Chapter 9

International Oil Price, National Market Distortion, and Output Growth: Theory and Evidence from China

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CHAPTER 9

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Energy prices are often distorted by government control. This is justified on the grounds that it will help mitigate the negative impacts of price volatility from oil imports and will have a positive effect on the domestic economy. In this paper, we establish, in a two-sector growth model, that such price distortions do affect the economy and then based on that model we empirically estimate its impact on the output growth in China, using monthly time series data. In contrast to the arguments for price control, we find that 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. Price control is a significant barrier to energy market integration. Since the induced distortion dampens the domestic economy, the grounds to maintain price control are seriously undermined. Therefore, the finding of this paper lends support to the energy market integration that many regions, such as East Asia, are advocating.

Keywords: 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 the 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 instigated 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 and Kilian, 2004). Many early studies, such as Darby (1982) and Hamilton (Hamilton, 1983, 1985), demonstrated that changes in the oil price have substantial 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 (Clark and Terry, 2009; Chen, 2009; Bernanke, *et al*., 1997). These issues were revitalised in the 2000s when oil prices rose more than 600 per cent between 2001 and 2008, while the average quarterly core inflation in the US was about 2 per cent over the same period (Clark and Terry, 2009). A more recent study finds that a relationship may exist in some cases of oil shocks but not in others (Kilian, 2008).

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

Despite the empirical results being inconclusive, it appears that policy makers generally believe that oil price shocks exert a negative impact on the domestic economy and due to this belief price regulations in the energy market, such as price caps and subsidies, have been practiced for a long time and still prevail in many countries (IEA, 2012). Many policy makers prefer to have such price regulations on the grounds that these measures will insulate the domestic economy from the 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, price regulation will inevitably lead to price distortion in the energy market and it is a significant barrier to the energy market integration that many regions, such as East Asia, are advocating (Shi and Kimura, 2010). Although policy makers hope such price regulations will benefit the domestic economy, the induced distortion may actually exert negative impacts. If the distortion dampens the domestic economy, the justification to maintain price regulation will be seriously undermined.

Therefore, examining the impact of price distortion will present important implications for policy makers and will lead to a better understanding of energy market integration. However, even with its policy significance, there is no previous study that explores the impact of energy price distortion on the domestic economy. To fill this gap, this paper intends to explore the impact of energy price distortion, both theoretically by using a two-sector growth model and empirically by a time-series analysis of China's situation.

This paper focuses on China, a large developing economy. On the one hand, China's fast economic growth creates a huge demand for resources such as oil. On the other hand it also maintains a number of intervention measures, such as price control in the domestic energy market. Since 2009, imported oil has accounted for more than half of the total oil consumption in China and 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 is four-fold. First, we explicitly introduce the role of energy market distortion into the thoroughly 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 developing economy with a high dependence on imported oil and price control. This will lead to significant implications for policy makers in China and other developing countries. We also propose several measures on the price distortion in China. Fourth, our study also sheds light on a better understanding of energy market integration, which is often hindered by subsides and other price control measures in the domestic markets.

The remainder of this paper is as follows. Following the introduction, Section 2 presents a discussion on oil consumption and the energy pricing mechanism in China, which gives background information for the subsequent exercise and measures the energy price distortion in China. Section 3 presents a two-sector growth model where we demonstrate that oil price distortion affects the domestic economy. Using these implications from 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 the gradual liberalising of the domestic oil pricing mechanism, researchers have expected a more active interaction between the world oil price and China's macroeconomy (Du, *et al.*, 2010; Wu, *et al.*, forthcoming). Therefore, China is a suitable case study for 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 over the past two decades and is expected to 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 a 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 and before 1998, it was heavily regulated. In the 1980s and 1990s, China adopted a dual-track pricing system, under which the prices for most oil products were tightly regulated, while the rest were traded in the market more or less freely. 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 benchmarked against the Singapore futures markets and later in 2001 the benchmark was extended to Singapore, Rotterdam, and New York futures markets, where an unpublished weight was used to set 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. Although this price benchmarking enables the domestic markets to follow the international markets, it is also intended to insulate the domestic markets from the volatility of petroleum prices in the global markets (IEA, 2010). Due to this intention, even with the liberalizing reforms implemented in the early 2000, the pricing regime was besotted with ad hoc subsidies and the non-transparent, inconsistent enforcement of 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 tends to alleviate 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 be in case 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). This flaw was taken advantage of by distributors and consumers who profited from hoarding oil products when international oil prices registered large rises and selling them after government price adjustments (China.org.cn, 2013).

With the increasing demand for the full marketisation of domestic oil product prices, China changed its oil pricing mechanism in March 2013. It can adjust domestic oil prices every 10 working days regardless of how much international oil prices change. Domestic prices will be changed if price changes in the international oil markets are not more than 50 Yuan per tone. However, the government retains the authority to suspend, postpone or downsize the price adjustment in special cases, such as sharp rises in domestic inflation, emergencies or dramatic swings in global oil prices. Nevertheless, there are no pre-defined conditions under which the government will intervene and thus the government may surprise the market. The National Development and Reform Commission (NDRC) claims that the new mechanism is more responsive to global oil market changes and will help the country to better utilise overseas resources to ensure domestic oil supplies (China.org.cn, 2013).

2.2. Measurement of Oil Price Distortions

The on-going adjustment of oil product pricing regimes provides a good case study for the impact of price distortion. Even though China is gradually liberalising 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 and we measured the price distortion in the following way.

First, we calculated the average monthly gasoline price (Chinese Yuan per ton) in China for three types of gasoline without lead (gasoline no. 90, 93, and 97), the prices for these types are sourced from the CEIC database. Second, we extracted the average end user price of all grade motor gasoline in the US, which was sourced from the US Energy Information Administration (EIA). The unit for this price is US dollar per gallon, which we then converted 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 average period of official nominal exchange rate sourced from the IMF.

Third, after we obtained the Chinese and US gasoline prices with the same unit (Chinese Yuan per ton), we calculated three measures of domestic oil price distortion.

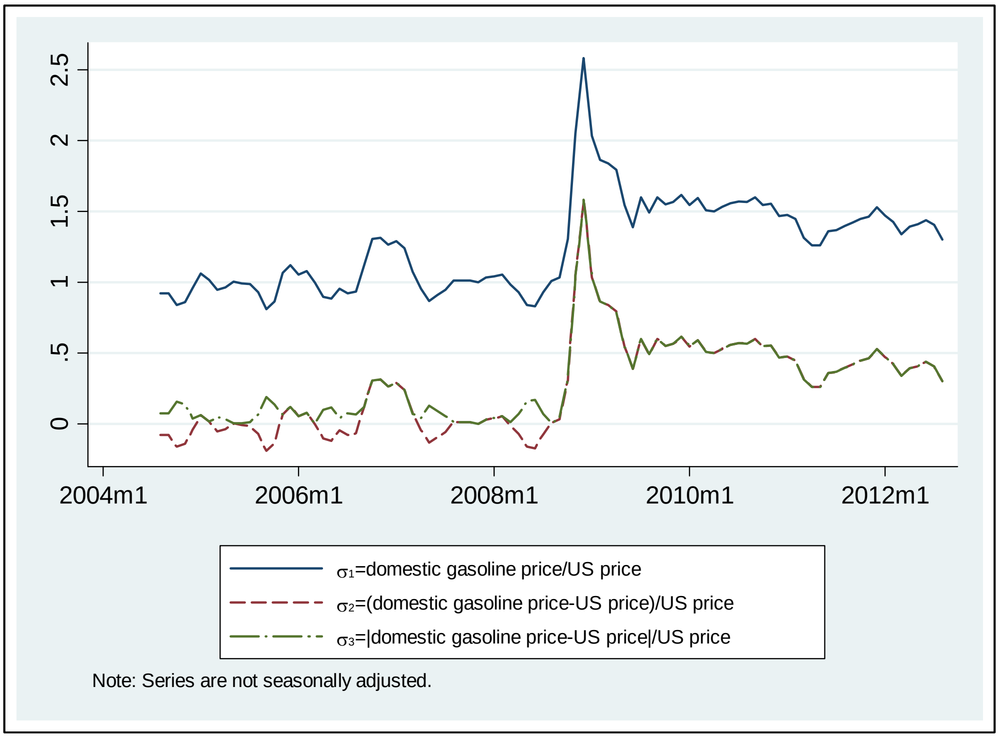
The first measure is the ratio of Chinese price against US price, namely $\sigma_1 = P_{China} / P_{US}$, where P denotes price and σ denotes price distortion.[1] The second measure is the percentage difference between Chinese and US prices, namely $\sigma_2 = (P_{China} – P_{US}) / P_{US}$. For σ_2. It is also possible that the direction of percentage difference does not matter in affecting the economy and the impact is symmetric. Considering this point, we also calculated the third measure as $\sigma_3 = |P_{China} – P_{US}| / P_{US}$.

In measuring the price distortion, as in Lin and Jiang (2011), we used the US gasoline price as a reference. We assumed that the US price would be close to the perfectly competitive market price. Although the US gasoline price cannot be a perfectly competitive market price, it is possibly the best available proxy to the perfectly competitive market price for the following two reasons. First, the US enforces a 13% tax, which is lower than that in all European countries (Thompson, 2011), and compared to European countries the distortion from the government intervention is minor. Second, the US maintains strict control on anticompetitive conduct in the petroleum industry, including the gasoline market (The US Federal Trade Commission, 2007) and so the distortion from market power is minor. In addition, as long as the US gasoline price is not systematically correlated to market distortion in the Chinese gasoline market the benchmark price, although not a perfect competitive price, is acceptable to be used to measure the gaps.

Figure 1 represents 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 attempting to liberalise 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 before 2009m1. One reason for the sudden increase in gasoline price is that the fuel tax was increased from 0.2 CNY (US 3 cent) per litter to 1 CNY (US 15 cent) per litter since 2009. For the continuous high level of oil price, it is argued that the gasoline was under-priced (Xin Jing Bao, 2011).

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

Figure 1: The Price Distortion in China



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

3. The Model

Price controls are the main reason for the price distortion in the energy market. Nevertheless, they are often justified because they can shield the domestic economy from undesired oil price shocks in the world market. Such oil price shocks can lead to inflation and recession in the domestic economy (Barsky and Kilian, 2004; Darby, 1982). This negative impact, however, is questioned in 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 but from the policy response to the oil price shocks (Kilian, 2008).

In addition, price controls such as subsidies negatively affect the domestic economy. A number of studies show that price distortion hurts economic growth (Wu, *et al.*, 2012; Tang, *et al.*, 2010). Theoretically, the regulated energy prices can affect the domestic economy in the following three ways. First, the subsidies, or the surrendering of profits from state owned oil companies, essentially transfer government revenue to consumers in a way that is not necessarily efficient. Consequentially, we can expect welfare loss from such subsidies.

Second, price distortion leads to the 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 this leads to 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 lead to inefficient consumption and the waste of energy (GSI, 2011). For example, when presented with cheaper fuel prices consumers are more likely to use vehicles intensively and have less incentive to switch to more energy efficient vehicles.

Therefore, we expect price distortion to affect the domestic economy in a negative manner. Below we explore the impacts of oil price distortion, measured as the price deviation between domestic and world markets, on the 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, specifically the oil sector and final goods sector. A representative consumer chooses a sequence of consumption of final goods to maximise their lifetime 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 presented with the following budget constraint:

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

where k denotes capital they own, w is their wage income, and r and δ are rental and depreciation rates of capital respectively. Solving the utility maximisation problem, we obtain an Euler equation as follows:

$$\frac{c_{t+1}}{\rho c_t} = r_{t+1} + 1 - \delta \quad (1)$$

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

$$Y_t = AL_t^{1-\alpha-\beta} K_{yt}^{\alpha} O_t^{\beta}$$
(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 the 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 the domestic oil price.

Firms in the final goods sector choose employment of labour, capital, and oil to maximise 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, specifically the share of oil consumption that is sourced from the world market. The profit maximisation yields the following first order conditions:

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

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

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

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

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

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

$$X_t = S_t K_{xt}^{\eta} \quad (7)$$

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:

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

Subject to the transition of state variable S (Equation 8), firms in the oil sector choose the level of capital to maximise 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:

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

which characterises 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 the marginal cost (the left hand side of Equation 9). Since current oil extraction affects future oil extraction by the reduction of oil reserves, 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 (final goods market clears) implies that:

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

where $C_t = Lc_t$ and $K_{xt} + K_{yt} = Lk_t$. An equilibrium in the economy is then characterised 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, specifically $C_t = C$, $Y_t = Y$, 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 find that the oil demand is constant as well ($O_t = O$). At the 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 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 characterised by Equations (8), (9), and (11), together with Equation (12).

At the steady state, K_{xt} cannot be constant. If not, then equation (8) implies that the oil reserve is depleting at a constant rate. From Equation (12), γ_t is decreasing at a constant rate. A constantly decreasing γ_t and a constant K_{xt} violate the resource constraint (Equation 11). Similarly, γ_t cannot be constant as well. If γ_t is instead constant (i.e. $\gamma_t = \gamma$), 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 $K_{xt+1} = \frac{K_{xt}}{(1+K_{xt}^{\eta})^{1/\eta}}$. 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 the requirement that K_{xt} must be increasing across time so 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 of the national economy. Plug Equation (12) into Equation (11), we obtain:

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

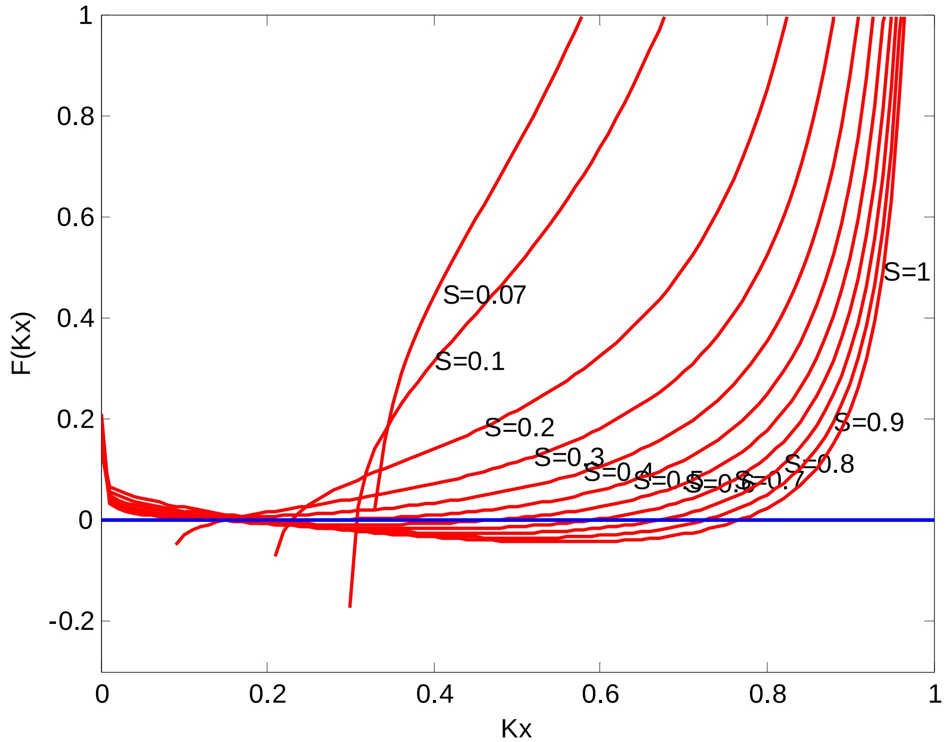
where $N \equiv Y - C - \delta K_y - Op$. Plug Equations (12) and (13) and the steady state values, such as $Y_t = Y$, into Equation (9), and after a series of algebraic manipulations we obtain the following equation:

$$F(K_{xt}, S_t, \sigma) \equiv \frac{\beta Z O^{\beta}\sigma}{S_t K_{xt}^{\eta}(\sigma-1)+O} - \frac{\rho\beta Z O^{\beta}\sigma}{S_t\left(1-K_{xt}^{\eta}\right)[(1-S_t p-\delta)K_{xt}+S_t p+N]^{\eta}(\sigma-1)+O} - \frac{r\left(K_{xt}^{\eta}-K_{xt}\right)}{\eta S_t\left(1-K_{xt}^{\eta}\right)} - \frac{\rho r\{[(1-S_t p-\delta)K_{xt}+S_t p+N]^{1-\eta}-[(1-S_t p-\delta)K_{xt}+S_t p+N]\}}{\eta S_t\left(1-K_{xt}^{\eta}\right)} = 0 \quad (14)$$

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 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 relies completely on oil imports (i.e. $\gamma = 0$). 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: Graph of F(S(t), K_x(t), other parameters) σ=1.5



Figures 3, 4, and 5 reveal the possible dynamics of K_{xt}, S_t, and 1-γ_t (i.e. 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 picked one solution if multiple solutions exist; and (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 (Figure 3), in the end the oil reserve is so low that the domestic economy increasingly has to rely on oil imports. When the oil dependency rate approaches 1 (Figure 5), it suggests that the economy will eventually shut down the domestic oil sector.

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

Figure 3: Dynamics of K_x

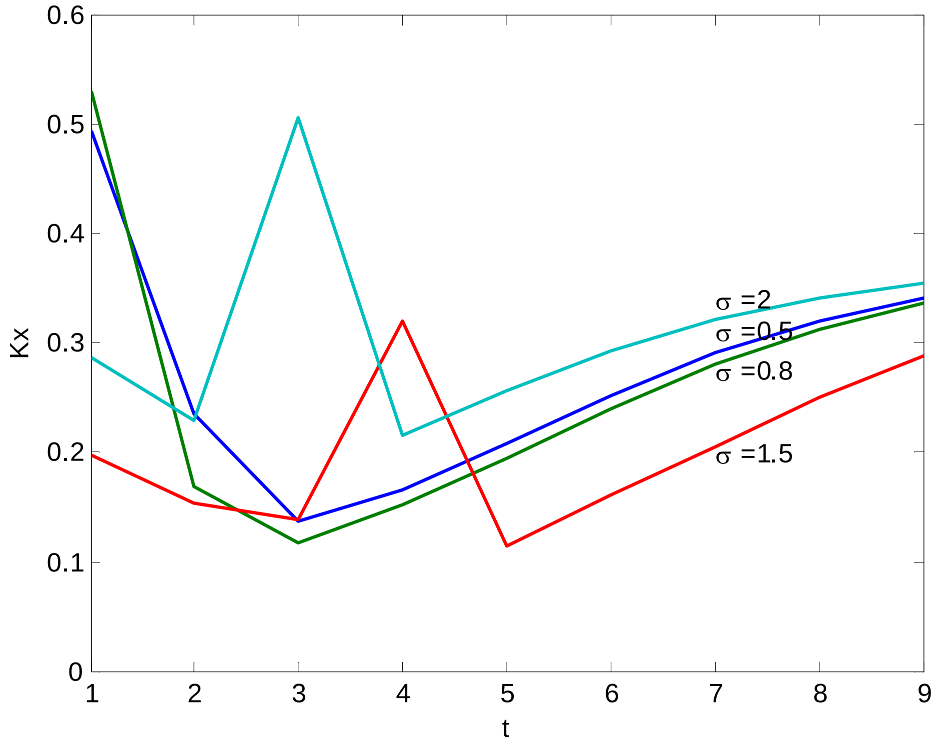


Figure 4: Dynamics of Oil Reserve (S)

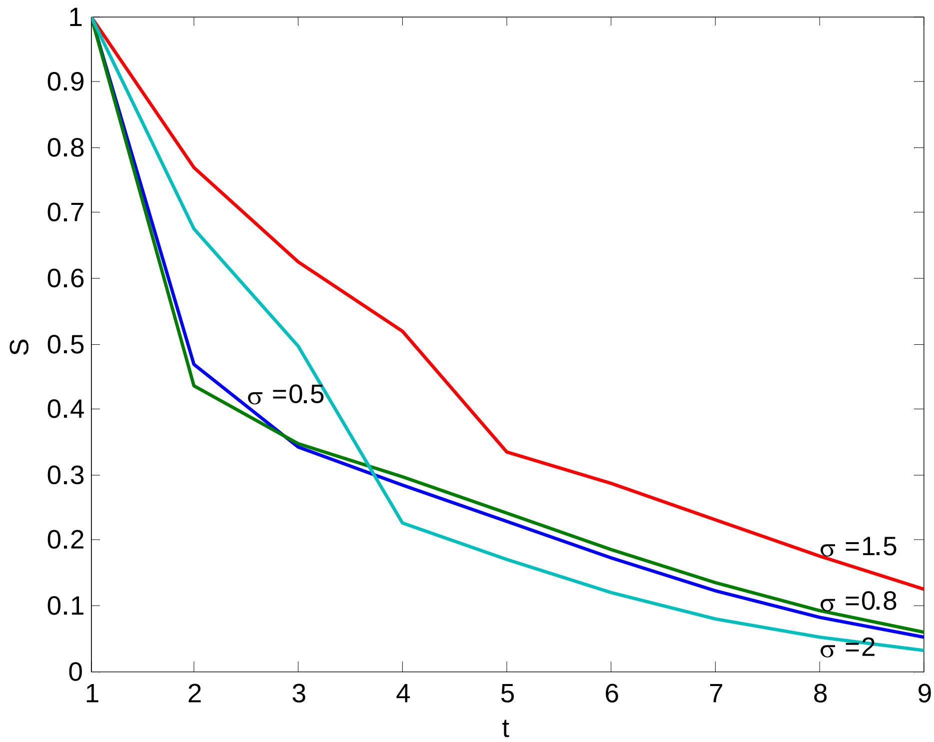
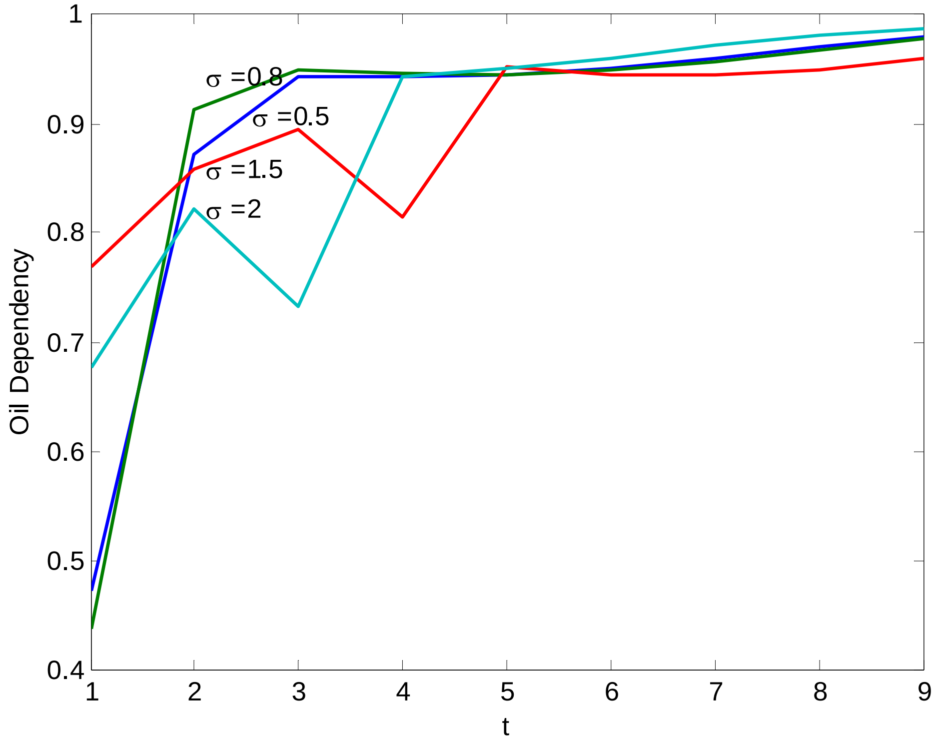


Figure 5: Dynamics of Oil Dependecy (1γ)



4. Empirical Estimations

In Section 3, we investigated 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:

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

(16)

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

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

(17)

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

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

(18)

where λ_0, λ_1, □, and $\boldsymbol{\theta}$ are short-run parameters with the long-run parameters being $\lambda_0/(1 - □)$, $\lambda_1/(1 - □)$, and $\boldsymbol{\theta}/(1 - □)$, 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 used 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 (ARDL1,0) and we can generalise it by allowing for lags in $\boldsymbol{Z}_t$ and longer lags in Y_t as follows:

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

(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 non-stationary. Pesaran and Shin (1999) showed 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 oil imports contribute positively to domestic economic growth, while on the other hand, as the economy grows, it may become increasingly dependent on oil imports and specifically 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 and 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:

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

where $\phi^*(L) = \sum_{j=1}^{p} \phi_j L^j - L$, Δ denotes the difference operator (i.e. $\Delta = 1 - L$) and m denotes the length of lags. 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 a monthly time series from 2004M8 to 2012M8 in China. We obtained the data from the CEIC database, which in turn collects data from different sources. We used two series to measure the output (y). The first one is the industrial production index, which is calculated from a series (percentage change of industrial production index over the corresponding month of previous year) sourced from the International Monetary Fund (IMF), assuming year 1993 is 100. The other is industrial sales in a billion Chinese Yuan sourced from the National Bureau of Statistics (NBS). We used the producer price index for industrial products, which is sourced from the NBS and has a base year of 1997 to deflate the industrial sales. The labour (L) is also sourced from the 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.

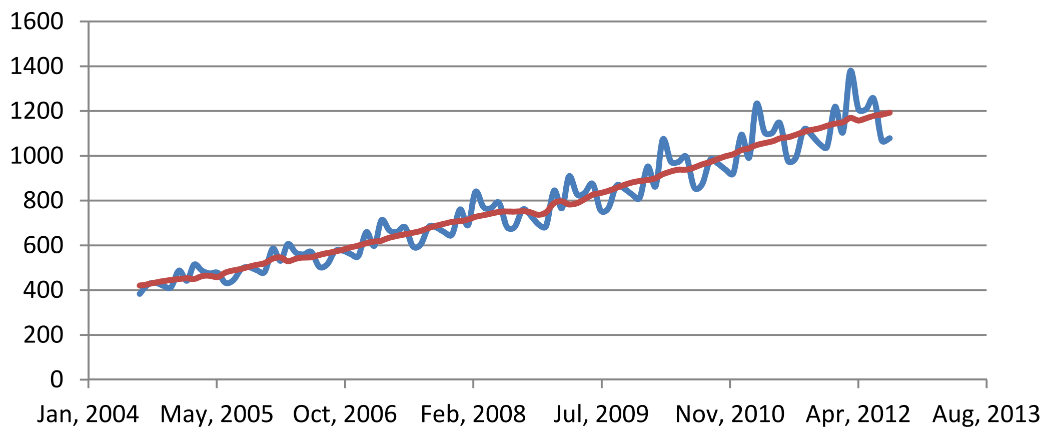
The capital (K_y, in billion Yuan) is constructed from fixed asset investment. First, we calculated the monthly increment of fixed asset investment in secondary industry from year-to-date fixed asset investment data and deflated it using the fixed asset price index with a base year of 2003. Second, we assumed a monthly capital depreciation rate of 0.4 per cent, which translates to a 4.9 per cent per annum depreciate rate, and took 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 $K_{y0} = I_0$.

Oil dependency ($1 - \gamma$) is measured as the share of oil imports in domestic oil consumption and is constructed as follows. First, we extracted the imports and exports of crude oil (million US dollars) and the import and export prices (US dollars per ton), which are sourced from the General Administration of Customs from the CEIC database. From the value and price of imports and exports, we calculated the quantity of exports and imports. Second, we extracted the domestic production of crude oil, which is sourced from the 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 the IMF and π denotes the monthly inflation rate. The monthly inflation rate is calculated from the consumer price index, which is sourced from the International Financial Statistics (IFS) by the 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 unexpected that they exhibit seasonality. We adjusted the data series by using the X-12-ARIMA Seasonal Adjustment Program to eliminate the influence of seasonal fluctuation[2]. 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-seasonalisation. The blue curve is the original series and it is evident that it contains seasonality in addition to an upward trending. The de-seasonalised series (red curve) appears to eliminate the seasonality while maintaining the same upward trending.

Figure 6: Industrial Production Index, 1993=100



Source: CEIC Database.

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

4.3. Unit Root Tests

We first carried 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 and Fuller, 1979) and Phillips–Perron (PP) unit root test (Phillips and Perron, 1988) are used. 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.

For the three measures of domestic oil price distortion, since Figure 1 suggests that there exists structural break, we carried 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 $\ln\sigma_1$, 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 are 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 because 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 and Pesaran, 1997).

Table 1: Unit Root Tests

Variables	Levels ADF Constant	Constant + Trend	PP Constant	Constant + Trend	First Difference ADF Constant	Constant + Trend	PP 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

4.4. Regression Results

To estimate Equation (20), we have two measures of industrial output (i.e. industrial sales and industrial production index) and three measures of domestic oil price distortions, which lead to six regressions. In the following, we described the empirical exercise using industrial sales as the measure of industrial output and the ratio of China's gasoline price against US gasoline price ($\ln\sigma_1$) as a measure of oil price distortions and the rest regressions will follow the same specification and serve as sensitivity analysis. The first step in the exercise is to determine the length of lags. We used both the Akaike Information Criteria (AIC) and the Schwartz-Bayesian Criteria (SBC) to determine lag length and chose the length of lags that yielded a minimal AIC and SBC. The maximum length of lags is set to be five[3]. 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-run coefficients as in Equation (20) and the right panel is the associated long-run coefficients. After the regression, we carried out a set of diagnostic tests. The Breusch-Godfrey test for serial correlation finds no evidence of first, second, third, fourth, or fifth order autocorrelation. A LM test for autoregressive conditional heteroskedasticity (ARCH) also failed 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 failed to reject the null of homoskedasticity at the 1 per cent level. The Ramsey RESET test obtains a test statistic of 3.63, and failed to reject the null of no omitted variables at the 1 per cent level. We also examined the stationarity of the residual by conducting both ADF and PP tests with both rejecting the null hypothesis of unit root at 1 per cent level. Therefore, the regression is appropriate.

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

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	-			
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	-	0.8069	-4.1	-4.081***	0.8842	-
oil dependency (1 –	0.4848**	0.2241	2.16	0.5974**	0.2597	2.30
distortion ($\ln\sigma_{lt}$)	-	0.0241	-	-	0.0233	-
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 □$_y$ denote the coefficient of lagged industrial output ($\ln y_{t-1}$). Let □$_y$ = □ – 1 in Equation 20, then $\varphi = -\theta_l$ / □$_y$. To obtain the associated standard error, we first linearized φ by the first order Taylor approximation at the point estimates of θ_l and □$_y$, 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 negative coefficient of lagged industrial sales suggests that industrial growth rate decreases as it grows bigger.[4] This regressive development is

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

consistent with the findings of Sheng and Shi (Sheng and Shi, 2013) which states that economic growth across countries converges unconditionally. The growth rate exhibits a significant increasing trend, possibly owing to technological progress and consequently labour and capital contribute positively to 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 the goods and oil sector (*ceteris paribus*) and subsequently impairs industrial growth. This supports arguments in the literature that the actual reason for the slowing of economy growth after oil price shocks is the tightening of the monetary policy (Bernanke, *et al*., 1997). Oil dependency ($1-\gamma_t$) appears to affect positively on 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. This suggests that the oil price distortion impairs 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. Labour and capital contribute 43.9 and 10.5 per cent to the industrial sales respectively, which adds up to less than one because there are other factors such as oil that contributes to the industrial sales. The real interest rate exerts a significant 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.

Table 3 reports the results where the dependent variable is the industrial production index. Due to the manner in which the original data was reported, the original series is the percentage change of industrial production index over the corresponding month of previous year, we had 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, the results in Table 3 serve only as a comparison to those in Table 2. Compared with Table 2, the negative impacts of oil price distortion continue to hold in 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. Moreover, the coefficients of labour, real interest rate, and oil dependency rate are now insignificant at the 1 per cent level. Therefore, even though we observed 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 revealed that the oil price distortion exerts a significant and negative impact on industrial production in 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 used are described above. We re-estimated Equation (20) using these two measures, where the length of lag is one and Table 4 reports the results. Comparing the estimated coefficient of oil price distortion, the sign is negative in both regressions, consistent with the findings in Table 2, although there exist variations in the magnitude. The coefficients of the other variables are approximately in line with those of Table 2. Therefore, the negative impact of oil price distortion in the short and long run is robust to these two alternative measures of oil price distortion.

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
$\ln\sigma_I$	-	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.

Figure 1 suggests that there exists a structural break for oil price distortion in 2009m1. Therefore, in the above exercise, we also included 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 little variation in the coefficients of the other variables. Thus, this structural break appears not to significantly affect the regression results.

5. Policy Implications

Since price distortion, which occurs mainly due to price regulation, impairs economic growth this finding contradicts a common argument of energy price regulation; price regulation can shield the domestic economy from negative oil price shocks in the world market. Consequently, this study supports energy price deregulation. It also advocates for the removal of policies and interventions, such as subsidies, that may distort domestic energy prices because they are detrimental to the domestic economy. A market oriented energy price regime may improve the resilience of the domestic economy to global oil price shocks. Although the removal of subsidies is a sensitive issue and difficult, a gradual approach is still possible as China has demonstrated in the past (Lin and Jiang, 2011). This study also implies that a monetary policy, which may be tightened over concerns about inflation resulting from international price shocks, should be finely tuned to avoid impairing economic growth.

This study also leads to a better understanding of energy market integration. Price regulations are the main obstacles to energy market integration. Given that price regulations lead to undesired price distortion, it is worthwhile promoting the integration of the energy market between net energy exporters and importers, which helps to eliminate price distortions. This point is particularly relevant to East Asia, since many East Asian countries still have tight regulations on energy pricing. Brunei, Indonesia, and Malaysia are excellent examples with practically fixed gasoline prices.

6. Concluding Remarks

This paper explores the impact of oil price distortion on the domestic economy, both theoretically in a two-sector growth model and empirically in China. In the theoretical model, we illustrated the impacts of price distortion on the state oil sector capital accumulation and oil dependency. Empirically, using a specification derived from the theoretical model, we applied the ARDL modelling technique to a monthly time series dataset in China from 2004M8 to 2012M8 and found that oil price distortion jeopardises 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.

Price control is a significant barrier to energy market integration. Since the induced distortion dampens domestic economy, the justifications to maintain price control are seriously undermined. Therefore, the finding of this paper supports energy market integration that many regions, such as East Asia, are advocating.

References

Andrews, D. and E. Zivot (1992), 'Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis', *Journal of Business and Economic Statistics,* 10, pp.251-70.

Barsky, R. and L. Kilian (2004), 'Oil and the Macroeconomy Since the 1970s', NBER Working Paper 10855. Cambridge: National Bureau of Economic Research.

Bernanke, B. S. G. Markwardt and M. W. Watson (1997), 'Systematic Monetary Policy and the Effects of Oil Price Shocks', *Brookings Papers on Economic Activity,* 1, pp.91-142.

Chen, S.-S. (2009), 'Oil Price Pass-Through into Inflation', *Energy Economics,* 31.

China.org.cn. (2013), *China adjusts oil price mechanism* [Online]. Available: http://www.china.org.cn/business/2013-03/26/content_28365275.htm (accessed 3 May 2013).

Clark, T. E. and S. J. Terry (2009), Time Var iation in the Inflation Passthrough of Energy Pr ices. *Research Working Papers RWP09-06.* Kansas: The Federal Reserve Bank of Kansas City Economic Research Department.

Darby, M. (1982), 'The price of oil and world inflation and recession', *American Economic Review,* 72**,** 738-751.

Dickey, D. A. and W. A. Fuller (1979), 'Distribution of the estimators for autoregressive time series with a unit root', *Journal of the American Statistical Association,* 74, pp.427-431.

Du, L., Y. He and C. Wei (2010), 'The Relationship between oil price shocks and China's marco-economy: An empirical analysis', *Energy Policy,* 38, pp.4142-4151.

Global Subsidies Initative (GSI) (2011), *People's Guideline to Energy Subsidies in In Indonesia*. Geneva: IISD/GSI.

Government of China (2008), *State Council Notice on the Implementation of Oil Price and Tax Reform [27/2008]* [Online]. Beijing: China State Council. Available: http://www.gov.cn/zwgk/2008-12/19/content_1182128.htm.

Hamilton, J. (1983), 'Oil and the Macroeconomy Since Wolrd War II', *Journal of Political Economy,* 91, pp.921-48.

Hamilton, J. (1985), 'Historical Causes of Postward Oil Shocks and Recessions', *The Energy Journal,* 6, pp.97-116.

IEA (2010), *World Energy Outlook 2010,* Paris: International Energy Agency.

IEA (2012), *World Energy Outlook 2012,* Paris: International Energy Agency.

Jones, D. W. P. N. Leiby and I. K Paik (2004), 'Oil Prices Shocks and the Macroeconomy: What Has Been Learned Since 1996', *The Energy Journal,* 25, pp.1-32.

Kilian, L. (2008), 'A Comparison of the Effects of Exogenous Oil Supply Shocks on Output and Inflation in the G7 Countries', *Journal of the European Economic Association,* 6, pp.78-121.

Kojima, M. (2012), 'Oil price risks and pump price adjustments', Policy Research Working Paper 6227. The World Bank.

Lescaroux, F. and G. Suez (2009), 'Measuring the effects of oil prices on China's economy: A factor-augmented vector autoregressive approach', *Pacific Economic Review,* 14, pp.410-425.

Lin, B. and Z. Jiang (2011), 'Estimates of Energy Subsidies in China and Impact of Energy Subsidy Reform', *Energy Economics,* 33, pp.273-283.

Ou, B., X. Zhang and S. Wang (2012), 'How does China's macro-economy response to the world crude oil price shock: A structural dynamic factor model approach', *Computers & Industrial Engineering,* 63, pp.634-640.

Pesaran, M.H. and B. Pesaran (1997), *Working with Microfit 4.0: Interactive Econometric Analysis,* Oxford, Oxford University Press.

Pesaran, M. H. and Y. Shin (1999), 'An autoregressive distributed lag modelling approach to cointegration analysis', In Strom, S., A. Holly and P. Diamond (eds.), *Econometrics and Economic Theory in the 20th Century: The Ragner Frisch Centennial Symposium.* Cambridge: Cambridge University Press.

Phillips, P. C. B. and P. Perron (1988), 'Testing for a unit root in time series regression', *Biometrika,* 75, pp335-346.

Segal, P. (2007), 'Why Do Oil Price Shocks No Longer Shock?', Oxford Institute for Energy Studies Working Paper WPM 35. Oxford: Oxford Institute for Energy Studies.

Sheng Y. and X. Shi (2013), 'Energy market integration and Equitable Growth Accross Countries', *Applied Energy,* 104, pp.319-325.

Shi, X. and F. Kimura (2010), *Energy Market Integration in the East Asia Summit Region: Review of Initiatives and Estimation of Benefits*. Jakarta: Economic Research Institute for ASEAN and East Asia (ERIA).

Stock, J. H. and M. W. Watson (1993), 'A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems', *Econometrica,* 61, pp.783-820.

Tang, W, L. Wu and Z. Zhang (2010), 'Oil Price Shocks and Their short- and long-term effects on the Chinese economy', *Energy Economics,* 32, s.3-14.

The US Federal Trade Commission (2007), Prepared Statement of the Federal Trade Commission On Market Forces, Competitive Dynamics, and Gasoline Prices: FTC Initiatives To Protect Competitive Markets. *Before the Subcommittee on Oversight and Investigations Committee on Energy and Commerce U.S. House of Representatives.* Washington, D.C.: The US Federal Trade Commission.

Thompson, D. (2011), 'Gas Prices Around the World: Cheaper Than Water and $10 a Gallon', *The Atlantic*, 3 May 2011.

Wu, L., J. Li and Z. Zhang (forthcoming), 'Inflationary effect of oil-price shocks in an imperfect market: A partial transmission input–output analysis', *Journal of Policy Modeling*.

Wu, Y., X. Shi and F Kimura (eds.) (2012), *Energy Market Integration in East Asia: Theories, Electricity Sector and Subsidies,* Jakarta: Economic Research Institute for ASEAN and East Asia.

Xin Jing Bao (2011), Why China's Gasoline Price is More Expensive than the US's. *Xin Jing Bao*.

Zaouali, S. (2007), 'Impact of Higher Oil Prices on the Chinese Economy', *OPEC Review,* 3**,** 191-214.