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How to promote the growth of new energy industry at different stages?

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ABSTRACT

China is currently the world's largest emitter of carbon dioxide (CO_2). Vigorously developing new energy sources has become an important way to reduce CO_2 emissions. Therefore, more and more scholars have studied effective ways to promote the development of new energy industry. However, most of the existing research use single-equation linear models or static models to study the driving forces of the new energy industry. This not only ignores the large number of dynamic relationships between economic variables, but also produces endogeneity problems. In order to overcome the shortcomings of existing research, this paper uses vector autoregressive model to study the new energy industry. The results show that energy consumption structure has a positive effect on the new energy industry in the short run, but the effect is limited in the long run. The impact of the agriculture industry is gradually narrowing over time due to the gradual reduction of crop acreage. However, the influence of economic growth is positive both in the short and long run. This is due to the gradual optimization of industrial structure. Technological progress produces a similar impact, owing to continued investment in research and development funding as well as research and development personnel.

1. Introduction

Urbanization and industrialization has led to continued rapid growth of the global economy. However, economic growth requires a lot of fossil energy, leading to a fast growth in CO_2 emissions. The accumulation of CO_2 emissions causes series of environmental imbalances such as global warming, sea–level rises and frequent extreme weather events (Xu and Lin, 2018). All these will have negative impact on the balance of the earth's ecosystem and environmental security, and even threaten human survival.

It is well known that fossil energy is an exhaustive energy source (Gippner and Torney, 2017). In reference to the World Energy Outlook (2016) released by the International Energy Agency (IEA), it is estimated that there are about 137 billion tons of oil reserves under the Earth surface. In accordance with the existing production capacity, the world can produce 3 billion tons of oil per year. Therefore, the global oil reserves can only be mined for 40–50 years. Similarly, the world's coal reserves are estimated at 1031.6 billion tons. Given the level of coal demand, the world's coal will be exhausted after 200 years. Huge energy demand and limited reserves have prompted countries around the world to compete for the limited oil and coal, leading to a growth in energy prices. The rise in energy prices has increased the cost of economic growth, and slowed the pace of global economic growth (Ewing and Malik, 2017). Addressing the challenge of economic growth, energy consumption and environmental protection has become a challenge for the world today. New energy (e.g., solar, wind, biomass and nuclear energy) has the following advantages: large reserves, unlimited development potential, clean, environmentally friendly and renewable (Xu et al., 2017). Thus, countries around the world are actively developing new energy and promoting the rapid growth of this industry.

China's GDP ranks second in the world. It is second only to the United States. Large industrial scale and long–term extensive economic growth lead to large fossil fuel use and CO_2 emissions. China is already the largest energy consumer and CO_2 emitter in the world (Xu and Lin, 2016). In reference to the data in China Statistical Yearbook, China's energy consumption and CO_2 emissions in 2015 were 4.30 billion tce (ton of standard coal equivalent) and 11.61 billion tons respectively. Therefore, the Chinese government is confronted with enormous pressure to reduce CO_2 emissions. Meanwhile, China's energy reserves are characterized by "rich coal and less oil." In order to meet the fast-growing oil consumption, China needs to import large amounts of oil each year. Since 2014, China's oil imports have surpassed the United States, becoming the largest oil importer in the world. Excessive oil

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imports rapidly increase China's foreign oil dependence from 29.7% in 2000 to 60.5% in 2015. Looking for clean and pollution–free alternative energy has become the fundamental way for the Chinese government to resolve the above problems. With a vast territory, China is rich in clean new energy such as solar, wind, biomass and nuclear energies (Dai et al., 2017). So in recent years, the government at all levels actively cultivated and developed new energy industries. Investigating the main driving forces of new energy industry is of great practical significance for developing this industry and reducing environmental pollution.

Given that the new energy industry plays an important role in easing energy crisis and mitigating environmental pollution, many scholars have conducted in–depth research on the main driving forces of the industry (Nizami et al., 2017; Malkki and Alanne, 2017). However, the existing research still has some shortcomings. Firstly, most of the existing studies use static models to examine the driving forces of the new energy industry. In fact, there is often some dynamic relationships between economic variables (Lee et al., 2017; Batten et al., 2017), that is, these driving forces not only impact the new energy industry in the short term, but also affect the new energy industry in the long term. Moreover, the short-term effects of these driving forces are different from their long-term effects. Investigating the relationships between the new energy industry and its driving forces with static models will inevitably lead to errors in the estimation results. Secondly, most researchers use traditional single–equation linear models to explore the relationships between the new energy industry and its driving forces. However, the new energy industry and its driving factors are often intertwined, that is, there is an endogeneity problem in the new energy industry and the driving forces. The traditional linear models cannot solve the problem of endogeneity, thus leading to the estimation of the model being biased and inconsistent.

The vector autoregressive (VAR) model is a structural model (García-Ascanio and Maté, 2010). It takes each endogenous variable in the system as a function of the lag values of all endogenous variables, so as to establish a model. Moreover, the VAR model does not need to presuppose that there is a theoretical economic relationship between economic variables. This leads to the fact that the VAR can not only reveal the dynamic relationships between economic variables, but also solve the problem of endogeneity. Therefore, this article uses the VAR model to examine the main driving forces of the new energy industry. The findings of this study will help government authorities to develop appropriate policies to promote the development of new energy industries.

The rest of this article includes the following sections. Section 2 briefly describes the relevant research literature. Section 3 presents the econometric approach and sample data. Section 4 provides the empirical results. Section 5 is an in–depth discussion of the empirical analysis results, and the conclusions and policy suggestions are presented in Section 6.

2. Literature review

Previous studies on the driving forces of the new energy industry have been conducted using different methods.

The first method is the input–output method. Using the input–output method, Hayashi et al. (2016) analyzed the relationships between information technology, thermal power production costs, government environmental regulation and Japan new energy industry. The empirical results showed that increase in fossil energy prices, information technology, and the strengthening of environmental regulation boosted the development of the new energy industry. Wiebe (2016) employed a multi–regional input–output method to assess the impact of R&D (research and development) funding investment on the new energy industry in Europe. The results indicated that expanding R&D investment can reduce the cost of new energy products, and is further conducive to the popularization of new energy products. Therefore, he proposed that European countries should reduce the economic burden of new energy production enterprises with fiscal and tax incentives. Garrett-Peltier (2017) investigated the impact of public and private sector spending on new energy products using the input–output method, and the results showed that increasing new energy consumption was conducive to developing new energy industry and expanding employment. Therefore, they suggested that government should expand subsidies on new energy products (e.g., solar panels and solar water heaters) in order to promote the growth of the industry.

The second method is system optimization method. Using the system optimization method, Al-Falahi et al. (2017) assessed the impacts of economic growth and technological stability on the solar and wind energy industries. They concluded that economic growth increased demand for new energy, and technological progress is conducive to expanding the scale of new energy production. Ye et al. (2017) applied a regional optimization method to explore the main drivers of wind energy in China's Jiuquan Satellite Launch Center, and found that the energy structure optimization and environmental regulation contributed to the wind energy development. Moreover, they further pointed out that the development of wind energy resources can further meet the energy needs of the region's energy systems. Golari et al. (2017) investigated the plight of new energy development at different stages using a multistage stochastic optimization method. The empirical results showed that in the early stages, low–priced fossil fuels can meet the needs of industrial energy consumption, so new energy development didn’t get enough attention. With further economic growth and the increase in fossil energy prices, most countries gradually attach importance to the development of new energy industries.

The third method is econometric method. Based on the 1980–2012 panel data of 17 emerging countries, Destek and Aslan (2017) used the bootstrap panel causality test to examine the relationships between economic growth and new energy development. The empirical findings denoted that the impact of economic growth on new energy industry was different across country. Using the panel cointegration model and the data of 11 developing countries, Paramati et al. (2017) found that there is a long-term equilibrium relationship between economic growth and new energy industry. Kahia et al. (2017) applied the panel error correction model to investigate the nexus between new energy consumption and economic growth, and similarly concluded that there is a bidirectional causal relationship between the two variables. Furthermore, Lyu and Shi (2018) studied the roles of financial investment, private equity, R&D investment, stock market development and venture capital in promoting the development of the new energy industry using the data envelopment analysis (DEA). The results showed that the efficient of financial investment is more than that of private equity, venture capital and stock market development.

Although several key studies have been conducted on the driving forces of the new energy industry, they still have two shortcomings. Firstly, most studies use static models to examine the relationships between the new energy industry and its driving forces. For example, Wiebe (2016) used the input-output method to investigate the role of R &D investment in the European new energy industry. However, his research cannot show the impact of lagging R&D investment on the new energy industry. In fact, there are often many dynamic relationships between socio-economic variables (Juselius, 2006). Using static models for empirical analysis will inevitably lead to results that cannot effectively explain the economic reality. Secondly, most scholars use traditional methods (e.g., index decomposition and input–output methods) to examine the new energy industry. Traditional methods artificially divide variables into exogenous and endogenous variables. For example, Lyu and Shi (2018) applied the data envelopment analysis (DEA) to investigate the efficiency of fiscal support for global new energy industry. They artificially set R&D investment, stock market development, financial investment, venture capital and private equity as exogenous variables, and used new energy generation as endogenous variable. In fact, there may be a two-way causal relationship between the new industry and these economic variables. Artificially setting