

Research on the Impact of Higher Education Financial Expenditures on Sustainable Economic Development from a Green Total Factor Productivity Perspective

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Abstract: Guided by the goal of “double carbon,” China's economy is transitioning towards innovation-driven development and quality improvement. As a strategic intersection of technology, talent and innovation, higher education plays a key role in improving green total factor productivity and promoting sustainable economic development. Financial expenditure on higher education can effectively improve green total factor productivity and promote sustainable economic development. Mechanism analysis shows that the reform can improve green total factor productivity through two channels: human capital effects and green technology R&D and industrial transformation support. Finally, this paper puts forward suggestions on the mechanism of action, providing policy inspiration for subsequent improvement of green total factor productivity and promotion of sustainable economic development.

Keywords: Higher Education Financial Expenditure; Sustainable Development; Green Total Factor Productivity Perspective.

1. Introduction

The Led by the "dual-carbon" goal, the Chinese economy is undergoing a profound transformation from factor-driven to innovation-driven and from scale expansion to quality improvement. Green Total Factor Productivity (GTFP), which balances economic growth and environmental issues, is an important indicator of sustainable economic development, and improving GTFP has become an important tool for promoting sustainable economic development. Higher education, as the strategic intersection of science and technology as the first productive force, talent as the first resource, and innovation as the first driving force, plays a key role in promoting sustainable economic development. In today's era, talent has become an important resource for promoting high-quality economic development, and higher education, as the main way of talent cultivation (Fang Huilin, 2023), has become more prominent. The development of higher education cannot be separated from the financial support, so it is especially important to study the scale of higher education financial expenditure. Based on this, this paper will study the impact of the scale of financial expenditure on higher education on green total factor productivity to provide an effective way to promote sustainable economic development.

Currently, studies on fiscal expenditure on higher education and green total factor productivity focus on: López et al. (2011) explored and analyzed the effect of fiscal expenditure layout on the environment, and through the construction of a theoretical model found that due to the strong positive externality of public products such as culture and education, which can enhance efficiency by mitigating market failures and supplementing private investment, a bias toward public products such as culture and education expenditure structure will effectively reduce pollution emissions. Hua et al. (2018) subdivided public service expenditures into science and technology expenditures and education expenditures, and examined the impact of financial science and education

expenditures on sulfur dioxide and dust pollution, and found that financial science and education expenditures have a positive impact on environmental quality, and that education expenditures are able to better improve environmental quality compared to the effect of technological improvement brought about by science and technology expenditures. Li et al. (2016) found that the level of human capital increases as the level of education improves, and these higher human capitals have higher requirements for individuals and even collectives in terms of resource conservation, environmental protection, and the use of environmentally friendly technologies, which is conducive to the realization of sustainable development.

2. Relevant Concepts

2.1. Higher Education Financial Expenditure

Domestic and foreign scholars have given different definitions of public goods, among which the definition given by Samuelson in 1954 is recognized by most scholars. Samuelson defined pure public goods as products that are completely non-competitive and non-exclusive. Products that do not fully possess these two characteristics are quasi-public goods. Although quasi-public products do not have complete non-exclusivity or complete non-competitiveness, they are not non-existent, but the degree of their characteristics is lighter than that of pure public products. Higher education is a typical quasi-public product and has certain positive externalities, which determines that the government should bear most of the investment costs of higher education (Zhou Xiafei et al., 2022). From the dimension of all levels and types of education, China's education financial expenditures can be divided into five categories: pre-school education financial expenditures, compulsory education financial expenditures, general high school education financial expenditures, vocational education financial expenditures, and higher education financial expenditures. Among them, higher education financial expenditures refer to the education financial expenditures for higher schools. The education

expenditure of higher education can be mainly divided into three categories, namely, education business expenses, capital construction funds, and scientific research funds.

2.2. Sustainable Economic Development Figures

Sustainable economic development refers to ensuring the development needs of the present generation without compromising the ability of future generations to meet their needs, and its core lies in realizing a dynamic balance between economic growth, resource conservation and ecological protection. This development paradigm breaks away from the traditional single GDP growth-oriented model, and emphasizes the construction of a sustainable economic system that takes into account intra-generational equity and inter-generational justice through the improvement of factor allocation efficiency, the drive for technological innovation, and the optimization of institutional structure. Green Total Factor Productivity (GTFP), as an important indicator for measuring sustainable economic development, incorporates environmental costs such as energy consumption and pollution emissions into the analytical framework of traditional Total Factor Productivity, and comprehensively reflects the level of quality and efficiency of economic growth and the degree of ecological cost coordination through the measurement of input and output efficiencies under environmental constraints. Through the green restructuring of production methods, the resource dependence and environmental load per unit of output can be reduced, so as to realize the sustainability of the economic system in the synergy of efficiency improvement and ecological loss reduction. In this process, sustainable economic development requires breaking through the dichotomy of "growth-environment," stimulating the diffusion effect of green technology, the ecological adaptability of human capital, and the incentive compatibility of the market mechanism through institutional innovation, and ultimately forming the endogenous growth path that is resource-intensive, environmentally friendly, and innovation-driven. The dynamic evolution of GTFP essentially reveals the ability of the economic system to transform from "brown growth" to "green convergence," and its growth rate and stability are not only a quantitative characterization of the achievement of the SDGs, but also a core evaluation basis for the effect of policy intervention. The rate and stability of growth is not only a quantitative characterization of the achievement of the SDGs, but also the core basis for assessing the effectiveness of policy interventions.

3. Theoretical Analysis

As an important part of public education expenditure, fiscal expenditure on higher education covers education utility fees, capital construction funds, and research funds, and is subject to the statutory constraints of the Education Law on the "three growths" of fiscal education expenditure, as well as reflecting the policy tilt of local governments towards higher education priorities under the fiscal decentralization system. Existing studies have shown that financial education expenditure affects green total factor productivity mainly through human capital effects and green technology R&D and industrial transformation support (Pang Yumeng et al., 2020). The following describes their respective mechanisms of action that affect green total factor productivity.

3.1. Human Capital Effects

As an important means of public resource allocation, financial expenditure on higher education has a structural impact on the formation and accumulation of human capital. Theoretical studies have shown that financial investment in education can significantly enhance the reserve of middle and higher human capital by optimizing educational facilities, improving the quality of teachers and expanding the scale of academic research, and its mechanism of action is reflected in the systematic strengthening of knowledge transfer efficiency and specialized skill cultivation. Although the effect of financial support at the primary education level is not significant in some studies, most analyses support the sustained role of financial expenditure on higher education in promoting the growth of human capital stock, especially in technology-intensive and innovation-driven economies, where the highly skilled labor force formed by higher education has become a core element of regional competitive advantage. It is worth noting that the effectiveness of fiscal investment in may be moderated by the structure of expenditure, the degree of policy synergy, and the stage of regional economic development. For example, targeted funding for science and engineering can often reduce the risk of outflow of high-skilled labor through the improvement of infrastructure and the effect of talent pooling, which in turn creates a positive cycle of human capital accumulation.

The contribution of human capital accumulation to sustainable economic development is mainly realized through the optimization of total factor productivity and the improvement of environmental quality. In the dimension of efficiency improvement, high-skilled human capital can effectively break through the constraint of diminishing marginal returns of traditional factor inputs and drive the total factor productivity to converge to the technological frontier by enhancing the technology absorption capacity, promoting original innovation and optimizing the management of production processes. At the ecological sustainability level, the enhancement of human capital not only strengthens the awareness of environmental responsibility of individuals and organizations, and promotes the endogenous evolution of clean technology research and development and green consumption preference, but also forces the industrial sector to reduce the intensity of resource consumption and the scale of pollution emission through the upgrading of the demand structure induced by income growth. The two paths do not exist in isolation, but form a synergistic mechanism through the knowledge spillover effect and behavioral demonstration effect. For example, the enhancement of innovation capacity can accelerate the diffusion of environmental protection technologies and reduce the ecological footprint per unit of output through the improvement of production efficiency, so as to achieve the goal of sustainable development in the resonance of efficiency change and green transformation.

3.2. Green Technology R&D and Industrial Transformation Support

Through targeted resource allocation and institutional incentives, financial expenditures on higher education have provided basic guarantees for green technology research and development and industrial transformation support. At the level of green technology R&D, financial investment can systematically improve the original innovation ability and engineering transformation efficiency of green technology,

and reduce the cyclical and uncertain risks of technology R&D by supporting the construction of basic research platforms, the formation of interdisciplinary teams, and the technological research in key areas of universities and scientific research institutions; at the level of supporting industrial transformation, financial funds can accelerate the penetration and diffusion of green technology into real industries by building a synergistic network of production, academia, and research, and financing technology transfer centers and pilot bases, and promote the penetration and diffusion of traditional production processes. At the level of industrial transformation support, the financial funds accelerate the penetration and diffusion of green technologies into real industries by building industry-university-research collaborative networks, funding technology transfer centers and pilot bases, promoting the clean transformation of traditional production processes and the incubation and cultivation of the emerging green industry chain, and forming an effective docking between technology supply and industrial demand. The two together build a complete chain of "knowledge production-technology transformation-industry application," which makes the financial expenditure of higher education go beyond the traditional function of human capital accumulation and become the core hub of green innovation ecosystem.

Green technology research and development and industrial transformation support have a direct impact on the path of green total factor productivity enhancement by reshaping the interaction between the production function and environmental constraints. Green technology R&D reduces resource consumption and environmental load per unit of output by breaking through key technological bottlenecks such as energy efficiency improvement, end-of-pollution treatment and circular economy, and promotes the expansion of production frontiers in the direction of eco-friendliness; and industrial transformation support optimizes the efficiency of factor allocation and industrial synergies through the large-scale application of green technology and collaborative innovation of the industrial chain, and reduces structural friction and resource mismatch loss. The synergistic effect of the two can not only realize the internalization of environmental costs and the improvement of production efficiency in parallel, but also stimulate the dynamic adaptive capacity of regional innovation system through technological spillover and network effect, and ultimately drive the green total factor productivity to achieve sustainable growth with equal emphasis on both quality and efficiency under the composite mechanism of technological progress, resource allocation and structural optimization.

4. Conclusion

The research shows that the scale of higher education financial expenditure can promote sustainable economic development by increasing green total factor productivity through human capital effects and green technology R&D and industrial transformation support. Based on the research results, this paper puts forward the following two policy recommendations: one is to optimize the structure of financial expenditure on higher education and strengthen the green adaptability of human capital; the other is to build a financial support system for green technology research and development and industrial transformation, and activate the innovation ecosystem.

4.1. Optimize the Structure of Financial Expenditure on Higher Education and Strengthen the Green Adaptability of Human Capital

Higher education financial expenditure needs to shift from scale expansion to structural optimization in order to accurately cultivate high-quality human capital adapted to the needs of green transformation. Firstly, a "green-oriented" mechanism of financial investment should be established to prioritize support for the construction of disciplines closely related to sustainable development, such as environmental science, new energy technology, ecological engineering, etc., and to enhance the scale and quality of green human resources training through the establishment of special funds and the improvement of laboratories and training bases, etc. Secondly, a dynamic adjustment mechanism should be established to strengthen human capital's green adaptation ability. Secondly, a dynamic adjustment mechanism should be constructed to differentiate the allocation of educational resources according to the degree of greening of regional industries and the demand for technological innovation, for example, focusing on the cultivation of talents in cleaner production technology in areas where high-energy-consuming industries are concentrated, and reinforcing the layout of disciplines of environmental governance in ecologically fragile areas, so as to avoid the mismatch of resources caused by the input of "one-size-fits-all." In addition, it is necessary to strengthen the synergistic connection between higher education and green industry, and guide enterprises to participate in joint training programs between universities and enterprises and directional commissioned scientific research programs through financial subsidies, so as to embed the accumulation of human capital into the practical scenarios of green technology research and development and application, and to shorten the cycle of knowledge transformation. For less developed regions, a cross-regional compensatory financial fund should be set up to bridge the regional imbalance in the supply of human capital through the exchange of teachers and the sharing of digital education resources, so as to prevent the "Matthew effect" in the process of green transformation. Finally, improve the human capital incentive policy, give tax breaks, scientific research incentives and other support to professionals engaged in green technology research and development, ecological governance and other fields, and enhance the market recognition of human capital through the green skills certification system, forming a closed-loop mechanism of "cultivation-allocation-retention." A closed-loop mechanism of "cultivate - allocate - retain" has been formed to ensure the sustainable release of the human capital effect of higher education financial expenditures.

4.2. Build a Financial Support System for Green Technology Research and Development and Industrial Transformation, and Activate the Innovation Ecosystem

Higher education financial expenditures should go beyond the traditional education service function and be deeply embedded in the whole chain of green technology innovation and industrial upgrading. On the one hand, it is necessary to strengthen the long-term stable support of financial funds, support basic research in green technology, and set up

platforms such as national green laboratories and interdisciplinary research centers in universities, with a focus on funding original research in key areas such as clean energy, carbon capture, and circular economies. It also enhances the efficiency of R&D through new research organization modes such as "Horse Racing System." On the other hand, we will improve incentive policies for technology transformation, set up a green patent fast-track approval channel and an industrialization support fund, implement tax rebates for green technology transfer income from universities, encourage researchers to participate in green transformation of start-ups or traditional enterprises with their achievements, and crack the "lab-production line" interface bottleneck. Bottlenecks in the "lab-production line" interface. At the level of industrial support, promote the synergy between financial investment in higher education and the cultivation of green industry chain, for example, through special bonds to support universities and industrial parks to build green technology pilot bases and industrial innovation alliances, and guide financial funds to tilt towards emerging areas such as green and intelligent manufacturing and eco-service industry, so as to accelerate the diffusion of technology and the formation of cluster effects. At the same time, through financial subsidies, risk compensation, and other means, social capital is mobilized to participate in green technology investment, and an input mechanism is established in which multiple entities share risks and benefits. In addition, it is necessary to establish a dynamic assessment system for green technology R&D performance, and incorporate ecological indicators such as the reduction of carbon emission intensity and the improvement of resource recycling rate into the financial allocation assessment standards of universities, so as to force

the precise docking of scientific research activities with industrial demands. Through the above measures, we can systematically enhance the two-way empowerment effectiveness of higher education financial expenditures on the supply side of green technology and the application side of industry, and inject innovative kinetic energy into the sustainable development of the economy.

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