Oil price shocks, market distortion and output growth: Theory and evidence from China

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Abstract:

Energy prices are often distorted by government control, which is usually justified on the ground that such control will help mitigate the negative impact of price volatility from oil imports and thus positively affect domestic economy. In this paper, we show in a two-sector growth model that such price distortion indeed affects the economy, and then based on the model, we empirically estimate its impact on the output growth in China, using monthly time series data. In contrast to the usual argument for price control, we find that the price distortion negatively affects the output growth in China in both the short run and long run, which is robust to different measures of output and price distortion. The price control is one important barrier towards energy market integration. Since the induced distortion dampens domestic economy, the ground to maintain price control is seriously undermined. Therefore, the finding of this paper lends support to the energy market integration that many regions, such as East Asia, are advocating.

Key words: price regulation; macroeconomy; price distortion; energy market integration; China

JEL classification: C02, E23, Q43

1. Introduction

The relationship between oil price and macroeconomy has been debated since early 1980s (Hamilton, 1983) with the first oil crisis and the global recessions that followed (Jones et al., 2004; Segal, 2007). These studies were initially spurred by the stagnation of the US economy in the 1970s as oil price shocks were thought to be the only promising hypothesis to explain the stagflation (Barsky & Kilian, 2004). Many early studies, such as Darby (1982) and

Hamilton (1983; 1985), demonstrate that changes in oil price have significant impacts on output, employment, inflation and economic growth. However, others argue that, the induced monetary policy, rather than oil price shock itself, is the key driver for recessions after oil price shocks (Bernanke et al., 1997; Chen, 2009; Clark & Terry, 2009). The issues were revitalized in the 2000s with the fact that oil price has risen more than 600 per cent between 2001 and 2008, while the average quarterly core inflation in the US was only about 2 per cent over the same period (Clark & Terry, 2009). A more recent study finds that the relationship may exist in some cases of oil shocks but not in the others (Kilian, 2008).

In China, on which this paper focuses, literature on the impact of international oil price shock on economic growth also yields inconclusive findings. Zaouali (2007), using a CGE model, finds that an oil price hike will have negative impact on GDP, and the impacts on the petroleum sector is much more serious than on the non-petroleum sector. Tang et al. (2010) also find that oil price increase will lead to output decrease. Using a structural dynamic factor model approach, Ou et al. (2012) find that oil price shock will make China's industrial output increase initially but decrease for a long term subsequently. Lescaroux & Suez (2009) show that an oil price shocks leads to a delayed negative impact on GDP as well. However, in contrast, Du *et al.* (Du *et al.*, 2010; Wu *et al.*, forthcoming) find that China's GDP is positively related to oil price increase.

Despite the empirical results are inconclusive, it appears that policy makers generally believe that oil price shocks exert a negative impact on domestic economy, and due to this belief price regulation in the energy market, such as price cap and subsidies, has been practiced for a long time and is still prevailing in many countries (IEA, 2012). Many policy makers prefer to have such price regulation on the ground that these measures can insulate the domestic economy from negative impacts of high oil prices in the world market. For example, Indonesia and Malaysia fixed their petroleum prices at a very low level (Wu *et al.*, 2012).

Nevertheless, the price regulation will inevitably lead to price distortion in the energy market, and is one important barrier towards energy market integration that many regions, such as East Asia, are advocating (Shi & Kimura, 2010). Although policy makers hope such price regulation may help domestic economy, the induced distortion may actually exert negative impacts. If the distortion dampens domestic economy, the ground to maintain price regulation will be seriously undermined.

Therefore examining the impact of price distortion will present significant implications to policy makers, and shed light on a better understanding of energy market integration.

However, even for its policy significance, to the best of our knowledge, there is no previous study that explores the impact of energy price distortion on domestic economy. To fill this gap, this paper intends to explore the impact of energy price distortion, both theoretically through a two-sector growth model and empirically by a time-series analysis of China's case.

This paper focuses on China, a large developing economy. On the one hand, China's fast economic growth creates a huge demand for such resources as oil; while on the other hand it also maintains a number of intervention measures, such as price control, in the domestic energy market. Since 2009, the imported oil has accounted for more than half of total oil consumption in China, and meanwhile the oil price has become more volatile. Investigating the impact of price distortion, which occurs due to these intervention measures, will lead to significant implications for policy makers not only in China but also in other developing economies. Later, our empirical exercise will reveal that such distortion does harm to the industrial output.

The contribution of this paper lies in four folds. First, we explicitly introduce the role of energy market distortion into the well examined oil price shock-macroeconomy nexus. We further argue that market distortion, including energy price distortion, will have a significant negative impact on the relationship. . Second, we illustrate the impact of the price distortion in a two-sector growth model. Third, our empirical exercise focuses on China, a large and fast growing developing economy with high dependence on imported oil and price control, which will lead to significant implications for policy makers both in China and other developing countries. We also propose several measures of the price distortion in China. Fourth, our study will also shed light on a better understanding of energy market integration which is often blocked by subsides and other price control measures in domestic markets.

The rest of the paper proceeds as follows. Following the introduction, in Section 2 we present a discussion of the oil consumption and energy pricing mechanism in China, which gives background information for subsequent exercise, and measures the energy price distortion in China. Section 3 presents a two-sector growth model, where we illustrate that oil price distortion indeed affects domestic economy. Using implication of the theoretical model in Section 3, we then propose the empirical specification and discuss the data in Section 4, and in Section 5 we report empirical results. Section 6 concludes the paper.

2. Oil pricing mechanism and price distortion in China

Due to its escalating volume of oil consumption, increasing dependence on oil imports, and gradually liberalizing domestic oil pricing mechanism, researchers have expected a more active interaction between the world oil price and China's macro-economy (Du *et al.*, 2010; Wu *et al.*, forthcoming). Therefore, not surprisingly, China is a good case to study the role of market distortion and oil price shocks. In this section, we will discuss the pricing mechanisms in the energy market, and measure the associated price distortion.

2.1 The oil consumption and pricing mechanisms

China's energy consumption, as well as its dependence on imported oil, has been increasing dramatically in the past two decades and is expected to continuously grow in the future (IEA, 2012). During 1990-2008, China's GDP grew at an annual rate of 10 per cent on average, and is expected to grow at an annual average rate of 5.7 per cent during 2008-2035 (IEA, 2010). Such fast economic growth leads to strong demand for energy. In 2009, China became the world's largest energy consumer.

Meanwhile, China's domestic oil price has also experienced significant changes. Before 1998, it was heavily regulated. In the 1980s and 1990s, China adopted a dual-track pricing system, under which prices for most of the oil products were tightly regulated. A market-based petroleum pricing mechanism was adopted in 1998 and in October 2001, oil product prices were linked to major international futures markets (Du *et al.*, 2010). They were firstly benchmarked against the Singapore futures markets, and later in 2001 the benchmark was extended to Singapore, Rotterdam and New York futures markets, where a unpublished weight was used in setting the domestic prices (Du *et al.*, 2010). In 2006, this price benchmark was changed from refinery product prices to the Brent, Dubai and Minas crude oil prices.

However, this price benchmarking, although it enables the domestic markets to follow the international markets, also intends to insulate domestic markets from the volatility of petroleum prices in the global markets (IEA, 2010). Due to this intention, even with those liberalizing reforms implemented in the early 2000, the pricing regime was besotted with ad hoc subsidies and non-transparent and not consistently enforced pricing behaviour.

In 2009, China introduced a formula-based pricing mechanism for oil products. According to this formula, domestic fuel prices may be adjusted when international crude oil prices, measured as a weighted average of the Brent, Dubai and Cinta crude oil prices, change more than 4 per cent over a period of 22 working days (Government of China, 2008).

This pricing mechanism can smooth the price volatility in the fuel markets and subsequently the shocks in China will be less severe. When the average crude oil price is below US$ 80 a barrel, domestic gasoline prices move relatively freely; between US$ 80 and US$ 130 a barrel, domestic prices are responsive, but cannot incase as much as the crude oil prices does; and above US$ 130, fuel tax breaks will be used to keep domestic prices low. Furthermore, fuel price adjustments have lagged behind the world price movement (Kojima, 2012). However, it was reported that the China may change its oil pricing mechanism: it may adjust domestic oil prices every ten working days regardless of how much international oil prices change (CNC, 2012).

2.2 Measurement of oil price distortions

Even though China is gradually liberalizing the pricing mechanism of domestic oil products, there still exists significant price control in the energy market, as discussed above. Such price control creates distortions in the energy market. We measure the price distortion in the following way:

First, we calculate the average monthly gasoline price (yuan per ton) in China over three types of gasoline without lead (namely gasoline no. 90, 93, and 97), where the prices for these three types of gasoline are sourced from the CEIC database. Second, we extract the average end user price of all grade motor gasoline in the US, which is sourced from the US Energy Information Administration (EIA). The unit of this price is US dollar per gallon, which we then convert into US dollar per ton by using the formula of 1 gallon gasoline = 2.7974 kg gasoline. This price is further converted into Chinese currency (yuan) by using the period average of official nominal exchange rate sourced from IMF.

Third, after we obtain the China and US gasoline prices with the same unit (Chinese yuan per ton), we calculate three measures of domestic oil price distortion. The first measure is a ratio of China price against US price, namely $\sigma_1 = P_{China} / P_{US}$, where P denotes price and σ denotes price distortion[1]. The second measure is a percentage difference between China and US prices, namely $\sigma_2 = (P_{China} - P_{US}) / P_{US}$. For σ_2, it is also possible that the direction of percentage difference does not matter in affecting the economy, namely the impact is symmetric. Considering this point, we also calculate the third measure as $\sigma_3 = |P_{China} - P_{US}| / P_{US}$.

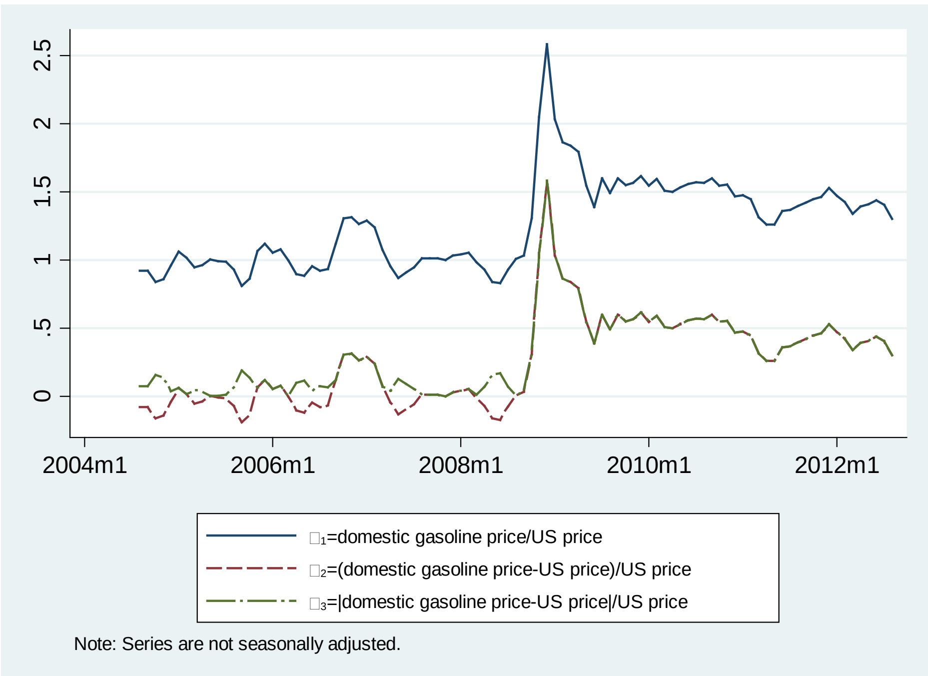
Note that in measuring the price distortion, as in Lin & Jiang (2011) we use the US gasoline price as a reference, namely we assume that the US price to be close to the perfectly competitive market price. Although the US gasoline price cannot be a perfectly competitive

[1] Later we use this measure in the theoretical model.

market price, it is probably the best available proxy to the perfectly competitive market price for the following two reasons. First, the US enforce a 13% tax, lower than that in all European countries (Thompson, 2011), and thus compared to European countries, the distortion from the government intervention is small. Second, the US maintains a strict control on anticompetitive conduct in the petroleum industry, including the gasoline market (The US Federal Trade Commission, 2007) and thus the distortion from market power is small too.

Figure 1 presents the constructed price distortion. We can observe that there exist significant price distortions in China. On average China's price is around 26 per cent higher than that of the US. In addition, even though China is trying to liberalize its oil product pricing mechanism, the distortion does not appear to be reducing. In addition, there appears to be a structural break in 2009m1. After 2009m1, the average price distortion is clearly higher than that of before 2009m1. One reason for the suddenly increase of gasoline price is that fuel tax was increased from 0.2 CNY (US$ 3 cent) per litter to 1 CNY (US$ 15 cent) per litter from 2009. While for the continuous high level of oil price, it is argued that even the gasoline was under priced.[2]

Figure 1 The Price Distortion in China



Source: The authors' calculation with data sourced from the CEIC database, EIA, and IMF

[2] 油价上涨六问油价　中国油价为何比美国贵？，http://auto.people.com.cn/GB/14038392.html

3. The model

Price controls are the main reason for the price distortion in the energy market. Nevertheless, they are often justified on the ground that they can shield domestic economy from undesired oil price shocks in the world market. Such oil price shocks can lead to inflation and recession in domestic economy (Darby, 1982; Barsky & Kilian, 2004). This negative impact, however, is questioned in the later studies (Bernanke *et al.*, 1997) and a number of recent studies suggest that the negative impact does not derive from the oil price shocks themselves, instead from the policy response to the oil price shocks (Kilian, 2008).

In addition, price controls, such as subsidies, themselves negatively affect domestic economy. A number of studies show that price distortion hurts economic growth (Tang *et al.*, 2010; Wu *et al.*, 2012). Conceptually, the regulated energy prices can affect domestic economy in the following three ways:

First, the subsidies, or in the way of surrendering profits of state owned oil companies, essentially transfer government revenue to consumers in a way that is not necessarily efficient. Not surprisingly, we can expect welfare loss from such subsidies.

Second, the price distortion leads to inefficient allocation of energy among industrial users. A price lower than the perfectly competitive market price induces firms to substitute away from other factors into energy, and in turn leads to a low energy productivity and efficiency loss. In addition, given a low energy price, firms have little incentive to upgrade their energy technology.

Third, for retail consumers, the low energy price can also lead to inefficient consumption, and even waste, of energy (GSI,2011). For example, faced with cheaper fuel prices, consumers are more likely to use vehicles more intensively, and have less incentive switch to more energy efficient vehicles.

Therefore, we expect price distortion to affect domestic economy negatively. Below we explore the impacts of oil price distortion, measured as the price deviation between domestic and world markets, on domestic economy in a two sector growth model.

3.1 A two sector growth model

With an endowment of labour L, the economy consists of two sectors, namely the oil sector and final goods sector. A representative consumer chooses a sequence of consumption of final goods to maximize her life time utility, as follows:

$$\max_{\{c_t\}} U = \sum_{t=0}^{\infty} \rho^t ln(c_t)$$

where t denotes time, ρ is the discount rate and c denotes quantity of consumption. At each period, the consumer is faced with the following budget constraint:

$$c_t + k_{t+1} = w_t + r_t k_t + (1-\delta)k_t$$

where k denotes capital she owns, w is her wage income, and r and δ are rental and depreciation rates of capital respectively. Solving the utility maximization problem, we obtain an Euler equation as follows:

$$\frac{c_{t+1}}{\rho c_t} = r_{t+1} + 1 - \delta \tag{1}$$

In the final goods sector, capital, labour, and oil are used to produce final goods in a constant return to scale Cobb-Douglas function:

$$Y_t = AL_t^{1-\alpha-\beta} K_{yt}^{\alpha} O_t^{\beta} \tag{2}$$

where Y, A, L, K_y, and O denote the output, technology, labour, capital used in the final goods sector, and oil inputs respectively, and α and β are two parameters where $\alpha \in (0,1)$, $\beta \in (0,1)$, $\alpha + \beta \in (0,1)$. The oil inputs are sourced from either domestic or world markets. Let p_t denote the oil price in the world market and $\sigma_t p_t$ denote domestic oil price. Thus σ_t measures the distortion in domestic oil price.

Firms in the final goods sector choose employment of labour, capital, and oil to maximize their profits:

$$\max_{\{L_t, K_{yt}, O_t\}} Y_t - w_t L_t - r_t K_{yt} - \gamma_t O_t \sigma_t p_t - (1-\gamma_t) O_t p_t$$

where 1-γ denotes oil dependence, namely the share of oil consumption that is sourced from world market. The profit maximization yields the following first order conditions:

$$w_t = (1-\alpha-\beta) AL_t^{-\alpha-\beta} K_{yt}^{\alpha} O_t^{\beta} \tag{3}$$

$$r_t = \alpha AL_t^{1-\alpha-\beta} K_{yt}^{\alpha-1} O_t^{\beta} \tag{4}$$

$$\beta AL_t^{1-\alpha-\beta} K_{yt}^{\alpha} O_t^{\beta-1} - (\gamma_t \sigma_t + 1 - \gamma_t) p_t = 0 \tag{5}$$

Equation (5) defines the demand for oil, from which we can derive the corresponding demand for domestic oil as:

$$\gamma_t O_t = \gamma_t \left[\frac{\beta AL_t^{1-\alpha-\beta} K_{yt}^{\alpha}}{(\gamma_t \sigma_t + 1 - \gamma_t) p_t} \right]^{1/(1-\beta)} \tag{6}$$

In the oil sector, the production function is also Cobb-Douglas, as follows:

$$X_t = S_t K_{xt}^{\eta} \tag{7}$$

where X, S, and K_x denote the oil output, oil reserve, and capital used in the oil sector ($K_{xt} \in [0,1]$), and η is the parameter that takes a value between zero and one. The economy is initially endowed with an oil reserve of S_0, and subsequently the oil reserve evolves in the following manner:

$$S_{t+1} = S_t\left(1 - K_{xt}^{\eta}\right) \tag{8}$$

Subject to the transition of state variable S (Equation 8), firms in the oil sector choose the level of capital to maximize their life time profits, with the Bellman equation as follows:

$$V(S_t) = \max_{\{K_{xt}\}}\{X_t\sigma_t p_t - r_t K_{xt} + \rho V(S_{t+1})\} = \max_{\{K_{xt}\}}\left\{M_t S_t^{\beta} K_{xt}^{\beta\eta} - r_t K_{xt} + \rho V(S_{t+1})\right\}$$

where $V()$ denotes the value function and $M_t \equiv \frac{\beta A L_t^{1-\alpha-\beta} K_{yt}^{\alpha} \gamma_t^{1-\beta}\sigma_t}{\gamma_t\sigma_t + 1 - \gamma_t}$. The second equality is obtained by plugging in the demand for domestic oil (Equation 6) and oil production function (Equation 7) into the first equality.

Differentiate the value function with respect to K_{xt}, we obtain the first order condition as $\beta\eta M_t S_t^{\beta} K_{xt}^{\beta\eta-1} - r_t - \rho\eta S_t K_{xt}^{\eta-1}\frac{\partial V}{\partial S_{t+1}} = 0$. Using the Envelope Theorem, we can obtain $\frac{\partial V}{\partial S_t} = \beta M_t S_t^{\beta-1} K_{xt}^{(\beta-1)\eta} - \frac{r_t(1-K_{xt}^{\eta})}{\eta S_t K_{xt}^{\eta-1}}$, which is then shifted one period forward ($\frac{\partial V}{\partial S_{t+1}} = \beta M_{t+1} S_{t+1}^{\beta-1} K_{xt+1}^{(\beta-1)\eta} - \frac{r_{t+1}(1-K_{xt+1}^{\eta})}{\eta S_{t+1} K_{xt+1}^{\eta-1}}$) and plugged into the above first order condition to obtain the following equation:

$$\beta\eta M_t S_t^{\beta} K_{xt}^{\beta\eta-1} = r_t + \rho\eta S_t K_{xt}^{\eta-1}\left[\beta M_{t+1} S_{t+1}^{\beta-1} K_{xt+1}^{(\beta-1)\eta} - \frac{r_{t+1}(1-K_{xt+1}^{\eta})}{\eta S_{t+1} K_{xt+1}^{\eta-1}}\right] \tag{9}$$

which characterizes the optimal level of capital in the oil sector. Equation (9) indicates that the optimal level of capital in the oil sector shall be such that its marginal revenue (the right hand side of Equation 9) is equal to marginal cost (the left hand side of Equation 9). Note that since current oil extraction affects future oil extraction through the reduction of oil reserve, the marginal cost is the rental rate plus a term that accounts for the cost of reduction in oil reserve.

The resource constraint in the economy (namely final goods market clears) implies that:

$$C_t + K_{yt+1} - (1-\delta)K_{yt} + K_{xt+1} - (1-\delta)K_{xt} + (1-\gamma_t)O_t p_t = Y_t \tag{10}$$

where $C_t = Lc_t$ and $K_{xt} + K_{yt} = Lk_t$. An equilibrium in the economy is then characterized by $\{C_t, K_{yt}, K_{xt}, w_t, r_t, \gamma_t\}_{t=0}^{\infty}$ such that Equations (1), (3), (4), (5), (8), (9), and (10) are satisfied.

3.2 Impacts of price distortion (σ) at steady state

We now focus on a steady state where consumption, output in the final goods sector, and domestic oil price distortion are constant, namely $C_t = C$, $Y_t = Y$, and $\sigma_t = \sigma$. Since $C_t = C$, the equilibrium interest rate in the steady state is constant, $r = \frac{1}{\rho} + \delta - 1$. From Equations (2) and (4), we can rewrite the interest rate as $r_t = \alpha Y_t / K_{yt}$. Therefore constant Y and r imply that K_{yt} is constant as well, namely $K_{yt} = K_y$. Similarly, from Equation 2, we can find that the oil demand is constant as well ($O_t = O$). At steady state, the resource constraint is transformed into:

$$C + \delta K_y + K_{xt+1} - (1-\delta)K_{xt} + (1-\gamma_t)Op = Y \tag{11}$$

where we assume the world oil price (p) is constant in the steady state. Allowing p to change across time will not affect the subsequent results since p is exogenous to the model. From the production function in the oil sector (Equation 7), we can obtain the following relationship among γ, S, and K_x:

$$\gamma_t = \frac{S_t K_{xt}^{\eta}}{O} \tag{12}$$

Then at steady state the economy is characterized by Equations (8), (9), and (11), together with Equation (12).

At steady state, K_{xt} cannot be constant. If not, Equation (8) implies that oil reserve is depleting at a constant rate. Then from Equation (12), γ_t is decreasing at a constant rate. A constantly decreasing γ_t and a constant K_{xt} then violate the resource constraint (Equation 11). Similarly, γ_t cannot be constant as well. If γ_t is instead constant (namely $\gamma_t = \gamma$), Equation (12) indicates that to maintain a constant level of oil production, K_{xt} must be increasing as the oil reserve (S_t) depletes. Equation (12) also implies $S_t K_{xt}^{\eta} = S_{t+1} K_{xt+1}^{\eta}$, which together with Equation (8) leads to $K_{xt+1} = \frac{K_{xt}}{\left(1+K_{xt}^{\eta}\right)^{1/\eta}}$. Plug this equation into the resource constraint (Equation 11), we obtain:

$$\frac{K_{xt}}{\left(1+K_{xt}^{\eta}\right)^{1/\eta}} - (1-\delta)K_{xt} = Y - C - \delta K_y - (1-\gamma)Op$$

which suggests that K_{xt} is constant and thus contradicts with the requirement that K_{xt} must be increasing across time such that the level of oil production is constant.

Therefore, we explore the dynamics of K_{xt} and γ_t at the steady state where the consumption and output are constant, and in particular focus on the impacts of domestic oil price distortion (σ) on the dynamics. Plug Equation (12) into Equation (11), we obtain:

$$K_{xt+1} = (1 - S_t p - \delta)K_{xt} + S_t p + N \tag{13}$$

where $N \equiv Y - C - \delta K_y - Op$. Plug Equations (12) and (13) and the steady state values, such as $Y_t = Y$, into Equation (9), and after a series of algebraic manipulations, we can obtain the following equation:

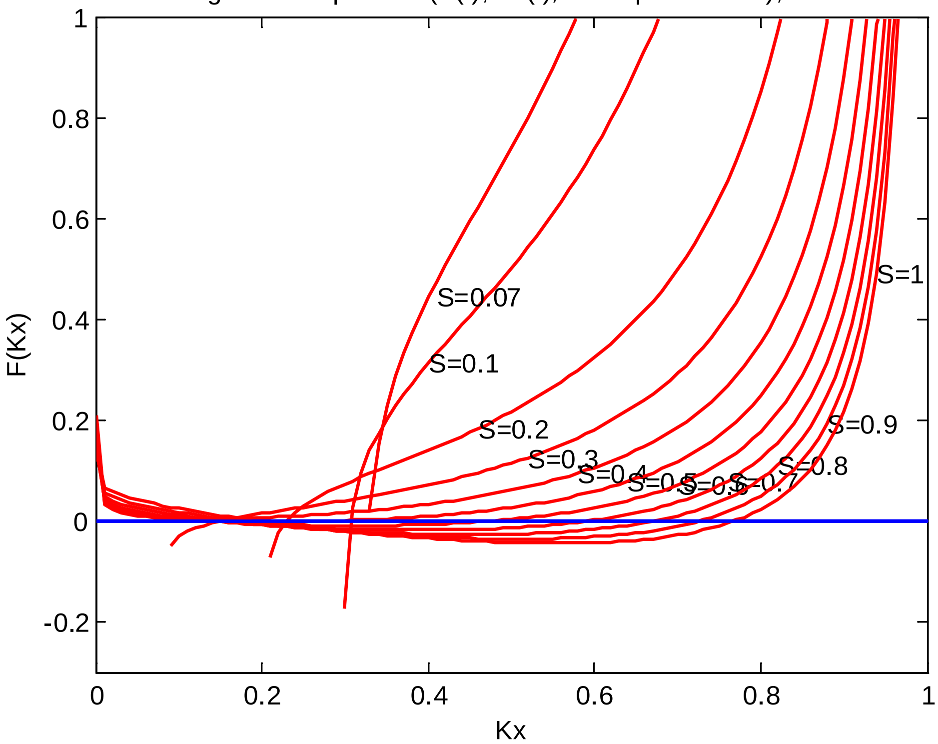
$$F(K_{xt}, S_t, \sigma) \equiv \frac{\beta Z O^{\beta}\sigma}{S_t K_{xt}^{\eta}(\sigma-1)+O} - \frac{\rho\beta Z O^{\beta}\sigma}{S_t(1-K_{xt}^{\eta})[(1-S_t p-\delta)K_{xt}+S_t p+N]^{\eta}(\sigma-1)+O} - \frac{r(K_{xt}^{\eta}-K_{xt})}{\eta S_t(1-K_{xt}^{\eta})} -$$

$$\frac{\rho r\{[(1-S_t p-\delta)K_{xt}+S_t p+N]^{1-\eta}-[(1-S_t p-\delta)K_{xt}+S_t p+N]\}}{\eta S_t(1-K_{xt}^{\eta})} = 0 \qquad (14)$$

where $Z \equiv \beta A L^{1-\alpha-\beta} K_y^{\alpha}$. Equation (14) defines K_{xt} as a function of S_t and σ, namely $K_{xt} = f(S_t, \sigma)$. Given the initial endowment of oil reserve (S_0), Equations (14), (8), and (12) describe the dynamics of K_{xt} and γ_t recursively.

To further illustrate the impacts of domestic oil price distortion, we then carry out a numerical exercise, where we set $\alpha = 0.1$, $\beta = 0.5$, $\eta = 0.9$, $\delta = 0.05$, $\rho = 0.95$, $S_0 = 1$, $L = 1$, $A = 1$, $Y = 1$, $C = 0.3$, $p = 1$, and $\sigma \in \{0.5, 0.8, 1.5, 2\}$. Note that given S_t, the equation $F(K_{xt}, S_t, \sigma) = 0$ may have no real solution, one real solution, or more than one real solution. If the equation has no real solution, it suggests that the domestic oil sector has been shut down and the economy completely rely on oil imports (namely $\gamma = 0$). If the equation has more than one solution, then K_{xt} has multiple dynamics. Figure 2 depicts the graphs of $F(K_{xt}, S_t, \sigma)$ at 11 levels of oil reserve where $\sigma = 1.5$. It can be observed that if $S = 0.07$, the equation $F(K_{xt}, S_t, \sigma) = 0$ does not have any real solution.

Figure 2 Graphs of F(S(t), Kx(t), other parameters)σ=1.5



Figures 3, 4, and 5 report the possible dynamics of K_{xt}, S_t, and 1-γ_t (namely oil dependency) respectively. The dynamics are calculated in the following way: (1) first plug S_0 = 1 into Equation (14) to solve for K_{x0}, which we randomly pick one solution if multiple solutions exist; (2) then given S_0 and K_{x0}, we solve for γ_0 from Equation (12) and S_1 from Equation (9). These two steps are repeated to compute the values of next period K_x, S, and γ.

Not surprisingly, Figure 4 indicates that the oil reserves depletes across time. Even though capital stock in the domestic oil sector appears to increase eventually (Figure 3), the oil reserve is so low that domestic economy increasingly relies on oil imports in the end. The oil dependency rate approaches 1 (Figure 5), suggesting that the economy eventually shut down the domestic oil sector.

Regarding the impacts of domestic oil price distortion (σ), Figures 3, 4, and 5 suggests that there exist impacts from the oil price distortion on the dynamics of oil sector capital stock (K_{xt}), oil reserve (S_t), and oil dependency rate (1- γ_t). Nevertheless, there appears no systematic pattern of such impacts in the three figures.

Figure 3 Dynamics of Kx

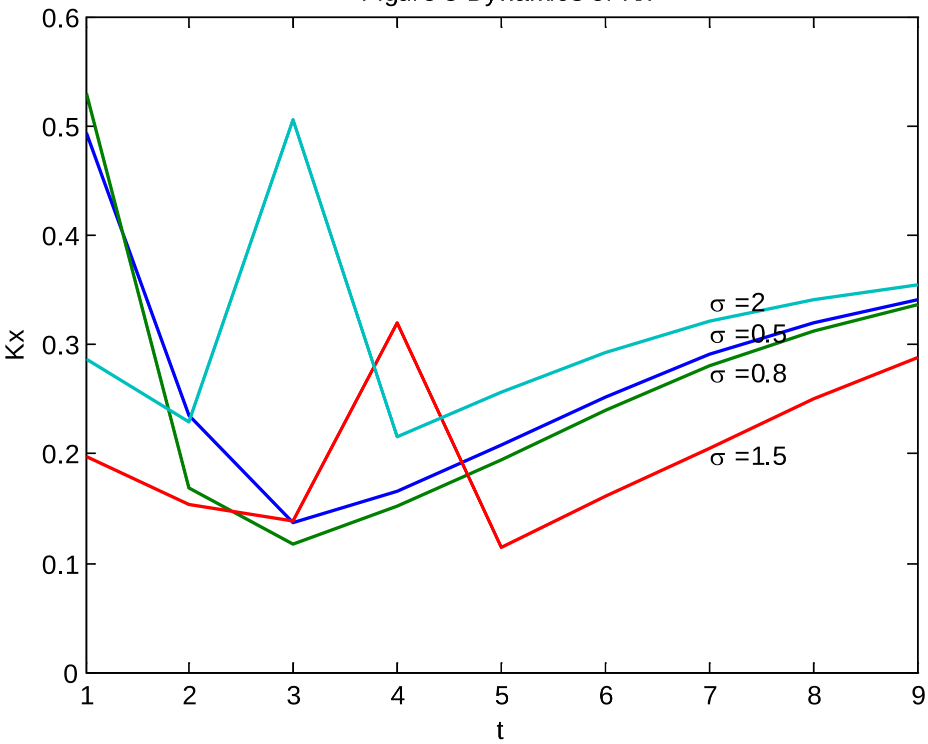


Figure 4 Dynamics of Oil Reserve (S)

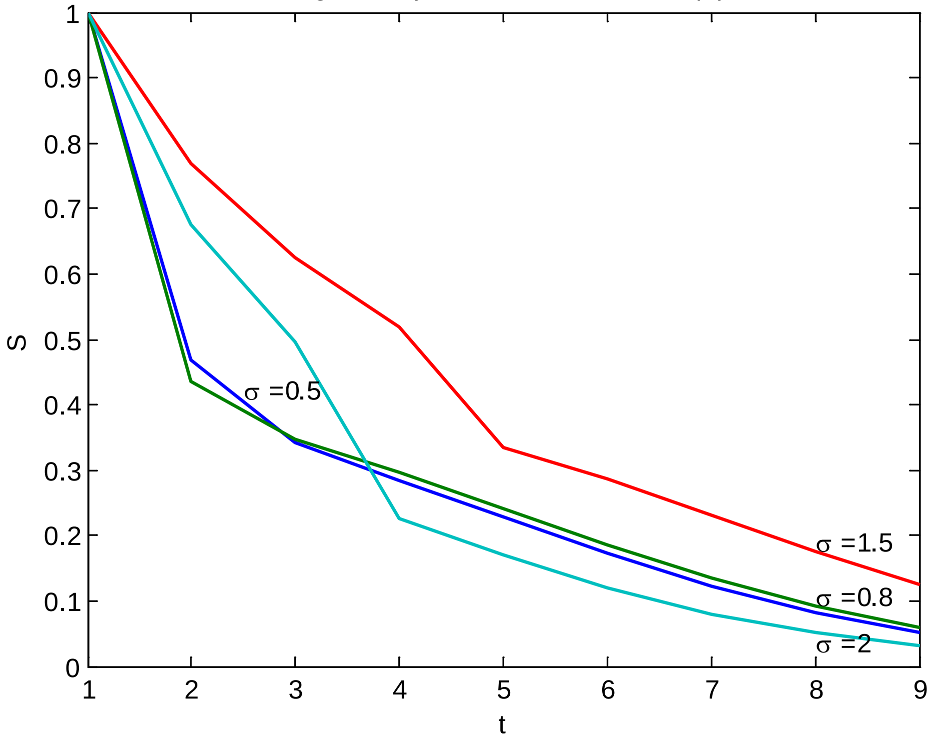
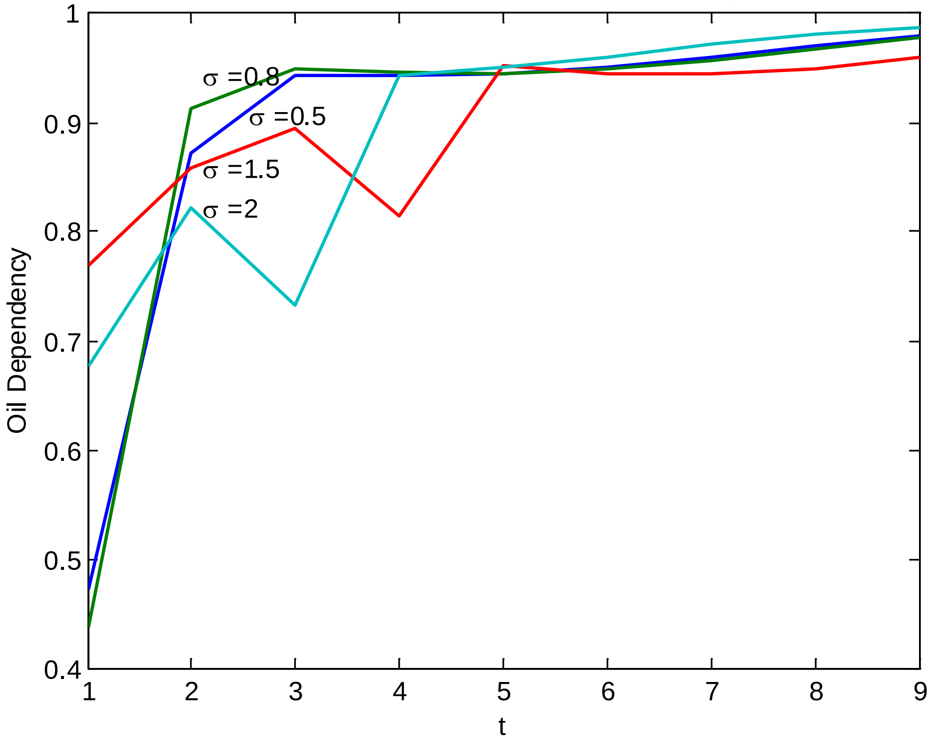


Figure 5 Dynamics of Oil Dependecy (1-γ)



4. Empirical estimations

In Section 3, we investigate the impact of oil price distortion in a two-sector growth model. We now turn to an empirical exercise, using time series data from China.

4.1 Empirical specification

Equations (8) and (9) define the optimal level of capital stock in the oil sector as a function of its one period lag, labour, capital stock in the final goods sector, real interest rate, oil reserve, and oil dependency, as follows:

$$K_{xt} = g\left(K_{xt-1}, S_t, L_t, K_{yt}, \gamma_t, \sigma_t, r_t, L_{t-1}, K_{yt-1}, \gamma_{t-1}, \sigma_{t-1}, r_{t-1}\right) \quad (15)$$

where $g()$ denotes the associated functional form derived from Equations (8) and (9). Plug Equation (15) into Equation (7) and use the fact that domestic production of oil must be equal to domestic demand minus oil imports, we can obtain the following equation:

$$O_t = \frac{1}{\gamma_t} S_t g\left(K_{xt-1}, S_t, L_t, K_{yt}, \gamma_t, \sigma_t, r_t, L_{t-1}, K_{yt-1}, \gamma_{t-1}, \sigma_{t-1}, r_{t-1}\right)^{\eta} \quad (16)$$

which can be plugged into Equation (2) to obtain the following equation:

$$Y_t = A L_t^{1-\alpha-\beta} K_{yt}^{\alpha} \frac{1}{\gamma_t^{\beta}} S_t^{\beta} g\left(K_{xt-1}, S_t, L_t, K_{yt}, \gamma_t, \sigma_t, r_t, L_{t-1}, K_{yt-1}, \gamma_{t-1}, \sigma_{t-1}, r_{t-1}\right)^{\beta\eta} \quad (17)$$

We then use the following logarithm linear specification to approximate Equation (17):

$$ln(Y_t) = \phi ln(Y_{t-1}) + \lambda_0 + \lambda_1 t + \boldsymbol{\theta}' \boldsymbol{Z}_t + u_t \quad (18)$$

where λ_0, λ_1, ϕ, and $\boldsymbol{\theta}$ are short-run parameters, with the long-run parameters being $\lambda_0/(1-\phi)$, $\lambda_1/(1-\phi)$, and $\boldsymbol{\theta}/(1-\phi)$, and $\boldsymbol{Z}_t = (L_t\ K_{yt}\ 1\text{-}\gamma_t\ \sigma_t\ r_t)'$, and u_t is an i.i.d. error term. We use Y_{t-1} to capture the impact of lagged variables, such as L_{t-1}, in Equation (17), and $\lambda_0 + \lambda_1 t + u_t$ to capture the rest factors, such as S_t and A. Note that Equation (18) is an autoregressive distributed lag model (ARDL(1,0)), and we can generalize it by allowing for lags in $\boldsymbol{Z}_t$ and longer lags in Y_t, as follows:

$$\phi(L) ln(Y_t) = \lambda_0 + \lambda_1 t + \boldsymbol{\theta}'(L) \boldsymbol{Z}_t + u_t \quad (19)$$

where $\phi(L) = 1 - \sum_{j=1}^{p} \phi_j L^j$, and $\boldsymbol{\theta}(L) = \sum_{j=1}^{q} \boldsymbol{\theta}_j L^j$, and p and q denote lag length. Since our data are time series, it is not surprising that $\boldsymbol{Z}$s can be nonstationary. Pesaran and Shin (1999) show that the ordinary least square estimator of the short-run parameters and the corresponding long-run parameters estimates are consistent even if the regressors ($\boldsymbol{Z}_t$) are I(1).

It can also be argued that $\boldsymbol{Z}_t$ can be endogenous, namely $E(u_t|Z_t) \neq 0$. For example, on the one hand the oil imports positively contribute to domestic economic growth, while on the other hand as the economy grows, it may become more and more dependent on oil imports, namely a higher level of Y leads to a higher level of γ. This endogeneity can be controlled by including a number of leads and lags of the regressors in differences, which absorb the correlation between regressors and the error term (Stock & Watson, 1993). Therefore, we augment Equation (19) by including the leads and lags of differenced Z and re-write the right hand side variables, as follows:

$$\Delta ln(Y_t) = \lambda_0 + \lambda_1 t + \phi^*(L) ln(Y_t) + \boldsymbol{\theta}' \boldsymbol{Z}_t + \sum_{j=-m}^{m} \Delta \boldsymbol{Z}_{t-j} + u_t \qquad (20)$$

where $\phi^*(L) = \sum_{j=1}^{p} \phi_j L^j - L$, Δ denotes the difference operator (namely $\Delta = 1 - L$), and m denotes the length of lags. Note that the summation in Equation (20) is made from $-m$ to m, and thus leads of differenced $\boldsymbol{Z}$ are included as well.

4.2 Variable construction and data

The dataset is monthly time series from 2004M8 to 2012M8 in China. We obtain the data from the CEIC database, which in turn collects data from different sources. We use two series to measure the output (y). The first one is industrial production index, which is calculated from a series (percentage change of industrial production index over the corresponding month of previous year) sourced from International Monetary Fund (IMF), assuming year 1993 is 100. The other is industrial sales in billion Chinese yuan sourced from National Bureau of Statistics (NBS). We use the producer price index for industrial products, which is sourced from NBS and has a base year of 1997, to deflate the industrial sales. The labour (L) is also sourced from NBS, and is measured as the number of employees in industrial enterprises with the unit being thousand persons. The labour series has missing values which are replaced by an interpolation.

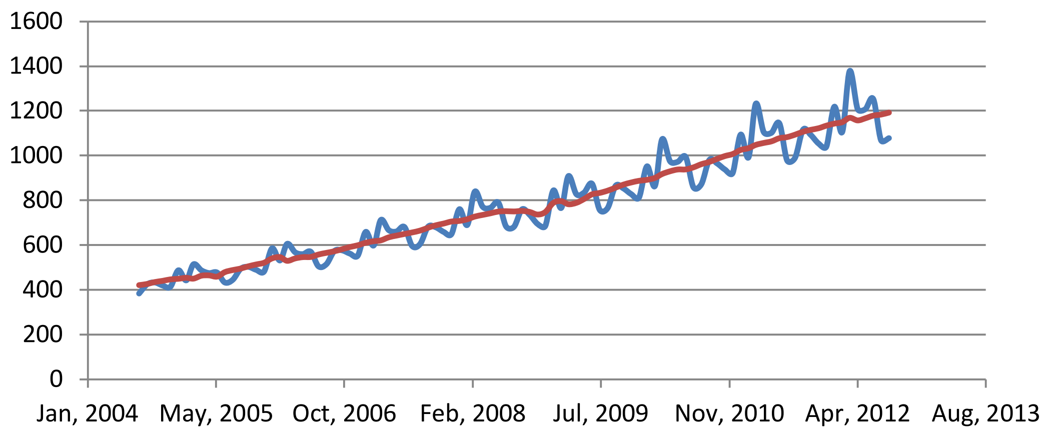
The capital (K_y, in billion yuan) is constructed from fixed asset investment. First, we calculate the monthly increment of fixed asset investment in secondary industry from year-to-date fixed asset investment data, and deflated it using the fixed asset price index with a base year of 2003. Second, we assume a monthly capital depreciation rate of 0.4 per cent, which translates to a 4.9 per cent per annum depreciate rate, and take 2004M1 fixed asset investment as the initial capital stock. The capital stock in subsequent periods is then calculated as: $K_{yt} = I_t + (1- 0.004) \times K_{yt-1}$, where I_t denotes newly increased fixed asset investment in period t and $K_{y0} = I_0$.

The oil dependency $(1- \gamma)$ is measured as the share of oil imports in domestic oil consumption, and is constructed as follows: first we extract the imports and exports of crude oil (in million US dollars) and the import and export prices (in US dollars per ton), which are sourced from General Administration of Customs, from the CEIC database. From the value and price of imports and exports, we then calculate the quantity of exports and imports. Second, we extract the domestic production of crude oil, which is sourced from NBS. The oil dependency ratio is then calculated as: $1- \gamma = Q_{imports} / (Q_{imports} + Q_{production} - Q_{exports})$, where Q denotes quantity.

The real interest rate (r) is calculated as $r = i - \pi$, where i denotes the short term discount rate sourced from IMF and π denotes the monthly inflation rate. The monthly inflation rate is in turn calculated from the consumer price index which is sourced from International Financial Statistics (IFS) of IMF and has a base year of 2005. The measures of oil price distortion are constructed as discussed in Section 2.

Since the data are monthly time series, it is not surprising that they exhibit seasonality. We thus adjust the data series by using the X-12-ARIMA Seasonal Adjustment Program to eliminate the influence of seasonal fluctuation[3]. The X-12-ARIMA is a standard approach used by the US Census Bureau for seasonal adjustment of time series data. Figure 6 presents the series of industrial production index before and after de-seasonalization. The blue curve is the original series, and it is clear that it contains seasonality in addition to an upward trending. The de-seasonalized series (red curve) appears to eliminate the seasonality while maintain the same upward trending.

Figure 6 Industrial Production Index, 1993=100



Source: CEIC Database.

4.3 Unit root tests

We first carry out unit root tests to check the stationarity of the time series. Table 1 reports the results, where both the Augmented Dickey-Fuller (ADF) unit root test (Dickey & Fuller, 1979) and Phillips–Perron (PP) unit root test (Phillips & Perron, 1988) are used. Not surprisingly, it can be observed that some variables are I(1), while the others are I(0). The capital stock, real interest rate, and oil dependency ratio are all I(0), where the null hypothesis of unit root is rejected at the 1 per cent level.

[3] Details of the X-12-ARIMA can be found at http://www.census.gov/srd/www/x12a/.

For the three measures of domestic oil price distortion, since Figure 1 suggests that there exists structural break, we carry out the Andrews and Zivot (1992) unit root test that allows for a structural break. Although results in Table 1 indicate that these three measures are I(1), the Andrews and Zivot test suggests that they are I(0), with the test statistic being -5.68, -6.05, and -5.32 for lnσ_1, σ_2, σ_3 respectively which are all significant at the 1 per cent level.

The industrial production index and industrial sales are I(1). For the industrial sales, the ADF test with time trend obtains a test statistic of -3.8 with a p-value of 0.016, and the PP test with time trend obtains a test statistic of -3.44 with a p-value of 0.046. The test statistics for level variables with no time trend are insignificant and test statistics for differenced variables are all significant at 1 per cent level. Therefore at the 1 per cent significance level, industrial sales is I(1). The labour series is also considered to be I(1) at the 1 per cent level since the test statistics of both ADF and PP with time trend for level variable are only significant at the 10 per cent level and the test statistics for first differenced variable are significant at the 1 per cent level. Given that variables are a mixture of I(1) and I(0), the ARDL modelling is an appropriate approach in the sense that it can be applied when variables are of different order of integration, which is considered to be the main advantage of ARDL modelling (Pesaran & Pesaran, 1997).

<*Table 1 about here*>

4.4 Regression results

To estimate Equation (20), we have two measures of industrial output (namely industrial sales and industrial production index) and three measures of domestic oil price distortions, which leads to six regressions. In the following, we describe the empirical exercise using industrial sales as the measure of industrial output and the ratio of China gasoline price against US gasoline price (lnσ_1) as a measure of oil price distortions, and the rest regressions will follow a same specification and serve as sensitivity analysis. The first step in the exercise is to determine the length of lags. We use both the Akaike Information Criteria (AIC) and Schwartz-Bayesian Criteria (SBC) in determining lag length, and choose the length of lags that yields a minimal AIC and SBC. The maximum length of lags is set to be five[4]. Both AIC and SBC suggest an optimal lag length of one for both the dependent and explanatory variables in Equation (20).

Table 2 reports the regression results, where the left panel is the estimated results of short-

[4] Longer length leads to estimation problem due to multicollinearity.

run coefficients as in Equation (20) and the right panel is the associated long-run coefficients. After the regression, we also carry out a set of diagnostic tests. The Breusch-Godfrey test for serial correlation finds no evidence of first, second, third, fourth, and fifth order autocorrelation. A LM test for autoregressive conditional heteroskedasticity (ARCH) also fails to reject the null hypothesis of no ARCH effects at the 1 per cent level. The Breusch-Pagan / Cook-Weisberg test for heteroskedasticity obtains a test statistic of 22.11, which fails to reject the null of homoskedasticity at the 1 per cent level. The Ramsey RESET test obtains a test statistic of 3.63, and fails to reject the null of no omitted variables at the 1 per cent level. We also examine the stationarity of the residual by conducting both ADF and PP tests, which both rejects the null hypothesis of unit root at 1 per cent level. Therefore the regression is appropriate.

Table 2 Regression Results with Industrial Sales and Gasoline Price Ratio

	Short-run coefficients			Long-run coefficients		
	Coef.	Std. Err.	t	Coef.	Std. Err.	t
$\ln y_{t-1}$	-0.8116***	0.1050	-7.73			
t	0.0067***	0.0012	5.79	0.0082***	0.0010	7.89
$\ln l_t$	0.3565**	0.1368	2.61	0.4393**	0.1554	2.83
$\ln k_t$	0.0848**	0.0368	2.31	0.1045**	0.0419	2.50
r_t	-3.3120***	0.8069	-4.1	-4.081***	0.8842	-4.62
oil dependency $(1-\gamma_t)$	0.4848**	0.2241	2.16	0.5974**	0.2597	2.30
distortion ($\ln\sigma_{1t}$)	-0.0890***	0.0241	-3.69	-0.1097***	0.0233	-4.71
constant	1.3582	1.3785	0.99	1.6735	1.7048	0.98
No. of obs.	94					
F	9.5					
Adjusted R^2	0.67					

Note: the dependent variable is $\Delta\ln(y_t)$; the estimated coefficients of ΔZ_t are not reported to save space; ***, **, and * denote significance at the 1, 5, and 10 per cent respectively.

The long-run (steady state) coefficients in Table 2 are computed as the short-run coefficients divided by the negative of the coefficient of $\ln y_{t-1}$, and the associated standard errors are computed using the delta method. For example, let φ and θ_l (one element of $\boldsymbol{\theta}$ in Equation 20) denote the long-run and short-run coefficients of the labour ($\ln l_t$) respectively, and ϕ_y denote the coefficient of lagged industrial output ($\ln y_{t-1}$). Let $\phi_y = \phi - 1$ in Equation 20, then $\varphi = -\theta_l / \phi_y$. To obtain the associated standard error, we first linearize φ by the first order Taylor approximation at the point estimates of θ_l and ϕ_y, namely $\varphi \cong -\hat{\theta}_l/\hat{\phi}_y -$

$(\theta_l - \hat{\theta}_l)/\hat{\phi}_y + \hat{\theta}_l(\phi_y - \hat{\phi}_y)/\hat{\phi}_y^2$, where the hat denotes point estimate. Then $\widehat{var(\varphi)} = \widehat{var(\theta_l)}/\hat{\phi}_y^2 + \hat{\theta}_l^2\widehat{var(\phi_y)}/\hat{\phi}_y^4 - 2\hat{\theta}_l\widehat{cov(\theta_l, \phi_y)}/\hat{\phi}_y^3$, and $se = \sqrt{\widehat{var(\varphi)}}$, where *var*, *cov* and *se* denote variance, covariance and standard error respectively.

In Table 2, the significantly negative coefficient of lagged industrial sales suggests that industrial growth rate decreases as it grows bigger[5]. This regressive development is consistent with the finding of Sheng and Shi (Sheng & Shi, 2013) that economic growth across countries converges unconditionally. The growth rate exhibits a significant increasing trend, possibly owing to technological progress. Not surprisingly, the labour and capital positively contribute to the industrial growth. The real interest rate exerts a significantly negative impact on the industrial growth rate. A higher real interest rate means a higher investment cost, which decreases investment in both the goods sector and oil sector, *ceteris paribus*, and subsequently hurts the industrial growth. This support some agurment in the literature that the true reason for slowing down of economy growth after oil price shocks is like a tighten of monetary policy (Bernanke *et al.*, 1997). The oil dependency (1– γ_t) appears to positively affect industrial growth in the short run, reflecting the importance of oil imports in domestic industrial development.

The coefficient of domestic oil price distortion, measured as the ratio of domestic gasoline price against US gasoline price, is negative and significant at the 1 per cent level, suggesting that the oil price distortion indeed hurts industrial growth. A 10 per cent increase in the distortion leads to a reduction of 0.89 per cent in the industrial growth rate.

In the long run (steady state), the coefficients of all the variables are significant and maintain the same sign as in the short run. The steady state industrial sales exhibit an increasing time trend, driven by technological progress. The labour and capital contribute 43.9 and 10.5 per cent to the industrial sales respectively, which not surprisingly sums up to less than one in that there are other factors, such as oil, that contribute the industrial sales. The real interest rate exerts a significantly negative impact on the industrial sales, similar to the short run, due to its negative impact on investment. The oil dependency rate also significantly and positively affects industrial sales in the long run, same as in the short run. The negative impact from domestic oil price distortion persists to the long run, and with a 10 per cent increase in the distortion, the steady state industrial output decreases by around 1.1 per cent.

[5] Note $\Delta\ln(y_t)$ is approximately growth rate of industrial output.

Table 3 reports the results where the dependent variable is industrial production index. Due to the way that the original data are reported, namely the original series is the percentage change of industrial production index over the corresponding month of previous year, we have to assume that in each month of 1993 the production index is 100 in order to calculate the index from 2004M8 to 2012M8. Owing to this assumption, results in Table 3 serve only as a comparison to those in Table 2. Comparing with Table 2, the negative impacts of oil price distortion continue to hold in both the short and long run, even though the magnitude is smaller. The coefficients of lagged industrial production index, time, and capital have the same sign as those of Table 2, while their magnitude is different. Besides, the coefficients of labour, real interest rate, oil dependency rate are now not significant at the 1 per cent level. Therefore, even though we observe some variations in the coefficient estimate between Tables 2 and 3, the negative impact of oil price distortion appears to be robust to different measures of industrial production.

Table 3 Regression Results with Industrial Production Index and Gasoline Price Ratio

	Short-run coefficients			Long-run coefficients		
	Coef.	Std. Err.	t	Coef.	Std. Err.	t
$\ln y_{t-1}$	-0.3880***	0.0848	-4.57			
t	0.0023***	0.0007	3.18	0.0059***	0.0009	6.40
$\ln l_t$	0.0690	0.0520	1.33	0.1779	0.1273	1.40
$\ln k_t$	0.0637***	0.0159	4	0.1641***	0.0366	4.48
r_t	-0.4185	0.2881	-1.45	-1.0787	0.7263	-1.49
$1-\gamma_t$	0.0391	0.0829	0.47	0.1007	0.2125	0.47
$\ln\sigma_{1t}$	-0.0254**	0.0097	-2.61	-0.0654***	0.0188	-3.47
constant	1.0640*	0.5996	1.77	2.7426*	1.3945	1.97
No. of obs.	94					
F	4.47					
Adjusted R^2	0.45					

Note: the dependent variable is $\Delta\ln(y_t)$; the estimated coefficients of ΔZ_t are not reported to save space; ***, **, and * denote significance at the 1, 5, and 10 per cent respectively.

4.5 Robustness

The previous exercise finds that the oil price distortion exerts a significantly negative impact on industrial production in both the short and long run, which is robust to different measures of industrial production. However, is this finding robust to different measures of oil price distortion? In this section, we explore such impacts using alternative measures of oil price distortion.

The alternative two measures we use are described in the above. We re-estimate Equation (20) using these two measures, where the length of lag is one. Table 4 reports the results. Comparing the estimated coefficient of oil price distortion, the sign is all negative in both regressions, consistent with the finding of Table 2, although there exist variations in the magnitude. The coefficients of the other variables are also approximately in line with those of Table 2. Therefore the negative impact of oil price distortion in both the short and long run is robust to these two alternative measures of oil price distortion.

<*Table 4 about here*>

Figure 1 suggests that there exists a structural break for oil price distortion in 2009m1. So in the above exercise, we also include a dummy variable that takes a value of one in the time after 2009m1 into the regression. The estimation finds that the coefficient of the dummy variable is insignificant at the 1 per cent level, and there is only little variation in the coefficients of the other variables. Thus, this structural break appears not to significantly affect the regression results.

5. Policy implications

6. Concluding remarks

This paper explores the impact of oil price distortion on domestic economy both theoretically in a two-sector growth model and empirically in China. In the theoretical model, we illustrate the impacts of price distortion on the steady state oil sector capital accumulation and oil dependency. Empirically, using a specification derived from the theoretical model, we apply the ARDL modeling technique to a monthly time series dataset in China from 2004M8 to 2012M8, and find that oil price distortion hurts industrial growth in the short run, and furthermore this negative impact persists to the long run. The negative impact of oil price distortion appears to be robust to different measures of industrial production and oil price distortion.

As the price distortion, which occurs mainly due to price regulation, does harm to economic growth, this finding contradicts with a common argument of energy price regulation, namely the price regulation can shield domestic economy from negative oil price shocks in the world market. Thus, this study lends its support to the energy price deregulation, namely the policies and interventions, such as subsidies, that may distort domestic energy prices, are justified to be removed on the ground that they hurt domestic economy. A market oriented energy price regime may improve the resilience of domestic economy to the global oil price shocks. This study also implies that monetary policy, which may be tighten after concern on inflation coming with international price shocks, should be finely turned to avoid hurt economic growth.

This study also sheds light on a better understanding of energy market integration. Price regulations are main obstacles to the energy market integration. Given that price regulations lead to undesired price distortion, it is worthwhile to promote the integration of energy market between net energy exporter and importer, which helps to eliminate price distortions. This message is particularly relevant to East Asia since many East Asian countries still have tight regulations on energy pricing. Brunei, Indonesia, and Malaysia are outstanding examples with almost fixed gasoline prices.

Table 1 Unit Root Tests

	Levels				First Difference				
	ADF		PP		ADF		PP		
Variables	Constant	Constant + Trend	Constant	Constant + Trend	Constant	Constant + Trend	Constant	Constant + Trend	Results
Industrial sales (lnY)	-1.37	-3.8**	-1.85	-3.44**	-16.85***	-17.08***	-17.81***	-18.63***	I(1)
Industrial production index (lnY)	-1.51	-2.1	-1.78	-1.9	-9.56***	-9.68***	-9.63***	-9.83***	I(1)
Labour (lnL)	-1.52	-3.41*	-1.62	-3.17*	-12.76***	-12.9***	-13.3***	-13.42***	I(1)
Capital (lnK)	-16.82***	-18.31***	-10.67***	-15.34***	-5.17***	-5.77***	-6.29***	-6.44***	I(0)
Real interest rate (r)	-6.11***	-6.33***	-6.23***	-6.45***	-17.77***	-17.69***	-20.21***	-20.09***	I(0)
Oil dependency (1-γ)	-3.17**	-9.91***	-2.68*	-9.98***	-19.16***	-19.08***	-24.29***	-24.17***	I(0)
Oil price distortion ($\ln\sigma_1$)	-1.81	-2.35	-1.88	-2.54	-7.77***	-7.74***	-7.59***	-7.55***	I(1)
Oil price distortion (σ_2)	-2.03	-2.57	-2.11	-2.76	-7.65***	-7.62***	-7.45***	-7.4***	I(1)
Oil price distortion (σ_3)	-2.28	-2.79	-2.22	-2.79	-8.81***	-8.77***	-8.78***	-8.73***	I(1)

Note: The null hypothesis is that the series contain a unit root. ***, **, and * denote significance at the 1, 5, and 10 per cent respectively.

Table 4 Regression Results with Alternative Measure of Oil Price distortion

	[1]						[2]					
	Short-run coefficients			Long-run coefficients			Short-run coefficients			Long-run coefficients		
	Coef.	Std. Err.	t	Coef.	Std. Err.	t	Coef.	Std. Err.	t	Coef.	Std. Err.	t
$\ln y_{t-1}$	-	0.1051	-7.97				-	0.1097	-6.93			
t	0.0067***	0.0011	6.04	0.0080***	0.0010	8.28	0.0058***	0.0012	4.83	0.0076	0.0012***	6.27
$\ln l$	0.4317***	0.1349	3.2	0.5158***	0.1447	3.56	0.3944**	0.1541	2.56	0.5190	0.1820**	2.85
$\ln k$	0.0966***	0.0362	2.67	0.1154**	0.0389	2.96	0.1052***	0.0394	2.67	0.1384	0.0475***	2.92
r	-	0.7830	-3.88	-	0.8160	-4.45	-	0.7625	-4.04	-	0.9285***	-4.37
$1-\gamma$	0.3735*	0.2130	1.75	0.4463*	0.2463	1.81	0.2689	0.2396	1.12	0.3538	0.3038	1.16
$\ln\sigma_1$	-	0.0172	-4.18	-	0.0153	-5.60	-	0.0198	-3.31	-	0.0207***	-4.17
constant	0.6472	1.3292	0.49	0.7733	1.5930	0.49	0.4476	1.5310	0.29	0.5890	2.0219	0.29
Number of obs	94						94					
F	10.79						7.87					
Adjusted R2	0.7						0.62					

Note: the dependent variable is $\Delta\ln(y_t)$, where y is industrial sales; [1] uses the percentage difference of gasoline price between China and US as a measure of oil price distortion; [2] uses the absolute value of such difference as a measure of oil price distortion; the estimated coefficients of ΔZ_t are not reported to save space; ***, **, and * denote significance at the 1, 5, and 10 per cent respectively.

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