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Research Progress and Prospects of Total Factor Productivity in the Construction Industry

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Abstract The high-quality development of the construction industry fundamentally stems from the significant improvement of total factor productivity. Therefore, it is of crucial significance for promoting the development of the construction industry to a higher level by scientifically and accurately measuring the total factor productivity of the construction industry and deeply analyzing the influencing factors behind it. Based on a comprehensive consideration of research methods and influencing factors, this paper systematically reviews the existing relevant literature on total factor productivity in the construction industry, aiming to reveal the current research development trend in this field and point out potential problems. This effort aims to provide a solid theoretical foundation and valuable reference for further in-depth research, and jointly promote the continuous progress and development of total factor productivity research in the construction industry.

Key words Construction industry, Total factor productivity, Research progress, Influence factor, Theoretical basis

1 Introduction

At the 75th United Nations General Assembly in 2020, Chinese president Xi Jinping solemnly pledged: "China will achieve carbon peaking by 2030 and carbon neutrality by 2060". This grand goal not only demonstrates China's firm determination to address global climate change, but also points us in the direction of future green development. The construction industry, as a pillar industry of the national economy, is facing severe challenges of high energy consumption and high emissions while promoting steady economic growth. According to the *China Building Energy Consumption Research Report* (2019), the expected time for China's construction industry to reach its carbon peak is around 2039, which means that after achieving carbon peak nationwide, the carbon emissions of the construction industry will continue to increase for about 9 years. This trend undoubtedly brings enormous pressure to China to achieve the carbonpeaking and carbonneutrality goals. Therefore, the green and low-carbon development of the construction industry is not only of great significance for achieving China's overall carbon emission goals, but also an inevitable choice to promote high-quality economic development. In the context of the new era, the "14th *Five-year Plan" for the Development of the Construction Industry* clearly proposes to promote the industry to shift from pursuing high-speed growth to pursuing high-quality development, from expanding in quantity to improving in quality, and to achieve green and low-carbon development. This marks a critical period of transformation and development for the construction industry, and it needs to pay more attention to green total factor productivity integrating environmental constraints while focusing on its scale expansion.

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Green total factor productivity is an important indicator for measuring the level of green development in the construction industry, which comprehensively considers factors such as resource utilization efficiency, environmental pollution level, and technological progress. Therefore, comprehensively improving green total factor productivity is an important way to promote the high-quality development of the construction industry. Therefore, it is necessary to continuously track the research and development trend of total factor productivity in the construction industry, in order to provide theoretical reference for subsequent research and provide decision-making basis for formulating scientific and reasonable carbon reduction policies in the construction industry.

2 Measurement of total factor productivity in the construction industry

The construction industry is an important component of the world's national economy. Due to its scale and the nature of its products as production resources, it is extremely important to improve the productivity in the construction industry. In the early stages of research, scholars devoted themselves to analyzing the productivity of the construction industry by citing different productivity concepts. Due to the lack of statistical data, they often used labor productivity as a biased measurement standard, ignoring the impact of factor substitution and changes in relative prices[1]. With the expansion of research, total factor productivity (TFP), a more meaningful measure, has been used in the study of productivity in the construction industry. Because the development driven by total factor productivity is endogenous and sustainable, it does not reduce or even increase marginal utility[2]. To scientifically evaluate the total factor productivity of the construction industry, existing literature has used research methods such as C-D production function method[3], transcendental logarithmic production function method[4], Tornqvist index method[5], Färe-Primont DEA method[6], Malmquist index method[7-8], DEA-Malmquist index method[9-10], among which DEA-Malmquist productivity in-

dex method is the most widely used. In terms of analysis of measurement results, existing literature mainly focuses on its evolutionary characteristics, regional differences, convergence, *etc.* Due to different research objects, methods, and data selection, the conclusions of existing research are also different.

However, most studies generally do not consider energy consumption when measuring total factor productivity of buildings[11]. As one of the three major areas of energy consumption, the construction industry is an important source of global carbon emissions. It is expected that the proportion of carbon emissions from the construction industry to global carbon emissions will reach 52% by 2050, playing an important role in mitigating global climate change[12]. Therefore, when measuring the total factor productivity of the construction industry, it is urgent to consider energy consumption and environmental pollution. The research by Hu *et al.*[13] also confirms that energy consumption plays an important role in the change of total factor productivity in the construction industry, and there is a close relationship between energy productivity and total factor productivity in the construction industry. Therefore, a few scholars have conducted research on the green total factor productivity (GTFP) of the construction industry from a macro perspective, and used methods such as GML index[14-15], DEA-Malmquist index method[16-17], two-stage network DEA model[18], super efficiency SBM-GML model[19] to measure and analyze its dynamic evolution trend.

3 Factors influencing total factor productivity in the construction industry

The productivity of the construction industry helps to understand its spatio-temporal evolution pattern, and further analysis of the driving factors behind it can formulate targeted policies for the improvement in construction industry productivity, especially green total factor productivity. From the perspective of influencing factor selection, existing literature has empirically tested the impact of industry technological capabilities and market structure[20], energy consumption structure[14], environmental regulations[19,21], employment quantity[2], capital investment[4], minimum wage standards[22], industrial agglomeration[23], technological progress[8,20,24] and other factors on the productivity of the construction industry. Due to the influence of factors such as sample data selection, existing literature also has some different conclusions regarding the factors affecting the productivity of the construction industry. Most literature suggests that the growth of TFP in the construction industry is mainly due to technological progress, while Chen Min *et al.*[25] found that due to the impact of diseconomies of scale, the contribution of technological progress to TFP in the construction industry is not high. At the same time, there are also different perspectives in research on large contractors in the Chinese construction industry[26-27]. In addition, a few studies have further explored the impact of TFP on output in the construction industry based on its measurement, and have reached inconsistent conclusions. Research by Wang Yousong *et al.*[28] found that the growth of labor input has the greatest contribution rate to the growth of the total output value of the construction industry, with a TFP contribution rate of 25.94%. Li Zhan *et al.*[29] found that the growth of intermediate inputs has the greatest contribution to the growth of the total output value of the construction industry, and TFP has an inhibitory effect on it.

4 Conclusions and prospects

In the current research context, the achievements have significantly expanded the research scope of construction industry productivity, not only providing solid theoretical and practical support for improving construction industry productivity, but also deepening the understanding of productivity measurement methods in the construction industry, further revealing the overall trend and influencing factors of regional construction industry productivity, which is of great significance for promoting sustainable development of the construction industry. However, it also has to face the fact that the current research on green total factor productivity in the construction industry is still insufficient.

From the perspective of research methods, the measurement methods of total factor productivity in the construction industry can be mainly divided into: production function method and index method. Among them, the index method is represented by the DEA index method and the GML index method. Both of these schools are based on input-output indicator systems. Therefore, how to scientifically and reasonably select input-output indicators has become a key issue. In existing research, input indicators cover multiple aspects such as labor, capital, energy, and intermediate inputs. Among them, labor indicators are mostly measured by the quantity of labor, with less consideration given to the quality of labor; capital indicators often select data such as total assets of the construction industry and net value of fixed assets; energy data covers both direct and indirect energy consumption in the construction industry. In terms of output indicators, data such as the added value of the construction industry and carbon emissions from the construction industry are frequently used. However, due to differences in research areas and data availability, existing literature presents a certain degree of diversity in the selection of indicator data. In the future, scientific quantitative methods are needed to further clarify the indicator system of total factor productivity in the construction industry.

From the perspective of influencing factors, existing literature has a relatively broad research perspective, mainly focusing on the impact of technological and economic factors on the total factor productivity of the construction industry. However, research on environmental regulations and other aspects is still weak, and the characterization indicators are relatively single. Furthermore, few studies have touched upon their underlying transmission mechanisms in the in-depth analysis of influencing factors.

Looking ahead to the future, it needs to further strengthen the comprehensiveness and timeliness of statistical data in the research. Through a comprehensive approach of qualitative and quantitative analysis, it needs to construct a more comprehensive evaluation index system, especially incorporating green indicators such as energy consumption and carbon emissions from the construction industry, and comprehensively measuring the total factor productivity of the construction industry from the perspective of green development. At the same time, in the selection of research methods, it should also maintain an open attitude and introduce advanced methods such as the SE-SBM model into the measure-

ment of total factor productivity in the construction industry, in order to promote the deepening and development of research.

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