Factor substitution and rebound effect in China's food industry

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A B S T R A C T

Energy efficiency improvement can reduce the energy consumption of an industry, and thus promote energy conservation. However, the reduction of effective energy prices caused by energy efficiency improvement will lower energy costs for enterprises, making them substitute energy for other input factors. Therefore, energy conservation brought about by efficiency improvement will be partly offset. This offset is called the energy rebound effect of an industry. This paper estimates the system of cost share equations in China's food industry, analyzes the substitution relationship between each input factor, and calculates the direct rebound effect. The results show that: there exist substitution relationships between energy and other input factors, among which the substitution elasticity between energy and labor is the biggest, and the substitution of energy for capital dominates that of capital for energy. The direct rebound effect is approximately 34.39%, which means that about 34.39% of energy conservation caused by energy efficiency enhancement in the industry has been offset by the rebound effect. The paper proposes some policy suggestions on energy conservation according to the results of substitution relationship among input factors and the rebound effect of the industry. The policy suggestions include reducing the capital and labor costs of the food industry by decreasing financing costs of small businesses, optimizing personnel management, and rationalizing the energy pricing mechanism to form a reasonable energy price.

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1. Introduction

China's food industry provides food for about 1.4 billion people and can maintain balanced trade, which implies the huge scale of the industry. Meanwhile, along with the development of the economy and the improvement in people's living standard, the industry has experienced rapid growth in recent years. The sales revenue of China's food industry increased 4.5 times from 609.40 billion CNY in 2003, reaching 3326.09 billion CNY in 2012 (at constant 1990 prices).[1] The gross output value of the industry was 7681.36 billion CNY (at current prices), accounting for 9.10% of the whole industrial output value in China. Although the food industry is non-energy intensive, in which energy cost is only a small part of the total production cost (about 3%) [1], it is still an important energy consumer due to its massive scale. The energy consumption of the industry was about 57.95 million tons of coal equivalent (tce), representing 2.84% of the total energy consumption in the entire manufacturing

industries in 2012, and ranking the sixth energy-consuming sector in the manufacturing industries. Fig. 1 shows the energy consumption of China's food industry since 1980.

The food industry studied in this paper refers in particular to food processing and manufacturing, including the processing and manufacturing of food, beverage, and tobacco. The specific classification of China's food industry is shown in Fig. 2. The energy consumption and gross output value of the four sub-industries of food industry is depicted in Fig. 3.

The food industry in China is labor intensive. In 2011, the ratio of fixed assets value to labor in the industry was 325.27 thousand CNY per person, and the ratio in all the industries is 421.16 thousand CNY per person (at current prices). In addition, small and private businesses make up large majority of all the companies in the industry. The number of private enterprises was 19332 in 2011, accounting for 58.96%. Also, small businesses occupied 74.86% of all the businesses in the industry. Unlike other manufacturing industries, the cost of raw materials is very high in food industry. According to China's input–output table in 2010, the proportion of intermediate input in total input reached up to 78.92%. Intermediate input from agriculture is the largest, accounting for 50.24% of all the intermediate inputs. In general, similar to the food industry in Taiwan [2], China's food industry is also characterized

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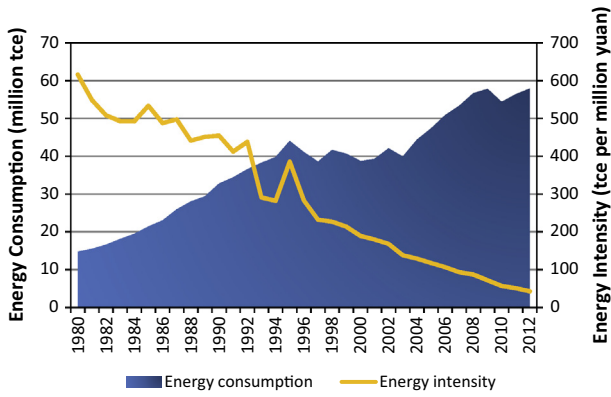[1] Source: CEIC China Database.

Fig. 1. Energy consumption and energy intensity in China's food industry. *Source:* China's National Bureau of Statistics (CNBS).

by labor intensive, high cost of raw materials and large number of small and private businesses.

Because of the important status of China's food industry in the economic system and the relatively large energy consumption, more attention has been focused on energy conservation in the industry, as concerns about energy security and sustainable environment is taking increasing precedence in public agenda. For the study of energy conservation in industries, the substitution effect between energy and other input factors and energy rebound effect are two of the most important issues. As mentioned by Wallgren and Höjer [3] and Ma et al. [2], the most important method to reduce energy use in food processing industry is developing energy-saving technology and improving energy efficiency. This method is closely related to the substitution of energy and other input factors. In order to reduce energy use, capital and labor inputs need to be increased to enhance research and development of the most energy-efficient technology. It can be regarded as the
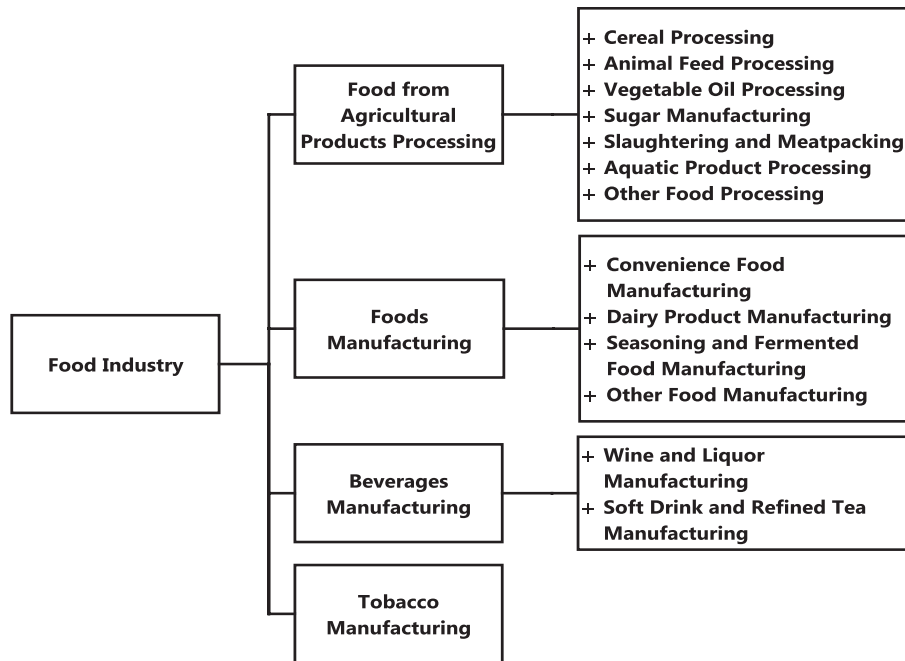

Fig. 2. Classification of China's food industry. *Source:* Classification of National Economic Industries, 2011.
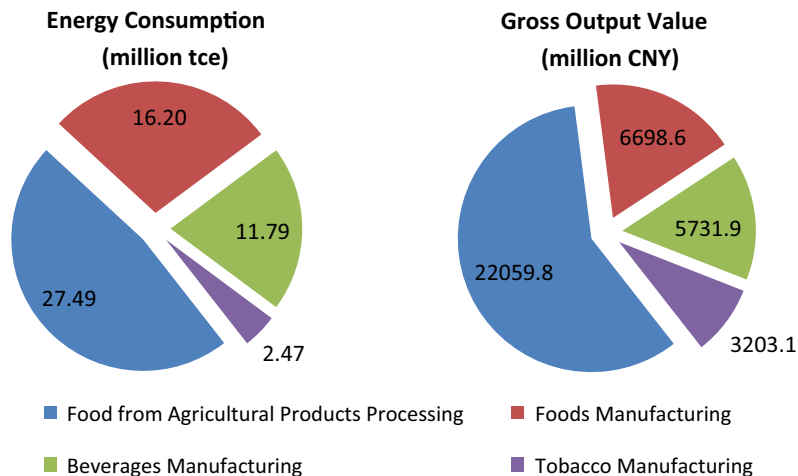

Fig. 3. Energy consumption and gross output value of the four sub-industries of China's food industry (2012). *Source:* China's National Bureau of Statistics (CNBS).