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The Influence of Oil Price Shocks on China's Macro-economy : A Perspective of International Trade

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The Influence of Oil Price Shocks on China's Macro-economy :A Perspective of International Trade*

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Abstract

International trade has been playing an extremely significant role in China over the last 20 years. This paper is aimed at investigating and understanding the relationship between China's macro-economy and oil price from this new perspective. We find strong evidence to suggest that the increase of China's price level, resulting from oil price shocks, is statistically less than that of its main trade partners'. This helps us to understand the confused empirical results estimated within the SVAR framework and sheds light on recent data. More specifically, as for the empirical results, we find China's output level is positively correlated with the oil price, and oil price shocks slightly appreciate the RMB against the US dollar. Positive correlation between China's output and oil price shocks presumably results from the drop in China's relative price induced by oil price shocks, which is inclined to stimulate China's goods and service exports. The slight appreciation of the RMB could be justified by the drop in China's relative price, which is indicated by economic theory. Moreover, constructing a simple model, our new perspective also helps us to understand the recent fact that together with the dramatic surge of the world oil price, while the oil imports of the other major countries (especially the largest oil import country US) in the world steadily decline or remain stable, China's oil imports, in contrast, have kept rising steeply since the year 2004.

Keywords Oil price shocks, International trade, China's macro-economy

JEL Classification F41, Q43, Q48

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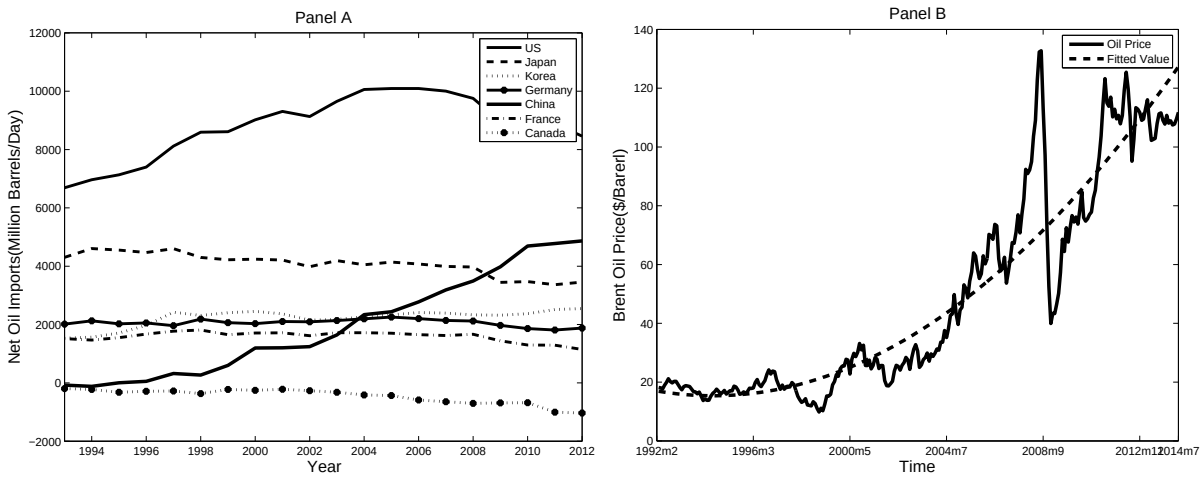
1 Motivation and Introduction

China has enjoyed impressive economic growth and undergone spectacular economic transformation since introduction of profound economic reforms in 1978. At the same time, it is also increasingly dependent on oil resources. The International Energy Agency (IEA) documented in a research report that the oil demand of China would keep increasing in a foreseeable future, associated with its fast speed industrialisation and urbanisation. According to Panel A of Figure 1, China first became an oil-import country in around 1992, which happens at the time of Deng Xiaoping's Southern Tour and China's shift towards a fully-fledged market economy. Since then, oil imports to China have steadily increased, and was even immune to the financial crisis of 2008; it surpassed Japan and became the second largest oil-importer that year.

Figure 1: Net Oil Imports of Main Countries and World Oil Price



Morever, increasing oil imports to China have been accompanied by rising oil price in general. What we can easily conclude from Panel B of Figure 1 is that the oil price has gradually climbed, with a small drop during 1997-1999 possibly resulting from Asian financial crisis, since 1992. It upsurges dramatically after 2002. Interestingly, this timing quite closely follows that of China's entry into the WTO. Although with a sharp decline during the financial crisis between 2008 and 2009, the price gained momentum and instantaneously rebounded back after that, more importantly, seemingly with a higher volatility. Unambiguously, the interactions between the world oil price and China's macro-economy should have been more significant than ever.

Apart from many distinguished characteristics (the pricing of oil being not completely commercialised, for instance) from other economic entities, a salient feature of China is that it relies heavily on international trade. To study and better understand the effects of oil price shocks on China's macro-economy, it is essential and helpful to put sufficient attention on the fact that China is a typical export-oriented country. Concretely, it ranks first in terms of the proportion of total trade to GDP, which peaked to 65.3 % in 2006. On average, this proportion is as high as 46.5% during 1992-2013. These figures are calculated according to data from China's National Bureau of Statistics (NBS). As shown in Figure 2, both total trade and exports from China rose gradually from 1992, with a dramatic upsurge around 2001, and with a descend in 2008, but immediately followed by a retaliatory rebound, and even more sharp growth thereafter.

Figure 2: Trade and Exports of China

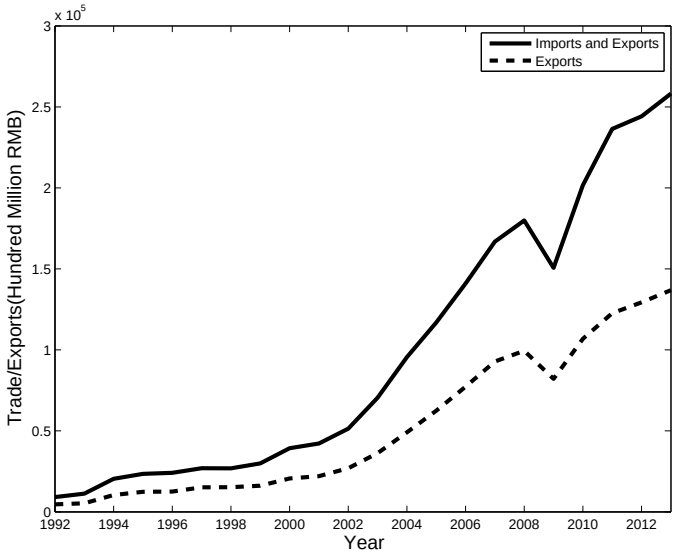
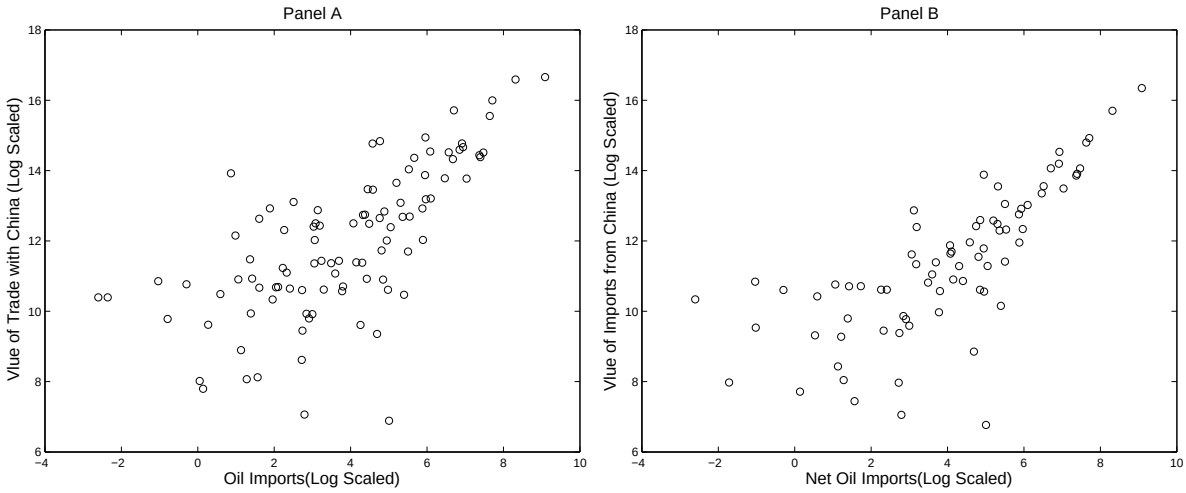


Figure 3: Value of Trade with China and Oil Imports of Different Countries



In addition, Panel A of Figure 3 illustrates that the countries importing more oil are basically the ones that trade more with China, and Panel B of Figure 3 with alternative measurement–net oil imports–documents almost the same case. As the value of oil imports and the value of trade with China span a large interval, we use a log-scaled coordinate system in Figure 3. Figure 2 and Figure 3 combined show on the one hand, that international trade is essential for China (indicated by Figure 2), on the other hand, that China's main trade partners are also major oil-dependent countries in the world (indicated by Figure 3). We have reason to believe that oil, as the most important bulk commodity in international trade today, will potentially change China and its partners' relative price level and further the goods and service exports of China or other relevant variables. This insight enlightens us to study and understand the effects of oil shocks on China estimated by econometric models and observable facts in the data from this new perspective, and accordingly distinguishes our paper from the existing literature.

The remainder of the paper is organised as follows. In section 2, we review the literature related to our paper, followed by the methodology used in our paper in section 3. We describe the data and report the empirical results in section 4. Section 5 concludes. An appendix is also available in the end of this paper.

2 Related Literature Review

The first oil crisis occurred in the 70s of the last century has spurred a large amount of literature which concentrates on the relationship between oil shocks and macro-economic activities. Nevertheless, considerable debates persist over the effects of oil price shocks in terms of both quantity and direction. Moreover, a variety of distinguished underlying transmission mechanisms have been raised to rationalize the corresponding different empirical results.

Observing the fact that seven out of the eight postwar U.S. recessions have been preceded by a sharp increase in the price of crude petroleum, Hamilton (1983) concludes that oil shocks are a contributing factor in at least some of the US recessions prior to 1972. Hamilton (1996) proposes a measure of asymmetric oil price–net oil price increase, which is the maximum of zero and the difference between the level of the crude oil price in quarter t and the maximum value for the level achieved during the previous four quarters. The author draws a conclusion that supports his point in 1983 that real output of the US is negatively correlated with oil price shocks and the relationship is also statistically significant. A series of his following work (Hamilton (2005), Hamilton (2009) and Hamilton (2010)) reported similar results. Jiménez-Rodrígueza et al. (2005) confirm that the real GDP growth of oil importing economies suffers from increases in oil prices in both linear and non-linear models. Constructing large-scale macro-financial-econometric-model, Morana(2013) finds that oil market shocks have contributed to slow economic growth since the first Persian Gulf War episode. Lin&Mou (2008) explore the effects of oil price shocks on China within the framework of computational general equilibrium (CGE), and also present similar results. It is also the case for Zhang & Xu(2010). Le & Chang (2013) study the relationship between oil price shocks and trade imbalances, and find that for net oil importing economies, unfavourable outcomes are associated with oil price shocks.

By contrast, other prominent researches have drawn modest or even different conclusions. Bernanke et al. (1997) suggest that an important part of the effect of oil price shocks on the economy results is not from the change in oil price itself, but from the resulting tightening of monetary policy. Darrat et al. (1996) provide evidence to show that once the resulting interest rate increase is controlled, the effects of oil price shocks on the US economy will not be statistically significant any more. Barsky & Kilian (2004), argue that the effect is small and that oil shocks alone cannot explain the US stagflation of the 1970s. , Blanchard & Galí (2007) present evidence showing that the dynamic effect of oil shocks has decreased considerably over time, owing to a combination of improvements in monetary policy, more flexible labour markets, and a smaller share of oil in production. Wong (2013) provides evidence to show that inflation pass-through from oil shocks in the 21st century relative to the 1970s has dampened. Establishing a five-variable VAR model Du et al. (2010) examine the influences of oil price shocks on China's macro-economy. Their results show that China's output is positively correlated with oil price shocks, which is similar to our findings. But our paper is different from Du et al. (2010) in both methodology and explanation.

Some researches are committed to studying the underlying transmission mechanisms through

which oil price shocks influence the macro-economy. Noticing that the empirical results are different, it is rather natural that the corresponding underlying transmission mechanisms used to interpret them are also dissimilar. In general, there are two different views on the relationship between oil price shocks and economic recession. One is they are statistically correlated to each other, the other is that this relationship is not significant or is not clear.

We first concentrate on the ones supposing that economic recession is statistically correlated to oil price shocks. According to Bernanke (1983), uncertainty could lead to a postponement of purchases for capital and durable goods, so the oil price shocks will influence the economy by increasing the uncertainty firms are confronted with. Rotemberg and Woodford (1996) suggest that the imperfect competition of the production market may better interpret the large negative effects of oil price shocks. Finn (2000) points out that in order to minimize depreciation expenses, when energy price changes, firms adjust capital utilisation rates. Ramey& Vine (2010) argue that when the oil price rises, a shift in demand away from larger cars seems to have been a critical feature of the macroeconomic response to historical oil shocks. We now turn to the other side. Rogff (2006) elaborates that the effects of the oil shocks on the economy are generally weakened by technological advancements, improved energy efficiency, and the development of the financial market. As for the result that China's output is positively correlated with oil price shocks found by Du et al. (2010), the authors argue that this is presumably linked to that both China's growth and the world's oil price are affected by US and EU countries' economic activity in the same direction. Morana (2013) documents that as the negative impact on domestic demand may be mitigated by the increase of external demand (due to boosted imports of net oil export countries), the overall implications of the oil price drag mechanism are, however, not clear.

In summary, it can be stated that there is no consensus on empirical results about the effects of oil price shocks on the macro-economy. In addition, it is also the case for the transmission mechanisms through which the oil price shocks affect the macro-economy. Moreover, although a large amount literature has studied the transmission mechanisms, quite a few concentrate on the issue of China. Considering the reasons mentioned in section 1, We start by examining how international trade transmission mechanism works and then investigate the effects of oil price shocks on China's macro-economy from this perspective. Finally, constructing a simple model, we fit this transmission mechanism to recent data. A related paper is Rasmussen & Roitman(2011). The authors argue that the negative impact of oil price shocks on oil-importing countries is partly offset by concurrent increases in exports and other income flows, and argue that these flows arise from high commodity prices being associated with good times for the world economy as well as from the recycling of petrodollars by oil-exporting. By contrast, we model these flows via a drop in China's relative price resulting from oil price shocks. Another related paper is Allegret et al. (2014), which investigates oil price shocks' effects and their associated transmission channels on global imbalances. They find that associated with oil price shocks, there is a transfer of wealth from oil-importing countries to oil-exporting ones. Our paper, however, proposes that this transfer can also happen between oil-import countries.

3 Methodology

We first investigate the relationship between oil price and price levels of different countries. Then we explore and understand the structural vector auto regression (SVAR, hereafter) estimation results and a recent stylized fact from this perspective. More specifically, we first

convey a simple regression model to explore the relationship between the oil price and price levels of China and other countries, and further the relative price of goods and services of China to other countries, which plays an essential role in international trade. Secondly, the SVAR method, which is used to find the effects of oil price shocks on China's main macroeconomic variables, is introduced; After that, to check the plausibility and robustness of the SVAR model, the asymmetric test and alternative oil price specification are presented. Finally, we also construct a simple model to illustrate the implications of our findings to recent data.

3.1 Oil Price and Price Level of Different Countries

International trade is influenced by many factors, for simplicity and tractability, we exclusively concentrate on the most essential one–the relative price level of goods and services of different countries. In order to investigate the relationship between the oil price and the price level of different countries, we consider the regressions of (China's and other countries's) price levels on the world oil price. In the light of the analysis above, we don't include all countries that trade with China, instead, we choose the countries according to the criteria: The country is a member of the OECD countries or BRICS (Brazil, Russia, India, China and South Africa) in our paper; The country is one of China's major trade partners and also imports oil from other countries. The countries that simultaneously satisfy all of the criteria are reported in Table 7. Other countries are excluded. For example, although Norway is a member of the OECD countries and one of China's major trade partners, it is an oil-export country (it exports 2285 thousand barrels per day over the period 1992-2012), thus is excluded from our analysis.

Our regression model is:

$$CPI = \alpha_0 + \alpha_1 OilP + \boldsymbol{\alpha_2 X} + \mu \tag{1}$$

In which CPI denotes the general price level, $OilP$ is the world oil price, and $\boldsymbol{X}$ is control variables including GDP growth rates, short-term interest rates, money supply growth rates and the exchange rates against the US dollar. To compare the different effects of world oil price on China and the countries we choose according to the three criteria above, we first run the regression for China, and then for other countries as a whole. In the view of the fact that central banks may react to price level increases, we also carry out instrumental variable (IV, hereafter) estimations which will be described in detail in section (4). In addition, while we have controlled the important variables, it may be the case that the lag of oil price could still affect price level, therefore the lag of oil price should be included in the regression model.

In addition, increased oil price volatility may affect the price level, since increased uncertainty presumably influences firms' investment decisions (Bernanke(1983) & Pindyck(1991)) which in turn are closely linked to price level. The world oil price volatility itself is of relevance and emphasised by many authors (Merton (1980), Anderson et al. (2003), Park & Ratti (2008) and Pinno & Serletis (2013), for example). For robustness, oil price volatility needs to be included in the regression model (equation (1)), which can be regarded as another sensitivity check of the regressions above. Before doing this, we need to measure the oil price volatility. In the paper of Merton (1980), Anderson et al. (2003) and Park & Ratti (2008), the measure of monthly oil price volatility is defined as the the sum of squared first log differences in a daily spot oil price:

$$VOL_t = \sum_{i=1}^{n_t} \frac{(log(P_t^{d+1}) - log(P_t^d))^2}{n_t} \tag{2}$$

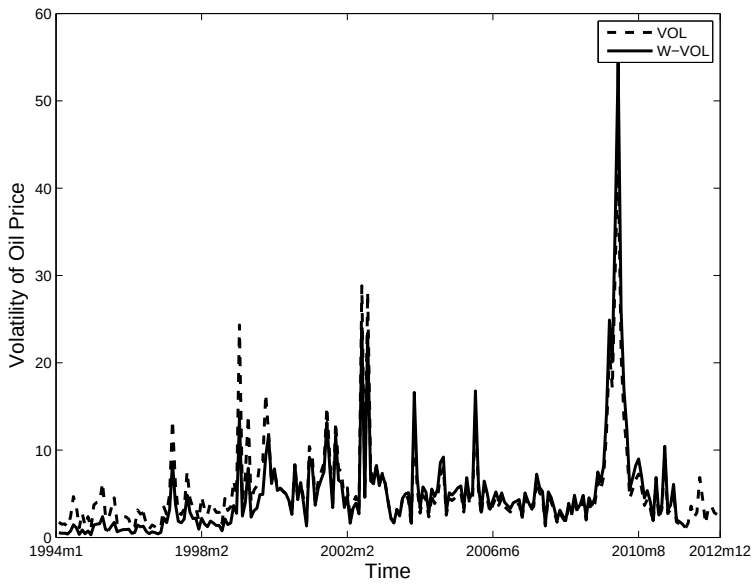
In which n_t denotes the number of trading days in month t. Since trading days in different months are not the same, we can not simply replace n_t with 30. P_t^d stands for the spot oil price in day d of month t .

China is a transition country, and its oil imports in 2012 are 15.8 times as many as those in 1993. We calculate this number based on the data from U.S. Energy Information Administration (EIA, hereafter). Obviously, the oil price volatility in 1993 is different from that in 2012. In view of this distinguished characteristic of China, we need to introduce a new measure of oil price volatility, which is intended to capture the transition features of China. What we do is weight the measure of Merton (1980), Anderson et al. (2003) and Park & Ratti (2008) by the ratio of oil import to output. Formally, it could be formulated as:

$$WVOL_t = \frac{E_t}{Y_t} \cdot \sum_{i=1}^{n_t} \frac{(log(P_t^{d+1}) - log(P_t^d))^2}{n_t} \tag{3}$$

Where $WVOL_t$ is weighted oil price volatility, and the remainder notations possess the same meanings as the ones in equation (2). $WVOL_t$ and VOL_t is plotted in Figure 4. Both $WVOL_t$ and VOL_t are normalised values. Figure 4 suggests that $WVOL_t$ is statistically less than VOL_t from 1994 to 2000, reflecting the less importance of oil for China in this period. Nevertheless, they are quite close to each other ($WVOL_t$ is marginally higher than VOL_t) after 2000. Both $WVOL_t$ and VOL_t show that the three sharpest spikes are successively in 1999, 2003 and 2009. The one in 1999 presumably associated with the Asian financial crisis happened during 1998-2000; The spike in 2003 may be due to the Iraq War waged in March 2003. The last, also the sharpest, spike may largely be contributed by the financial crisis of 2008. The oil price volatility is included in the regression model (equation (1)).

Figure 4: The Volatility of Oil Price



3.2 SVAR Model

In virtue of the work of Sims (1980), the vector auto-regression (VAR), has already become a widely used approach in macro-economy empirical analysis. Nevertheless, VAR is also con-

stantly exposed to the criticism that it lacks economic interpretations. As Bernanke et al. (1997) indicates, it is not possible to infer the effects of changes in policy rules from a standard identified VAR system, since this approach typically provides little or no structural interpretation of coefficients that make up the lag structure of the model. By contrast, SVAR incorporates some structures or the economic theory into the analysis. Hence, we will investigate oil price shocks within the framework of the SVAR in this paper. Formally, the SVAR system is formulated as:

$$\mathbf{A}(\mathbf{I_K} - \mathbf{A_1L} - \mathbf{A_2L^2} - \cdots\cdots - \mathbf{A_PL^P})\mathbf{Y_t} = \mathbf{Be_t} \tag{4}$$

where $\mathbf{A}$ and $\mathbf{B}$ include the information that the economic theory implies and are $k \times k$ matrices. $\mathbf{L}$ denotes lag operator, $\mathbf{A_1} \cdots \mathbf{A_P}$ are $k \times k$ matrices, $\mathbf{e_t}$ is $k \times 1$ orthogonalized disturbance term, that is, $\mathbf{e_t} \sim \mathbf{N}(\mathbf{0}, \mathbf{I_K})$, and $\forall s \neq t$, $\mathbf{E}(\mathbf{e_t e_s'}) = \mathbf{0_K}$. But what we can directly estimate is its reduced form:

$$\mathbf{Y_t} = \mathbf{A_1Y_{t-1}} + \mathbf{A_2Y_{t-2}} + \cdots\cdots + \mathbf{A_PY_{t-P}} + \mathbf{u_t} \tag{5}$$

Where $\mathbf{u_t}$ is disturbance term and $\mathbf{u_t} \sim \mathbf{N}(\mathbf{0}, \mathbf{\Sigma})$. Thus the relationship of the parameters in equation (4) and equation (5) can be written as:

$$\mathbf{u_t} = \mathbf{A^{-1}Be_t} \qquad \mathbf{\Sigma} = \mathbf{A^{-1}B}(\mathbf{A^{-1}B})' \tag{6}$$

By comparing the number of parameters between (4) and (5), we know that $\frac{3k^2-k}{2}$ constraints are needed to identify (4), where k is the number of endogenous variables. In order to identify the model, we order the variables in the SVAR model as: oil price, real output, price level, interest rate, money supply and exchange rate. That is, the oil price is prior to other macroeconomy variables, signifying the oil price has a contemporary effects on other variables, but not the other way around; a reasonable assumption, since the oil price is primarily determined by the environment of the whole world but not a single country. Besides, we put all nominal variables after the real output. This is equivalent to what we assume, that the real output has contemporary effects on them, but not the opposite; also, a weak assumption, since the commonly known time-lag influences of nominal and policy variables on real variables, which are indicated by the economic theory. Furthermore, we suppose the off-diagonal elements of the B matrix are all zero, meaning that the error terms of different times are not correlated. Considering that we have included current variables in the system, this assumption is also not unreasonable. For now, combined with the normalization of the current variables' coefficients to 1, we will exactly identify the SVAR system. The identification information is briefly summarized as:

$$\mathbf{A} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 \end{pmatrix} \qquad \mathbf{B} = \begin{pmatrix} b_{11} & 0 & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & b_{55} & 0 \\ 0 & 0 & 0 & 0 & 0 & b_{66} \end{pmatrix}$$

3.3 Nonlinear Test and Alternative Specification

Both VAR and SVAR models are based on linear specifications. Therefore, they can't reflect asymmetric macroeconomic variables, Mork (1989), Lee et al. (1995), Ferderer (1996), Davis & Haltiwanger (2001), Balke et al. (2002), Hamilton (1996, 2003), Kilian & Vigfusson (2009), Carlton (2010), Ravazzolo & Rothman (2010) and Herrera et al. (2010). Before estimating the model, it is useful and necessary to carry out a nonlinearity test of the oil price's effects. Define

OP_t as the log difference of oil price. Following Mork (1989), we separate the oil price into positive and negative ones: $OP_t^+ = max(0, OP_t)$ and $OP_t^- = min(0, OP_t)$. Along the lines of Hamilton (2003), we run OLS as follows:

$$V_t = c + \sum_{i=1}^{p} \alpha_i V_{t-i} + \sum_{i=1}^{p} \beta_i OP_{t-i} + \sum_{i=1}^{p} \gamma_i OP_{t-i}^{\#} + \varepsilon_t \tag{7}$$

In which $V_t \in$ {real output, price level, interest rate, money supply, exchange rate} and is in log difference form, $OP_{t-i}^{\#} \in \{OP_t^+, OP_t^-\}$. Our null hypothesis is that the oil price has no asymmetry effects, meaning $\gamma_1 = \gamma_2 = \cdots = \gamma_p = 0$.

For robustness reasons, we also consider the transformation of oil price to allow for the measure of how unsettling an increase in the price of oil is likely to be for the spending decisions of consumers and firms, which is carefully studied by Hamilton (1996). Following literature, we exploit the transformation due to Hamilton (1996), as is titled as "Net Oil Price Increase" and is formally defined as:

$$NOPI_t^n = max(0, OP_t - max(OP_{t-1}, OP_{t-2} \cdots OP_{t-n})) \tag{8}$$

where $NOPI_t^n$ denotes "Net Oil Price Increase", OP_t stands for the current log-difference oil price as before. Note that we have used log-difference of the variables in the SVAR analysis above, thus this transformation is used for log-difference oil price. The parameter n need to be chosen, following Park&Ratti (2008) and Wang et al. (2013), we choose n = 6.

3.4 Oil Price and Recent Data

According to Figure 1, along the substantial surge of world oil price, while the oil imports of the other major countries (especially the largest oil import country US) in the world steadily decline or remain stable, China's oil imports, in contrast, have kept rapidly rising since the year 2004. Although this can be interpreted by many factors, our findings above will potentially shed light on this. To see this, we now consider a simple framework. The relationship between total output Y, and the three production inputs, the stock of capital K, labour L and energy E at the aggregate level of the economy is interpreted as the following technology:

$$Y_i = F(N_i, K_i, E_i) \tag{9}$$

In which the subscript $i \in$ {c=China, o=other major countries}, China and other major countries are denoted by "c" and "o" for short, respectively (same as below). Suppose the price of output is P, labour is paid W, capital is rented at price r and energy is bought at price Q. The representative firm's problem is to choose the number of workers, the amount of physical capital and energy to be used in production to maximise the profits:

$$\pi_i = P_i F(N_i, K_i, E_i) - r_i K_i - W_i N_i - Q_i E_i \tag{10}$$

The standard optimality condition for energy use is:

$$P_i F_E(N_i, K_i, E_i) - Q_i = 0 \tag{11}$$

Where $F_E(N_i, K_i, E_i)$ denotes the partial derivative of $F(\cdot)$ with respect to energy use E. After some simple transformations, the elasticity of output Y to energy use E is derived from (11):

$$\eta_i = \frac{\partial lnF_i}{\partial lnE_i} = \frac{E_i Q_i}{Y_i P_i} \tag{12}$$

Note that the world oil price is the same for all the countries, i.e. $Q_c = Q_0$. The relative elasticity of output to energy use between China and other major countries (denoted by ν_c^o) is therefore:

$$\nu_o^c = (\frac{E_c}{Y_c}\frac{Y_o}{E_o})\frac{P_o}{P_c} \tag{13}$$

When we denote the expression $\frac{E_c}{Y_c}\frac{Y_o}{E_o}$ by G, the relative elasticity of output to energy use between China and other major countries can be rewritten as:

$$\nu_o^c = G\frac{P_o}{P_c} \tag{14}$$

It is broadly known that the elasticity of output to energy is the percents of output increase with respect to one percent rise of energy use. Hence, (14) can be seen as the relative elasticity of output to energy between China and other major countries. Therefore, if oil price shocks influence $\frac{P_o}{P_c}$ and G stays stable, we will claim that oil price will influence the relative elasticity of output to energy and further influence the oil imports of China and other major countries. This argument will be explored in detail in section 4.

4 Data and Empirical Results

4.1 Data

In the SVAR estimation, we convey monthly data spanning from 1994 to 2012 to uncover the effects of oil price shocks on China's macro-economy. While we can easily explore the influences of oil price shocks on other macro-economic variables of relevance, we primarily focus on real output, general price level, money supply, interest rate and exchange rate on two grounds. First, they are most relevant to living standards and thus have received the closest attention from ordinary people. Second, in oil literature (Bernanke et al. (1997), Zhang and Xu (2010), Du et al.(2010) and so on) they are also the most commonly studied, therefore, primarily focusing on these variables allows our results to be more comparable to the existing literature. In addition, what is worthy of attention is although we can, to some extent, control the effect of exchange rate by directly transforming the US dollar oil price to the RMB price (for example, Cong et al.(2008), Du et al.(2010)), we explicitly incorporate the exchange rate into the variable system. This is quite natural and reasonable, especially recognising the above-mentioned essential role of international trade in China.

For the reason that the National Bureau of Statistics of China (NBS) only publishes yearly and quarterly GDP data, following Zhang and Xu (2010), we use monthly industry output as the proxy of monthly output, and deflating them into real output. Consumer price index (CPI) is generally regarded as an appropriate proxy of the price level. We use CPI, compared to the same month in the previous year, available in NBS as the proxy of price level. It is widely known that the central bank frequently reacts to the fluctuations of the macro-economy. Therefore, variables that could best capture the central bank's policy should be incorporated. Money supply is regularly regarded as the monetary policy instrument of the People's Bank of China. Taking the broadly recognised distinctions between M1 and M2 into account, instead of M2, we exploit M1 (obtained from the web-site of the People's Bank of China) to stand for monetary supply. In the view of the fact that the formation mechanism of interest rates is becoming increasingly market-oriented, we also involve interest rates into our system, which may, potentially, further capture the monetary policy. It is measured by the 6-month short-term

loan interest rate derived from the arithmetic mean of the daily data, and, again, obtained from the web-site of the People's Bank of China. As for exchange rates and oil prices, we get them from the OECD and EIA databases, respectively.

Table 1: Definitions and Statistics of Variables

Variables	Definition	Mean	Stand Error	Minimum	Maximum
OilP($/Barrel)	Oil Price	43.86	30.94	9.82	132.70
ER(RMB/$)	Exchange Rate	7.90	0.66	6.30	8.71
M1(Hundred Million RMB)	Money Supply	95045	74936	15435	289847
IR(%)	Interest Rate	7.06	2.17	5.31	12.06
Y(Hundred Million RMB)	Output	20694	19993	2992	77574
CPI(%)	Price Level	4.31	6.34	-2.20	27.70

Note: We have normalised consumer price index(CPI) by subtracting 100.

As for the data used in the regression model (equation(1)), different countries' GDP growth rates, short-term interest rates, money supply growth rates and exchange rates against the US dollar over the period 1992:q1-2014:q2 are from the OECD database. As the GDP growth rate of China from 1992:q1 to 2010:q4 is missing in the OECD database, we calculate the missing values on the basis of the published NBS data. World oil price data is from EIA. It should be noted that although, for China's data, we can use those from domestic databases, instead, we use the data from the OECD database, which enables our comparisons below more convincing, since due to different calculation methods or reference points, even the same variable from different databases will be diverse.

4.2 Asymmetric Effects of Oil Price on The Price Level of China and Other Major Countries

The regression results of (1) are presented in Table 2. These results provide substantial support to the point that the effects of oil price on China's price level and those of its major trade partners' are asymmetric–the oil price rise is intended to increase the price level of China's major trade partners more than that of China's, thus China's relative price drops. These asymmetry effects are presumably correlated to the fact that oil pricing is not completely liberalized in China. More concretely, the oil price in China is to some extent regulated by the government, and thus oil price shocks will be inclined to have less influence on China's price level. Table 2 suggests that our results survive different methods and the choices of different countries, and therefore are quite robust.

In addition, considering that central banks frequently react to price level increases, we also report IV estimators in Table 2. Specifically, for China, we use a two period-lag money supply as the instrument of money supply itself; For its major trade partners, we use a two period-lag interest rate as the instrument of interest rate itself. Since the time interval of one period is one quarter, supposing that a two period-lag of money policy variable is not correlated with a price level is a good approximation. Using one period-lag of money policy variable as instruments does not essentially change the results. The previous IV estimation means that we regard money supply as the endogenous variable in the regression for China, and the interest rate as the endogenous variable in the regression for its major trade partners. We also consider the interest rate is endogenous in the regression for China, the difference of the results are negligible.

Besides, for the reason that the world oil price is the same for all the individual countries, fixed effect regression is not implementable, we do not report fixed effect estimators.

Table 2: Oil Price Effects on Price Level

	OLS			IV		
	China	Chosen Countries		China	Chosen Countries	
		RE	BE		RE	BE
All OECD Countries and BRICS	0.0581	0.2703	0.2145	0.0578	0.2697	0.2121
Top 20						
Net import from China and net oil import	-	0.2473	0.2201	–	0.2471	0.2172
Total trade with China and oil import	-	0.2329	0.1792	–	0.2339	0.1772
Top 40						
Net import from China and net oil import	-	0.2694	0.1952	–	0.2761	0.1948
Total trade with China and oil import	-	0.2700	0.1864	–	0.2600	0.1766
Top 60						
Net import from China and net oil import	-	0.2694	0.1952	–	0.2761	0.1948
Total trade with China and oil import	-	0.2623	0.2264	–	0.2602	0.2129

Note: The item "Net import from China and net oil import" under "**Top 20**" contains the countries whose net import from China and net oil import from other countries simultaneously rank in the top 20 in the world and also belong to the OECD or BRICS, and it corresponds to "Countries-A" in Table 7 in **APPENDIX**. The item "Total trade with China and oil import" under "**Top 20**" contains the countries whose total trade with China and oil import from other countries simultaneously rank in the top 20 in the world and also belongs to the OECD or BRICS, it conresponds to "Countries-B" in Table 7 in **APPENDIX**. The explanations of the remainders are similar. Note that the coefficients of two rows are the same, this is because, relative to the former criterion, only one more country (Finland) is included according to the latter criterion. RE and BE stands for random effect and between estimator, respectively.

- denotes 0.0581
– denotes 0.0578
All the coefficients are significant at 5 % level.

It should be noted that although we control the important variables, it may be the case that the lag of oil price affect the price level. We therefore report the results (see Table 3) that control the lag of oil price. Basically, our results do not change. Considering the limited space, only the case that one-lag of oil price is controlled is reported. The results are similar in other cases. While the coefficients of the current oil price substantially change, the sum of the coefficients of the current oil price and one-period lag oil price is quite close to the coefficients in which lag oil price is not controlled in Tabel 2. On the one hand, as it is indicated in section 3 the oil price volatility may affect the price level; on the other hand, it is obviously correlated with the oil price itself. That is oil price volatility is potentially endogenous, therefore it needs to be included in the regression model. The estimated results controlling oil price volatility are reported in Table 4. The coefficients are essentially similar to the ones in Table 2, again suggesting the robustness of our results.

4.3 SVAR Results and A New Interpretation

Using the methodology described in section 3, we are able to investigate the effects of oil price shocks on China's macro-economy. The SVAR model is estimated using 2 lags, as determined by AIC and FPE criterions.

The asymmetry test results based on (7) are reported in Table 5. While we can report the

Table 3: Oil Price Effects on Price Level (Lag Oil Prices Are Controlled)

	OLS			IV		
	China	Chosen Countries		China	Chosen Countries	
		RE	BE		RE	BE
All OECD Countries and BRICS	0.0454	0.1293	0.1414	0.0453	0.1311	0.1411
	(0.0159)	(0.1471)	(0.0797)	(0.0160)	(0.1446)	(0.0795)
Top 20						
Net import from China and net oil import	-	0.1660	0.1393	–	0.1657	0.1373
	-	(0.0847)	(0.0876)	–	(0.0846)	(0.0877)
Total trade with China and oil import	-	0.1610	0.1109	–	0.1589	0.1100
	-	(0.0747)	(0.0729)	–	(0.0776)	(0.0727)
Top 40						
Net import from China and net oil import	-	0.1532	0.1223	–	0.1513	0.1161
	-	(0.1207)	(0.0812)	–	0.1231	(0.0883)
Total trade with China and oil import	-	0.1431	0.1095	–	0.1479	0.1012
	-	(0.1232)	(0.0834)	–	(0.1168)	(0.0867)
Top 60						
Net import from China and net oil import	-	0.1532	0.1223	–	0.1513	0.1161
	-	(0.1207)	(0.0812)	–	0.1231	(0.0883)
Total trade with China and oil import	-	0.1246	0.1435	–	0.1266	0.1307
	-	(0.1440)	(0.0901)	–	(0.1393)	(0.0977)

Note: The explanations of this table is similar to those of Table 2. The numbers denote the coefficients of the current and lag oil price. And the ones in brackets stand for the coefficients of one-period-lag oil price.

- denotes 0.0454 (0.0159)

– denotes 0.0453 (0.0160)

All the coefficients are significant at 5 % level.

lags chosen by certain criterion, we instead present all lags of interest. This is motivated by the combined observations that the lag lengths chosen based on different criteria are not consistent and the criterion values of different lags are quite close. It can be claimed from the results that the null hypothesis couldn't be rejected in most cases, which in turn signifies that the linear symmetric model provides a good approximation in modelling the responses to oil price shocks (Kilian & Vigfusson (2011)), and increases the credibility of our model specification. Figure 5 presents the resulting impulse functions of real output, level price, interest rate, money supply and exchange rate to oil price shocks.

The response of main macro-economy variables are presented in Figure (5). We also re-estimate the SVAR model under the specification of Hamilton (1996), and the resulting impulse response functions are shown in Figure(6). Though the results is quantitatively different from those illustrated in Figure 5, the response directions don't essentially change. Even if the differences between them in terms of quantity can well be explained by recognising that this transformation moderates the fluctuation of the oil price.

Both Figure 5 and Figure 6 show that, except for the responses of output and exchange rate, our findings are quite intuitive and consistent with most of the existing literature. Specifically, the general price level of China rises in response to an increase in oil price. The rise in interest rates and decrease (although there is a small rise in period 4, it is not statistically significant)

Table 4: Oil Price Effects on Price Level (Volatility is Included)

	OLS			IV		
	China	Chosen Countries		China	Chosen Countries	
		RE	BE		RE	BE
All OECD Countries and BRICS	0.0594	0.2577	0.2115	0.0600	0.2565	0.2101
Top 20						
Net import from China and net oil import	-	0.2366	0.2120	–	0.2350	0.2079
Total trade with China and oil import	-	0.2210	0.1786	–	0.2203	0.1793
Top 40						
Net import from China and net oil import	-	0.2646	0.1905	–	0.2635	0.1891
Total trade with China and oil import	-	0.2412	0.1935	–	0.2395	0.1906
Top 60						
Net import from China and net oil import	-	0.2646	0.1905	–	0.2635	0.1891
Total trade with China and oil import	-	0.2413	0.2164	–	0.2395	0.2010

Note: The explanations of this table is similar to those of Table 2.

- denotes 0.0594
– denotes 0.0600
All the coefficients are significant at 5 % level.

Table 5: Asymmetry Test

	1-Lag	2-Lags	3-Lags	4-Lags	5-Lags	6-Lags	7-Lags	8-Lags	9-Lags	10-Lags
Output	0.4885	0.6985	0.3452	0.8074	0.9220	0.9393	0.9561	0.7935	0.8072	0.8931
	(0.48)	(0.36)	(1.11)	(0.40)	(0.28)	(0.29)	(0.29)	(0.58)	(0.59)	(0.49)
Price Level	0.0418**	0.1287**	0.3643	0.3004	0.3065	0.6717	0.5333	0.8620	0.6534	0.8605
	(4.22)	(2.08)	(1.07)	(1.23)	(1.22)	(0.67)	(0.87)	(0.49)	(0.76)	(0.54)
Interest Rate	0.0129**	0.0235**	0.0744*	0.0916*	0.1367	0.2802	0.2933	0.4101	0.5261	0.5343
	(6.29)	(3.82)	(2.34)	(2.03)	(1.70)	(1.42)	(1.22)	(1.04)	(0.90)	(0.90)
Money Supply	0.7656	0.9229	0.8787	0.9759	0.9381	0.8076	0.7773	0.5028	0.4356	0.6990
	(0.09)	(0.08)	(0.23)	(0.12)	(0.25)	(0.50)	(0.57)	(0.92)	(1.01)	(0.73)
Exchange Rate	0.7188	0.5657	0.7055	0.4853	0.4794	0.6016	0.7008	0.7649	0.8221	0.8820
	(0.13)	(0.57)	(0.47)	(0.87)	(0.90)	(0.76)	(0.67)	(0.61)	(0.57)	(0.51)

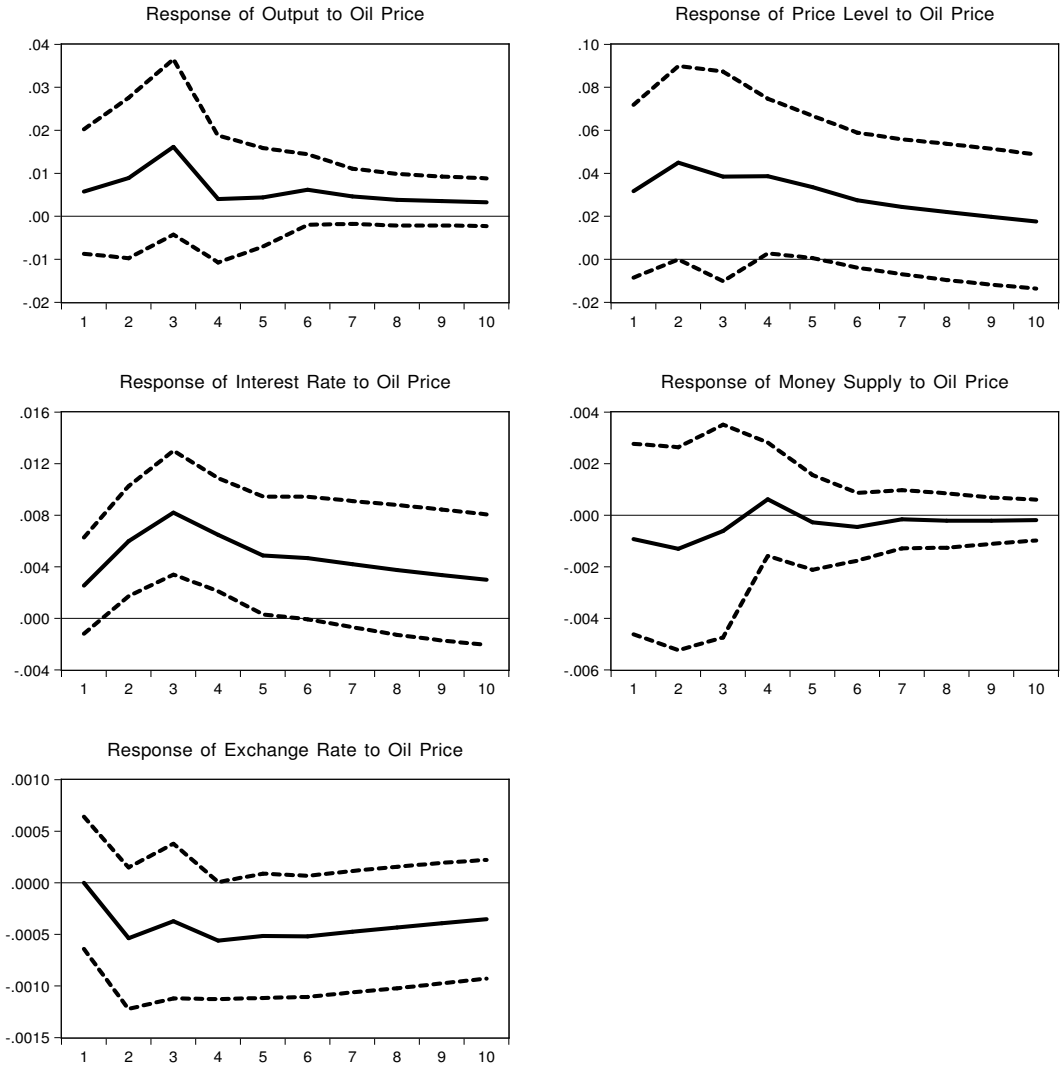
Note: The numbers out and in parentheses are p-values and F statistics, respectively. Null hypothesis is that the world oil price has no asymmetry effects on the variables of interest.

*** denotes significant at 1% level
** denotes significant at 5% level
* denotes significant at 10% level

in money supply indicate the monetary policy tends to be tight in response to oil price shocks, showing the central bank's worry about inflation induced by oil price rising. Interestingly and notably, the response of interest rate is more persistent and quantitatively significant than that of money supply. This may reflect the swing in China's monetary policy instrument from giving priority to money quantity towards money price. Actually, in as early as 2001, Xia & Liao (2001) pointed out that money quantity is not appropriate to function as an intermediate target of monetary policy any more.

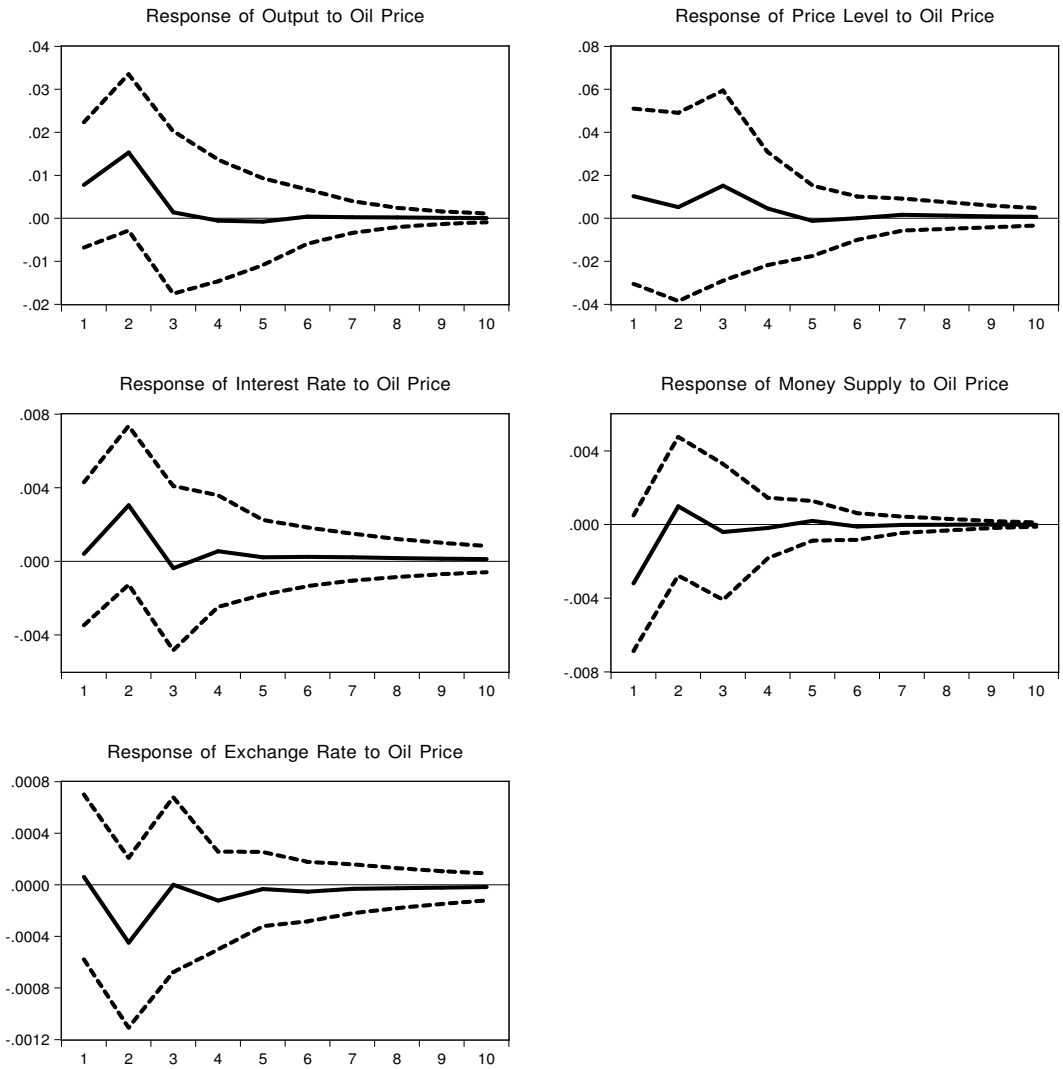
One puzzle that emerges is that the real output of China is positively correlated with oil price shocks. This finding is similar to that of Du et al. (2010) whose study period spans from 1995 to 2008. In their paper, by arguing that "$\cdots$ both China's growth and the world's oil price

Figure 5: The Responses of Main Macro-economy Variables to Oil Price Shocks (95% confidence interval)



are affected by US and EU countries' economic activity in the same direction, and this in turn makes us observe $\cdots$ China's GDP and world's oil price is positively correlated from 1995 to 2008" , the authors give a possible and preliminary interpretation for this. But we want to go further and examine this puzzle not only from exogenous factors, but also pay more attention on China itself. As for the response of the exchange rate, according to Figure 5 and Figure 6, it can be claimed that oil price shocks slightly appreciate the RMB, which is also counter-intuitive. A similar pattern is found by Huang & Guo (2007), which specialises in the study of the effects of oil price shocks on China's exchange rate, using a four variable VAR system. The authors' explanation is "$\cdots$ China's less dependence on imported oil than its trade partners included in the RMB basket peg regime and rigorous energy regulation." Their study period spans over 1990-2005, we know from Figure 1 that this argument maybe a plausible approximation for the real condition of that period. But after 2008, China has been the world's second largest oil-import country and its oil imports still keep rising, obviously their argument will not convincing any more.

Figure 6: The Responses of Main Macro-economy Variables to Oil Price Shocks (Hamilton Specifications) (95% confidence interval)



Is there any mechanism that can simultaneously interpret these two puzzles in a unified framework? We find above that there is a higher increase in the price level of China's main trade partners resulting from oil price shocks than that of China's. Based on this result, not only can we interpret the abnormal phenomenon of the output's response to oil shocks, but also, in prospect, resolve the puzzle of the RMB's slight appreciation. This is because, relative to China, the higher increase of its main trade-partners price levels resulting from oil price shocks will tend to stimulate China's exports and thus its output; In addition, economic theory documents that the decline of the relative price will be inclined to appreciate the exchange rate, which implies that our results potentially provide a justification of the slight appreciation of the RMB against the US dollar resulting from oil price shocks. Although the appreciation of the RMB will moderate the positive effects of relative price decrease on the exports, we have reason to believe that it will not change the effects, since both Figure 5 and Figure 6 suggest that the appreciation resulting from oil price shocks is marginal.

4.4 Our Findings and Recent Data

We investigate that the way oil price shocks influence the relative price of China to its major trade partners in the world is also well consistent with recent data. One of the most salient facts is that along the substantial surge of the world oil price , while the oil imports of the other major countries (especially the largest oil import country US) in the world steadily decline or remain stable, China's oil imports, in contrast, have kept rapidly rising since the year 2004.

Note that from (14) $\frac{P_o}{P_c}$ is the relative price of other major countries to China. The evidence we present above suggests that the magnitude of price level rise induced by oil price shocks of China is less than that of other major countries in the world, which implies that $\frac{P_o}{P_c}$ rises. And this, in turn, tends to increase the relative elasticity of output to energy use ν_o^c. Here, we implicitly assume G in equation (14) stays stable or the change of G is independent of $\frac{P_o}{P_c}$. There are two possibilities that G stays stable, one is both $\frac{E_c}{Y_c}$ and $\frac{Y_o}{E_o}$ are stable, the other is that they change in the same direction. To see this assumption is not an unreasonable approximation, we calculate the ratios of energy E to output Y of China and other countries (all OECD countries and BRICS as a whole). Both output Y and energy use E here are in real terms. The results are shown in Table 6. It can be easily argued that the values of G basically stay stable. While there seems to be a structural change in about 2008, to a great extent, it can be largely contributed by the financial crisis in 2008 (thus is exogenous) rather than the change of $\frac{P_o}{P_c}$.

Table 6: Ratios of Energy Use to Output

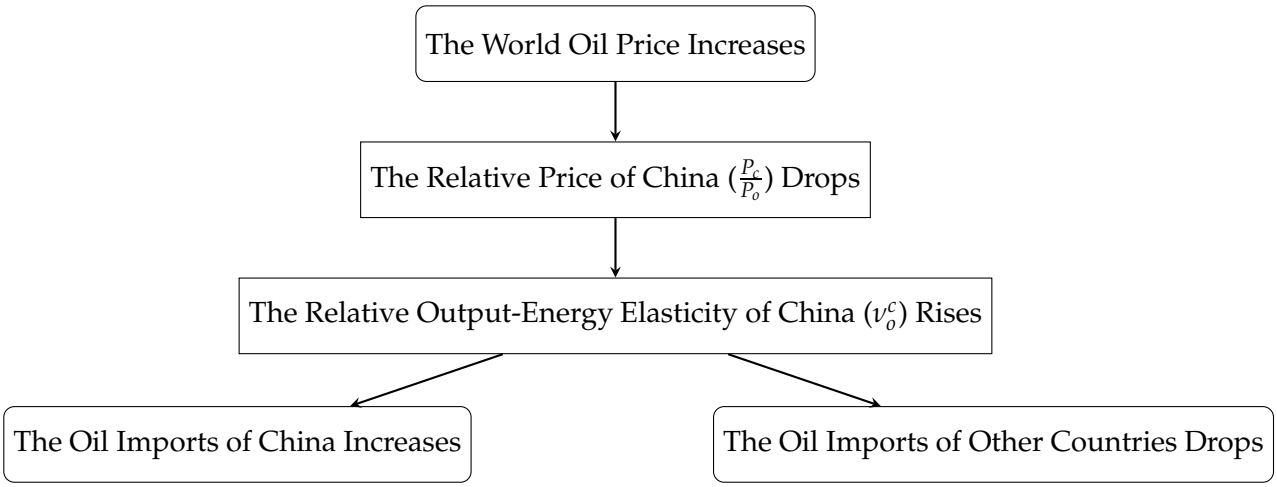
Year	$\frac{E_c}{Y_c}$	$\frac{E_o}{Y_o}$	G
2004	1.2078	0.8990	1.3435
2005	1.1515	0.8792	1.3098
2006	1.1422	0.8491	1.3452
2007	1.1243	0.8263	1.3607
2008	1.1241	0.8176	1.3748
2009	1.1743	0.7993	1.4691
2010	1.2382	0.7818	1.5837
2011	1.1537	0.7536	1.5309
2012	1.0915	0.7453	1.4645

Note: The real outputs Y_c and Y_o data is obtained from World Bank database. Their units are billion (2005 constant) US dollars. E_c and E_o are from EIA database as above, the units are Thousand Barrels/day.

As we have mentioned in part 4 of section 3, ν_o^c can be considered to be the relative elasticity of output to energy of China to other major countries. Straightforwardly, the rise of relative elasticity of output to energy of China to other major countries contributed by oil price increase, could partially explain the increase of China's oil imports and the drop of other major countries' oil imports in recent years. This is because the rise of the elasticity in output with respect to a given energy use, which implies that energy is more useful to China, will stimulate it to import more energy, and also induce the firms to substitute other input factors by energy. In

order to see more clearly how our findings fit the fact that together with the dramatic surge of world oil price , while the oil imports of the other major countries (especially the largest oil import country US) in the world steadily decline or remain stable, China's oil imports, in contrast, have kept steadily rising since the year 2004, we have briefly summarized our points above in a flowchart as follows:

Figure 7: A Interpretation For Observed Facts



5 Conclusion and Policy Implications

International trade has played a significant role in China over the last 20 years. In this paper we examined the influences of oil price shocks on China from this new perspective. We find that world oil price shocks have a positive relationship with both China's real output and price level. We argue that the asymmetry effects (may be resulted from the fact that the oil pricing is to some extent regulated by the government in China) of oil price shocks on China and its major trade partners maybe an important factor in accounting for the "abnormal" response of output to oil price shocks. Besides, this argument also provides a new, possibly more reasonable, interpretation for the slight appreciation of the RMB responding to oil price increase, also found by other authors. Moreover, our results also shed light on the fact that together with the dramatic surge of world oil price, while the oil imports of the other major countries (especially the largest oil import country US) in the world steadily decline or remain stable, China's oil imports, in contrast, have kept rising fast since the year 2004. What needs to be pointed out is that China's exchange rate slightly appreciates in response to oil price rises. Future work is needed to identify to what extent this slight appreciation of exchange rate depresses the positive effects of relative price decrease on the exports of China and thus on output.

Our paper also has significant policy implications. We have found that both the real output and price levels of China are positively correlated with oil price shocks. Imagine that, confronted with an oil price increase, the authority mistakenly considers the output is, just as many papers imply, negatively correlated with oil price shocks, and take steps to stimulate the economy. This may lead to a second round increase in both the real output and the price level, the economy will consequently be liable to get overheated. Now consider another case that the

authority wants to offset the inflation induced by oil price increases. If it believe that the output negatively responds to oil price increases, worrying about further recession in output caused by tight policy, the authority will be inclined to compromise its original target and take modest measures to offset the inflation induced by the oil price increase. Our results, however, imply that a relatively severe measure may be a better choice in this case.

APPENDIX

Table 7: Classification of Countries

Countries-A	Countries-B	Countries-C	Countries-D		Countries-E	Countries-F	
US	US	US	US	Finland	US	US	Ireland
Turkey	UK	Turkey	UK	Chile	Turkey	UK	Indonesia
Poland	Netherlands	Spain	Turkey	Canada	Spain	Turkey	India
Netherlands	Korea	Portugal	Sweden	Brazil	Portugal	Switzerland	Hungary
Italy	Japan	Poland	Spain	Belgium	Poland	Sweden	Greece
India	Italy	Netherlands	South Africa	Australia	Netherlands	Spain	Germany
France	India	Italy	Poland	-	Italy	South Africa	France
Belgium	Germany	Israel	Netherlands	-	Israel	Russia	Finland
-	France	India	Korea	-	India	Poland	Denmark
-	Canada	Hungary	Japan	-	Hungary	New Zealand	Chile
-	Brazil	Greece	Italy	-	Greece	Netherlands	Canada
-	Australia	France	Indonesia	-	France	Korea	Brazil
-	-	Belgium	India	-	Finland	Japan	Belgium
-	-	-	Germany	-	Belgium	Italy	Austria
-	-	-	France	-	-	Israel	Australia

Note: This table is a supplement of Table 2. And "-" in this table is intended to fill the space. With regard to the meanings of Countries-A$\cdots$Countries-F, see the note of Table 2.

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