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Cointegration and Causality in International Stock Markets

A study of long-run stochastic trends in Oil & Gas and Financials indices

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Abstract

As economies around the world grow and become more integrated, it is interesting to investigate how stock markets move in relation to one another. Some activists of the *theory of decoupling* argue that economies of emerging markets have become so self-sufficient that they have decoupled from the developed markets. The aim of this paper is to investigate whether the decoupling theory holds for market sectors, namely Oil & Gas and Financials, and whether there are any long-term relationships between equities belonging to the same sector but in different countries. The specific countries chosen are Brazil, Russia, India, the US, the UK, and Japan. The relationships are investigated for the period 2000-2009 and the time period is split into two sub-periods. By using the Augmented Engle-Granger test for cointegration it is found that there is more cointegration in the Oil & Gas sector, compared to the Financials sector, and that for both sectors there is less cointegration during the recent financial crisis. The VECM and VAR model are used to investigate the causal relationships among indices in each of the sectors. It is found that, for both sectors, causality increases between time periods (most likely due to volatility contagion), however this increase is larger for the Oil & Gas sector, compared to the Financials sector. The US has a predictive effect on all the studied markets and in both sectors. It is unclear whether Brazil is showing signs of decoupling or is able to price other markets due to its different market opening hours. The Russian Oil & Gas sector is not able to predict any of the other markets (except a weak effect on Japan).

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1. Introduction

The recent financial crisis did not hit just one country, but instead affected markets across the globe and significantly changed the financial sentiment. The American subprime crisis – which started in July 2007 – sparked the global downturn. Stock markets fell to historical lows, liquidity[1] dried up, and volatility levels reached new levels. After a record high oil price nearing 150 USD/barrel, it fell to below 40 USD and many companies saw billions disappear from their market capitalization. Banks and insurance companies were hit the hardest and were forced to make billion-dollar write-downs on their assets, causing several to collapse. In the aftermath of these events, it is interesting to investigate how the long term relationship between international financial markets has changed, and especially the relationship between securities in the Oil & Gas and Financials sectors. The aim of this paper to investigate whether the long-run relationship, the so-called *cointegration*, between these two international sectors has changed during the crisis. This paper also aims to study whether the ability of one market in forecasting another – the concept known as *causality* – has been altered by the crisis. This paper hopes to extend the previous research on these topics (which mainly focuses on cointegration and causality between international stock markets) by using international *sector* indices, i.e. Oil & Gas and Financials, as the base for our study. By investigating a global crisis, which is the first of its kind, this paper hopes to provide new insights regarding the topics of cointegration and causality.

2. Background

Few have failed to miss what often is referred to as *globalization*. The topic has been studied extensively in various research papers and is often covered in media. The phenomenon of globalization is typically characterized by increasing trade between countries, growing foreign direct investments, technological advances and other factors. International financial markets have also become more integrated, which according to Jeon and Chiang (1991), is due to market deregulation and liberalization, development of communication technology, innovations in financial products and services, and other factors.

Today, investors are able to purchase thousands of international stocks and other securities with the click of a mouse. Capital flows have increased tremendously during the past thirty years. Several markets, which previously could be considered illiquid or – as in the case of Russia – nonexistent, suddenly opened up for foreign investments due to eased regulatory systems and simplified bureaucratic processes. Liquidity was suddenly created in such markets as Brazil, India, Russia and

[1] Liquidity: the ability of an asset to be bought and sold without significantly changing the price (Financial Times Lexicon)

China (known as the BRIC[2] countries). Investing in the BRICs and other emerging markets in order to diversify one's portfolio[3] has become popular in asset management.

The BRIC-countries is a classic example of *emerging markets*. Countries that usually fall into this category have shown rapid GDP growth, increasing GDP per capita, rapid industrialization and improving infrastructure. The role of many of these markets is increasing in shaping the global economy, as their share of world GDP is on the rise[4]. Countries considered to be *emerging* are typically located in Asia, the Middle East, Central and South America, Africa and Eastern Europe. MSCI Barra, a provider of tools for making investment decisions and the creator of the widely-used MSCI-indices, considers 22 countries to be emerging and includes these in the MSCI Emerging Markets Index. *Developed countries*, on the other hand, are countries that typically have a high GDP per capita, high Human Development Index (HDI), and whose markets are typically dominated by the tertiary (service) sector. Countries which can be considered developed are the United States, Germany, United Kingdom, Japan, Australia and many of the EU countries.

Increased globalization has resulted in greater integration of stock markets and decreased regulation, which has given international investors the opportunity to invest in securities in emerging markets. Investors are now able to freely trade securities from these markets, just as American and Japanese stocks have been traded for decades before. The rapid growth that emerging markets have experienced has also been reflected in the stock prices of their securities, seen in figure 1 below. Although emerging market securities typically have higher risk than securities from the developed markets (due to increased political risk and greater chance of default), they have provided an attractive investment opportunity for many international asset managers.

[2] In 2001, Goldman Sachs' chief economist Jim O'Neill used the term "BRICs" for the first time. The BRICs are believed to have the most potential of the emerging markets and are foreseen to surpass the world's top richest nations in terms of GDP and population by 2050 (Financial Times Lexicon).

[3] Portfolio diversification: when investors spread risk by holding different classes of assets. Adding risks which are not correlated to each other allows one to add expected return without increasing the risk.

[4] "Dreaming with the BRICs: The Path to 2050", Goldman Sachs, October 2003.

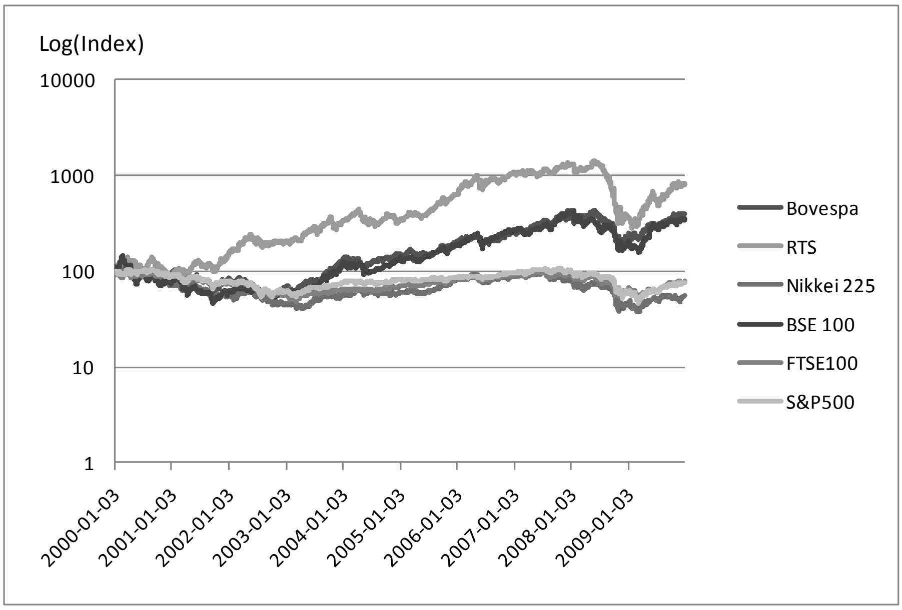


Figure 1: Log index prices of Bovespa (Brazil), RTS (Russia), Nikkei 225 (Japan), BSE 100 (India), FTSE100 (UK), and S&P500 (US).

The higher risk of emerging market securities has also resulted in higher returns. The classic risk-return relationship is represented by the Capital Market Line (CML) in a risk-return space in figure 2 below. The theory states that the higher the risk[5], σ^2, of a security the higher is its expected return[6], E(R). Moving outwards along the CML, it can be seen that as volatility increases, so does the expected return of the security. Many asset managers have set up funds focusing on investments in growing companies of emerging markets such as those of the BRIC, Eastern Europe, Asia, Turkey, and others. Examples of such fund managers include Templeton, East Capital, and Goldman Sachs Asset Management.

[5] Risk/volatility: measurable uncertainty that an investment will not generate the expected earnings (Financial Times Lexicon).
[6] Expected return: what an investor expects to earn from an investment (Financial Times Lexicon).

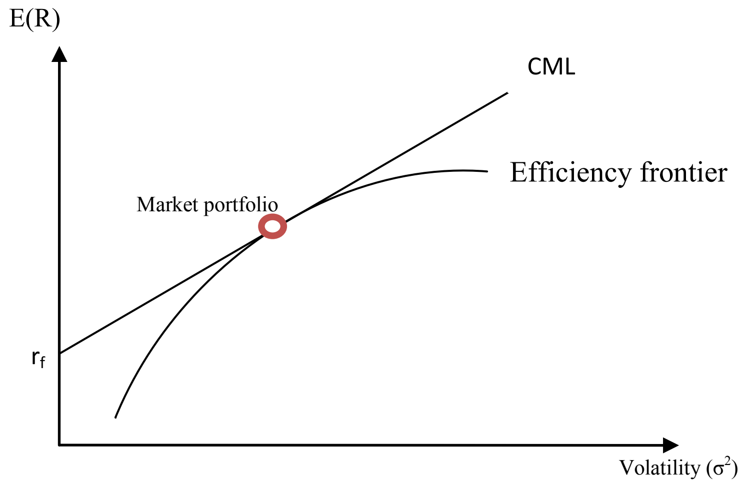


Figure 2: Capital Market Line: *Capital market line (CML) representing the relationship between an asset's risk, σ^2, and its expected return, E(R). The market portfolio is at the point where the efficiency frontier is tangent to the CML. The r_f is the risk-free rate at which the CML begins.*

Even though one cannot predict exactly how markets will move, what one can do instead is examine how stock markets move *in relation to one another* and whether there is any correlation between them. One can investigate the equilibrium relationship between indices of different stock markets. This long-run relationship is known as *cointegration*. Two time series series x_t and y_t are cointegrated if, and only if, each one is of order I(1), i.e. a random walk, but a linear combination of them is of order I(0), i.e. stationary (Herlemont 2004). This means that the series x_t and y_t may be following their own random walks, but at certain points in time their paths will become integrated and are thus no longer considered random walks. *Causality* also helps to investigate the long-run relationship between securities. Applied to stock pricing, causality can be defined as the ability of one security in forecasting the value of another security.

Despite the fact that economies are becoming more integrated, in recent years there have been extensive discussions regarding the *decoupling theory of emerging markets*. The theory of decoupling is based on the idea that some markets are growing so quickly compared to the developed markets and that their economies have become so strong, that they are relatively less prone to economic downturns compared to the mature economies. In their report "Dreaming with BRICs: The Path to 2050", Goldman Sachs provides sufficient fact that the BRIC economies may in 40 years surpass the G6 countries[7] in terms of GDP.

Possible initial conditions that may result in an emerging market economy decoupling from a developed market, could, for example, be significant variations in GDP growth rates, consumption levels, local interest rates and exchange rates. Fulfilling these conditions, suggests that there is good reason to believe that *financial markets* in emerging economies may decouple. However, after the US housing market collapsed in 2007, investors hurried to move their money to the equity markets of

[7] G6: US, Japan, UK, German, France and Italy.

Russia, Brazil, and India, many of them strongly believing that these markets have "decoupled" from the US. In retrospect, it can be said that this was most certainly not the case: as the US stock markets continued to decline, the equity markets of Russia, Brazil, and India fell sharply in October 2008. The decoupling theory of emerging markets had obviously failed.

Even though markets across the globe fell sharply once the crisis had started, an interesting question arises – does the decoupling theory of emerging markets hold for stock market sectors? Decoupling may not have occurred for two entire economies, for example between India and Japan, but taking this concept one step further, what does the relationship look like at sector level? The particular sectors of interest are the Oil & Gas and Financials sectors. Companies in the Oil & Gas sector (which consists mainly of producers of oil and gas) are to a large extent driven by the prevailing prices of oil and gas, which logically should mean that these companies follow a common trend, making the evidence of decoupling relatively weak. Looking at the Financials sector, the relationship is quite different. Financials – companies within the banking- and insurance sector – are driven by more domestic factors, for example, the local interest rates set by the central bank, the market risk premium, the company's interest spread[8], a stock's liquidity, and political stability in the country. It may also be the case that the Oil & Gas sector is partly driven by domestic factors; however, it can be said that the main drivers are still the prices of crude oil and natural gas. These factors, which are so different in nature and may vary from country to country, make decoupling more likely to occur.

By using the concept of causality – testing empirically whether a given sector index can help price another sector index – this paper attempts to investigate whether there is evidence of decoupling in the Oil & Gas and Financials sectors between emerging and developed markets. Does an increase in the American Oil & Gas market lead to an increase in the Indian Oil & Gas market? Is the reverse relationship true? Additionally, cointegrational relationships will also be investigated on a sector level. These are the main topics studied in this paper, which fundamentally will examine cointegration and causality in a variety of stock market indices. Goldman Sachs' report on the BRIC countries suggests that the decoupling theory of emerging markets holds in the long run, however, the collapse of such economies as the US and UK in the recent financial crisis seems to have had ripple effects across the globe, suggesting that perhaps the theory does not hold in the short term. Therefore, this study also aims at investigating the concepts of causality and cointegration in two different periods: before the financial crisis and during.

The study focuses on indices in six different *markets* – the United States (US), the United Kingdom (UK), Japan, Russia, Brazil and India – and on two different *market sectors*, namely Oil & Gas and Financials. Indices for each market sector in each chosen country will be tested for cointegration and causality between corresponding indices of the other countries. Although there is an extensive amount

[8] Interest spread: the difference between a financial company's borrowing and lending rates.

of research on cointegration and causality of international stock market indices, there is a lack of studies examining these concepts among sector-specific indices. Additionally, there are few studies investigating these relationships during the recent financial crisis.

2.1 Disposition

The outline of this paper is as follows: section 3 presents the research focus and objective of the study; section 4 examines the previous research on the topics of international markets and cointegration and causality; section 5 describes the theories related to the study, as well as the statistical methods used to perform the necessary tests; section 6 describes the dataset; section 7 presents the results of the unit root, cointegration, and causality tests; section 8 presents an analysis of the statistical findings; and finally, section 9 summarizes the study with some concluding remarks.

3. Research Focus and Objectives

The aim of this thesis is to investigate whether there is cointegration between Oil & Gas and Financials sector equity indices in the US, the UK, Japan, Russia, Brazil, and India. This paper would like to test whether there is any long term relationship between stocks which belong to the same *stock market sector* in different countries. A pair of same-sector indices but in two different countries is known as a *bivariate system*, for example, FTSE Russia Oil & Gas and FTSE USA Oil & GAS. Throughout this paper, the terms bivariate system or bivariate pair will be used to refer to any combination of same-sector indices in two different countries. When referring to a bivariate pair of indices, the terms *emerging-developed*, *emerging-emerging*, and *developed-developed* may be used to identify the combination of countries. Using the Oil & Gas sector as an example, this study aims to investigate whether USA's Oil & Gas index and Russia's Oil & Gas index follow a similar long-run stochastic trend. The study will also test for causality between the chosen sector indices, i.e. whether the American Oil & Gas securities can predict the price of the Russian Oil & Gas sector. In general, bivariate systems of Oil & Gas indices will be tested for cointegration and causality during two different time periods.

It was decided that three emerging market indices – Russia, Brazil, and India – would be investigated in this study. These three markets are classified as "emerging" according to MSCI Barra. As previously mentioned, the role of emerging markets has grown significantly in the last two decades. The remaining three markets, namely the US, UK, and Japan, are the investigated developed markets. A set of research questions, rather than specific hypotheses regarding bivariate pairs, have been developed.[9]

[9] This particular structure was chosen in order to aid the reader in following the analysis of test results later on in this paper.

Following the research of Sheng and Tu (2000), this paper would like to investigate whether cointegration changes during a period of crisis. The recent global financial crisis (which started with the US subprime crisis[10] in the summer of 2007) will be investigated. The chosen time period will be divided into two sub-periods, namely the "pre-crisis" period (1 January 2000 – 30 June 2007) and the crisis period (1 July 2007 – 31 December 2009).

Typically the performance of market sectors is driven by common macroeconomic, political and other similar events. The occurrence of such an event will often have an effect on the entire sector. Following this argument, it can be said that even though there may be no cointegration between two given countries, there is a possibility that cointegration can occur between two market sectors. The following research questions regarding cointegration will be investigated:

- *Is there cointegration between bivariate systems of emerging-developed Oil & Gas indices?*
- *Is there cointegration between bivariate systems of emerging-developed Financials indices?*
- *Has cointegration changed during the crisis period?*

As previously discussed, prices of oil and gas are the main drivers of security prices in the Oil & Gas sector, which speaks for why securities in this sector and across stock markets should show little evidence of the decoupling theory. The prices of oil and natural gas are quoted in USD, which means that revenues of oil- and gas-producing companies are also denominated in the USD. In the case of the Financials sector, the logic should be that it is easier for this sector to decouple compared to Oil & Gas. As mentioned earlier, Financials are driven by more domestic factors like interest rates and political stability. Price drivers of Financials will vary from institution to institution, and, even more so if they are located in different countries. A global economic slowdown is likely to lead to central banks cutting interest rates to speed up recovery, as seen in the recent financial crisis which resulted in central banks of the United States, Russia, and the European Union cutting their rates. Thus, one may conclude that decoupling is less likely to occur among Oil & Gas indices and more likely in Financials indices. If no dependent (causal) relationship between sector indices for two different countries is found, then one may conclude that these two market sectors are decoupled.

When investigating the concept of causality between the studied market sectors, it is important to think about the *size of the equity market* that it is a part of. According to the World Federation of Exchanges, at the end of 2009 the New York Stock Exchange (NYSE) was the largest in the world. In Financial

[10] Subprime crisis: a crisis which started in the US in the summer of 2007, once American banks realized that the large amount of high-risk securities associated with subprime mortgage loans were worth less than previously expected. This was partially due to decreasing housing prices, increasing interest rates and lenders defaulting on their loans. This period is often referred to as the "credit crunch", because lenders became reluctant to lend money to businesses and individuals because of the increased risk of default (Financial Times Lexicon).

Times (FT) Global 500 list of the world's largest companies by market capitalization[11], Exxon Mobil was the largest with 336.5 USD bn in value. Because of the sheer size of a company like Exxon, swings in its stock price due to exogenous factors should have an effect on the entire US Oil & Gas sector as well as on international Oil & Gas sectors. Therefore, it seems highly probable that a change in the value of FTSE USA Oil & Gas can predict a change in all the other Oil & Gas indices investigated in this study. In general, the developed stock markets investigated in this study have larger market capitalizations than the emerging markets. Figure 3 below summarizes market capitalizations for several exchanges located in the chosen countries. Again, the causal relationship between the Financials sectors may not be as obvious because of the different domestic factors influencing a sector.

Country	Exchange	Market Cap 2009 ($ m)
USA	NYSE Euronext (US)	11 837 793
UK	London SE	2 796 444
Japan	Tokyo SE Group	3 306 082
Russia	MICEX	736 307
Brazil	BM&FBOVESPA	1 337 248
India	National Stock Exchange India	1 224 806

Source: World Federation of Exchanges.

Figure 3: 2009 year-end market capitalizations for a selection of stock markets.

The above discussion of decoupling leads to the following research questions regarding causality, which this study will attempt to answer:

- *Is there a causal relationship between the Oil & Gas indices of developed and emerging markets? If no causal relationship is found, can this explain the theory of decoupling?*
- *Is there a causal relationship between the Financials indices of developed and emerging markets? If no causal relationship is found, can this explain the theory of decoupling?*
- *Has causality between the Oil & Gas sectors changed during the crisis period? What can this say about decoupling in the long term and in the short term?*
- *Has causality between the Financials sectors changed during the crisis period? What can this say about decoupling in the long term and in the short term?*

Continuing with the concept of causality, the findings of Sheng and Tu (2000) suggest that the US still has a "persisting dominant role" in influencing global equity markets, because their results showed that it could "cause" several of the Asia-Pacific countries. According to Wong, Agarwal and Du (2005) it was found that India did not cause the US or the Japanese market. On the other hand, it was

[11] Market capitalization: a company's market value (calculated as *stock price x number of shares*).

found that the markets of the US, Japan and UK (in the long run) caused India. Therefore, it is worth investigating whether this relationship holds for the Oil & Gas/Financials indices for the countries in this study:

- *Does the US Oil & Gas sector have the greatest influence on the corresponding sector of emerging market economies?*
- *Does the US Financials sector have the greatest influence on the corresponding sector of emerging market economies?*
- *Is the US also capable of influencing other developed markets?*

4. Previous Research

The bulk of the research on cointegration in financial markets focuses on testing for this phenomenon between various indices for entire stock markets or countries. Results in this field of research vary – some find strong evidence of cointegration between indices, others do not. Ahlgren and Antell (2002) test for cointegration between Finland, France, Germany, Sweden, the UK and the US for the time period January 1980 – February 1997. They concluded that evidence for cointegration is weak. Richards (1995) investigates cointegration during 1964-1994 between a world equity index and 16 national equity markets using both the Johansen test and the Engle-Granger methodology. The null hypothesis of "no cointegration" is only occasionally rejected, upon which the author concludes that foreign and domestic (in this case USA) equity markets will move significantly differently in the long run, highlighting the risk-reduction benefits of investing abroad. Corhay et al. (1995) studied cointegration among five major Pacific-Basin stock markets (Australia, Hong Kong, Japan, Singapore and New Zealand) and found evidence of a long-term stochastic trend among these countries. Choudhry (1997) investigates the long-run relationship between six Latin American stock indices (Argentina, Brazil, Chile, Colombia, Mexico and Venezuela) and the United States for the years 1989-1993. The author finds evidence of cointegration among the six Latin American indices with and without the United States index. Wong, Agarwal and Du (2005) investigate the short- and long-term relationship between India and three developed markets, namely the United States, United Kingdom, and Japan. The authors conclude that India is integrated with the mature markets and is sensitive to the dynamics in these markets in the long run.

Taking the concept of cointegration one step further, some researchers have also been focusing on stock market cointegration during crisis periods and pre-crisis periods. Sheng and Tu (2000) investigate whether there are different degrees of linkages among the South-East Asian and North-East Asian countries before and during the Asian financial crisis which started in 1997. Their results showed that there is no cointegrational relationship for the five North-East Asian country indices during and before the crisis period. However, at least one cointegrational relationship exists for the five South-East Asian country indices during the crisis period. Fan (2003) also tested for cointegration in the stock markets of the United States, Japan, Hong Kong, Singapore, Thailand and Taiwan, before and during the Asian crisis, and found that there is no evidence of strong co-movement before the crisis, but after the crisis there is evidence of a cointegrated relationship between the Asia-Pacific indices. Following Sheng and Tu (2000) and Fan (2003), cointegration is examined for various index pairs from developed and emerging markets during the recent financial crisis and in the period prior to the crisis. However, the tests will be performed on a sector-basis, as mentioned in the Research Objective.

In addition to testing for cointegration, many researchers have also examined causality among international indices. Sheng and Tu (2000) have found evidence suggesting that the US market still causes some Asian markets (such as Hong Kong and South Korea) during the period of the financial crisis. The authors conclude that the results reflect the US market's dominant role. Wong, Agarwal, and Du (2005) conclude that the Indian market is sensitive to dynamics in the markets of the US, the UK and Japan. In the short run, both the US and Japan Granger cause the Indian stock market, however there is no causality run from the Indian stock market to any of the developed markets in the study. Fan (2003) has also shown that unexpected changes in the US stock market have a profound effect on the Asia-Pacific markets, that Japan can only influence Thailand, and that none of the Asian markets of Hong Kong, Singapore, Taiwan or Thailand appear to be significant in influencing any other markets in the study. Similarly, this study will also focus on examining causality between the chosen indices.

Research on cointegration and causality among sector indices is not as prevalent as the tests for entire countries/indices. The paper by Constantinou et al. (2008) examines cointegration and causality among sector indices on the Cyprus Stock Exchange, attempting to study the concept of domestic portfolio diversification. First, using the Johansen (1988, 1991) and Johansen and Juselius (1990, 1992) methodology, the authors find that there is at least one statistically significant long-run relationship between the 12 sector indices. Secondly, they examine bivariate systems of sector indices and find that over time that they are independent. The authors finally conclude that the findings offer the opportunity for making long-term profits from portfolio diversification on the Cyprus Stock Exchange. There is a clear lack of research concerning bivariate tests of sector indices in an international context, which again highlights why the subject area of the current paper is worth the attention.

Additionally, the research papers examined prior to this study can be considered fairly dated. As previously mentioned, emerging markets are typically characterized by high growth rates in terms of both financial markets and GDP. Cointegration tests based on data from the 1980s, a period when many emerging markets started liberalization, may not be as accurate as the tests performed on data from the 1990s or later.

5. Methodology

This section will focus on explaining how the data set was used to perform tests for unit-root, cointegration and causality. In describing the chosen methodology to investigate the above mentioned research questions, several important econometric theories are covered briefly, aimed at facilitating the reader's understanding of the types of statistical tests chosen for our study. When explaining the theories, the variables X and Y are used to define the *series of prices* for the chosen indices; for example, X could represent the series of prices of FTSE USA Oil & Gas, while Y may represent FTSE Russia Oil & Gas. The statistics program used to perform all tests is STATA 9.

5.1 Stationary and non-stationary stochastic process

A stochastic process is defined as a series of random variables organized in time. This type of process can be either stationary or non-stationary, where a stationary stochastic process has a constant mean and variance over time (Gujarati 2003). A weak stationary process has the following properties:

Mean: $E(Y_t) = \mu$

Variance: $Var(Y_t) = E(Y_t - \mu)^2 = \sigma^2$

Covariance: $E[(Y_t - \mu)(Y_{t+1} - \mu)] = \gamma k,$

where the covariance is defined as the covariance between the values Y_t and Y_{t+k} at lag *k* and time *t*.

5.1.1 Random walk model

A **random walk model (RWM)** is a classic example of a non-stationary stochastic process. There are generally two types of random walks: random walk without drift and random walk with drift. A RWM without drift has no constant or intercept term. A RWM with drift, however, has a constant term. The time series Y_t for security Y is a **random walk without drift** when:

$$Y_t = Y_{t-1} + u_t \qquad (1)$$

where u_t is a white noise error term with mean 0 and variance σ^2.

The following equation is for the series Y_t of security Y which is a **random walk with drift**:

$$Y_t = \beta_0 + Y_{t-1} + u_t \qquad (2)$$

where β_0 is the drift parameter, which shows that Y_t drifts upwards (if β_0 is positive) or downwards (if β_0 is negative). In a random walk with drift the mean and variance increase over time, meaning this directly violates the conditions of stationarity. Security prices are said to be random walks, meaning they follow a stochastic non-stationary process. When testing for a unit root process, the model chosen for each time series (index) is a random walk with drift (equation (2)).[12]

5.2 Unit root process

The RWM is also known as a **unit root process**. The RWM can be written as:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + u_t \qquad -1 \leq \beta_1 \leq 1 \tag{3}$$

If β_1=1, then Y_t is a random walk model with drift. We then face what is called the unit root problem, i.e. the case of nonstationarity. However, if $|\beta_1|<1$ then the time series Y_t is stationary. To test whether a given time series in our study has a unit root, we regress Y_t on its lagged value Y_{t-1} to see whether the estimated β_1 is statistically equal to 1 (Gujarati 2003). If this is the case, then the time series Y_t is nonstationary.

The equation above can be re-written as:

$$\Delta Y_t = \beta_0 + \delta Y_{t-1} + u_t \tag{4}$$

where $\delta = (\beta_1 - 1)$, Δ is the first difference operator, and Y_{t-1} is the lagged value of Y (i.e. the value of Y from the period *t-1*). The hypotheses investigated are as follows:

H_0: $\delta = 0$ (the series has a unit root and is thus nonstationary; identical to testing $\beta_1 = 1$)

H_1: $\delta < 0$ (the series has no unit root and is thus stationary)

There are several tests available to check for a unit root in a time series, of which we have chosen the Augmented Engle-Granger test described below. However, because this test is based on the Augmented Dickey-Fuller test, it is necessary to clarify the Augmented Dickey Fuller test first.

5.2.1 The Dickey-Fuller and Augmented Dickey-Fuller unit root tests

When testing whether the estimated coefficient $\delta = 0$, it is erroneous to use the *t*-test, because under the null hypothesis the estimated coefficient of Y_{t-1} does not follow the *t* distribution. Instead, we use the Dickey-Fuller (DF) test, where *t* follows the tau (τ) statistic under the null hypothesis (Gujarati 2003). The particular DF test chosen for our study is for a time series Y_t following a random walk with drift:

$$\Delta Y_t = \beta_0 + \delta Y_{t-1} + u_t \tag{5}$$

[12] Even though the drift coefficients were found to be very small, a random walk with drift was used in this study.

In this particular case, if the null hypothesis (H_0: $\delta = 0$) is rejected, then Y_t is stationary around a deterministic trend in the equation above. The DF test is performed according to the following steps:

1. We estimate the above equation for ΔY_t using the Ordinary Least Squares (OLS) regression.
2. We then divide the estimated coefficient (δ) of Y_{t-1} in each case by its standard error in order to compute the τ statistic.
3. Using the DF tables, we check whether |τ| exceeds the critical τ –values in the table. If it does, then we reject the null hypothesis, implying that the time series is stationary. If |τ| does not exceed the critical tau value, then the null hypothesis cannot be rejected and the time series is nonstationary.

The DF test assumes that the error terms, u_t, are not correlated. However, if the errors are in fact correlated then the Augmented Dickey-Fuller (ADF) test can be used. The ADF adds lagged (past) values of the dependent variable ΔY_t to equation (5) above, which results in the following equation:

$$\Delta Y_t = \beta_0 + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \, \Delta Y_{t-i} + \varepsilon_t \qquad (6)$$

Where $\Delta Y_{t-i} = (Y_{t-i} - Y_{t-i-1})$ and ε_t is the white noise error term.

The idea behind the ADF test is to include enough lagged terms so that the error term is serially uncorrelated. In order to avoid the problem of error correlation, the augmented version of the DF test (and later of the Augmented Engle-Granger test for cointegration) was chosen. The statistical hypotheses tested when performing the ADF test are as mentioned in the section *Unit root process* above. In line with Richards (1995), the optimal lag is chosen according to the value of Akaike's Information Criterion (AIC), which is generated when the DF and ADF tests are run. The optimal lag is the one with the lowest AIC value.

5.3 Spurious regression

When investigating whether two times series have a common relationship one may typically use the Ordinary Least Squares (OLS) technique. In the case of security/index prices one may find that the series are nonstationary, which may lead to the problem of spurious regressions highlighted by Granger and Newbold (1973).The concept of spurious regression is explained below.

The series Y_t and X_t are two stochastic processes which follow a random walk:

$$Y_t = Y_{t-1} + u_t \qquad (7)$$

$$X_t = X_{t-1} + v_t \qquad (8)$$

Let's assume that the initial values of X and Y are zero and that the error terms, u_t and v_t, are serially and mutually uncorrelated. Under these conditions, when regressing Y_t on X_t one would expect the correlation coefficient, R^2, to be zero – there should be no correlation between the two series. However, in practice, one may find that the R^2 value is statistically significant and different from zero, which indicates a relationship between the two variables. This is known as spurious regression, a phenomenon that may occur in nonstationary time series (Gujarati 2003). To check whether the regression is spurious, one can compare the R^2 value to the Durbin-Watson statistic, d. If $R^2 > d$ then, as a rule of thumb, the regression is spurious. Instead of using the standard OLS regression to investigate the long-run relationship between two time series, one may use cointegration tests (described below) which avoids the problem of spurious regressions.

5.4 Cointegration tests

Two or more time series with stochastic trends can move together so closely over the long run that they appear to have a common trend (Stock and Watson 2003). Such a relationship is known as *cointegration*. Suppose X_t and Y_t are integrated of order one[13], and that for some cointegration coefficient θ, $Y_t - \theta X_t$ is integrated of order zero. Then X_t and Y_t are said to be cointegrated. Computing the difference $Y_t - \theta X_t$ eliminates the common stochastic trend.

The Augmented Engle-Granger methodology was chosen to test for cointegration between bivariate systems of indices for the two time periods.

5.4.1 Engle-Granger and Augmented Engle-Granger tests

Since the estimated u_t are based on the estimated β_1 parameter, it is inappropriate to use the DF and ADF critical values to test the hypothesis H_0: $\delta = 0$. Instead, the ADF tests were performed on residuals using critical values calculated by Engle and Granger. Similarly, Richards (1995) uses the Augmented Engle Granger test when testing for cointegration between national (US) return indices and rest-of-world return indices.

To test for cointegration, the following procedure is used:

- The ADF unit root test is performed to check whether the null hypothesis of "unit root" holds. Given that two or more chosen time series are nonstationary, one can continue to the next step.
- The cointegration equation can be written as (random walk with drift):

$$Y_t = \beta_0 + \theta X_t + u_t \tag{9}$$

[13] Integrated of order one, i.e. I(1): the stochastic process has one unit root.

- The cointegration equation (9) above is run to estimate the residuals, u_t. Equation (9) for cointegration can be re-written as:

$$u_t = Y_t - \beta_0 - \theta X_t \qquad (10)$$

- The ADF unit root test is run once again, however this time on the residuals obtained from equation (10). In doing so, the following equation is estimated:

$$\Delta\hat{u}_t = \alpha_0 - \varphi\hat{u}_{t-1} + v_t \qquad (11)^{14}$$

  The Durbin-Watson test is performed to check for spurious regressions. Because the error terms, u_t, are estimated using the estimated cointegrating parameter θ, critical values calculated by Engle and Granger are used instead of those used in the DF and ADF tests. Hence, these tests are known as the Engle-Granger and Augmented Engle-Granger tests.

- The test statistic is examined to determine whether there is evidence that the selected indices are cointegrated.

5.5 Causality

In the words of Stock and Watson (2003), the general definition of causality is that "a specific action leads to a specific, measurable consequence". The phenomenon of causality is prevalent in many different subject areas, such as philosophy, logic studies, and the sciences. Applied to asset pricing, the idea of a causality test is to examine whether the price of security Y can be explained and forecasted by using lagged values of security X and Y, i.e. X_{t-1} and Y_{t-1}. If Y_t can indeed be forecasted using the lagged terms of X, then X is *causing* Y. Following the methodology used by Wong, Agarwal and Du (2005), a Vector Error Correction Model (VECM) is used to test for causality if two indices are found to be cointegrated. On the other hand, if no cointegration is found, then a bivariate Vector Autoregression (VAR) is used. Both the VECM and the VAR model are explained below.

5.5.1 Vector auto regressions (VAR)

A VAR consisting of two time series variables, Y_t and X_t, is modelled by two equations, where in the first one the dependent variable is Y_t and in the second one where the dependent variable is X_t:

$$Y_t = \beta_{10} + \beta_{11}Y_{t-1} + \cdots + \beta_{1p}Y_{t-p} + \gamma_{11}X_{t-1} + \cdots + \gamma_{1p}X_{t-p} + u_{1t} \qquad (12)$$

$$X_t = \beta_{20} + \beta_{21}Y_{t-1} + \cdots + \beta_{2p}Y_{t-p} + \gamma_{21}X_{t-1} + \cdots + \gamma_{2p}X_{t-p} + u_{2t} \qquad (13)$$

The regressors in both equations are lagged values of both variables. For example, equation (12) above implies that the value of Y_t can be predicted by using lagged values of itself (Y_{t-p}), as well as lagged

[14] $\varphi = 1-\theta$

values of the X variable (X_{t-p}). In the case of international indices, the following is an example of a VAR model for testing whether the Brazilian Oil & Gas market causes the Indian Oil & Gas market:

$$India\_O\&G_t = \beta_{10} + \beta_{11} India\_O\&G_{t-1} + \cdots + \beta_{1p} India\_O\&G_{t-p} + \gamma_{11} Brazil\_O\&G_{t-1} + \cdots + \gamma_{1p} Brazil\_O\&G_{t-p} + u_{1t} \tag{14}$$

where $India\_O\&G$ and $Brazil\_O\&G$ are the values of the Indian and Brazilian Oil & Gas indices, respectively.

The causality test involves testing the hypothesis that the coefficients on all the values of one of the variables in equations (12) or (13) are zero (Stock and Watson 2003). For example, in testing whether Y_t can be predicted using lagged values of X_t the hypotheses tested are as follows:

H_0: $\gamma_{11} = \gamma_{12} = \ldots = \gamma_{1P} = 0$ (lagged values of X_t cannot help predict Y_t)

H_1: for some p, $\gamma_{1P} \neq 0$ (lagged values of X_t help predict Y_t)

Failing to reject the null hypothesis implies that lagged values of X_t do not cause Y_t. Rejecting the null hypothesis implies that causality is a fact. As previously mentioned, the VAR model will be used to test for causality between bivariate systems of indices where no cointegration is found.

5.5.2 Vector error correction model (VECM)

Generally, a stochastic trend in an I(1) variable Y_t may be eliminated by computing its first difference, ΔY_{t-1} (Stock and Watson 2003). The VECM is another way of eliminating a stochastic trend. If X_t and Y_t are cointegrated then the first difference of X_t and Y_t can be modeled by using a VAR which includes the error correction term Y_{t-1}-θX_{t-1}:

$$\Delta Y_t = \beta_{10} + \beta_{11}\Delta Y_{t-1} + \cdots + \beta_{1p}\Delta Y_{t-p} + \gamma_{11}\Delta X_{t-1} + \cdots + \gamma_{1p}\Delta X_{t-p} + \alpha_1(Y_{t-1} - \theta X_{t-1}) + u_{1t} \tag{15}$$

$$\Delta X_t = \beta_{20} + \beta_{21}\Delta Y_{t-1} + \cdots + \beta_{2p}\Delta Y_{t-p} + \gamma_{21}\Delta X_{t-1} + \cdots + \gamma_{2p}\Delta X_{t-p} + \alpha_2(Y_{t-1} - \theta X_{t-1}) + u_{2t} \tag{16}$$

In the VECM, past values of Y_t-θX_t help to predict future values of ΔY_t and/or ΔX_t. If bivariate systems of indices are found to be cointegrated then the VECM is used to test for causality between the variables. The null and alternative hypotheses tested are the same as for the VAR, described above.

5.6 Restrictions

The Augmented Engle-Granger and Augmented Dickey-Fuller tests are common to use when testing for cointegration and are often found in prominent research papers on the subject. However, it is worth mentioning the weaknesses with these tests, discussed by Bernier and Mouelhi (2008) in their paper on Canadian life insurance stocks. The authors state that the Augmented Dickey-Fuller test has been proven to be very sensitive to the chosen optimal lag. Because of this, one has to be careful when making a lag selection, remembering to test for the best lag using the AIC value.

6. Data

6.1 Selected indices

FTSE Oil & Gas and FTSE Financials indices for each chosen country are used in this study. The indices used are summarized in figure 4 below. The performance of the indices can be seen in figures A and B in the Appendix.

Country	Oil & Gas Index (index currency)	Financials Index (index currency)
United States	FTSE USA Oil & Gas (United States Dollar)	FTSE USA Financials (United States Dollar)
United Kingdom	FTSE UK Oil & Gas (United Kingdom Pound)	FTSE UK Financials (United Kingdom Pound)
Japan	FTSE Japan Oil & Gas (Japanese Yen)	FTSE Japan Financials (Japanese Yen)
Russia	FTSE Russia Oil & Gas (Russian Federation Rouble)	FTSE Russia Financials (Russian Federation Rouble)
Brazil	FTSE Brazil Oil & Gas (Brazilian Real)	FTSE Brazil Financials (Brazilian Real)
India	FTSE India Oil & Gas (Indian Rupee)	FTSE India Financials (Indian Rupee)

Figure 4: Selected indices.

When selecting country (and sector) indices for our study, the aim was to investigate a wide range of Oil & Gas and Financials indices from different parts of the world. The US, the UK, and Japan were chosen to represent the developed markets, as these are some of the world's most developed countries in terms of financial markets, Human Development Index, and GDP per capita. Three of the BRIC countries were chosen to represent the emerging markets. This allows collecting data for a longer historical period, as these countries are larger and more transparent than some of the other emerging economies.

6.2 Time period

The total time period chosen for this study is 1 January 2000 to 31 December 2009. The aim is to examine an identical total time period for all chosen indices, at the same time going back historically as far as the data allows. The chosen time period was divided into two sub-periods, namely the "pre-crisis" period and the "crisis" period:

1. *Pre-crisis period*: 1 January 2000 – 30 June 2007
2. *Crisis period*: 1 July 2007 – 31 December 2009

It is arguable on which exact date the crisis began. Different indicators can be used to determine the start date, for example the TED spread[15] and the S&P500 Volatility Index (VIX)[16]. The VIX was chosen to investigate when the crisis had started. It can be seen in figure 5 below that at the start of July 2007 there was a sharp increase in the VIX (marked by the blue dot), which is why the start date of the crisis was set to 1 July 2007.

Source: Yahoo Finance

Figure 5: S&P500 Volatility Index (VIX), period 2005-2009.

6.3 Data characteristics

Daily prices for the FTSE Oil & Gas indices for each country were downloaded for the period 1 January 2000 – 31 December 2009 using Thomson Reuters Datastream Advance. For FTSE Financials indices daily data for the investigated time period could be downloaded for all countries except for Russia. In the case of Russia, the data could only be downloaded from 23 June 2003. Therefore, the stock price of Sberbank, Russia's largest bank and the first one to be listed, was used as a proxy for the Russian Financials index for the period 1 January 2000 – 22 June 2003. Sberbank's prices were indexed in order to calculate the FTSE index prices prior to 23 June 2003. Using Sberbank as a proxy can be justified by the fact that during this time period, few financial companies were listed in Russia, making Sberbank the largest, which means that during this particular time period it would have had the greatest weight in the Financials index. The natural logarithm of all index prices (including the

[15] TED spread: the difference between the 3-month US Treasury bill rate and the 3-month London Interbank Offered Rate (LIBOR). (Bloomberg Financial Glossary).

[16] S&P500 Volatility Index (VIX): the implied volatility of the S&P500, which is a popular measure of market risk (Bloomberg Financial Glossary).

Sberbank proxy) is taken in line with common practice[17]. All data used is downloaded in local currency. It is assumed that, for example, a German investor wanting to invest in one stock/index dominated in USD and another stock/index dominated in British pound is responsible for hedging his/her currency risk.

Each observation represents the index price at the end of a given trading day. For the pre-crisis period, there is a total of 1955 observations per country and sector. In the crisis period, the number of observations is 654, again per country and sector. The number of observations (trading days) for the entire time period is 2609 per country and index.

7. Results

7.1 Testing for unit-root

All the chosen FTSE Oil & Gas and FTSE Financials indices were tested for a unit-root (non-stationarity) by running the ADF test using the optimal lag. The optimal lag is the one with the lowest AIC. All the computed test statistics, Z(t), are below the 5% critical value (found in figure 6 below) and statistically significant, thus the null hypothesis of "unit root" cannot be rejected. Because all indices have a unit-root, tests for cointegration and causality can be performed.

Augmented D-F	
Critical Values	
5%	10%
2,876	2,57

Figure 6: Augmented Dickey-Fuller critical values

	Unit Root test - Oil&Gas sector			
	Pre-Crisis		Crisis	
	Z(t)	p-value	Z(t)	p-value
Russia	-0.572	0.8771	-1.264	0.6455
Brazil	0.180	0.9711	-1.811	0.3752
India	-1.411	0.5771	-1.890	0.3368
USA	0.512	0.9852	-1.327	0.6166
UK	-1.048	0.7352	-2.681	0.0774
Japan	-0.602	0.8706	-1.646	0.4589

Figure 7: Augmented Dickey-Fuller test for unit-root - Oil & Gas sector

[17] This procedure is followed by Sheng and Tu (2000), Choudhry (1997), etc.

Unit Root test - Financials sector				
	Pre-Crisis		Crisis	
	Z(t)	p-value	Z(t)	p-value
Russia	0.317	0.9781	-1.320	0.6202
Brazil	0.460	0.9836	-1.847	0.3576
India	0.637	0.9885	-1.287	0.6350
USA	-1.836	0.3626	-1.543	0.5121
UK	-1.740	0.4107	-1.496	0.5356
Japan	-1.120	0.7070	-1.389	0.5877

Figure 8: Augmented Dickey-Fuller test for unit-root - Financials sector

7.2 Testing for cointegration

The Durbin-Watson statistic was computed for all possible bivariate systems of time series (indices) chosen for this study and compared to the value of the R^2. All regressions were found to be spurious[18], thus cointegration tests are used instead of OLS-regressions to test for long-run relationships.

The Augmented Engle-Granger test

The Augmented Engle-Granger test for cointegration between bivariate systems in the two sectors is performed on the optimal lag. The optimal lag is chosen according to the lowest AIC, after first setting the maximum number of lags to 25.[19] This means that the cointegration tests performed use data from the two variables from the previous 25 trading days. The null hypothesis of "no cointegration" between bivariate systems is accepted or rejected by examining the 5% critical value, shown in figure 9 below.

Augmented E-G	
Critical Values	
5%	10%
2,86	2,57

Figure 9: Augmented Engle-Granger critical values

Oil & Gas sector

Examining figure 10 below, one sees that the null hypothesis of "no cointegration" cannot be rejected for all bivariate systems in the pre-crisis period, except for the pairs India-USA, India-Japan, Russia-India, Brazil-India, USA-Japan, and Japan-UK, hence these pairs are cointegrated. These are marked in bold and with an asterisk. In the crisis period, the only cointegrating pair is Russia-USA.

[18] Values of the computed R-squared and Durbin-Watson statistics can be found in figures C and D in the Appendix.

[19] When using daily data, it is recommended that a relatively large number of lags are used.

Augmented E-G cointegration test - Oil & Gas				
	Pre-Crisis		Crisis	
	Z(t)	p-value	Z(t)	p-value
Emerging-Developed				
Russia-USA	-1,724	0,419	**-3,427***	0,010
Russia-UK	-1,477	0,545	-2,307	0,170
Russia-Japan	-1,899	0,333	-1,700	0,431
Brazil-USA	-1,981	0,295	-1,923	0,321
Brazil-UK	-1,796	0,383	-2,426	0,135
Brazil-Japan	-2,456	0,127	-1,862	0,350
India-USA	**-3,87***	0,002	-1,803	0,379
India-UK	-2,615	0,090	-2,578	0,098
Emerging-Emerging				
India-Japan	**-3,508***	0,008	-1,729	0,416
Russia-Brazil	-2,454	0,127	-2,052	0,264
Russia-India	**-3,629***	0,005	-2,049	0,266
Brazil-India	**-4,165***	0,001	-2,443	0,130
Developed-Developed				
USA-UK	-2,359	0,154	-1,420	0,573
US-Japan	**-2,915***	0,044	-1,643	0,461
UK-Japan	**-2,898***	0,046	-0,970	0,764

Figure 10: The Augmented Engle-Granger test for cointegration between international Oil& Gas indices: *the computed test statistics, Z(t), marked in bold and with an asterisk represent the cointegrating pairs. The null hypothesis of "no cointegration" is rejected if the test statistic exceeds the 5% critical value and the computed p-value is lower than 0.05.*

Financial sector

The computed test results for the Financials sector look different to the ones obtained for the Oil & Gas sector. The test results in figure 11 below show that before the crisis there is cointegration between India-USA, Brazil-India, USA-Japan, and Japan-UK (the alternative hypothesis of "cointegration" is accepted). During the crisis period, there are only two cointegrating pairs: Brazil-India and USA-UK.

Augmented E-G cointegration test - Financials				
	Pre-Crisis		Crisis	
	Z(t)	p-value	Z(t)	p-value
Emerging-Developed				
Russia-USA	-1,880	0,342	-1,514	0,527
Russia-UK	-0,265	0,930	-2,226	0,197
Russia-Japan	-0,817	0,814	-0,631	0,864
Brazil-USA	-2,837	0,053	-1,086	0,721
Brazil-UK	-0,856	0,802	-0,958	0,768
Brazil-Japan	-1,473	0,547	-0,722	0,841
India-USA	**-2,888***	0,047	-1,633	0,466
India-UK	-0,593	0,873	-1,567	0,500
Emerging-Emerging				
India-Japan	-1,303	0,628	-1,160	0,691
Russia-Brazil	-1,644	0,460	-2,004	0,285
Russia-India	-2,095	0,247	-2,155	0,223
Brazil-India	**-3,118***	0,025	**-3,277***	0,016
Developed-Developed				
USA-UK	-1,237	0,658	**-3,046***	0,031
US-Japan	**-3,132***	0,024	-1,488	0,539
UK-Japan	**-3,056***	0,030	-1,890	0,339

Figure 11: The Augmented Engle-Granger test for cointegration between international financial indices: *the computed test statistics, Z(t), marked in bold and with an asterisk represent the cointegrating pairs. The null hypothesis of "no cointegration" is rejected if the test statistic exceeds the 5% critical value and the computed p-value is lower than 0.05.*

7.3 Testing for Causality using the VAR model and VECM

As previously mentioned, the type of causality test performed depends on whether cointegration between bivariate systems of indices was found. If two bivariate systems are cointegrated the VECM is used to test for causality. If no cointegration was found then the VAR model is used instead. As a reminder, the null hypothesis of the causality test is *no causality*. Therefore, rejecting the null hypothesis implies that the tested independent variable can cause the tested dependent variable.

Oil & Gas sector

The results of the VAR and VECM causality tests for the Oil & Gas indices are shown in figure 12 below. The null hypothesis of "no causality" is rejected when the p-value is found to be below 0.05. It is clear that there is a sign of increasing causality between bivariate pairs of Oil & Gas indices between the periods. In the pre-crisis period 16 causal relationships[20] were found, whereas in the crisis period there are 27 causal relationships. From the results, it can be seen that the US has a predictive effect on all other tested countries both in the pre-crisis and crisis periods. This is also true for the Brazilian market, which predicts all the remaining countries in both time periods.

[20] To clarify, a causal relationship implies that the market of country X is able to predict/price the market of country Y. If the reverse relationship also holds, then there are two causal relationships.

Figure 12: VAR and VECM causality test - Oil & Gas indices: *The table includes all the **insignificant** lags found when performing causality tests, which implies that for all of these the null hypothesis of "no causality" is rejected and the alternative hypothesis is accepted. Causality tests were performed for the pre-crisis and the crisis periods. If no cointegration was found in the pre-crisis period, then a VAR model was used to test for causality. If cointegration was found, then a VECM was used instead. The null hypothesis of the causality test is that there is no causality, i.e. the coefficient (γ or β) is equal to zero. The null hypothesis is rejected when $p<0.05$.*

Causality tests - Oil&Gas sector																
	Pre-crisis							Crisis								
	Emerging-Developed															
	Lag #	Coeff.	std. Err.	Z(t)	p-value	95% conf int		Lag #	Coeff.	std. Err.	Z(t)	p-value	95% conf int	
USA→Russia	1	0,3865	0,04	10,16	0,00	0,31	0,46	1	0,4416	0,07	6,65	0,00	0,31	0,57
	2	-0,2691	0,05	-5,04	0,00	-0,37	-0,16	4	0,1305	0,07	1,81	0,07	-0,01	0,27
	3	-0,1140	0,04	-2,92	0,00	-0,19	-0,04	5	0,1918	0,07	2,66	0,01	0,05	0,33
								6	0,1245	0,07	1,73	0,08	-0,02	0,27
								8	0,1820	0,07	2,51	0,01	0,04	0,32
								10	0,1818	0,07	2,51	0,01	0,04	0,32
								11	0,1315	0,07	1,81	0,07	-0,01	0,27
								14	-0,1566	0,07	-2,25	0,02	-0,29	-0,02
								15	-0,1454	0,07	-2,23	0,03	-0,27	-0,02
Russia→USA								5	-0,0848	0,03	-2,59	0,01	-0,15	-0,02
								8	-0,1167	0,03	-3,61	0,00	-0,18	-0,05
								11	-0,0918	0,03	-2,83	0,01	-0,16	-0,03
								13	0,0772	0,03	2,37	0,02	0,01	0,14
UK→Russia	1	0,1650	0,04	4,12	0,00	0,09	0,24	4	0,2735	0,11	0,12	0,01	0,06	0,49
	2	-0,1213	0,06	-2,19	0,03	-0,23	-0,01	15	0,2288	0,11	0,09	0,04	0,02	0,44
Russia→UK								4	-0,1055	0,04	-2,92	0,00	-0,18	-0,03
								8	-0,1126	0,04	-3,11	0,00	-0,18	-0,04
								9	0,0852	0,04	0,11	0,02	0,01	0,16
								11	-0,0784	0,04	-2,16	0,03	-0,15	-0,01
								12	0,0805	0,04	0,10	0,03	0,01	0,15
								13	0,0965	0,04	0,13	0,01	0,03	0,17
								15	-0,1116	0,04	-3,05	0,00	-0,18	-0,04
								16	0,0771	0,03	0,15	0,00	0,03	0,13
Japan→Russia	1	0,0793	0,03	2,51	0,01	0,02	0,14	4	0,1756	0,09	0,09	0,04	0,01	0,34
								7	0,2024	0,09	0,11	0,02	0,03	0,37
								8	-0,2426	0,09	-2,78	0,01	-0,41	-0,07
Russia→Japan	1	0,0567	0,02	3,47	0,00	0,02	0,09	1	0,2166	0,03	0,34	0,00	0,16	0,27
								2	-0,2088	0,04	-5,28	0,00	-0,29	-0,13
								7	0,1013	0,04	0,12	0,01	0,02	0,18
								14	0,0976	0,04	0,11	0,02	0,02	0,18
								15	-0,1000	0,04	-2,45	0,01	-0,18	-0,02
USA→Brazil	1	0,1102	0,03	3,71	0,00	0,05	0,17	1	0,1319	0,07	0,11	0,05	0,00	0,26
								2	-0,2300	0,08	-2,85	0,00	-0,39	-0,07
								3	0,1969	0,08	0,11	0,02	0,04	0,36
								9	-0,1720	0,07	-2,64	0,01	-0,30	-0,04
Brazil→USA	10	-0,0532	0,02	-2,64	0,01	-0,09	-0,01	3	-0,1746	0,06	-2,79	0,01	-0,30	-0,05
								7	-0,1753	0,06	-2,83	0,01	-0,30	-0,05
								9	0,1310	0,04	0,15	0,00	0,04	0,22
UK→Brazil								4	0,2680	0,08	0,14	0,00	0,10	0,43
								5	-0,2143	0,07	-3,16	0,00	-0,35	-0,08
Brazil→UK	1	0,1128	0,02	5,85	0,00	0,08	0,15	1	0,1750	0,03	0,26	0,00	0,11	0,24
	2	-0,1406	0,03	-4,97	0,00	-0,20	-0,09	2	-0,2106	0,04	-5,21	0,00	-0,29	-0,13
Japan→Brazil								3	0,1873	0,07	0,13	0,01	0,05	0,32
								4	-0,1298	0,05	-2,70	0,01	-0,22	-0,04
Brazil→Japan	1	0,1816	0,02	7,96	0,00	0,14	0,23	1	0,4436	0,03	0,64	0,00	0,39	0,50
	2	-0,1187	0,03	-3,50	0,00	-0,19	-0,05	2	-0,4571	0,04	-11,00	0,00	-0,54	-0,38
	3	-0,0577	0,02	-2,49	0,01	-0,10	-0,01							
USA→India	5	0,0878	0,03	2,65	0,01	0,02	0,15	1	0,1024	0,04	0,11	0,02	0,02	0,19
								4	-0,1613	0,04	-3,71	0,00	-0,25	-0,08
India→USA								1	0,1019	0,04	0,13	0,01	0,03	0,18
UK→India								2	0,1649	0,07	0,10	0,02	0,02	0,31
India→UK								1	0,0944	0,03	0,15	0,00	0,03	0,16
								2	-0,0963	0,04	-2,15	0,03	-0,18	-0,01
Japan→India														
India→Japan								1	0,2710	0,04	0,33	0,00	0,20	0,34
								2	-0,1948	0,05	-3,81	0,00	-0,29	-0,09

	Pre-crisis							Emerging-Emerging			Crisis			
	Lag #	Coeff.	std. Err.	Z(t)	p-value	95% conf int		Lag #	Coeff.	std. Err.	Z(t)	p-value	95% conf int	
Brazil→Russia	1	0,2824	0,03	8,83	0,00	0,22	0,35	1	0,3101	0,05	0,27	0,00	0,21	0,41
	2	-0,2473	0,05	-5,22	0,00	-0,34	-0,15	2	-0,3008	0,07	-4,33	0,00	-0,44	-0,16
								15	0,1224	0,05	0,10	0,02	0,02	0,23
Russia→Brazil								1	0,1096	0,04	0,13	0,00	0,04	0,18
								5	-0,1029	0,05	-2,07	0,04	-0,20	-0,01
								7	0,1082	0,05	0,09	0,03	0,01	0,21
								13	0,1185	0,05	0,11	0,02	0,02	0,22
India→Russia								1	0,2468	0,06	0,19	0,00	0,13	0,36
								3	-0,1641	0,08	-2,06	0,04	-0,32	-0,01
								8	0,2807	0,08	0,16	0,00	0,13	0,44
								9	-0,2403	0,08	-3,02	0,00	-0,40	-0,08
								13	0,1730	0,08	0,09	0,03	0,01	0,33
Russia→India								10	-0,0925	0,04	-2,14	0,03	-0,18	-0,01
								12	0,0872	0,04	0,08	0,04	0,00	0,17
								15	-0,0946	0,03	-3,10	0,00	-0,15	-0,03
India→Brazil								1	0,1618	0,05	0,16	0,00	0,07	0,25
								2	-0,1463	0,06	-2,32	0,02	-0,27	-0,02
Brazil→India	1	0,1154	0,03	4,20	0,00	0,06	0,17	1	0,1276	0,04	0,16	0,00	0,06	0,20
								4	-0,0942	0,04	-2,59	0,01	-0,17	-0,02
	Pre-crisis							Developed-Developed			Crisis			
	Lag #	Coeff.	std. Err.	Z(t)	p-value	95% conf int		Lag #	Coeff.	std. Err.	Z(t)	p-value	95% conf int	
UK→USA	5	-0,1148	0,03	-3,39	0,00	-0,18	-0,05	1	0,1887	0,07	0,14	0,01	0,06	0,32
	6	0,0518	0,03	2,02	0,04	0,00	0,10	2	-0,3049	0,08	-3,94	0,00	-0,46	-0,15
								4	0,1905	0,07	0,12	0,01	0,04	0,34
USA→UK	1	0,3917	0,02	16,31	0,00	0,34	0,44	1	0,3432	0,04	0,39	0,00	0,27	0,42
	2	-0,3468	0,03	-10,92	0,00	-0,41	-0,28	2	-0,2974	0,04	-6,66	0,00	-0,38	-0,21
	4	-0,0845	0,03	-2,58	0,01	-0,15	-0,02							
Japan→USA														
USA→Japan	1	0,2782	0,03	10,15	0,00	0,22	0,33	1	0,5600	0,03	0,69	0,00	0,49	0,63
	2	0,1112	0,03	3,97	0,00	0,06	0,17	2	-0,4139	0,04	-9,30	0,00	-0,50	-0,33
	4	0,0853	0,03	3,04	0,00	0,03	0,14	4	-0,1117	0,04	-2,76	0,01	-0,19	-0,03
Japan→UK	1	0,0491	0,02	2,61	0,01	0,01	0,09							
UK→Japan	1	0,1772	0,03	6,27	0,00	0,12	0,23	1	0,5733	0,05	12,20	0,00	0,48	0,67
	2	0,0915	0,03	3,21	0,00	0,04	0,15	2	-0,5702	0,06	-9,38	0,00	-0,69	-0,45
	3	0,0807	0,03	2,83	0,01	0,02	0,14							
	4	0,0683	0,03	2,39	0,02	0,01	0,12							

Financials sector

Figure 13 below presents the causality results for the Financials sector using the VAR model and the VECM. There is a total of 18 causal relationships in the pre-crisis period, compared to 21 relationships during the crisis. The increase in causality between the periods is not as distinct as in the Oil & Gas sector, where the amount of relationships increased from 16 to 27. In line with the results for the Oil & Gas sector, the US has a strong influence on other markets in the Financials sector, and has a predictive (causal) effect on all the remaining countries in both periods.

Figure 13: VAR causality test - Financials indices: *The table includes all the* ***insignificant*** *lags found when performing causality tests, which implies that for all of these the null hypothesis of "no causality" is rejected and the alternative hypothesis is accepted. Causality tests were performed for the pre-crisis and the crisis periods. If no cointegration was found in the pre-crisis period, then a VAR model was used to test for causality. If cointegration was found, then a VECM was used instead. The null hypothesis of the causality test is that there is no causality, i.e. the coefficient (γ or β) is equal to zero. The null hypothesis is rejected when p<0.05.*

Causality tests - Financials sector														
	Pre-crisis							Crisis						
	Emerging-Developed													
	Lag #	Coeff.	std. Err.	Z(t)	p-value	95% conf int		Lag #	Coeff.	std. Err.	Z(t)	p-value	95% conf int	
USA→Russia	1	0,3225	0,05	0,32	0,00	0,23	0,41	1	0,2934	0,05	0,26	0,00	0,19	0,39
	2	-0,4481	0,07	-6,85	0,00	-0,58	-0,32	2	-0,2455	0,07	-3,75	0,00	-0,37	-0,12
	3	0,1263	0,05	0,13	0,01	0,03	0,22	5	0,1468	0,07	0,10	0,03	0,02	0,28
								7	-0,1362	0,07	-2,06	0,04	-0,27	-0,01
								11	-0,1566	0,07	-2,35	0,02	-0,29	-0,03
								14	-0,1850	0,07	-2,79	0,01	-0,32	-0,05
								15	0,1145	0,05	0,09	0,03	0,01	0,22
Russia→USA								13	0,1462	0,05	0,14	0,00	0,06	0,24
								14	-0,1827	0,05	-4,01	0,00	-0,27	-0,09
								15	0,0727	0,03	0,11	0,02	0,01	0,13
UK→Russia	1	0,0979	0,05	0,10	0,03	0,01	0,19							
	2	-0,1716	0,06	-2,70	0,01	-0,30	-0,05							
Russia→UK														
Japan→Russia								10	-0,2452	0,10	-2,53	0,01	-0,44	-0,06
								11	0,2296	0,10	0,11	0,02	0,04	0,42
								13	-0,4052	0,10	-4,17	0,00	-0,60	-0,21
								14	0,3193	0,10	0,14	0,00	0,13	0,51
Russia→Japan	1	0,0564	0,01	0,17	0,00	0,03	0,08	1	0,1631	0,03	0,27	0,00	0,11	0,21
	2	-0,0559	0,01	-3,97	0,00	-0,08	-0,03	2	-0,2048	0,04	-5,46	0,00	-0,28	-0,13
								5	0,0757	0,04	0,08	0,05	0,00	0,15
								6	-0,1016	0,04	-2,70	0,01	-0,18	-0,03
								8	-0,0954	0,04	-2,51	0,01	-0,17	-0,02
								17	0,1093	0,04	0,14	0,00	0,03	0,18
								18	-0,0980	0,03	-3,65	0,00	-0,15	-0,05
USA→Brazil	9	-0,0772	0,03	-2,21	0,03	-0,15	-0,01	15	-0,1131	0,05	-2,07	0,04	-0,22	-0,01
								18	-0,1500	0,06	-2,71	0,01	-0,26	-0,04
Brazil→USA								13	0,2076	0,09	0,11	0,02	0,04	0,38
UK→Brazil	11	-0,1069	0,03	-3,29	0,00	-0,17	-0,04	8	-0,1002	0,05	-2,20	0,03	-0,19	-0,01
Brazil→UK	1	0,0421	0,02	0,12	0,01	0,01	0,07	1	0,2610	0,05	0,25	0,00	0,17	0,35
	2	-0,0892	0,02	-3,60	0,00	-0,14	-0,04	2	-0,2722	0,06	-4,31	0,00	-0,40	-0,15
	3	0,0557	0,03	0,10	0,03	0,01	0,10							
	7	-0,0530	0,03	-2,12	0,03	-0,10	0,00							
Japan→Brazil														
Brazil→Japan	1	0,1398	0,02	0,30	0,00	0,10	0,18	1	0,5290	0,03	0,69	0,00	0,46	0,59
	2	-0,1979	0,03	-6,71	0,00	-0,26	-0,14	2	-0,5212	0,03	-15,66	0,00	-0,59	-0,46
	3	0,0601	0,02	0,13	0,00	0,02	0,10							
USA→India	1	0,1351	0,03	4,29	0,00	0,07	0,20	1	0,2391	0,03	0,32	0,00	0,17	0,31
								5	-0,0769	0,04	-2,16	0,03	-0,15	-0,01
India→USA														
UK→India	1	0,0939	0,03	0,13	0,00	0,03	0,15	1	0,1524	0,04	0,16	0,00	0,07	0,24
	2	-0,0987	0,04	-2,34	0,02	-0,18	-0,02							
India→UK														
Japan→India														
India→Japan	1	0,0442	0,02	0,09	0,04	0,00	0,09	1	0,2388	0,04	0,28	0,00	0,17	0,31
	2	-0,0423	0,02	-2,00	0,05	-0,08	0,00	2	-0,2745	0,05	-5,27	0,00	-0,38	-0,17
								7	-0,1570	0,05	-2,97	0,00	-0,26	-0,05

	Pre-crisis						Emerging-Emerging			Crisis				
	Lag #	Coeff.	std. Err.	Z(t)	p-value	95% conf int		Lag #	Coeff.	std. Err.	Z(t)	p-value	95% conf int	
Brazil→Russia	1	0,1873	0,03	0,27	0,00	0,13	0,25	1	0,4308	0,06	0,31	0,00	0,31	0,55
	2	-0,2503	0,05	-5,32	0,00	-0,34	-0,16	2	-0,3754	0,06	-5,95	0,00	-0,50	-0,25
	3	0,0655	0,03	0,09	0,04	0,00	0,13							
Russia→Brazil														
India→Russia								1	0,1246	0,06	0,08	0,04	0,00	0,25
								6	0,2162	0,09	0,12	0,01	0,05	0,39
								7	-0,2571	0,09	-2,99	0,00	-0,43	-0,09
								8	0,2338	0,09	0,13	0,01	0,06	0,40
								9	-0,1229	0,06	-2,01	0,05	-0,24	0,00
Russia→India	2	-0,0577	0,02	-2,68	0,01	-0,10	-0,02	1	0,0703	0,03	0,12	0,01	0,02	0,12
	3	0,0326	0,02	0,09	0,03	0,00	0,06	3	-0,0843	0,04	-2,12	0,03	-0,16	-0,01
								7	0,1177	0,04	0,15	0,00	0,04	0,20
								8	-0,1469	0,04	-3,64	0,00	-0,23	-0,07
India→Brazil														
Brazil→India	1	0,1401	0,02	6,57	0,00	0,10	0,18	1	0,2131	0,04	4,84	0,00	0,13	0,30
								2	0,1215	0,04	2,73	0,01	0,03	0,21
	2	-0,1674	0,03	-5,31	0,00	-0,23	-0,11							

	Pre-crisis						Developed-Developed			Crisis				
	Lag #	Coeff.	std. Err.	Z(t)	p-value	95% conf int		Lag #	Coeff.	std. Err.	Z(t)	p-value	95% conf int	
UK→USA	4	0,0789	0,03	0,12	0,01	0,02	0,14							
	5	-0,1013	0,03	-3,16	0,00	-0,16	-0,04							
	9	-0,0643	0,03	-2,00	0,05	-0,13	0,00							
USA→UK	1	0,3727	0,02	0,63	0,00	0,32	0,42	1	0,3440	0,04	7,72	0,00	0,26	0,43
	2	-0,2502	0,03	-7,46	0,00	-0,32	-0,18	2	0,1417	0,05	2,90	0,00	0,05	0,24
	4	-0,0887	0,03	-2,60	0,01	-0,16	-0,02							
	12	0,0797	0,03	0,11	0,02	0,01	0,15							
	13	-0,0620	0,03	-2,41	0,02	-0,11	-0,01							
Japan→USA								3	0,1007	0,05	0,09	0,04	0,01	0,19
USA→Japan	1	0,2934	0,03	10,19	0,00	0,24	0,35	1	0,4390	0,03	0,68	0,00	0,39	0,49
								2	-0,3269	0,04	-8,69	0,00	-0,40	-0,25
								3	-0,0961	0,03	-3,00	0,00	-0,16	-0,03
Japan→UK	8	-0,0599	0,02	-3,25	0,00	-0,10	-0,02	1	-0,0957	0,04	-2,16	0,03	-0,18	-0,01
								2	0,0933	0,04	2,12	0,03	0,01	0,18
UK→Japan	1	0,2366	0,03	8,40	0,00	0,18	0,29	1	0,4611	0,04	12,78	0,00	0,39	0,53
								2	-0,4516	0,04	-12,41	0,00	-0,52	-0,38

8. Analysis and Discussion of Empirical findings

8.1 Analysis of the unit-root test

Cootner (1964) and Malkiel (1973) argued that stock prices are random walks and can therefore not be predicted. The unit root tests in this study also showed that the six chosen indices are random walks, which is in line with Cootner's and Malkiel's earlier studies. It can be said that failing to reject the null hypothesis of unit root also proves that the efficient market hypothesis (EMH) holds for the Oil & Gas and Financials sectors. The EMH says that stock prices are random and cannot be predicted; all information is already incorporated in the market. The most likely form of the EMH that these markets exhibit is the *semi-strong* form, which says that stock prices reflect all past and current public information.[21] However, one can argue that even though the results of the unit root test are statistically significant, it is difficult to say exactly to what extent some of the investigated markets are efficient. The emerging markets in this study still have a relatively high degree of corruption[22] compared to the developed markets, which may prevent certain information from becoming public.

[21] Bloomberg Glossary.
[22] An index measuring corruption is presented in figure 21.

8.2 Analysis of the Augmented Engle-Granger test for cointegration

Oil & Gas sector

The aim of this section is to investigate whether the results of the cointegration tests confirm what may logically be expected – that the investigated countries' Oil & Gas indices should be cointegrated due to similar underlying factors (namely, oil and gas prices) driving the companies in the sector. For some bivariate systems which are found to be cointegrated, the authors will attempt to find factors which may potentially explain this long-term relationship. The authors are aware that readers may find this discussion somewhat arbitrary, as there are no definite explanations as to why cointegration may occur in the Oil & Gas sector.

A summary of the results from the Augmented Engle-Granger test for cointegration between Oil & Gas indices is presented in figure 14 below:

Cointegration in Oil & Gas sector		
	Pre-crisis	**Crisis**
Emerging-Developed	India-USA India-Japan	Russia-USA
Emerging-Emerging	Russia-India Brazil-India	
Developed-Developed	USA-Japan Japan-UK	

Figure 14: ADF test results for Oil & Gas indices in the pre-crisis and crisis periods.

The above results clearly show that there is more cointegration in the Oil & Gas sector in the pre-crisis period compared to the crisis period. Of the 15 pairs of indices tested, six were found to be cointegrating before the crisis. In the crisis period, there is only one cointegrating pair.

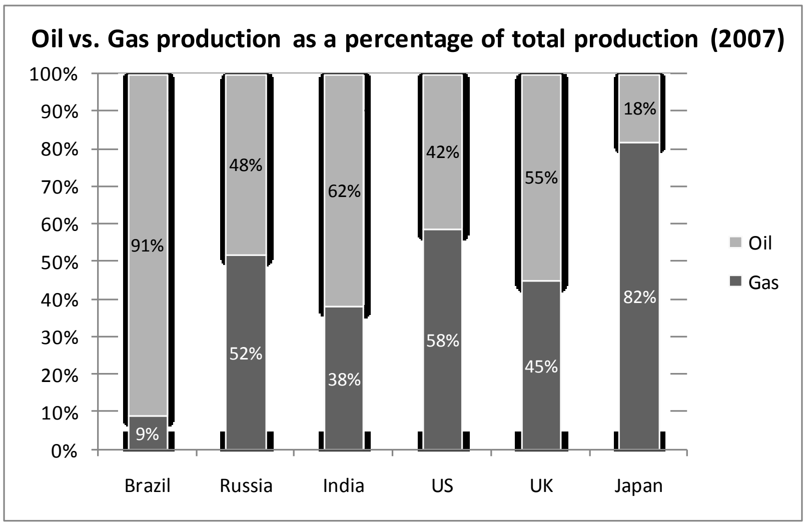
As previously explained, cointegration is expected between the chosen Oil & Gas sectors due to similar underlying factors driving the companies in this sector. However, not all 15 tested bivariate systems were found to be cointegrated before the crisis and just one cointegrating pair during the crisis. An attempt will be made to justify why no cointegration was found between the index pairs in the pre-crisis and crisis periods.

One potential explanation as to why no cointegration was found between the indices is the difference in exchange rates. Using the Russian and Indian currencies as examples this will be illustrated. Figure 15 below shows the India rupee-US dollar (INR-USD), Indian rupee-Russian ruble (INR-RUB), and Russian ruble-US dollar (RUB-USD) exchange rates. Prior to 2007, the INR-USD and the RUB-USD follow a more or less similar pattern. Ultimately, the cointegration between Indian and Russian Oil & Gas indices (pre-crisis) can be explained by the INR and RUB moving in a similar pattern in relation to the USD. However, in mid-2007 (when the US subprime crisis began), the gap between the three lines begins to increase as they move in different directions. The lack of cointegration between these two countries in the crisis period may be explained by both the INR and the RUB becoming weaker against the USD, but the INR becoming stronger against the RUB. The emerging market currencies are moving in opposite directions and since the Oil & Gas indices are denominated in local currencies, this is a possible explanation as to why no cointegration between Russia and India was found in the crisis period.

Figure 15: Indian rupee-US dollar, Russian RUB-US dollar, Indian rupee-Russian rub exchange rates for the period 2000-2009.[23]

Another reason for lack of cointegration (for example in the crisis period) in the Oil & Gas sector is the "disconnection" of the oil price from the price of natural gas. Brazil and the UK will be used to illustrate this. Brazil's share of crude oil (91%) of its total production of oil and gas is much larger than the UK's share (55%) of crude production.

[23] Yahoo Finance.



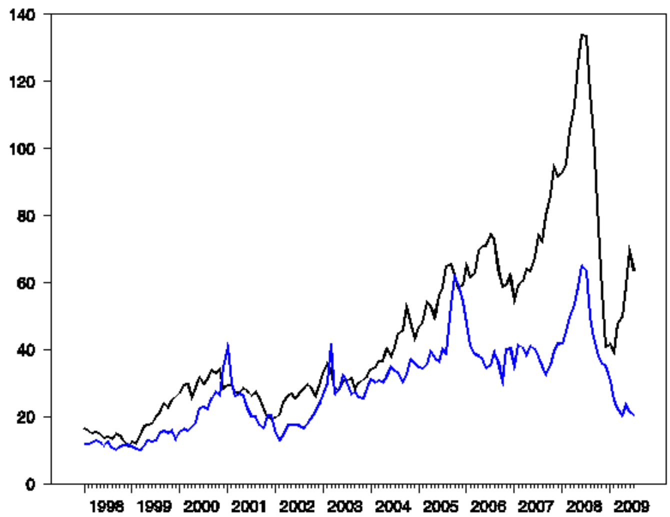
Source of data: International Energy Agency

Figure 16: Production of Oil vs. Gas as a percentage of total Oil & Gas production, 2007.

Looking at the oil price and the natural gas price in figure 17 below, it can be seen that in the beginning of the pre-crisis period the two were fairly interconnected; however, in 2005 the gap between the two prices started to increase. In the crisis period there is an obvious "disconnection" between crude oil and natural gas prices: in February 2009 the ratio between the price of one barrel of oil and one million BTU[24] of natural gas was 8:1, in June 2009 the gap had widened to 18:1.[25] Because the Brazilian Oil & Gas sector is dominated by the production of crude oil (and is obviously more driven by the oil price) this may explain why no cointegration was found between Brazil and the UK in the crisis period. This argument potentially speaks for why more cointegrating pairs should be found in the pre-crisis period (oil and natural gas prices more connected). However, during the crisis the dominant type of production in each country gains more importance because of the "disconnection" between the prices of oil and natural gas. This can explain why less cointegrational relationships were found during the crisis period.

[24] BTU: British Thermal Units

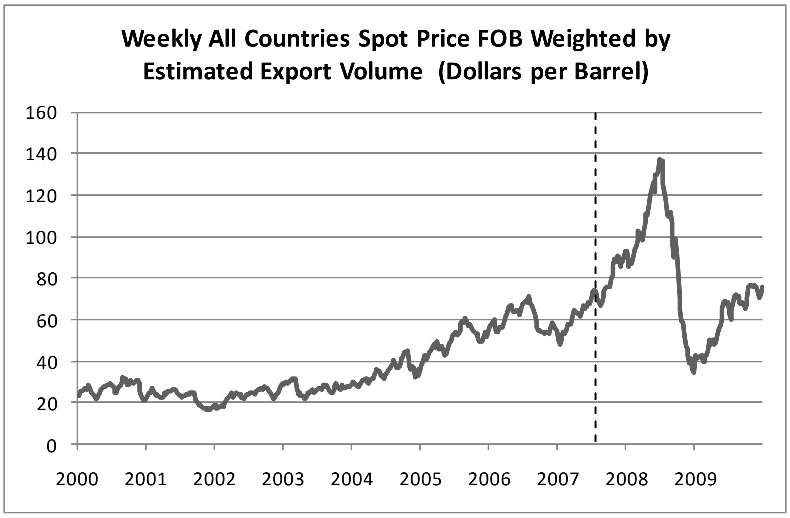
[25] "The price disconnect between oil and natural gas", http://www.financialpost.com/story.html?id=1686177



Source: www.econbrowser.com

Figure 17: WTI crude oil $/barrel (black line) vs. US natural gas wellhead price (blue line)

The results of the cointegration tests show that the only cointegrating bivariate system during the crisis period is Russia-US. As of 2008, Russia and the US are the world's second and third biggest producers of crude oil, respectively. As producers of natural gas, Russia and the US are the largest and second largest producers, respectively. It can be seen in figure 16 that as of 2007 Russia's total production of oil and gas consisted of 48% oil and 52% gas. For the US, the distribution was 42% oil and 58% gas of total oil and gas production. Thus, one can see that the distribution between production of oil and gas is fairly similar for the two countries. The US does not export the oil that it produces, in fact, according to the International Energy Agency, it is the world's largest importer of crude oil. In Russia, the situation is different. Russia is the world's second largest exporter of oil. Looking at figure 18 below, one sees that when the financial crisis began in mid-2007, the oil price continued to increase from around 73 USD/barrel until mid-2008, when it peaked at around 140 USD/barrel. It then proceeded to fall sharply until the start of 2009 when it reached as low as 35 USD/barrel. The sharp increase of the oil price and then the rapid fall is one possible explanation as to why the Russian and American Oil & Gas indices were found to be cointegrated. Both countries are highly dependent on producing oil (for Russia it is important to export it, while for the US it is important to produce it because its demand is so high), which seems to be a fairly logical explanation of the long-term stochastic trend between these two countries' Oil & Gas indices.



Source of data: International Energy Agency/U.S. Energy Information Administration

Figure 18: International crude oil spot price, 2000-2009.

Following the discussion above, the reader may wonder why no cointegration was found between Russia and the US before the crisis. A possible explanation can be found by looking at the finding costs of crude oil in the two countries. Russia benefits from having a relatively low finding cost of oil (10.45USD/barrel) compared to the US (29.11 USD/barrel)[26]. This makes Russian oil producers fairly more profitable at lower oil prices. Thus, a low oil price may have still have a somewhat positive effect on the stock prices of listed Russian oil producers, whereas oil producers in the US will most likely be affected negatively. This is a possible explanation as to why no cointegration was found between the two countries in the pre-crisis period, when the oil price was relatively low.

Sheng and Tu (2000) and Fan (2003) found that cointegration between international stock indices increases during a period of crisis. However, in this study on the Oil & Gas sector, only one cointegrating pair of indices was found during the crisis. Perhaps the reason is that these markets are not as connected as had been expected, and there may be factors which affect Oil & Gas companies differently in different countries. For example, the Indian government spends billions of dollars on subsidizing fuel for its citizens every year. Indian oil companies have to buy oil on international markets at international rates and sell it at a subsidized price in India, meaning they lose large sums of money every day.[27] In general, different countries may have different policies regarding taxation on Oil & Gas production and export restrictions, which means that the stock prices of oil producers may react differently to different factors. This is a possible explanation as to why no cointegration was found between many bivariate pairs both before and during the crisis.

Financials sector

Similar to the analysis of the Oil & Gas sector, the Financials sector will be analyzed with the aim of

[26] U.S. Energy Information Administration.
[27] http://news.bbc.co.uk/2/hi/business/7421778.stm

drawing general conclusions about the cointegrational relationships. A summary of the results from the Augmented Engle-Granger test for cointegration between Financials indices is presented in figure 19 below:

Cointegration in Financials sector		
	Pre-crisis	**Crisis**
Emerging-Developed	India-USA	
Emerging-Emerging	Brazil-India	Brazil-India
Developed-Developed	USA-Japan Japan-UK	USA-UK

Figure 19: ADF results for Financials indices in the pre-crisis and crisis periods.

As previously mentioned, it is not as apparent that companies in the Financials sector should cointegrate since they are driven by domestic factors, rather than one specific factor that affects the whole industry (like the oil and gas prices in the Oil & Gas sector). Examples of these factors include the interest rates set by a country's central bank, risk premiums, industry regulation and the general stability of the economy. Figure 20 presents interbank rates[28] for each chosen country at the start of the total time period (January 2000) and at the end (December 2009). One can see that for some countries interest rates have changed dramatically during the time period. In some countries this occurred due to liberalization of financial markets, as in the case of Russia and India, and in others due to changes in monetary policy. Because of these differences it seems less probable that cointegration would occur in the Financials sector.

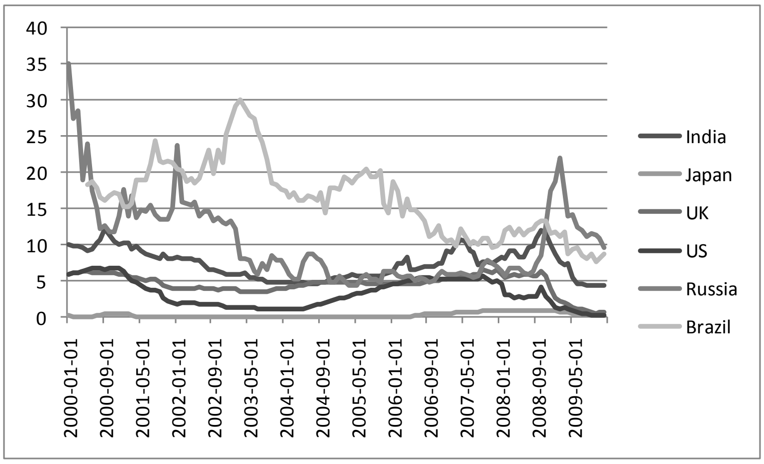


Figure 20: Interbank three-month rates

[28] Interbank rate: interest rate at which banks lend to each other (FT Lexicon).

The average risk premium – the return on a risky investment in excess of the risk-free rate – is also going to vary from country to country, depending on the local interest rate and the relative risk of the investment. Countries which have a relatively high sovereign risk[29] are also likely to give investors large risk premiums, however, the possibility of losing a lot of money is also greater (the risk-return relationship was previously discussed in the introduction to this paper). Political risk[30] is another factor which may affect the overall risk premium of the economy. Unstable governments and regime changes may result in a negative change of policy, leading to less favorable terms for foreign investors. Based on this reasoning one can conclude that for countries which have significantly different monetary policies and political situations one would expect to find very few cointegration relationships, as opposed to the Oil & Gas sector (which is more or less driven by one factor – the price of oil/gas).

The results of the cointegration tests for the Financials sector are in line with the discussion above. Fewer cointegrating pairs were found in the Financials sector compared to the Oil & Gas sector. These results follow the reasoning that companies in the Financials sector can be driven by a wide variety of factors, ranging from interest rates to various domestic policies and regulations. An interesting observation is that no cointegrational relationship was found between the Russian Financials index and any of the other indices in neither of the time periods investigated. A possible explanation of this can be the governance situation in the country. The 2009 Legatum Prosperity Index Report states that nine out of ten Russian's view both the government and businesses as corrupt, giving it a rank of 147 (out of a total of 180) according to the Transparency International Corruption Perceptions Index (see figure 21 below). This suggests that Russia has relatively high political risk compared to India and Brazil, and especially in comparison to the developed markets. The very different political situation in Russia (which can affect other factors with a direct effect on the Financials sector, such as interest rates) can potentially explain why its Financials sector does not cointegrate with those of the remaining countries.

[29] Sovereign risk: the risk associated with investing in one particular country/the risk that the government will default on its foreign debt (FT Lexicon).
[30] Political risk: risk of operating/investing in a country where political changes may have an adverse impact on earnings or returns (FT Lexicon).

Transparency International Corruption Perceptions Index	
Country	**Rank (out of 180)**
Russia	147
India	85
Brazil	80
USA	18
Japan	18
UK	16

Figure 21: Transparency International Corruption Perceptions Index

Another factor which may explain why little cointegration was found and why this is expected in the Financials sector is the restrictions on foreign direct investments, such as in the case of Russia, where the government has a veto over any deal in which a foreign company wants to buy control (more than 50%) of any Russian company.[31]

In general, one would expect to see little cointegration among the countries' Financials sectors unless the countries follow similar monetary policies and have similar underlying factors driving the Financials sector. One could also make the conclusion that during crisis periods cointegrational relationships should be more common, as seen in the findings of Sheng and Tu (2000). This is most likely due to governments and central banks having to take similar actions in order to stimulate the economy. However, if prior to the crisis the economies follow different monetary policies and have different factors driving their Financials sector then they could potentially act differently in a crisis.

Two examples where cointegration was found are USA-Japan and Japan-UK in the pre-crisis period. These three markets are very developed financially with the world's most advanced global financial institutions such as banks and insurance companies. The financial markets of these countries can be seen as somewhat similar, and the following factors may drive their Financials sector: markets are fully liberalized, interest rates are low (so is the risk-premium), many of the companies are global and stock market liquidity is high. This may explain why USA-Japan and Japan-UK cointegrate in the pre-crisis period. An interesting factor is that USA and UK do not cointegrate before the crisis, but cointegration was found during the crisis. Again, the explanation may be the financial policy followed in these markets. During the crisis, both the US and UK cut interest rates significantly, which would've had quite similar effects on companies in the Financials sector of these economies. Even though Japan also cut interest rates in this period (to 0.1%), its rate was already so low (0.5%) that the

[31] http://www.cbc.ca/money/story/2008/03/21/russia-ownership.html

effect of the cut may have been much less significant than in the US and UK, who cut rates from 5.25% to 0.25% and 5.75% to 0.5, respectively. Additionally, subprime loans and the related mortgage back securities (MBS)[32] that American financial institutions were active in trading, is another factor which may explain why a cointegrational relationship between the two countries' Financials sectors was found: mainly the financial institutions of developed markets, especially those in the US and Europe, were holding these securities. Once banks and insurance companies realized that these high-risk instruments were practically worthless, their stock prices plummeted and they were forced to make massive write-downs. This may explain the cointegrating pair US-UK during the crisis period.

An important point to remember is that the data used in this study are daily. The investigated markets are located in different parts of the world, and therefore their stock markets have different opening hours. For example, Tokyo is open during 0:00-02:00 and 04:00-06:00, whereas New York is open 14:30-21:00 in Greenwich Mean Time (GMT). Differences in time imply that some markets may until the next day stay unaffected at the occurrence of a significant event, but this event may in turn affect another market which happens to be open at the time.

8.3 Analysis of the causality tests

The aim of this section is to analyze the causal trend among the different markets, rather than to investigate the causal relationship between each possible bivariate combination of countries. The main focus of the analysis will be on the relationships between bivariate systems of emerging and developed markets, and the discussion will also briefly cover the causal relationships of emerging-emerging and developed-developed markets. For the Oil & Gas sector, the tests have shown that causal relationships increase during the crisis period with the US being one of the main drivers; that Brazil is able to price all markets in the pre-crisis period but no one (except the US) can price Brazil, which is either a sign of decoupling or the fact that its opening hours differ from those of the remaining markets; that the Russian Oil & Gas market – which today is the second largest in the world – cannot predict any of the remaining markets in the pre-crisis period (except for a very weak causal relationship on Japan). For the Financials sector, there is also an increase in causal relationships in the crisis period, but this increase is not as large as for the Oil & Gas sector. In general, causal relationships are seen for all various bivariate systems of markets. A sign of decoupling is shown by the Russian Financials sector. Brazil's strong influence can either be a sign of decoupling or depends on the different market opening hours. These findings are analyzed in more detail throughout this section.

Figures 22 and 23 represented the summarized results of the VAR and VECM causality tests for the Oil & Gas sector and the Financials sector, respectively. The number of significant lagged (past)

[32] Mortgage backed securities (MBS): securities backed by mortgages on properties (Financial Times Lexicon). The MBS market in the US finally collapsed in 2007, due to the large amount of subprime mortgages that banks had allowed and which lenders could not pay back.

values is not taken into account in these tables, just the existence of causality in each bivariate system, for example, just the predictive effect of the US on Russia is taken into account, but not all the lagged values of the US are counted and included in the table.

VAR & VECM causality test - Oil & Gas sector	Pre-crisis	Crisis
	Emerging-Developed	
	Causality	Causality
Russia→USA		✓
USA→Russia	✓	✓
Russia→UK		✓
UK→Russia	✓	✓
Russia→Japan	✓	✓
Japan→Russia	✓	✓
Brazil→USA	✓	✓
USA→Brazil	✓	✓
Brazil→UK	✓	✓
UK→Brazil		✓
Brazil→Japan	✓	✓
Japan→Brazil		✓
India→USA		✓
USA→India	✓	✓
India→UK		✓
UK→India		✓
India→Japan		✓
Japan→India		
# of sig. coeff.	9	17
	Emerging-Emerging	
	Causality	Causality
Russia→Brazil		✓
Brazil→Russia	✓	✓
Russia→India		✓
India→Russia		✓
Brazil→India	✓	✓
India→Brazil		✓
# of sig. coeff.	2	6
	Developed-Developed	
	Causality	Causality
USA→UK	✓	✓
UK→USA	✓	✓
USA→Japan	✓	✓
Japan→USA		
Japan→UK	✓	
UK→Japan	✓	✓
# of sig. coeff.	5	4
Total number of significant coefficients	16	27

Figure 22: Summary of causality tests for Oil & Gas sector

VAR & VECM causality test - Financials sector	Pre-crisis	Crisis
	Emerging-Developed	
	Causality	Causality
Russia→USA		✓
USA→Russia	✓	✓
Russia→UK		
UK→Russia	✓	
Russia→Japan	✓	✓
Japan→Russia		✓
Brazil→USA		✓
USA→Brazil	✓	✓
Brazil→UK	✓	✓
UK→Brazil	✓	✓
Brazil→Japan	✓	✓
Japan→Brazil		
India→USA		
USA→India	✓	✓
India→UK		
UK→India	✓	✓
India→Japan	✓	✓
Japan→India		
# of sig. coeff.	10	12
	Emerging-Emerging	
	Causality	Causality
Russia→Brazil		
Brazil→Russia	✓	✓
Russia→India	✓	✓
India→Russia		✓
Brazil→India	✓	✓
India→Brazil		
# of sig. coeff.	3	4
	Developed-Developed	
	Causality	Causality
USA→UK	✓	✓
UK→USA	✓	
USA→Japan	✓	✓
Japan→USA		✓
Japan→UK	✓	✓
UK→Japan	✓	✓
# of sig. coeff.	5	5
Total number of significant coefficients	18	21

Figure 23: Summary of causality test for Financials sector

Oil & Gas sector

Looking at the results of the VAR and VECM causality test for Oil & Gas indices in figure 22 above, specifically at the causal relationship between emerging and developed country indices, it is clear that there are more causal relationships between these markets in the crisis period (17 relationships) compared to the pre-crisis period (9 relationships). Among emerging-emerging pairs, there are two causal relationships in the pre-crisis period and six such relationships during the crisis. For developed-developed pairs, there are more causal relationships in the pre-crisis period (5) than in the crisis period (4).

Focusing on the emerging-developed and developed-emerging pairs, one can investigate whether the theory of decoupling holds for the Oil & Gas sector: have the Oil & Gas sectors of emerging markets really decoupled from those of developed markets? Extracts of results from figure 12 can be found in figures 24, 25, and 26 below. Starting with Brazil, in figure 24, one can see that in the pre-crisis period the only developed country which has an explanatory effect on the Brazilian Oil & Gas sector is the US. From the emerging-emerging pairs, none of the other markets can predict Brazil. The results are quite different during the crisis – all the remaining countries are able to predict the Brazilian Oil & Gas market. One conclusion which can be drawn from this is that the Brazilian Oil & Gas market has decoupled from the remaining developed markets, except the US, and cannot be predicted by the emerging markets. However, the decoupling theory does not hold during the crisis period (the short term period). A possible explanation of this is the volatility which spread across world equity markets once the financial crisis began, and which made all markets move in tandem.

As a counter-argument to the decoupling of Brazil one can also argue that the reason no country has a predictive effect on Brazil (except the US), but Brazil has a predictive effect on all remaining markets, is the different stock market opening hours. Once the Brazilian market closes, only a few hours remain before the Asian markets open and soon after the European. Also, Brazil opens just a few hours before the US, which means that there is a large overlap between their trading hours. This implies that if a significant event occurs in the US market, it may affect the Brazilian market, which in turn may affect the Asian and European markets on their next trading day. Therefore, it may look as if Brazil is causing the remaining markets, but it seems more likely that it is the US which affects these markets indirectly via Brazil. The dominant effect of the US is discussed further on in this section. However, because all other markets are able to predict Brazil in the crisis, one can argue that opening hours become less important during periods of instability and high volatility.

Causality tests: Brazil - Oil&Gas sector								
	Pre-crisis				Crisis			
	Emerging-Developed							
	Lag #	Coeff.	Z(t)	p-value	Lag #	Coeff.	Z(t)	p-value
USA→Brazil	1	0,1102	3,71	0,00	1	0,1319	0,11	0,05
					2	-0,2300	-2,85	0,00
					3	0,1969	0,11	0,02
					9	-0,1720	-2,64	0,01
UK→Brazil					4	0,2680	0,14	0,00
					5	-0,2143	-3,16	0,00
Japan→Brazil					3	0,1873	0,13	0,01
					4	-0,1298	-2,70	0,01
	Emerging-Emerging							
	Lag #	Coeff.	Z(t)	p-value	Lag #	Coeff.	Z(t)	p-value
Russia→Brazil					1	0,1096	0,13	0,00
					5	-0,1029	-2,07	0,04
					7	0,1082	0,09	0,03
					13	0,1185	0,11	0,02
India→Brazil					1	0,1618	0,16	0,00
					2	-0,1463	-2,32	0,02

Figure 24: Extract from results of causality tests for Brazilian Oil & Gas sector

Continuing with India, in figure 25 below it can be seen that, similarly to Brazil, the only developed markets which can price the Indian Oil & Gas market in the pre-crisis period is the US. However, one emerging market can also price the Indian, namely Brazil. The interpretation that one can make based on these results is that the Indian Oil & Gas market has decoupled from all the developed markets tested, but not from the US market, and the only emerging market which is able to price India's Oil & Gas sector is Brazil, but this is perhaps due to the different opening hours.

Causality tests: India - Oil&Gas sector								
	Pre-crisis				Crisis			
	Emerging-Developed							
	Lag #	Coeff.	Z(t)	p-value	Lag #	Coeff.	Z(t)	p-value
USA→India	5	0,0878	2,65	0,01	1	0,1024	0,11	0,02
					4	-0,1613	-3,71	0,00
UK→India					2	0,1649	0,10	0,02
Japan→India								
	Emerging-Emerging							
	Lag #	Coeff.	Z(t)	p-value	Lag #	Coeff.	Z(t)	p-value
Russia→India					10	-0,0925	-2,14	0,03
					12	0,0872	0,08	0,04
					15	-0,0946	-3,10	0,00
Brazil→India	1	0,1154	4,20	0,00	1	0,1276	0,16	0,00
					4	-0,0942	-2,59	0,01

Figure 25: Extract from results of causality tests for Indian Oil & Gas sector

Finally, examining the Russian Oil & Gas sector, in figure 26 it can be seen that all the investigated Oil & Gas markets, except India, can help predict the Russian market before the crisis. The predictive relationship during the crisis is even more apparent, as all countries can now price the Russian Oil & Gas market. The conclusion which can be drawn from this is that the Russian Oil & Gas market has not yet decoupled from the three developed markets, and can also be influenced by other emerging markets. It is interesting that Russia's Oil & Gas sector, which is one of the largest in the world, cannot predict any of the other markets in the pre-crisis period (except for Japan, but this effect is very weak), but is able to predict all the markets during the crisis. The most likely explanation of this is the lack of liquidity in the Russian stock market at the start and throughout most of the pre-crisis period. One of Russia's largest Oil & Gas companies, Gazprom, was closed for foreign investment until

January 2006. The lack of movement in the market can potentially explain why Russia's Oil & Gas sector is not able to price any of the other countries in the pre-crisis period. Therefore, it is difficult to say for sure whether Russia has or has not decoupled, because its Oil & Gas sector has been relatively illiquid until recent years.

Causality tests: Russia - Oil&Gas sector								
	Pre-crisis				Crisis			
Emerging-Developed								
	Lag #	Coeff.	Z(t)	p-value	Lag #	Coeff.	Z(t)	p-value
USA→Russia	1	0,3865	10,16	0,00	1	0,4416	6,65	0,00
	2	-0,2691	-5,04	0,00	4	0,1305	1,81	0,07
	3	-0,1140	-2,92	0,00	5	0,1918	2,66	0,01
					6	0,1245	1,73	0,08
					8	0,1820	2,51	0,01
					10	0,1818	2,51	0,01
					11	0,1315	1,81	0,07
					14	-0,1566	-2,25	0,02
					15	-0,1454	-2,23	0,03
UK→Russia	1	0,1650	4,12	0,00	4	0,2735	0,12	0,01
	2	-0,1213	-2,19	0,03	15	0,2288	0,09	0,04
Japan→Russia	1	0,0793	2,51	0,01	4	0,1756	0,09	0,04
					7	0,2024	0,11	0,02
					8	-0,2426	-2,78	0,01
Emerging-Emerging								
	Lag #	Coeff.	Z(t)	p-value	Lag #	Coeff.	Z(t)	p-value
Brazil→Russia	1	0,2824	8,83	0,00	1	0,3101	0,27	0,00
	2	-0,2473	-5,22	0,00	2	-0,3008	-4,33	0,00
					15	0,1224	0,10	0,02
India→Russia					1	0,2468	0,19	0,00
					3	-0,1641	-2,06	0,04
					8	0,2807	0,16	0,00
					9	-0,2403	-3,02	0,00
					13	0,1730	0,09	0,03

Figure 26: Extract from results of causality tests for Russian Oil & Gas sector

In general, causality tests show that the US Oil & Gas index can help predict all three emerging markets, whereas the UK and India can predict only one (namely Russia). The strong influential relationship of the US is expected, as mentioned in the section *Research Focus and Objectives*. The US has the biggest stock market in the world, as well as the world's biggest company, Exxon Mobil, which also happens to be an Oil & Gas producer. These findings are in line with Sheng and Tu (2000), who find that the US stock market causes the Asian-Pacific markets during the Asian crisis of 1997-1998. Examining the coefficients in figure 12 in the Results-section, one can see that the coefficient for each country that the US causes *increases* during the crisis period. For example, in the pre-crisis period the coefficient for US-Russia is 0.3865 when using one lag, whereas in the crisis period it is 0.4416 also using one lag. This suggests that the US has an even stronger influence on the Oil & Gas stocks in Russia during the crisis period. Similar observations can be seen for US-Brazil and US-India. The conclusion which can be drawn from this is that the American Oil & Gas sector, because of its large size, sets the trend for all the remaining sector indices.

Financials sector

Compared to the Oil & Gas sector, the results of the VAR and VECM causality tests for the Financials sector do not differ as drastically between periods. Looking at the summarized results in figure 23 above, one can see that among emerging-developed pairs there are 10 causal relationships in the pre-crisis period and 12 during the crisis, among emerging-emerging pairs, there are three causal relationships in the pre-crisis and four such relationships in the crisis. For developed-developed pairs, there are a total of five causal relationships in both periods. Overall, the causal relationships are more prevalent in the Oil & Gas sector. Possible reasons for this are most likely related to the fundamental drivers of the sectors. For example, if the oil or gas prices go down then all Oil & Gas companies may be affected as their revenues shrink. However, if one central bank cuts its interest rates to stimulate the economy it doesn't automatically imply that other stock markets will be affected by the change.

In general, the results show a lot of causal relationships among various combinations of bivariate pairs of Financials indices, making it difficult to draw any definite conclusions about decoupling. However, a potential example of decoupling may be the relationship between UK-Russia. The UK has a weak causal effect on Russia before the crisis and no effect during the crisis, suggesting that the Russian Financials market has decoupled from the UK both in the long-term and in the short-term. One reason which possibly can explain this effect is the relatively small amount of high-risk securities associated with subprime mortgages held by Russian financial companies. This allowed them to avoid massive write-downs, which many UK banks suffered. The UK's Financials sector has become more significant in driving the other countries. A reason for this is the fact that it is one of the largest and most developed financial markets in the world, and similarly to the US, it too can set the trend for other markets.

Just like in the Oil & Gas sector, the US also seems to have a dominant relationship in the Financials sector and is able to predict all markets in both periods. Again, this can most likely be explained by its important role for the global financial markets and in setting the market sentiment. Japan on the other hand, which is also a large and developed financial market, is not able to predict any of the other markets (except a weak effect on the UK) prior to the crisis. The possible explanation for this is the different opening hours of its market. During the crisis, though, Japan is able to price Russia, as well as the UK and US, which speaks for the volatility contagion which occurred once the crisis began. Brazil's significant causal effect on all other financial markets (excluding the US) is most likely again due to the different market opening hours, and possibly the indirect effect of the US market. From these mixed results it is difficult to say whether any of the emerging markets have truly decoupled, however, what is clear is that the largest Financials sectors, i.e. the US and UK, are trendsetters for the remaining markets.

8.4 Limitations of the study

It can be argued that in order to eliminate the effect of currency fluctuations and the inflation effect, the results would have been more robust if index prices quoted in USD were used to perform the cointegration and causality tests. However, as previously mentioned, the assumption behind the decision to use domestic currencies for each chosen index is that each investor is responsible for hedging his/her own currency risk. The fact that a single currency is not used also makes it difficult to make any conclusions about whether a given market can be used as a form of diversification. An American investor investing in the Russian Oil & Gas sector cares about his return in USD, i.e. his domestic currency, not in terms of the ruble. Therefore, drawing conclusions from these results about which markets are effective in diversifying an investor's portfolio are difficult to make when different currencies are used.

Another possible limitation of this study is the definition of the crisis period, especially when referring to the Oil & Gas sector. The American subprime crisis began in the summer of 2007, which also defines the start of the crisis period in this paper. However, the oil price continued to increase until it peaked in July 2008. This implies that perhaps a later start date of the crisis period should've been used for the Oil & Gas sector. It would be interesting to see whether the results of the cointegration and causality tests would change significantly if the time period was altered. Finally, the different stock market opening hours in the different countries make it difficult to tell exactly whether decoupling has truly occurred.

9. Conclusion

The first objective of this paper was to investigate whether there is cointegration between various sector indices, specifically among the Oil & Gas and Financials sectors, across stock markets of emerging and developed countries. The second objective was to investigate the predictive qualities (causality) of one market on another in the different sectors. Using first the Augmented Dickey-Fuller test to check for unit root in all series and then the Augmented Engle-Granger test for cointegration, it was found that prior to the crisis there was generally more cointegration in the Oil & Gas sector than in the Financials sector. This is in line with what could be expected, as the Oil & Gas sector is primarily driven by the prices of oil and natural gas, whereas the Financials sector is driven by a variety of different factors ranging from interest rates to a country's political risk. The lack of cointegration during the crisis period in the Oil & Gas sector can be explained by the "disconnection" which occurred between the oil price and natural gas price. If one country produces more gas, while another country produces more oil cointegration is less likely to occur if the prices of these two commodities are out of sync. Differences in regulation and taxation are another potential factor which may explain the lack of cointegration in the Oil & Gas sector.

As mentioned above, fewer cointegrating bivariate systems were found in the Financials sector, highlighting the reasoning that there is a broader variety of factors which drive this sector. It was found that the Russian Financials sector does not cointegrate with any of the other markets in the pre-crisis period, which can potentially be explained by the large political risk in the country. Cointegration was found between the Financials sectors for USA-Japan and Japan-UK which can be explained by the fact that these countries have highly developed financial markets and relatively low interest rates.

Using the VAR and VECM causality tests, it was found that there is an obvious increase of causal relationships between periods in the Oil & Gas sector; however, the increase is not as striking in the Financials sector. For the Oil & Gas sector, it can be argued that Brazil has decoupled from the developed markets (except from the US) and has no connection to the remaining markets, as they are not able to price Brazil prior to the crises. However, this relationship could also be explained by the differing stock market opening hours between the investigated countries. The decoupling theory does not hold for Brazil during the crisis period, as other markets are now also able to price it. It was also found that the Russian Oil & Gas sector does not have a predictive effect on the other markets in the pre-crisis period, except for a weak effect on Japan. This is most likely due to its relatively small market size at the time, as well as its lack of liquidity. As mentioned above, causality also increases in the Financials sector during the crisis. The variety of causal relationships is wide, making it difficult to identify whether any Financials sectors of emerging markets have decoupled from the developed markets. However, a possible sign of decoupling is seen between Russia and the UK. Also, Brazil's strong influence on the other markets can again be explained by either the fact that it is decoupled or by its different market opening hours.

In conclusion it can be said that a small number of market drivers should result in greater cointegration between sector indices, as was seen in the Oil & Gas sector. A large variety of factors driving the sector should result in less cointegration among indices. When it comes to causality and predictive qualities of one market on another, it is difficult to draw definite conclusions about whether one market has truly decoupled from another. Such factors as market opening hours and volatility contagion may have a large effect on the causal relationships. Especially during the recent financial crisis, and the current crisis in Greece, volatility spread very quickly across markets, creating the effect of a downward spiral – once one market starts falling, it is very likely that others will follow. Another reason as to why there are weak signs of decoupling, especially during the crisis period, is the general assumption behind the theory – "that [emerging markets] have broadened and deepened"[33] – which can be false. It is difficult to say exactly how much a market has matured, and it is especially hard to measure how insulated it is from a crisis. Finally, the theory of decoupling is by default contradictive to the phenomenon of globalization. As markets grow and mature, there is a tendency for stock markets across different countries to become more homogenous, making it difficult for decoupling to occur.

[33]"*Economic Decoupling Theory – Present Status*", Noble Trading.

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Appendix

Performance of selected Oil & Gas indices

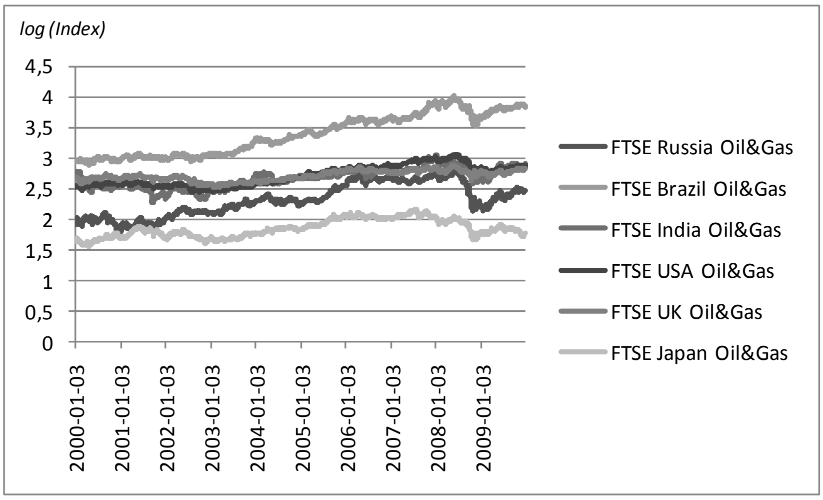

Figure A: Performance of selected indices in the Oil & Gas sector.

Performance of selected Financials indices

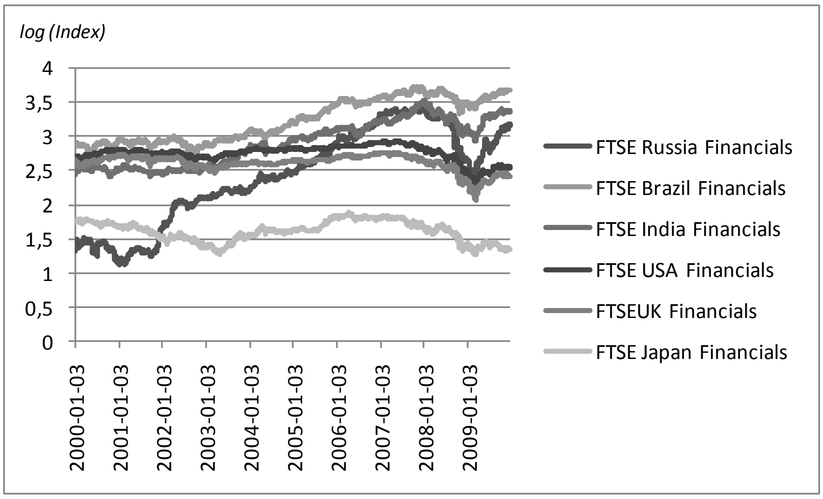

Figure B: Performance of selected indices in the Financials sector.

Testing for spurious regression using the Durbin-Watson test

Looking at the computed R^2-values for the bivariate systems in figures C and D below, a sign of spurious regression can be seen in the Oil & Gas and Financials sectors since $R^2 > d$ (rule of thumb), as discussed by Granger and Newbold (1973) .

Spurious regression tests - Oil & Gas				
	Pre-Crisis		Crisis	
	R-squared	DW	R-squared	DW
Russia-USA	0,7158	0,0100	0,9219	0,2153
Russia-UK	0,3946	0,0057	0,6008	0,0575
Russia-Japan	0,7021	0,0115	0,7198	0,0304
Brazil-USA	0,8726	0,0137	0,3864	0,0182
Brazil-UK	0,5389	0,0078	0,4374	0,0373
Brazil-Japan	0,8491	0,0193	0,1498	0,0228
India-USA	0,6857	0,0185	0,4994	0,0347
India-UK	0,4390	0,0120	0,4869	0,0521
India-Japan	0,5642	0,0142	0,3688	0,0220
Russia-Brazil	0,9081	0,0241	0,4820	0,0203
Russia-India	0,6372	0,0118	0,6548	0,0319
Brazil-India	0,7351	0,0150	0,7001	0,0764
USA-UK	0,7995	0,0228	0,6242	0,0676
USA-Japan	0,8882	0,0371	0,6786	0,0663
Japan-UK	0,7478	0,0265	0,3762	0,0323

Figure C: Summary of Durbin-Watson test statistics and correlation coefficient – Oil & Gas sector

Spurious regression tests - Financials				
	Pre-Crisis		Crisis	
	R-squared	DW	R-squared	DW
Russia-USA	0,5247	0,0081	0,8605	0,0600
Russia-UK	0,0787	0,0009	0,8891	0,0410
Russia-Japan	0,1174	0,0006	0,6842	0,0170
Brazil-USA	0,8008	0,0268	0,5332	0,0299
Brazil-UK	0,3731	0,0056	0,5863	0,0383
Brazil-Japan	0,4119	0,0031	0,3450	0,0332
India-USA	0,7311	0,0221	0,5366	0,0223
India-UK	0,2130	0,0033	0,5830	0,0201
India-Japan	0,3398	0,0023	0,3265	0,0132
Russia-Brazil	0,8007	0,0048	0,7808	0,0710
Russia-India	0,8562	0,0065	0,7429	0,0300
Brazil-India	0,9251	0,0206	0,8067	0,1055
USA-UK	0,6241	0,0211	0,9848	0,4760
USA-Japan	0,4749	0,0150	0,8854	0,1133
Japan-UK	0,5582	0,0147	0,8480	0,0502

Figure D: Summary of Durbin-Watson test statistics and correlation coefficients – Financials sector