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Driving force of rising renewable energy in China: Environment, regulation and employment

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ABSTRACT

This paper studies the development of renewable energy in China by examining the driving force of environment quality, regulation and employment on renewable energy generation. We adopt renewable energy as a metric for environment quality, and test the relationship between renewable energy and income using Environment Kuznets Curve (EKC) theories. The impact of employment on renewable energy is tested, and dummy variables are used to indicate when the regulation was in effect. The results show that there exists a quadratic relationship between renewable energy and income. But the results fail to provide that the renewable energy generation is a job creator when the lagged unemployment rate is included as an explaining variable. We consider the employment population, and the finding shows that the employment can promote the development of renewable energy. The regulation has significantly positive impacts on renewable energy. The interaction of income and employment show that along with the income increases, the impacts of employment on renewable energy decrease. Our findings are helpful for government to figure out the determinants for rising the renewable energy generation, and take efficient measures to promote its development.

1. Introduction

Since opening-up policy was implemented, China has experienced dramatic development, with averaged 9.8% annual growth rates of gross domestic product (GDP), in comparison with the world's average of 3.3%. China has become the world's second largest economy. Simultaneously abundant fossil fuel has been consumed. In 1978, coal consumption is 282.8 million tons of oil equivalent, accounting for 70.7% of primary energy consumption, well above the world's average (26.2%) [1]. The proportion decreased gradually remaining above 70% until 2000, and then falling with some fluctuations, to 66% in 2014. The total increase since 1978 has been 1.68 billion tons of oil equivalent, almost increasing 15 times. Crude oil consumption was 91.2 million tons in 1978; by 2014 it had increased 5.7 times to 520.3 million tons, and the share has decreased from a 22.7–17.1% with fluctuation. Natural gas increased by 13 times, but stayed below a 3% share until 2006, and rised to 5.7% in 2014 [2], shown in Fig. 1.

Crude oil dominates the energy picture in world primary energy consumption, accounting for 30.1% in 2014, followed with 27.7% of coal and 21.9% of natural gas, and fossil energy almost controls 80% of total consumption [1]. Compared with the world level, China's unbalanced structure results in a series of problems that may hinder sustainable development. This coal based structure weakens energy efficiency and causes environmental deterioration. Energy consumption per GDP is three-times higher than the world's average, and doubles that of developing countries. According to "Research on China's energy development strategy and policy" [3], energy consumption may decrease 20 million Mtce (million tons of coal equivalent) when the proportion of coal in total primary energy drops 1%.

This increasing combustion of fossil fuels is the largest contributor to CO_2 emissions. CO_2 emissions accounted for 1.46 million metric tons in 1978 and 10.03 million tons in 2012, almost a 10-times increase [4]. As an emerging developing country and one of the largest CO_2 emitter, China is facing great pressure to reduce fossil fuel and CO_2 emissions while maintaining unprecedented economic growth. Meanwhile, traditional fossil energy companies takes great social responsibilities for employment, and the reduction of fossil energy may significantly hurt the employment. How to balance the environment quality, economic growth and employment is an intractable problem ahead of us.

One measure to relief this dilemma is increasing the supply and consumption of renewable energy. Renewable energy generation proportion has increased more than 10% from 1980 to 2012 in China [5]. Especially, the wind turbine and photovoltaic (solar) installed capacity shift dramatically, increasing more than hundred times during the recent years [1]. For the concerns of environment and

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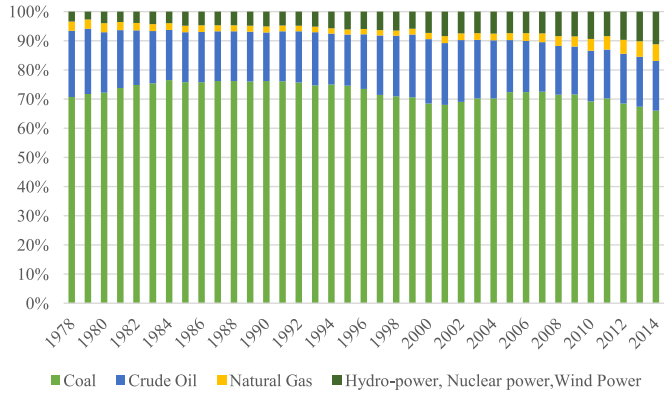

Fig. 1. China's primary energy consumption composition.
Source: NBSC, 2015 [2]

strategic security, a series of regulation and strategy plan have been proposed to support renewable energy development. The Renewable Energy Law was enacted on 28th February 2005, and major subsidy policies for renewable energy were put forward. In 2014, National Development and Reform Commission projects that the proportion of renewable energy strives upwards to 15% in primary energy consumption in 2020. More renewable energy is encouraged to contribute the low-carbon and sustainable economy.

Simultaneously, a job killer or job creator, is a controversy occurred in the transition from fossil energy to renewable energy (RE). As emerging resources, RE development creates a lot of new jobs via increasing investment. However, technical progress and energy substitution of RE will lead to "creative destruction". Therefore, the effects of creation or destruction on employment need to be tested.

Several theories present inverted U-shaped relationship between environment pollution and economic growth. Since environment quality is stressed to promote the RE development, we use RE as a metric for environment quality, presenting U-shaped relationship between RE and per capita GDP.

This paper analyzes the transition from fossil energy to renewable energy through empirically examining the nexus between economic growth, employment, regulation and relative use of renewable energy. The rest of this paper is structured as follows. Section 2 will make a brief literature review on the nexus between renewable energy and relative factors. In Section 3 we will present the data and methodology. The empirical analysis will be displayed in Section 4, and the conclusions and policy implication will be outlined in Section 5.

2. Brief literature review

The nexus between renewable energy and the determinants has attracted attention of researchers in different countries or areas during recent years. These studies differ in countries chosen, time period covered, econometric techniques employed and data type. Recent literature concerning renewable energy indicates that capital, labor, technological progress, and economic growth are the basic elements. The analytical framework used is neoclassical Cobb-Douglas production function, which is developed by Liao et al. [6] and justified by Arbex and Perobelli [7]. Fang [8] studies the relationship between GDP, renewable energy consumption and its share, capital, labor and per capita R & D expenditure using Cobb-Douglas production function. She finds that renewable energy consumption has significantly positive impacts on real GDP and GDP per capita. Salim et al. [9] adopt production function to estimate the relationship between GDP (industrial output), renewable and non-renewable energy, capital and labor. The results show bidirectional causality between industrial output and both renewable and non-renewable energy consumption. Inglesi-Lotz [10] also employs Cobb-Douglas function to describe the impact of renewable energy consumption, employment, R & D expenditure on economic welfare by using panel data techniques. The results showed there was positive and statically significant influence between them.

Some authors adopt the autoregressive distributed lag (ARDL) method to determine the cointegration relationship among variables. Lin and Moubarak [11] analyze the relationship between GDP, renewable energy consumption, carbon dioxide emissions and labor employing ARDL and Johansen cointegration techniques. The results show that there is a bi-directional causality between renewable energy consumption and economic growth, and labor influences renewable energy consumption in the short term, but there is no evidence of causality between carbon emissions and renewable energy consumption. Sebri and Ben-Salha [12] investigated the causal relationship between renewable energy consumption, economic growth, trade openness and CO_2 emission in the BRICS countries using ARDL bounds testing approach and vector error correction model. They found the bi-directional Granger causality existing among the competing variables. Jebli and Youssef [13] use ARDL bounds testing and the vector error correction model (VECM) and Granger causality approach to investigate relationships between per capita CO_2 emissions, GDP, renewable and non-renewable energy consumption and international trade for Tunisia. They find a short-run unidirectional causality running from trade, GDP, CO_2 emission and non-renewable energy to renewable energy, and renewable energy impacts on CO_2 emission weakly and insignificantly. The inverted U-shaped environmental Kuznets curve (EKC) hypothesis is not supported graphically.

Renewable energy as a means to mitigate the environmental impact of carbon emissions. The EKC is used to describe the relationship between environmental pollutants and economic growth with turning point. Several empirical studies test the validity of the EKC hypothesis, most of them focusing on fossil energy. Apergis and Payne [14] find that there is bidirectional causality between energy consumption and emissions, and real output exhibits the inverted U-shape pattern of EKC. Jalil and Mahmud [15] examine the long-run relationship between carbon emissions and energy consumption, income and foreign trade in China. They find there exists EKC relationship between CO_2 emissions and per capita real GDP, unidirectional causality from economic growth to CO_2 emissions and insignificant impact of trade on CO_2 emissions. Ozturk and Acaravci [16] examine the long run causal relationship between economic growth, carbon emissions, energy consumption and the employment ratio in Turkey. They find that only the employment ratio impacts real GDP per capita in the short run, and the EKC hypothesis is not valid in Turkey. Pao and Tsai [17] examine dynamic causal relationships between pollutant emissions, energy consumption and output for a panel of BRIC countries. They find real output exhibits the inverted U-shape pattern associated with the EKC hypothesis, and bidirectional causality between energy consumption and emissions, energy consumption and output.

Renewable energy is an engine to create green jobs presented by several studies. Kammen et al. [18] find that more renewable generation can lead to job creation. They calculate the job impacts of replacing one unit of electricity generation from conventional technologies by renewable technologies. U.S Environmental Protection Agency (EPA) and Renewable Energy Policy Network for the 21st Century (REN21) make statistics that the employment of renewable energy has increased along with the enlarging scale of this industry. Some articles include the impacts of employment in analyzing the relationship between renewable energy and economic growth. Fang [8] presents a positive and insignificant coefficient of the number of employees relative to GDP in China. Salim et al. [9] and Inglesi-Lotz [10] show a significant and positive coefficient of labor on GDP for OECD countries.

Several studies consider the impacts of regulation on energy supply and consumption or carbon emissions. Johnstone et al. [19] examines the effect of environmental policies on technological innovation of renewable energy by patent data. They find that public policy plays a