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Nonparametric panel data model for crude oil and stock market prices in net oil importing countries

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ABSTRACT

This paper introduces an innovative nonparametric panel data approach to model the long-run relationship between the monthly oil price index and stock market price indices of ten large net oil importing countries; namely, the United States, Japan, China, South Korea, India, Germany, France, Singapore, Italy and Spain. In the proposed model, we allow the coefficient on the oil price index to be a time-varying function which evolves over time in a way that is assumed to be unknown. We also allow the common trend function to evolve over time, as well as extending the model further to incorporate country-specific trend functions. We employ a data-driven local linear method to estimate these time-varying trend and coefficient functions. The results show that, despite being largely positive, there are several downward trends, reflecting the aftermath of the Iraq war and the recent unprecedented drop in the oil price. Overall, we find that the nonparametric panel data model better captures the way in which the underlying stock-oil price relationship has evolved over time in comparison to the point estimates of the parametric counterpart. Moreover, we find that stock market fundamentals play a significant role in determining the oil-stock price relationship. Our findings have important implication for policymakers and financial speculators.

1. Introduction

Several studies have shown that oil price shocks are responsible for recessions. Hamilton (1983) found that crude oil price shocks were an important factor contributing to every recession in the United States (US) since World War II. More recently, in testimony prepared for the Joint Economic Committee of the US Congress, Hamilton (2009) stated that the "surge in oil prices [that occurred between June 2007 and June 2008] was an important factor that contributed to the economic recession that began in the US in 2007:Q4". In addition to having a negative effect on GDP, oil price increases have been shown to be responsible for higher inflation. For example, Cologni and Manera (2008) find that oil price increases have had an instantaneous, albeit temporary, effect on higher inflation in the G7 economies.

If oil prices have an effect on GDP and inflation, one would expect that oil price increases would also have an effect on stock markets. There are several avenues through which oil prices could influence stock prices. The value of a stock is the discounted value of future cash flows. Oil prices can affect macroeconomic conditions, such as economic growth, inflation and consumer confidence, which are fundamental determinants of future cash flows as well as having an indirect effect on the interest rate, which is used to discount future cash flows. If interest rates increase this will make the bond market more attractive relative to the stock market, resulting in downward pressure on stock prices. Oil is a major input into the production process; hence, oil price fluctuations can result in changes in the cost of production that impact on the profits of firms, and, hence, their stock price. Oil price fluctuations can also result in wealth transfers from oil consumers to oil producers, having differential effects on the stock prices of listed firms in different industries (see, for example, Nandha and Faff, 2008; Narayan and Sharma, 2011; Salisu and Oloko, 2015).

There has been increased attention given to the effect of oil price shocks on GDP and stock prices since the oil price shocks of 1973–1974 and 1979–1980 (Masih et al. (2011). This attention has been intensified in the fallout from the Global Financial Crisis (GFC) (Balcilar et al., 2015; Mollick and Assefa, 2013; Tsai, 2015). As the quote from Hamilton (2009) above makes clear, there is widespread recognition that surging oil prices in 2007–08 contributed to the GFC

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and that the GFC was associated with a drastic plunge in world stock markets. There was, first, a long, gradual decline in US stock markets between mid-2007 and September 2008 and then a sharp fall in September 2008 following the collapse of Lehman Brothers. The decline in US stock markets spread to European and other global markets (Dooley and Hutchison, 2009; Longstaff, 2010). The relationship between rising oil prices and the subsequent collapse of global stock markets, during the GFC, appears too close for possible causal links to be ignored (Masih et al., 2011), which has focused attention on the relationship between oil prices and stock market movements more generally.

The findings in the existing literature concerning the relationship between oil and stock prices have, however, at best, been mixed with some studies finding that oil price increases have a negative effect on stock prices (see, for example, Basher and Sadorsky, 2006; Hammoudeh and Choi, 2007; Jones and Kaul, 1996; Kilian and Park, 2009; Nandha and Faff, 2008; Sadorsky, 1999), but other studies finding ambiguous effects (for example, Miller and Ratti, 2009) or no effect at all (for example, Apergis and Miller, 2009; Henriques and Sadorsky, 2008; Sukcharoen et al., 2014; Wang et al., 2013). Existing research on the relationship between oil prices and stock prices have two main features. First, most of the studies that have examined this relationship have used parametric models, including univariate time series models with volatilities, asymmetric cointegration models and Markov switching models, among others. As the relationship between oil and stock market prices has become somewhat complex, the problem is that parametric models may not uncover the underlying relationship and the way in which it has changed over time. Kilian and Park (2009) argue that the relationship between oil prices and stock prices is characterized by instability and that this explains the mixed findings in the literature. As noted in the literature review below, there is much evidence of structural shifts, time-varying volatility and nonlinearities in the relationship between oil and stock prices over time. To accommodate structural breaks in the oil-stock price relationship, parametric models with dummy variables and the Markov switching model have been widely used. However, due a large number of (known and unknown) events that may have had significant impacts on the oil-stock price relationship, the parametric model appears too restrictive to capture the nature, and the extent, of changes in the underlying relationship. Specifically, due to the recent plunge in the oil price and chaotic behavior of stock markets, one would expect this relationship to be very complex.

Second, most studies have applied univariate models to examine the relationship between aggregate stock prices and oil prices on a country-by-country basis or the disaggregated relationship for particular industries. There is a dearth of studies that have used panel data. Exceptions are Arouri and Rault (2012), Asteriou and Bashmakova (2013), Jouini (2013), Li et al. (2012) and Zhu et al. (2011), but these, too, use parametric modeling techniques. Use of panel data has advantages over the use of cross-sectional or time series data. Panel data can reveal the effect of individual differences and time transitions and because panel data has more observations this increases degrees of freedom, enhances estimation efficiency and reduces problems associated with multicollinearity (Wang, 2012). Furthermore, by utilizing a panel data modeling approach, the presence of cross-section correlation can be taken into account when estimating the model coefficients, thereby leading to consistent and efficient estimation, resulting in accurate statistical inference.

In this paper, we propose an innovative nonparametric panel data model with fixed effects to examine the long-run relationship between oil prices and stock prices of ten large net oil importing countries in Asia, Europe and North America; namely, the US, Japan, China, South Korea, India, Germany, France, Singapore, Italy and Spain. The sample period covers September 1999 to December 2015. We use the log of real prices denominated in US dollars to accommodate the effects of exchange rates and inflation on the oil-stock price relationship. The other explanatory variables added to the panel data model as control variables include the log of unemployment rates and the log of 10-year bond rates, and the coefficients of these two variables are also allowed to be time-varying functions.

The time-varying coefficients of a panel model can be estimated either by a parametric method, which requires some structure to be imposed on parameters as to how they vary over time, or by a nonparametric method, which does not assume any structure and, hence allows the data to speak for itself. In most empirical applications, researchers do not have prior knowledge as to the way in which the model parameters vary over time. Therefore, we believe it is advantageous to apply the nonparametric method to estimate the time-varying parameters and the time trend(s), in order to study the oil-stock price relationship.

This paper makes several contributions to the literature on the oil-stock price relationship, mostly in terms of the flexibility of the proposed model which accommodates several aspects that are noteworthy in panel modeling of the oil-stock price relationship. The first contribution is to allow the coefficient of the oil price index to evolve over time as an unknown functional form. The assumption of the constant or time-varying coefficient with a known structure made by previous studies may not fully explain the underlying effect of the oil price index on stock price indices, and how it has evolved over time, because there are several crises (such as the GFC), major events (such as the Iraq war) and unknown factors that are expected to have deep effects on the oil-stock price relationship. Thus, the way in which this relationship changes overtime is mostly unknown.

The second contribution is to allow the common trend in the panel model to evolve over time with unknown functional form. When modeling stock price indices, an appropriate model for the trend is crucial because it captures the countries' future real economic activities, technological advances and investors' perceptions about the stability of financial markets (see, for example, Phillips, 2001). A linear/polynomial trend, which is utilized in many empirical studies maybe inadequate to capture the underlying complex trending behavior of stock price indices.

The third contribution is to extend the proposed model further to include country specific trend functions. Such modeling is plausible, because countries have varying economic and financial structures and performance, and thus, stock markets are very likely to exhibit heterogeneous trending behaviors. We apply a local linear estimation method for the proposed panel model, by integrating the ideas presented in Chen et al. (2012) and Zhang et al. (2012), and introduce a bootstrap method to generate the confidence intervals for the underlying trend and coefficient functions in order to conduct statistical inference. The flexible specification of our proposed model accommodates problems such as heteroscedasticity and cross-sectional dependence that are common in panel data models.

The fourth contribution is to test the robustness of the oil-stock price relationship in the presence of stock market fundamentals incorporated into the panel model as additional control variables. In the literature on the long run oil-stock price relationship, macroeconomic variables are mostly included in the panel model as control variables. In the finance literature, on the other hand, stock market fundamentals, such as market capitalization, the price earnings ratio and the dividend yield are proffered to explain movements of stock market price indices. In this paper, we study two panel model settings, one with only macro fundamentals, and the other with both macro and stock market fundamentals, and test if the oil-stock price relationship is robust and if stock market fundamentals have any influence on this relationship.

The remainder of this paper is organized as follows. The next section provides an overview of the extant literature. In Section 3, we present a nonparametric panel data model with time-varying trend