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Modelling dynamic dependence between crude oil prices and Asia-Pacific stock market returns

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ABSTRACT

This paper investigates the dynamic dependence between crude oil prices and stock markets in ten countries across the Asia-Pacific region during the period from January 4, 2000 to March 30, 2012 by using unconditional and conditional copula models. The model is implemented using an AR (p)-GARCH (1, 1)-t model for the marginal distributions and constant and time-varying copulas for the joint distribution. The results show that the dependence between crude oil prices and Asia-Pacific stock market returns is generally weak, that it was positive before the global financial crisis, except in Hong Kong, and that it increased significantly in the aftermath of the crisis. The lower tail dependence between oil prices and Asia-Pacific stock markets exceeds that of the upper tail dependence, except in Japan and Singapore in the post-crisis period. Moreover, we show that time-varying copulas best capture the tail dependence and that taking the tail correlation into account leads to improved accuracy of VaR estimates. These findings have important implications for investors interested in Asia-Pacific markets for portfolio diversification, risk management, and international asset allocation.

1. Introduction

Crude oil is a natural and non-renewable resource and plays a significant role in the development of the real economy and financial markets. The relationship between stock market prices and oil prices has drawn considerable attention in the past because of its implications for portfolio selection, risk management, and international asset allocation. In this paper, we analyse the dynamic interdependence between oil prices and Asia-Pacific stock market returns. The reasons we focus on the Asia-Pacific region are as follows. First, most studies of the relationship between oil prices and stock prices have focused on the U.S. and developed European countries,[1] while few studies have focused on the time-varying dynamic dependence between crude oil prices and Asia-Pacific stock returns. Second, in recent years, crude oil consumption has significantly increased in many Asia-Pacific countries, and an inclining trend in oil consumption in Asia-Pacific countries was reported in the British Petroleum Energy Review in 2011. Specifically, oil consumption in the region was 5.3% higher in 2011 than in 2010 and now accounts for almost 31.5% of total world oil consumption, with growth considerably higher than the world growth in oil demand. As countries

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[1] See, for example, Jones and Kaul (1996) for the U.S., Canada, U.K., and Japan; Papapetrou (2001) for Greece; Hammoudeh, Dibooglu, and Aleisa (2004) for the U.S.; Park and Ratti (2008) for the U.S. and 13 European countries; Chang, McAleer, and Tansuchat (2012) for the U.K. and U.S.

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in the Asia-Pacific region have few oil fields and are more dependent on non-renewable energy, changes in crude oil prices have had a greater impact on Asian economies than on those of the U.S. and developed European countries.

Since 2000, crude oil prices have been rising rapidly. In February 2008, the price of both WTI crude oil and Brent crude oil surpassed $100/barrel, and the price hit a historic high of $145/barrel in July 2008. However, the price had dropped by nearly half just one and a-half months; this caused large fluctuations in the international energy markets and a further domestic oil price shock in the Asia-Pacific region, which in turn caused an energy price shock in coal and electricity. Changes in crude oil prices have produced greater shocks in developing economies than in developed economies, according to studies by the International Energy Agency (IEA) and the International Monetary Fund (IMF).

Recently, the relationship between oil price shocks and stock prices has been extensively investigated. Jones and Kaul (1996) analyse oil prices and stock prices in the U.S., Canada, Japan, and the UK, using a standard cash flow valuation model and finding that increases in post-war oil prices are negatively correlated with stock prices. Sadorsky (1999) reports that the volatility of oil price shocks has played an important role in U.S. stock market movements, with increases in oil prices causing negative shocks to U.S. stock prices. Papapetrou (2001), using impulse response functions, finds that positive oil price shocks have negatively affected Greek stock returns. Miller and Ratti (2009) examine the relationship between oil prices and stock returns in six OECD countries, using a cointegrated vector error correlation, which is a negative correlation supported by most literature on the subject. On the other hand, Huang, Masulis, and Stoll (1996) find a significant nonlinear relationship between actual stock returns and crude oil futures prices. Arouri and Rault (2012) find cointegration between oil prices and stock prices in Gulf Cooperation Council (GCC) countries and indicate that oil price increases positively affect GCC stock prices, except in Saudi Arabia. Park and Ratti (2008) find, using a multivariate vector autoregression model, that oil prices have a statistically significant impact on stock returns and that asymmetry in the relationship is seen in many European countries only between 1986 and 2005. El-Sharif, Brown, Burton, Nixon, and Russell (2005) show that a rise in oil prices results in increasing returns in oil and gas markets. Narayan and Narayan (2010), who analyse the cointegration of stock prices, oil prices, and nominal exchange rates, find that oil prices have a positive and statistically significant effect on Vietnamese stock prices. Nguyen and Bhatti (2012) find no tail dependence in the relationship between international oil price changes and Chinese stock returns.

This paper also examines the issue of structural dependence and/or tail dependence between financial markets. The objectives of the paper are threefold: (1) to determine the general and tail dependence coefficients in the relationship between crude oil prices and stock market returns in ten countries in the Asia-Pacific region, both before and after the recent financial crisis, and the extent of the differences between these time periods; (2) to explain those differences through the use of constant and time-varying methods; and (3) to analyse which model is most suited to describing the dependence structure.

Research on dynamic structural dependence between financial markets is important for effective risk management and international asset allocation.[2] As noted above, scholars have extensively investigated the relationship between oil price shocks and stock market returns prior to the recent financial crisis, as well as the complex relationships between oil price shocks and financial markets more broadly. The majority of these studies involve the use of traditional time-series models, such as vector autoregression (VAR) or cointegrated vector error-correction (VEC) models.[3] Although these models have some advantages, they assume that asset returns follow normal or Student *t*-distributions and thus neglect certain stylised facts. In particular, the assumption of normality is at odds with previous empirical research, which shows that crude oil and stock returns are skewed, leptokurtic, and fat-tailed.[4] Furthermore, it is well known that traditional mean variance optimisation analysis portfolios are symmetric measures that cannot capture non-linear dependence or changes in the tails of asset return curves and that investors pay closer attention to downside than to upside risk (Chen et al., 2005; Tsafack, 2009).

Moreover, previous literature has commonly used multivariate GARCH models to evaluate time-varying dependence structures.[5] Such models, based on tight restrictions and linear correlations, guarantee a well-defined covariance matrix that contains a serious deficiency, namely, that it is a variant under non-linear strictly increasing transformations.[6]

We propose unconditional and time-varying copula–GARCH models (similar to the method used, e.g., in Patton, 2006a, 2006b; Sun, Rachev, Fabozzi, and Kalev, 2009; Ning, 2010; Reboredo, 2011, 2012; Wang, Chen, and Huang, 2011) to study the dependence structure between crude oil prices and stock returns in ten Asia-Pacific countries during the recent global financial crisis. The copula–GARCH models allow us to describe the potential skewness and leptokurtosis of each asset return and to consider the marginal distribution and improved flexibility in joint distributions achieved by avoiding the assumption of a bivariate normal or Student's *t*-distribution; thus, the functions contain all relevant information about the joint behaviour of the random financial variables. Second, they enable us to capture the non-linear or asymmetrical dependence between oil prices and stock market returns by excluding extreme events.[7] The third advantage is invariance under strictly increasing transforms, as the

[2] Boubaker and Sghaier (2013) discuss a new method of minimising Conditional Value at Risk, assuming that the dependence structure is modelled by the copula parameter; Aloui, Ben Aïssa, and Nguyen (2013) explains that the Student-*t* copulas model can improve the accuracy of VaR forecasts.

[3] Examples include Sadorsky (1999), Papapetrou (2001), Miller and Ratti (2009), and Park and Ratti (2008).

[4] Examples include Cuñado and Pérez de Gracia (2003), Basher and Sadorsky (2006), Narayan and Narayan (2010), Chang et al. (2012), Aloui et al. (2013).

[5] Examples include Ng (2012), and Lee and Yoder (2007).

[6] The use of linear correlation to depict the financial market dependence structure has many disadvantages, as noted by Embrechts, McNeil, and Straumann (1999).

[7] The non-linear or asymmetrical dependence structure has been reported by several scholars, include Basher and Sadorsky (2006), Broadstock et al.(2012), Boubaker and Sghaier (2013), Chang et al.(2012), Ciner (2001), Cuñado and Pérez de Gracia (2003), El-Sharif et al. (2005), Hammoudeh et al.(2004), Jones and Kaul (2012), Maghyereh (2004), Maghyereh and Al-Kandari (2007), Naifar and Al Dohaiman (2013), Narayan and Narayan (2010), Nguyen and Bhatti (2012), Park and Ratti (2008), Wen et al.(2012).