations: 842
Number of factors: Fraction of total variance = .5
Prior communalities: Squared multiple correlation
Convergence achieved after 4 iterations

	Loadings		
	F1	Communality	Uniqueness
AUSTRALIA__GOL...	0.826729	0.683480	0.316521
CANADA__GOLDS...	0.953763	0.909664	0.090337
FRANCE__GOLDS...	0.319655	0.102179	0.897821
IRELAND__GOLDS...	0.092550	0.008566	0.991434
PERU__GOLDSPE...	0.709721	0.503704	0.496296
SOUTH_AFRICA__...	0.812923	0.660843	0.339158
UK__GOLDSUK_	0.600186	0.360223	0.639777
US__GOLDSUS	0.893054	0.797546	0.202448

Factor	Variance	Cumulative	Difference	Proportion	Cumulative
F1	4.026206	4.026206	---	1.000000	1.000000
Total	4.026206	4.026206		1.000000	

	Model	Independenc...	Saturated
Discrepancy	0.148727	4.609665	0.000000
Chi-square statistic	125.0793	3876.728	---
Chi-square prob.	0.0000	0.0000	---
Bartlett chi-square	124.4596	3860.595	---
Bartlett probability	0.0000	0.0000	---
Parameters	16	8	36
Degrees-of-freedo...	20	28	---

Minimum average partial test

Factor Method: Maximum Likelihood
Date: 10/06/16 Time: 11:30
Covariance Analysis: Ordinary Correlation
Sample: 7/07/1997 8/19/2013
Included observations: 842
Number of factors: Minimum average partial
Prior communalities: Squared multiple correlation
Convergence achieved after 1 iteration

	Loadings F1	Communality	Uniqueness
AUSTRALIA__GOL...	0.830857	0.690323	0.311061
CANADA__GOLDS...	0.947475	0.897709	0.106134
FRANCE__GOLDS...	0.322376	0.103926	0.894297
IRELAND__GOLDS...	0.093505	0.008743	0.991193
PERU__GOLDSPE...	0.714154	0.510017	0.486924
SOUTH_AFRICA__...	0.817742	0.668702	0.328594
UK__GOLDSUK_	0.603552	0.364275	0.635588
US__GOLDSUS	0.888945	0.790224	0.221447

Factor	Variance	Cumulative	Difference	Proportion	Cumulative
F1	4.033919	4.033919	---	1.000000	1.000000
Total	4.033919	4.033919		1.000000	

	Model	Independenc...	Saturated
Discrepancy	0.154186	4.609665	0.000000
Chi-square statistic	129.6706	3876.728	---
Chi-square prob.	0.0000	0.0000	---
Bartlett chi-square	129.0282	3860.595	---
Bartlett probability	0.0000	0.0000	---
Parameters	16	8	36
Degrees-of-freedo...	20	28	---

Appendix C

In addition, one, three and five factors are also regressed for each South African index in order to perform the same rolling window approach. This is an attempt to further account for any possible signs of significant variation that may exist among the different factor selections. Appendix C 1.1 displays the level of correlation for the R^2's for one, three and five factors. Notice the noteworthy relationship that exists for the various factor loadings. Consequently this suggests that the choice pertaining to the number of factors is not at issue. Moreover, these relationships can also be interpreted by means of visual inspection.

When examining the three graphs for Iron & Steel, an upward trend is apparent and although the graph movements are quite similar, instances occur with more noticeable movements, suggesting that different factors drive Iron & Steel at specific periods in time. The three graphs for Mining seem to be consolidating; however, they do indicate prominent movements during the first half of the time period. The graphs also seem to mimic each other but the extent of this varies for each graph during different time periods, which also suggests that different factors drive Mining at certain periods in time. Lastly the graphs for Gold appear very similar for all three factor selections, suggesting that there is a dominant factor that drives Gold. Consequently the discussion and evidence provided here validates the decision for the number of factors retained for each sector.

C 1.1: Correlation coefficients for the R^2's

Iron & Steel

	1 Factor	*3 Factors*	*5 Factors*
1 Factor	1		
3 Factors	0.914474	1	
5 Factors	0.668880	0.760196	1

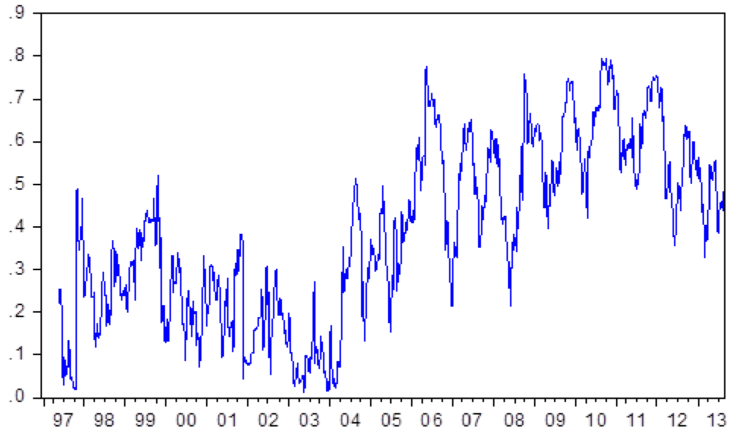
Mining

	1 Factor	*3 Factors*	*5 Factors*
1 Factor	1		
3 Factors	0.897908	1	
5 Factors	0.764730	0.860486	1

Gold

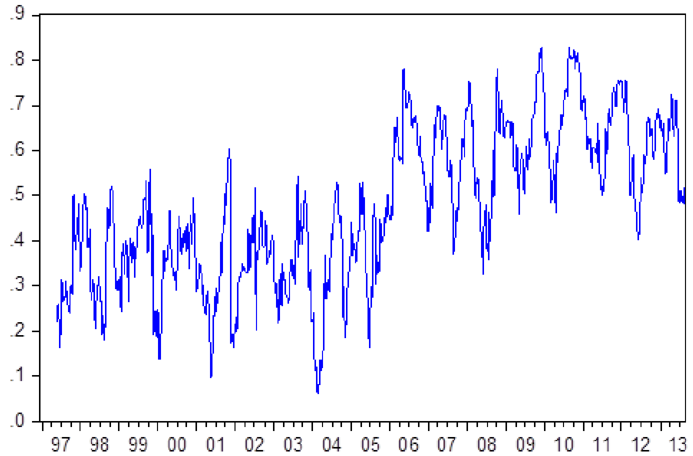
	1 Factor	*3 Factors*	*5 Factors*
1 Factor	1		
3 Factors	0.961923	1	
5 Factors	0.898417	0.917613	1

C 1.2: R^2 of rolling regressions for South African Iron & Steel returns



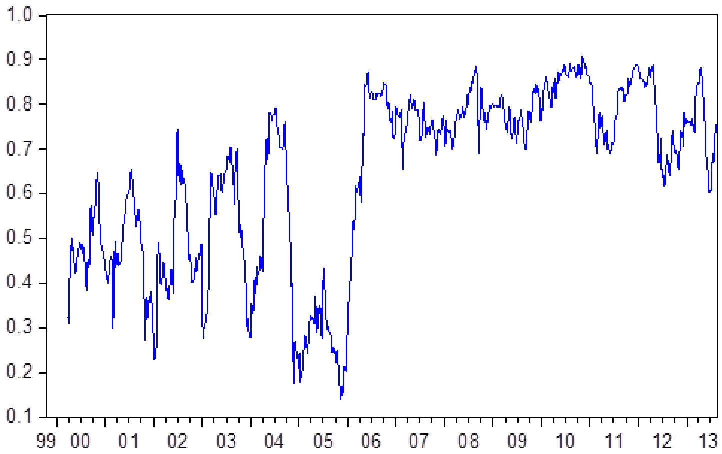
Note: One factor is extracted for Iron & Steel

C 1.3: R^2 of rolling regressions for South African Iron & Steel returns



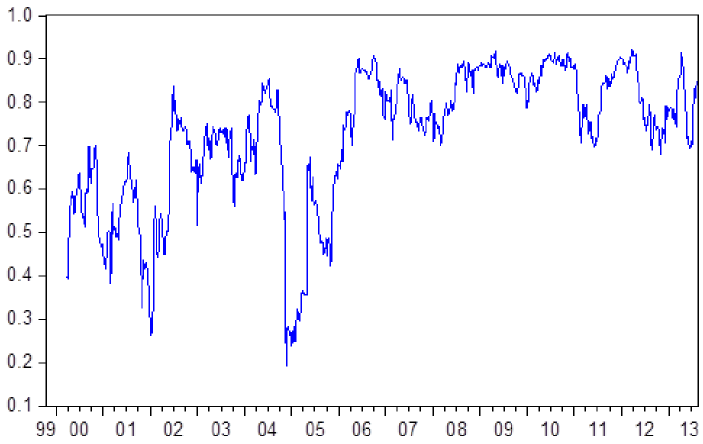
Note: Three factors are extracted for Iron & Steel

C 1.4: R^2 of rolling regressions for South African Mining returns



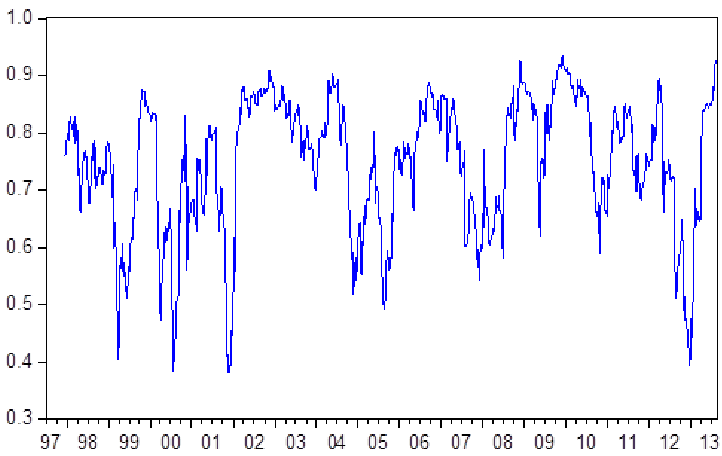
Note: One factor is extracted for Mining

C 1.5: R^2 of rolling regressions for South African Mining returns



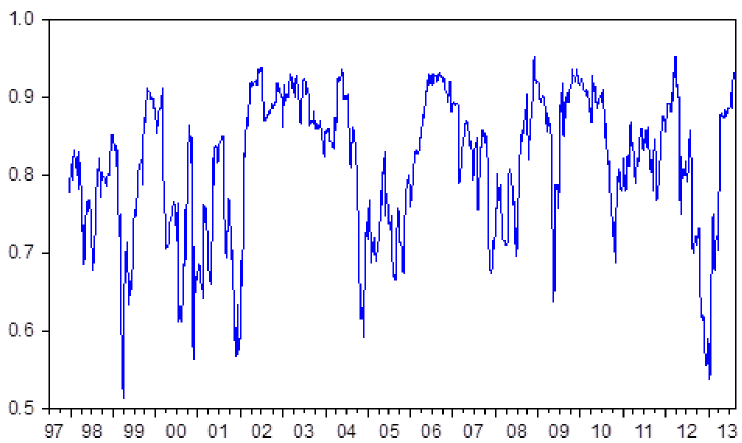
Note: Three factors are extracted for Mining

C 1.6: R^2 of rolling regressions for South African Gold returns



Note: Three factors are extracted for Gold

C 1.7: R^2 of rolling regressions for South African Gold returns



Note: Five factors are extracted for Gold

Appendix D

Complete tables of correlation coefficients for weekly and monthly variables

D 1.1: Correlation coefficients for weekly variables

	Iron & Steel F1	*Mining F1*	*Gold F1*	*Dollar/Euro Rate*	*Oil Price*	*Gold Price*	*VIX*
Iron & Steel F1	1						
Mining F1	0.887224559	1					
Gold F1	0.541177676	0.765911147	1				
Dollar/Euro Rate	-0.450530881	-0.483262504	-0.462039994	1			
Oil Price	0.373705897	0.409999222	0.290701239	-0.195853141	1		
Gold Price	0.294713475	0.531196410	0.785645659	-0.428273749	0.238408776	1	
VIX	-0.300661367	-0.225197439	-0.128030598	0.080815000	-0.062785603	0.043727334	1

D 1.2: Correlation coefficients for monthly variables

	Iron & Steel F1	*Mining F1*	*Gold F1*	*CIP*	*EA 19 Rate*	*US Rate*
Iron & Steel F1	1					
Mining F1	0.888147905	1				
Gold F1	0.489594835	0.726555032	1			
CIP	0.266836548	0.347958891	0.301745076	1		
EA 19 Rate	0.109880788	0.093881443	-0.034065002	-0.017332578	1	
US Rate	0.288714513	0.175530009	-0.123692910	0.023843126	0.539224772	1