Applied Energy 165 (2016) 329–334

Contents lists available at ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

Effects of energy price fluctuations on industries with energy inputs: An application to China ☆

Pu-yan Nie *, Yong-cong Yang

Guangdong University of Finance & Economics, Guangzhou 510320, PR China

HIGHLIGHTS

- This article captures the effects of energy price shocks on the industries.
- Rising energy price reduces the outputs and social welfare.
- Vertical market structure acts as an amplifier about energy price shocks.
- Price regulation can reach the environmental objection or weaken the market power.
- Entry regulation can reduce the emission.

ARTICLE INFO

Article history:
Received 1 July 2015
Received in revised form 24 November 2015
Accepted 17 December 2015

Keywords:
Energy price fluctuations
Industries with energy inputs
Price regulation
Emission

ABSTRACT

This article captures the effects of energy price fluctuations on the demand and supply of energy. By focusing on the industries that depend on energy inputs, we are able to apply these effects and analyze the Chinese energy industry. Four main sets of results are presented. First, rising energy prices reduce output and social welfare. Second, the energy industry in China has a vertical market structure, which acts as an amplifier of energy price fluctuations that increase with market power of energy firms. Third, environmental objectives can be achieved through energy price regulation, thereby weakening the market power of energy firms. Interestingly, the formula of price regulation needed to achieve the environmental objectives is given. Finally, entry-level regulation can reduce emissions. In summary, this article supports the concept of energy industry regulation by decision-makers.

1. Introduction

As the modern economy depends heavily on energy, price fluctuations have significant effects on the economy [1–4]. Many researchers capture the relationship between the economy and fluctuations in the price of energy. Several articles highlight the factors that impact the price of energy. For example, Venditti [5] discusses the path from oil to the price of energy. Aydin [6] models the relationship between the resource and the price of energy. Wang and Tian [7] establish the dynamic system model of energy price-energy supply-economic growth to capture the effects of energy price fluctuations. Others focus on the economic effect of energy price fluctuations [8]. The following review focuses on the economic effect of energy price fluctuations.

In recent years, there has been extensive research on the effects of energy price fluctuations on the economy, both at the macroeconomic and microeconomic levels. For examples, see the interesting and significant papers and corresponding references of Kilian [3], Kilian [2] mentioned herein.

Regarding the macroeconomic effect on energy price fluctuations, Kilian [9] asserts that there is not sufficient evidence to support macroeconomic factors affecting energy price in the U.S. affecting energy price, while Ju et al. [10] find that energy price fluctuations in China have a significant macroeconomic effect. Thus, authors highlight the macroeconomic effects of energy price fluctuations. Regarding the macroeconomic impact of energy price fluctuations, many authors focus on the effects of energy price fluctuations on economic growth. Berk and Yetkiner [11] have recently reviewed the relationship between energy price fluctuations and

☆ This work is partially supported by Foundation for High-level Talents in Higher Education of Guangdong, GDUPS (2012) and National Natural Science Foundation of PRC (71271100), Fundamental Research Funds for the Central Universities, Characteristic and Innovative Foundation (Humanities and Social Sciences) for Higher Education of Guangdong (2014), and, Research Center for the Industrial Development of Guangdong and its Regional Cooperation with Hong Kong, Macau and Taiwan.

* Corresponding author. Tel.: +86 20 85221069; fax: +86 20 85221001.
E-mail address: pynie2013@163.com (P.-y. Nie).

http://dx.doi.org/10.1016/j.apenergy.2015.12.076
0306-2619/

economic growth. Behmiri and Manso [12] examine three groups in Latin America and find differences in the relationship between economic growth and crude oil consumption in these different countries.

Regarding the empirical aspect, several articles examine the effects of energy price fluctuations on the economy of certain countries. Chang and Wong [13] notice that the impact of oil price fluctuations on the economic growth of Singapore is marginal. Farzanegan and Markwardt [14] find that a strong positive relationship between positive oil price changes and industrial output growth in Iran. In Brazil and U.S.A., Cavalcanti and Jalles [15] identify the macroeconomic effects of energy price fluctuations and find that the volatility in output for the United States has decreased over time. Such fluctuations do not seem to have a clear effect on the growth of output in Brazil. Chen [16] examines the inflationary effect of coal price fluctuations in China and shows that the induced inflationary expense is between 0.03% and 0.97% of China's GDP, three quarters of which is burdened by investors and foreigners. Kilian and Vigfusson [17] forecast the GDP of US by oil price and find that the predictive relationship between the price of oil and the U.S. real GDP is nonlinear.

In recent years, few papers study the effect of oil price fluctuations on macroeconomics. Liu et al. [18] discuss the stabilization of oil price on global welfare and conclude that the optimal level of oil price stabilization is chosen by developing countries. Hamilton and Wu [19] show that the interaction between financial investors can produce a factor structure for commodity futures prices.

Some researchers highlight the microeconomic effects of energy price fluctuations. Zhang et al. [20] address the microeconomic effects of energy price fluctuations in China and demonstrate that the most immediate and direct effect is the consumption of pass through transportation. Similarly, referencing the framework of Zhang et al. [20], Moshiri [21] analyzes the situation in Iran and achieves similar conclusions. Using enterprise data from 15 European countries, Ratti et al. [22] find that an increase in the price og energy has a negative effect on firm investment. Likewise, Sadath and Acharya [23] conclude that a relatively higher energy price leads to less investment in manufacturing sector, which depends on heavily on energy inputs.

Existing research focuses on the macroeconomic and microeconomic effects of energy price fluctuations. With the exception of Wang and McPhail [24], very little research has been conducted about the industrial effects of energy price fluctuations. Wang and McPhail [24] examine the effect of energy price fluctuations on the US agricultural industry and find that a fluctuation in the price of energy and an agricultural productivity shock each account for approximately 10% of U.S. agricultural commodity price volatility. The productivity shock's contribution is slightly higher. This article aims to capture the effects of energy price fluctuations on industries with energy inputs and to illustrate the theory of governmental regulation on the energy industry.

We investigate the industrial effects of energy price fluctuations because the effects of energy price fluctuations depend heavily on market power and government regulation. For example, by comparing the Feed-in tariff (FIT) policy with the renewable portfolio standard (RPS) policy in the renewable energy industry, Sun and Nie [25] conclude that FIT is more efficient than RPS in increasing the quantity of renewable energy under under an oligopoly. In contrast, Tamas et al. [26] conclude that the schemes have the same effectiveness in perfectly competitive markets. The different conclusions are derived from different market power.

Furthermore, energy price fluctuations have different effects on different industries. For example, a high petroleum price yields high industry tax costs. Because of the high petroleum price in 2011, the initial tax (in China, the initial price of a tax is fixed if the total distance is less than 2.3 km.) increases from 7 Yuan RMB (for first 2.3 km) to 10 Yuan RMB (for first 2.3 km) in the city of Guangzhou in south China. In the restaurant industry, the rising petroleum price has almost no effect, resulting in no significant change in restaurant prices. This result comes from the fact that the tax industry is more dependent on the petroleum industry.

These factors motivate us to capture the effects of energy price fluctuations on industries in China. We know that China is not only one of the world's largest energy-consuming countries, it is also one of the largest energy importers. In 2013, the total energy consumption of China is equivalent to 3750 million tons of coal, while the total import of crude oil has reached 271 million tons. Even so, China has little market power in negotiating crude oil supply contracts, which is significantly different from the U.S. Meanwhile, strong government intervention in China creates market power in the energy industry, whereas the U. S. energy industry is more competitive. As a result, the effects of macroeconomic energy price fluctuations in China are different from those in U.S. [9,10]. For instance, due to the lack of market power, China faces lower economic growth and higher inflation than the U.S in times of rising energy prices. Generally speaking, the influence of energy price fluctuations on macroeconomics in China is more significant than in the U.S. Most literature pays little attention to the imbalance between energy consumption and bargaining power and regulatory strategies in China. Therefore, applying the theory model to China helps identify the effects of energy price fluctuations on major emerging economies such as China.

In addition, the existing literature neglects the market power of the energy industry in developing countries. This paper will consider market power when addressing the effects of energy price fluctuations. This article highlights the effects of energy price fluctuations on industries with energy inputs. From the game theory model, we find that the vertical market structure (which is employed in China and some other developing countries) acts as an amplifier of energy price fluctuations. Furthermore, we show that these amplifying effects depend on the market structure of the energy industry in China. Moreover, we present the explicit formula necessary for the regulated price to achieve its environmental objective. We demonstrate that price regulation efficiently weakens the market power of energy firms.

The rest of this paper is organized as follows: the Model is established in Section 2. The model is analyzed in Section 3. First, we prove the existence of the solution. Then, the equilibrium is given and discussed. Starting with the energy market in China, we extend the model to the vertical market structure and analyze the results. Next, we discuss and compare the effects of energy price regulation and entry regulation in developing countries. We outline the explicit price regulation formula needed to achieve the environmental objective. Finally, we present the conclusions in the last section.

2. Model

We establish the model to capture the effects of energy price fluctuations on industries that depend on energy. Consider an industry with N firms that produce identical products using energy inputs. We make a general assumption to simplify the analysis so that we can focus on the effects of energy price fluctuations. We assume that the price of the final products is p. For $i = 1, 2, \ldots, N$, we denote the output of firm i to be q_i. The inverse demand function of this industry is:

$$p = A - \sum_{i=1}^{N} q_i, \tag{1}$$

where $A > 0$, which stands for the market size, is constant.