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Natural resources utilization efficiency under the influence of green technological innovation

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ABSTRACT

Innovation is the fundamental force to drive economic and social development, green technological innovation is the key driving force to achieve the development of low-carbon economic and enhance the efficiency of natural resources. With a panel data between 2001 and 2015, this paper applies the stochastic frontier analysis on the impact of green technological innovation on natural resources utilization efficiency taking high-tech industries as the research object, and analyzes the influence factors of natural resources utilization efficiency. The empirical result shows that under green technological innovation, the level of natural resources utilization efficiency is relatively higher and the change trend is increasing. Besides, green technology introduction funds and green new product development funds play a significant positive role on natural resources utilization efficiency, while green technology transformation funds and technological staff have the negative effect. Finally, policy suggestions about improving natural resources utilization efficiency are put forward. This paper makes an empirical study on the theoretical relationship between green technology innovation and natural resource utilization efficiency, clarifies the mechanism of green technological innovation on the efficiency of natural resource utilization based on the stochastic frontier analysis method, and analyzes the positive and negative factors of green technological innovation. The results can help to select the optimal innovation behavior to create the conditions of rational use of natural resources and realize economic development and environmental protection.

1. Introduction

With the rapid growth of the world population, the living space has been drastically reduced. The traditional production, manufacturing and business model cannot largely keep up with the pace of economic development. Natural resources are becoming increasingly scarce, and environmental damage is increasing day by day (Vivanco et al., 2015; Tõnurist, 2015). In order to save resources and energy, avoid and eliminate or reduce the environmental pollution and ecological destruction, each country pays more and more attention to green technological innovation for the sustainable development and the maximum economic and ecological benefits with minimum cost and minimum pollution (Lindman and Söderholm, 2015; Lee et al., 2015). Green technological innovation can improve and adjust the utilization and allocation of natural resources, and improve the utilization efficiency of raw materials and energy to develop various energy-saving products (Diaz-Rainey and Ashton, 2015; Yabar et al., 2012). Green technological innovation can help to promote the "three high and one low" production mode to the "three low and one high" change, and constantly expand the low carbon economic growth point, to achieve leapfrog development. It can improve and adjust the use and allocation of natural resources, develop a variety of raw materials and energy conservation products, improve the utilization efficiency of raw materials and energy; promote the use of natural resources to the direction of knowledge and skills, improve the utilization efficiency and output efficiency of natural resources. However, the relationship between green technological innovation and natural resource utilization efficiency is mainly theoretically, it lacks the practical research, especially the influence of green technological innovation on the utilization efficiency of natural resources. Therefore, the paper will start from this new perspective, help to clarify the impact mechanism of green technological innovation on the utilization efficiency of natural resource, play the positive role of green technological innovation, choose the best green technological innovation model, and improve the utilization efficiency of natural resources. It is of great theoretical significance and practical value to further improve the application of green

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technological innovation and promote the coordinated development of resource development, resource protection and social economy, ecological economy.

Natural resources are important material basis for development of the national economy and society (Yu et al., 2015; Peck and Parker, 2016). With the development of industrialization and population, the human huge demand for natural resources and large-scale exploitation of the natural resources have undermined and degraded the resources base (Rosen, 2013). However, the low utilization efficiency of natural resources and serious environmental pollution bring about a strong impact on the economic development (Sonnenschein and Mundaca, 2016; Hall and Helmers, 2013). It is imperative to improve the utilization efficiency relying on the green technological innovation capability, achieve energy conservation and emission reduction, and promote economic transformation development for sustainable utilization of natural resources (Hyard, 2013; Gosens and Lu, 2013).

In 2016, China economy is slow in stabilization and steady to good; GDP grows by 6.7% and is among the highest in the world, the contribution to global economic growth rate is over 30%. However, compared with the developed countries, China's natural resource consumption intensity is still large; the high degree of environmental pollution has a serious impact on China's sustainable economic development. Therefore, this paper analyzes the efficiency of natural resources utilization in the process of China's rapid economic growth by using Chinese data between 2001 and 2015, all which realize energy conservation and emission reduction and fulfill the "2016 Paris Agreement" to promote the rapid growth of low carbonation in the global economy. At present, the utilization of natural resources in China is characterized by low overall utilization level, rough utilization mode and backward utilization technique. The economic development excessively relies on resources and energy investment and brings about massive waste and pollution. The relationship between excessive development and utilization of resources and natural environmental degradation is ignored. There is lack of a policy analysis mechanism for effective natural resources and information support for decisions, particularly the inter-departmental policy analysis and the information sharing (Ghisetti and Quatraro, 2017). Thus, in consideration of the above issues, the author believes that it is necessary to further explore and quantitatively study the utilization efficiency of natural resources. The paper is intended to integrate the ideas of resources saving, environmental friendliness and the thought of green technology, fully consider a series of internal and external factors, such as ecology, resources, environment, scientific research input, technological management, etc. After constructing the inter-provincial panel data between 2001 and 2015, the paper studies the impact mechanism of green technological innovation on natural resources utilization efficiency in China by using the stochastic frontier analysis method (SFA) of logarithmic Cobb-Douglas production functions. Finally, the paper draws related conclusions based on the research results, proposes appropriate countermeasures and suggestions, and establishes and implements the policies on energy conservation and emission reduction at the macro levels of nations and provinces and the micro levels of specific institutions.

2. Literature review

The arrival of a new round of technological revolution and industrial change, which is a challenge and an opportunity for the green development of the world. It is urgent to take scientific and technological innovation as a strategic basis to improve natural resources utilization efficiency. To lead the development of green innovation, green technological innovation which solves the economic low-carbon development mode and environmental protection dilemma has become a hot spot for domestic and foreign scholars. Amore and Bennedsen (2016) studied the relationship between corporate governance system and enterprises green energy technology, and pointed out that the ineffective corporate governance system became the main obstacle to green technological innovation. Bi et al. (2016) proposed an analytic framework for the low-carbon technological innovation process under the global value chain, and analyzed the low-carbon technological innovation performance and its influencing factors in China's manufacturing industry by using the factor analysis and DEA-Tobit two-stage approach. Albort-Morant et al. (2016) pointed out that good green innovation efficiency can help to achieve greater corporate performance, and made an empirical analysis that shew the dynamic and static capacity of enterprises has a positive and significant direct impact on green innovation efficiency. Hrovatin et al. (2016) analyzed similar factors that affect the energy efficiency of enterprises green technologies, pointed out that energy cost share, market share and export orientation have a significant impact.

Natural resources are an important material basis for national economic and social development. With the development of industrialization and population, the huge demand for natural resources and their large-scale exploitation have led to the weakening and degradation of the resource base. With the lowest environmental costs to ensure the sustainable utilization of natural resources, has become a major problem in the national economic and social development process. Balta-Ozkan et al. (2015) studied the transition relationship between regional organizations on economic activity and energy systems through the establishment of regional energy transformation, and proposed effective and equitable policy results from the perspective of urban and regional planning. Xu and Lin (2017) pointed out that it is critical for make effective environmental policies to determining the driving factors of carbon emissions, made an empirical analysis by taking China's steel industry as research object that the results shew that energy efficiency plays a leading role in green development of steel industry. Emodi et al. (2017) used the scenario analysis method to study the impact of Nigeria's future energy demand factors, analyzed Nigeria's energy policy from four different scenarios. Wang et al. (2015) pointed out that the driving factors causing changes in China's carbon dioxide emissions contributed to the formation of better carbon reduction policies and the development of low-carbon economies, the empirical results show that energy structure and low energy efficiency are the biggest contributors to increasing carbon dioxide emissions.

There are three main problems in the study of green technological innovation and natural resource efficiency. Green technological innovation is carried out under the policy guidance of China's innovation-driven development strategy, the uncertainty of macro policy is of great importance to green technological innovation (Roper and Tapinos, 2016). Current models of production and energy use are driving green technologies with innovation and improving environmental quality as the core (Marra Antonelli and Pozzi, 2017). However, the research of green technological innovation focused on innovation and environment and economics efficiency but neglected the influence of various direct factors related to profitability (Palmer and Truong, 2017) such as system, scientific research investment and science and technology management on green technology innovation. The factors that affect the efficiency of natural resources are multifaceted and comprehensive. Therefore, we must not only analyze the influencing factors of natural resource efficiency, but also analyze the technologies, systems and so on factors that relate to energy use and carbon emission (Wang et al., 2017; Fernando and Xin, 2017). The methods and means to improve the utilization efficiency of natural resources need to be improved (Huysveld et al., 2015; Yu et al., 2016). According to the existing research literature, there is a lack of research on the relationship between green technological innovation and the development of low carbon economy, the utilization efficiency of natural resources (Sueyoshi and Goto, 2014; Purchase et al., 2016). For example, it is still not perfect that the research on the realization ways of various measures and strategies to improve the utilization efficiency of natural resources, and the research on the driving force of green technological innovation is also not perfect, especially the differences of the impact of green