Sectoral Co-integration and Portfolio Diversification Benefits
A Business Cycle Examination of South African Equity Sectors

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MASTERS OF COMMERCE in FINANCIAL MARKETS

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By

Tinashe S Hofisi

Supervisor: Ms. Jamela Hoveni

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Declaration

I Tinashe Stanford Hofisi do hereby declare that except for references specifically indicated in the text and such help as I have acknowledged, this thesis is wholly my own work and has not been submitted at any other University or Technikon for any degree purposes.

Signed________________________ on this 2nd day of December 2019.

Abstract

The onset of globalisation and simultaneous changes in financial technology and financial reforms dissipated hurdles once faced in financial transactions among stock markets. Hence, stock markets around the world became increasingly integrated because there was a free flow of cross border investments. Consequently, international diversification diminished thereby undermining the ability of investors to diversify investments across borders. For that reason, recent literature on portfolio diversification is urging investors to shift their focus to domestic portfolio diversification as an alternative.

On that account, this study aims to examine the co-integration and dynamic causalities between South African equity market sectors in order to ascertain the sectoral diversification opportunities available to domestic investors over time. The study was examined over the different phases of the business cycle as well as the full sample, i.e. 2004 – 2018, with a view to shedding light on the inter-sectoral diversification opportunities of domestic investors over the South African business cycle. The phases of the business cycle applied are a| expansion and boom; b| recession and recovery phase and c| stagnation phase. The Johansen co-integration and Granger-causality tests were employed. The hypothesis of the study is that, if sectors are not cointegrated, then diversification benefits can be reaped by constructing a portfolio that combines stocks from the respective sectors.

On the whole, the findings of this study show that there are both long-run and short-run diversification opportunities across the different phases of the South African business cycle as well as the full sample. However, there are lesser diversification opportunities in the recession and recovery phase over both the long-run and short-run. These results indicate that domestic sectoral portfolio diversification is least effective when it is needed the most (i.e. in a period of heightened volatility such as recession and recovery phase).

This study will contribute to the existing literature in two ways; firstly, to investors who intend to diversify their portfolios domestically rather than internationally and, secondly, after reasonably thorough research it was evident that there is scant literature on domestic sectoral diversification in South Africa. As a result, the study attempts to address this gap. Additionally, the essence of the business cycle in this study is to make investors aware of potential diversification opportunities when positioning their portfolios for the next shift in the business cycle.

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‘Faith does not make it easy, it makes it possible’ - Steve Harvey

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Abbreviations

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
COM	Communication Services Index
DIS	Consumer Discretionary Index
ENG	Energy Index
FIN	Financials Index
FPE	Final Prediction Error
GICS	Global Industry Classification Standard
HLT	Health Index
HQ	Hannan-Quinn Information Criterion
IND	Industrials Index
MAT	Materials Index
MPC	Monetary Policy Committee
MPT	Modern Portfolio Theory
MSCI	Morgan Stanley Capital International
PP	Phillips Peron
RET	Real Estate Index
SARB	South African Reserve Bank
SC	Schwarz Criterion
STP	Consumer Staples Index
TEC	Information Technology Index
UTL	Utilities Index
VAR	Vector Autoregression

1

Introduction

1.1 Research context

Markowitz (1952) presented the concept of portfolio diversification and termed it Modern Portfolio Theory (MPT). The Portfolio theory is founded on three main branches (1) Security Analysis, (2) Portfolio Analysis and (3) Portfolio Selection. From the time when Modern Portfolio Theory was initiated, it received much attention within the investment field. Markowitz (1952) asserted that portfolio risk could be minimized by selecting different assets that have a low negative correlation. Sharp (1964) further extended this work by adding borrowing and lending opportunities which gave birth to the Capital Asset Pricing Model (CAPM). He argued that only systematic risk is relevant and unsystematic risk could be diversified away through the inclusion of uncorrelated securities.

Grubel and Fadner (1971) alluded that diversification opportunities became increasingly available in global capital markets. The discussion on measuring market integration began in the 1980s and the trend increased in the 1990s with the evolution of emerging markets. Investors began to diversify their investment portfolios, initially at the domestic level, and then leveraging the concept to create globally diversified portfolios. Globalization, the emergence of multinational companies and electronic stock trading have since reduced the barriers to international investment. There has been a marked increase in cross border investments in capital markets. At the same time, international stock markets have become more integrated, causing diversification opportunities to shrink (Ahmed et al., 2018).

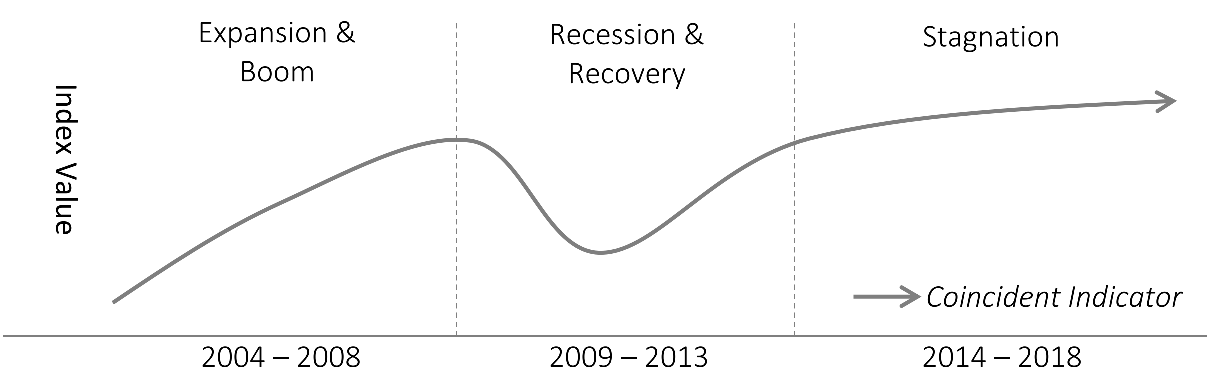
Wong et al. (2004) note that integration among the stock markets of different countries increased after the market crash of 1987. Ahmed et al. (2017) also note that integration has increased further since the Asian Financial crisis of 1997. The impact of the 9/11 attacks and the global financial crisis of 2008 on capital markets across almost all developed and developing economies indicates that international portfolio diversification is not necessarily as effective as perceived. The most recent example is the Turkish currency and debt crisis that shook the global markets in 2018.

Following a waning trend in international portfolio diversification in the wake of greater global market interdependence, investors have begun to refocus on domestic portfolio diversification (Ahmed et al. 2018). Comprehensive studies have been conducted to explore the opportunities of portfolio diversification across sectors of a stock market; Gee and Karim (2005) in Malaysia, Wang et al. (2005) in China, Constantinou et al. (2008) in Cyprus, Al-Fayoumi et al. (2009) in Jordan, Ahmed (2012) in Egypt, Noor et al. (2014) in India, Ahmed et al. (2017) in Pakistan and Ahmed et al. (2018) in Sri Lanka. These studies found that the benefits of portfolio diversification can be reaped by forming a portfolio across sectors of a stock market. In contrast, a study by Katze (2013) in South Africa found no substantial evidence of sectoral diversification benefits available.

The utility of diversification is that it protects funds from wild swings (i.e. business cycle) of the economy, thus it is ideal for achieving long-term growth. Diversification does not necessarily guarantee protection against risks; however, it goes a long way in ensuring that one more easily achieves financial goals. This investment strategy also improves the diversification premium of the portfolio, i.e. generating excess returns. In terms of the asset allocation theory, portfolio efficiency (higher returns per unit of risk) can be achieved by forming a portfolio invested in different assets so as to minimize unsystematic risk. An efficient portfolio can be constructed using asset diversification. Surya and Natasha (2018) posit that sectoral diversification is one of the ways used to attempt to reduce portfolio risk since there are unique relationships among sector classifications.

Embsdo-Mattingly et al. (2017), researchers at Fidelity Investments, published a comprehensive paper titled The Business Cycle Approach to Equity Sector Investing. They highlighted that every cycle is different and so are the performance patterns among equity sectors, which implies that the business cycle is a key determinant of equity sector performance. Different sectors of the stock market tend to lag the overall market in an upswing or a downswing. Cyclical sectors such as industrials and financials, for example, tend to outperform the overall market during the upswing, while defensive sectors such as health and telecom will outperform the overall market during the downswing phase. For this reason, we are interested in how sectoral diversification varies over the business cycle. The study will use the SARB dating approach as presented in economic reports over the period 2004 – 2008. Figure 1.1 illustrates the South African business cycle and its respective phases.

Figure 1.1 South African Business Cycle



Data Source: South African Reserve Bank

The aim of the study is to examine the diversification opportunities across the MSCI[1] listed equity sector indices in South Africa over the different phases of the South African business cycle as well as the full sample. Within the Modern Portfolio Theory, portfolio diversification is achieved when combined assets have limited co-movement or are uncorrelated. However, correlation has been found to be an inadequate measure of diversification because it does not tell us anything about the existence of a long-run stationary relationship between variables (Alexander et al., 2001). Ahmed et al. (2017) argued that a co-integration analysis must be performed to determine whether an equilibrium exists.

Co-integration also entails the co-movement between variables; therefore, in line with Modern Portfolio Theory, assets that have limited co-movement or no co-movement can be combined to attain portfolio diversification (Noor et al., 2005). Accordingly, this gives rise to the hypothesis we want to test in this study that sectors which are not cointegrated with others offer good portfolio diversification benefits.

[1] Morgan Stanley Capital International

1.1.1 Contribution of the study

The contribution of this study is targeting the literature on Modern Portfolio Theory, specifically around the issue of domestic portfolio diversification and exploring sectoral co-integration as a way of reaping portfolio diversification opportunities in South Africa. To enhance the meaning of the co-integration results, the study will be examined over different phases of the business cycle (BC) and this this BC approach is a major contribution of this study. The essence of the business cycle analysis is to make investors aware of potential diversification opportunities when positioning their portfolios for a next shift in the business cycle.

There is scant literature on the co-integration of equity market sectors in South Africa. Katzke (2013) is one study on sectoral diversification although this study is limited because it does not consider bivariate co-integration and Granger causality tests which are regarded to be more appropriate in examining the co-integration between sectors and identifying inter-sectoral diversification benefits (Ahmed et al., 2017 and 2018)[2]. The findings of this study could prove useful for investors in portfolio formation by identifying which sectors provide the most diversification opportunities to minimize unsystematic risk. Although the study has a domestic focus, it may be of equal interest to investors from emerging economies and the African continent, given that the South African Equity Market is the oldest and largest stock exchange in Africa and South Africa is classified as an emerging economy.

1.1.2 Problem statement

The onset of globalisation and simultaneous changes in financial technology and financial reforms have dissipated hurdles once faced in financial transactions among stock markets. As a result, the world became increasingly integrated because there was a free flow of cross border investments. Consequently, international portfolio diversification diminished thereby undermining the ability of investors to diversify across borders (Ahmed et al., 2018). For that

[2] Katzke (2013) focused more on conditional correlations as measures of diversification as opposed to the conventional correlations to improve the robustness of the results. However, in general correlations are regarded to be inadequate in measuring diversification benefits because they are based on returns which are short-term memory processes, hence making it difficult to examine long-run relationships between sectors (Alexander et al., 2001).

reason, recent literature on portfolio diversification is urging investors to shift their focus to domestic portfolio diversification as an alternative (Ahmed, 2012).

1.2 Research objectives

The goals of the research are to:

i. Establish whether there is pairwise co-integration between the South African equity market sectors and identify possible diversification opportunities available over different phases of the business cycle.
ii. Examine whether there are short-run dynamic casual linkages between the South African equity market sectors.

1.3 Methods, procedures and techniques

The study used a positivistic research paradigm. It was undertaken to answer questions about relationships between variables with the purpose of explaining, predicting and controlling phenomena. Therefore, it involved collecting and analysing data that could be statistically interpreted and analysed (Collis and Hussey, 2003).

Daily closing prices of the MSCI[3] South African equity market sectors were collected from Thomson Reuters and then transformed into natural logarithms. These sector indices are communication services, consumer discretionary, consumer staples, energy, financials, health, industrials and materials. Information technology, real estate and utilities have been excluded because they have missing data. The study was examined over different phases of the business cycle as well as the full sample, i.e. 2004 – 2018 as depicted in figure 1.1. The different phases of the business cycle defined the sub samples.

The coincident indicator has been used to capture the historical movement of the South African business cycle. To ascertain the different phases of the South African business cycle over the 15-year period (2004 – 2018), each phase of the business cycle was carefully analysed using technical analysis and key guidelines on fundamental analysis (*Refer to chapter 3)*.

[3] Morgan Stanley Capital International

The Johansen Multivariate co-integration and pair wise co-integration tests were applied to determine co-integration between the sectors and the Granger Causality test was employed to determine their short-term causal dynamics. Sectors that are not co-integrated imply that there is no co-movement over time. In statistical terms it entails that those sectors do not share a stochastic trend. Therefore, to construct diversified portfolios, investors will select stocks from sectors that are not co-integrated. The pair-wise correlation was applied as well since it also measures the degree of co-movement between two variables. However, it does not suffice to ascertain the presence of a long-run stationary relationship between two variables. For that reason, a co-integration analysis must be performed to determine whether an equilibrium relation exists (Ahmed et al., 2017).

Based on the objectives of this study, Johansen was the most suitable co-integration method as opposed to the Engle-Granger method. Engle-Granger requires us to select one variable as the dependent variable and include the remaining variables as regressors. In this case, it is possible to find that one regression indicates that the variables are co-integrated, whereas reversing the order indicates no co-integration. This is not a desirable feature of the Engle-Granger method, since co-integration must be invariant to the choice of the variable selected (Koirala, 2009).

Johansen co-integration approach is typically used in a setting where variables in the system are integrated of order 1 (Österholm and Hjalmarsson, 2010). Therefore, ADF (Augmented Dickey Fuller) and Phillips Peron tests were used in this regard. ADF has critical limitations of serial correlation, hence the use of Phillips Peron to account for heteroscedasticity, autocorrelation in the error terms and the likelihood of a structural break (Ahmed et al., 2017). Thereafter, the study determined the number of optimal lags using the VAR Lag Selection. Conclusive selection of the lags was based on the SC (Schwarz Criterion) because it is generally superior with fairly large samples (Enders, 2015).

The proposed co-integration methodology has been employed in studies of the same nature by Constantinou et al. (2008), Noor et al. (2014) and Ahmed et al. (2017 & 2018). The only variation was the inclusion of the business cycle.

1.4 The organisation of the study

- Chapter one provides an overview of the research, problem statement and the research goals.
- Chapter two presents a literature review on domestic diversification.
- Chapter three presents an analysis of the business cycle and sectors.
- Chapter four details the methodology.
- Chapter five presents and analyses the results.
- Chapter six will provide a summary and conclusion, recommendations and areas for further study.

1.5 Summary

This chapter introduced the background of the research and presented the problem statement, objectives of the study and its significance. A brief explanation of the methodology was given. The next chapter presents the literature and empirical evidence from other studies.

2

Literature Review

2.1 Introduction

The Modern Portfolio Theory (MPT) transformed the practice of investment management in the 1950s. The theory recognized that the creation of an optimal portfolio is attainable through combining securities with limited co-movement and therefore desirable risk-return characteristics. This means that investors should consider both the characteristics and relationships between securities in building portfolios. MPT is premised on two main concepts: a) Maximization of returns for any level of risk, and b) Portfolio risk reduction by diversifying through unrelated securities.

This chapter first describes the theoretical framework of the portfolio theory and diversification as established by Markowitz (1952). This is done to understand how diversification can be used to reduce or minimize portfolio variance and develop the hypothesis discussed in chapter one. Moreover, the chapter outlines the theoretical link between diversification and business cycle equity sector investing. The link is built around the fact that the performance of equity market sectors is often tied to the state of the business cycle and because every cycle is different, portfolio diversification opportunities will also tend to vary.

Thereafter, the chapter presents the trend on international portfolio diversification and the empirical evidence on sectoral diversification opportunities. The diversification argument is premised on the basis that international diversification is no longer as effective as it used to be because global markets have become more integrated as a result of globalization and deregulation; therefore, recent literature is advocating for domestic portfolio diversification as an alternative.

2.2 Modern Portfolio Theory

Modern Portfolio Theory states that it is inadequate to look at the risk and return of individual security investments; instead, investors are urged to construct a portfolio that diversifies across different securities. To diversify, a portfolio should be constructed with uncorrelated securities in a manner that will optimize the efficiency of the portfolio. Portfolio efficiency is achieved when the return is maximized for a given level of risk or risk is minimized for a given level of return. A crucial insight of MPT is that a risky security can reduce the overall risk of the portfolio if there is low covariance of returns between the risky security and other securities in the portfolio.

The portfolio theory asserts that investors have different levels of risk tolerance and preferences; as a result, Markowitz (1952) formulated a set of portfolios to capture different mean-variance choices of investors. He termed this the efficient frontier, which is a set of portfolios (i.e. collection of risky securities) investors may possibly select to diversify their investments given their risk tolerance and preference. Therefore, any portfolio that does not lie on the efficient frontier is deemed to be inefficient.

MPT shows how to choose a portfolio with the maximum possible expected return for a given amount of risk. Markowitz explained this as a form of diversification which seeks to find the best possible diversification strategy. The process of finding the best possible strategy is split into two parts. Firstly, select a combination of uncorrelated securities, i.e. diversification and, secondly, determine the optimal weight allocation on these securities. The focus of this study is premised on the former. The determination of optimal weight allocation is a different topic and too complex to be addressed in a study of this nature because it involves the whole process of portfolio construction.

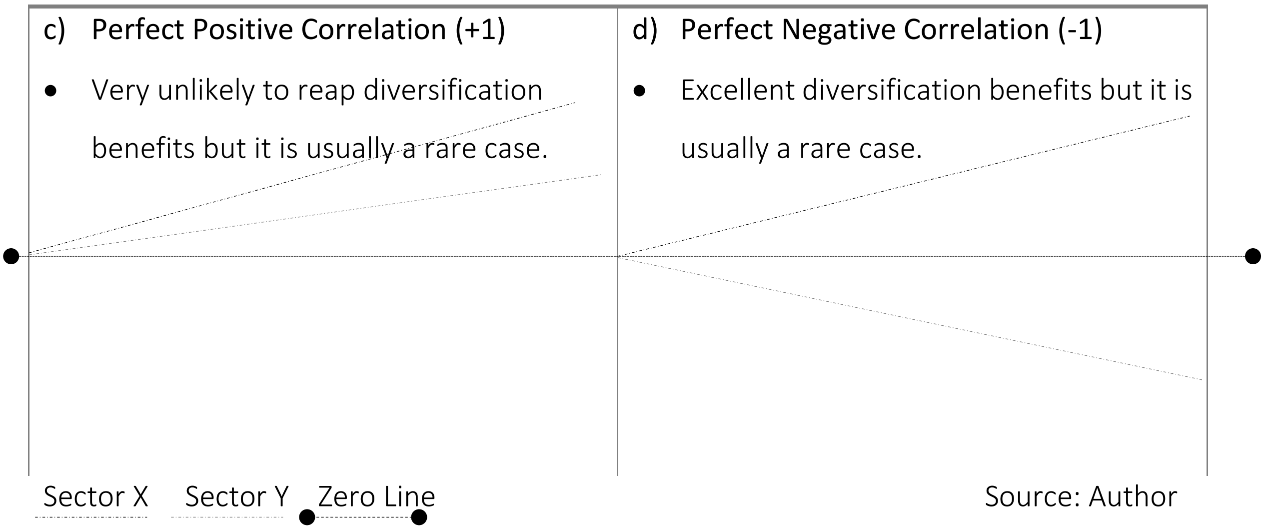
The concept of correlation was first introduced by Sir Francis Galton (1886) and it was introduced in finance by Harry Markowitz (1952) when developing Modern Portfolio Theory (Lhabitant, 2011). Markowitz illustrated that the variance of a portfolio's return was a weighted average of the correlation coefficients of the returns of its component assets. Since all the weights in this average were positive, the obvious solution to reduce the portfolio variance was to search for "uncorrelated assets" or even "negatively correlated assets" if possible.

The financial concept of correlation is imperative in Modern Portfolio Theory, largely because it states that the objective of portfolio diversification is achieved through combining assets with low correlation and lower portfolio volatility. By putting low correlated and/or negatively correlated investments in a portfolio, the overall volatility of the portfolio is reduced (Faulkenberry, 2006). Combining assets from different categories that have a low correlation reduces the volatility as a whole and allows the portfolio manager to invest more aggressively. In other words, a portfolio manager willing to accept a given amount of volatility can invest in higher return/risk investments. This is because the volatility of the overall portfolio is lower due to combining non-correlated assets. This is called portfolio optimization.

Bausys (2013) states that the underlying driver of the diversification effect is the correlation between returns of portfolio components because diversification is an investment approach that aims to combine different investments in order to reduce the overall risk in a portfolio. The fundamental argument is that the portfolio volatility is always lower than the weighted average volatility of each asset as long as the movement of one asset can be expected to at least partially mitigate the movements of the second asset. The less correlated the assets are, the more significant the diversification benefits (see table 4.1).

Table 2.1 Correlation Typical Forms

a) Positive Correlation **(Below +1 but greater than 0)** • According to Modern Portfolio Theory if two assets are positively correlated there are less diversification opportunities because the portfolio variance is going to increase.	b) Negative Correlation **(Below 0 but greater than -1)** • According to Modern Portfolio Theory if two assets are negatively correlated there are good diversification because the portfolio variance will decline.



Source: Author

Succinctly, diversification and high positive correlation among portfolio constituents are opposing forces. The financial concept compels investors and portfolio managers to combine assets with limited or negative correlation and improve diversification, thus reducing downside risk (Torray LLC, 2018).

From the mathematical definition of portfolio variance, the following relationship must hold for all two-asset portfolios:

$$Portfolio\ Variance\ ({\sigma^2}_p) = variance\ (\sigma^2)_X \times\ {weights^2}_X\ +\ variance\ (\sigma^2)_Y + {weights^2}_Y + correlation\ (\rho_{XY}) \quad (10)$$

A direct implication of this equation is that correlation is most relevant to diversification arguments, and most powerful in reducing portfolio volatility, when asset volatilities are more similar (Phillips et al., 2012).

The cross-sector correlations are estimated as follows:

$$\rho_{xy} = \frac{\sigma_{XY}}{\sigma_X \sigma_Y} \quad (11)$$

Where ρ_{XY} is the correlation coefficient, σ_{XY} denotes the covariance between sectors $X\ \&\ Y$ and $\sigma_X \&\ \sigma_Y$ are the standard deviations of the returns on sectors $X\ \&\ Y$.

However, correlation does not tell us much about the long-term behaviour between two variables. It is a short-run measure because it is based on returns, which are a short memory process (Alexander et al., 2001). As a result, correlation then becomes an inadequate measure of diversification because it does not suffice to ascertain the presence of a long-run stationary relationship between two variables (Ahmed et al., 2017). Ahmed et al. (2017) then argue that a co-integration analysis must be performed to determine whether an equilibrium exists. Co-integrated variables share a common stochastic trend, meaning they are tied together in the long run (Waston, 1988). This means that co-integration can also be used to ascertain the existence of co-movement between variables. Therefore, in line with MPT, assets that have limited or no co-movement can be used to attain portfolio diversification. Accordingly, this gives rise to the hypothesis we want to test in this study which states that sectors that are not cointegrated offer diversification benefits.

The relevance of Modern Portfolio Theory on sector portfolio diversification is to ascertain sector indices that do not co-move together over time which can, therefore, be combined in a portfolio in order to reap diversification benefits. When sector co-movements have been established, investors should then construct a portfolio and diversify across different securities with limited co-movement. The construction of a diversified portfolio enables investors to improve portfolio efficiency, which is to minimize risk per given return or to maximize returns per given level of risk. Succinctly, portfolio efficiency is the ultimate goal of Modern Portfolio and it is achieved through constructing a diversified portfolio with securities that have limited co-movement.

2.3 Diversification and business cycle approach to equity sector investing

Business cycles are fluctuations in the aggregate economic activity that drive fundamentals that affect asset prices (Vervuurt, 2016). Over the intermediate term, asset performance is often driven by cyclical factors tied to the state of the economy. Therefore, each asset has unique cash flow and risk characteristics during different phases of the business cycle. The business cycle, which encompasses the cyclical fluctuations in an economy over many months or a few years, can therefore be a critical determinant of equity market returns and the performance of equity sectors (Fidelity, 2019). Different sectors of the stock market tend to lag the overall market in an upswing or a downswing. Cyclical sectors such as industrials and financials, for example, tend to outperform the overall market during the upswing, while defensive sectors such as health and telecom will outperform the overall market during the downswing phase (Embsdo-Mattingly et al., 2017).

Business cycle analysis provides investors with insight on the direction of the financial markets (Owen and Griffiths, 2006). This is essential information that they need before they start making decisions on the appropriate allocation of sectors within their portfolios. By setting stock selection within the context of cyclical analysis, investors will know whether it is appropriate to chase momentum or pursue a more defensive strategy (Dzikevičius and Vetrov, 2012). A business cycle approach also allows investors to formulate strategic asset allocation targets and adjust these tactically when the cycle changes. In this way, this approach allows investors to spot the turning points and shift asset allocation between various asset classes accordingly.

Academic literature contains some evidence that the expected returns and volatility of asset classes vary through time. In their study, Van Vliet and Blitz (2011) state that the risk and return properties of asset classes are highly dependent on the prevailing business cycle phase. Velázquez and Smith (2013) found that expected stock returns in the UK are related to long and short variations in the business cycle, implying that there is a significant relationship between business cycle indicators and excess equity market returns in the UK. Their study examines if dissimilarities in asset classes behaviour over the business cycle can be used to add value to portfolio optimisation.

In the same light, a study by Farroukh (2016) which focuses on the European bloc found evidence that country-level business cycles fail to predict stock returns whereas the aggregate Eurozone business cycle demonstrated a significant predictive ability for country-level equity market excess returns. This is due to that fact that stock market wealth accounts for a much lower percentage of household's wealth in Continental European countries which means that the European BC is a bigger driver of country index stock returns. A comprehensive study by Muchaonyerwa and Choga (2015) sought to investigate the link between the business cycles and stock market performance in South Africa. Their results also arrived at similar findings that there is a significant association between stock market performance and the business cycles which implies that economic fluctuations in SA propagate the equity market.

Dzikevičius and Vetrov (2012) looked at the integration of the business cycle approach into the construction of optimal investment portfolios and found that risk and return properties of asset classes vary considerably across business cycle phases. For that reason, their study suggested a practical investment framework for dynamic asset allocation across the business cycle. In this study, the integration of the business cycle approach into the construction of diversified portfolios (i.e. portfolio optimization) is also premised on the basis that equity market sector performance is tied to the state of the business cycle. Every cycle is different and therefore portfolio diversification opportunities will also tend to vary with the business cycle. These variations in diversification opportunities over the business cycle raise the need to take on cyclical rebalancing or cyclical asset allocation in order to keep the portfolio optimized throughout the phases of the business cycle (Dzikevičius and Vetrov, 2012). With an understanding of how certain sectors have typically performed during each phase of the business cycle, investors may be able to position their portfolios optimally (Hogue, 2019).

According to Dzikevičius and Vetrov (2012), the historical simulation of cyclical asset allocation strategies shows a better performance of active versus passive investment strategies on the basis of risk and return measures. Passive portfolio risk and return for example change considerably with the phases of the business cycle (Dzikevičius and Vetrov, 2012). This fact reveals that in the absence of cyclical rebalancing, investment benefits enjoyed during recoveries, expansions and slowdowns are substantially diluted during downturns (Dzikevičius and Vetrov, 2012). As a result, a passive management approach can result in a less than optimal return/risk profile over a complete business cycle. Grobys (2012) also confirms that, when taking into account the business cycle phases, active strategies perform better than the passive ones.

Based on the fact that the risk and return performance of equity market sectors is tied to the state of the business cycle and also considering that diversification opportunities vary with the business cycle. This study suggests that investors should adopt a practical portfolio construction framework for dynamic sector allocation across the business cycle to continuously attain portfolio optimization despite the state of the economy.

2.4 International portfolio diversification

Following the concept of diversification as suggested by Markowitz's Modern Portfolio Theory (1952), it became apparent to investors that portfolio diversification could be achieved by combining securities with limited co-movement over time. Investors then began to diversify their portfolios domestically and later on the concept of international diversification also began. The early emerging consensus was that international portfolio diversification was more effective compared to domestic portfolio diversification (Heston and Rouwenhorts, 1994). However, due to the increasing integration and globalization of markets, there is evidence that correlations have been not only unstable but also increasing over the years (Hatemi-J and Roca, 2006). Consequently, international diversification opportunities were reduced (Hyde et al., 2007; Quinn and Voth, 2008 & Tavares, 2009).

The preliminary work on international diversification was undertaken by Grubel (1968), Levy and Sarnat (1970), Solnik (1974) and Lessard (1974). They focused on the existence and degree of potential benefits from exploiting low cross-country correlations between securities returns through diversification as suggested by Modern Portfolio Theory. The overall conclusion was that the correlations between stock markets were low, meaning investing in capital markets of other countries provided good diversification opportunities to investors and lower risk without sacrificing return. Levy and Sanat (1970) found that diversification benefits on developed markets were not very significant relative to emerging markets.

As more studies on portfolio diversification began to emerge in support of international diversification, risk reduction by international portfolio diversification increased prominence. Resultantly, finance academics and practitioners became more aware that sovereign risk could be sufficiently minimized by cross-border investments if the returns of cross-country correlations are low (Zafaranloo and Sapian, 2013).

From the perspective of Nordic investors, Haavisto and Hanson (1992) found the existence of international portfolio diversification benefits during the period 1970 – 1988. From the point of view of the US and Japanese investors during the period 1978 – 1989, Eun and Resnick (1994) found international diversification benefits to be significant for both investors; however, they were more significant for US investors. A study by Lijeblom et al. (1997) also focused on Nordic investors' diversification benefits into seventeen OECD markets and Hong Kong during the periods 1974 – 1986 and 1987 – 1993 and confirmed the results of Haavisto and Hanson (1992).

Erb et al. (1994) examined the cross-country correlations of the G-7[4] countries and found that correlations were highest when any two countries are in a recession, and lower during a growth phase. The study also suggested that the business cycle is a key determinant of the variations in correlations over time. Furthermore, a study by Longin and Solnik (1995) on the dependence structure of international equity markets from 1958 to 1996 found that correlations increased in bear markets relative to bull markets. Therefore, the duo suggested that correlation is not related to market volatility per se but to the market trend. In addition, the overall implication of these results is that international diversification is least effective when needed the most. In a different light, Hanna et al. (1999) found that in the 1990s international diversification by American investors into six foreign developed countries could not result in any diversification gain because the returns from these six countries were lower than those in the US.

It is rational to aver that international diversification was ignited at the onset of globalization and with simultaneous changes in financial technology and financial reforms in the 1970s hurdles in financial transactions among stock markets began to dissipate. For that reason, the 1970s saw a rising trend in cross-border diversification (Ahmed et al., 2017). Credible affirmation of the increasing trend in cross-border diversification was well documented in a book published by The World Bank in 1997[5]. The book states that, when the world financial markets transformed to global marketplaces, investors saw an opportunity to diversify their portfolios across various developing countries to achieve higher returns and minimize risk (World Bank, 1997).

On the contrary, when globalization was fully matured, international stock markets became more integrated causing diversification opportunities to shrink (Ahmed et al., 2017). Using the Engle Granger co-integration method, Masih and Masih (2002) examined the degree of integration among the six major stock markets[6] before and after the upsurge of globalization that occurred in the 1980s. Their study found that these stock markets became more

[4] France, USA, Japan, Canada, Italy, Germany and United Kingdom
[5] Private Capital Flows to Developing Countries: The Road to Financial Integration.
[6] United States (US), Japan (JPN), United Kingdom (UK), Germany (GER), Canada (CAD) and Australia (AU)

integrated post globalization, indicating that the opportunities for cross-border diversification had been minimized, possibly against the backdrop of globalization.

The spill-over effects experienced during all the market crashes support the evidence of integrated global financial markets. A spill-over effect happens when two or more markets are integrated such that if one market crashes the consequences are that the other market(s) will face the same turmoil (Nath and Verma, 2003). Wong et al. (2004) assert that the integration among the stock markets of different countries increased after the Wall Street crash in 1987. In the same line of argument, Ahmed (2012) also asserts that the viability of cross-border portfolio diversification has fallen heavily since the 1987 Wall Street crash. In a slightly different light, Schwebach et al. (2002) observed that the benefits of international diversification declined significantly after the Asian crisis of 1997.

The 9/11 attacks created an u investment environment for internationally diversified investors, with the impact reaching stock markets in the UK, Germany and Japan (Mun, 2005). These attacks were not market-related yet global financial markets almost came to a halt due to the extent of integration caused by globalisation. The impact of the global financial crisis (GFC) of 2008 on capital markets across almost all developed and developing economies indicates that international portfolio diversification is not necessarily as effective as perceived, particularly at the time when it is needed the most like, for example, during a market crisis (Ahmed et al. 2018). The most recent example is the Turkish currency and debt crisis that shook the global markets in 2018. Financial markets have become vulnerable to events that happen outside their economic space at the backdrop of globalisation. The after-effects of all these market crashes or crises serve to demonstrate the extent to which global financial markets are integrated.

Studies on the integration of financial markets have shifted focus from correlation as a determinant of diversification benefits to exploring co-integration analysis (Msimanga, 2010). Correlations have been found to be changing over time. In order to understand the stability of these correlations, it is important to know the causal interaction of the markets. For instance, the unconditional correlation between any two markets can be low and therefore provides international diversification benefits but this can disappear over time if the two markets are found to have a stationary (i.e. stable) long-term relationship. Hence, total reliance on unconditional correlations can be misleading (Hatemi-J and Roca, 2006). Unlike correlation, co-integration refers to co-movements in prices and not returns. The existence of co-integration between two or more stock prices could be seen as evidence of a long-run relationship between these series. With respect to portfolio diversification, the existence of co-integration between two or more stock prices implies that in the long run these prices co-move and therefore, portfolio diversification opportunities are limited.

In contrast, the lack of co-integration implies that there are significant long-run benefits from the reduction of risk without loss in the expected returns (Msimanga, 2010). Following the emergence of co-integration techniques and emerging markets, numerous studies attempted to measure the co-integration of developed, emerging and regional markets. Most of these studies focused on equity markets in developed countries or regions, including the US, Europe and Japan (Ahmed et al., 2017). Rangvid (2001) and Erdinc and Milla (2009) examined stock market co-integration among France, Germany and the UK during the periods 1960 – 1999 and 1991 – 2006 respectively. Both studies documented that the stock exchange markets of France, Germany, and the UK are cointegrated with each other and they have been increasingly integrated since the 1990s.

During the period 1997 – 1998, Aggarwal et al. (2003) found the presence of long-run equilibrium relations between the European markets and the US market by adopting time varying co-integration techniques. Adjasi and Biekepe (2006) suggest the presence of co-integration between African stock markets[7] from 1997 – 2005, therefore implying the existence of long-run relationships between Africa stock markets. A study by Majid et al. (2008) examined the interrelationships among the ASEAN emerging markets[8] and also their relationship with the Japanese and US stock markets over the period the 1988 - 2006. The findings reveal that the Asian region is highly integrated among them and also with the Japanese and US stock markets. The results suggest that long-run diversification benefits that can be gained by investors across the ASEAN markets tend to diminish. These results support

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[7] Botswana, Egypt, Cote d'Ivoire, Ghana, Kenya, Morocco, Mauritius, Namibia, Swaziland, Tunisia, South Africa, Zambia, Zimbabwe

[8] ASEAN – Association of South East Asian Nations, i.e. Malyasia, Thailand, Indonesia, the Philippines and Singapore

the notion of a waning trend in international portfolio diversification benefits due to increased integration of stock markets around the globe.

Balarezo (2010) bivariate and multivariate co-integration results conclude that Brazil, Russia, India, China, Mexico, South Africa, Taiwan, Germany, Spain and Australia offer optimal diversification benefits. However, Balarezo (2010) suggests that England, France, Sweden and Japan should be avoided. Shankar et al.'s (2015) findings suggest that there is no evidence of a pair-wise long-run relationship between Indian stock markets and twelve global stock markets[9] from 2003 – 2015.

According to Golab et al. (2018) co-integration results suggest the presence of long-run relationships between Europe and the significant trading partners, namely the US, China, Japan and Australia for the period 2010 – 2016. The study period captures the impact of the European sovereign debt crisis and the Greek crisis. Granger causality tests reveal that the Asia-pacific region and the US are closely related with each other. There is also interdependence between Europe and other global markets but there is no interdependence among the European countries during the sovereign debt crisis period.

Lu and Ryschkow (2018) applied time-varying co-integration analysis over a period of 20 years from 1997 – 2018, with two sub samples: pre-crisis (1997-2008) and post-crisis (2009 – 2018). The full sample results reveal no co-integration between China, Europe and Russia. Additionally, there were no long-run relationships found between all these markets in the pre-crisis period. However, the post crisis period has shown an increase in co-integration relations between Europe and China, indicating few diversification benefits in contrast to the pre-crisis period.

In the South African context, a number of studies have been conducted to measure SA stock market co-integration with regional and global markets. Piesse and Hearn (2002) found that the South African and SACU equity markets are cointegrated using the ARDL co-integration analysis from January 1990 to January 2000. Msimanga (2010) show that emerging markets[10] co-move together over time suggesting that emerging markets offer limited diversification benefits to South African investors. The study was conducted over the period 1998 – 2008

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[9] US, European Union, UK, Australia, Japan, Mexico, Brazil, China, Malaysia, Canada, Singapore and Thailand
[10] Amman, Athens, Brazil, India, Israel, Korea and Russia

using the Johansen co-integration and the Vector Error methodology to ascertain whether there are diversification benefits.

Kabundi (2015) conducted a comprehensive study using Asset Pricing theories and factors to analyse the integration of South Africa with the world. The study period spans from May 1998 to December 2014. The findings revealed that the South African stock market is much more integrated with the global markets than the bond and currency markets, also suggesting limited opportunities for international diversification. Kabundi (2015) also concludes that the South African financial market as a whole is integrated with world markets.

Despite the drawbacks of correlation in measuring diversification, finance academics and practitioners have not shunned it, largely because it is the conventional approach of portfolio risk management (Alexander et al., 2001). Studies by Swart (1999) and Wade (2014) advocate that South African investors can reap international diversification benefits as South Africa has a low correlation with international markets. The study by Wade (2014) was more specific in mentioning that South African investors seeking to maximize returns and minimize risk should diversify particularly in developing economies. Nonetheless, these findings do not provide any evidence of a stationary long-run relationship; therefore, we cannot conclude that the benefits of diversification are unlikely to be eroded for South Africans over the foreseeable future. Hence, studies based on co-integration provide a reliable platform to make such a conclusion as opposed to correlation.

Ampomah (2008) used co-integration to examine the nature and extent of linkages between African stock markets and global indices from January 1998 to December 2007. The study used S&P indices for 10 African countries[11] and the S&P Global 1200 index as a proxy for the global benchmark. This paper found that all the African stock markets are not integrated with global markets except for South Africa stock market, JSE[12]. The JSE is the largest and most liquid stock exchange in Africa which attracts cross border investments hence it is integrated with global markets (Dabengwa, 2017).

Kapingura et al. (2014) investigated the extent to which the South African stock market is integrated to other African stock markets (i.e. Nigeria, Botswana, Egypt and Mauritius) as well

[11] South Africa, Egypt, Morocco, Nigeria, Kenya, Botswana, Ivory Coast, Ghana, Mauritius and Tunisia
[12] Johannesburg Stock Exchange

as developed markets represented by the US, Japan and German. They used the ARDL approach to co-integration for the period 2000 – 2010. Their findings suggest that the South African stock market is fully integrated into the developed markets. However, it is not fully integrated to other African stock markets (i.e. Egypt and Namibia, suggesting investors may possibly reap diversification on these African stock markets.

Arif et al. (2017) also applied the ARDL (Auto Regressive Distributive Lag) co-integration approach to explore the benefits associated with international portfolio diversification among BRICS-P[13]. The sample period spans from November 2003 to October 2016. The findings show that substantial long-run and short-run portfolio benefits exist when the securities of Brazil, Russia, South Africa and China are merged. Moreover, Pakistan and India's stock markets are cointegrated; therefore, investors may only reap short-run diversification benefits.

The basis of the argument is not to claim that international diversification is extinct, which is unlikely to happen, but to assert that, though international diversification is still present as the results of Lu and Ryschkow (2018) and Balarezo (2010) have shown, it is no longer as effective as it used to be. The ineffectiveness of an international portfolio is dependent on the degree of integration between financial markets. Studies by Rangvid (2001) and Erdnic and Milla (2009) have argued that stocks markets have been increasingly integrated since the 1990s, hence international portfolio diversification has become less effective.

The gains from international diversification have been declining since the inception of globalization. In as much as cross-border diversification benefits are present, they are very much limited now at the backdrop of increasing integration between financial markets across the globe. As a result, risk-averse investors are most likely compelled to search for diversification opportunities elsewhere. In this case, literature in the next section is urging investors to shift their focus to domestic sector portfolio diversification.

To sum up, even though some literature has documented the non-existence of integration between various national stock markets, it is undeniable that the global financial markets have increasingly become integrated hence reducing opportunities for international diversification.

[13] Brazil, Russia, India, China and South Africa – Pakistan (BRICS-P)

2.5 Domestic sector portfolio diversification

Pursuant to prior submissions on the ineffectiveness of international portfolio diversification, there are studies that have compared the effectiveness of cross-border diversification with domestic diversification, also known as home bias. Domestic sectoral diversification was not regarded to be important in risk reduction; however, growing literature suggests that since the mid-1990s the relative benefits of cross border diversification and sectors may have changed (Utharntharm, 2003).

Errunza et al. (1999) present interesting findings in support of domestic diversification. Their study suggests that the benefits of cross-border portfolio diversification were statistically and economically insignificant in comparison to domestic portfolio diversification. In the same line of argument, Cavaglia et al. (2000) show that the Sharpe ratios of portfolios diversified across industries are better than those for portfolios diversified across countries. These studies establish that incremental gains from international portfolio diversification over domestic portfolio diversification have diminished (Ahmed et al., 2017).

Following the increased integration and reduced diversification across global financial markets, investors and academics have shifted their focus to the diversification opportunities available domestically. Arbelaez et al. (2001) investigated the short-run and long-run relationships among sector indices of the Colombian Stock Market. The study collected daily data for six sector indices, spanning the period between January 1988 and August 1994. These sector indices are general, industrial, financial, commercial, various and select. The Johansen co-integration method was employed, and it provided substantial evidence of no long-run co-integration amongst the sector indices. These findings entail that the Colombian Stock Market offers sectoral diversification benefits. Gee and Karim (2005) investigated the degree of integration among five sectors of the Kuala Lumpur Stock Exchange in Malaysia. Using daily and weekly data over three periods (pre-crisis, crisis and post-crisis), the researchers employed multivariate co-integration and causality tests.

The results show that there exists a short-run causality relationship between the sectors in the Malaysian stock market for the whole period under study. The daily price movement in the construction sector is found to lead the daily price movement from other sectors for the period before and after the financial crisis. However, the trend of causal relationships shifts during the 1997 Asian financial crisis in which the financial sector plays a major role in influencing the price movement of other sectors. These results indicated that there are limited sectoral diversification benefits in Malaysia.

Using the Johansen co-integration test, a high degree of interdependence was found to exist for the period 1993 – 2001 among the major sector indices on the Shanghai and Shenzhen stock exchange (Wang et al., 2005). These findings imply that potential long-term diversification benefits among the sectors are limited. Moreover, short term causality tests found that the Industrial Index is the most influential sector in both exchanges, while on the Shenzhen stock exchange the Financial Index is least integrated with other sectors, implying that it offers short-term diversification opportunities within the Chinese stock market.

Meric et al. (2005) argued that international portfolio diversification has better opportunities opposed to domestic sector portfolio diversification. Their study analysed the co-movements of sector index returns in the world's major stock markets[14] in bull (1997 – 2000) and bear (2000 – 2002) markets using principal component analysis and Granger-causality tests. They found that in a bull market investors can obtain more benefits with global diversification than with domestic sector diversification even if they invest in the same sector in different countries as opposed to investing in different sectors within the same country. In a bear market, the sectors of different countries tend to be more closely correlated and country diversification opportunities are limited. The credibility of the principal component analysis is questionable since it involves the use of correlations which have been found to be an erratic and unreliable measures of diversification benefits (Hatemi-J and Roca, 2006).

Despite the strong criticism of correlation in examining diversification benefits, Mohamad et al. (2006) employed correlation to analyse diversification benefits across different sectoral indices of the Kuala Lumpur Stock Exchange composite index in Malaysia. The empirical results

[14] US, UK, German, French and Japanese

indicate high and unstable correlation relationships between different industry sectors. This implies that there are no substantial sectoral diversification benefits in Malaysia.

Up to this point, literature has mixed results with regards to the existence of domestic sectoral diversification opportunities. However, there is a reasonable amount evidence of sectoral diversification benefits as shown below by Constantinou et al. (2008), Noor et al. (2014) and Ahmed et al. (2017 & 2018). It is worth noting that most of the studies which found the evidence of sectoral diversification benefits were conducted during and after the 2007 – 2008 Financial Crisis.

Constantinou et al. (2008) undertook a study from the perspective of a Cypriot investor who is interested in domestic portfolio diversification, using the pairwise Johansen co-integration technique. The study used daily price index data for 12 sectors[15] listed on the Cyprus Stock Exchange (CSE) from 1996 to 2002. Their findings suggest there was no evidence of co-integration in most bivariate cases, inferring that the CSE offers opportunities for sectoral portfolio diversification. To construct a diversified portfolio these results, suggest that investors should identify sector pairs (e.g. Energy and Health) that are non-cointegrated and then select stocks from these respective sectors.

Al-fayoumi et al. (2009) investigated the degree of sectoral integration in the Amman stock exchange (ASE) in Jordan with daily data spanning from September 2000 to August 2007. The sectors used were General, Financial, Industrial and Services. The multivariate co-integration analysis suggested that the four sector indices share one long-run equilibrium relationship. In addition, Granger causality results provide evidence of bidirectional relationships amongst all sectors, except the Services sector. Therefore, the Services sector may offer appealing short-term diversification opportunities within ASE since it is not linked to other sectors. The multivariate co-integration tests do not suffice in examining which sectors are integrated. Therefore, it is probable that, if bivariate co-integration tests had been conducted just like in the study by Constantinou et al. (2008), a substantial amount of sectoral diversification benefits could have been found.

[15] Banks, Construction, Fisheries and Fish trading companies, Investment companies, Manufacturing, Insurance, Hotels, Tourist services, Real estate, Informatics, Financial services and Others

Ahmed (2012) examined the short-run and long-run relationship among 12 sectors of the Egyptian stock market, using daily sector indices data from 2007 – 2010. Applying multivariate co-integration and Granger-causality tests, Ahmed (2012) found that the stock market offers diversification opportunities in the short-run, whereas the long-run diversification opportunities are limited. Once again, if bivariate co-integration tests were conducted they could have found a significant amount of sectoral diversification.

A study by Katzke (2013) looked at the dynamics of return co-movements between the largest economics sectors in South Africa, with a view to shed a light on the inter-sectoral diversification opportunities of domestic investors over time. The study period spans from 2002 – 2013 and it employed Dynamic Conditional Correlations (DCC) and Asymmetric Dynamic Conditional Correlations (A-DCC) derived from a Multivariate GARCH model. Significantly high correlations were found from both the DCC and A-DCC, suggesting the absence of substantial diversification opportunities. Furthermore, the results also suggested that periods of heightened global and domestic market uncertainty magnify the co-movements between sectors. As a result, it undermines the ability of investors to diversify across local sectors.

Although the study was done on South Africa, it did not consider bivariate co-integration and Granger-causality tests which are regarded to be more appropriate in examining the integration between sectors and identifying inter-sectoral diversification benefits (Ahmed et al., 2017 and 2018). Katzke (2013) focused more on conditional correlations as measures of diversification as opposed to the conventional correlations to improve the robustness of the results. However, in general correlation is inadequate in measuring portfolio diversification benefits because they are based on returns which are short-term memory processes, hence making it difficult to examine long-run relationships between sectors (Alexander et al., 2001). In addition, the study was also not undertaken over the business cycle, which this study focuses on.

Noor et al. (2014) examined the integration among ten sectors of the Bombay Stock Exchange (BSE), using daily sector indices data for 2010 – 2013. To capture the interdependence among sectors, the authors employed the pairwise co-integration and Granger-causality tests. They found no co-integration in all sector pairs of BSE except the pairs of Banking and IT and

Consumer Durables and Reality. Granger-causality tests suggest a high degree of independence between the sectors because in most bivariate cases the null hypothesis of no pairwise causal relationship was not rejected at the conventional level of significance. Ultimately, the results suggest the presence of diversification opportunities over both the long-run and short-run investment horizons in India.

Ahmed et al. (2017) examined the sectoral integration among the ten sectors on the Karachi Stock Exchange (KSE) seeking to find domestic portfolio opportunities. Their study used market value-weighted index and daily stock price data for 2001 – 2014. Applying the pairwise co-integration, the study found that, apart from automobiles and cement, all other sectors listed on the KSE provide good diversification opportunities. The Granger-causality revealed signs of high independence between sectors. These results infer that domestic investors can benefit from diversifying their investments in both the long run and short run across different sectors.

Ahmed et al. (2018) examined the diversification opportunities within sectors of Colombo Stock Exchange (CSE) by measuring co-integration among sectors. The study also applied Granger-Causality test to determine which sectors of CSE cause other sectors. Ahmed et al. (2018) employed daily closing indices of all sectors listed on the CSE during the period January 2013 to August 2016. Pairwise co-integration tests reveal that none of the sectors are cointegrated. The Granger-causality test revealed signs of moderate independence between sectors. As a result, diversification opportunities can be reaped in both the long run and short run; however, long-run opportunities are more significant.

2.5 Conclusion

Markowitz's work modernized the practice of investment management in the late 1950s. Before the inception of the MPT, investors focused mainly on evaluating the risks and rewards of individual securities. The guidelines used by investors to construct portfolios were purely judgment and experience. When Markowitz (1952) brought the idea of diversification, he emphasised that the main focus of the Modern Portfolio Theory is that securities could not be selected only on characteristics that were unique to the security. Instead, investors should consider how each security co-moved with all other securities and select a portfolio with risky securities that have limited co-movement.

In portfolio diversification, there are two main forms: - international and domestic. This chapter presents a critical examination of both forms of diversification. However, the examination was skewed towards accepting domestic bias more than cross border diversification. The bias towards domestic diversification is premised on the reasoning that global financial markets have become more integrated; hence, international portfolio diversification benefits have diminished. On that account, domestic sectoral diversification is recommended when pursuing portfolio diversification vis-à-vis cross border diversification.

This chapter reveals that there is scant literature on domestic sectoral diversification opportunities in the context of South Africa and in general. However, with regards to cross-border diversification opportunities several studies have measured the degree of co-integration between South Africa and other stock markets in developed and emerging markets. As a result, this study attempts to investigate the co-integration and causal relationships between the sectors of the South African equity market in order to find clues on domestic diversification opportunities. The findings of this study are expected to guide investors in diversification decisions in order to minimize portfolio risk. To enhance the meaning of the co-integration results, the study was conducted over different phases of the business cycle. Chapter three provides an in-depth analysis of the business cycle and sectors.

3

Analysis of the Business Cycle and Sectors

3.1 Introduction

The aim of this chapter is to provide insight into the performance of sectors over the different phases of the business cycle since sectors have a tendency to perform differently in different phases. The chapter starts with a presentation of business cycle phases, followed by technical and fundamental analysis of the South African business cycle. Thereafter, the chapter proceeds to define the stock market sectors and then presents the performance metrics of the sectors throughout the business cycle over the last 10 years. Modern Portfolio Theory states that investors should consider both the characteristics and relationships between securities when building portfolios. Hence, this chapter is looking at the performance metrics of sectors to have an understanding of general characteristics of the stocks found within each of the equity market sectors in South Africa. In chapter five, the relationships between the securities will be examined.

3.2 Understanding business cycle phases

A business cycle is a cycle of fluctuations in economic activity. These cyclical fluctuations are essentially distinct changes in the rate of growth in economic activity, particularly changes in three key cycles – the corporate cycle, the credit cycle and the inventory cycle – as well as changes in the employment backdrop and monetary policy. Changes in these key indicators provide a relatively reliable guide to recognizing the different phases of a business cycle (Embsdo-Mattingly et al., 2017). There are four distinct phases of a typical business cycle – recovery, expansion, boom and recession. In this study, the analysis of the South African business cycle discovered five distinct phases instead of the conventional four phases. The fifth phase is stagnation and the probable reason it does not form part of the conventional business cycle could be that it can occur at any time of the business cycle (Chappelow, 2019). Table 3.1 provides a description of these different phases and key fundamental guidelines to be followed when ascertaining the different phases of the business cycle. Figure 3.1 gives a graphical presentation of the different phases of the business cycle.

Table 3.1 Understanding Business Cycles

Expansion	Boom	Recession	Recovery	Stagnation
✓Growth peaking ✓Credit growth strong ✓Profit growth peaks ✓Monetary policy neutral ✓Inventories, sales grow, equilibrium reached	✓Growth moderating ✓Credit tightens ✓Earnings under pressure ✓Monetary policy contractionary ✓Inventories grow, sales growth falls	✓Falling activity ✓Credit dries up ✓Profits decline ✓Monetary policy eases ✓Inventories, sales fall	✓Economic activity rebounds (GDP, IP, employment, incomes) ✓Credit begins to grow ✓Profits grow rapidly ✓Monetary policy still stimulative ✓Inventories low; sales improve	✓Slow or muted (flat) economic growth ✓High unemployment ✓Termed the Stationary State by classical economists ✓An absence of market highs and lows

Source: Embsdo-Mattingly et al. (2017)

3.2.1 Business cycle dating approach

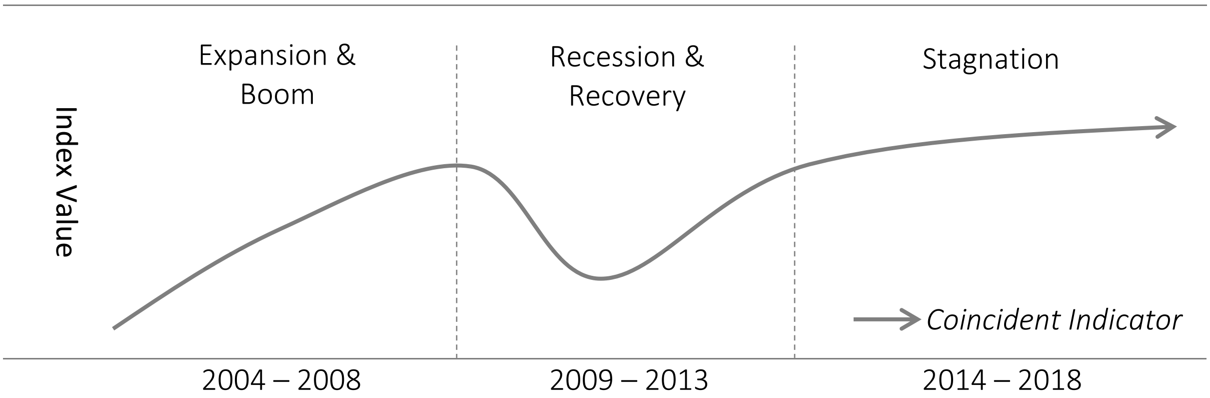
A study by Bosch and Ruch (2012) applied a Markov switching model to yearly GDP (Gross Domestic Product) to provide an alternative classification of the South African business cycle. The study found that the model estimates generally coincide with the dating of SARB's business cycle turning points. Bismans and Le Roux (2013) also conducted a similar study applying the Markov switching model to the real quarterly GDP and their results were similar to the study by Bosch and Ruch (2012). For simplicity sake, this study used the SARB dating approach as presented in the economic reports from the period 2004 – 2018.

However, instead of just picking turning points of the South African business cycle from SARB, it seemed necessary to also give a brief economic overview of each cycle phase as presented in the annual economic reports of the SARB and then compare it to the key fundamentals of business cycle phases presented by Embsdo-Mattingly et al. (2017) in table 3.1.

Therefore, note ✓ on table 3.1 serves to confirmation that the key fundamentals of the business cycle phases by Embsdo-Mattingly et al. (2017) match with the economic fundamentals stipulated by the SARB in its economic reports over the period 2004 - 2018.

Figure 3.1 illustrates the South African business cycle and its phases as shown by SARB in its economic reports over the period 2004 – 2018.

Figure 3.1. South African Business Cycle



Data Source: SARB

3.2.2 Brief overview of South African business cycle phases

- Expansion and boom (2004 – 2008)

The performance of the South African economy in the period 2004 – 2008 was solid and consistent (SARB, 2008). The annual economic report by the SARB (2006) noted that in 2005 real GDP registered more than 23 quarters of uninterrupted increase and recorded a real growth rate of almost 5 per cent, the strongest since 1984. This economic expansion in 2005 formed part of a sustained and robust upswing since 1984, making it the longest in the South Africa business cycle history.

Due to inflationary pressures poised by the strong economic growth, the SARB started a cycle of tightening the monetary policy in the second half of 2006. In 2007 the repo rate was increased four times and twice in 2008 an indication that the economy was heating up (SARB, 2008). Prior to 2006, the monetary policy stance was slightly stimulative with the repo rate having been reduced by 1% over the period of three years.

The annual economic report by the SARB (2008) highlighted that real inventory accumulated almost uninterruptedly for nearly ten years. The same report also revealed that growth in total loans and advances extended to the private sector slowed in twelve months to June 2008 as lending and lending conditions became unfavourable due a tight monetary policy stance by the SARB. These economic developments during the period 2004 – 2008 match the characteristics of an expansion and boom phase.

- Recession and recovery (2009 – 2013)

The longest business cycle upswing on record came to an end in 2007 and in 2008 the economy lost its momentum. Real growth ran out of steam in the first three quarters of 2008, falling below trend and signalling the onset of a downswing that intensified as growth subsequently turned negative. In the second quarter of 2009 real GDP shrank by 3% compared with its recent peak in the 3rd quarter of 2008, reflecting the negative impact of the deep recession in the world economy (SARB, 2009).

Consequently, firms experienced a series of decline in sales leading to reduced levels of real inventory levels (SARB, 2009). Rapid declines in inventories were registered in both the second half of 2008 and the first half of 2009. The unemployment rate rose to 23.6% in the second quarter of 2009. Growth in total loans and advances extended to the private sector slowed significantly throughout 2008 and slipped to near record lows in early 2009. As of result of falling economic activity, the SARB started a cycle of monetary policy easing in December 2008. The Monetary Policy Committee (MPC) reduced the repurchase rate by 50 basis points, followed by a 100-basis point reduction in the 1st quarter of 2009 and the repo rate was left unchanged at 7.5% at the conclusion of the June 2009 MPC meeting (2009).

In the 1st quarter of 2010, the repo rate was further reduced by 50 basis points against the backdrop of continued weakness in domestic household consumption expenditure. In the 4th quarter of 2010, economic growth responded to the accommodative Monetary Policy easing as real GDP grew at an annual rate of 4.4%. As a result, domestic economic growth prospects improved, and the inflation outlook was more upward. In 2011, MPC left the repo rate unchanged as they expected the economy to continue to recover and inflation was viewed as likely to remain within the inflation target range over the forecast period (SARB, 2011). In May 2011 the MPC meeting noted the sustained domestic economic recovery, which remained moderate and without signs of a significant increase in employment. The gross domestic product came out at 3.1%. Monetary policy remained unchanged, with the repo rate held at 5.5% per annum (SARB, 2011).

In 2012, the economy decelerated but GDP growth remained positive (SARB, 2012). However, in 2013 the economic recovery lost its growth stint, marking an end to the recovery phase. Domestic growth remained subdued and insufficient to make inroads into unemployment.

Surprisingly GDP had better than expected fourth-quarter results in 2012 (SARB, 2012). Monetary policy remained accommodative with the repo rate unchanged at 5.5% per annum anticipating that the economy would respond again and continue to recover (SARB, 2013).

- Stagnation (2014 – 2018)

In 2014, the economy struggled to reach its potential and unemployment was stubbornly high (SARB, 2014). Since the 2011 post-crisis recovery, the economy started to slow down in 2014. However, it expanded slightly by 1.5% in 2014 (SARB, 2015). The repo rate was increased from 5 to 5.5% per annum in January 2014, after remaining unchanged since July 2012. Credit growth was muted, with bank lending rising at about 3% in real terms in each of the past three years.

In July 2014, the MPC increased the repo rate to 5.75% and then paused the tightening cycle in the 3rd and 4th quarters as the MPC faced the dilemma of stubbornly high inflation in a context of weak economic growth. In 2014, inflation was recorded at 6.1% outside the inflation target range. The economy expanded by 1.3% in 2015 further registering the slowest rate of increase since the Great Recession. Inflation went down to 4.6%, slightly above the midpoint of the target range and the MPC increased the repo rate by 75 basis points taking it to 7% (2015). Real GDP recorded a new post-crisis low as it expanded by 0.3% in 2016. Despite the continuous economic slow-down, inflation was above the 3-6% target range for all but two months, averaging 6.3% in 2016 (SARB, 2016). Real GDP expanded by a moderate 1.3% in 2017; nonetheless the growth rate remained weak historically (SARB, 2017). Unemployment remained persistently high, reaching a peak of 27.7% in the third quarter of 2018 and settling at 26.7% in the first quarter of 2018.

3.3 Understanding sectors

Listed equity sectors are classified according to the Global Industry Classification Standard (GICS). The GICS identified 11 sectors present in an economy. These sectors are - Communication Services, Consumer Discretionary, Consumer Staples, Energy, Financials, Health Care, Industrials, Information Technology, Materials, Real Estate and Utilities (MSCI[16], 2018). The definitions of GICS sectors are as follows:

[16] Morgan Stanley Capital International

- **Communication Services (COM)**

The communication services sector includes companies that facilitate communication and offer related content and information through various mediums. It includes telecom and media & entertainment companies including producers of interactive gaming products and companies engaged in content and information creation or distribution through proprietary platforms (MSCI, 2018).

- **Consumer Discretionary (DIS)**

The consumer discretionary sector encompasses those businesses that tend to be the most sensitive to economic cycles. Its manufacturing segment includes automotive, household durable goods, leisure equipment and textiles and apparel. The services segment includes hotels, restaurants and other leisure facilities, media production and services, consumer retailing and services (MSCI, 2018).

- **Consumer Staples (STP)**

The consumer staples sector comprises companies whose businesses are less sensitive to economic cycles. It includes manufacturers and distributors of food, beverages and tobacco and producers of non-durable household goods and personal products. It also includes food and drug retailing companies as well as hypermarkets and consumer super-centres (MSCI, 2018).

- **Energy (ENG)**

The energy sector comprises companies engaged in exploration and production, refining and marketing, and storage and transportation of oil and gas and consumable fuels. It also includes companies that offer oil and gas equipment services (MSCI, 2018).

- **Financials (FIN)**

The financial sector contains companies involved in banking, thrifts and mortgage finance, specialized finance, consumer finance, asset management and custody banks, investment banking and brokerage and insurance. It also includes financial exchanges and data, and mortgages REITs (Real Estate Investment Trusts) (MSCI, 2018).

- **Industrials (IND)**

The industrials sector includes manufacturers and distributors of capital goods such as aerospace and defence, building products, electrical equipment and machinery and companies that offer construction and engineering services. It also includes providers of commercial and professional services including printing, environmental services, research and consulting services. It also includes companies that provide transportation services (MSCI, 2018).

- **Information Technology (TEC)**

The information technology comprises companies that offer software and information technology services, manufacturers and distributors of technology hardware and equipment such as communications equipment, mobile phones, computers and peripherals, electronic equipment and related instruments, and semiconductors (MSCI, 2018).

- **Materials (MAT)**

The materials sector includes companies that manufacture chemicals, construction materials, glass, paper, forest products and related packaging products, and metals, minerals and mining companies including producers of steel (MSCI, 2018).

- **Real Estate (RET)**

The real estate sector contains companies engaged in real estate development and operation. It also includes companies offering real estate related services and equity real estate investment trusts (REITs) (MSCI, 2018).

- **Utilities (UTL)**

The utility sector comprises utility companies such as electric, gas and water utilities. It also includes independent power producers and energy traders and companies that engage in generation and distribution of electricity using renewable sources (MSCI, 2018).

3.4 Looking at sectors throughout the business cycle

MPT states that investors should consider both the characteristics and relationships between securities when building portfolios. Therefore, the purpose of this section is to present the general characteristics of stocks found within each of the equity market sectors in South Africa. In chapter five, the relationships between the securities will be examined.

The performance of equity market sectors has a tendency of rotating as the overall economy shifts from one phase of the business cycle to the next, with different sectors assuming performance leadership in different economic phases. Due to structural shifts in the economy, technological innovation, varying regulatory backdrops and other factors, no one sector has behaved uniformly for every business cycle (Embsdo-Mattingly et al., 2017). See Table 3.2 for typical performances of sectors over the business cycle.

Table 3.3 displays the alpha of South Africa sectors over the business cycle and it affirms that sectors perform differently over different phases of the business cycle. In this case, alpha measures the extent of outperformance or underperformance, therefore (++) or (+) represent outperformance and (--) and (-) represent underperformance. It is worth noting that the results displayed in table 3.3 almost match the typical or conventional performance of sectors over the different phases of the business cycle as presented in Table 3.2.

Table 3.2 Typical Performance of Sectors over the Business Cycle

	Expansion	Boom	Recession	Recovery
Outperform	Economically Sensitive	Defensive and Inflation Sensitive	Defensive	Economically and Interest Rate Sensitive
Underperform	Defensive	Economically Sensitive	Economically Sensitive	Defensive
Outperform	• Industrials • Information Technology	• Consumer Staples • Energy • Health Care • Materials • Utilities	• Consumer Staples • Health Care • Telecommunications • Utilities	• Consumer Discretionary • Financials • Industrials • Information Technology
Underperform	• Materials • Utilities	• Consumer Discretionary • Information Technology	• Industrials • Information Technology • Financials • Materials	• Energy • Telecommunications • Utilities • Health Care • Consumer Staples

Source: Embsdo-Mattingly et al., 2017

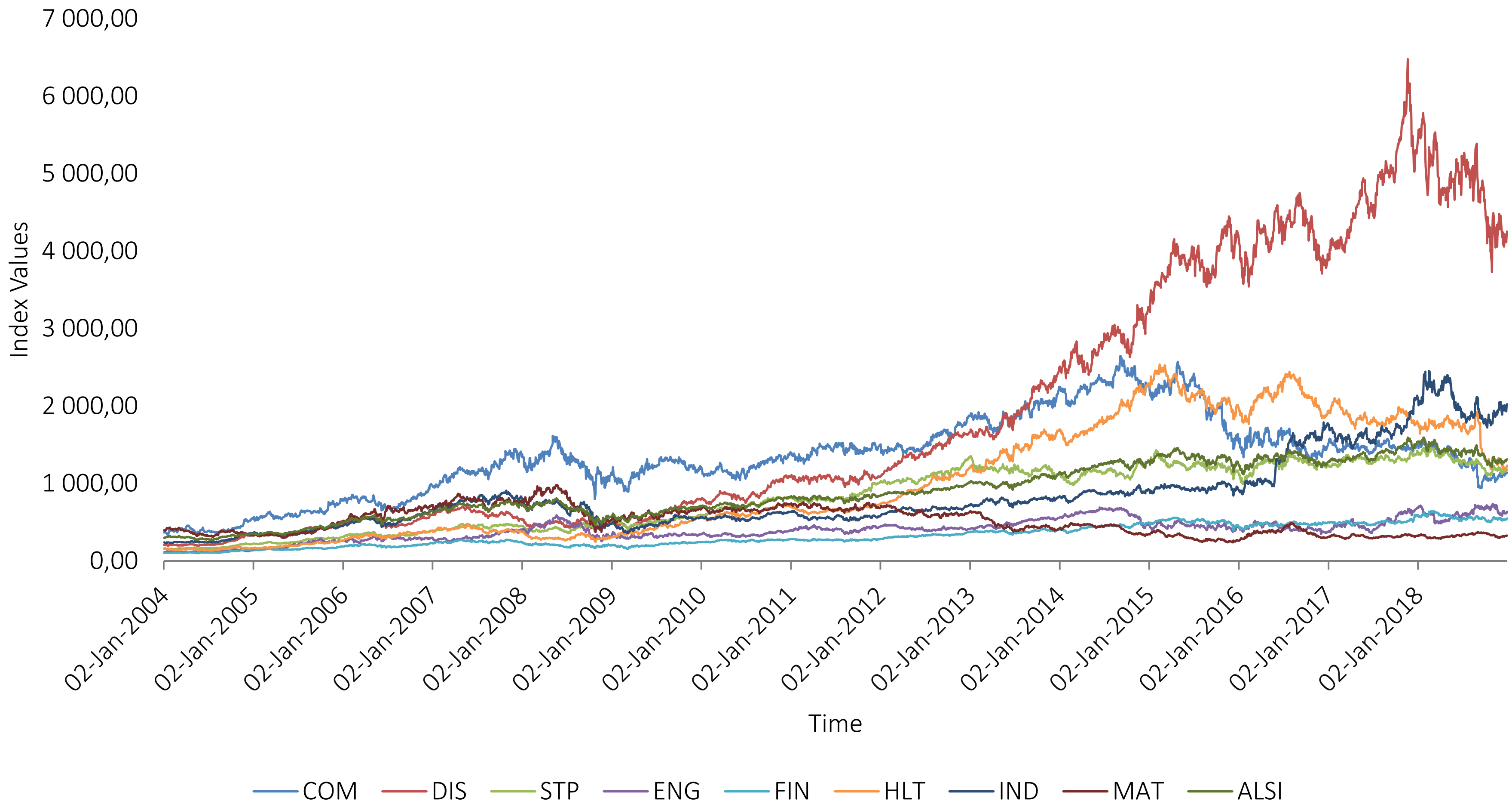
Table 3.3 MSCI South African Sectors Alpha Performance (+/-)

MSCI SA Sectors	2004 - 2018 Full Sample	2004 - 2008 Expansion and Boom	2009 – 2013 Recession and Recovery	2014 – 2018 Stagnation
Communication Services	-	++	+	--
Consumer Discretionary	++	++	++	++
Consumer Staples	+	++	++	-
Energy	+	++	-	+
Financials	+	+	+	+
Health	++	+	++	--
Industrials	++	+	-	++
Materials	--	--	--	--

alpha return (annualized) greater than 10%	++
alpha return (annualized) less than 10% but greater than 0%	+
alpha return (annualized) less than -10%	--
alpha return (annualized) greater than -10% but less than 0%	-

Source: Author

Figure 3.2 Historical Performance of Sector Indices



Data Source: Thompson Reuters

COM ~ Communication Services; **DIS** ~ Consumer Discretionary; **STP** ~ Consumer Staples; **ENG** ~ Energy; **FIN** ~ Financials; **HLT** ~ Health; **IND** ~ Industrials; **MAT** ~ Materials; **ALSI** ~ South African All Share Index

Table 3.4 MSCI South African Sectors Alpha Performance

2004 - 2018	2004 - 2008	2009 – 2013	2014 – 2018	
Full Sample	Expansion and Boom	Recession and Recovery	Stagnation	Sectors
-9,10%	25,10%	3,79%	-19,32%	Communication Services
28,51%	12,59%	42,34%	17,35%	Consumer Discretionary
3,38%	26,36%	10,09%	-2,59%	Consumer Staple
2,41%	22,60%	-4,22%	8,03%	Energy
4,86%	4,40%	2,74%	6,28%	Financials
14,11%	8,13%	51,94%	-12,67%	Health
14,38%	5,35%	-1,37%	29,60%	Industrials
-17,51%	-10,76%	-28,41%	-10,03%	Materials

Note: Positive = outperformance; Negative = underperformance Source: Author

Table 3.4 displays the extent to which sectors outperformed or underperformed in the South African Equity Market over the different phases of the business cycle as well as the full sample. In the full sample, there are two sectors that underperformed, and these include: MAT (-17.51%) and COM (-9.10%). The rest of the sectors outperformed, and the highest performer was DIS 28.51%. In the expansion and boom, only MAT (-10.76%) underperformed whereas the rest of the sectors outperformed. The highest outperformers were STP, COM and ENG with 26.36%, 25.10% and 22.60% respectively. In the recession and recovery phase, there were three sectors that underperformed, and these were: MAT (-28.41%), ENG (-4.22%) and IND (-1.37%). The rest of the sectors outperformed, and the highest performers were HLT and DIS with 51.94% and 42.34% respectively. In the stagnation phase, four sectors underperformed, and these consisted of: COM (-19.32%), HLT (-12.67), MAT (-10.03%) and STP (-2.59%). The rest outperformed and the highest performer was IND (29.60%).

For the most part, sectors DIS and FIN consistently outperformed whereas MAT consistently underperformed. Finally, these results also reveal that the expansion and boom phases had more sectors that outperformed (7) and the stagnation phase had more sectors that underperformed (4). Overall, the SA equity market sectors performed as expected given the swings in the business cycle.

Table 3.5 MSCI South African Sectors Beta Performance

2004 - 2018 Full Sample	2004 - 2008 Expansion and Boom	2009 – 2013 Recession and Recovery	2014 – 2018 Stagnation	Sectors
1,05	1,07	1,08	0,97	Communication Services
0,98	0,76	0,99	1,29	Consumer Discretionary
0,66	0,57	0,68	0,76	Consumer Staple
1,13	1,23	1,13	0,96	Energy
0,93	0,87	0,96	0,99	Financials
0,65	0,63	0,63	0,68	Health
0,86	0,82	0,89	0,88	Industrials
0,91	1,17	1,04	0,41	Materials
0,89	**0,89**	**0,93**	**0,87**	**Sectors Average**

Note: High Risk ≈ 1 **<** Beta < 1 ≈ Low Risk

Source: Author

Table 3.5 displays the riskiness of the South African equity market sectors over the different phases of the business cycle as well as the full sample. In the full sample, sectors with the highest risk were ENG and COM with betas of 1.13 and 1.05 respectively. Sectors with lowest risk were STP and HLT with betas of 0.66 and 0.65 respectively. In the expansion and boom phase, the sectors with highest risk were ENG, MAT and COM with betas of 1.23, 1.17 and 1.07 respectively, whereas the sectors with lowest were STP and HLT with betas of 0.57 and 0.63 respectively. In the recession and recovery phase, sectors with the highest risk were ENG, COM and MAT with betas of 1.13, 1.08 and 1.04. On the other hand, sectors with the lowest risk were HLT and STP with betas of 0.63 and 0.68 respectively. In the stagnation phase, DIS had a high beta of 1.29 making it the riskiest sector, whereas sectors with the lowest risk were MAT, HLT and STP with betas of 0.41, 0.68 and 0.76.

For the most part, sectors with the highest risk were COM and ENG. This is expected for ENG because it is economically sensitive; however, for COM it is surprising because it is regarded as defensive, i.e. economically insensitive. Sectors with the lowest risk are STP and HLT which is expected because both sectors are known to be economically insensitive. Finally, the results also reveal that the recession and recovery phase had the highest average beta which is expected because this is a period of heightened volatility. On that account, diversification opportunities will be desired more in this phase of recession and recovery compared to other phases of the South African business cycle.

Table 3.6 MSCI South African Sectors Sharpe Ratio Performance

2004 - 2018	2004 - 2008	2009 – 2013	2014 – 2018	
Full Sample	Expansion and Boom	Recession and Recovery	Stagnation	Sectors
0,17	1,21	0,92	-0,35	Communication Services
1,45	1,21	2,43	0,69	Consumer Discretionary
0,70	1,92	1,35	0,18	Consumer Staple
0,44	1,11	0,68	0,33	Energy
0,64	0,95	1,16	0,30	SA Equity Market
0,72	0,94	1,11	0,48	Financials
0,93	0,82	2,75	-0,21	Health
0,97	0,93	0,84	1,13	Industrials
-0,09	0,46	-0,11	-0,08	Materials
0,73	**1,08**	**1,25**	**0,27**	**Sectors Average**

Note: Good performance ≈ 1 < Sharpe Ratio < 1 ≈ Poor Performance.

Source: Author

Table 3.6 displays the Sharpe ratios of SA equity market sectors over the business cycle. As noted earlier, the Sharpe ratio is a measure of risk adjusted returns which is used to ascertain the extent to which returns are optimized per unit of risk (Surya and Natasha, 2018). Normally, a Sharpe ratio above 1 entails good performance in terms of minimizing risk per unit of return or alternatively maximizing returns per unit of risk and a Sharpe ratio below 1 means poor performance (Maverick, 2019).

In the full sample, DIS had a Sharpe ratio of 1.45 and it was the only sector with a Sharpe ratio above 1. The rest were below 1 while MAT has the lowest Sharpe ratio of -0.09. In the expansion and boom phase, there were four sectors with Sharpe ratios above 1 and four with Sharpe ratios below 1. The highest performer is STP with 1.92 and the lowest performer was MAT with 0.46. In the recession and recovery phase, again there were four sectors with Sharpe ratios above 1 and four with Sharpe ratios below 1. The highest performer was HLT with 2.75 followed by DIS with 2.43. The lowest performer was MAT with -0.11. In the stagnation phase, IND (1.13) was the only sector with a Sharpe ratio above 1 and the rest were below 1. The lowest performer was MAT with -0.08.

On average, the Stagnation phase (1.25) had the highest risk adjusted returns followed by the Expansion and Boom phase (1.08). Stagnation had the lowest performance with a Sharpe ratio of 0.27.

3.5 Merits of business cycle approach

The business cycle approach to 'sector investing'[17] that is used in the thesis can be used as a tool to position diversified portfolios in order to take advantage of the next business cycle shift as a way of managing risks and/or enhancing the performance of the portfolio. The business cycle approach offers considerable potential for taking advantage of relative sector performance opportunities. As the probability of a shift in phase increases, such a strategy allows investors to adjust their exposure to sectors that are expected to have good performance patterns in the next phase of the cycle.

There are different investment approaches to identify sector winners and losers, such as price momentum strategies, a top-down approach based on specific macroeconomic indicators or bottom-up approaches to identify sectors with improving fundamentals. One widely used approach is business cycle analysis (Bartolini, 2019). Since economic cycles usually exhibit characteristics that impact sectors or industries differently, investors may identify sectors that are favoured by different cycles. Understanding cycle dependency on sectors is important to sector portfolio construction, particularly for a top-down approach (Bartolini, 2019).

3.6 Preliminary formulas

Below are preliminary formulas used in calculating the performance metrics presented in this chapter.

- Returns (r) = $\frac{P_1}{P_{t-1}} - 1$ (4)

  Where: $P_1 \sim price\ today;\ P_{t-1} \sim price\ yesterday$

- Annualized Returns (ar) = $\left(1 + r_{average\ daily}\right)^{365} - 1$ (5)

[17] Sector investing offers targeted exposure to the stocks of companies in specific sectors of the economy and can help in pursuing growth, diversifying portfolios and managing risks (Embsdo-Mattingly et al., 2017).

- Standard Deviation (σ) = $\sqrt{\frac{\sum(x - \mu)^2}{n}}$ (6)

  Where: $x \sim daily\ return;\ \mu \sim average\ of\ daily\ returns; n \sim number\ of\ days$

- Annualized Standard Deviation ($a\sigma$) = $\sigma * \sqrt{365}$ (7)

- CAPM (r_e) = $r_f + \beta_i(r_m - r_f)$, where r_f is risk free rate, (8)

  r_m is market return and β_i is beta

- Sharpe Ratio (sr) *see chapter 2*

- Alpha (α) = $r - [r_f + \beta_i(r_m - r_f)]$ (9)

3.7 Conclusion

In this chapter, we present an analysis of the South African business and the equity market sectors. The chapter starts with outlining key fundamentals applied to categorize business cycle phases. Then, it gives a synopsis of the dating approach of the South Africa business used in this study accompanied with a brief economic overview of each business cycle phase.

Thereafter, the chapter focuses on sectors, particularly how they perform over different phases of the business cycle. Several metrics were used to capture risk and return performances of the South African market sectors over the business cycle. Merits of the business cycle approach to equity market sectors investing have be discussed. The chapter then ends by presenting the formulas of the metrics used to ascertain the performance of the sectors over the South African business cycle.

4

Methodology

4.1 Introduction

Markowitz's Modern Portfolio Theory (1952) stated that a diversified portfolio should be constructed with securities that have limited or no co-movement over time to optimize portfolio efficiency. The initial measure of co-movement that will be considered in this chapter is correlation as suggested by Markowitz (1952). Understanding co-movement of security returns as measured by the correlation and their volatility with each portfolio is central to realizing gains from portfolio diversification. A higher positive co-movement among stocks implies lower gains with regards to risk management from portfolio diversification. Hence investors generally look for combination of stocks with low or negative correlation to attain the full benefits from diversification (Idwan and Mansur, 2014).

However, as time progressed more sophisticated measures of co-movement began to emerge, for example the well-known co-integration methods by Engle and Granger (1987), Johansen and Julius (1990). Studies that have used the Johansen and Julius method include Constantinou et al. (2008); Noor et al. (2014) and Ahmed et al. (2017 & 2018). This method is preferred over Engle-Granger because its statistical properties are superior, and they will be discussed later in this chapter. The absence of co-integration between securities suggests that securities do not co-move together which then implies the possible existence of portfolio diversification opportunities over a considerable investment horizon. Granger causality will also be used to test the short-run dynamics of the sectors with a bearing on the degree of independence of the sectors and possible portfolio diversification benefits in the short run.

4.2 Data

Daily closing prices of the MSCI[18] listed equity sector indices in South Africa were collected from Thomson Reuters and then transformed into natural logarithms. These sector indices are communication services (COM), consumer discretionary (DIS), consumer staples (STP), energy (ENG), financials (FIN), health (HLT), industrials (IND) and materials (MAT). Information technology (TEC), real estate (RET) and utilities (UTL) have been excluded because they have missing data. The study will examine the different phases of the business cycle as well as the full sample, i.e. 2004 – 2018 as depicted in figure 1.1. The different phases of the business cycle will define the sub samples (see table 4.1).

The coincident indicator has been used to capture the historical movement of the South African business cycle. To ascertain the different phases of the South African business cycle over the 15 year period (2004 – 2018), each phase of the business cycle has been carefully analysed using technical analysis and fundamental analysis key guidelines provided by Fidelity Investments researchers Embsdo-Mattingly et al. (2017) (refer to chapter 3).

Table 4.1 Study Samples Analysed

Business Cycle Phases	Period
Full Cycle	2004 – 2018
Expansion and Boom	2004 – 2008
Recession and Recovery	2009 – 2013
Stagnation	2014 – 2018

Source: Author

[18] Morgan Stanley Capital International

4.3 Methodology, techniques and procedures

Table 4.2 Methods, Techniques and Procedures

	Methods Employed	Formulas Used	Purpose
1	Correlation Coefficient	$\rho_{xy} = \frac{\sigma_{xy}}{\sigma_x \sigma_y}$	To measure the direction and strength of the relationship between two or more variables.
2	Unit Root Tests	$\Delta y_t = \alpha + \pi + \delta y_{t-1} + \sum_{i=1}^{m} \beta_i \Delta y_{t-1} + \varepsilon_t$	To assess the stationarity of the selected data
3	VAR Lag Selection Schwarz Criterion	$-2 \ln \frac{(L)}{T} + n \frac{\ln (T)}{T}$	To ascertain appropriate lag length for co-integration and causality tests
4	Johansen's Co-integration Test	$\lambda_{trace} = -T \sum_{i=r+1}^{n} \ln\left(1 - \hat{\lambda}_i\right)$ $\lambda_{max} = -T \ln(1 - \hat{\lambda}_{r+1})$	Is employed to ascertain the presence of long-run equilibrium relationship between the selected times series data
5	Granger Causality Test	$X_t = \alpha + \sum_{i=1}^{m} \beta_i X_{t-i} + \sum_{j=1}^{n} \tau_j Y_{t-j} + \mu_t$ $Y_t = \theta + \sum_{i=1}^{P} \emptyset_i Y_{t-i} + \sum_{j=1}^{q} \varphi_j X_{t-j} + \eta_t$	Is applied to find the direction of causality and short-run relationship between selected time-series data

Source: Bhuvaneshwari and Ramya (2017)

4.3.1 Co-integration technique

Despite the fact that correlation analysis measures the degree of co-movement between two series over a particular period. It does not suffice to ascertain the presence of a long-run stationary relationship between the two (Ahmed et al., 2017). For that reason, a co-integration analysis must be performed to determine whether an equilibrium relation exists (Ahmed et al., 2017).

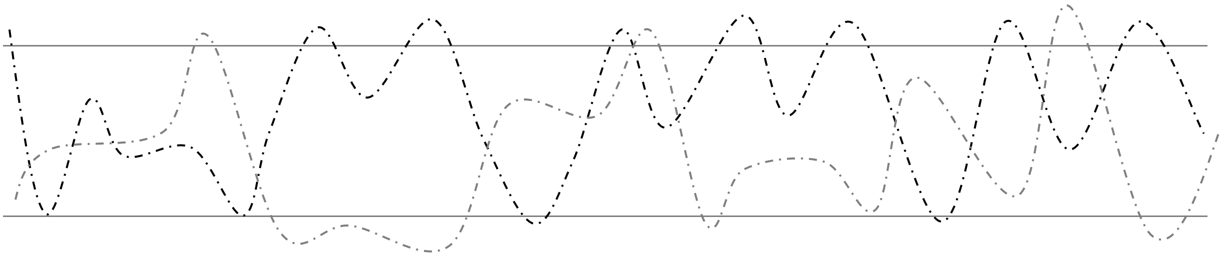
To prove this argument, let's consider a regression model with two sectors X & Y:

$$Y_t = \alpha_1 + \alpha_2 X_t + \varepsilon_t \tag{12}$$

Let's assume that $X_t \sim I(1)$, but $Y_t \sim I(0)$. In this case, X_t is non-stationary but Y_t is stationary at level. Even though X_t and Y_t exhibit significant correlation over time, a long-run stationary relationship between the two sectors does not exist. Since X_t is non-stationary, its variance will surge over time, consequently causing the estimator α_2 to converge to 0 as the sample size increases. The estimator α_2 does not have an asymptotic distribution and is therefore no longer unbiased (Ahmed et al., 2017).

Stock prices, interest rate or yield data are not normally stationary, in fact they are usually a random walk, or at least integrated of order 1, denoted I(1). A set of I(1) prices series are termed co-integrated if there is a linear combination of these series that is stationary. Co-integration measures the difference of price series not the actual price levels. This difference in price series is called a spread. If the spread is mean reverting, asset prices are tied together in the long run by a common stochastic trend, and we say that the price series are co-integrated (Alexander et al., 2001) (see figure 4.2).

Figure 4.1 Spread between Sector A and Sector B



Sector X Sector Y

Source: Author

Chan (2006) provides a similar explanation by stating that co-integration is when two price series cannot wander off in opposite directions for a very long time without coming back to mean distance eventually. But it does not mean that on a daily basis the two prices have to move in synchrony at all. Co-integrated asset prices have a common stochastic trend (Stock and Waston, 1988). They are tied together in the long-run whereas they might drift apart in the short-run because the spread or some other linear combination is mean-reverting. The aim of co-integration analysis is to detect any common stochastic trends in the price data.

Co-integration and correlation are related but different concepts. High correlation does not imply high co-integration and vice versa. In fact, co-integrated series can have correlations that are quite low at times. High correlation may occur when there is co-integration, or when there is no co-integration. Correlation tells us nothing about the long-term behaviour between two markets; they may or may not be moving together over long periods of time, and correlation is not an adequate tool for measuring this. Even a strong correlation of close to 1 does not ensure that prices of different time series stay together over longer horizons (De Jong and Schneider, 2009). Correlation is essentially a short-run measure because it is based on returns, which are short memory processes. Therefore, diversification methodologies on co-integration tests should be more effective in the long run (Alexander et al., 2001).

For circumstances where economic fundamentals are suggestive of a specific relationship between two or more price series, the concept of co-integration becomes very useful. The idea behind co-integration is that individual prices may be non-stationary, but one or more weighted combinations of the series are stationary (De Jong and Schneider, 2009). In many cases, stationarity can be achieved by first-order differencing or by other mathematical transformations such as seasonal adjustments. A typical application in financial market analysis is therefore to model returns or price differences rather price levels. Yet this approach of differencing non-stationary economic series into stationary series has been criticized for throwing out and ignoring valuable long-run equilibrium information (Engle and Granger, 1987).

Intuitively, co-integration among a set of variables implies that there exist fundamental economic forces that make the variables move together stochastically over time (De Jong and Schneider, 2009). The enforcement of the co-integration relationship is easiest to understand in the so-called error correction mechanism of two price series $X\ and\ Y$. Suppose that $X\ and\ Y$ are both random walks, so integrated of order 1, I(1). If there is an equilibrium relationship between $X\ and\ Y$ equal to:

$$X_t = a_0 + a_1 Y_t \tag{13}$$

This means there is a linear combination of $X\ and\ Y$ that is stationary or integrated of order 0, I(0). The actual dynamics may consequently be described as:

$$X_t = X_{t-1} - kX_{t-1} - a_0 + a_1 Y_{t-1} + u_t \tag{14}$$

with u_t being normally distributed and independent and $k > 0$ being the mean-reversion rate. The formulation shows that co-integration may be interpreted as mean reversion in a weighted combination of two or more variables.

Since the seminal work of Engle and Granger (1987) co-integration has become the prevalent tool of time series econometrics. The co-integration methodology is a powerful tool for mitigating risk of an investment and provides a sound methodology for modelling both long-run and short-run dynamics in a system (Alexander et al., 2001). Although empirical models of co-integrated financial time series are commonplace in the academic literature, the practical implementation of these models into systems for investment analysis or portfolio risk is still in its early stages. This is because the traditional starting point for portfolio allocation and risk management is a correlation analysis of returns (Alexander et al., 2001).

a) Stationary Tests

Time series data is stationary if its statistical properties (mean, variance and auto correlation) are constant over time, implying that future predictions can be made from past data (Enders, 2015). In practice most finance and economic time series are usually non-stationary when expressed in their original units of measurement, thus using OLS based estimations becomes inappropriate and leads to spurious estimations. Non-stationary variables can be transformed into stationary variables by differencing the times series. The number of times variables must be differenced to become stationary is referred to as the order of integration (Kawawa, 2018).

The Johansen co-integration approach is typically used in a setting where variables in the system are integrated of order 1 (Osterholm and Hjalmarsson, 2007). In this study, the Augmented Dickey Fuller test (ADF) and Phillips Peron (PP) are both used to ascertain the order of integration of sectors. The ADF test is the popular method for testing unit roots and its null hypothesis is that a variable has a unit root implying that it is non-stationary. However, the ADF has limitations hence the use of the Phillips Peron test to ensure the robustness of the test. The ADF has a weak power of test meaning it is not good at distinguishing between a series that has a unit root and one which although it appears might have a unit root, actually does not. It also does not detect a structural break in a time series. In these cases, ADF has a tendency of accepting the null hypothesis of a unit root even when there is none. To mitigate the limitations of ADF, the PP test is used. It has an advantage over ADF when testing time series that are auto correlated and have a structural break (Glynn et al., 2007).

b) VaR Lag Selection

Subsequently, after unit root tests it is imperative to determine the lag length prior to co-integration and Granger-causality tests because inappropriate lag length may lead to serial correlation (Ahmed, 2012). Ideally the lag length is determined based on tests of Akaike Information Criteria and SBIC (Schwarz Bayesian Information Criterion). Conclusive selection of the lags will be based on SBIC because it is generally superior in fairly large samples (Enders, 2015).

c) Johansen Co-integration

Two or more sectors are said to be co-integrated if their trend paths are linked, implying that these sectors co-move together overtime. Co-integration analysis can either be bivariate (pairwise) or multivariate. Bivariate co-integration is a co-integration test on two-sector indices and multivariate co-integration is applied to more than two sector indices. The application of the multivariate co-integration test gives evidence on the number of co-integrating vectors present in the data. However, it’s limitation in the context of sector co-integration is that it does not show unique relationships between sector pairs. To measure the co-integration between two sectors or combinations of two sectors, the pairwise (bivariate) co-integration test is employed (Ahmed et al., 2017).

The Johansen co-integration method is simply a multivariate generalization of the Dickey-Fuller test (Dwyer, 2015). For n variables let's consider:

$$X_t = A_1 X_{t-1} + \varepsilon_t \quad (15)$$

Taking the 1st difference, we get;

$$\Delta X_t = (A_1 - I) X_{t-1} + \varepsilon_t \quad (16)$$

$$\vdots \quad = \prod X_{t-1} + \varepsilon_t \quad (17)$$

Where:

X_t & ε_t are $n \times 1$ vector of variables

$A_1 \approx n \times n$ matrix of parameters

$I \approx n \times n$ identity matrix

$\prod \approx (A_1 - 1)$ = rank of the matrix

The rank of $\prod \approx (A_1 - 1)$ is equal to the number of co-integrating vectors. The hypothesis testing for the rank of the matrix is shown below as follows:

$H_O: \prod = 0$ ∴ No co-integration

$H_1: \prod \neq 0$ ∴ Co-integration

If $\prod \approx (A_1 - 1) = 0$ it means all x_t sequences are unit root processes as there is no linear combination of $\{X_t\}$ that is stationary ∴ the variables (sectors) are not co-integrated.

If $\prod \approx (A_1 - 1) \neq 0$ it means we have a system of convergence (all X_t sequences are stationary) ∴ therefore the variables (sectors) are co-integrated.

Since the rank of a matrix $\prod \approx (A_1 - 1)$ is equal to the number of characters that differ from zero, we obtain the number of co-integration vectors by analysing the statistical significance of the characteristic roots of $\prod \approx (A_1 - 1)$.

The Johansen co-integration approach has two likelihood ratio tests for the determination of the number of co-integrated sectors. The first one is the Maximum Eigenvalue test which evaluates the null hypothesis that there are at most r co-integration sectors against the alternative of $r+1$ co-integrating sectors (Noor et al., 2014). The maximum eigenvalue statistic is given by:

$$\lambda_{max} = -T\ln(1-\hat{\lambda}_{r+1})$$
(18)

The second test is the trace statistic which tests the null hypothesis of r co-integrating vectors against the alternative of r or more co-integrating vectors. This statistic is given by:

$$\lambda_{trace} = -T\sum_{i=r+1}^{n}\ln\left(1-\hat{\lambda}_i\right)$$
(19)

Where $\hat{\lambda}$ represents the estimated value of the characteristic roots (i.e. eigenvalue) and T is the number of observations.

Based on Eviews (econometrics software), the decision rule according to λ_trace is made based on trace statistic with a 5 per cent critical value of 15.49471. If the trace statistic value is less than 15.49471, we fail to reject the null hypothesis and conclude that there is no co-integration between the selected sectors. According to λ_max, the decision is made based on max statistic with a 5 per cent critical value of 14.26460. Similarly, there is no co-integration between the selected sectors if the max statistic value is less than 14.26460. The opposite is also true in both cases. If both statistics exceed the critical value, we reject the null hypothesis and conclude that the sectors are cointegrated. In the papers that have been reviewed in this study, for instance (Noor et al., 2014 and Ahmed et al., 2018), the λ_trace statistic has been used in the literature on sectoral co-integration. As a result, this study also focused on λ_trace when determining the co-integration in both the multivariate and bivariate tests.

Based on the objectives of this study Johansen is the most suitable co-integration method as opposed to the Engle-Granger method. Engle-Granger requires us to select one variable as the dependent variable and include the remaining variables as regressors. In this case, it is possible to find that one regression indicates that the variables are co-integrated, whereas reversing the order indicates no co-integration. This is not a desirable feature of the Engle-Granger method since co-integration must be invariant to the choice of the variable selected (Koirala, 2009).

4.3.2 Granger-causality Tests

The co-integration analysis examines whether there is a long-run relationship between two or more sectors. Granger causality is used to ascertain the direction of short-term dynamics (Angelovska, 2017). The absence of co-integration suggests there might only be short-run interactions between variables (Ibrahim, 2000). Granger causality is adopted to ascertain the potential cross-interactions among the sectors. The cross-interactions of the sectors can either be unidirectional or bidirectional. Unidirectional interaction indicates changes in one sector occur independently of the other. On the other hand, bidirectional interaction indicates that changes in both sectors dependent on each other, that is neither sector evolves independently of the other (Ahmed et al., 2017).

Considering sectors $X\ and\ Y$ the following two OLS (Ordinary Least Squares) equations can be specified. Let's suppose $X\ \approx Health\ (HLT)\ and\ Y \approx Energy\ (ENG)$

$$(HLT)_t = \alpha + \sum_{i=1}^{m} \beta_i (HLT)_{t-i} + \sum_{j=1}^{n} \tau_j (ENG)_{t-j} + \mu_t \quad (20)$$

$$(ENG)_t = \theta + \sum_{i=1}^{p} \emptyset_i (ENG)_{t-i} + \sum_{j=1}^{q} \varphi_j (HLT)_{t-j} + \eta_t \quad (21)$$

Where: α and θ are constants; τ and φ are measures of influence; μ and η are error terms

Wald test is used to verify (i.e. accept or reject) the following hypotheses:

$H_{0,1}: HLT\ does\ not\ Granger\ cause\ Sector\ ENG$

$H_{0,2}: ENG\ does\ not\ Granger\ cause\ Sector\ HLT$

Based on the estimated OLS coefficients from the above equations four different hypotheses about the relationship between $X\ and\ Y$ can be formulated:

- Unidirectional Granger-causality from Energy to Health. In this case the Health index values increase the prediction of the Energy sector but not vice versa.
  Thus $\sum_{j=1}^{n} \tau_j \neq 0$ and $\sum_{j=1}^{q} \varphi_j = 0$
- Unidirectional Granger-causality from Health to Energy. In this case the Energy index values increase the prediction of the Health sector but not vice versa.
  Thus $\sum_{j=1}^{n} \tau_j = 0$ and $\sum_{j=1}^{q} \varphi_j \neq 0$

- Bidirectional causality. In this case $\sum_{j=1}^{n} \tau_j \neq 0$ and $\sum_{j=1}^{q} \varphi_j \neq 0$, so the Health sector increases prediction of the Energy sector and vice versa.
- Independence between the Health sector and Energy. In this case there is no Granger Causality in any direction, thus $\sum_{j=1}^{n} \tau_j = 0$ and $\sum_{j=1}^{q} \varphi_j = 0$

Obtaining one of these results makes it possible to detect the causality relationships between sectors which then translates into the degree of independence of the sectors and possibly portfolio diversification benefits available to investors in the short run.

4.4 Conclusion

In conclusion, the key focus of this chapter was to outline and discuss the methodologies used in this study to examine the co-movement and causal relationships between variables, with a bearing on the potential benefits that can be derived from sectoral portfolio diversification. The first method discussed was correlation largely because it is a conventional pillar of portfolio risk management as presented by Markowitz (1952). Diversification through correlation is achieved when securities are low or negatively correlated. In other words, the lower the correlation the more significant the diversification opportunities. However, the papers reviewed in this study on sectoral co-integration have criticised correlation as an ineffective measure of portfolio diversification, such as Ahmed et al. (2017 & 2018).

Secondly, the Johansen co-integration test was discussed as well as the procedures that precede this test, which are unit root and VaR optimal lag length. ADF and PP were both used in unit root tests to increase the robustness of the results because ADF has a weak power of test. Determining the optimal lag length was based on Schwarz' information criterion. The notion is that diversification benefits exist within a considerable investment horizon if there is no co-integration between sectors. Lastly, Granger causality determines the short-run causality relationships between sectors which translates into their degree of independence and possible diversification benefits that exist in the short run.

This methodology has been employed in the same nature of study by Constantinou et al. (2008), Noor et al. (2014) and Ahmed et al. (2017 & 2018).

5

Results and Analysis

5.1 Introduction

This chapter presents the empirical results of this study followed by an in-depth analysis to ascertain the degree of co-movement and dynamic causalities between the equity market sectors in South Africa. These sectors are Communication Services (COM), Consumer Discretionary (DIS), Consumer Staples (STP), Energy (ENG), Health (HLT), Financials (FIN), Industrials (IND) and Materials (MAT).

The chapter starts with an analysis of the descriptive statistics to analyse the distribution of the sectoral returns. Generally, stock returns are not normally distributed. They exhibit leptokurtosis which implies positive skewness and fat tails (Ahmed et al., 2017). After an analysis of the descriptive statistics, firstly the study analyses correlation results over the full sample and the different phases of the South African business cycle. The analysis of correlation is premised on the notion that the lower the correlation coefficient between sectors the more significant the diversification benefits.

Secondly, co-integration procedures and techniques were employed. The initial step was to conduct unit root tests using ADF and PP to increase the robustness of the results. Thereafter, optimal lag length was determined based on Schwarz' Criterion. Subsequently, multivariate and pairwise (i.e. bivariate) co-integration was conducted to examine the diversification benefits present to investors over the different phases of the business cycle and the full sample. The absence of co-integration suggests the existence of diversification opportunities. Multivariate tests only show the number of co-integration equations present among sectors; it does not indicate which sectors are cointegrated. To assess that, bivariate co-integration was used. Lastly, Granger causality was employed to ascertain the degree of dependence between sectors and if investors could set up short term diversification strategies over the different phases of the business cycle and the full sample.

5.2 Descriptive statistics

Table 5.1 Descriptive Statistics

Sectors	Mean	Median	Max	Min	Std Dev	Skewness	Kurtosis	Jarque-Bera	Prob	Obs
COM	0,004%	0,003%	0,013%	0,002%	0,002%	1,613755	4,322329	1900,333	0,000	3749
DIS	0,093%	0,135%	7,994%	-7,441%	1,577%	-0,040617	4,980187	613,5454	0,000	3749
STP	0,061%	0,061%	7,411%	-5,214%	1,205%	0,058226	4,5744	389,3172	0,000	3749
ENG	0,071%	0,059%	12,111%	-11,847%	2,200%	0,072503	5,815019	1241,131	0,000	3749
FIN	0,055%	0,066%	8,253%	-9,997%	1,413%	0,018417	5,982113	1389,372	0,000	3749
HLT	0,066%	0,046%	7,552%	-10,183%	1,510%	-0,117236	5,583235	1050,982	0,000	3749
IND	0,069%	0,077%	12,546%	-8,212%	1,533%	0,147248	6,709876	2163,471	0,000	3749
MAT	0,011%	-0,007%	9,686%	-9,595%	1,776%	0,1088	5,66647	1118,047	0,000	3749

Source: Author

Acquiring information on the distribution of the underlying price series is imperative to investors as it reveals the possibility of acute fluctuations in prices. Return dynamics such as mean, volatility, skewness, kurtosis and Jarque-Bera are often employed as inputs to models in portfolio selection and optimization (Ahmed, 2017). The results show that DIS and ENG have the highest returns with values of 0.093% and 0.071% with standard deviations of 1.205%, 2.2%% respectively. COM and MAT have the lowest return values of 0.004% and 0.011%, with standard deviations of 0.002% and 1.776% respectively. ENG is the most volatile sector having the highest standard deviation (2.2%), followed by MAT (1.77%) while COM (0.002%) sector shows the least volatility. IND, ENG and MAT have the highest maximum returns, with values of 12.546%, 12.111% and 9.686% respectively. ENG, HLT, FIN and MAT have the lowest minimum returns, with values of -11.847%, -10.183%, -9.997% and -9.595% respectively. The results also reveal that, apart from DIS and HLT, the returns of all sectors are positively skewed, which points to the presence of extreme values at the positive end of the distribution. The kurtosis value for all sectors is greater than 3, suggesting a leptokurtic distribution. This finding is unsurprising as stock returns often tend to be fat-tailed and positively skewed (Anderson et al., 2001). Jarque-Bera test, an asymptotic test of normality, indicates that none of the sector indices is normally distributed as the probability is less than 0.05.

5.3 Correlation

Modern Portfolio Theory suggests an inverse relationship between correlation and portfolio diversification. When the correlation between portfolio constituents increases, diversification benefits decrease and when correlation decreases, diversification benefits increase (Lhabitant, 2011). In summary, the lower the correlation coefficient the more significant the diversification benefits. Table 5.2 displays the correlation coefficient thresholds employed in this study. After consulting a number of sources[19] for the conventional threshold values of a correlation coefficient, we found them not to be in conformity. Therefore, it could be argued that threshold values for correlation are rather subjective. However, correlation coefficients below the 0.5 were generally considered to be low, which in this study would suggest the existence of portfolio diversification opportunities. See table 5.2.

Table 5.2 Correlation Coefficient Thresholds

Correlation Coefficient Thresholds	Degree of Positive Co-movement	Diversification Benefits
0.80 – 1.00	Very High	Very Low Possibility
0.50 – 0.79	High	Low Possibility
0.30 – 0.49	Moderate	Moderate Possibility
0.10 – 0.29	Low	High Possibility
Below 0.09	Very Low	Very High Possibility

Source: Author

Table 5.3 Correlations - Full Sample (2004 – 2018)

Sectors	COM	DIS	STP	ENG	FIN	HLT	IND	MAT
COM	1,000							
DIS	0,013*	1,000						
STP	-0,005*[L]	0,559	1,000					
ENG	0,024*	0,400	0,336	1,000				
FIN	0,019*	0,610	0,654	0,411	1,000			
HLT	0,031*	0,428	0,468	0,253*	0,517	1,000		
IND	0,040*	0,537	0,576	0,375	0,658[H]	0,432	1,000	
MAT	0,024*	0,315	0,297	0,471	0,319	0,253*	0,348	1,000

* ~ low correlation; [L] ~ lowest correlation; [H] ~ highest correlation

Source: Author

[19] Andrews University (2005); Mukaka (2012) & Statistics Solutions (2019)

Table 5.3 exhibits correlation coefficients of sectors over the full sample. Out of the 28 cases, there were 9 cases with low correlations (less than 0.3). The lowest correlation of -0.005*L was found between COM & STP which implies that investors can select stocks from these sectors to reap portfolio diversification opportunities. This is true of all of sectors identified as having low correlation coefficients. The highest correlation value of 0.658H was shown between IND and FIN, which means portfolio diversification opportunities are less likely to be present when stocks from these sectors are included in a portfolio.

The COM sector had low correlation coefficients with all of the other sectors (see the highlighted column on the table), therefore this means COM provides the best opportunities in combination with any of the other sectors in this context. Other portfolio diversification benefits could be achieved from ENG and HLT (0.253), and HLT and MAT (0.253). In summary, these results show a considerable amount of portfolio diversification benefits present over the full sample.

Table 5.4 Correlations – Expansion and Boom (2004 – 2008)

Sectors	COM	DIS	STP	ENG	FIN	HLT	IND	MAT
COM	1,000							
DIS	0,544	1,000						
STP	0,506	0,679	1,000					
ENG	0,362	0,408	0,373	1,000				
FIN	0,586	0.684H	0,640	0,425	1,000			
HLT	0,375	0,459	0,473	0.263*L	0,543	1,000		
IND	0,513	0,679	0,650	0,430	0,673	0,474	1,000	
MAT	0,352	0,436	0,395	0,566	0,443	0,328	0,492	1,000

* ~ low correlation; L ~ lowest correlation; H ~ highest correlation

Source: Author

Table 5.4 exhibits the correlation coefficients of sectors over the expansion and boom phase. The highest correlation of 0.6843H was found between DIS and FIN. The lowest correlation of 0.263 L was found between HLT and ENG. Other sector pairs with low correlations and possibility of diversification benefits are highlighted in grey above. These results suggest that in the expansion and boom phase investors can achieve diversification benefits by constructing a portfolio with stocks from HLT and ENG. This combination is unsurprising since Health (HLT) is economically insensitive and Energy (ENG) is economically sensitive, meaning these sectors behave differently to changes in the economy. In summary, these results suggest that the expansion and boom phase provides limited portfolio diversification opportunities compared to the full sample.

Table 5.5 Correlations – Recession and Recovery (2009 – 2013)

Sectors	COM	DIS	STP	ENG	FIN	HLT	IND	MAT
COM	1,000							
DIS	0,490	1,000						
STP	0,448	0,576	1,000					
ENG	0,371	0,463	0,399	1,000				
FIN	0,557	0,656	0,612	0,555	1,000			
HLT	0,369	0,454	0,450	0,269*	0,494	1,000		
IND	0,500	0,573	0,528	0,507	0,668^{H}	0,432	1,000	
MAT	0,345	0,384	0,347	0,512	0,418	0,264*^{L}	0,451	1,000

* ~ low correlation; ^{L} ~ lowest correlation; ^{H} ~ highest correlation

Source: Author

Table 5.5 exhibits the correlation coefficients of sectors over the recession and recovery phase. FIN and IND had the highest correlation of 0.668^{H} therefore investors may not be able to achieve portfolio diversification by selecting stocks from these sectors. The lowest correlation of 0.264^{L} was found between HLT and MAT, followed by HLT and ENG with a correlation coefficient of 0.269. It is interesting to note that HLT was the least correlated sector with all the sectors since it has correlation coefficients below 0.5 with all the sectors (see the highlighted section). These results confirm why stocks from the HLT sector are regarded to be economically insensitive or defensive, particularly during times of heightened volatility such as this recession and recovery phase. In summary, these results suggest that the recession and recovery phase provides limited portfolio diversification benefits, compared to the expansion and boom phase and the full sample.

Table 5.6 Correlations – Stagnation (2014 – 2018)

Sectors	COM	DIS	STP	ENG	FIN	HLT	IND	MAT
COM	1,000							
DIS	0,340	1,000						
STP	0,432	0,454	1,000					
ENG	0,274*	0,364	0,263	1,000				
FIN	0,550	0,523	0,706^{H}	0,302	1,000			
HLT	0,368	0,391	0,485	0,232	0,502	1,000		
IND	0,400	0,407	0,545	0,248	0,641	0,394	1,000	
MAT	0,095*	0,153*	0,147*	0,327	0,076*^{L}	0,133*	0,119*	1,000

* ~ low correlation; L ~ lowest correlation; H ~ highest correlation

Source: Author

Table 5.6 exhibits the correlation coefficients of sectors over the stagnation phase. The highest correlation coefficient of 0.706^{H} was found between FIN and STP. The lowest correlation coefficient of 0.076^{*} was found between MAT and COM. As a result, it means MAT and COM provide the best opportunity for portfolio diversification over the stagnation phase. MAT was the least correlated sector with all the sectors except for ENG with 0.327 (see the highlighted section). This means to achieve diversification benefits investors could construct a portfolio with stocks from COM with either MAT, DIS, STP, FIN, HLT or IND. Other portfolio diversification benefits could be achieved from ENG and HLT (0.232), ENG and IND (0.248), ENG and STP (0.263), and ENG and COM (0.274). In summary, these results reveal a considerable amount of portfolio diversification opportunities available to investors in the stagnation phase because it has the highest number of correlations that are below 0.3. See table 5.7 below.

Table 5.7 Correlation Analysis over the Business Cycle

	Full Sample	Expansion and Boom	Recession and Recovery	Stagnation
Very High to High correlated sectors	FIN & IND (0.658)	FIN & DIS (0.684)	FIN & IND (0.668)	FIN & STP (0.706)
	FIN & STP (0.654)	DIS & STP (0.679)	FIN & DIS (0.656)	FIN & IND (0.641)
	FIN & DIS (0.610)	DIS & IND (0.679)	FIN & STP 0.612)	FIN & COM (0.55)
	STP & IND (0.576)	FIN & IND (0.673)	DIS & IND (0.573)	STP & IND (0.545)
	STP & DIS (0.559)	STP & IND (0.650)	FIN & COM (0.557)	FIN & DIS (0.523)
	DIS & IND (0.537)	STP & FIN (0.640)	FIN & ENG (0.555)	FIN & HLT (0.502)
	FIN & HLT (0.517)	FIN & COM (0.586)	STP & IND (0.528)	
		ENG & MAT (0.566)	ENG & MAT (0.512)	
		COM & DIS (0.544)	ENG & IND (0.507)	
		FIN & HLT (0.543)	COM & IND (0.500)	
		COM & IND (0.513)		
		COM & STP (0.506)		

Very Low to Low correlated sectors	COM & STP (-0.005)	HLT & ENG (0.263)	HLT & MAT (0.264)	MAT & FIN (0.076)
	COM & DIS (0.013)		HLT & ENG (0.269)	MAT & COM (0.095)
	COM & FIN 0.0019)			MAT & IND (0.119)
	COM & MAT (0.024)			MAT & HLT (0.133)
	COM & ENG (0.024)			MAT & STP (0.147)
	COM & HLT (0.031)			MAT & DIS (0.153)
	COM & IND (0.040)			ENG & HLT (0.232)
				ENG & IND (0.248)
				ENG & STP (0.263)
				ENG & COM (0.274)

Source: Author

Table 5.7 summarizes correlation results of the sectors over the South African business cycle (2004 – 2018). COM provides more diversification opportunities over the full sample, and MAT provides more diversification opportunities over the stagnation phase, followed by HLT. However, there were limited opportunities over both the expansion and boom, and recession and recovery phases. In both phases investors could reap portfolio diversification benefits from HLT and ENG. The stagnation phase had the most diversification opportunities, albeit the best diversification benefits are found over the full sample.

Correlation is an inadequate measure of diversification. Ahmed et al. (2017) assert that correlations do not provide any information on the spread between the returns or price series of two sectors or whether the mean is reverting. In other words, the presence of a high correlation does not necessarily imply a long-run equilibrium between the returns of different sector indices. For a long-run equilibrium to exist, the spread or linear combination of two returns series must be stationary. To verify the presence of long-run equilibrium, a co-integration procedure must be employed (Ahmed et al., 2017).

Lhabitant (2011) stated that investors relying exclusively on correlations to construct diversified portfolios might find all their underlying assets sharing the same trend, regardless of low or negative correlations. Moreover, Lhabitant (2011) emphasised that additional indicators such as trend gaps, or the difference between the returns of different assets or between portfolios, should be taken into consideration when assessing portfolio diversification (such as co-integration). Correlation is intrinsically a short-run measure because it is based on returns, which are short memory processes. Even if two non-stationary series are strongly uncorrelated, it may not be possible to draw valid inferences based on past behaviour. Thus, as already mentioned in chapter four, diversification methodologies that rely on co-integration tests should be more effective (Alexander et al., 2001).

5.4 Co-integration

5.4.1 Unit root tests

One of the assumptions of the Johansen co-integration tests is that variables must be integrated of the same order of I(0), i.e. stationarity after first difference. The ADF and Phillips Peron tests were employed to examine the stationarity of the sector indices. In both tests, the null hypothesis of non-stationarity cannot be rejected because the p-values are greater than the 5% significance level. As a result, the sectors were re-examined in first difference on both tests and tables 5.8 – 5.11 reveal that the null hypothesis is rejected for all sectors, a clear indication that all sectors are integrated of order 1.

Table 5.8 Unit Root - Full Sample (2004 – 2018)

Sector	ADF Test I(0)		ADF Test I(1)		PP Test I(0)		PP Test I(1)	
	t-stat	Prob	t-stat	Prob	t-stat	Prob	t-stat	Prob
COM	-2,700	0,074	-47,011	0,000	-2,796	0,059	-64,072	0,000
DIS	-1,334	0,616	-44,833	0,000	-1,373	0,597	-59,947	0,000
STP	-2,545	0,105	-38,115	0,000	-2,661	0,081	-60,081	0,000
ENG	-2,602	0,093	-61,259	0,000	-2,534	0,108	-62,660	0,000
FIN	-1,796	0,383	-34,553	0,000	-1,808	0,377	-61,995	0,000
HLT	-1,763	0,400	-59,592	0,000	-1,802	0,380	-59,631	0,000
IND	-1,030	0,745	-60,540	0,000	-1,007	0,753	-60,569	0,000
MAT	-1,411	0,579	-44,706	0,000	-1,409	0,579	-58,582	0,000

Source: Author

Table 5.9 Unit Root - Expansion and Boom (2004 – 2008)

Sector	ADF Test I(0)		ADF Test I(1)		PP Test I(0)		PP Test I(1)	
	t-stat	Prob	t-stat	Prob	t-stat	Prob	t-stat	Prob
COM	-1,543	0,512	-33,851	0,000	-1,523	0,522	-35,472	0,000
DIS	-1,999	0,288	-31,814	0,000	-2,060	0,261	-31,647	0,000
STP	-1,385	0,591	-32,457	0,000	-1,368	0,599	-32,354	0,000
ENG	-1,716	0,423	-34,522	0,000	-1,701	0,430	-35,120	0,000
FIN	-1,923	0,322	-26,741	0,000	-1,939	0,315	-34,985	0,000
HLT	-1,378	0,595	-33,249	0,000	-1,354	0,606	-33,289	0,000
IND	-1,773	0,394	-33,169	0,000	-1,775	0,393	-33,108	0,000
MAT	-1,314	0,625	-32,312	0,000	-1,247	0,656	-32,192	0,000

Source: Author

Table 5.10 Unit Root - Recession and Recovery (2009 – 2013)

Sector	ADF Test I(0)		ADF Test I(1)		PP Test I(0)		PP Test I(1)	
	t-stat	Prob	t-stat	Prob	t-stat	Prob	t-stat	Prob
COM	-0,354	0,914	-29,422	0,000	-0,179	0,939	-39,924	0,000
DIS	-0,395	0,908	-36,484	0,000	-0,278	0,926	-36,774	0,000
STP	-1,260	0,650	-35,075	0,000	-1,269	0,646	-35,338	0,000
ENG	-1,393	0,587	-35,593	0,000	-0,701	0,845	-37,887	0,000
FIN	-0,957	0,770	-36,160	0,000	-0,758	0,830	-36,879	0,000
HLT	-0,944	0,775	-35,119	0,000	-0,930	0,779	-35,530	0,000
IND	-1,004	0,754	-34,225	0,000	-0,876	0,796	-34,338	0,000
MAT	-0,976	0,763	-34,135	0,000	-1,017	0,749	-34,122	0,000

Source: Author

Table 5.11 Unit Root - Stagnation (2014 – 2018)

Sector	ADF Test I(0)		ADF Test I(1)		PP Test I(0)		PP Test I(1)	
	t-stat	Prob	t-stat	Prob	t-stat	Prob	t-stat	Prob
COM	-1,169	0,690	-27,538	0,000	-0,973	0,765	-36,858	0,000
DIS	-2,222	0,199	-35,148	0,000	-2,150	0,225	-35,566	0,000
STP	-2,924	0,0429*	-36,368	0,000	-2,781	0,061	-36,480	0,000
ENG	-2,076	0,255	-36,456	0,000	-1,968	0,301	-36,458	0,000
FIN	-2,671	0,080	-26,858	0,000	-2,543	0,106	-35,078	0,000
HLT	-0,504	0,888	-35,775	0,000	-0,503	0,888	-35,775	0,000
IND	-0,821	0,812	-37,026	0,000	-0,795	0,820	-37,014	0,000
MAT	-2,027	0,275	-27,181	0,000	-2,021	0,278	-35,882	0,000

Source: Author

5.4.2 VAR lag selection

To run co-integration and Granger-causality tests it is important to determine the lag length. The VAR lag length selection test is run to determine the appropriate lag length. The test uses five methods, but the conclusive selection was derived from the SC (Schwarz information criterion).

Table 5.12 indicates that the SC (Schwarz information criterion) recommends a lag length of 1 for the multivariate tests. Table 5.13 shows the appropriate lag length for the pairwise tests as recommended by the SC (Schwarz information criterion).

Table 5.12 Multivariate VAR Lag Selection

Full Sample (2004 – 2018)						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	8300.925	NA	1.64e-12	-4.432349	-4.419036	-4.427614
1	86909.95	156839.9	9.63e-31	-46.41259	-46.29277*	-46.36997*
2	86978.48	136.4429	9.60e-31	-46.41501	-46.18868	-46.33451
3	87072.68	187.1321	9.45e-31*	-46.43115*	-46.09831	-46.31277
Expansion and Boom (2004 – 2008)						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	8060,323	NA	3,30E-16	-12,94586	-12,91289	-12,93346
1	28678,1	40937,23	1,47E-30	-45,99052	-45,69383*	-45,87896*
2	28783,43	207,7748	1,37e-30*	-46,05696*	-45,49655	-45,84623
3	28835.95	102.9419	1.40e-30	-46.03851	-45.21438	-45.72862
Recession and Recovery (2009 – 2013)						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	11494,74	NA	1,28E-18	-18,49717	-18,46416	-18,48475
1	30546,98	37828,36	6,72e-32*	-49,07404*	-48,77697*	-48,96233*
2	30606.73	117.8718	6.77e-32	-49.06721	-48.50607	-48.85619
3	30663.52	111.2942	6.85e-32	-49.05560	-48.23040	-48.74528
Stagnation (2014 – 2018)						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	8099,523	NA	0,000	-13,051	-13,018	-13,038
1	28271,990	40052,100	2,44e-30*	-45,48385*	-45,18639*	-45,37198*
2	28299.96	55.18591	2.58e-30	-45.42574	-44.86388	-45.21444
3	28362.52	122.5963	2.59e-30	-45.42342	-44.59715	-45.11268

Note: * indicates lag order selected by the criterion

Source: Author

Table 5.13 Pairwise VAR Lag Selection (All Samples)

Full Sample (2004 – 2018)								
Sectors	COM	DIS	STP	ENG	FIN	HLT	IND	MAT
COM								
DIS	1							
STP	1	1						
ENG	1	1	1					
FIN	1	1	1	1				
HLT	1	1	1	1	1			
IND	1	1	1	1	1	1		
MAT	1	1	1	1	3	1	1	
Expansion and Boom (2004 – 2008)								
Sectors	COM	DIS	STP	ENG	FIN	HLT	IND	MAT
COM								
DIS	2							
STP	2	1						
ENG	1	1	1					
FIN	1	1	2	1				
HLT	1	1	1	1	1			
IND	1	1	1	1	1	1		
MAT	1	2	2	1	2	1	2	
Recession and Recovery (2009 – 2013)								
Sectors	COM	DIS	STP	ENG	FIN	HLT	IND	MAT
COM								
DIS	1							
STP	1	1						
ENG	1	1	1					
FIN	1	1	1	1				
HLT	1	1	1	1	1			
IND	1	1	1	1	1	1		
MAT	1	1	1	1	1	1	1	
Stagnation (2014 – 2018)								
Sectors	COM	DIS	STP	ENG	FIN	HLT	IND	MAT
COM								
DIS	1							
STP	1	1						
ENG	1	1	1					
FIN	1	1	1	1				
HLT	1	1	1	1	1			
IND	1	1	1	1	1	1		
MAT	1	1	1	1	1	1	1	

Source: Author

5.4.3 Multivariate and pairwise co-integration

a) Multivariate co-integration

Table 5.14 – 5.17 presents results of the multivariate co-integration test. The tests reveal 2 (two) co-integrating equations in the recession and recovery phase, 1 co-integrating equation in both the full sample and the expansion and boom phase and 0 (zero) in the stagnation phase. The presence of a co-integrating equation sums up the existence of long-run equilibrium among the eight selected sector indices. On the contrary, the absence of a co-integration equation entails that a long-run equilibrium among sector indices is non-existent. Since the Johansen multivariate co-integration only gives the number of co-integrating equations or sectors, less can be deduced in terms of which sector pairs are co-integrated (Ahmed et al., 2017). To assess this, the pairwise co-integration was employed.

Table 5.14 Full Sample (2004 – 2018)

Co-integration Rank Test (Trace)				
Max Rank	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob
$\boldsymbol{r = 0}$*	0.011650	163.0032	159.5297	0.0319
$\boldsymbol{r \leq 1}$	0.010042	119.0813	125.6154	0.1168
$\boldsymbol{r \leq 2}$	0.008434	81.25388	95.75366	0.3241
$\boldsymbol{r \leq 3}$	0.004642	49.50917	69.81889	0.6590
$\boldsymbol{r \leq 4}$	0.003206	32.07095	47.85613	0.6082
$\boldsymbol{r \leq 5}$	0.003008	20.03475	29.79707	0.4205
$\boldsymbol{r \leq 6}$	0.001369	8.742287	15.49471	0.3898
$\boldsymbol{r \leq 7}$	0.000962	3.606283	3.841465	0.0576

Note: Trace test indicates 1 co-integrating equation at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

Source: Author

Table 5.15 Multivariate Co-integration – Expansion and Boom

Co-integration Rank Test (Trace)				
Max Rank	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob
$r = 0$*	0,04514	178,2918	1,60E+02	0,0032
$r \leq 1$	0,042947	120,5532	1,26E+02	0,0977
$r \leq 2$	0,019407	65,6823	9,58E+01	0,8485
$r \leq 3$	0,014068	41,18495	6,98E+01	0,9276
$r \leq 4$	0,00835	23,4746	4,79E+01	0,9529
$r \leq 5$	0,004879	12,99376	2,98E+01	0,8919
$r \leq 6$	0,004135	6,880462	15,49471	0,5916
$r \leq 7$	0,00136	1,700595	3,841465	0,1922

Trace test indicates 1 co-integrating equation at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

Source: Author

Table 5.16 Multivariate Co-integration – Recession and Recovery

Co-integration Rank Test (Trace)				
Max Rank	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob
$r = 0$*	0,058794	218,7033	159,5297	0,0000
$r \leq 1$*	0,043314	143,0828	125,6154	0,0028
$r \leq 2$	0,025590	87,8208	95,7537	0,1550
$r \leq 3$	0,019772	55,4687	69,8189	0,3996
$r \leq 4$	0,013186	30,5460	47,8561	0,6907
$r \leq 5$	0,006230	13,9803	29,7971	0,8417
$r \leq 6$	0,004404	6,1814	15,4947	0,6741
$r \leq 7$	0,000540	0,6735	3,8415	0,4118

Trace test indicates 2 co-integrating equation at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

Source: Author

Table 5.17 Multivariate Co-integration - Stagnation

Co-integration Rank Test (Trace)				
Max Rank	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob
$r = 0$	0,027765	122,5233	159,5297	0,8029
$r \leq 1$	0,02031	87,4385	125,6154	0,9105
$r \leq 2$	0,016755	61,87113	9,58E+01	0,9249
$r \leq 3$	0,012407	40,81702	6,98E+01	0,9343
$r \leq 4$	0,011427	25,26059	4,79E+01	0,9116
$r \leq 5$	0,004162	10,9409	2,98E+01	0,9626
$r \leq 6$	0,003205	5,744059	1,55E+01	0,7255
$r \leq 7$	0,001399	1,744292	3,84E+00	0,1866

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

Source: Author

b) Pairwise co-integration

Tables 5.18 – 5.21 present results of the pairwise co-integration test. The hypothesis results will be determined by looking at the Trace statistic value. The critical value for trace statistic at 5% level of significance is 15.49471. Therefore, if the value of trace statistic is ≥ the critical value of 15.49471 at 5% significance level we reject the null hypothesis of no co-integration and conclude that these sectors are cointegrated. If the statistic value is < 15.49471 (critical value) we fail to reject the null hypothesis.

Table 5.18 Pairwise Co-integration – Full Sample (2004 – 2018)

Sector	COM	DIS	STP¤	ENG	FIN	HLT	IND¤	MAT¤
COM								
DIS	8,338							
STP¤	11,979	8,999						
ENG	16,773*	11,955	17,287					
FIN	7,776	20,179*	12,174	14,332				
HLT	15,282	10,09	13,339	12,931	16,480*			
IND¤	7,357	11,079	9,424	10,79	6,112	11,327		
MAT¤	10,905	8,131	10,348	9,666	7,846	7,793	6,405	

Note: 5% critical value = 15.495 ∴ * ~ co-integration

¤ ~ No co-integration with all the other the sectors Source: Author

Table 5.18 exhibits co-integration results of sector pairs over the full sample. Sector pairs that are not cointegrated provide an opportunity for investors to construct a diversified portfolio. Out of the 28 cases, 3 were cointegrated. These were: COM & ENG; DIS & FIN and FIN & HLT. Thus, the rest of the sectors show that the null hypothesis of no co-integration could not be rejected at the conventional level of significance, i.e. 5%, implying that there is a considerable amount of portfolio diversification opportunities that can be reaped by investors. Sectors STP¤, IND¤, and MAT¤ were not co-integrated with all the other sectors (see the highlighted parts). Therefore, these sectors provide the most portfolio diversification benefits over the full sample. On that account, an investor can construct a diversification portfolio which includes, for example, stocks of the STP with stocks either of the COM, DIS, FIN, HLT, IND or MAT. In the case of co-integration between, for example, COM & ENG, an investor is unlikely to realize diversification benefits by constructing a portfolio with stocks from these sectors. In summary, opportunities for sectoral portfolio diversification are present in South Africa over the full sample.

Table 5.19 Pairwise Co-integration – Expansion and Boom (2004 – 2008)

Sectors	COM¤	DIS	STP¤	ENG¤	FIN	HLT	IND¤	MAT¤
COM¤								
DIS	9,106							
STP¤	8,376	5,465						
ENG¤	13,309	9,247	6,882					
FIN	9,507	17,126*	5,063	10,477				
HLT	5,930	15,750*	5,144	6,501	16,528*			
IND¤	13,581	11,004	4,639	8,012	14,320	10,647		
MAT¤	7,107	10,718	5,754	6,434	11,180	8,760	10,555	

Note: 5% critical value = 15.495 ∴ *indicates co-integration

¤ ~ No co-integration with all the other sectors Source: Author

Table 5.19 exhibits co-integration results of sector pairs over the expansion and boom phase. Out of the 28 cases, 3 were co-integrated. These include: DIS & FIN; DIS & HLT and FIN & HLT. Thus, the rest of the sectors show that the null hypothesis of no co-integration could not be rejected at the conventional level of significance. As a result, there is a sizeable amount of portfolio diversification benefits that can be derived by constructing portfolios with non-co-integrated sectors. Sectors COM¤, STP¤, ENG¤, IND¤ and MAT¤ were not co-integrated with all the other sectors (see the highlighted parts). Therefore, these sectors offer more diversification benefits in relation to DIS, FIN and HLT. To reap portfolio diversification benefits, an investor may construct a portfolio which includes, for example, stocks of MAT with stocks either of the COM, DIS, STP, FIN, HLT or IND. This is true for every sector combination that is not co-integrated. In summary, the expansion and boom phase provides opportunities to reap sectoral portfolio diversification in South Africa.

Table 5.20 Pairwise Co-integration – Recession and Recovery (2009 – 2013)

Sectors	COM	DIS	STP¤	ENG	FIN	HLT	IND	MAT¤
COM								
DIS	16,472*							
STP¤	5,557	1,7401						
ENG	20,656*	18,5988*	12,711					
FIN	8,701	17,0616*	6,919	10,705				
HLT	15,291	13,7631	2,351	19,007*	22,024*			
IND	11,190	16,3058*	7,513	8,772	17,058*	21,227*		
MAT¤	9,745	8,3919	8,349	11,819	7,902	12,079	9,266	

Note: 5% critical value = 15.495 ∴ *indicates co-integration

¤ ~ No co-integration with all the other sectors Source: Author

Table 5.20 exhibits co-integration results of sector pairs over the recession and recovery phase. Out of 28 cases, 9 were co-integrated. These include: COM & DIS; COM & ENG; DIS & ENG; DIS & FIN; DIS & IND; ENG & HLT; FIN & HLT; FIN & IND and IND & HLT. Despite a relatively high number of co-integrated sectors in this phase, there was a considerable amount of sectoral portfolio diversification benefits. Sectors STP¤ and MAT¤ were not co-integrated with all the other sectors. These results suggest that portfolio diversification opportunities are mostly offered by STP¤ and MAT¤. In summary, investors can reap sectoral diversification benefits in the recession and recovery phases. However, co-integration appears to rise in this period of heightened volatility where diversification is of uttermost importance. These findings are similar to that of Longin and Solnik (1995) on international equity markets which stated that correlations increased in the bear market in relation to a bull market. Therefore, in general, portfolio diversification (i.e. either international or domestic sectoral) appears to be least effective when needed the most.

Table 5.21 Pairwise Co-integration – Stagnation (2014 – 2018)

Sectors	COM¤	DIS	STP	ENG¤	FIN	HLT¤	IND¤	MAT
COM¤								
DIS	12,878							
STP	11,658	18,076*						
ENG¤	6,038	10,143	13,365					
FIN	12,023	14,355	15,007	12,491				
HLT¤	13,007	7,338	8,907	11,864	10,016			
IND¤	9,370	9,527	10,206	5,187	11,192	5,096		
MAT	6,893	11,268	14,159	8,096	17,064*	6,845	5,391	

Note: 5% critical value = 15.495 ∴ *indicates co-integration

¤ ~ No co-integration with all the other sectors Source: Author

Table 5.21 exhibits co-integration results for sector pairs over the stagnation phase. Out of the 28 cases, 2 were co-integrated. These include: STP & DIS and FIN & MAT. Thus, in most cases, the null hypothesis of no co-integration cannot be rejected at the conventional level of significance. As a result, there is a substantial amount of portfolio diversification benefits that can be derived by constructing portfolios with non-co-integrated sectors. Sectors COM¤, ENG¤, HLT¤, and IND¤ were not co-integrated with all the other sectors. These sectors offer more portfolio diversification benefits relative to DIS, STP, FIN and MAT. To construct a diversified portfolio investors could use, for example, stocks of MAT with stocks either of the COM, DIS, STP, FIN, HLT or IND. In summary, the stagnation phase provides opportunities to reap diversification benefits in South Africa.

Table 5.22 Possible Sector Combinations for Portfolio Diversification

	Possible Portfolio Combinations			Full Sample	Expansion and Boom	Recession and Recovery	Stagnation
1	COM	●⋯●	DIS			×	
2	COM	●⋯●	STP				×
3	COM	●⋯●	ENG	×		×	
4	COM	●⋯●	FIN				
5	COM	●⋯●	HLT				
6	COM	●⋯●	IND				
7	COM	●⋯●	MAT				
8	DIS	●⋯●	STP				
9	DIS	●⋯●	ENG			×	
10	DIS	●⋯●	FIN	×	×	×	
11	DIS	●⋯●	HLT		×		
12	DIS	●⋯●	IND			×	
13	DIS	●⋯●	MAT				
14	STP	●⋯●	ENG				
15	STP	●⋯●	FIN				
16	STP	●⋯●	HLT				
17	STP	●⋯●	IND				
18	STP	●⋯●	MAT				
19	ENG	●⋯●	FIN				
20	ENG	●⋯●	HLT			×	
21	ENG	●⋯●	IND				
22	ENG	●⋯●	MAT				
23	FIN	●⋯●	HLT	×	×	×	
24	FIN	●⋯●	IND			×	
25	FIN	●⋯●	MAT				×
26	HLT	●⋯●	IND			×	
27	HLT	●⋯●	MAT				
28	IND	●⋯●	MAT				

$\times \sim \boldsymbol{denotes\ co - integrated\ sector\ combinations}$

Source: Author

Table 5.22 exhibits a summary of co-integration results on sector pairs over the different phases of the business cycle as well as the full sample. On the whole, pairwise co-integration tests reveal that diversification benefits were mostly available in the stagnation phase, followed by either the full sample or the expansion and boom phases. However, there were fewer benefits available in the recession and recovery phases. Nonetheless, overall, these results suggest that investors have opportunities to make necessary portfolio adjustments over the business cycle to achieve portfolio efficiency (i.e. minimize risk per unit of return or maximize return per unit of risk) through diversification. According to MPT, diversification allows investors to reduce risk without sacrificing returns.

5.5 Granger-causality

There are 56 causality combinations that can be identified from the tables 5.23 – 5.26. The presence of causality is either unidirectional or bidirectional, implying that there is a certain degree of interdependence between sectors. Unidirectional interaction indicates changes in one sector occur independently of the other. On the other hand, bidirectional interaction indicates that changes in both sectors are dependent on each other, such that neither sector evolves independently of the other (Ahmed et al., 2017). These results have a bearing on the potential benefits available from diversifying portfolios in the short run (Ahmed, 2012).

Table 5.23 Pairwise Granger Causality – Full Sample (2004 – 2018)

Sectors	COM	DIS	STP	ENG	FIN	HLT	IND	MAT
COM		0,085	0,019	3,255	0,087	3,313	0,692	2,33
		[0.771]	*[0.892]*	*[0.071]*	*[0.768]*	*[0.069]*	*[0.405]*	*[0.127]*
DIS	0,002		0,009	3,891*	13,165*	0,981	5,073*$\boldsymbol{\tau}$	3,01
	[0.968]		*[0.924]*	*[0.049]*	*[0.000]*	*[0.322]*	*[0.024]*	*[0.083]*
STP	0,708	0,736		5,073*	2,984	2,388	0,174	2,59
	[0.400]	*[0.391]*		*[0.024]*	*[0.084]*	*[0.122]*	*[0.677]*	*[0.108]*
ENG	0,022	2,189	0,653		0,562	0,137	0,713	3,39
	[0.883]	*[0.139]*	*[0.419]*		*[0.454]*	*[0.711]*	*[0.399]*	*[0.066]*
FIN	0,006	1,148	1,246	4,689*		3,294	1,139	3,13
	[0.939]	*[0.284]*	*[0.264]*	*[0.030]*		*[0.069]*	*[0.286]*	*[0.077]*
HLT	0,249	6,076*	0,301	3,61	11,179*		2,29	2,99
	[0.618]	[0.014]	*[0.584]*	*[0.058]*	*[0.001]*		*[0.130]*	*[0.084]*
IND	0,352	7,487*$\boldsymbol{\tau}$	1,668	3,223	0,146	7,867*		2,87
	[0.553]	*[0.006]*	*[0.197]*	*[0.073]*	*[0.703]*	*[0.005]*		*[0.091]*
MAT	0,222	3,317	0,052*	0,504	2,036	0,007*	2,102	
	[0.638]	*[0.069]*	*[0.820]*	*[0.478]*	*[0.154]*	*[0.935]*	*[0.147]*	

[ ] ~ p-values of Wald Test F-statistic; Source: Author
** ~ reject the null hypothesis (does not Granger Cause);* $\boldsymbol{\tau}$ *~ bidirectional causality*

Table 5.23 exhibits the pairwise Granger causality results in the full sample. Out of the 56 causality cases, there were eleven (11) cases that showed the existence of either unidirectional or bidirectional causality (see the asterisks*). There was one (1) significant bidirectional causality between DIS↔IND, denoted by $\boldsymbol{\tau}$. The rest were unidirectional, and they include FIN→ENG, STP→ENG, DIS→ENG, DIS→FIN, HLT→FIN, HLT→DIS, MAT→STP, MAT→HLT, and IND→HLT. Thus, in most bivariate cases, the null hypothesis of no pairwise causal relationship could not be rejected at the conventional level of significance[20], implying that there is a higher degree of independence between the sectors.

The results also suggest that sectors COM and ENG do not exert significant influence on stock price movements on all the other sectors. Moreover, COM was not influenced by price movements from any of the other sectors. ENG {3}[21] was the most Granger caused sector; the least Granger caused sector was STP {1}. On the other hand, the dominant[22] sectors were DIS {3}, HLT {2} and MAT {2}.

In summary, these findings suggest that the degree of dependence between the sectors is considerably limited. Therefore, investors are likely to reap portfolio diversification opportunities over the full sample in the short run.

Table 5.24 Pairwise Granger Causality – Expansion and Boom (2004 – 2008)

Sectors	COM	DIS	STP	ENG	FIN	HLT	IND	MAT
COM		0,798	0,021	4,567*	0,160	0,062	2,493	0,697
		[0.372]	*[0.885]*	*[0.033]*	*[0.689]*	*[0.803]*	*[0.115]*	*[0.404]*
DIS	1,491		0,833	2,063	7,253*	7,763*	4,544*	3,295
	[0.222]		*[0.361]*	*[0.151]*	*[0.007]*	[0.005]	*[0.033]*	*[0.069]*
STP	2,811	0,921		1,879	0,523	0,441	0,702	1,785
	[0.094]	*[0.337]*		*[0.171]*	*[0.469]*	*[0.507]*	*[0.402]*	*[0.182]*
ENG	0,492	1,125	0,067		0,495	0,260	0,222	0,138
	[0.483]	*[0.289]*	*[0.796]*		*[0.482]*	*[0.610]*	*[0.637]*	*[0.710]*
FIN	2,658	0,503	0,124	3,146		2,277	5,034*	4,265*
	[0.103]	*[0.478]*	*[0.725]*	*[0.076]*		*[0.131]*	*[0.025]*	*[0.039]*
HLT	1,040	0,171	0,170	0,844	2,033		4,117*	4,343*
	[0.308]	*[0.679]*	*[0.680]*	*[0.358]*	*[0.154]*		*[0.042]*	*[0.037]*
IND	6,665*	2,632	0,317	2,035	0,006	0,014		0,822
	[0.001]	*[0.105]*	*[0.574]*	*[0.154]*	*[0.938]*	*[0.907]*		*[0.365]*
MAT	0,741	1,764	1,826	0,437	0,381	0,211	1,238	
	[0.389]	[0.184]	*[0.177]*	[0.509]	*[0.537]*	*[0.646]*	*[0.266]*	

[ ] ~ p-values of Wald Test F-statistic; Source: Author
** ~ reject the null hypothesis (does not Granger Cause)*

[20] 5% significant level
[21] { } indicates the number of times a sector is Granger caused or Granger causes other sectors.
[22] Dominant sector/s – refers to sector/sectors that Granger causes other sectors more than the rest.

Table 5.24 exhibits the pairwise Granger causality results in the expansion and boom phase. Out of the 56 causality cases, there was no bidirectional causality present but there were nine (9) cases that showed the existence of unidirectional causality (see the asterisks*). These include IND→COM, COM→ENG, DIS→FIN, DIS→HLT, DIS→IND, FIN→IND, FIN→MAT, HLT→MAT and HLT→IND. Thus, in most bivariate cases, the null hypothesis of no pairwise causal relationship could not be rejected at the conventional level of significance, implying that there is a higher degree of independence between the sectors.

The results also suggest that sectors STP, ENG and MAT do not exert significant influence on stock price movements of all the other sectors. Moreover, sectors DIS and STP were not significantly influenced by price movements from any of the other sectors. The most Granger caused sectors were IND {3} and MAT {2}, respectively. The least Granger caused sectors {1} were COM, ENG, and FIN. On the other hand, the dominant sectors were DIS {3}, HLT {2} and IND {2}, respectively.

In summary, these findings suggest that the degree of dependence between the sectors is considerably limited. Based on that account, investors are likely to reap portfolio diversification opportunities over the expansion and boom phase in the short run.

Table 5.25 Pairwise Granger Causality – Recession and Recovery (2009 – 2013)

Sectors	COM	DIS	STP	ENG	FIN	HLT	IND	MAT
COM		1,965	0,317	13,861*	1,280	0,345	6,562*	6,034*$\boldsymbol{\omega}$
		[0.161]	*[0.573]*	*[0.000]*	*[0.258]*	*[0.557]*	*[0.010]*	*[0.014]*
DIS	6,342*		0,000	13,423*	8,177*	0,057	8,604*	4,832*$\boldsymbol{\tau}$
	[0.012]		*[0.995]*	*[0.000]*	*[0.004]*	*[0.810]*	*[0.003]*	*[0.028]*
STP	3,081	0,037		7,140*	4,116*	0,380	4,178*	5,006*
	[0.079]	*[0.848]*		*[0.008]*	*[0.043]*	*[0.538]*	*[0.041]*	*[0.025]*
ENG	0,031	1,123	2,680		0,474	2,022	0,000	10,202*$\boldsymbol{\varphi}$
	[0.861]	*[0.289]*	*[0.102]*		*[0.491]*	*[0.155]*	*[0.984]*	*[0.001]*
FIN	1,810	0,109	0,510	5,426*		0,588	8,681*	7,320*
	[0.179]	*[0.741]*	*[0.475]*	*[0.020]*		*[0.443]*	*[0.003]*	*[0.007]*
HLT	9,975*	9,535*	0,045	13,615*	18,598*		15,695*	5,034*$\boldsymbol{\alpha}$
	[0.002]	*[0.002]*	*[0.831]*	*[0.000]*	*[0.000]*		*[0.000]*	*[0.025]*
IND	0,019	0,047	1,004	4,027*	0,000	0,099		7,950*
	[0.891]	*[0.828]*	*[0.317]*	*[0.045]*	*[0.992]*	*[0.753]*		[0.005]
MAT	6,071*$\boldsymbol{\omega}$	4,530*$\boldsymbol{\tau}$	0,487	3,385*$\boldsymbol{\varphi}$	1,071	8,481*$\boldsymbol{\alpha}$	1,943	
	[0.014]	*[0.034]*	*[0.486]*	*[0.066]*	*[0.301]*	*[0.004]*	*[0.164]*	

[ ] ~ p-values of Wald Test F-statistic; Source: Author

** ~ reject the null hypothesis (does not Granger cause);* $\boldsymbol{\omega}, \boldsymbol{\tau}, \boldsymbol{\varphi}, \boldsymbol{\alpha}$ *~ bidirectional causalities*

Table 5.25 exhibits the pairwise Granger causality results in the recession and recovery phase. Out of these 56 cases, there were twenty-eight (28) cases that showed the existence of either unidirectional or bidirectional causality (see the asterisks*). There were four (4) significant bidirectional causalities between MAT↔COM $(\boldsymbol{\omega})$, MAT↔DIS $(\boldsymbol{\tau})$, MAT↔ENG $(\boldsymbol{\varphi})$ and MAT↔HLT $(\boldsymbol{\alpha})$. The rest were unidirectional and can be identified by*. To be precise, there were twenty (20) unidirectional cases in this phase (see the summary on table 5.23). Thus, the null of hypothesis of no pairwise causal relationship could not be rejected at the conventional level of significance in half of the bivariate cases, implying that there is some degree of dependence between the sectors.

The results also suggest that all sectors exert significant influence on stock price movements of the other sectors. Moreover, STP was not influenced by all the other sectors. ENG {7} and MAT {7} were the most Granger caused sectors, whereas the least Granger caused sectors were HLT {1} and DIS {2}. On the other hand, the dominant sectors were HLT {6} and DIS {5}.

In summary, the findings suggest that there exists some degree of dependence between the sectors. Nonetheless, investors are likely to reap portfolio diversification opportunities over the recession and recovery phase in the short run.

Table 5.26 Pairwise Granger Causality – Stagnation (2014 – 2018)

Sectors	COM	DIS	STP	ENG	FIN	HLT	IND	MAT
COM		1,386	0,638	1,267	2,069	7,310*	6,193*$\boldsymbol{\tau}$	0,210
		[0.239]	*[0.425]*	*[0.261]*	*[0.151]*	*[0.007]*	*[0.013]*	*[0.647]*
DIS	7,530*		1,692	0,094	1,486	4,235*	1,499	0,645
	[0.006]		*[0.194]*	*[0.759]*	*[0.223]*	*[0.039]*	*[0.221]*	*[0.422]*
STP	5,214*	0,469		1,768	0,119	3,412	0,783	2,215
	[0.023]	*[0.493]*		*[0.184]*	*[0.730]*	*[0.065]*	*[0.376]*	*[0.137]*
ENG	0,064	1,935	0,763		0,116	1,032	0,298	0,166
	[0.800]	*[0.164]*	*[0.382]*		*[0.734]*	*[0.309]*	*[0.585]*	*[0.684]*
FIN	6,626*	0,489	0,152	0,639		5,759*	4,109*	5,860*
	[0.010]	*[0.485]*	*[0.696]*	*[0.424]*		*[0.017]*	*[0.043]*	*[0.015]*
HLT	2,155	0,038	0,336	7,606*	0,984		0,753	0,894
	[0.142]	*[0.845]*	*[0.562]*	*[0.006]*	*[0.321]*		*[0.386]*	*[0.345]*
IND	5,963*$\boldsymbol{\tau}$	0,156	1,141	0,310	2,690	4,763*		0,402
	[0.015]	*[0.693]*	*[0.286]*	*[0.578]*	*[0.101]*	*[0.029]*		*[0.526]*
MAT	1,038	1,879*	0,301	0,132	0,138	1,053	0,044	
	[0.309]	*[0.171]*	*[0.584]*	*[0.717]*	*[0.710]*	*[0.305]*	*[0.835]*	

[ ] ~ p-values of Wald Test F-statistic; Source: Author

** ~ reject the null hypothesis (does not Granger cause;* $\boldsymbol{\tau}$ ~ bidirectional causality

Table 5.26 exhibits the pairwise Granger causality results in the stagnation phase. Out of these 56 cases, there were thirteen (13) cases that showed the existence of either unidirectional or bidirectional causality (see the asterisks*). There was only one (1) significant bidirectional causality between INDI↔COM (τ). The rest were unidirectional and they include DIS→COM, STP→COM, FIN→COM, MAT→DIS, HLT→ENG, IND→HLT, COM→HLT, DIS→HLT, FIN→HLT, FIN→HLT, FIN→IND and FIN→MAT. Thus, in most bivariate cases, the null hypothesis of no pairwise causal relationship could not be rejected at the conventional level of significance, implying that there is a high degree of independence between sectors.

The results also suggest that ENG does not exert significant influence on stock price movements of any of the other sectors. Moreover, sectors STP and FIN were not influenced by any of the other sectors. HLT {4} and COM {4} were the most Granger caused sectors, whereas the least Granger caused sectors were ENG {1}, IND {1} and MAT {1}. On the other hand, the dominant sector was DIS {4}.

In summary, the findings suggest that the degree of dependence between the sectors is considerably limited suggesting investors are likely to reap portfolio diversification opportunities over the stagnation phase in the short run.

Table 5.27 below presents a summary of causality results on the different phases of the South Africa business cycle and the full sample. These findings suggest that the short-term causal relationships between the sectors were considerably limited in all the samples of the study except in the recession and recovery phase. Causality between sectors rises during the recession and recovery phase which implies that benefits of portfolio diversification in the short-run are significantly reduced when they are needed the most. These results are in conformity with co-integration results presented earlier. On the whole, Granger causality tests reveal that short-run diversification benefits are available mostly in the expansion and boom phase. By and large, investors can set up short term investment strategies to reap portfolio diversification opportunities over the different phases of the business cycle and also the full sample.

Table 5.27 Granger Causality Summary over the Business Cycle

Causality	Full Sample	Expansion and Boom	Recession and Recovery	Stagnation
Unidirectional	FIN → ENG	IND → COM	DIS → COM	DIS → COM
	STP → ENG	COM → ENG	HLT → COM	STP → COM
	DIS → ENG	DIS → FIN	HLT → DIS	FIN → COM
	DIS → FIN	DIS → HLT	FIN → ENG	MAT → DIS
	HLT → FIN	DIS → IND	HLT → ENG	HLT → ENG
	HLT → DIS	FIN → IND	IND → ENG	IND → HLT
	MAT → STP	FIN → MAT	COM → ENG	COM → HLT
	MAT → HLT	HLT → MAT	DIS → ENG	DIS → HLT
	IND → HLT	HLT → IND	STP → ENG	FIN → HLT
			HLT → FIN	FIN → IND
			DIS → FIN	FIN → MAT
			STP → FIN	
			COM → IND	
			DIS → IND	
			STP → IND	
			FIN → IND	
			HLT → IND	
			STP → MAT	
			FIN → MAT	
			IND → MAT	
Bidirectional	DIS ↔ IND		MAT ↔ COM	IND ↔ COM
			MAT ↔ DIS	
			MAT ↔ ENG	
			MAT ↔ HLT	
No Influence[23]	COM ; ENG	STP ; ENG ; MAT		ENG
Not Influenced[24]	COM	DIS ; STP	STP	STP ; FIN

Source: Author

[23] No Influence – sector does not influence all the other sectors
[24] Not Influenced – sector is not influenced by all the other sectors

5.6 Conclusion

This chapter conducted an empirical analysis of sectoral portfolio diversification benefits over the South African business cycle. The analysis applied correlation and co-integration techniques to ascertain the existence of sectoral diversification. Due to the statistical limitations of correlation discussed in the chapter two literature review, the study has focused its analysis on co-integration as a better measure of diversification benefits. Granger causality tests were also applied.

The co-integration technique found the existence of domestic portfolio diversification in South African over the full sample as well on the different phases of the business cycle. However, less diversification opportunities were found to exist in the recession and recovery phase compared to the rest of the phases. On the other hand, the most diversification opportunities were found to exist in the Stagnation phase. Granger causality tests had similar findings as well.

6

Summary and Conclusion

6.1 Introduction

This study sought to examine the co-integration of listed equity market sectors and portfolio diversification opportunities available over the business cycle in South Africa. Chapter one outlines the research context, problem statement and contributions of the study. It also presents the research objectives and methods employed. The research objectives are - First, examine whether there is pairwise co-integration of South African equity market sector indices over the business cycle. The study uses MSCI South African sectors that are classified according to the GICS (Global Industry Classification Standard). Second, identify possible sector combinations that can be used for portfolio diversification. Last, examine the short-run causal relationships between sectors. The main hypothesis was that if sectors are not co-integrated then benefits of portfolio diversification can be reaped by selecting stocks from those sectors.

6.2 Summary and conclusion

Chapter two presents the theoretical framework of the study which is anchored on the Modern Portfolio Theory presented by Markowitz (1952). Modern Portfolio Theory presents the mean variance trade-off as the universal portfolio problem faced by all investors. Markowitz recommended that investors should not focus on individual securities but rather construct a portfolio and diversify. To achieve portfolio diversification, the MPT asserts that investors should include securities that have limited co-movement or are uncorrelated. However, correlation has statistical limitations around explaining a stationary long-run relationship between variables. Ahmed et al. (2017) then argue that a co-integration analysis must be performed to determine whether an equilibrium exists. This gave rise to the hypothesis used in this study which states that sectors that are not co-integrated offer diversification opportunities.

The theoretical relationship between diversification and business cycle equity sector investing was also outlined. The link is built around the fact that the performance of equity market sectors is often tied to the state of the business cycle and because every cycle is different portfolio diversification opportunities will also tend to vary. Dzikevičius and Vetrov (2012) asserts that, in such an instance, investors should develop a practical investment framework for cyclical sector allocation in order to keep the portfolio optimized (i.e. portfolio diversification) throughout the phases of the business cycle.

The concept of portfolio diversification initially began domestically then, later on, it was leveraged to international diversification (Grubel and Fadner, 1971). The trend in cross border investments was ignited by globalization, deregulation and financial technology. However, when globalization was fully matured, economies became increasingly integrated, consequently reducing the benefits of portfolio diversification. The market crashes that have occurred since the 1980s and again recently have shown signs that international diversification is not necessarily as effective as originally perceived. Most of the studies post-2000 suggest that global financial markets have become more integrated, an indication that international diversification has become limited. As a result, finance academics and investors have begun to shift focus to domestic portfolio diversification benefits. Most studies on domestic sector portfolio diversification suggest the significant presence of sectoral portfolio diversification benefits. The main argument of the study is not to claim that international diversification opportunities are extinct, which is very improbable, but to assert that the degree of integration in global financial markets has lessened its effectiveness; thereby, investors should consider domestic bias as an alternative to diversify their portfolios.

In chapter three, three distinct business cycle phases were found by adopting the SARB business cycle dating approach. These phases are a) expansion and boom b) recession and recovery and c) stagnation. The performance of sectors in the different phases of the business cycle was also analysed. The analysis suggests that the high performers of the expansion and boom phase are Energy (ENG) and Consumer Staples (STP). Consumer Discretionary (DIS) is the highest performer in both the recession and recovery, and stagnation phases. MAT is the lowest performer in all the phases.

In this study the Johansen co-integration and Granger causality tests have been employed in order to examine the co-integration of sectors and portfolio diversification opportunities. The prerequisite of the methodology is that variables are supposed to be integrated of order 1, I(1). Therefore, ADF and

PP were used to ascertain that all variables were stationary at first difference. If the null hypothesis of no pairwise co-integration cannot be rejected, it suggests the existence of diversification benefits. Thereafter, Granger causality tests were conducted to examine the short-run causal relationships between sectors. These tests were undertaken over the different phases of the business cycle as well as over the full sample.

In chapter five the results of correlation analysis which show the co-movement of sectors suggest that there are diversification benefits in the full sample and stagnation phase, although they are limited in the expansion boom phase and recession recovery phase. On the whole, correlations suggest the existence of diversification opportunities in South Africa. However, the credibility of correlations in measuring diversification benefits is questionable because correlations are erratic and unstable over time.

The multivariate co-integration tests indicated 2 (two) co-integrating equations in the recession and recovery phase, 1 (one) co-integrating equation in the expansion and boom phase and as well in the full sample periods and 0 (zero) in the stagnation phase These results could potentially suggest that there are diversification benefits in the stagnation phase but none or limited benefits in the full sample and other phases of the business cycle. However, less can be deduced from the multivariate co-integration tests in terms of the co-integration between sectors and the presence of diversification benefits. To assess the extent of sectoral co-integration in determining the diversification opportunities present in each phase of the business cycle, the study looked at bivariate (i.e. pairwise) co-integration tests which revealed interesting findings. The stagnation phase provides more portfolio diversification opportunities, followed by expansion and boom, then the full sample and, lastly, the recession and recovery phase. The results imply that diversification is least effective when it is needed the most, during a recession. Overall, investors can reap considerable portfolio diversification benefits across the equity market sectors in South Africa.

On the other hand, the results of Granger's causality analysis show that the short-run causal relationships between the equity market sectors of South Africa are considerably limited and, where they exist, are practically unidirectional. These results imply that there is a considerable degree of independence between the SA equity market sectors. However, there is a higher degree of dependence between sectors in the recession and recovery phase since many Granger causalities were found. Granger causality results also have a bearing on the potential benefits from diversifying portfolios into different sectors. Therefore, the results suggest that there are diversification opportunities in the short run, but they appear to be limited in the recession and recovery phase.

On the whole, investors can reap sectoral portfolio diversification benefits both in the long run and short run across the different phases of the business cycle in South Africa. By and large, these results are consistent with the findings of Constantinou et al. (2008) in Cyprus, Noor et al. (2014) and Ahmed et al. (2017 and 2018) in Pakistan and Colombia.

6.3 Recommendations

Since the results of this study reveal diverse sectoral portfolio diversification opportunities available to investors over the South African business cycle, the study recommends investors to adopt a practical portfolio construction framework for dynamic sector allocation across the business cycle. In this way, portfolio optimization is maintained throughout the phases of the business cycle. The historical simulation of cyclical asset allocation strategies shows a better performance of active versus passive investment strategies on the basis of risk and return measures. Passive portfolio risk and return for example change considerably with the phases of the business cycle (Dzikevičius and Vetrov, 2012). This fact reveals that in the absence of cyclical rebalancing, investment benefits enjoyed during recoveries, expansions and slowdowns are substantially diluted during downturns (Dzikevičius and Vetrov, 2012). As a result, passive management approach can result in a less than optimal risk/return profile over a complete business cycle. Grobys (2012) also confirms that, when taking into account the business cycle phases, active strategies perform better than the passive ones.

6.4 Areas of further study

With regards to the South African business cycle, this study used the SARB dating approach to categorize the different phases of the South African business cycle, but it will also be interesting to use the output gap methodology as an alternative. Moreover, researchers could employ JSE Sector Indices data set to examine sectoral diversification benefits as opposed to MSCI South African Equity Market Sector Indices which have been used in this study.

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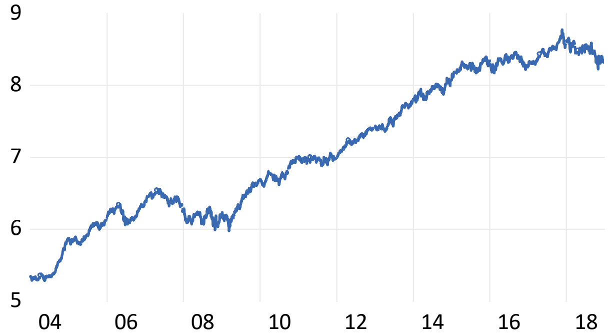
Appendix A

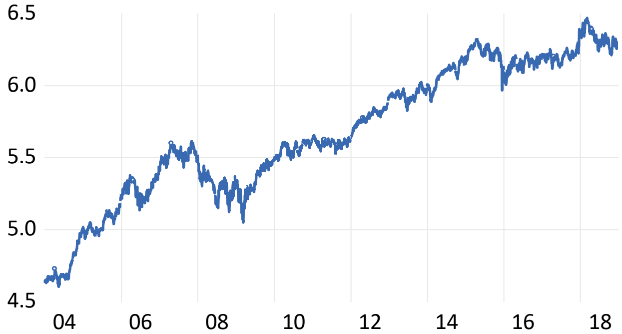
LNCOM

LNDIS



LNENG

LNFIN

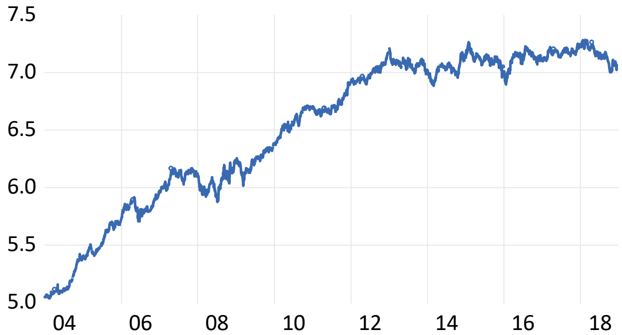


LNHLT

LNIND

LNMAT

LNSTP



Appendix B

Full Sample 2004 - 2018

Date: 09/18/19 Time: 18:46
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.011650	163.0032	159.5297	0.0319
At most 1	0.010042	119.0813	125.6154	0.1168
At most 2	0.008434	81.25388	95.75366	0.3241
At most 3	0.004642	49.50917	69.81889	0.6590
At most 4	0.003206	32.07095	47.85613	0.6082
At most 5	0.003008	20.03475	29.79707	0.4205
At most 6	0.001369	8.742287	15.49471	0.3898
At most 7	0.000962	3.606283	3.841465	0.0576

Trace test indicates 1 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Recession and Recovery Phase 2009 – 2013

Date: 09/18/19 Time: 18:52
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.058794	218.7033	159.5297	0.0000
At most 1 *	0.043314	143.0828	125.6154	0.0028
At most 2	0.025590	87.82075	95.75366	0.1550
At most 3	0.019772	55.46869	69.81889	0.3996
At most 4	0.013186	30.54595	47.85613	0.6907
At most 5	0.006230	13.98032	29.79707	0.8417
At most 6	0.004404	6.181397	15.49471	0.6741
At most 7	0.000540	0.673494	3.841465	0.4118

Trace test indicates 2 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Expansion and Boom Phase 2004 – 2008

Date: 09/18/19 Time: 18:49
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.045140	178.2918	159.5297	0.0032
At most 1	0.042947	120.5532	125.6154	0.0977
At most 2	0.019407	65.68230	95.75366	0.8485
At most 3	0.014068	41.18495	69.81889	0.9276
At most 4	0.008350	23.47460	47.85613	0.9529
At most 5	0.004879	12.99376	29.79707	0.8919
At most 6	0.004135	6.880462	15.49471	0.5916
At most 7	0.001360	1.700595	3.841465	0.1922

Trace test indicates 1 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Stagnation Phase 2014 – 2018

Date: 09/18/19 Time: 18:54
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.027765	122.5233	159.5297	0.8029
At most 1	0.020310	87.43850	125.6154	0.9105
At most 2	0.016755	61.87113	95.75366	0.9249
At most 3	0.012407	40.81702	69.81889	0.9343
At most 4	0.011427	25.26059	47.85613	0.9116
At most 5	0.004162	10.94090	29.79707	0.9626
At most 6	0.003205	5.744059	15.49471	0.7255
At most 7	0.001399	1.744292	3.841465	0.1866

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & DIS

Date: 09/19/19 Time: 18:47
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNCONS_DISC
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.001916	8.338198	15.49471	0.4300
At most 1	0.000307	1.150014	3.841465	0.2835

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & STP

Date: 09/19/19 Time: 18:48
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNCONS_STAP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.002248	11.97923	15.49471	0.1579
At most 1	0.000945	3.542763	3.841465	0.0598

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & ENG

Date: 09/19/19 Time: 18:49
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNENERGY
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.002702	16.77300	15.49471	0.0319
At most 1 *	0.001768	6.631675	3.841465	0.0100

Trace test indicates 2 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & FIN

Date: 09/19/19 Time: 18:50
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNFIN
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.001890	7.775874	15.49471	0.4897
At most 1	0.000183	0.686875	3.841465	0.4072

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & HLT

Date: 09/19/19 Time: 18:50
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNHEALTH
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.002810	15.28205	15.49471	0.0538
At most 1 *	0.001262	4.734192	3.841465	0.0296

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & IND

Date: 09/19/19 Time: 18:51
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.001961	7.357149	15.49471	0.5365
At most 1	5.08E-07	0.001903	3.841465	0.9621

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Appendix C

Johansen Co-integration – Pairwise

(Full Sample)

COM & MAT

Date: 09/19/19 Time: 18:52
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.002071	10.90530	15.49471	0.2174
At most 1	0.000836	3.133302	3.841465	0.0767

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

DIS & FIN

Date: 09/19/19 Time: 18:54
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNFIN
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.005014	20.17895	15.49471	0.0091
At most 1	0.000357	1.339252	3.841465	0.2472

Trace test indicates 1 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

DIS & STP

Date: 09/19/19 Time: 18:52
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNCONS_STAP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.001889	8.998661	15.49471	0.3655
At most 1	0.000510	1.913718	3.841465	0.1665

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

DIS & HLT

Date: 09/19/19 Time: 18:55
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNHEALTH
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.002053	10.08977	15.49471	0.2739
At most 1	0.000637	2.387649	3.841465	0.1223

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

DIS & ENG

Date: 09/19/19 Time: 18:53
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNENERGY
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.002941	11.95498	15.49471	0.1591
At most 1	0.000245	0.917346	3.841465	0.3382

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

DIS & IND

Date: 09/19/19 Time: 18:56
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.002486	11.07850	15.49471	0.2067
At most 1	0.000466	1.747823	3.841465	0.1861

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Appendix C

Johansen Co-integration – Pairwise
(Full Sample)

DIS & MAT

Date: 09/19/19 Time: 18:58
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.002085	8.131333	15.49471	0.4515
At most 1	8.23E-05	0.308513	3.841465	0.5786

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

STP & HLT

Date: 09/19/19 Time: 19:00
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_STAP LNHEALTH
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.002178	13.33884	15.49471	0.1030
At most 1 *	0.001377	5.165337	3.841465	0.0230

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

STP & ENG

Date: 09/19/19 Time: 18:58
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_STAP LNENERGY
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.003278	17.28713	15.49471	0.0266
At most 1 *	0.001328	4.979314	3.841465	0.0256

Trace test indicates 2 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

STP & IND

Date: 09/19/19 Time: 19:02
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_STAP LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.002394	9.423569	15.49471	0.3276
At most 1	0.000117	0.439073	3.841465	0.5076

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

STP & FIN

Date: 09/19/19 Time: 18:59
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_STAP LNFIN
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.002210	12.17382	15.49471	0.1488
At most 1 *	0.001035	3.882190	3.841465	0.0488

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

STP & MAT

Date: 09/19/19 Time: 19:03
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_STAP LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.001936	10.34849	15.49471	0.2549
At most 1	0.000822	3.083547	3.841465	0.0791

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Appendix C

Johansen Co-integration – Pairwise

(Full Sample)

ENG & FIN

Date: 09/19/19 Time: 19:03
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNENERGY LNFIN
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.003122	14.33167	15.49471	0.0743
At most 1	0.000696	2.610422	3.841465	0.1062

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

ENG & MAT

Date: 09/19/19 Time: 19:06
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNENERGY LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.002309	9.666271	15.49471	0.3073
At most 1	0.000268	1.003791	3.841465	0.3164

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

ENG & HLT

Date: 09/19/19 Time: 19:04
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNENERGY LNHEALTH
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.002797	12.93149	15.49471	0.1174
At most 1	0.000649	2.432486	3.841465	0.1188

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

FIN & HLT

Date: 09/19/19 Time: 19:06
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNFIN LNHEALTH
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.003860	16.48011	15.49471	0.0354
At most 1	0.000530	1.985232	3.841465	0.1588

Trace test indicates 1 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

ENG & IND

Date: 09/19/19 Time: 19:05
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNENERGY LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.002713	10.79031	15.49471	0.2247
At most 1	0.000163	0.609275	3.841465	0.4351

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

FIN & IND

Date: 09/19/19 Time: 19:07
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNFIN LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.001107	6.112211	15.49471	0.6823
At most 1	0.000523	1.959974	3.841465	0.1615

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

FIN & MAT

Date: 09/19/19 Time: 19:08
Sample (adjusted): 1/08/2004 12/31/2018
Included observations: 3746 after adjustments
Trend assumption: Linear deterministic trend
Series: LNFIN LNMATERIALS
Lags interval (in first differences): 1 to 3

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.001910	7.845916	15.49471	0.4820
At most 1	0.000183	0.685184	3.841465	0.4078

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

HLT & IND

Date: 09/19/19 Time: 19:09
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNHEALTH LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.002721	11.32736	15.49471	0.1922
At most 1	0.000297	1.114083	3.841465	0.2912

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

HLT & MAT

Date: 09/19/19 Time: 19:10
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNHEALTH LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.001448	7.793140	15.49471	0.4878
At most 1	0.000630	2.362099	3.841465	0.1243

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

IND & MAT

Date: 09/19/19 Time: 19:10
Sample (adjusted): 1/06/2004 12/31/2018
Included observations: 3748 after adjustments
Trend assumption: Linear deterministic trend
Series: LNINDI LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.001693	6.404644	15.49471	0.6477
At most 1	1.40E-05	0.052513	3.841465	0.8187

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Appendix D

Pairwise

Expansion and Boom Phase 2004 – 2008

COM & DIS

Date: 09/19/19 Time: 19:22
Sample (adjusted): 1/07/2004 12/31/2008
Included observations: 1249 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNCONS_DISC
Lags interval (in first differences): 1 to 2

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.004787	9.105706	15.49471	0.3557
At most 1	0.002488	3.111890	3.841465	0.0777

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & FIN

Date: 09/19/19 Time: 19:26
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNFIN
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.004494	9.507128	15.49471	0.3205
At most 1 *	0.003097	3.877203	3.841465	0.0489

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & STP

Date: 09/19/19 Time: 19:24
Sample (adjusted): 1/07/2004 12/31/2008
Included observations: 1249 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNCONS_STAP
Lags interval (in first differences): 1 to 2

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.005462	8.375789	15.49471	0.4261
At most 1	0.001229	1.535595	3.841465	0.2153

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & HLT

Date: 09/19/19 Time: 19:27
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNHEALTH
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.003255	5.929749	15.49471	0.7038
At most 1	0.001482	1.854079	3.841465	0.1733

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & ENG

Date: 09/19/19 Time: 19:26
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNENERGY
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.008591	13.30928	15.49471	0.1039
At most 1	0.002017	2.524124	3.841465	0.1121

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & IND

Date: 09/19/19 Time: 19:27
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.008741	13.58060	15.49471	0.0952
At most 1	0.002083	2.606647	3.841465	0.1064

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Appendix D
Pairwise

Expansion and Boom Phase 2004 – 2008

COM & MAT

Date: 09/19/19 Time: 19:27
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.004204	7.107340	15.49471	0.5652
At most 1	0.001472	1.841504	3.841465	0.1748

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

DIS & FIN

Date: 09/19/19 Time: 19:28
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNFIN
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.010549	17.12600	15.49471	0.0282
At most 1 *	0.003091	3.869473	3.841465	0.0492

Trace test indicates 2 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

DIS & STP

Date: 09/19/19 Time: 19:28
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNCONS_STAP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.003686	5.464938	15.49471	0.7576
At most 1	0.000679	0.848569	3.841465	0.3570

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

DIS & HLT

Date: 09/19/19 Time: 19:29
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNHEALTH
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.009378	15.75043	15.49471	0.0458
At most 1 *	0.003173	3.972925	3.841465	0.0462

Trace test indicates 2 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

DIS & ENG

Date: 09/19/19 Time: 19:28
Sample (adjusted): 1/07/2004 12/31/2008
Included observations: 1249 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNENERGY
Lags interval (in first differences): 1 to 2

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.004898	9.247273	15.49471	0.3430
At most 1	0.002491	3.114947	3.841465	0.0776

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

DIS & IND

Date: 09/19/19 Time: 19:29
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.005684	11.00424	15.49471	0.2112
At most 1 *	0.003099	3.879275	3.841465	0.0489

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Appendix D

Johansen Co-integration – Pairwise

Expansion and Boom Phase 2004 – 2008

DIS & MAT

Date: 09/19/19 Time: 19:29
Sample (adjusted): 1/07/2004 12/31/2008
Included observations: 1249 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNMATERIALS
Lags interval (in first differences): 1 to 2

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.004403	10.71750	15.49471	0.2295
At most 1 *	0.004160	5.206574	3.841465	0.0225

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

STP & HLT

Date: 09/19/19 Time: 19:30
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_STAP LNHEALTH
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.002490	5.143916	15.49471	0.7934
At most 1	0.001621	2.027985	3.841465	0.1544

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

STP & ENG

Date: 09/19/19 Time: 19:29
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_STAP LNENERGY
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.004159	6.882413	15.49471	0.5914
At most 1	0.001338	1.673289	3.841465	0.1958

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

STP & IND

Date: 09/19/19 Time: 19:30
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_STAP LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.002898	4.638587	15.49471	0.8459
At most 1	0.000808	1.010759	3.841465	0.3147

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

STP & FIN

Date: 09/19/19 Time: 19:30
Sample (adjusted): 1/07/2004 12/31/2008
Included observations: 1249 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_STAP LNFIN
Lags interval (in first differences): 1 to 2

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.003425	5.062736	15.49471	0.8021
At most 1	0.000622	0.777578	3.841465	0.3779

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

STP & MAT

Date: 09/19/19 Time: 19:30
Sample (adjusted): 1/07/2004 12/31/2008
Included observations: 1249 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_STAP LNMATERIALS
Lags interval (in first differences): 1 to 2

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.003398	5.754165	15.49471	0.7243
At most 1	0.001203	1.503065	3.841465	0.2202

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Appendix D

Pairwise

Johansen Co-integration –

Expansion and Boom Phase 2004 – 2008

ENG & FIN

Date: 09/19/19 Time: 19:31
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Series: LNENERGY LNFIN
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.005379	10.47654	15.49471	0.2459
At most 1	0.002983	3.734718	3.841465	0.0533

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

ENG & MAT

Date: 09/19/19 Time: 19:31
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Series: LNENERGY LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.003586	6.434211	15.49471	0.6442
At most 1	0.001554	1.943804	3.841465	0.1633

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

ENG & HLT

Date: 09/19/19 Time: 19:31
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Series: LNENERGY LNHEALTH
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.003535	6.501199	15.49471	0.6363
At most 1	0.001658	2.074347	3.841465	0.1498

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

FIN & HLT

Date: 09/19/19 Time: 19:32
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Series: LNFIN LNHEALTH
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.011210	16.52793	15.49471	0.0348
At most 1	0.001947	2.436206	3.841465	0.1186

Trace test indicates 1 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

ENG & IND

Date: 09/19/19 Time: 19:31
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Series: LNENERGY LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.004262	8.012439	15.49471	0.4641
At most 1	0.002136	2.673207	3.841465	0.1020

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

FIN & IND

Date: 09/19/19 Time: 19:32
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Series: LNFIN LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.008482	14.32003	15.49471	0.0746
At most 1	0.002934	3.672749	3.841465	0.0553

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Appendix D

Pairwise

Johansen Co-integration –

Expansion and Boom Phase 2004 – 2008

FIN & MAT

Date: 09/19/19 Time: 19:32
Sample (adjusted): 1/07/2004 12/31/2008
Included observations: 1249 after adjustments
Trend assumption: Linear deterministic trend
Series: LNFIN LNMATERIALS
Lags interval (in first differences): 1 to 2

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.005725	11.17968	15.49471	0.2007
At most 1 *	0.003205	4.008911	3.841465	0.0453

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

HLT & IND

Date: 09/19/19 Time: 19:33
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Series: LNHEALTH LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.007027	10.64697	15.49471	0.2342
At most 1	0.001464	1.831642	3.841465	0.1759

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

HLT & MAT

Date: 09/19/19 Time: 19:33
Sample (adjusted): 1/06/2004 12/31/2008
Included observations: 1250 after adjustments
Trend assumption: Linear deterministic trend
Series: LNHEALTH LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.005481	8.759887	15.49471	0.3881
At most 1	0.001511	1.889927	3.841465	0.1692

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

IND & MAT

Date: 09/19/19 Time: 19:33
Sample (adjusted): 1/07/2004 12/31/2008
Included observations: 1249 after adjustments
Trend assumption: Linear deterministic trend
Series: LNINDI LNMATERIALS
Lags interval (in first differences): 1 to 2

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.006826	10.55529	15.49471	0.2404
At most 1	0.001600	2.000566	3.841465	0.1572

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & DIS

Date: 09/19/19 Time: 19:47
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNCONS_DISC
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.013106	16.47225	15.49471	0.0355
At most 1	6.21E-06	0.007746	3.841465	0.9294

Trace test indicates 1 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & FIN

Date: 09/19/19 Time: 19:49
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNFIN
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.006703	8.701132	15.49471	0.3938
At most 1	0.000246	0.307178	3.841465	0.5794

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & STP

Date: 09/19/19 Time: 19:48
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNCONS_STAP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.003042	5.557447	15.49471	0.7471
At most 1	0.001406	1.755577	3.841465	0.1852

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & HLT

Date: 09/19/19 Time: 19:49
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNHEALTH
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.011834	15.29111	15.49471	0.0536
At most 1	0.000348	0.434570	3.841465	0.5098

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & ENG

Date: 09/19/19 Time: 19:49
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNENERGY
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.016075	20.65638	15.49471	0.0076
At most 1	0.000346	0.431263	3.841465	0.5114

Trace test indicates 1 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & IND

Date: 09/19/19 Time: 19:50
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.008534	11.19001	15.49471	0.2001
At most 1	0.000396	0.494067	3.841465	0.4821

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Appendix E

Recession and Recovery Phase 2009 – 2013

COM & MAT

Date: 09/19/19 Time: 19:50
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.007514	9.745371	15.49471	0.3008
At most 1	0.000267	0.333018	3.841465	0.5639

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

DIS & FIN

Date: 09/19/19 Time: 19:51
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNFIN
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.013522	17.06164	15.49471	0.0288
At most 1	5.74E-05	0.071610	3.841465	0.7890

Trace test indicates 1 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

DIS & STP

Date: 09/19/19 Time: 19:50
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNCONS_STAP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.001393	1.740097	15.49471	0.9976
At most 1	2.63E-07	0.000329	3.841465	0.9876

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

DIS & HLT

Date: 09/19/19 Time: 19:51
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNHEALTH
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.010459	13.76312	15.49471	0.0897
At most 1	0.000514	0.641509	3.841465	0.4232

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

DIS & ENG

Date: 09/19/19 Time: 19:51
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNENERGY
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.014555	18.59881	15.49471	0.0165
At most 1	0.000241	0.300193	3.841465	0.5838

Trace test indicates 1 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

DIS & IND

Date: 09/19/19 Time: 19:51
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.012916	16.30575	15.49471	0.0377
At most 1	6.54E-05	0.081597	3.841465	0.7751

Trace test indicates 1 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Appendix E

Recession and Recovery Phase 2009 – 2013

DIS & MAT

Date: 09/19/19 Time: 19:52
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.005788	8.391929	15.49471	0.4245
At most 1	0.000919	1.147129	3.841465	0.2842

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

STP & HLT

Date: 09/19/19 Time: 19:53
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_STAP LNHEALTH
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.001240	2.351425	15.49471	0.9887
At most 1	0.000643	0.802866	3.841465	0.3702

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

STP & ENG

Date: 09/19/19 Time: 19:52
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_STAP LNENERGY
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.008269	12.71072	15.49471	0.1259
At most 1	0.001880	2.348651	3.841465	0.1254

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

STP & IND

Date: 09/19/19 Time: 19:53
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_STAP LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.004321	7.512939	15.49471	0.5188
At most 1	0.001689	2.109261	3.841465	0.1464

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

STP & FIN

Date: 09/19/19 Time: 19:53
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_STAP LNFIN
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.004191	6.918508	15.49471	0.5872
At most 1	0.001343	1.677703	3.841465	0.1952

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

STP & MAT

Date: 09/19/19 Time: 19:54
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_STAP LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.005126	8.348965	15.49471	0.4289
At most 1	0.001549	1.934715	3.841465	0.1642

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Recession and Recovery Phase 2009 – 2013

ENG & FIN

Date: 09/19/19 Time: 19:54
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNENERGY LNFIN
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.007704	10.70509	15.49471	0.2303
At most 1	0.000844	1.053796	3.841465	0.3046

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

ENG & MAT

Date: 09/19/19 Time: 19:55
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNENERGY LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.009211	11.81863	15.49471	0.1658
At most 1	0.000217	0.270403	3.841465	0.6031

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

ENG & HLT

Date: 09/19/19 Time: 19:54
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNENERGY LNHEALTH
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.014057	19.00673	15.49471	0.0142
At most 1	0.001072	1.339036	3.841465	0.2472

Trace test indicates 1 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

FIN & HLT

Date: 09/19/19 Time: 19:56
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNFIN LNHEALTH
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.016875	22.02374	15.49471	0.0045
At most 1	0.000628	0.784073	3.841465	0.3759

Trace test indicates 1 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

ENG & IND

Date: 09/19/19 Time: 19:55
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNENERGY LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.006118	8.771842	15.49471	0.3869
At most 1	0.000892	1.113556	3.841465	0.2913

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

FIN & IND

Date: 09/19/19 Time: 19:56
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNFIN LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.012947	17.05768	15.49471	0.0289
At most 1	0.000637	0.794692	3.841465	0.3727

Trace test indicates 1 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Appendix E

Recession and Recovery Phase 2009 – 2013

FIN & MAT

Date: 09/19/19 Time: 19:56
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNFIN LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.006312	7.902092	15.49471	0.4759
At most 1	7.51E-08	9.37E-05	3.841465	0.9935

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

IND & MAT

Date: 09/19/19 Time: 19:57
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNINDI LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.007361	9.265851	15.49471	0.3414
At most 1	3.64E-05	0.045430	3.841465	0.8312

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

HLT & IND

Date: 09/19/19 Time: 19:57
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNHEALTH LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.016213	21.22690	15.49471	0.0061
At most 1	0.000662	0.827051	3.841465	0.3631

Trace test indicates 1 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

HLT & MAT

Date: 09/19/19 Time: 19:57
Sample (adjusted): 1/06/2009 12/31/2013
Included observations: 1248 after adjustments
Trend assumption: Linear deterministic trend
Series: LNHEALTH LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.009354	12.07915	15.49471	0.1532
At most 1	0.000280	0.350106	3.841465	0.5541

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

Appendix F

Stagnation Phase 2009 – 2013

COM & DIS

Date: 09/19/19 Time: 20:15
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNCONS_DISC
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.008132	12.87817	15.49471	0.1194
At most 1	0.002168	2.704699	3.841465	0.1001

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & STP

Date: 09/19/19 Time: 20:16
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNCONS_STAP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.008020	11.65804	15.49471	0.1741
At most 1	0.001303	1.624361	3.841465	0.2025

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & ENG

Date: 09/19/19 Time: 20:16
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNENERGY
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.004271	6.037776	15.49471	0.6911
At most 1	0.000565	0.704358	3.841465	0.4013

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & FIN

Date: 09/19/19 Time: 20:18
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNFIN
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.008880	12.02320	15.49471	0.1558
At most 1	0.000730	0.909815	3.841465	0.3402

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & HLT

Date: 09/19/19 Time: 20:18
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNHEALTH
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.007674	13.00675	15.49471	0.1146
At most 1	0.002731	3.408081	3.841465	0.0649

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

COM & IND

Date: 09/19/19 Time: 20:18
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.007367	9.369979	15.49471	0.3323
At most 1	0.000126	0.156740	3.841465	0.6922

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Stagnation Phase 2009 – 2013

COM & MAT

Date: 09/19/19 Time: 20:19
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCOM_SER LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.003881	6.892790	15.49471	0.5902
At most 1	0.001642	2.047134	3.841465	0.1525

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

DIS & FIN

Date: 09/19/19 Time: 20:20
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNFIN
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.007532	14.35547	15.49471	0.0737
At most 1 *	0.003953	4.935174	3.841465	0.0263

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

DIS & STP

Date: 09/19/19 Time: 20:19
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNCONS_STAP
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.010255	18.07564	15.49471	0.0200
At most 1 *	0.004190	5.231668	3.841465	0.0222

Trace test indicates 2 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

DIS & HLT

Date: 09/19/19 Time: 20:20
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNHEALTH
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.005543	7.337960	15.49471	0.5387
At most 1	0.000331	0.412693	3.841465	0.5206

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

DIS & ENG

Date: 09/19/19 Time: 20:20
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNENERGY
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.005331	10.14332	15.49471	0.2699
At most 1	0.002791	3.482694	3.841465	0.0620

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

DIS & IND

Date: 09/19/19 Time: 20:21
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.006435	9.526878	15.49471	0.3189
At most 1	0.001190	1.483213	3.841465	0.2233

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Stagnation Phase 2009 – 2013

DIS & MAT

Date: 09/19/19 Time: 20:21
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_DISC LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.005792	11.26804	15.49471	0.1955
At most 1 *	0.003230	4.030539	3.841465	0.0447

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

STP & HLT

Date: 09/19/19 Time: 20:23
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_STAP LNHEALTH
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.007061	8.906591	15.49471	0.3741
At most 1	6.17E-05	0.076880	3.841465	0.7816

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

STP & ENG

Date: 09/19/19 Time: 20:22
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_STAP LNENERGY
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.008130	13.36516	15.49471	0.1021
At most 1	0.002560	3.193240	3.841465	0.0739

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

STP & IND

Date: 09/19/19 Time: 20:23
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_STAP LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.007878	10.20629	15.49471	0.2652
At most 1	0.000282	0.351674	3.841465	0.5532

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

STP & FIN

Date: 09/19/19 Time: 20:22
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_STAP LNFIN
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.006949	15.00739	15.49471	0.0591
At most 1 *	0.005058	6.318575	3.841465	0.0119

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

STP & MAT

Date: 09/19/19 Time: 20:23
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNCONS_STAP LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.007836	14.15877	15.49471	0.0787
At most 1 *	0.003490	4.356084	3.841465	0.0369

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Stagnation Phase 2009 – 2013

ENG & FIN

Date: 09/19/19 Time: 20:24
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNENERGY LNFIN
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.006227	12.49115	15.49471	0.1348
At most 1 *	0.003771	4.707553	3.841465	0.0300

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

ENG & MAT

Date: 09/19/19 Time: 20:25
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNENERGY LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.003611	8.095861	15.49471	0.4552
At most 1	0.002876	3.588845	3.841465	0.0582

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

END & HLT

Date: 09/19/19 Time: 20:24
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNENERGY LNHEALTH
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.009469	11.86427	15.49471	0.1636
At most 1	7.77E-06	0.009677	3.841465	0.9213

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

FIN & HLT

Date: 09/19/19 Time: 20:25
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNFIN LNHEALTH
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.007913	10.01584	15.49471	0.2795
At most 1	9.35E-05	0.116476	3.841465	0.7329

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

ENG & IND

Date: 09/19/19 Time: 20:25
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNENERGY LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.003514	5.187463	15.49471	0.7886
At most 1	0.000643	0.801881	3.841465	0.3705

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

FIN & IND

Date: 09/19/19 Time: 20:25
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNFIN LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.008692	11.19167	15.49471	0.2000
At most 1	0.000252	0.314055	3.841465	0.5752

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Appendix F

Stagnation Phase 2009 – 2013

FIN & MAT

Date: 09/19/19 Time: 20:26
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNFIN LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.009719	17.06368	15.49471	0.0288
At most 1 *	0.003921	4.894711	3.841465	0.0269

Trace test indicates 2 co-integration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

IND & MAT

Date: 09/19/19 Time: 20:27
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNINDI LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.003824	5.390667	15.49471	0.7660
At most 1	0.000495	0.616862	3.841465	0.4322

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

HLT & IND

Date: 09/19/19 Time: 20:27
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNHEALTH LNINDI
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.004034	5.096254	15.49471	0.7985
At most 1	4.82E-05	0.060065	3.841465	0.8064

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

HLT & MAT

Date: 09/19/19 Time: 20:27
Sample (adjusted): 1/06/2014 12/31/2018
Included observations: 1246 after adjustments
Trend assumption: Linear deterministic trend
Series: LNHEALTH LNMATERIALS
Lags interval (in first differences): 1 to 1

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.004994	6.845364	15.49471	0.5957
At most 1	0.000487	0.606841	3.841465	0.4360

Trace test indicates no co-integration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Appendix H

Granger Causality – Full Sample 2004 – 2018

Pairwise Granger Causality Tests
Date: 09/19/19 Time: 20:39
Sample: 1/02/2004 12/31/2018
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
LNCONS_DISC does not Granger Cause LNCOM_SER	3749	0.00159	0.9682
LNCOM_SER does not Granger Cause LNCONS_DISC		0.08505	0.7706
LNCONS_STAP does not Granger Cause LNCOM_SER	3749	0.70848	0.4000
LNCOM_SER does not Granger Cause LNCONS_STAP		0.01857	0.8916
LNENERGY does not Granger Cause LNCOM_SER	3749	0.02152	0.8834
LNCOM_SER does not Granger Cause LNENERGY		3.25536	0.0713
LNFIN does not Granger Cause LNCOM_SER	3749	0.00580	0.9393
LNCOM_SER does not Granger Cause LNFIN		0.08695	0.7681
LNHEALTH does not Granger Cause LNCOM_SER	3749	0.24909	0.6177
LNCOM_SER does not Granger Cause LNHEALTH		3.31347	0.0688
LNINDI does not Granger Cause LNCOM_SER	3749	0.35238	0.5528
LNCOM_SER does not Granger Cause LNINDI		0.69226	0.4055
LNMATERIALS does not Granger Cause LNCOM_SER	3749	0.22208	0.6375
LNCOM_SER does not Granger Cause LNMATERIALS		2.32675	0.1273
LNCONS_STAP does not Granger Cause LNCONS_DISC	3749	0.73602	0.3910
LNCONS_DISC does not Granger Cause LNCONS_STAP		0.00900	0.9244
LNENERGY does not Granger Cause LNCONS_DISC	3749	2.18921	0.1391
LNCONS_DISC does not Granger Cause LNENERGY		3.89079	0.0486
LNFIN does not Granger Cause LNCONS_DISC	3749	1.14765	0.2841
LNCONS_DISC does not Granger Cause LNFIN		13.1647	0.0003
LNHEALTH does not Granger Cause LNCONS_DISC	3749	6.07601	0.0137
LNCONS_DISC does not Granger Cause LNHEALTH		0.98093	0.3220
LNINDI does not Granger Cause LNCONS_DISC	3749	7.48722	0.0062
LNCONS_DISC does not Granger Cause LNINDI		5.07274	0.0244
LNMATERIALS does not Granger Cause LNCONS_DISC	3749	3.31655	0.0687
LNCONS_DISC does not Granger Cause LNMATERIALS		3.01097	0.0828
LNENERGY does not Granger Cause LNCONS_STAP	3749	0.65275	0.4192
LNCONS_STAP does not Granger Cause LNENERGY		5.07276	0.0244
LNFIN does not Granger Cause LNCONS_STAP	3749	1.24579	0.2644
LNCONS_STAP does not Granger Cause LNFIN		2.98351	0.0842
LNHEALTH does not Granger Cause LNCONS_STAP	3749	0.30062	0.5835
LNCONS_STAP does not Granger Cause LNHEALTH		2.38780	0.1224
LNINDI does not Granger Cause LNCONS_STAP	3749	1.66768	0.1966
LNCONS_STAP does not Granger Cause LNINDI		0.17379	0.6768
LNMATERIALS does not Granger Cause LNCONS_STAP	3749	0.05182	0.8199
LNCONS_STAP does not Granger Cause LNMATERIALS		2.58813	0.1078

Appendix H

Granger Causality – Full Sample 2004 – 2018

LNFIN does not Granger Cause LNENERGY	3749	4.68935	0.0304
LNENERGY does not Granger Cause LNFIN		0.56172	0.4536
LNHEALTH does not Granger Cause LNENERGY	3749	3.60965	0.0575
LNENERGY does not Granger Cause LNHEALTH		0.13702	0.7113
LNINDI does not Granger Cause LNENERGY	3749	3.22288	0.0727
LNENERGY does not Granger Cause LNINDI		0.71250	0.3987
LNMATERIALS does not Granger Cause LNENERGY	3749	0.50351	0.4780
LNENERGY does not Granger Cause LNMATERIALS		3.38598	0.0658
LNHEALTH does not Granger Cause LNFIN	3749	11.1785	0.0008
LNFIN does not Granger Cause LNHEALTH		3.29430	0.0696
LNINDI does not Granger Cause LNFIN	3749	0.14560	0.7028
LNFIN does not Granger Cause LNINDI		1.13921	0.2859
LNMATERIALS does not Granger Cause LNFIN	3749	2.03632	0.1537
LNFIN does not Granger Cause LNMATERIALS		3.13045	0.0769
LNINDI does not Granger Cause LNHEALTH	3749	7.86670	0.0051
LNHEALTH does not Granger Cause LNINDI		2.28950	0.1303
LNMATERIALS does not Granger Cause LNHEALTH	3749	0.00665	0.9350
LNHEALTH does not Granger Cause LNMATERIALS		2.99186	0.0838
LNMATERIALS does not Granger Cause LNINDI	3749	2.10150	0.1472
LNINDI does not Granger Cause LNMATERIALS		2.86555	0.0906

Appendix J

Granger Causality – Expansion and Boom Phase 2004 – 2008

Pairwise Granger Causality Tests
Date: 09/19/19 Time: 20:39
Sample: 1/02/2004 12/31/2008
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
LNCONS_DISC does not Granger Cause LNCOM_SER	1251	1.49095	0.2223
LNCOM_SER does not Granger Cause LNCONS_DISC		0.79781	0.3719
LNCONS_STAP does not Granger Cause LNCOM_SER	1251	2.81055	0.0939
LNCOM_SER does not Granger Cause LNCONS_STAP		0.02087	0.8852
LNENERGY does not Granger Cause LNCOM_SER	1251	0.49235	0.4830
LNCOM_SER does not Granger Cause LNENERGY		4.56684	0.0328
LNFIN does not Granger Cause LNCOM_SER	1251	2.65816	0.1033
LNCOM_SER does not Granger Cause LNFIN		0.15961	0.6896
LNHEALTH does not Granger Cause LNCOM_SER	1251	1.04023	0.3080
LNCOM_SER does not Granger Cause LNHEALTH		0.06241	0.8028
LNINDI does not Granger Cause LNCOM_SER	1251	6.66479	0.0099
LNCOM_SER does not Granger Cause LNINDI		2.49261	0.1146
LNMATERIALS does not Granger Cause LNCOM_SER	1251	0.74080	0.3896
LNCOM_SER does not Granger Cause LNMATERIALS		0.69687	0.4040
LNCONS_STAP does not Granger Cause LNCONS_DISC	1251	0.92148	0.3373
LNCONS_DISC does not Granger Cause LNCONS_STAP		0.83349	0.3614
LNENERGY does not Granger Cause LNCONS_DISC	1251	1.12545	0.2890
LNCONS_DISC does not Granger Cause LNENERGY		2.06251	0.1512
LNFIN does not Granger Cause LNCONS_DISC	1251	0.50294	0.4783
LNCONS_DISC does not Granger Cause LNFIN		7.25283	0.0072
LNHEALTH does not Granger Cause LNCONS_DISC	1251	0.17086	0.6794
LNCONS_DISC does not Granger Cause LNHEALTH		7.76282	0.0054
LNINDI does not Granger Cause LNCONS_DISC	1251	2.63171	0.1050
LNCONS_DISC does not Granger Cause LNINDI		4.54374	0.0332
LNMATERIALS does not Granger Cause LNCONS_DISC	1251	1.76408	0.1844
LNCONS_DISC does not Granger Cause LNMATERIALS		3.29477	0.0697
LNENERGY does not Granger Cause LNCONS_STAP	1251	0.06721	0.7955
LNCONS_STAP does not Granger Cause LNENERGY		1.87884	0.1707
LNFIN does not Granger Cause LNCONS_STAP	1251	0.12416	0.7246
LNCONS_STAP does not Granger Cause LNFIN		0.52341	0.4695
LNHEALTH does not Granger Cause LNCONS_STAP	1251	0.16994	0.6802
LNCONS_STAP does not Granger Cause LNHEALTH		0.44116	0.5067
LNINDI does not Granger Cause LNCONS_STAP	1251	0.31674	0.5737
LNCONS_STAP does not Granger Cause LNINDI		0.70244	0.4021
LNMATERIALS does not Granger Cause LNCONS_STAP	1251	1.82579	0.1769
LNCONS_STAP does not Granger Cause LNMATERIALS		1.78471	0.1818

Appendix J

Granger Causality – Expansion and Boom Phase 2004 – 2008

LNFIN does not Granger Cause LNENERGY	1251	3.14556	0.0764
LNENERGY does not Granger Cause LNFIN		0.49461	0.4820
LNHEALTH does not Granger Cause LNENERGY	1251	0.84424	0.3584
LNENERGY does not Granger Cause LNHEALTH		0.25972	0.6104
LNINDI does not Granger Cause LNENERGY	1251	2.03477	0.1540
LNENERGY does not Granger Cause LNINDI		0.22232	0.6374
LNMATERIALS does not Granger Cause LNENERGY	1251	0.43661	0.5089
LNENERGY does not Granger Cause LNMATERIALS		0.13826	0.7101
LNHEALTH does not Granger Cause LNFIN	1251	2.03273	0.1542
LNFIN does not Granger Cause LNHEALTH		2.27743	0.1315
LNINDI does not Granger Cause LNFIN	1251	0.00603	0.9381
LNFIN does not Granger Cause LNINDI		5.03363	0.0250
LNMATERIALS does not Granger Cause LNFIN	1251	0.38145	0.5369
LNFIN does not Granger Cause LNMATERIALS		4.26517	0.0391
LNINDI does not Granger Cause LNHEALTH	1251	0.01354	0.9074
LNHEALTH does not Granger Cause LNINDI		4.11680	0.0427
LNMATERIALS does not Granger Cause LNHEALTH	1251	0.21149	0.6457
LNHEALTH does not Granger Cause LNMATERIALS		4.34340	0.0374
LNMATERIALS does not Granger Cause LNINDI	1251	1.23829	0.2660
LNINDI does not Granger Cause LNMATERIALS		0.82172	0.3649

Granger Causality – Recession and Recovery Phase 2009 – 2013

Pairwise Granger Causality Tests
Date: 09/19/19 Time: 20:40
Sample: 1/02/2009 12/31/2013
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
LNCONS_DISC does not Granger Cause LNCOM_SER	1249	6.34221	0.0119
LNCOM_SER does not Granger Cause LNCONS_DISC		1.96451	0.1613
LNCONS_STAP does not Granger Cause LNCOM_SER	1249	3.08128	0.0794
LNCOM_SER does not Granger Cause LNCONS_STAP		0.31719	0.5734
LNENERGY does not Granger Cause LNCOM_SER	1249	0.03054	0.8613
LNCOM_SER does not Granger Cause LNENERGY		13.8612	0.0002
LNFIN does not Granger Cause LNCOM_SER	1249	1.80997	0.1788
LNCOM_SER does not Granger Cause LNFIN		1.28005	0.2581
LNHEALTH does not Granger Cause LNCOM_SER	1249	9.97534	0.0016
LNCOM_SER does not Granger Cause LNHEALTH		0.34450	0.5574
LNINDI does not Granger Cause LNCOM_SER	1249	0.01880	0.8910
LNCOM_SER does not Granger Cause LNINDI		6.56249	0.0105
LNMATERIALS does not Granger Cause LNCOM_SER	1249	6.07100	0.0139
LNCOM_SER does not Granger Cause LNMATERIALS		6.03427	0.0142
LNCONS_STAP does not Granger Cause LNCONS_DISC	1249	0.03678	0.8479
LNCONS_DISC does not Granger Cause LNCONS_STAP		3.0E-05	0.9956
LNENERGY does not Granger Cause LNCONS_DISC	1249	1.12273	0.2895
LNCONS_DISC does not Granger Cause LNENERGY		13.4233	0.0003
LNFIN does not Granger Cause LNCONS_DISC	1249	0.10915	0.7412
LNCONS_DISC does not Granger Cause LNFIN		8.17668	0.0043
LNHEALTH does not Granger Cause LNCONS_DISC	1249	9.53457	0.0021
LNCONS_DISC does not Granger Cause LNHEALTH		0.05744	0.8106
LNINDI does not Granger Cause LNCONS_DISC	1249	0.04707	0.8283
LNCONS_DISC does not Granger Cause LNINDI		8.60418	0.0034
LNMATERIALS does not Granger Cause LNCONS_DISC	1249	4.52986	0.0335
LNCONS_DISC does not Granger Cause LNMATERIALS		4.83152	0.0281
LNENERGY does not Granger Cause LNCONS_STAP	1249	2.68035	0.1018
LNCONS_STAP does not Granger Cause LNENERGY		7.14018	0.0076
LNFIN does not Granger Cause LNCONS_STAP	1249	0.51026	0.4752
LNCONS_STAP does not Granger Cause LNFIN		4.11632	0.0427
LNHEALTH does not Granger Cause LNCONS_STAP	1249	0.04533	0.8314
LNCONS_STAP does not Granger Cause LNHEALTH		0.38001	0.5377
LNINDI does not Granger Cause LNCONS_STAP	1249	1.00383	0.3166
LNCONS_STAP does not Granger Cause LNINDI		4.17842	0.0412
LNMATERIALS does not Granger Cause LNCONS_STAP	1249	0.48676	0.4855
LNCONS_STAP does not Granger Cause LNMATERIALS		5.00592	0.0254
LNFIN does not Granger Cause LNENERGY	1249	5.42606	0.0200

Granger Causality – Recession and Recovery Phase 2009 – 2013

LNENERGY does not Granger Cause LNFIN		0.47379	0.4914
LNHEALTH does not Granger Cause LNENERGY	1249	13.6152	0.0002
LNENERGY does not Granger Cause LNHEALTH		2.02233	0.1553
LNINDI does not Granger Cause LNENERGY	1249	4.02651	0.0450
LNENERGY does not Granger Cause LNINDI		0.00042	0.9837
LNMATERIALS does not Granger Cause LNENERGY	1249	3.38484	0.0660
LNENERGY does not Granger Cause LNMATERIALS		10.2018	0.0014
LNHEALTH does not Granger Cause LNFIN	1249	18.5983	2.E-05
LNFIN does not Granger Cause LNHEALTH		0.58759	0.4435
LNINDI does not Granger Cause LNFIN	1249	0.00011	0.9915
LNFIN does not Granger Cause LNINDI		8.68147	0.0033
LNMATERIALS does not Granger Cause LNFIN	1249	1.07095	0.3009
LNFIN does not Granger Cause LNMATERIALS		7.31971	0.0069
LNINDI does not Granger Cause LNHEALTH	1249	0.09948	0.7525
LNHEALTH does not Granger Cause LNINDI		15.6948	8.E-05
LNMATERIALS does not Granger Cause LNHEALTH	1249	8.48054	0.0037
LNHEALTH does not Granger Cause LNMATERIALS		5.03357	0.0250
LNMATERIALS does not Granger Cause LNINDI	1249	1.94262	0.1636
LNINDI does not Granger Cause LNMATERIALS		7.94985	0.0049

Appendix J

Granger Causality – Stagnation Phase 2009 – 2018

Pairwise Granger Causality Tests
Date: 09/19/19 Time: 20:40
Sample: 1/02/2014 12/31/2018
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
LNCONS_DISC does not Granger Cause LNCOM_SER	1247	7.53008	0.0062
LNCOM_SER does not Granger Cause LNCONS_DISC		1.38566	0.2394
LNCONS_STAP does not Granger Cause LNCOM_SER	1247	5.21446	0.0226
LNCOM_SER does not Granger Cause LNCONS_STAP		0.63795	0.4246
LNENERGY does not Granger Cause LNCOM_SER	1247	0.06405	0.8002
LNCOM_SER does not Granger Cause LNENERGY		1.26679	0.2606
LNFIN does not Granger Cause LNCOM_SER	1247	6.62552	0.0102
LNCOM_SER does not Granger Cause LNFIN		2.06863	0.1506
LNHEALTH does not Granger Cause LNCOM_SER	1247	2.15475	0.1424
LNCOM_SER does not Granger Cause LNHEALTH		7.30976	0.0070
LNINDI does not Granger Cause LNCOM_SER	1247	5.96303	0.0147
LNCOM_SER does not Granger Cause LNINDI		6.19322	0.0130
LNMATERIALS does not Granger Cause LNCOM_SER	1247	1.03778	0.3085
LNCOM_SER does not Granger Cause LNMATERIALS		0.20986	0.6470
LNCONS_STAP does not Granger Cause LNCONS_DISC	1247	0.46850	0.4938
LNCONS_DISC does not Granger Cause LNCONS_STAP		1.69230	0.1935
LNENERGY does not Granger Cause LNCONS_DISC	1247	1.93515	0.1644
LNCONS_DISC does not Granger Cause LNENERGY		0.09368	0.7596
LNFIN does not Granger Cause LNCONS_DISC	1247	0.48862	0.4847
LNCONS_DISC does not Granger Cause LNFIN		1.48597	0.2231
LNHEALTH does not Granger Cause LNCONS_DISC	1247	0.03817	0.8451
LNCONS_DISC does not Granger Cause LNHEALTH		4.23487	0.0398
LNINDI does not Granger Cause LNCONS_DISC	1247	0.15620	0.6927
LNCONS_DISC does not Granger Cause LNINDI		1.49910	0.2210
LNMATERIALS does not Granger Cause LNCONS_DISC	1247	1.87860	0.1707
LNCONS_DISC does not Granger Cause LNMATERIALS		0.64504	0.4220
LNENERGY does not Granger Cause LNCONS_STAP	1247	0.76344	0.3824
LNCONS_STAP does not Granger Cause LNENERGY		1.76830	0.1838
LNFIN does not Granger Cause LNCONS_STAP	1247	0.15236	0.6964
LNCONS_STAP does not Granger Cause LNFIN		0.11890	0.7303
LNHEALTH does not Granger Cause LNCONS_STAP	1247	0.33591	0.5623
LNCONS_STAP does not Granger Cause LNHEALTH		3.41225	0.0650
LNINDI does not Granger Cause LNCONS_STAP	1247	1.14142	0.2856
LNCONS_STAP does not Granger Cause LNINDI		0.78329	0.3763
LNMATERIALS does not Granger Cause LNCONS_STAP	1247	0.30071	0.5835
LNCONS_STAP does not Granger Cause LNMATERIALS		2.21517	0.1369
LNFIN does not Granger Cause LNENERGY	1247	0.63891	0.4243

Granger Causality – Stagnation Phase 2009 – 2018

LNENERGY does not Granger Cause LNFIN		0.11587	0.7336
LNHEALTH does not Granger Cause LNENERGY	1247	7.60571	0.0059
LNENERGY does not Granger Cause LNHEALTH		1.03238	0.3098
LNINDI does not Granger Cause LNENERGY	1247	0.30976	0.5779
LNENERGY does not Granger Cause LNINDI		0.29777	0.5854
LNMATERIALS does not Granger Cause LNENERGY	1247	0.13160	0.7168
LNENERGY does not Granger Cause LNMATERIALS		0.16586	0.6839
LNHEALTH does not Granger Cause LNFIN	1247	0.98392	0.3214
LNFIN does not Granger Cause LNHEALTH		5.75895	0.0166
LNINDI does not Granger Cause LNFIN	1247	2.69013	0.1012
LNFIN does not Granger Cause LNINDI		4.10913	0.0429
LNMATERIALS does not Granger Cause LNFIN	1247	0.13795	0.7104
LNFIN does not Granger Cause LNMATERIALS		5.86039	0.0156
LNINDI does not Granger Cause LNHEALTH	1247	4.76307	0.0293
LNHEALTH does not Granger Cause LNINDI		0.75255	0.3858
LNMATERIALS does not Granger Cause LNHEALTH	1247	1.05344	0.3049
LNHEALTH does not Granger Cause LNMATERIALS		0.89426	0.3445
LNMATERIALS does not Granger Cause LNINDI	1247	0.04354	0.8347
LNINDI does not Granger Cause LNMATERIALS		0.40198	0.5262

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Department of Economics and Economics History
Rhodes University
Grahamstown, 6139
Eastern Cape, South Africa
www.ru.ac.za