# MAF016

# The Baltic Dry Index: A Leading Economic Indicator and its use in a South African context.

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## Abstract

This paper investigates the Baltic Dry Index (hereinafter BDI); an often misunderstood index, which tracks the cost of shipping dry bulk cargo globally. The research is based on the hypothesis that movements in the BDI price are driven largely by changes in the underlying demand for goods which are consumed globally. Accordingly, this paper aims to investigate whether changes in the BDI price may be used to predict future economic movements in a South African context. In this regard, the paper first conducts a thorough synthesis of the available literature, in order to formulate the conclusion that the BDI price is driven by a multitude of variables, including the global demand for goods, the global supply of ships, the laycan period, bunker prices, global piracy, global winter severity, as well as the inclusion of a cyclical component. The global demand for goods is concluded to be chief among these. Based on these findings, the paper then conducts empirical testing on the usefulness of the BDI in a South African context, and concludes that the BDI is useful when used as a leading economic indicator in South Africa, especially when used in order to predict long-term economic movements, across a period of 3 – 4.5 years. Finally, strong evidence is found to support the existence of a relationship between the BDI and the Johannesburg Stock Exchange Mining Index, although further investigation is required in order to form a definitive conclusion in this regard.

## 1. Introduction

As a result of increased globalization in the 21st Century, as well as significant reductions in transport costs, approximately 80% of world trade is currently transported by ship, via more than 93 000 freight vessels and 1.25 million crew members (Bowden 2010). These vessels transport an estimated 6 billion tonnes of cargo on an annual basis; the largest proportion of which represents dry bulk cargo[46] - a category of goods which accounts for 40% of the world fleet[47] (Geman and Smith 2012). In a South African context, the importance of dry bulk shipping is extremely significant, with approximately 132.7 million tonnes of dry bulk cargo having been exported by ship during 2010. This represents approximately 87% of the country's total seaward exports for the year (South African National Department of Transport 2011). In total, South African foreign maritime trade comprises 3% - 4% of the aggregate tonne-miles[48] of world carriage.

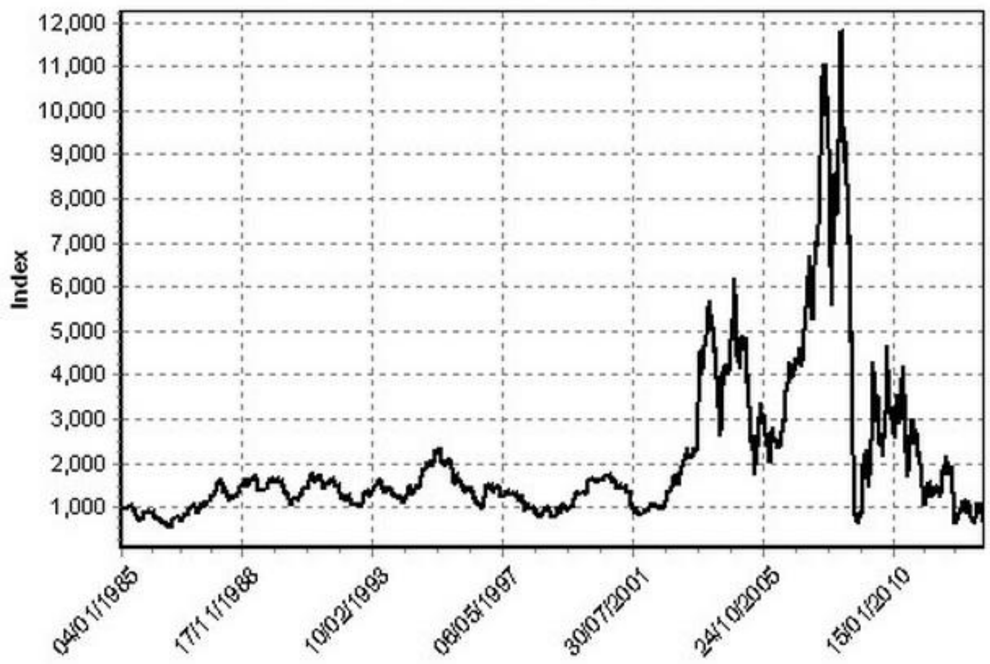
In order to assist the public in monitoring the cost of dry bulk shipping globally, the Baltic Dry Index[49] (BDI) is released every weekday at 13:00 by the Baltic Exchange (Baltic Exchange 2012). The BDI tracks global shipping prices of various forms of dry bulk cargo across twenty-five key dry bulk shipping routes, the contracts for which are negotiated and traded on the Baltic Exchange. These prices are obtained through the involvement of a panel of international ship-

[46] Dry bulk cargo is dominated by five main commodities: iron ore, coal, phosphate, grain and alumina (Oomen 2012).
[47] The remainder of the world's cargo fleet is comprised as follows: 38% represents tankers and 22% represents container ships (Geman and Smith 2012).
[48] Investopedia (2012) defines a tonne mile as a "single ton[ne] of goods that is transported for one mile."
[49] The Baltic Dry Index is the successor to the Baltic Freight Index and was brought into operation for the first time on 1 November 1999 (Baltic Exchange 2012).

brokers, who submit dry bulk shipping prices to the Baltic Dry Exchange on a daily basis. Figure 1, below, depicts the price movements of the BDI for the period April 1985 – December 2012.

In the short term, the supply of dry bulk cargo is tight and inelastic (Bakshi, Panayotov and Skoulakis 2010). This is due to the fact that the supply of ships, being large and expensive capital assets, is mostly fixed in the short term (Devanney 2010). As a result of this relatively constant vessel supply, changes in demand, driven by increased global production and exports, directly affect the BDI price.

**Figure 1: 1985 – 2012 Baltic Dry Index Price Chart**




Source: Baltic Exchange (2012)

This unique, price-sensitive relationship has resulted in economic experts, such as economists, accountants and investment analysts using the BDI as a leading economic indicator[50]. Said differently, as a result of the fact that the world freight market is a competitive environment in which the factors of supply and demand determine the freight rate (Koskinen and Hilmola 2005), it may be possible for the BDI to be used in order to predict future stock returns and economic activity. This is as a result of the fact that changes in the BDI price are believed to be reflective of changes in global demand for raw materials (Alizadeh and Talley 2010). Phillips (2010), an author for the Wall Street Journal, epitomizes this viewpoint:

> *"And since its [the BDI's] recent May 26 peak of 4209, the index has dropped by nearly 55% to 1902 Friday. So, are prices in the shipping markets signalling a hard-landing, or worse, a double dip recession?"*

Blanchflower (2010: 1), too, discusses the signalling effect of the BDI. He asserts that despite the positive economic sentiment of most investors during 2010, the subsequent drop in the BDI *"*signal[led] trouble ahead*"*. This assertion is strengthened by the fact that economists believe the BDI to be a pure economic indicator which is largely devoid of speculative activity (Mowry and Pescatori 2008). According to the Baltic Exchange (2012):

> *"… it provides both a rare window into the highly opaque and diffuse shipping market and an accurate barometer of the volume of global trade – devoid of political and other agenda concerns."*

It is clear that the financial public perceive the BDI to be a pure and efficient economic indicator. Despite this, the use of the BDI as a leading economic indicator is subject to a number of complications which are yet to be resolved,

[50] Investopedia (2012) defines a leading economic indicator as "a measurable economic factor that changes before the economy starts to follow a particular pattern or trend."

given the very limited amount of research which has been conducted on this index. The first such issue stems from the fact that, although perceived to be a pure economic indicator, the BDI price is nevertheless subject to a multitude of complex external factors which may potentially impact on its price. These factors are detailed further in the Literature Review, below. The existing literature has not taken cognisance of this fact and, as such, an extensive research and synthesis of these factors in the context of the BDI, is not yet available. The second issue is that previous studies have not investigated the usefulness of the BDI as a predictor for future stock returns and economic activity in a South African context. As such, the potential exists that South African market participants are not as efficient as their global counterparts, due to a lack of knowledge regarding the relationship between the South African economy and the BDI; a potential investment analysis tool.

### 1.1 Research Problem

The purpose of this research is to analyse the key factors which influence the BDI price, as well as to assess the predictive properties of the BDI in a South African context. In light of the aforementioned relationship between the BDI and the demand for goods which are exported globally, it is hypothesized that the BDI and its sub-indices may be used in order to predict stock price movements and economic activity in a South African context. This is coupled with the fact that the export of goods must intuitively precede their ultimate sale. In order to investigate this relationship, the following two research questions are established:

1. Research Question 1 (RQ1): Which factors influence movements in the BDI price?

2. Research Question 2 (RQ2): Can the BDI be used as a predictor for South African stock price movements and economic growth?

### 1.2 Scope and Delimitations

RQ1 is focused on identifying the fundamental BDI price drivers only. It is noted that, due to the complexity of modern-day trade, there are likely to be a number of ancillary factors which drive the BDI price which will not be identified in this research. In addition, this research does not aim to develop a model in which the potential impact of non-demand related BDI price drivers are removed in order to develop a more pure BDI price. This is as a result of the fact that many fundamental BDI drivers are of a non-discrete nature and can therefore not be quantified numerically.

As regards the research pertaining to RQ2, it is noted that his study is of an exploratory nature only. As such, a full empirical investigation of the relationship between a lagged BDI and all JSE sectors is outside the scope of this paper. In addition, in interpreting the findings of RQ2, it is noted that economic activity is a function of many factors which are not limited to the BDI price alone. These factors, however, are not relevant to this research as it is only the relationship between the BDI and economic activity which falls within the scope of this paper.

## 2. Literature Review

The literature review investigates the economics of the BDI and its subsequent linkages to economic activity. In addition, in order to present the data necessary in order to answer RQ1, the first section of this review will conduct an extensive analysis and synthesis of the available literature in order to identify the *fundamental* factors which drive the BDI price.

### 2.1 The Economics of the BDI

#### 2.1.1 Inelasticity of Supply

In order for the hypothesis of this paper to hold true, it must be proven that the supply of ships is tight and inelastic in the short-term. To this end, Bakshi, Panayotov and Skoulakis (2010: 4) detail how the high costs and significant lead times involved in new ship acquisitions results in a situation where the "supply structure of the shipping industry is generally predictable and relatively inflexible [over a short-term horizon]." Devanney (2010) agrees with this, by explaining that the short-run container ship supply function is simply the horizontal sum of the global fleet's tonne-mile capacity. The capital-intensive task of manufacturing a new cargo ship, for example, can take two to three years complete; a time frame which is far longer than the short-term fluctuations experienced on the demand-side of cargo carriage (Koskinen and Hilmola 2005; Wall Street Journal 2007).

High costs are not the only factor leading to the relatively stable supply of the global cargo fleet, however. Koskinen and Hilmola (2005) explain that the uncertain profitability expectations associated with ownership of expensive cargo ships, coupled with the aforementioned lengthy ship manufacturing process, leads to a situation in which would-be ship-owners seek to rather lease freight vessels as opposed to obtaining the outright ownership thereof. Matthews (2003) provides an example of the effect of this stable ship supply on the BDI price, by detailing how the BDI price doubled during the two months ended October 2003 as a result of the fact that surging Chinese demand for freight vessels far outstripped supply at the time.

### 2.1.2 Global Commodity Demand

In order to uncover the drivers of the BDI price, the Baltic Exchange (2012) identifies a number of variables. They explain that while the BDI is driven by a large range of external factors, there are a number of fundamental drivers which underpin all BDI price changes. The first, and most fundamental of these drivers is the demand for commodities, which the Baltic Exchange identifies as being influenced by issues such as the global level of industrial production, the quality of crop harvests, global industry performance, power usage, etc. Figure 5, below, evidences this link graphically, by plotting the annual growth in the world Gross Domestic Product[51] (GDP) against the growth in global exports across an equivalent time period. It is clear that growth in the global GDP has the effect of increasing the number of goods which are exported, with the opposite holding true for a decline in the global GDP.

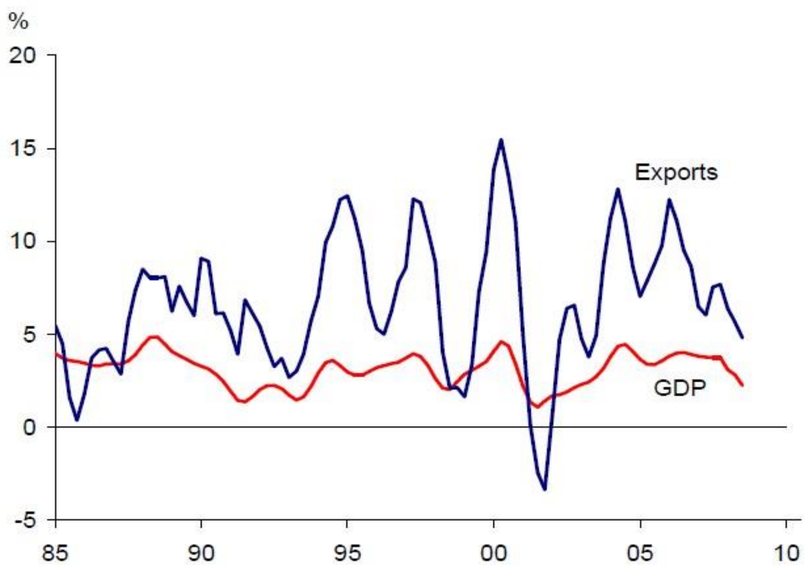
The literature above has established that the global supply of ships is relatively stable in the short-run, rendering the BDI a demand-driven index. As such, an increase in the level of goods exported globally, as per Figure 5, will have the

[51] Gross Domestic Product is a term which denotes the total monetary value of all finished goods and services which are produced within a territory for a given period of time, normally measured in years. This figure is calculated by determining the sum of all private and public consumption, investments and exports and subtracting from this the value of any imports made into that territory across the same time frame (Investopedia 2012).

effect of increasing the BDI price (Oxford Economics 2007). This provides proof that changes in commodity demand is a fundamental BDI price driver.

Changes in the BDI price have also been linked to changes in economic activity in various other world economies. In a Chinese context, Hyung-geun (2011) details how the BDI price decreased 38% in two months post the decision by the Chinese government to ban new investment in industries such as steel, automobiles and real estate. In a British context, Oxford Economics (2009) evidence this link by detailing that the British shipping industry directly contributes a turnover of £9.8 billion to the British GDP. Finally, in a global context, Radelet and Sachs (1998) evidence a statistically significant link between a country's proximity to a harbour and its economic growth rate.

**Figure 5: Growth Rate of Global Exports Plotted Against Global GDP Growth Rates**




Source: Oxford Economics (2007)

### 2.1.3 Other Key BDI Price Drivers

Having explored the impact of commodity demand on the BDI, it is necessary to research the potential impacts of other drivers on the BDI price. To this end, Alziadeh and Talley (2010) conclude that in both the Capesize and Panamax markets, the laycan period[52], as well as the size of the transport vessels used, is statistically significant when regressed against the BDI price. The intuitive hypothesis that as ships grows older, they grow more expensive to operate, is also proven true as a result of the negative and nonlinear relationship which is evidenced between vessel ages and their respective hire rates (Alziadeh and Talley 2010).

Bunker prices[53] account for approximately 25% - 33% of the total cost of operating a transport vessel (Baltic Exchange 2012). As a result of the fact that bunker prices are closely related to crude oil prices, the extremely volatile movements in the oil price directly affect ship owners and, in turn, the BDI price (Notteboom and Vernimmen 2008; Geman and Smith 2012). Figure 6, below, depicts the movements in the crude oil price during the period 2008 – 2012.

The aforementioned relationship is also empirically tested in the literature, through the work of Notteboom and Vernimmen (2008), who explain that a major factor considered by ship-owners when deciding where to dock their ships is the

[52] The laycan period is jargon specific to the shipping industry (Alziadeh and Talley 2010) and denotes the period of time between the fixture date and the layday. The fixture date is defined as the date of the conclusion of negotiations between the ship-owner and ship-charterer. The product of these negotiations is a signed charter contract. The layday is defined as the contractually stipulated date on which the chartered ship must be delivered to the charterer.

[53] The Oxford Dictionary (2012) defines a bunker as “a large container or compartment for storing fuel.” For a detailed description on the production methods of bunker fuel, see Notteboom and Vernimmen (2008).

relative price of bunker fuel across available ports, which differs as a result of varying fiscal policies and fuel taxes between countries.

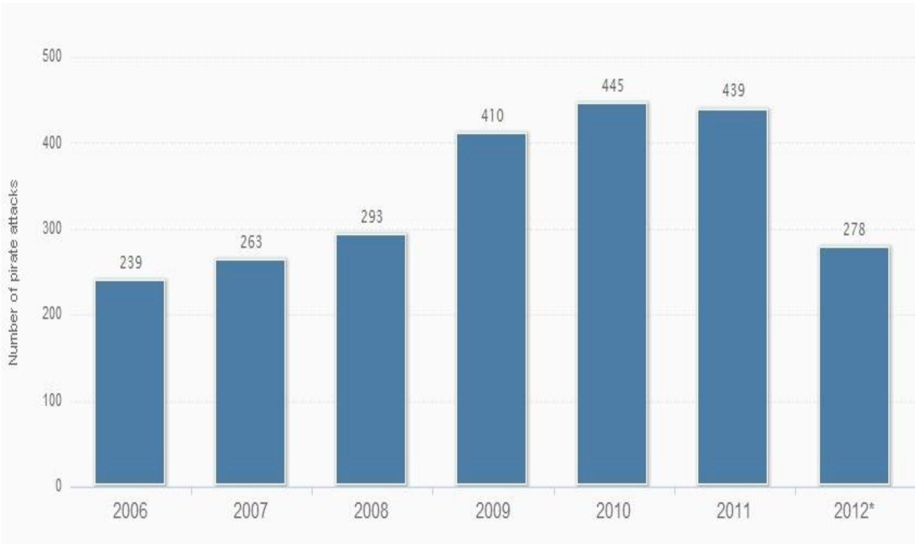
**Figure 6: 2008 – 2012 Crude Oil Price**


Source: NASDAQ (2013)

The existence of choke points in global shipping routes is identified as another key factor driving the BDI price (Fu, Ng and Lau 2010). Nearly half of the world's oil tankers pass through a handful of narrow sea corridors, which are often subject to terrorist attack, conflict, severe winters and accidents as a result of high traffic volumes (Baltic Exchange 2012). Should any of these incidents occur, the corrective or evasive actions required by shipping companies would adversely affect the world's supply patterns; a cost which is ultimately borne by the final consumer.

In recent times, piracy in areas such as the Somali coastline, the Gulf of Aden and the Suez Canal has become the most significant consequence of the existence of these choke points. According to Bowden (2010), approximately 500 seafarers from more than 18 countries were held hostage by pirates around the globe at the end of 2010. Although difficult to quantify, Bowden estimates that piracy costs the global economy between $7 billion and $12 billion per year. For some cargo operators, the increased risk associated with travel in these regions has rendered travel through the Gulf of Aden and the Suez Canal unfeasible. As a result, many cargo operators have decided to re-route South, past the Cape of Good Hope – a diversion which adds 3500 miles to the voyage of most cargo vessels (Gilpin 2009). Figure 7, below, plots the global incidents of piracy reported during the period 2006 – 2012[54].

**Figure 7: 2006 – 2012 Global Incidents of Piracy**




Source: Statista (2012)

The length and severity of ice winters along key shipping routes, coupled with seasonal pressures such as reduced global crop yields during the winter months which would otherwise have required shipping, is identified as a further BDI price

[54] At the time of writing this paper, the total statistics for 2012 had not yet been gathered due to delays in the collation and transmission of piracy incidence data.

driver (Baltic Exchange 2012). These pressures are especially significant along the choke points outlined in the paragraphs above, especially between January and March each year (Hagen and Feistel 2005).

Koslowski and Loewe (1994) investigate variations in the extent of winter ice cover over the Baltic Sea. The research shows that weak to moderate ice winters prevail, occurring 75.4% of the time, whilst very strong ice winters occur 24.6% of the time. This research indicates that approximately one in every four Baltic winter is likely to adversely affect ship operators along the route; a significant figure in light of the high volumes of traffic passing through the Baltic region on an annual basis.

In addition to the drivers identified above, Goulielmos and Psifia (2006) show that freight rates possess a 2.25 to 4.5 year cyclical tendency; a finding which is logically re-enforced by the fact that both the recessions of the 1970s and of the 1990s lasted approximately 5 years. The mean reverting nature of freight rates, discussed above, adds credence to this argument (Tvedt 2003). If it is understood that freight rates tend to diverge from their mean value, and then revert back to that value at some point in the future, it can be argued that this property is in itself is a form of cyclicality, provided that the length of the reversion property is constant. In the case of freight rates, this is proven true through the findings of Goulielmos and Psifia.

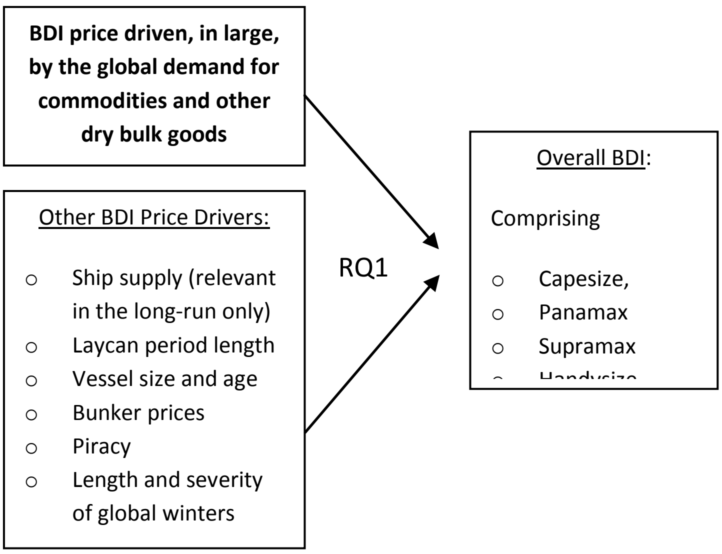
### 2.1.4 Ancillary Drivers

Other ancillary BDI price drivers are also identified in the literature, although most authors concede that these factors are not fundamental BDI price determinants. An example of such a driver is the quality of port administration and infrastructure; the more efficient the port authority, the less bureaucratic red tape and customs clearance corruption is encountered when shipping, thereby lowering freight prices (Radelet and Sachs 1998). Despite the existence of these ancillary drivers, they are not identified as being fundamental to the determination of the BDI price and are therefore not considered further in this research.

### 2.1.5 Conceptual Framework

The identification of these factors allows for the formulation of the first element of the Conceptual Framework, on which the remainder of the research will be based:

**Figure 8: Conceptual Framework I**




## 2.2 The BDI as a Predictor of Economic Activity

The next component of this research aims to analyse the literature pertaining to the use of the BDI as a predictor of economic activity in a global context. This will guide the Data and Method section of the paper, below.

### 2.2.1 Methods Employed in Other Studies

The first of the aforementioned papers to be published is the work of Bakshi, Panayotov and Skoulakis (2010). The aim of their research is to investigate whether the BDI price has predictive ability when compared to a range of global stock markets and commodity prices. The market data against which the BDI is tested is obtained from four MSCI[55] regional stock market indices, as well as from the individual stock markets of all of the G-7 countries. In addition, stock market data from 12 developing countries is included in order to avoid a developed-economy bias. It is worth noting that South Africa forms one of the developing economies included in the research. Despite this, however, the study does not provide a vast quantity of quantifiable data as to the usefulness of BDI as a predictor in a South African context, as a result of the fact that Bakshi, Panayotov and Skoulakis do not perform their regression analyses on a country-by-country basis, but rather on a broader level of aggregation, which includes all countries which form a part of the MSCI, as well as the developing countries selected. As such, the findings of the study draw a conclusion on the relationship between the BDI and the global economy only, and not on a territory-specific basis.

In order to develop a point-estimate of the performance of the BDI, against which the MSCI stock returns may be tested, Bakshi, Panayotov and Skoulakis (2010) use a lagged, three month BDI growth rate, although this lag period is neither tested, nor justified by the authors. As such, the abstract selection of a lag period for the purposes of the testing is identified as a shortcoming which the Data and Method section of this paper will seek to overcome.

[55] Metals Service Centre Institute

The work of Oomen (2012) builds on that of Bakshi, Panayotov and Skoulakis (2010), by removing the developed-territory bias exhibited in their work. In order to achieve this, Oomen amends the quantity of undeveloped countries tested to 25, and reduces the quantity of developed countries tested to 23. Unlike Bakshi, Panayotov and Skoulakis, Oomen does provide a brief discussion regarding the factors which drive the BDI price, although this discussion is based almost entirely on the information provided by the Baltic Exchange (2012), and is not externally verified and independently analysed with reference to the empirical testing available in the literature.

Oomen (2012) employs a basic regression model in order to test the relationship between a lagged 1 month BDI growth rate and stock returns for the MSCI, the G-7 nations and the 23 developed and 25 undeveloped nations detailed above. This testing is performed for the period May 1985 – December 2011. Interestingly, Oomen also performs research into the optimal lag period, in months, which may be applied in order to allow for the predictive property of the BDI to be maximized. By performing preliminary regressions across 1, 2 and 3 month lag periods, he concludes that a one month period allows for the $R^2$ statistic to be maximized when tested against movements in global stock prices. Similarly to Bakshi, Panayotov and Skoulakis (2010), this lag period is not tested beyond a period of 3 months.

### 2.2.2 Empirical Evidence

Upon completion of their testing, Bakshi, Panayotov and Skoulakis (2010) are able to conclude that an increase in the BDI growth rate is associated with higher future stock returns across a one month time horizon, especially in the Industrial sector. This they prove through the findings of in and out-of-sample testing which indicates that 8 out of the 11 regional indices tested show *p*-values of below 0.05. In addition, the adjusted $R^2$'s of between 1.9% and 3.8% indicate a relatively high level of correlation, when compared to the findings of other predictive regressions which have been performed using estimators other than the BDI in the past.

Oomen (2012) finds that a 1 month lagged BDI growth rate shows positive $\alpha_2$ coefficients for the countries tested, indicating that the BDI returns have a positive effect on global stock markets. More specifically, an increase in the BDI return of one standard deviation, or 16.2%, is found to result in an increase of 0.78% in the MSCI World Index return. Furthermore, when analysing the predictive properties of an oil-corrected BDI in the context of 10 industry-specific sectors, it is found that the BDI is most effective as a predictor for global stock returns in the Technology, Telecommunications, Consumer Services and Industrial sectors. The BDI Panamax Index is also shown to be the best predictor of economic activity, although no explanation is provided as to the possible reasons for this.

Finally, Oomen (2012) finds that the BDI can only be concluded to be an accurate predictor of global stock returns for the period 2001-2007 in developed countries, and for the periods 2001-2007 and 2008-2011 in undeveloped countries. This, he hypothesises, may be as a result of the fact that an economic boom was only experienced during the period 2001-2007 in developed countries, prior to the global financial crisis. As such, it may be possible that the BDI is reliant on periods of economic growth and stability in order to serve as a predictor for global economic activity and stock returns. The validity of this finding in a South

African context will be tested further in Data and Method section of this paper, below.

### 2.2.3 Other Studies

Other papers which evidence of the predictive property of the BDI are also identified, including the work of Ou-Yang, Wei and Zhang (2009), who agree with the findings of Bakshi, Panayotov and Skoulakis (2010), by concluding that the BDI has predictive power in an American context. In addition, Kärrlander and Lanneström (2010) uncover a statistically significant correlation between the BDI and the MSCI Metals & Mining index. Mariana (2008), too, uses mathematical models in order to conclude that steel and corn prices show the strongest correlation to the BDI growth rate. This indicates that the BDI can be used to forecast movements in the value of these commodity indices, albeit that the research is conducted in a non-South African context.

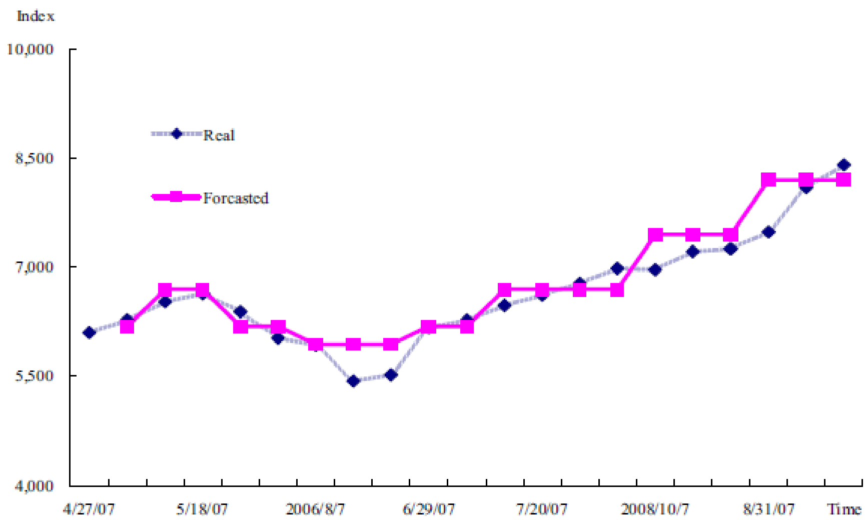
### 2.2.4 Forecasting Short-Term BDI Price Movements

It is submitted that this research paper is neither concerned with the methods by which the BDI can be forecast, nor on identifying which of these methods is most effective. It is nevertheless noted that a large quantity of research has been conducted with the objective of predicting the BDI price in both the short and long terms. This is as a result of the fact that this paper would have very little practical application should it not be possible to forecast movements in the BDI price.

One such prediction model is Chou and Lee's Fuzzy Time Series Model (Chou 2008), which is able to predict BDI price movements across a one month period.

This forecast is generated, plotted graphically in Figure 9, below, and compared to actual BDI movements for the given time period. The root-mean-squared-errors are then calculated and used to assess the significance of BDI forecasting errors, from which Chou is able to conclude that Chou and Lee's Fuzzy Time Series Model is suitable for the BDI's prediction.

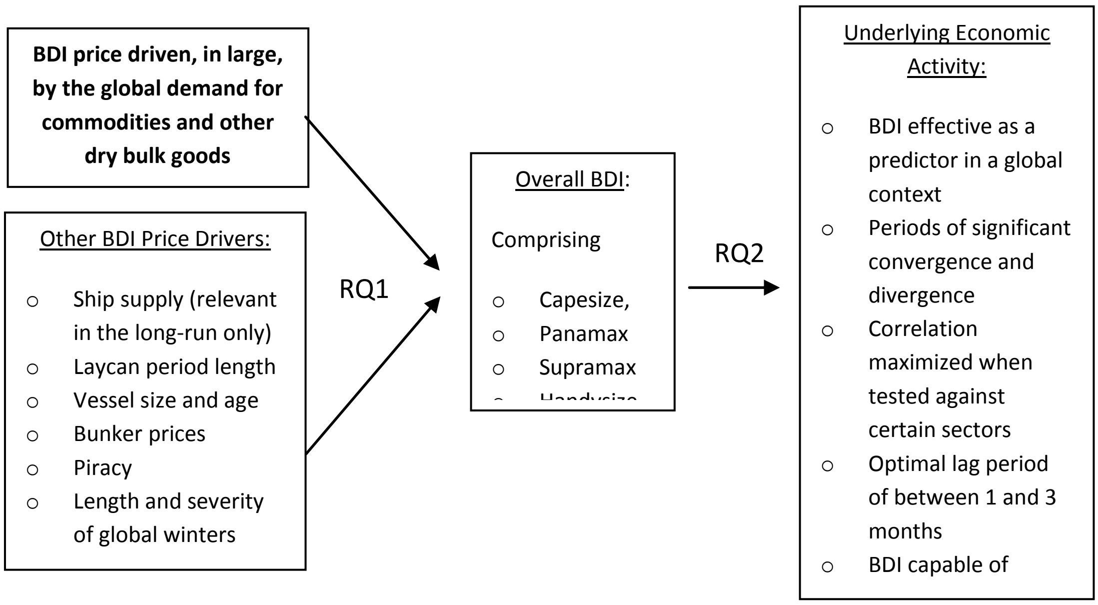
**Figure 9 – Real and Forecast BDI using *Chou and Lee's Fuzzy Time Series Model***




### 2.3 Conceptual Framework

Having outlined the literature pertaining to RQ2, the Conceptual Framework developed in Figure 8, above, may be extended in order to outline the interaction between RQ1, RQ2 and the literature discussed. This Conceptual Framework will underpin the remainder of the research to be performed, and is presented in Figure 10, below:

**Figure 10: Conceptual Framework II**




## 3. Data and Method

The Data and Method section outlines the particulars of the method applied in order to meet the Research Objectives, outlined above. It also details the data inputs used in order to perform this research, along with the necessary internal and external validity testing which is required in order to assess the appropriateness of the research findings.

### 3.1 Research Question 1

As has been indicated in the Literature Review, this study employs a mixed-methods approach in order to answer Research Question 1: which factors influence movements in the BDI price? This is due to the large quantity of complex factors which influence the BDI price, and the subsequent influence of these factors on economic activity (Ryan and Scapens 2002). Furthermore, Contents Analysis (Creswell and Piano 2007) has been employed in order to identify consistent themes and patterns in the literature.

In this regard, the validity of findings has been ensured through the inclusion of research which has been obtained from reputable sources only. These sources include journal articles, theses published by recognized educational institutions, conference papers and information obtained directly from the subjects of the research, such as the Baltic Exchange (2012). The validity of findings has been further ensured by comparing the results of the papers discussed above with the large quantity of other research available on the respective topics. This has been performed in order to ensure that the findings thereof are logical and in line with the arguments presented in this paper.

This analysis has led to the creation of a single, focused set of empirically tested data, which may be used in support of the definitive identification of the fundamental BDI price drivers. Mathematically, the first Research Question is formulated as:

$$BDI = f(X1 + X2 + X3 + \ldots Xi)$$

Where X = factors influencing the BDI price.

Through the development of the conceptual framework understanding of the factors which drive the BDI price, the extensive Literature Review conducted allows for the quantification of the proposed solution to this Research Question, without the performance of additional empirical testing. These research findings are detailed in the Findings section, below.

### 3.2 Research Question 2

The second phase of this research will comprise the empirical testing of the relationship between the BDI and the South African economy, in order to resolve

Research Question 2: can the BDI be used as a predictor for South African stock price movements and economic growth? As such, it must be proven that South African share or commodity prices are a function of the BDI price, should it be concluded that the BDI may be used as a leading economic indicator in a South African context. For the purposes of the empirical testing, this objective is formulated mathematically, as:

Share Price/Commodity Price = f(BDI)

### 3.2.1 Data

The Reuters (2013) website is utilized in order to access the BDI price data to be used as the independent variable input in the testing, below. In order to obtain the Johannesburg Stock Exchange (JSE) Index data established as the dependent variable in the testing performed, the McGregor Bureau for Financial Analysis (2013) website has been utilized. As such, the data extracted in this research may be accepted as being accurate and complete, as it has been obtained from reputable sources. Finally, monthly BDI and JSE Index returns have been extracted for the period 01/04/1997 - 31/01/2013 for all testing performed.

### 3.2.2 Method

A four-stage approach is adopted in order to conduct the testing per RQ2. Each of these stages is outlined in detail below:

#### 3.2.2.1 Descriptive Analysis

The first stage of testing comprises a descriptive analysis, with the aim of evidencing a *prima facie* relationship between the BDI and the JSE All Share Index (ALSI). This *prima facie* analysis is performed by plotting monthly movements in both the BDI price and the JSE ALSI price graphically, in order to assess the relationship between the two variables from a visual perspective. In addition, a cyclic filter will be applied to the data presented, in order to remove any 'white noise' contained therein.

#### 3.2.2.2 Correlation Analysis

The second stage of testing comprises an extensive correlation analysis between the BDI and a number of preselected JSE Indices, with the objective of identifying the indices which exhibit the greatest correlation to the BDI. For the purposes of this testing, the correlation coefficient, or $R^2$, between a non-lagged BDI and the various JSE Indices is calculated in terms of the following equation:

$$R^2 = \frac{SS_{yy} - SSE}{SS_{yy}} = \frac{SS_{yy}}{SS_{yy}} - \frac{SSE}{SS_{yy}} = 1 - \frac{SSE}{SS_{yy}}$$

Where

$SS_{yy}$ = Deviation from the mean

SSE = Deviation between observations and their predicted values.

The JSE Indices selected for testing are summarised in Figure 11, below:

**Figure 11: Indices Selected for Correlation Analysis**

| Index Analysed | JSE Code | Reason Selected for Testing |
|---|---|---|
| All-Share Index | J203 | To assess the overall relationship between the BDI and the South African economy |
| Top 40 | J200 | To determine whether the BDI exhibits a statistically stronger relationship when regressed against entities of a particular size |
| Mid-Cap | J201 | |
| Small Cap | J202 | |
| Mining | J177 | To determine whether the magnitude of the mining sector within the South African economy, |

| | | |
|---|---|---|
| | | as well as the inclusion of a South African route within the BDI price calculation, results in a stronger correlation between the BDI and the South African Mining Industry. |
| Technology | J590 | To test the findings of Oomen (2012), in a South African context |
| Telecommunications | J560 | |
| Consumer Services | J550 | |
| Industrials | J520 | |
| Food Producers | J357 | |

#### 3.2.2.3 Optimal Lag Period

Post the completion of the correlation analysis, the third phase of empirical testing is conducted in order to assess the practicality of potential investors and other market participants being able to use the BDI as a leading economic indicator. In order to assess this, the BDI price will be lagged and tested against the ALSI, as well as the Index which exhibits the strongest correlation against the BDI, in order to determine the lag period, in months, which maximizes the correlation coefficients between the two. Should this optimal period be found to be a lag period, it may be concluded that the BDI is useful when applied as a leading economic indicator.

#### 3.2.2.4 ARIMA Regression

The fourth and final stage of testing comprises the application of an Auto-Regressive Integrated Moving Average (ARIMA) analysis, in order to prove that a causal relationship exists between the BDI and the South African market as a whole. Such a finding is necessary in order to enhance the usefulness of the findings of the correlation analysis, which is only capable of indicating the existence of a relationship between variables, and not the existence of causal relationship between the two.

The ARIMA model is selected due to the fact that it is able to account for non-stationarity in data (Duke University 2013). As such, the model accounts for the fact that both the BDI and the ALSI exhibit a trend over time. Should these trends not be incorporated in the regression model run, the existence thereof may lead to misleading findings regarding causality. The ARIMA model applied is quantified as:

$$y_t = \alpha + \rho y_{t-1} + \theta \epsilon_{t-1} + \epsilon_t$$

where

$\rho$ is the first-order autocorrelation parameter

$\theta$ is the first-order moving-average parameter

$\epsilon_t$ $\sim$ *i.i.d.* $N(0, \sigma^2)$, meaning that $\epsilon_t$ is a white-noise disturbance

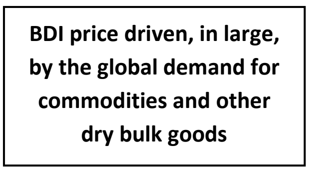
As stated in the Scope and Delimitations section, it is important to note that this regression analysis is only performed with the objective of proving a causal relationship between the BDI and the ALSI, in order to enhance the findings of the correlation testing. As such, it is only the relationship between the ALSI a non-lagged BDI which is tested. The testing of the ALSI against a lagged BDI is outside the scope of this paper, but is identified as a potential for future research.

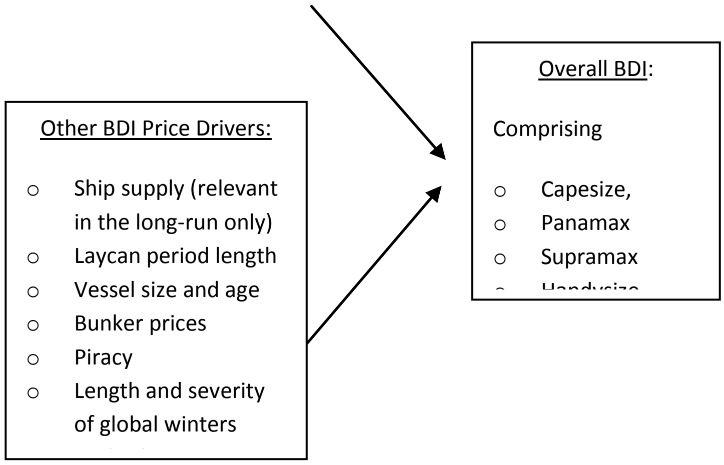
## 4. Findings

### 4.1 Research Question 1

The extensive review of the literature above indicates that the BDI price is driven by a multitude of factors. These factors are summarized in Figure 12, below:

**Figure 12: BDI Price Drivers**






Mathematically, this relationship may be quantified as:

> BDI = f(underlying economic activity, ship supply, laycan period length, vessel size and age, bunker prices, global maritime piracy, global winter severity, cyclicality, error term)

The literature has presented a clear set of BDI price drivers, with very little contradiction having been evidenced amongst the articles identified. Furthermore, upon analysis of additional papers in order to evidence the validity of findings, the research conclusions were found to be logical and consistent with the large quantity of additional articles consulted.

### 4.2 Research Question 2

Sections 4.2.1 – 4.2.4, below, detail the findings of the research conducted. Thereafter, Section 5 provides a detailed discussion of these findings.

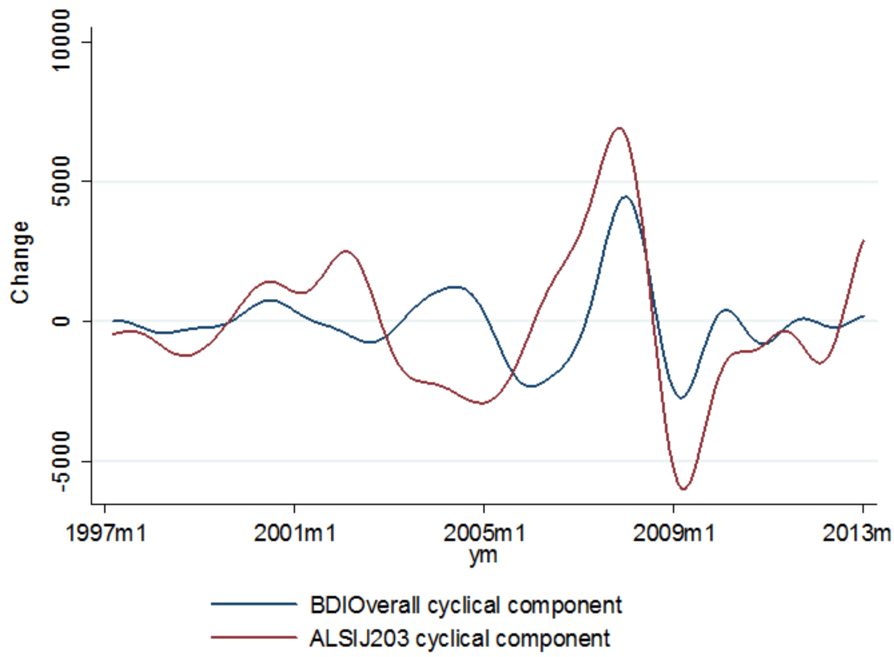
#### 4.2.1 Descriptive Analysis

Figure 13, below, depicts the relationship between monthly BDI price and JSE All-Share Index price movements for the period 01/04/1997 - 31/01/2013.

**Figure 13: BDI/ALSI Price Chart**


In order to further assess this relationship, the 'white noise' contained within the data above has been eliminated by smoothing the returns through the use of a cyclic filter, in Figure 14, below.

**Figure 14: BDI/ALSI Smoothed Price Chart**




### 4.2.2 Correlation Analysis

The correlation analysis performed at a zero lag period reveals a statistically significant degree of correlation between the BDI and a large number of the JSE Indices tested. A summary of these findings is depicted in Figure 15, below. Interestingly, the testing reveals that the degree of correlation between the BDI and the dependent variables tested is maximized when the BDI price is regressed against the JSE Mining Index, which exhibits a correlation coefficient of 0.5125.

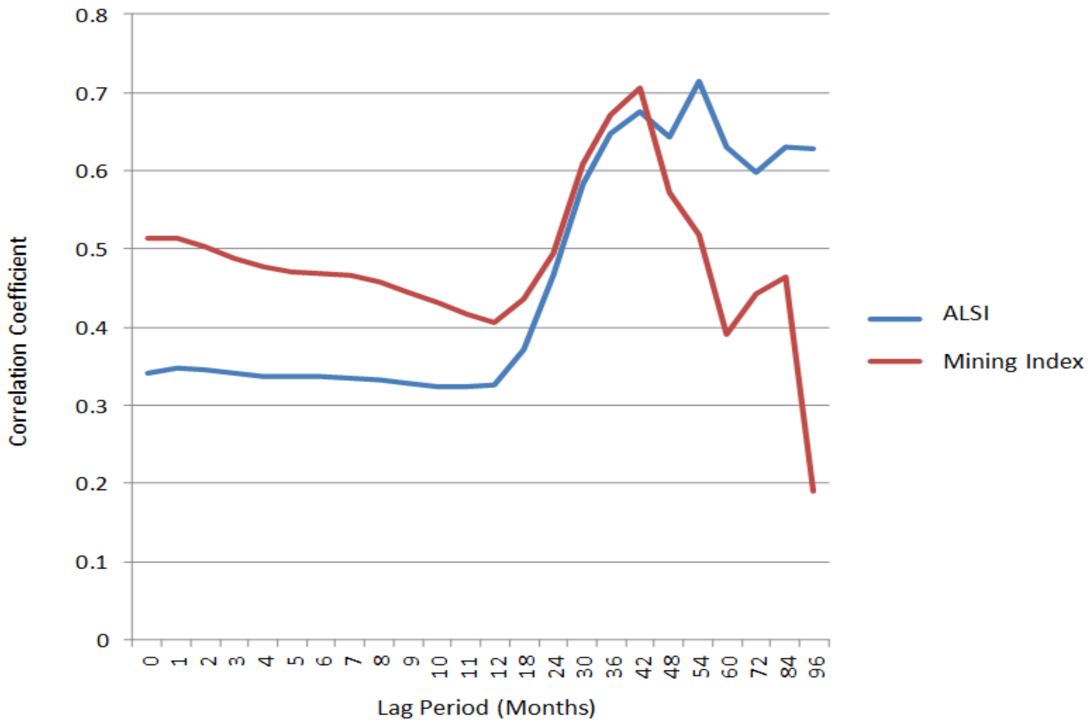
**Figure 15: BDI/JSE Index Correlation Coefficients**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| BDIOverall | 1.0000 | | | | | | |
| ALSIJ203 | 0.3412 | 1.0000 | | | | | |
| Top40J200 | 0.3574 | 0.9994 | 1.0000 | | | | |
| MidCapJ201 | 0.2266 | 0.9825 | 0.9758 | 1.0000 | | | |
| SmallCapJ202 | 0.3654 | 0.9847 | 0.9810 | 0.9803 | 1.0000 | | |
| **MiningJ177** | **0.5125** | 0.9572 | 0.9643 | 0.8956 | 0.9292 | 1.0000 | |
| Technolo~590 | -0.3876 | -0.1735 | -0.1836 | -0.1096 | -0.1367 | -0.3255 | 1.0000 |
| Telecomm~560 | 0.3331 | 0.9804 | 0.9786 | 0.9695 | 0.9734 | 0.9273 | -0.1206 |
| Consumer~550 | 0.0562 | 0.9236 | 0.9125 | 0.9700 | 0.9218 | 0.7785 | 0.0404 |
| Industri~520 | 0.3657 | 0.9918 | 0.9897 | 0.9806 | 0.9926 | 0.9421 | -0.1975 |
| FoodProd~357 | 0.1466 | 0.9663 | 0.9587 | 0.9913 | 0.9564 | 0.8626 | -0.1236 |

### 4.2.3 Optimal Lag Period

In order to perform the third phase of analysis, a further examination of the degree of correlation between a lagged BDI and the ALSI, as well as a lagged BDI and the Mining Index, is performed. The findings of this analysis are depicted in Figure 16, below.

**Figure 16: BDI/ALSI and BDI/Mining Lagged Correlation Coefficients**




The correlation between the BDI and the Mining Index is maximized at a lag period of 36 months, at which the correlation coefficient peaks at a correlation of close to 0.7. In contrast, the BDI/ALSI correlation coefficient continues to increase beyond the 36 month lag, and is maximized at period of 54 months, where the correlation peaks at a similar level of approximately 0.7.

#### 4.2.4 ARIMA Regression

The ARIMA[56] regression results are detailed in Figure 17, below:

**Figure 17: ARIMA Regression Results**

```
Sample:  1997m4 - 2013m1                          Number of Obs      =       190
                                                  Wald chi2(4)       =    962.43
Log likelihood = -1515.473                        Prob > chi2        =    0.0000
------------------------------------------------------------------------------
             |                 OPG
  D.ALSIJ203 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
ALSIJ203     |
  BDIOverall |
         D1. |   .4920909   .0568536     8.66   0.000       .38066    .6035219
       _cons |   180.5938   70.25791     2.57   0.010     42.89087    318.2968
-------------+----------------------------------------------------------------
ARMA         |
          ar |
         L1. |  -.8569306   .0908496    -9.43   0.000    -1.034993   -.6788686
             |
          ma |
         L1. |   1.109336   .2774411     4.00   0.000     .5655615    1.653111
         L4. |   .1090618   .0701997     1.55   0.120     -.028527    .2466506
-------------+----------------------------------------------------------------
      /sigma |   698.5416   133.5864     5.23   0.000      436.717    960.3663
------------------------------------------------------------------------------

Note: The test of the variance against zero is one sided, and the two-sided confidence
interval is truncated at zero.
```

The regression indicates a significant causal relationship between the BDI and the ALSI, with Z = 8.66 and P>|z| = 0.000, when

$$\sum_{i=1}^{n} y_{ti} - y_{ti} - 1 = f(\sum_{j=1}^{n} x_{tj} - x_{tj} - 1)$$

There are still high levels of autocorrelation with respect to the first difference, as denoted by AR(L1), as well as for the first moving average, as denoted by

[56] The ARIMA regression has been performed using Stata Version 10, with ARIMA Specification (1, 1, 1): ARMA Lags AR1, MA1 and MA4.

MA(L1). This significant autocorrelation is not evidenced in the fourth difference of moving average MA(L4), however. In its entirety, the ARIMA model has accounted for autocorrelation, as indicated by the Portmanteau Q-Statistic in Figure 18, below, which shows Prob>chi2 = 0.4476. This indicates that no significant autocorrelation exists in the model residuals.

**Figure 18: Portmanteau Test**

```
A Portmanteau test confirms that there is no significant autocorrelation in the
residuals of the model.

---------------------------------------

 Portmanteau (Q) statistic =    40.5137

 Prob > chi2(40)           =     0.4476
```

The Z-Statistic test of variance against zero is found to be one sided, thereby evidencing the validity of the finding that the BDI, as the independent variable, is the factor driving movements in the Indices tested. This finding is further enhanced through the conclusion that the more rigorous, two-sided Chi-Square test is truncated at zero, at a 95% confidence level. As such, the validity of the causal relationship between the BDI price and the Indices tested is proven.

## 5. Discussion of Findings

### 5.1 Research Question 1

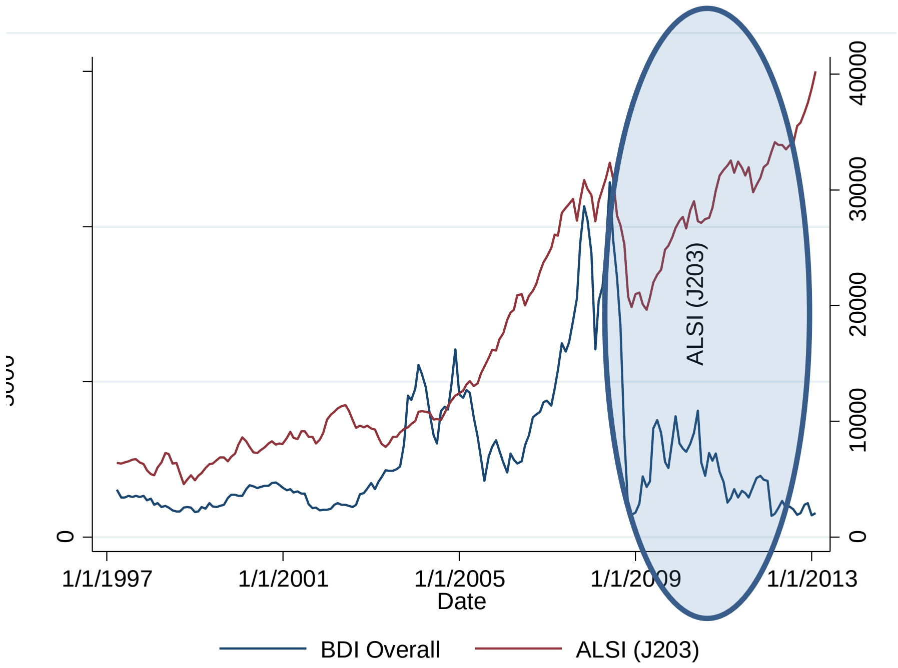
As hypothesized at the beginning of this paper, it is found that the BDI price is a product of a large number of variables, which are not confined to the global demand for commodities alone. Despite this, the conclusion that demand is a fundamental BDI price driver, allows for the creation of the theoretical foundation from which the analysis of the second research question may be performed.

### 5.2 Research Question 2

#### 5.2.1 Periods of Significant Convergence/Divergence

On initial inspection of the graphical relationship between the BDI and the ALSI, it is immediately clear that there exists some form of a relationship between the BDI and the South African stock market. This is further enhanced through the application of the cyclic filter, which indicates that the hypothesized predictive power of the BDI appears to hold true. Interestingly, the relationship between the BDI and the overall South African economy exhibits a period of significant convergence between 1997 and 2011, and a period of significant divergence during 2011 and January 2013. This finding is consistent with that of Oomen (2012) and is highlighted in Figure 19, below.

**Figure 19: BDI/ALSI Divergence**




#### 5.2.2 Correlation Analysis

On performance of the correlation testing, it is found that, at a lag period of zero months, the monthly BDI returns show the most significant correlation to the JSE Mining Index. This result is of significance, as it is contrary to the finding of Bakshi, Panayotov and Skoulakis (2010), that the BDI exhibits the strongest correlation to the global Industrial sector. This is testament to the fact that the South African economy differs to the world economy in the sense that it is driven, in large, by the Mining Industry, which in turn uses local harbours to export the largest percentage of ore extracted during the mining process.

When regressed against the ALSI, the BDI exhibits a correlation coefficient of 0.3412, indicating that a strong relationship exists between the BDI and the South African economy as a whole. It is also found that the BDI price exhibits a strong correlation to the Top 40, Small Cap, Telecommunications and Industrial Indices, with a BDI correlation in excess of 0.33 for all of four of these sectors. As such, the finding of Oomen (2012) that the BDI exhibits a statistically significant relationship when regressed against the Telecommunications and Industrial Indices, is upheld in a South African context.

### 5.2.3 Optimal Lag Period

Interestingly, the BDI lag period which maximizes the BDI/ALSI correlation coefficients appears higher than initially hypothesized, at 3 years when regressed against the ALSI, and 4.5 years when regressed against the Mining Index. This is also contrary to the findings of Bakshi, Panayotov and Skoulakis (2010), as well as of Oomen (2012), who both conclude that far shorter lag periods, of 3 months and 1 month respectively, maximize this correlation. It is submitted, however, that neither of these analyses considered the potential of a longer-term lag period. As such, the conclusions drawn from these papers are not directly comparable against the findings of this research.

The magnitude of the discrepancy between the optimal lag period identified in a South African context, and those identified in a global context per previous studies, is nevertheless significant. As such, further research pertaining to the optimal BDI lag period is identified as a possibility for future investigation.

### 5.2.4 ARIMA Regression

It is important to note that the findings discussed above are based predominantly on the strength of the evidence obtained from the conducting of numerous correlation analyses. Although the analysis of the correlation between two variables is useful in highlighting the relationship between the two, it does not necessarily indicate that this is a causal relationship. As such, the ARIMA regression between the BDI and the ALSI, as a proxy for the overall South African economy, is very significant as a result of the fact that it evidences that a change in the BDI price causes a corresponding change in the ALSI price.

## 6. Conclusion

This paper has conducted a thorough analysis of the BDI and its usefulness as a leading economic indicator in a South African context. In the course of this research, a number of findings have been identified, from which the following conclusions may be drawn:

First, in pursuance of RQ1, although many believe the BDI price to be a pure economic indicator, it is nevertheless driven by a number of underlying variables. These variables include, but are not limited to, the global demand for commodities, the global supply of ships, the laycan period, bunker prices, piracy, global winter severity, as well as the inclusion of a cyclical component. Second, in pursuance of RQ2, strong evidence is obtained in order to support the conclusion that the BDI is effective when used as a leading economic indicator in a South African context, although its usefulness varies depending on the JSE market sector analysed. In addition, the BDI appears most effective when used in order to predict long-term economic growth, with an associated lag period of between 3 and 4.5 years, depending on the JSE sector analysed.

Finally, investors and potential market participants are cautioned that the current divergence between the BDI price and the JSE ALSI may suggest a future economic downturn in the South African economy. The reasons for this divergence, along with a full investigation of the relationship between a lagged BDI, its lagged sub-indices[57] and all available JSE Indices, are further identified as possibilities for future investigation and research.

[57] As outlined earlier in this paper, the BDI sub-indices comprise the Baltic Capesize, Panamax, Supramax and Handysize Indices.

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