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How is China's coke price related with the world oil price? The role of extreme movements

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ABSTRACT

This paper focuses on the relationship between the world oil price and China's coke price, particularly with respect to extreme movements in the world oil price. Based on a daily sample from 2009 to 2015 and the ARJI-GARCH models and copulas, our empirical results show that China's coke price and the world oil price are characterized by GARCH volatility and jump behaviors. Specifically, negative oil price shocks lead to falls in China's coke returns on the following day while positive oil prices have no significant effects. In addition, current coke returns positively respond to the very recent oil price jump intensity, and a time-varying and volatile lower tail dependence is found between the world oil price and China's coke price. Our results are expected to have implications for coke producers and users and policy makers.

1. Introduction

As a crucial raw material in the iron and steel industries, coke has been fueling the engine of China's economic boom economy for the past decade. Domestic coke consumption in China surged from around 108 million metric tons (MMTs) in 2000 to around 469 MMTs in 2014, and production increased dramatically from 122 MMTs in 2000 to 480 MMTs in 2014 (China Energy Statistics Yearbook, 2015). Various official public sources have reported that China is the world's largest consumer and producer of coke.

Following the rapid increase in the consumption and production of coke, China launched coke spot and future markets in 2009 and 2011, respectively, to facilitate coke trading, inventory management, and, more importantly, risk hedging for domestic coke users and producers. However, due to its immaturity, the coke market is very speculative, thus indicating that the coke price is very sensitive and vulnerable to market shocks. Accordingly, understanding the relationship between the domestic coke price and its related risk factors is particularly important for risk management of the coke price.

According to the Energy Information Administration, 2014, China's coal mines primarily produce bituminous coal and fair amounts of anthracite and lignite. These elements make up steam coal, which is mainly used to generate electricity and produce heat in the industrial sector, and coking coal, which is primarily used to produce coke for iron smelting and steel production. Due to its close relationship with these production processes, the coke industry is reported to be the third largest coal consumer in China after the power generation and manufacturing industries (Huo et al., 2012), and the coal price is a primary determinant of the coke price. At the same time, given that coke is an indispensable raw material in iron and steel production, the production capacities of the iron and steel industries are another main factor in determining the coke price. Moreover, the Coke Manual (2011) published by the Bohai Commodity Exchange (BCE) points out that coke inventories and domestic macro fundamentals should also be considered when analyzing the coke price.

However, with China's integration into the world energy market, it is evident that domestic risk factors cannot provide the complete risk pattern for the coke price. The high correlation between the world oil and

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coal prices since 2008 and China's dominant role in importing international oil and coal has been greatly emphasized in the literature (Yang et al., 2012; Zaklan et al., 2012). These factors have also aroused the attention of domestic coke users and producers on world energy price disturbances. As the benchmark in the world energy market, the crude oil price is generally regarded as more volatile than other energy products, and is considered to be the best candidate for the risk transmission to other markets (Regnier, 2007; Lautier and Raynaud, 2012). The external risk factor of the world oil price is especially highlighted in the Coke Manual. Nonetheless, in sharp contrast to the abundant data analyses on domestic risk factors, thus far, there has been no related analysis of the relationship between China's coke price and the world oil price.

Furthermore, the ongoing financialization of commodities, the advent of the 2008–2009 global financial crisis, and the subsequent global economic slowdown have been accompanied by extreme movements in oil prices, which have attracted the attention of market participants worldwide. In recent years, the price of oil has fluctuated at levels that have not been observed since the energy crisis of the 1970s. For example, the price of WTI (West Texas Intermediate) crude oil rose from 37 dollars per barrel to a historic maximum of 145 dollars per barrel from the beginning of 2003 to mid-2008, and then decreased sharply to 33 dollars per barrel at the end of 2008. Following a mild upward price trend throughout 2009, the price promptly rose from 80 dollars per barrel to almost 100 dollars per barrel at the end of 2010 and into 2011. Recently, weak economic growth coupled with surging U.S. production and OPEC's decision to not cut oil production caused the oil price to collapse to around 40 dollars per barrel from about 105 dollars per barrel in June 2014. Notably, significant fluctuations have been observed in other energy markets, such as coal, electricity, natural gas and refined petroleum, along with the dramatic changes in the world oil price. The literature has mostly analyzed such extreme market conditions using uncertain macro fundamentals, fads, and herd behavior, and emphasized that they can impose non-negligible effects on investment decisions and macro policy making (see Ghorbel and Travelsi, 2014; Joëts, 2014; Tong et al., 2013; Yang et al., 2012, among others). This further motivates us to examine the relationship between China's coke price and the world oil price, especially in light of the extreme movements in the oil price.

In addition to revealing the implications of risk management for coke users and producers, uncovering the relationship between China's coke price and the world oil price, especially with respect to the extreme oil price fluctuations, is expected to assist domestic policy makers in regulating the market risk, facilitate the development of the domestic energy-related markets, improve the asset pricing of domestic energy products, and help adjust energy policies to reduce China's heavy reliance on imported oil.

To this end, we use an autoregressive conditional jump intensity (ARJI) model with the GARCH process to describe the world oil price and China's coke market, given its speculative characteristics, thus guaranteeing that the jumps in the oil and coke prices will be captured. In particular, we add the world oil price jump intensity and the negative and positive returns of the oil price into the mean equation of China's coke returns to comprehensively investigate the effect of world oil price shocks on China's coke price. In addition to focusing on the effect of extreme oil price shocks (oil price jump intensity) on China's coke price in average conditions, we further investigate how the commodity prices co-move in extreme market cases. Then, using the estimates from the ARJI-GARCH models, we apply diverse copulas (including the static and time-varying Gaussian copula, Student-*t* copula, Clayton copula and its rotation, and Gumbel copula and its rotation) to further examine the dependence structure of coke and oil.

The main findings of this paper, which are based on a daily spot sample of China's coke price and the WTI price from 2009 to 2015, are summarized as follows. First, extreme jumps are evident in both the world oil price and China's coke price, thus confirming that they are not only characterized by GARCH volatility but also by jump behaviors. Second, negative oil price shocks lead to falls in China's coke returns on the following day, while the effect of positive oil price shocks is insignificant. China's current coke returns also positively react to the very recent jump intensity in the world oil price, while the two-day lagged oil price jump intensity has no significant effect. Third, there is time-varying and volatile lower tail dependence between the world oil price and China's coke price, indicating co-movements in their extreme negative returns.

The remainder of this paper is organized as follows. Section 2 provides a brief overview of China's coke trading market. Section 3 presents the literature review. The methods, including the ARJI-GARCH model and copulas, are introduced in Section 4. The descriptive statistics of the data and the empirical results are presented in Sections 5 and 6, respectively. Section 7 concludes the paper and presents the final discussion.

2. China's coke trading market

Spot trading on China's coke market was launched on the BCE on December 18, 2009 with the purpose of facilitating coke trading, inventory management, and price risk hedging. To maintain continuous spot transactions, the BCE is structured on the basis of a daily delivery declare and delay delivery compensation system. Similar to futures trading, the continuous spot trading system allows traders to hold short positions and uses the T + 0 transaction mechanics. However, different from futures trading, spot trading requires a higher margin ratio of 20% of the contract value. The tick size and trading unit are set at RMB 2/MT and 1 MT, respectively. The daily price limit is +/− 8% of the guided price on the first listing day, whereas after that date it is +/− 8% of the last settlement price. Coke spot trading is based on the physical delivery and the trading hours are divided into three sessions: 19:00–3:00, 9:00–11:30, and 13:30–16:00 (all Beijing time).[1]

To better hedge the risk of the coke price, a coke futures market was subsequently launched on August 15, 2011 on the Dalian Commodity Exchange (DCE). Coke futures trading requires a minimum margin ratio of 5% of the contract value. The tick size and trading unit are RMB 0.5/MT and 100MT/contract, respectively. The daily price limit is set to be 4% of the last settlement price. The expiration day of a coke futures contract is the second day after the last trading day of the delivery month (coke contracts are monthly contracts, comprising of 12 contracts per year, and the last trading day is the tenth trading day of the delivery month) and is based on physical delivery. The trading hours for coke futures are divided into two sessions: 9:00–11:30 and 13:30–15:00 from Monday to Friday (all Beijing time).[2]

Thus far, three coal-related spots (coke, coking coal, and steam coal) have been introduced on the BCE. Coke spot trading was introduced first and has the largest trading volumes, with the daily trading volume being around 153 thousand MT on average. Coke, coking coal, and steam coal futures are also traded on the DEC. Like the coke spots, coke futures were launched earlier than the other two coal-related futures, and are the most actively traded of the three coal-related futures, with an average daily trading volume around 399 thousand contracts. Compared with coke users and producers, speculators and arbitragers comprise a larger proportion of the participants in the domestic coke spot and futures markets. Moreover, according to the averaged ratio of the trading volume and open interest, the coke spot and futures markets are mainly characterized by speculation.

3. Literature review

As noted above, no studies have empirically examined the relationship between China's coke price and the world oil price. The most

[1] More details can be found at www.boce.com.
[2] More details can be found at www.dce.com.cn.