Interdependence of oil prices and stock market indices: A copula approach

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A R T I C L E   I N F O

A B S T R A C T

In this paper we study the relationship between the oil price and stock market index of various countries between 1982 and 2007. We exclude oil and gas stock companies from the stock indices to remove the obvious direct linkage. Oil price series are converted into local currency to account for possible exchange rate effects. The method of copula is used to model the general dependence between stock returns and oil price returns. Our findings suggest a weak dependence between oil prices and stock indices for most cases, which are consistent with the results from previous studies. Exceptions are for the stock index returns of large oil consuming and producing countries (United States and Canada), which are shown to have a relatively strong dependence with the oil price series. The introduction of Euro in 1999 altered considerably dependence between oil prices and stock returns.

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1. Introduction

Major news channels discuss at least one story everyday about oil, its demand and supply, present and future price movements, or the potential effect on financial markets. The reason for such attention on oil is due to its prominent importance for most of the economies in the world (Nandha and Faff, 2008). Moreover, the demand for oil increases persistently as countries become more developed. For example, the demand for oil by China and India, which are in the process of rapid development, is growing rapidly over time. At the same time, the demand by developed countries for oil is not decreasing in spite of the vigorous search for an alternative fuel. Thus, oil will remain an important factor for the global economy for some time and the large oil producing countries will continue having a decisive role in determining the oil production and its pricing strategies. It is therefore important to thoroughly comprehend the effect of oil prices and pricing strategies on the world economy.

It is widely accepted that the oil prices influence the state of economy; however, it is not clear how the relationship changes depending upon the availability and usage of the oil in a particular

country/region. For instance, the oil price increase is likely to positively influence the GDP of Saudi Arabia, whereas the opposite would perhaps be the case for France. The issue of whether and how this relationship varies across countries with different oil demand and supply structure remains unanswered. This study attempts to fill this gap in the literature. Inclusion of various countries such as large oil producing, oil consuming, or the combination of both in our investigation will help to illustrate how much, if any, and to which direction the relation between the oil and the financial markets changes.

The dependence between the oil price and stock market has been studied mainly under the assumption of normality, under which the dependence is symmetric and conveniently captured by linear correlation. Possible non-linear and asymmetric relationships were largely overlooked. A few studies examined asymmetric relationship between the series (Balke et al., 2002; Ciner, 2001; Hamilton, 1996; Mohanty et al., 2011; Mork, 1989). However, there is a lack of information on the general dependence structure between the oil prices and global stock market indices. Instead of restricting our attention to a particular type of relationship, in this study we adopt the copula approach to explore the general dependence between the series. The copula method provides two key advantages in multivariate analyses. First, it allows researchers to model the marginal distributions and their dependence structure separately, facilitating the separation of their respective influences. Second, the copula function captures the dependence between

variables completely. There exist a large number of copulas to capture a myriad of dependence structure, allowing fat-tailedness, asymmetry, tail dependence and so on.

In this study we examine the interdependence of oil prices and international stock market indices. We note that different stock market indices put different weights on the oil and gas company stocks. Because the relationship between stock market index and oil price returns may be largely determined by the co-movements between oil prices and oil and gas stocks, we exclude oil and gas effects from the stock market index series to remove this direct linkage. Two oil price series are used: Brent and OPEC oil price series, wherein OPEC oil price is specifically used for sensitivity analysis of the results. Each oil price series is transformed into the local currency to account for the influence of exchange rates on both oil prices and stock market indices. We explore the general dependence structure without distributional assumptions on the series. For this purpose, copula functions are used to model the dependence structure for the entire distribution. Furthermore, the analyses are conducted on both developed and developing countries, as well as on large oil consuming and producing countries. Lastly, the interdependence dynamics between the series is studied to examine whether there were significant changes in their dependencies over time.

The remainder of this article is organized as follows. A brief review of existing literature is provided in Section 2. Section 3 is devoted to explaining the data and methodology. The main results of the paper are given in Section 4 followed by the implications and conclusion of the results which are reported in Section 5.

2. Literature review

Existing literature suggests a link between the oil price and the state of economy. It has been shown that the economies of most countries are inversely related to the oil price changes (Burbidge and Harrison, 1984; Gisser and Goodwin, 1986; Hamilton, 1983; IEA, 2004; Jones et al., 2004; Lardic and Mignon, 2008; Lee et al., 1995; Loungani, 1986; Mork, 1989; Mork et al., 1994; Mussa, 2000). The data and methodologies applied in these studies vary, but most of them come to a similar conclusion — oil is an important factor for the economy.

The reported relationship of oil prices and the economy generated new ideas and avenues of research. The reasoning behind many of the recent studies arises from the empirical evidence that oil price has an impact on the overall economy; hence it may have an impact on the individual industries as well. Consequently, many studies examined the relationship between the various industry sectors and the oil prices. Faff and Brailsford (1999) claimed that oil, gas and diversified resources industries are positively correlated with the oil prices, while negative correlation is observed for industries, such as paper and packaging, financials and transport. Furthermore, the individual stocks have become the focus of many studies. Combining the equity returns of different industries these studies also had some industry implication and confirmed the results of Faff and Brailsford (1999) (Cong et al., 2008).

Equity markets have later been studied for the possibility of being influenced by oil price shocks. The rationale for the possible oil price impact on stock returns comes from the fact that oil, being a major input, directly affects the cost structure of firms. The increased cost, ceteris paribus, will result in smaller profit which will negatively affect the expected earnings and will result in depressed aggregate stock prices (Arouri and Nguyen, 2010; Ciner, 2001; Nandha and Faff, 2008). These hypotheses have been empirically accepted for Greece (Papapetrou, 2001) and for the UK (El-Sharif et al., 2005). They show that oil price shocks have negative and weak influence on the non-oil or non-gas stock returns. On the other hand, if one looks from the perspective of oil producing company, the abovementioned notion will be reversed resulting in positive impact of oil price increases on stock returns of mainly oil and gas industries (companies from these industries). The notion seems to be supported by some studies that use stock returns of oil and gas industries, individual companies

(or oil-intensive companies) and oil prices (Al-Mudhaf and Goodwin, 1993; Arouri, 2011; Boyer and Filion, 2007; Cong et al., 2008; El-Sharif et al., 2005; Faff and Brailsford, 1999; Gogineni, 2010; Hammoudeh and Li, 2004; Nandha and Faff, 2008; Papapetrou, 2001; Sadorsky, 1999, 2001).

Although the individual stock returns are indeed influenced by the oil price movements, Jones and Kaul (1996), Huang et al. (1996), and Apergis and Miller (2009) show that overall stock market indices are statistically unrelated to the oil price shocks. On the other hand, Sadorsky (1999), Papapetrou (2001), and Miller and Ratti (2009) find that oil price movements are important in explaining movements in the aggregate stock returns. However, the analysis of nonlinear or asymmetric relationship between the oil prices and economy, as well as stock markets, showed the existence of nonlinear relation such that an oil price increase is more detrimental to the U.S. economy and financial markets, than an oil price decrease, which is beneficial (Balke et al., 2002; Hamilton, 1996; Mork, 1989; Park and Ratti, 2008). Asymmetric effects of oil price changes on stock market returns in Gulf Cooperation Council (GCC) are also documented in Mohanty et al. (2011). In addition, nonlinear Granger causality from oil futures return to S&P 500 index return is found (Ciner, 2001). In this paper we propose the use of copula functions to study the general dependence structure between the series. Copula functions facilitate flexible modeling of univariate marginal distributions. In addition, the dependence can be estimated based on the entire dependence structure rather than just univariate measures (Chollete et al., 2005). The results will indicate whether the relationships are symmetric, asymmetric, linear, or nonlinear.

Oil prices have been mainly denominated in U.S. dollar, however, the decline of the U.S. dollar against other currencies has let OPEC to consider an alternative currency for crude oil pricing (Amuzegar, 1978; Haughton, 1991; Samii et al., 2004; Verlegar, 2003). This issue emerged in the late 1970s and the early 1980s when the U.S. dollar was devalued. It resurfaced in recent years as the U.S. dollar is losing its value and dominance in the global economy. The importance of the appropriate currency for crude oil pricing stems from the claims that oil price movements are partially due to the currency movements, meaning that exchange rate fluctuations cause oil price movements (Basher and Sadorsky, 2006; Samii and Clemenz, 1988; Zhang et al., 2008). This is an important issue that needs to be accounted for in such studies because the possible significant relationship between stock markets and oil prices might be masked by the exchange rate movements. Moreover, numerous studies showed that stock markets of many countries are influenced by exchange rate movements as well (Dominguez and Tesar, 2006; Francis et al., 2006; He and Ng, 2002; Jorion, 1990). Hence, exchange rates are common causes for movements in both variables of interest and thus must be accounted for. Only a few studies have controlled for exchange rates when studying the relationship between the oil prices and stock market indices. Cologni and Manera (2008) included the Special Drawing Rights (SDR) exchange rate as an explanatory variable in their regression analyses to control for the exchange rate risk. Similarly, Basher and Sadorsky (2006) included a weighted average of the foreign exchange value of the U.S. dollar against a subset of the broad index currencies in the OLS regression to account for the exchange rate effect. To account for currency movements, we convert oil price series into the local currency. This construction removes the influence of exchange rate and facilitates our estimation of the dependence between the oil prices and stock market indices.

3. Data and methodology

3.1. Data

The data used in this study include daily oil price series, exchange rates, and industry price indices, as well as their respective market values, from both developed and developing countries over the period