ELSEVIER

Energy Policy 35 (2007) 2287–2295

ENERGY POLICY

www.elsevier.com/locate/enpol

Can market oriented economic reforms contribute to energy efficiency improvement? Evidence from China

Ying Fan[a,b], Hua Liao[a,b,c], Yi-Ming Wei[a,b,*]

[a]*Center for Energy and Environmental Policy of the Institute of Policy and Management, Chinese Academy of Sciences, P.O. Box 8712, Beijing 100080, China*

[b]*Center for Forecasting Sciences of the Chinese Academy of Sciences, Beijing 100080, China*

[c]*Graduate School of the Chinese Academy of Sciences, Beijing 100080, China*

Available online 25 September 2006

Abstract

Since China accelerated its market oriented economic reforms at the end of 1992, its energy intensity has declined 3.6% annually over 1993–2005. However, its energy intensity declined 4.2% annually during its first reform period 1979–1992. Therefore, can we conclude that the accelerated marketization since the end of 1992 has made no contribution to its energy efficiency improvement? In order to answer this challenging question, we examine the changes of energy own-price elasticity, as well as the elasticities of substitution between energy and non-energy (capital and labor) in China during the periods of 1979–1992 and 1993–2003. Generally, in transition or developing economies, holding the technology and output level fixed, if the energy own-price elasticity (algebraic value) declines or the substitution elasticity between factors rises, they will contribute to energy efficiency improvement. Our empirical study finds that: (1) during 1979–1992, the energy own-price elasticity is positive (0.285), and capital-energy, labor-energy are both Morishima complementary; which indicates a distorted energy price and inefficient allocation; and (2) during 1993–2003, the own-price elasticity for energy is negative (−1.236), and capital-energy and labor-energy are both Morishima substitute. All factor demands become more elastic, and all elasticities of substitution increase. The implication is that the accelerated marketization contributes substantially to energy efficiency improvement since 1993.

Keywords: Energy efficiency; Elasticity; China

1. Introduction

Since China accelerated its *market oriented economic reforms* at the end of 1992, its energy intensity has declined 3.6% annually during the period 1993–2005.[1] However, during its previous reform periods (1979–1992), the energy intensity declined 4.2%; higher than during 1993–2005. This might lead us to conclude that the accelerated marketization observed since the end of 1992 has had no contribution to energy efficiency improvement. We will explore this challenging notion in this paper.

Energy efficiency is not only a ratio of energy consumption to GDP, but is also associated with economic structure, technical levels, living conditions, institutions and management. By using input–output analysis, Wei et al. (2006a, b) investigate the technical effects on energy saving potential for the year of 2020 in China. Many literatures have also discussed the functions of market mechanism to energy efficiency improvement. As Anderson (1995) proffers many scholars believe that the more commercial policies there are, and the greater the openness to private investment, then the more substantial energy efficiency there is; moreover, this conclusion is especially relevant for developing countries. Meyers (1998) discusses the strategies that aim at strengthening the effectiveness of market forces in delivering greater energy efficiency. Sinton and Fridley (2000) find that the shift from state-owned to collective, private and foreign invested ownership plays an

*Corresponding author. Center for Energy and Environmental Policy of the Institute of Policy and Management, Chinese Academy of Sciences, P.O. Box 8712, Beijing 100080, China. Tel./fax: +86 106 2650861.

E-mail addresses: ymwei@deas.harvard.edu, ymwei@263.net (Y.-M. Wei).

[1]Calculated form NBS (2005, 2006).

0301-4215/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.enpol.2006.07.011

important role in improving energy efficiency since 1996 in China. By examining approximately 2500 enterprises in a survey, Fisher-Vanden et al. (2004) find that the reform in ownership and rising energy prices were also the drivers of China's declining energy intensity. By using a dynamic computable general equilibrium analysis, Fisher-Vanden (2003) also argues that further implementation of market reforms in China will result in a structural shift to less carbon-intensive production (also shifting to less energy-intensive production).

The market is not just a resources allocation instrument, but also an incentive mechanism. Deregulating energy prices, clarifying and decentralizing property are helpful to optimize energy allocation and motivate energy consumers to reduce wasting, or to choose the most cost-effective energy saving equipments and appliances. Energy price is a significant signal. When it rises, producers will decrease energy consumption by turning to other substitutable factors. It may also induce energy saving technologies or innovations (Jorgenson and Wilcoxen, 1993; Popp, 2002). Except for some market failures, generally in transition or developing economies, holding technology and output levels fixed, the more market-driven or less government planned resource allocation, then the more flexible the economy and the more elastic the factors substitution.

de La Grandville (1997) suggests to view the elasticity of substitution as an efficiency parameter. He show that how the rate of growth of an economy was directly linked to the size of the elasticity of substitution. In this paper we will examine whether the accelerated economic reforms raise the elasticity of substitution, and then contribute to energy efficiency improvement. We will investigate the change in energy own-price elasticity, as well as the elasticities of substitution between energy and non-energy (capital and labor) in China during the periods 1979–1992 and 1993–2003. If the energy own-price elasticity (algebraic value) declines and the elasticities of substitution between factors rise resulted from economic reforms, it shows that the accelerated economic reforms contribute to the energy efficiency improvement.

The paper is organized as follows. We begin with a brief introduction of energy efficiency, market mechanism and elasticity of substitution. Section 2 describes the methodology and data collection and analysis process. In Section 3, we discuss the empirical results, and put forward some policy implications on improving energy efficiency. We conclude with a summary in the last section.

2. Methodology and data

2.1. Methodology

Since Berndt and Wood (1975) studied the factors price elasticities and substitution elasticities by using translog cost function, many empirical studies on different countries have emerged. Likewise, the research methodology and data process have also been discussed or compared (Apostolakis, 1990; Renou-Maissant, 1999; Frondel, 2004; Frondel and Schmidt, 2002; Jaccard and Bataille, 2000; Thompson, 2006; Welsch and Ochsen, 2005). Different empirical results have appeared in several countries for alternative time periods. As with most of the literatures, we also employ translog cost function to estimate the elasticity; and, consider the technical change. The function can be stated as:

$$\ln C = \alpha_0 + \left[\sum_i \alpha_i \ln P_i + \frac{1}{2}\sum_i\sum_j \alpha_{ij} \ln P_i \ln P_j\right] + \left[\gamma_1 \ln Y + \frac{1}{2}\gamma_2(\ln Y)^2\right] + \left[\lambda_1 T + \frac{1}{2}\lambda_2 T^2 + \lambda_3 T \ln Y + \sum_i \lambda_i T \ln P_i\right] \quad (i,j = K, L, E), \tag{1}$$

where C denotes total cost, Y denotes the output, K, L, E denotes capital, labor and energy, respectively, P_i denotes the price of factor i, and T denotes the time trends, used as a proxy for technical progress. α_0, α_i, α_{ij}, λ_1, λ_2, λ_3, λ_i, γ_1, γ_2 ($i = K, L, E$) are parameters of the cost function. To ensure the usual properties of Hessian matrix symmetry, linear homogeneity in factor prices, we assume the following constraints:

$$\alpha_{ij} = \alpha_{ji}, \quad \sum_i \alpha_i = 1, \text{ and } \sum_i \alpha_{ij} = \sum_j \alpha_{ij} = \sum_i \lambda_i = 0 \quad \text{for } i,j = K, L, E. \tag{2}$$

According to Shepherd's Lemma $X_i = \partial C/\partial P_i$, we can derive a linear share cost function:

$$S_i = \frac{P_i X_i}{C} = \alpha_i + \sum_j \alpha_{ij} \ln P_j + \lambda_i T, \tag{3}$$

where S_i is the cost share of factor i, X_i denotes factor i input. λ_i represents the bias of technical change.

The price elasticity η_{ij} of factor i with respect to the change in price of factor j:

$$\eta_{ij} = \frac{\partial \ln X_i}{\partial \ln P_j} = \begin{cases} (\alpha_{ij} + S_i S_j)/S_i & (i \neq j), \\ (\alpha_{ii} - S_i + S_i^2)/S_i & (i = j). \end{cases} \tag{4}$$

If $i = j$, it represents the own price elasticity of factor i. In a market economy, η_{ii} is generally negative. If $i \neq j$, it represents the cross price elasticity between factor i and j.

Allen partial elasticity of substitution (AES) is a popular elasticity measure. However, there are some debates about the elasticity of substitution, especially in the multi-factor production system. When using AES, it is difficult to measure the relative prices changes among three or more factors.

Blackorby and Russell (1989) argue that: AES is (incrementally) completely uninformative elasticity. And Morishima elasticity of substitution (MES): (i) is a measure of curvature, or ease of substitution, (ii) is a sufficient statistic for assessing-quantitatively as well as qualitatively-the effects of changes in price or quantity ratios on relative