The effects of oil price shocks on output and inflation in China

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ABSTRACT

Crude oil price shocks derive from many sources, each of which may bring about different effects on macro-economy variables and require completely different designs in macro-economic policy; thus, distinguishing the sources of oil price fluctuations is crucial when evaluating these effects. This paper establishes an open-economy dynamic stochastic general equilibrium (DSGE) model with two economies: China and the rest of the world. To assess the effects of oil price shocks, the CES production function is extended by adding oil as an input. Based on the model, the effects of four types of oil price fluctuations are evaluated. The four types of oil price shocks are supply shocks driven by political events in OPEC countries, other oil supply shocks, aggregate shocks to the demand for industrial commodities, and demand shocks that are specific to the crude oil market. Simulation results indicate the following: Oil supply shocks driven by political events mainly produce short-term effects on China's output and inflation, while the other three shocks produce relatively long-term effects; in addition, demand shocks that are specific to the crude oil market contribute the most to the fluctuations in China's output and inflation.

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1. Introduction

As one of the most important commodities in the world, crude oil is crucial for the global economy. Much of the literature has discussed the effects of oil price shocks on the macro-economy. A common view is that there is a correlation between increases in the oil price and subsequent economic downturns, but divergence appears when measuring the effects of oil prices in driving aggregate macro-economic fluctuations. The majority of the literature confirms that oil prices have important effects on economic aggregates. Hamilton (1983) concludes that an increase in the price of oil is responsible for almost every post-World War II U.S. recession. Papapetrou (2001) demonstrates that oil price fluctuations bring about significant effects on output and employment in Greece. Cunado and Perez de Gracia (2003) indicate that oil prices do affect industrial production significantly in European countries, although the relationship between the oil price and industrial production is nonlinear. However, other researchers find that there are few effects of oil price shocks on the macro-economy. For instance, Kim and Loungani (1992) include energy as one of the productive inputs in their real business cycle model, in which the energy price is treated as an exogenous random process. They find that oil prices do not play a major role in driving output fluctuations. Dhawan and Jeske (2008) extend Kim and Loungani's (1992) model by including durable goods

consumption and find that oil price shocks have small effects on output fluctuations.

Implicit in most of the above literature is an assumption that different sources of the oil price are of no great importance in assessing the effects of oil price shocks. However, this assumption has been proved to be incorrect. As Bernanke (2004) indicates, different economic conditions may cushion or amplify the effects of oil price shocks, and it is inappropriate to discuss the effects of a rising oil price with all other factors held equal. Considerable research finds that supply and demand oil price shocks may have differing effects on economic variables (Apergis and Miller, 2009; Basher et al., 2012; Hamilton, 2003, 2008; Kilian, 2008a, 2008b, 2008c, 2009). On the supply side of oil, available capacity and geopolitical developments determine the total oil production. Available capacity is highly correlated with productivity in oil-exporting countries, which is time varying. Geopolitical development often relates to political events, which can produce drastic changes in oil production and subsequently in the oil price. On the demand side, economic expansion in both industrialized and emerging-market economies contributes to oil consumption and brings changes in the oil price. The causal relationships between oil price and its diverse sources may have different effects on economic aggregates, so distinguishing diverse sources is crucial in measuring the effects of oil price shocks. Kilian (2008c) addresses a number of key issues for the oil price and economic performance and finally concludes that demand and supply shocks in the oil price can produce various effects and distinguishing between them is crucial. Kilian (2009) uses a newly developed measure of global real

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economic activity; proposes a structural decomposition of the real price of crude oil; and quantifies the magnitude and timing of these shocks.

Another issue in studying the relationship between oil price and economic aggregates is endogeneity. As one of the most important macro-economy variables, oil price is correlated with many other variables, and it should be considered endogenous when measuring its effects. These feedback mechanisms are common and non-negligible in measuring the effects of different oil price shocks. To distinguish different sources of oil prices, to assess the fluctuations in the aggregates under diverse oil price shocks, and to solve the endogeneity problem with an assessment of the effect of oil prices, DSGE models are widely used to study the effects of oil prices on economic aggregates. Compared with econometric models, DSGE models emphasize structural analysis based on economic theory rather than statistics, so they can provide a more theoretical framework for identifying both the diverse sources of oil price shocks and the diverse transmission paths of oil prices to the economic aggregates. Unalmis et al. (2009) measure the macroeconomic consequences of different oil price shocks proposed by Kilian (2009) based on a small open DSGE model. In their model, both supply and demand shocks can bring about oil price fluctuations, so oil price is endogenous. Conclusions indicate that different sources of oil price shocks produce significant diverse effects. Balke et al. (2010) construct a three-country DSGE model. Based on their model, they distinguish demand and supply shocks in the oil price and conclude that it is more reasonable to treat oil price as endogenous. Based on an estimated two-country DSGE model, Guerrieri and Bodenstein (2012) treat oil price as endogenous by clearing the world oil market, while distinguishing among country-specific oil supply shocks, various domestic and foreign activity shocks, and oil efficiency shocks. There are also other studies related to the endogeneity of oil prices, such as Barsky and Kilian (2002a, 2002b), Bodenstein et al. (2007), Nakov and Pescatori (2007a, 2007b), Kilian (2008a, 2008b, 2009), Arora and Gomis-Porqueras (2011), and Antonakakis et al. (2014).

As opposed to the above literature, which focuses for the most part on industrialized countries, this paper focuses on the response of China's macro-economy to global oil price changes by distinguishing the diverse sources of these changes. This issue is important for both China and international oil markets. For China, the domestic refined oil prices are set according to the average fluctuations in oil prices of Brent, Dubai and Michael Essien tower crude oil markets, so international oil prices have a direct impact on domestic refined oil markets, in addition to economic aggregates. Fig. 1 describes China's consumer price index (CPI) and international oil price performance between Q1 2004 and Q1 2012. Significant positive correlation between China's CPI and international oil price is indicated in this graph. For international oil markets, the rapidly growing oil demand from China has been one of the prominent driving forces of oil price fluctuations in recent years (Eckaus, 2008; Kilian, 2009; Roache, 2012).
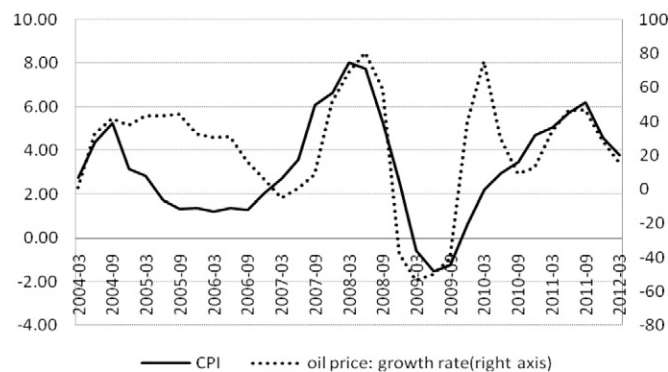

Fig. 1. Consumer price index in China and international oil price.
Source: National Bureau of Statistics of China.
Source: Organization of the Petroleum Exporting Countries (OPEC).

The main contribution of this paper is to construct an open-economy DSGE model to distinguish and analyze the effects of different oil price shocks on China's output and inflation. Four types of oil price shocks are distinguished by defining the correlations between the oil price shock and its various sources. In addition, oil is endogenous by treating it as an input of the CES production function. Because few papers considered the endogeneity problem and the different sources of oil price shocks simultaneously for the Chinese economy, our paper will help to fill this gap. In this DSGE model, China is considered to be a large open economy rather than a small open economy. The main difference between these two types of economies is: The variables of the rest of the world are exogenous in a small open economy, while this is not the case in an open economy. That is, oil demand from China is so large that to some extent it can affect oil prices outside of China. In addition, the interest rate and exchange rate in both countries are linked by an improved uncovered interest parity (UIP) assumption, which helps to avoid the "forward premium puzzle" (a currency with a high interest rate tends to appreciate, which implies that the risk premium must be negatively correlated with the expected exchange rate depreciation).

The main findings of this paper are as follows. First, some inconsistencies appear between the results of Kilian (2009) and this paper. These inconsistencies reveal that the China and U.S. respond differently to oil price shocks. Specifically, oil supply shocks driven by political events have permanent effects on U.S. output, while they only bring about temporary fluctuations to China's output; under the aggregate demand shocks of oil price, U.S. output responds in the short-term, while China's output response is in the long-term. As for the responses of inflation, oil supply shocks have no significant effects in the U.S., while they do affect inflation in China significantly; second, these four types of oil price shocks cause completely different effects on China's output and inflation. Among these four types of shocks, aggregate shocks to the demand for industrial commodities are the main factors that affect China's output and inflation; other oil supply shocks take second place; oil demand shocks that are specific to the oil market have only a slight impact on both output and inflation in China.

The rest of the paper is organized as follows: Section 2 describes the structure of the DSGE model. Section 3 presents the calibrated parameters. Four types of oil price shocks are distinguished in Section 4. The impulse responses and variance decomposition are also shown in this section. Discussions and conclusions are given in Section 5.

2. The open economy model

Christoffel et al. (2008) develop a New Area-Wide Model (NAWM) of the euro area, which provides a basic open-economy DSGE framework. In this paper, the Christoffel et al. (2008) framework is extended by adding the oil input in the production of immediate goods. The production function of immediate goods has three inputs (capital, labor and crude oil). As a type of input in the production process, oil is very important in analyzing the fluctuations of prices and real aggregates. Therefore, the relations between oil price shocks and economic aggregates (output and inflation) can be easily detected, and the impact of the energy market can be analyzed quantitatively. In this model, there exist two economic entities: the domestic economy (China) and the rest of the world; both countries have the same economic structure but different parameters. There are households, firms and government in each country. Decisions are made by households and firms for the purpose of utility maximization. Households decide their consumption, labor supply and wealth holdings to maximize their utility function over an infinite life horizon. The wealth of households exists in three forms: interest-free cash, riskless domestic bonds and risky foreign bonds. Labor supplied by households is different, so the labor supply market is monopoly competitive, and households have some power in wage decisions. In addition to labor, households rent capital to firms and decide how much capital to accumulate given certain capital adjusted costs. Intermediate firms input capital, labor and oil to produce heterogeneous