Journal of Cleaner Production xxx (2016) 1–9

Contents lists available at ScienceDirect

Journal of Cleaner Production

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

Resource misallocation in Chinese manufacturing enterprises: evidence from firm-level data

Chu Wei [a], Chuan-Zhong Li [b, c, d, *]

[a] School of Economics, Renmin University of China, Beijing, China
[b] Department of Economics, Uppsala University, Sweden
[c] The Beijer Institute, Royal Swedish Academy of Sciences, Sweden
[d] School of Business, Ningbo University, China

ARTICLE INFO

Article history:
Received 21 November 2015
Received in revised form
1 March 2016
Accepted 19 April 2016
Available online xxx

Keywords:
Resource misallocation
Energy productivity
Firm-level data
China

ABSTRACT

Despite the important policy and welfare implications of China's energy issues, to date there has been little investigation from a micro-level perspective of the misallocation of resources in manufacturing enterprises. To fill this gap, this paper deals with resource misallocations in China with special reference to energy and labor inputs. Using a large, novel dataset of manufacturing enterprises from Zhejiang province, we employ a simultaneous system of equations for (gross) industrial output value, wage bill, energy expenditure and carbon emissions. The explanatory variables include labor, educational attainment of employees, capital value, materials, and a list of energy-related variables. Our results show that, for the same energy content, non-coal energy inputs are more productive than coal and coal-related fuels. Non-coal energy is more environmentally friendly but more expensive than coal-related fuels. Using the model estimates, we conduct Wald tests on whether the marginal productivity of labor and energy significantly differ from their respective factor costs. The main findings are that there is substantial resource misallocation in manufacturing enterprises, with labor being underpaid and energy overpaid, on average, in comparison to their marginal productivity. For energy misallocation, however, the pattern varies considerably among the various subsectors. Specifically, energy is over-used in sectors such as *Textile*, *Paper*, *Chemical*, *Plastics*, *Non-metallic*, *Ferrous metals* and *Non-ferrous metal*. By contrast, energy is under-used in sectors such as *Beverages*, *Textile-wearing apparel*, *Leather*, *Metal*, *Transport equipment*, *Electrical machinery* and *Communication equipment*. These findings can assist decision-makers in targeting the sectors where there is the most misallocation, identifying which input factors are inappropriately used, improving economic efficiency and lowering overall production costs by reducing allocative inefficiency.

1. Introduction

The demand for energy and the emission of greenhouse gases in China have surged to record levels (Carraro and Massetti, 2012; Rosen and Houser, 2007). Although energy intensity has decreased considerably over the past decades, total energy consumption continues to increase due to economic growth. Compared with advanced economies such as the US and Germany, energy intensity – the energy required to producing a unit value of GDP – is about three times higher. Because the main sources for primary energy consumption in China are fossil fuels, with coal accounting for 69% and oil 18% in 2011 (EIA, 2014), the emission coefficients are much higher than in economies using more hydropower and other cleaner energy sources. In this paper, we use firm-level data to examine the effect of energy mix on output and environment, and to quantify the level of misallocation of energy resources and other inputs to production.

Since 2010, China has become the largest energy consumer in the world, with about 3250 million tons of standard coal equivalent (tce), surpassing the United States for the first time (though the per capita energy consumption is still much lower than in the US). Meanwhile, China is one of the world's top three nations for coal-related emissions, and its emissions exceeded those of the US in 2006 (Auffhammer and Carson, 2008). Starting the same year, China also became the largest emitter of greenhouse gases. According to the Carbon Dioxide Information Analysis Center (CDIAC), fossil fuel-related emissions went up from 671 million metric tons of carbon in 1990–2259.8 million metric tons of carbon in 2010 in China (Boden et al., 2013).

* Corresponding author. Department of Economics, Uppsala University, Sweden.
E-mail addresses: xiaochu1979@gmail.com (C. Wei), Chuanzhong.Li@nek.uu.se (C.-Z. Li).

http://dx.doi.org/10.1016/j.jclepro.2016.04.083
0959-6526/

China is also the biggest contributor globally to energy subsidies. The International Monetary Fund estimates the subsidies hit $5.3 trillion in 2014, equivalent to 6.5% of the world's gross domestic product (Bloomberg, 2015). All domestic state-owned and some private industrial firms, whether in the energy production sector or on the energy demand side, have benefited from heavy energy subsidies (TheEconomist, 2013). Obviously, the energy subsidy policy lowers the real cost for Chinese firms to compete with foreign companies, but it also leads to price distortions, which in turn breed over-use of energy and environmental externalities (Haley and Haley, 2013).

The academic community is also paying increased attention to China's energy issues. There is a vast literature on the interdependence of growth, energy and pollution issues in China. However, most studies rely on aggregated data for model buildings and scenario analyses of alternative policies (Liu et al., 2015; Zhou et al., 2014). While such studies may provide structured ways of thinking about the various issues, whether the aggregate relationships are consistent with the principles of microeconomics has been less explored. A few exceptions are the studies by Fisher-Vanden et al. (2004, 2006), Wu et al. (2015) and Wei et al. (2015), where firm-level data are used for empirical analysis. Based on 2500 observations of China's most energy-intensive firms, Fisher-Vanden et al. (2004) investigate the determinants of the decline of energy intensity in China and conclude that the decline contributed about 50% to efficiency improvement a the firm level and 50% to sectoral changes. In their 2006 study, the authors utilize an extended dataset with firm characteristics and technological innovation activities to identify the key determinants of rising energy productivity within China's industrial sector. Wu et al. (2015) apply an integrated enhanced Russell model to evaluate the environmental performance of 30 thermal power firms in China in 2010. Using a non-parametric technique, Wei et al. (2015) examine the energy saving and CO_2 abatement potential of coal-fired power generating firms in China. To improve decision-making, it is important to derive aggregate behavior from microeconomic-level decisions. We contribute to this literature.

As for the misallocation issue, the most relevant and important paper is by Hsieh and Klenow (2009). Using firm-level data from the Chinese Industrial Survey during 1998–2005, they measure the dispersion in the marginal products of capital and labor within four-digit manufacturing sectors. Nevertheless, their focus is to examine the impact of resource misallocation on aggregate total factor productivity (TFP). By comparing China, India and the US, they simulate the loss of TFP due to factor misallocation. Their results suggest that China would increase TFP by 30–50%, taking the US as the benchmark, if China could eliminate its distortions. However, their paper does not consider the energy resource.

To our knowledge, there has been no study using firm-level data in China on whether and to what extent energy and other resources are misallocated.[1] This paper aims at providing some quantitative evidence on China's resource misallocation in the manufacture sectors. This paper differs from the existing literature in two areas. First, for the first time, a large, novel dataset is used, consisting of 44,832 Chinese manufacturing enterprises from the First National Economic Census. It covers the firms' basic characteristics; employee, financial, production and business situations; the use of raw materials and energy; and scientific and technological activities. This enriched disaggregated data, combined with a complete system of equations with correlated stochastic disturbances, enables us to examine the effect of energy mix on output and environment, and to quantitatively measure the misallocation level. Second, this paper offers new insights into the magnitude and distribution of resource misallocation among sectors.[2] The results suggest that the marginal labor productivity for all sectors is significantly greater than the wage rate, indicating the labor force is underpaid. The misallocation of energy factor great disparity among sectors. Energy is over-used in some energy-intensive sectors while under-used in other sectors. These findings can assist decision-makers in targeting the sectors that are most misallocated, identifying which inputs are inappropriately used, and improving economic efficiency by reducing the degree of misallocation.

The remainder of the paper is structured as follows. Section 2 describes the dataset and the summary statistics of the main variables used in the study, and Section 3 formalizes the simultaneous system of equations for production, wage, energy expenditure and CO_2 emissions. Section 4 presents the empirical results and assesses the misallocation of production factors such as labor and energy. Section 5 sums up the study.

2. Data description

The econometric analysis is based on firm-level data that originated from the First National Economic Census of Zhejiang province in 2004. The National Economic Census aims at establishing a sound system of the registration and database of the economy, and to provide a solid statistical foundation for policy-making. The reference time was December 31, 2004 and the data covered the whole year of 2004. The economic census covered all legal person units, establishments and self-employed individuals who were engaged in the secondary and tertiary industries within the territory of China. The main contents of the census include the basic characteristics of the units, such as employees, financial accounts, production and business operations, production capacity, consumption of raw materials and energy, and scientific and technological activities. The State Council established the Leading Group for the First National Economic Census (LG-FNEC) for general organization and implementation. The office of LG-FNEC that is affiliated with the National Bureau of Statistics (NBS) is in charge of the routine organization and coordination. Under the supervision of the office of LG-FNEC, Zhejiang government established the leading group and office on February 13, 2004 and then started the census program jointly with the Zhejiang Provincial Bureau of Statistics. By using stratified systematic cluster random sampling, a spot-check among 11 prefecture-level divisions in Zhejiang province was made. This inspection includes 12,026 legal person units and establishments and 34,786 self-employed individuals in 126 census districts, accounting for 24.1‰ and 12.6‰, respectively, in the total samples. A spot-check evaluation indicator – 4.9‰ of the comprehensive error rate – shows that the data fulfill the requirements of the office of LG-FNEC and meet the target set for data quality. The data cover all large and medium-sized firms with annual sales from principal activities of at least five million Chinese Yuan.

The province of Zhejiang, located in the Yangtze River Delta, with a population of 54.8 million, is one of the most developed regions in China. In terms of GDP per capita, it is ranked 6th among provinces, with a share of 6.7% of national GDP and 11% of China's exports in 2012 (NBS, 2014). Energy demands in the

[1] Note that the manufacturing industries take up 70% of total energy consumption in China.

[2] Capital misallocation is not discussed in this paper. One reason is that capital is a fixed input in the short-run, and the other is that the estimated cost of holding capital involves too much uncertainty.

Please cite this article in press as: Wei, C., Li, C.-Z., Resource misallocation in Chinese manufacturing enterprises: evidence from firm-level data, Journal of Cleaner Production (2016), http://dx.doi.org/10.1016/j.jclepro.2016.04.083